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Report
Geotechnical Engineering Services
Family Fun Center
Tukwila, Washington

June 30, 1997

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Family Fun Center
Tukwila, Washington

June 30, 1997

For
Family Fun Centers

GeoEngineers

File No. 5925-001-37-1130/063097

GeoEngineers

Consulting Engineers
and Geoscientists
Offices in Washington,
Oregon, and Alaska

June 30, 1997

Family Fun Centers
c/o Mulvanny Partnership Architects P.S.
11820 Northup Way, No. E300
Bellevue, Washington 98005

Attention: Chandler Stever

We are pleased to submit eight copies of our report presenting the results of our geotechnical engineering services for the proposed Family Fun Center to be located in Tukwila, Washington. The scope of services for this study is described in our proposal dated June 2, 1997. Authorization to proceed with our services was provided by Scott Huish of Family Fun Centers on June 12, 1997. Portions of our preliminary conclusions and recommendations have been discussed with you as our findings were developed. We also are providing Phase I Environmental Site Assessment services for the site. The results of that study are being prepared as a separate report and will be transmitted under separate cover.

We appreciate the opportunity to provide geotechnical engineering services on this interesting project. We will be pleased to respond to any questions you have, to provide further consultation during design, and to assist you during construction of this facility.

Yours very truly,

GeoEngineers, Inc.

Mary S. Rutherford

Mary S. Rutherford, P.E.
Associate

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File No. 5925-001-37-1130

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REPORT
GEOTECHNICAL ENGINEERING SERVICES
FAMILY FUN CENTER
TUKWILA, WASHINGTON
FOR
FAMILY FUN CENTERS

INTRODUCTION

This report presents the results of our geotechnical engineering services for the proposed Family Fun Center to be located in Tukwila, Washington. The site is located northeast of the intersection between Interurban Avenue South and Southwest Grady Way, south of the Green River and west of the Burlington Northern Railroad. The site is shown relative to surrounding physical features on the Vicinity Map, Figure 1.

Our understanding of the project is based on information provided by Mulvanny Partnership Architects including a Concept Site Plan dated June 17, 1997. The site is separated into three parcels. Parcel 1 encompasses approximately 2.1 acres near the northwest corner of the site. Parcel 2 encompasses approximately 2.8 acres near the center of the north portion of the site. The remaining 8 to 9 acres comprise Parcel 3.

The site has a relatively complex history of grading activities that reportedly began as early as 1904. Currently, a large soil stockpile is located on the east portion of Parcel 3. A former milk bottling plant, several residences, a barn and other ancillary buildings are located on the south and central portions of Parcels 2 and 3. We understand that the existing structures will be demolished prior to construction. Most of Parcel 1 and the north portion of Parcel 2 are open pasture areas or overgrown with brush.

We understand that site grades are planned to be raised to about Elevation 26 feet. Accordingly, fills on the order of 3 to 6 feet will be necessary across much of the site with the exception of the soil stockpile area. The intent is to utilize as much of the existing soil stockpile material as possible for fill in other areas of the site. We understand that general site grading is planned to be begin in August 1997, pending permits.

The development will include a restaurant on Parcel 1, a four-story hotel on Parcel 2 and a Family Fun Center building on Parcel 3. Locations of the planned facilities are shown on the Site Plan, Figure 2. The restaurant will be situated near the northwest corner of Parcel 1 and encompass about 11,900 square feet. We anticipate the that restaurant will be a single-story structure with column loads on the order of 70 kips. Paved parking areas will be located to the south, east and west of the restaurant.

The Family Fun Center building will be located near the southeast corner of Parcel 3 and encompass approximately 35,500 square feet. The building will have a second and third story encompassing approximately 20,000 and 10,000 square feet, respectively. Current planning indicates that the lowest level of the Family Fun Center building will be constructed of concrete.

The second and third levels of the building are likely to be steel-framed. Column loads for the Family Fun Center building are expected to be about 180 kips in areas with two stories and up to about 280 kips in areas with three stories.

Paved parking will be located to the south and east of the Family Fun Center building. We also understand that the parking area grades may be raised to provide a second-story 'ground level' entrance to the Family Fun Center building. Additional facilities to be located on Parcel 3 will include an 18-hole miniature golf course and a go-cart race track.

The hotel will be situated on the central portion of Parcel 2. We understand that the development of Parcel 2, including the design and construction, will be coordinated by the ownership of the hotel. Accordingly, this report addresses the geotechnical considerations relative only to the development of Parcels 1 and 3, and does not apply to Parcel 2.

SCOPE OF GEOTECHNICAL SERVICES

The purpose of our geotechnical engineering services is to explore subsurface conditions at the site as a basis for developing geotechnical recommendations and design criteria for Parcels 1 and 3. Our specific scope of services included the following tasks:

1. Review available subsurface soil and ground water information for the site. This information includes reports prepared by Geotech Consultants, Inc. and Applied Geotechnology. Also, review available in-house subsurface information for surrounding sites.
2. Explore subsurface soil and ground water conditions within the footprint of the Family Fun Center building by drilling one boring to a depth of about 49 feet below the existing ground surface using truck-mounted, hollow-stem auger drilling equipment.
3. Explore subsurface soil and ground water conditions at the proposed location of the restaurant building by drilling one boring to a depth of about 44 feet below the existing ground surface using truck-mounted, hollow-stem auger drilling equipment.
4. Explore shallow subsurface soil and ground water conditions in building and pavement areas by excavating 12 test pits to depths of about 8.5 to 13.5 feet below the existing ground surface.
5. Evaluate the physical and engineering characteristics of the soils based on laboratory tests performed on samples obtained from the explorations. The laboratory tests included moisture content and dry density determinations, and consolidation tests. Also, specific gravity tests and expansion tests were performed on slag samples.
6. Provide recommendations for site preparation and earthwork including stripping requirements, recommendations for any imported borrow needed, and fill placement and compaction criteria. This will also include an evaluation of the effects of weather and/or construction equipment on the on-site soils.
7. Evaluate the suitability of on-site materials, including the soil stockpile materials, for use in structural fills or landscape fills, as appropriate.

8. Provide recommendations for the use of preload fills as a means of reducing postconstruction settlement of structures supported on shallow foundations, if appropriate.
9. Provide foundation design recommendations including allowable soil bearing pressures for shallow foundations and recommendations for the coefficient of friction and passive soil pressures to resist lateral loads.
10. Provide preliminary foundation design recommendations including allowable soil bearing pressures for shallow foundations to support the restaurant.
11. Provide recommendations for support of slab-on-grade floors.
12. Provide settlement estimates for fills, spread footings and floor slabs.
13. Provide design parameters for loading dock walls and/or other retaining walls including lateral soil pressures and drainage requirements.
14. Provide recommendations for the depth of frost penetration.
15. Provide an opinion regarding the presence of potentially expansive, deleterious, chemically active or corrosive materials, including the on-site slag or the presence of gas, including methane gas.
16. Provide recommendations for temporary and permanent surface and subsurface drainage requirements including temporary dewatering during construction.
17. Provide recommendations for pavement subgrade support and design pavement sections for auto traffic areas, truck traffic areas, and go-cart and miniature golf areas.
18. Provide recommendations for seismic design criteria and evaluate the liquefaction potential of the site soils.
19. Prepare a written report presenting our conclusions and recommendations along with supporting field and laboratory data.

PREVIOUS STUDIES

Several studies have been completed for the site and surrounding area. Site specific subsurface information is presented in the reports listed below. The information presented in these reports was incorporated into our geotechnical evaluation of the subsurface conditions at the site.

- "Supplemental Phase 2 Environmental Characterization Study, Nielsen Property, Southwest Grady Way and Interurban Avenue, Tukwila, Washington" by Geotech Consultants, Inc., dated January 24, 1997.
- "Phase 2 Environmental Site Assessment, Tukwila Park and Ride/Nielson Property, South Grady Way and Interurban Avenue, Tukwila, Washington" by Geotech Consultants, Inc., dated June 17, 1994.
- "Environmental Audit and Preliminary Geotechnical Evaluation, Nielson and Homewood Properties, Tukwila, Washington" by Applied Geotechnology, Inc., dated April 26, 1989.

SITE CONDITIONS

SURFACE CONDITIONS

The site is irregularly shaped and encompasses approximately 14 acres. The site has dimensions of roughly 600 feet by 1,000 feet in plan. Interurban Avenue South and Grady Way border the west and south property boundaries, respectively. The Green River and Burlington Northern Railroad tracks border the north and east property boundaries, respectively. Access to the site is provided near the southwest corner of the site from Monster Road. A gravel/asphalt road extends from Monster Road to the east and north to the approximate center of the site. The gravel road then extends in the east-west direction approximately bisecting the property. The site is separated into three parcels, as described below.

Parcel 1

Parcel 1 encompasses approximately 2.1 acres near the northwest corner of the site. The bank of the Green River forms the north boundary of the parcel. The bank of the Green River is inclined at about 1H:1V (horizontal to vertical) in the vicinity of Parcel 1. Most of the ground surface south of the bank varies between Elevation 20 feet and Elevation 25 feet. Interurban Avenue South, located along the west property boundary, is approximately 7 to 10 feet higher than the ground surface of most of the parcel. A steel tower for high-voltage power lines is located near the center of the north portion of the parcel. A wooden building, formerly the J.G. Nursery, is located on the south portion of the parcel. The ground surface is generally vegetated with tall grass, patches of dense brush and occasional trees.

Parcel 2

Although geotechnical recommendations for Parcel 2 are not considered part of this report, a site description is included for completeness. Parcel 2 encompasses approximately 2.8 acres near the center of the north portion of the site. The bank of the Green River forms the north boundary of the parcel. The inclination of the bank varies between about 1H:1V and 2.3H:1V in the vicinity of Parcel 2. Most of the ground surface south of the bank varies from about Elevation 19 feet to about Elevation 25 feet. A large wooden barn and horse stable is located near the southwest corner of the parcel. Stockpiles of shredded bark, barkdust and manure are located in the vicinity of the barn. Most of the parcel is vegetated with tall grass, patches of dense brush and occasional trees.

Parcel 3

Parcel 3 encompasses approximately 8.1 acres and occupies the east and south portions of the site. The bank of the Green River forms the north boundary of a portion of the parcel. The inclination of the bank is about 2H:1V. The ground surface of the west one-half of the parcel, south of the bank, varies from about Elevation 20 feet to about Elevation 26 feet. A large soil stockpile occupies much of the east one-half of the parcel. The soil stockpile is reportedly from a topsoil mixing operation which formerly occupied the parcel. The ground surface of the east one-half of the parcel varies from about Elevation 20 feet to about Elevation 55 feet.

Several wooden structures are located on the west one-half of the parcel. A concrete masonry unit (CMU) building, reportedly a former milk bottling operation, is located near the center of the south portion of the parcel. Several automobiles, boats and other mechanical equipment in various states of repair are located along the gravel road bisecting the site. Debris including concrete ecology blocks, tires, plastic and steel drums and machine parts also are located across the parcel.

The ground surface on much of the east one-half of the parcel is relatively bare with the exception of areas of short grass and patches of brush. The west one-half of the parcel is vegetated with grass, brush and trees. The area around the former milk bottling plant is paved with asphalt and portland cement concrete.

SUBSURFACE SOIL CONDITIONS

General

Subsurface soil and ground water conditions at Parcels 1 and 3 were explored by drilling two borings (GB-1 and GB-2) and excavating twelve test pits (GT-1 through GT-12). The borings were drilled to depths ranging from about 44 to 49 feet below the existing ground surface at the proposed locations of the Family Fun Center building and restaurant building. The test pits were excavated to depths ranging from about 8.5 to 13.5 feet below the existing ground surface.

The approximate locations of the explorations are shown on the Site Plan, Figure 2. Descriptions of the exploration program, geotechnical laboratory testing program and logs of the explorations are presented in Appendix A. The locations of the explorations previously completed by others are also shown on Figure 2. The logs of these explorations are included in Appendix B.

The site is located within an alluvial valley of sediments deposited by the Green River. It is likely that several meander channels existed at the site prior to filling of the site. As a result of the meander channels and filling, subsurface conditions vary both horizontally and vertically throughout the site. Based on our explorations and those completed by others, the site is generally underlain by variable fills and alluvial silt and sand deposits. These soil units are described in more detail below.

Stockpile Fill

A large soil stockpile is located on the east portion of Parcel 3. Test pits GT-4, GT-5, GT-6, GT-9, GT-10 and GT-11 were excavated in the stockpile. Test pits in the stockpile were also reported by others. In general, the stockpile material consists mostly of silty sand, silty gravel, and silt with variable amounts of sand and gravel. Much of the stockpile material contains fine organic matter. Portions of the material contain abundant fine organic matter. Debris was also encountered in the material. The debris includes wood, concrete, brick, metal, wire, slag, drums and other items. Layers of fibrous wood material were also encountered. In general, most of the stockpile material was in a medium dense to dense condition.

Site Grade Fill

Site grade fill extends over the majority of the site. Based on our explorations and those reported by others, the site grade fill extends to depths of zero to 21 feet, corresponding to about Elevation 17.5 feet to Elevation 9 feet. In general, the site grade fill consists mostly of sand, sand with silt, silty sand, and silt with variable amounts of sand. Debris was also encountered in portions of the site grade fill. The debris includes wood, concrete, brick, slag and railroad ties. In general, the site grade fill is typically loose.

Slag

Slag was encountered at a depth of about 1.5 feet in boring GB-1. Slag was also observed at the ground surface in the vicinity of boring GB-1, along the gravel road which bisects the site and on many of the driveways to the residential buildings at the site. Slag was reported by others within the existing site grade fill in borings AB-3, GCW-16 and GCW-17 and test pits AT-4, AT-5, and AT-6. Based on the description reported in these explorations, the slag appears to be mixed with the site grade fill in the areas these explorations were completed.

Alluvial Deposits

Alluvial sand and silt deposits underlie the existing site grade fill. Our explorations and those completed by others indicate that the Family Fun Center (Parcel 3) is underlain by soft silt interbedded with loose sand to depths corresponding to about Elevation +4 feet to Elevation -6 feet. The explorations also indicate that the thickness of soft silt is variable and ranges from about 4 feet to 15 feet thick. Medium dense to dense sand underlies the soft silt interbedded with loose sand.

The explorations indicate that the restaurant (Parcel 1) is underlain by loose sand below the existing site fill. The loose sand extends to depths of about 20 to 30 feet, corresponding to about Elevation zero to -9 feet. Below about Elevation -9 feet, the sand becomes medium dense.

GROUND WATER CONDITIONS

Ground water was encountered in borings GB-1 and GB-2 at depths of about 23.0 and 16.5 feet, respectively, during drilling. A zone of perched ground water was encountered at a depth of 2.0 feet in GB-1 during drilling. Slow ground water seepage was observed at depths ranging from about 7.0 to 13.0 feet in test pits GT-2, GT-3, GT-9 and GT-10. Ground water seepage was not encountered in the other test pits completed by GeoEngineers. Water levels were measured at depths of about 10.9 and 14.0 feet in monitoring wells GCW-16 and GCW-17, respectively, on June 17, 1997.

In general, ground water conditions at the site should be expected to fluctuate in response to the water level of the Green River and as a function of season, precipitation and other factors.

CONCLUSION AND RECOMMENDATIONS

GENERAL

Based on the explorations completed at the site, it is our opinion that development of the site as planned is feasible from a geotechnical standpoint. A summary of the primary geotechnical considerations for the development is provided below. The summary is presented for introductory purposes only and should be used in conjunction with the complete recommendations presented in this report. Portions of the development were in the preliminary planning stages at the time this report was prepared. We expect that additional consultation and/or modification to the recommendations presented below will be necessary as elements of the development are finalized.

- The subsurface conditions at the site include a thickness of several feet of loose fill overlying loose sand and soft silt deposits. The imposition of loads, including new site grade fill and building loads, will result in settlement.
- With proper site preparation, the restaurant building (Parcel 1) and Family Fun Center building (Parcel 3) may be supported on shallow foundations bearing on a minimum thickness of structural fill.
- Debris was encountered in a number of the explorations completed within the vicinity of the Family Fun Center building at depths below the planned finished floor elevation (Elevation 26 feet). It will be necessary to overexcavate the areas of debris and replace the material with structural fill to provide suitable conditions for use of shallow foundations.
- It will also be necessary to preload the footprint of the Family Fun Center building to reduce the post construction settlement of shallow foundations to within tolerable limits. Alternatively, the Family Fun Center building may be supported on piles.
- The restaurant building area is underlain by potentially liquefiable sand that will likely settle and spread laterally during a moderate to strong earthquake. To resist lateral spreading, the structure may be supported on spread footings that are structurally connected or on a continuous mat foundation. Alternatively, the building may be supported on piles.
- Most of the on-site soils, including the stockpiled soil, contain sufficient fines to be moisture sensitive and also contain fine organic matter. These soils will only be suitable for use as structural fill in pavement and recreation areas and during extended periods of dry weather.
- Imported material will likely be necessary for use as structural fill in building areas and during periods of wet weather.
- Site grade fill and/or preload fill will need to be placed far enough in advance of erection of the buildings so that the majority of settlement due to these loads will have occurred before footings are constructed. We estimate that a period of up to about 3 weeks may be necessary.

Our specific geotechnical recommendations are presented in the following sections.

EARTHWORK

General

Based on the subsurface soil conditions encountered at the site and those reported by others, we expect that the soils at the site may be excavated using conventional construction equipment. Debris was encountered in the existing fill soils on the site and may present some difficulty if encountered in excavations.

The existing near-surface soils at the site consist mostly of silty sand and silt soils. These soils contain sufficient fines (material passing the U.S. standard No. 200 sieve) to be moisture-sensitive and are susceptible to disturbance when wet. Ideally, earthwork should be done during extended periods of dry weather when the surficial soils will be less susceptible to disturbance and provide better support for construction equipment. Dry weather construction will help reduce earthwork costs. We understand that the current project schedule dictates that general site grading be accomplished during the month of August 1997. We suggest that a contingency be included in the project schedule and budget to account for increased earthwork difficulties if construction begins in late fall or winter.

Trafficability at the site will be difficult, especially during wet weather. We anticipate that temporary haul roads will be required for construction vehicles during extended wet weather. We anticipate that the existing gravel road bisecting the site may be used as one such road. Stripping and overexcavation should be done using a track-mounted excavator with a smooth-edged bucket or wide-tracked dozers. Following placement of structural fill, construction traffic on prepared floor slab and pavement subgrade areas should be kept to a minimum.

Clearing and Site Preparation

We understand that the existing structures located on the site will be demolished. We recommend that the foundation systems, septic systems, utilities, pavements and other improvements associated with the demolished structures be removed from within the proposed building, pavement and recreation (i.e., the go-cart and miniature golf) areas. Any depressions created by the removal of these facilities should be cleaned free of loose material and filled with structural fill compacted as described in a subsequent section of this report.

We recommend that trees, stumps, brush, sod, debris, and topsoil be cleared from the proposed building and pavement areas, and areas that will receive new fills. It will also be necessary to clear areas of shredded bark, barkdust and manure from these areas. The cleared material should be removed from the site. The topsoil, shredded bark and barkdust materials can be separated and stockpiled for use in areas to be landscaped.

The depth of stripping necessary is expected to be variable across the site. Stripping depths on Parcel 1 are expected to be in the range of about 2 to 6 inches. Stripping depths on the east portion of Parcel 3, in the vicinity of the soil stockpile, is expected to range from zero to 6 inches. Stripping depths on the remaining portion of Parcel 3 and most of Parcel 2 is expected to range from about 2 inches to 12 inches. Greater stripping depths may be required to remove localized zones of soft or organic soils, and/or debris. Actual stripping depths should be determined based on field observations at the time of construction.

Care must be taken to minimize softening of the subgrade soils during stripping operations. Areas of the exposed subgrade which become disturbed should be compacted to a firm, nonyielding condition, if practical, prior to placing any structural fill necessary to achieve design grades. If this is not practical, the disturbed material must be excavated and replaced with structural fill.

Subgrade Preparation

Following clearing operations, exposed subgrade areas should be evaluated prior to placing structural fill or pavement materials. If site preparation is done during extended periods of dry weather, we recommend that exposed subgrade areas be proofrolled with heavily loaded rubber-tired construction equipment. Proofrolling should only be done during periods of extended dry weather. If site preparation is done during wet weather, the exposed subgrade areas should be evaluated by probing with a steel hand probe. Particular attention should be directed to areas where our test pit excavations where located.

If soft or otherwise unsuitable areas revealed during proofrolling or probing cannot be compacted to a firm, nonyielding condition, the soft soils should be excavated and replaced with structural fill. We recommend that a representative of our firm observe the proofrolling or probing and subgrade preparation to evaluate whether subgrade disturbance or progressive deterioration is occurring.

Structural Fill Material

We recommend that fill placed at the site be placed and compacted as structural fill except in areas to be landscaped. In general, structural fill material should be free of debris, organic materials and particles larger than 6 inches. Much of the soil stockpile material contains fine organic matter. We anticipate that this material may be selectively used as structural fill in pavement and recreation areas, as discussed below. However, we recommend that the pavement and recreation areas be capped with a minimum thickness of 12 inches with structural fill which is free of any organic materials. Imported structural fill will likely be necessary for use as structural fill in the building areas.

The workability of material for use as structural fill will depend on the gradation and moisture content of the soil. As the amount of fines (material passing U.S. Standard No. 200 sieve) increases, soil becomes increasingly more sensitive to small changes in moisture content and adequate compaction becomes more difficult to achieve.

During extended periods of dry weather, granular material containing up to about 30 percent fines should be suitable, provided it is at a suitable moisture content to achieve the required compaction. If the material is too wet when excavated or delivered to the site, it must be aerated and dried out prior to placement. During wet weather conditions, structural fill should consist of pit run granular material containing less than 5 percent fines by weight relative to the fraction passing the 3/4-inch sieve. This material will need to be imported from a suitable borrow source.

On-Site Soils

Site Grade Fill. With the exception of the soil stockpile on Parcel 3, the ground surface at the site is relatively flat. The site grades are planned to be raised an average of about 3 to 6 feet. Therefore, we anticipate that excavations into the on-site soils will mostly be limited to utility trench excavations. The materials within the anticipated excavation depth for utilities consist mostly of existing site grade fill. The existing site grade fill typically consists of sand, sand with silt, silty sand, and silt with variable amounts of sand. Debris, including wood, concrete, brick, slag and railroad ties were also encountered in portions of the existing site grade fill.

The silt with variable amounts of sand is extremely moisture-sensitive. In our opinion, these materials will generally not be suitable for use as structural fill. Most of the sand contains an appreciable amount of silt (fines) to be moisture-sensitive. This material, if free of deleterious materials, may be selectively used for structural fill provided that adequate compaction can be achieved. Where debris is encountered during grading or excavation, the debris must be picked out or otherwise separated from the soil prior to use as structural fill.

Laboratory tests indicate that the moisture content of the existing site grade fill is typically greater than the optimum moisture content for compaction. Therefore, varying degrees of moisture conditioning (aeration) will likely be required prior to use, depending on the moisture content and silt content of the material. If construction is undertaken during periods of wet weather, it is likely that only the portion of the existing site grade fill containing minor amounts of silt will be suitable for use as structural fill.

Stockpile Fill. We understand that the soil stockpile material located on the east portion of Parcel 3 will be used to raise grades to the extent possible. The soil stockpile material consists mostly of silty sand, silty gravel and silt with variable amounts of sand and gravel. Much of the stockpile material contains fine organic matter. Portions of the material contain abundant fine organic matter. Debris was also encountered in the material. The debris includes wood, concrete, brick, metal, wire, slag, drums and other items.

In our opinion, the portion of the stockpile material which contains an appreciable amount of organic matter will not be suitable for use as structural fill. We recommend that this material be separated and used in landscape areas, if possible, or removed from the site. Much of the stockpile material which contains minor amounts of fine organic matter may be suitable for use as structural fill in pavement and recreation areas during extended periods of dry weather and provided that adequate compaction can be achieved. The stockpile material is moisture sensitive and even minor amounts of precipitation will make these soils unworkable.

Where debris is encountered in the material, the debris must be picked out or otherwise separated from the soil prior to use as structural fill. If this is not possible, the material should not be used as structural fill.

Laboratory tests indicate that the moisture content of the stockpile material is typically greater than the optimum moisture content for compaction. Therefore, varying degrees of moisture conditioning (aeration) will likely be required prior to use, depending on the moisture content and silt content of the material.

Slag. Slag was encountered at a depth of about 1.5 feet in boring GB-1. Slag was also observed at the ground surface in the vicinity of boring GB-1, along the gravel road bisecting the site and on many of the driveways to the residential buildings. Slag was reported by others in borings AB-3, GCW-16 and GCW-17 and test pits AT-4, AT-5, and AT-6. Specific gravity tests on the slag suggest the material may be expansive. Additional testing is currently underway to further evaluate the expansive characteristics of the slag. The result of this testing will be presented in an addendum to this report.

Slag encountered during grading should be separated to the extent possible. Where the slag is mixed with soil and cannot effectively be separated, we recommend that the mixed material be removed from building areas. We anticipate that the slag material may be used as structural fill in pavement and recreation areas where these areas will be capped with an impervious surface.

We have not conducted environmental testing of the slag to determine its inherent properties or the potential affect on soil and ground water. Our recommendations on the placement of slag are based on an assumption that the slag does not pose a threat to human health or the environment if it is capped by an impervious surface. Specific recommendations for the placement of slag may need to be developed based on the results of the expansion tests described above and additional environmental study.

Fill Placement and Compaction

We recommend that fill placed within building foundation areas and within a depth of 2 feet of pavement subgrade areas be compacted to at least 95 percent of the maximum dry density as determined in accordance with ASTM D-1557. Structural fill placed more than 2 feet below pavement subgrade areas, including utility trench backfill, should be compacted to at least 90 percent of the same standard. Fill placed outside of foundation and pavement areas should be compacted to at least 90 percent of the maximum dry density.

Structural fill should be mechanically compacted to a firm and nonyielding condition. Structural fill to be compacted by heavy equipment should be placed in horizontal lifts which are 10 inches or less in loose thickness. Loose lifts should not be thicker than 6 inches when lighter hand-operated equipment is used. Each lift should be uniformly compacted as recommended before placing additional lifts of fill.

We recommend that the appropriate lift thickness, and the adequacy of subgrade preparation and structural fill compaction be evaluated by a field representative from our firm during construction. A sufficient number of in-place density tests should be performed as the fill is being placed to evaluate whether the required compaction is being achieved.

Temporary Cut Slopes

Temporary cut slopes are anticipated for construction of underground utilities, removal of existing foundations and utilities associated with structures to be demolished and possibly for construction of retaining walls. Temporary cut slopes and shoring must comply with the provisions of Title 296 WAC, Part N, "Excavation, Trenching and Shoring." The contractor performing the work must have the primary responsibility for protection of workmen and adjacent improvements, deciding whether or not to use shoring, and for establishing the safe inclination for open-cut slopes.

Temporary unsupported cut slopes more than 4 feet high may be inclined at 1½H:1V or flatter within the existing fill soils or new structural fill. Flatter slopes may be necessary if seepage is present on the cut face. Some sloughing and ravelling of the cut slopes should be expected. Temporary covering with heavy plastic sheeting should be used to protect these slopes during periods of wet weather.

If temporary cut slopes experience excessive sloughing or ravelling during construction, it may become necessary to modify the cut slopes to maintain safe working conditions and protect adjacent facilities or structures. Slopes experiencing excessive sloughing or ravelling can be flattened, regraded to add intermediate slope benches, or additional dewatering can be provided if the poor slope performance is related to ground water seepage.

Permanent Slopes

We recommend that permanent cut and fill slopes be inclined no steeper than 2H:1V. To achieve uniform compaction, we recommend that fill slopes be overbuilt slightly and subsequently cut back to expose well compacted fill. Flatter cut slopes may be necessary in areas where persistent ground water seepage is encountered and/or where the slope may be subject to submergence such as the sidewalls of storm detention ponds.

To minimize erosion, newly constructed slopes should be planted or hydroseeded shortly after completion of grading. Until the vegetation is established, some sloughing and raveling of the slopes should be expected. This may require localized repairs and reseeding. Temporary covering, such as clear heavy plastic sheeting, jute fabric, loose straw or excelsior matting should be used to protect unvegetated slopes during periods of rainfall.

SETTLEMENT CONSIDERATIONS

General

The existing site grade fill is relatively loose/soft and the alluvial silt deposits beneath the fill are compressible. The placement of fill above existing site grades and the imposition of building loads will cause consolidation and settlement of these soils.

Ground settlement resulting from the raising of site grades will depend, in part, on the thickness of fill placed and the variability in the compressibility and thickness of the existing site grade fill and alluvial silt deposits. Because soft alluvial silt deposits were not encountered on Parcel 1, we expect the settlement on Parcel 1 will generally be less compared to Parcel 3. The estimated settlement for various increases in site grades is presented below.

Increase in Site Grade (feet)	Estimated Settlement (inches)	
	Parcel 1	Parcel 3
2	0.5	2.0
5	1.0	3.5
10	2.0	5.5

Estimating the magnitude of settlement based on field and laboratory data is not a precise procedure. Under reasonably good conditions the magnitude of settlement can often be estimated within an order of accuracy of about plus or minus 25 percent of the actual settlement. Accordingly, the values presented above should only be considered accurate to within these tolerances.

The majority of this settlement is expected to occur within about one to three weeks. Foundation installation should not be undertaken until settlement from the placement of site grade fill and/or preload fill is essentially complete and verified by settlement monitoring data.

Parcel 1

We have evaluated the potential settlement of shallow isolated column footings for the restaurant building. Our analyses indicate that settlement of isolated column footings will be less than about 3/4 inch, based on a design column load of 70 kips. Settlement resulting from a floor load of 200 pounds per square foot (psf) may be on the order of 1/2 inch. Therefore, we expect the restaurant building may be supported on shallow foundations without major ground improvement such as preloading. However, because the restaurant building will be underlain by potentially liquefiable soils and will be in relative close proximity to the bank of the Green River, the building will be subject to additional settlement during a moderate to strong earthquake. This is discussed in more detail in the "Seismicity" section of this report.

Parcel 3

We have evaluated the potential settlement of shallow isolated column footings for the Family Fun Center building. Our analyses indicate that without preloading, settlements on order of 2 and 2½ inches could occur below isolated column footings, based on a design column load of 180 and 280 kips, respectively. Settlement resulting from a floor load of 200 psf could be as much as 1 inch. We also expect that differential settlement may approach the total settlement because of the variability in the compressibility and thickness of the existing site grade fill and alluvial silt deposits, and because a portion of the Family Fun Center building area has effectively been preloaded by the existing soil stockpile.

In our opinion, settlements of this magnitude are likely to be detrimental to the structure. To mitigate the settlement potential, we recommend that the Family Fun Center building area either be preloaded or the building be supported on piles.

PRELOAD PROGRAM

General

If shallow foundations will be used to support the Family Fun Center building, it will be necessary to place a preload fill over the building area to induce a major portion of the settlement that would otherwise occur when building and floor loads are applied. A preload program involves placing a temporary soil fill over the area of the proposed structure to induce a major portion of the settlement that would otherwise occur when building and floor loads are applied. Such a preload program will reduce the amount of postconstruction settlement that the structure will experience from the imposition of building loads. The preload program will also reduce potential differential settlement due to variability in the thickness and compressibility of the underlying soils. The thickness of preload fill and the area covered by the fill are evaluated on the basis of the soil properties, the foundation loads and size, the time available to accomplish the preload program and the allowable postconstruction settlement that the structure can tolerate.

We evaluated a preload program for the Family Fun Center building based on a design load of 180 kips and 280 kips on interior column footings, combined dead and long-term live loads. Design floor loads of 200 psf were assumed. We also assumed that finished floor will be at Elevation 26 feet. If the design loads and grades vary from those assumed we should be given the opportunity to review the preload recommendations and provide any necessary modifications.

Preload Configuration

We recommend using a minimum preload height of 6 feet for building areas with column loads of 180 kips and 8 feet of preload fill for building areas with column loads of 280 kips to simulate the weight of the new structure. The preload fill should not be placed until overexcavations to remove debris from within the building area are completed, as described in a subsequent section of this report. The thickness of preload fill should be measured from the design finished floor elevation at the completion of the preload program. We estimate that up to 3 to 4 inches of settlement may occur as a result of placing the preload fill. Settlement will

For both the Family Fun Center building and restaurant building, the zone of compacted structural fill placed below footings should extend laterally beyond the edges of the footings a minimum distance equal to the thickness of structural fill placed.

Overexcavation. Debris was encountered in a number of the explorations completed within the vicinity of the Family Fun Center building at depths below the planned finished floor elevation (Elevation 26 feet). These explorations include test pits GT-4, GT-7, GT-8 and GT-10 where debris was encountered to depths corresponding to about Elevation 22, 18.5, 23, and 17 feet, respectively. Debris was also reported by others in test pits GCT-1, GCT-4 and GCT-6 to depths corresponding to about Elevation 25, 15 and 13 feet, respectively. The debris includes concrete, brick, wood, wire, plastic pails and a 25-gallon drum. If the Family Fun Center building is supported on shallow foundations and the debris is left below the building area, extremely large total and differential settlements may result. Therefore, we recommend that the areas of debris within the Family Fun Center building be overexcavated and replaced with structural fill prior to preloading. If the Family Fun Center building is supported on piles, it will not be necessary to overexcavate the debris.

The extent of debris is difficult to define. Based on the explorations, overexcavations up to about 14 feet below the existing ground surface will be required. We also anticipate that additional areas of debris, other than those identified by the explorations, are likely to be encountered. In general, we anticipate that significant overexcavation over a substantial portion of the building area may be necessary to remove the debris. Under these circumstances, we suggest performing a "mass excavation" within the areas of debris. This should allow more efficient use of equipment, make it easier to identify the extent of the area requiring overexcavation and result in a more uniform subgrade for shallow foundations.

Proper removal of the debris and replacement with structural fill is essential to the performance of shallow foundations. We recommend that the overexcavation and placement of structural fill be monitored by a field representative from our firm during construction.

Footing Design. Continuous strip footings should be at least 18 inches wide and isolated column footings should be at least 24 inches wide. Exterior footings should be founded at least 18 inches below the lowest adjacent finished grade. Interior footings should be at least 12 inches below the adjacent finished floor grade. Based on available published information and our experience in the area, these recommended footing embedment depths are below depths affected by average frost penetration for this area.

An allowable bearing pressure of 2,500 psf may be used for footings designed in accordance with the above recommendations. This recommended bearing pressure applies to the sum of all dead and long-term live loads, excluding the weight of the footings and any overlying backfill. This value may be increased by one-third when considering short-term live loads such as wind or seismic forces.

We recommend that all prepared footing excavations be observed by a representative from our firm prior to placing structural fill for footing support to confirm that subsurface conditions are as expected. We also recommend that the prepared footing subgrades be observed by a representative from our firm prior to placing reinforcing steel and structural concrete to confirm that the bearing surface has been prepared in a manner consistent with our recommendations.

Lateral Resistance. Lateral loads may be resisted by passive resistance on the sides of the footings and by friction on the base of the footings and slabs. Passive resistance may be evaluated using an equivalent fluid density of 300 pounds per cubic foot (pcf) provided that the footings are surrounded by undisturbed existing soil or structural fill, compacted to at least 95 percent of the maximum dry density (ASTM D-1557) and extending laterally a distance of at least twice the depth of the footing. Passive resistance should be calculated from the bottom of the adjacent floor slabs, or at a depth of 1 foot below the ground surface if the adjacent area is unpaved. Frictional resistance of footings and slabs may be evaluated using 0.35 for the coefficient of base friction. The above values incorporate a factor of safety of about 1.5.

Settlement. For the Family Fun Center building, we estimate that postconstruction settlement of footings supported as recommended on preloaded ground will be less than 1 inch for the column loads assumed. Maximum differential settlement should be less than about 3/4 inch measured along 50 feet of continuous wall footing or between adjacent, comparably loaded column footings.

For the restaurant building, we estimate that post construction settlement of footings supported as recommended will be less than about 3/4 inch. Maximum differential settlement should be less than about 1/2 inch measured along 50 feet of continuous wall footing or between adjacent, comparably loaded column footings.

Pile Foundations

General. Pile foundations may also be considered for support of either of the buildings. We anticipate that 14-inch-diameter augercast piles will be appropriate. Alternative pile diameters and pile types, such as driven steel, concrete and timer piles may also be considered but may not be as economical given the anticipated loads.

Axial Pile Capacities. Pile capacity in compression will be developed primarily from friction and end-bearing in the medium dense to dense alluvial sand deposits underlying the fill and silt deposits. Piles should be designed to extend through the fill and silt deposits and be embedded in the medium dense to dense alluvial sand deposits. We recommend that piles penetrate at least 20 feet into this bearing layer. This generally corresponds to a pile tip elevation of about -25 feet. Based on our analysis, 14-inch-diameter augercast piles may be designed for an allowable downward capacity of 50 tons for the embedment depth described above. An allowable uplift capacity of 20 tons may be used. These values are based on the strength of the supporting soils and include a factor of safety of about 2.5 and may be increased by one-third when considering design loads of short duration such as wind or seismic forces.

The allowable capacities presented above apply to single piles. If piles within groups are spaced at least 3-pile-diameters on center, no reduction for pile group action is required. We should be consulted for an appropriate pile reduction factor if closer pile spacing is desired. We recommend that a minimum of two piles be installed to support each major building column.

The characteristics of pile materials and structural connections might impose limitations on pile capacities and should be evaluated by your structural engineer. Full length steel reinforcing will be required to develop the full uplift capacity.

Pile Downdrag. Pile downdrag forces occur when soils surrounding a pile settle relative to the pile, thus interacting with and adding load to the pile. Fill placed to raise site grades will result in settlement of the underlying soils. Therefore, pile downdrag forces can be expected if pile installation is undertaken prior to or shortly following the placement of site grade fill. We recommend that the placement of site grade fill be undertaken sufficiently in advance of pile installations (i.e., several weeks) such that the settlement resulting from the placement of site grade fill will be essentially complete prior to pile installation. If this is not possible, we should be consulted to provide appropriate downdrag loads which will act on the piles.

Lateral Pile Capacity. The lateral load resisted by a vertical pile is a function of the soils surrounding the pile, the length and stiffness of the pile, the degree of fixity at the pile head, and the magnitude of deflection that can be tolerated by the structure. We recommend an allowable lateral pile capacity of 6 tons for 14-inch diameter augercast piles. This value applies to single piles and is based on a deflection of 1/2 inch at the pile head which is assumed to be fixed against rotation. The corresponding maximum bending moment for this lateral load and deflection is about 60,000 foot-pounds. We recommend that reinforcing sufficient to resist these bending moments be installed to a depth of at least 25 feet (point of fixity) below the bottom of the pile cap.

If piles within groups are spaced at least six pile diameters, center-to-center, no reduction for pile group action is necessary. We should be consulted for an appropriate group reduction factor if closer pile spacings are desired.

Pile Settlements. We estimate that the settlement of augercast piles designed and installed as recommended will be approximately 1/2 inch or less, excluding elastic compression of the pile. Most of this settlement is expected to occur rapidly as loads are applied. Postconstruction differential settlement between adjacent pile-supported columns is expected to be less than 1/2 inch.

Pile Installation Considerations. We recommend that augercast piles be installed by an experienced contractor to the recommended penetration using a continuous-flight hollow-stem auger. The presence of debris in the fill may obstruct the installation of piles. The contractor should be prepared to utilize drilling methods which will penetrate through obstructions where encountered. If it is not possible to penetrate through the debris, it may be necessary to alter the location of individual piles.

The pile is formed by pumping grout under pressure through the hollow stem as the auger is withdrawn. Reinforcing steel for bending and uplift loads is placed in the fresh grout column immediately after withdrawal of the auger. A centering device should be used to accurately center the reinforcing cage within the grout-filled hole. We recommend that a waiting period of at least 12 hours be maintained between installation of piles spaced closer than 6 feet center-to-center in order to avoid disturbance of fresh grout in a previously cast pile. We also recommend that a minimum 3,000 pounds per square inch (psi) grout strength be used for augercast piles.

Grout pumps must be fitted with a volume-measuring device and pressure gauge so that the volume of grout placed in each pile and the pressure head maintained during pumping can be determined. A minimum grout line pressure of 100 psi should be maintained. The rate of auger withdrawal should be controlled during grouting such that the volume of grout pumped is equal to at least 115 percent of the theoretical hole volume. A minimum head of 10 feet of grout should be maintained above the auger tip during withdrawal of the auger to maintain a full column of grout and prevent hole collapse.

We recommend that pile installation be monitored by a member of our staff who will observe the drilling operations, record indicated penetrations into the supporting soils, monitor grout injection procedures, record the volume of grout placed in each pile relative to the calculated volume of the hole, and evaluate the adequacy of individual pile penetrations.

FLOOR SLAB SUPPORT

In our opinion, the restaurant floor slab may be supported on-grade. The Family Fun Center floor slab may also be supported on-grade provided that the preload program and overexcavation of debris located within the building footprint described previously is completed prior to construction. Alternatively, the Family Fun Center floor slab should be pile-supported.

On-grade slab subgrade areas should be prepared as described in the previous sections of this report. We recommend that on-grade floor slabs be underlain by a minimum thickness of 12 inches of structural fill. This structural fill should consist of free-draining sand and gravel with less than 5 percent fines and be free of any organic materials. The top 6 inches should be 3/4-inch minus material. A vapor retarder is recommended in areas where moisture in the slab cannot be tolerated such as areas that will have vinyl, tile or carpeted finishes. The vapor retarder should consist of a layer of polyethylene sheeting overlaid by 2 inches of fine sand containing less than 3 percent fines.

Settlement of on-grade floor slabs will depend on the duration and distribution of loading. For both the Family Fun Center and restaurant buildings, we estimate that settlement of on-grade floor slabs will be less than 1/2 inch based on design floor load of 200 psf.

Building footings may be subject to the settlements induced by floor loads in addition to settlements due to footing loads since the footings will lie above the compressible soils. It is possible that differential settlement of interior columns could occur because of variations in floor loads. Differential settlements could affect the roof drainage gradient. The potential for differential settlement between columns should be taken into consideration in design.

RETAINING WALLS

Design Parameters

We understand that a portion of the lowest level of the Family Fun Center building may be below the adjacent parking grade. The proposed structures may also include dock-high walls at truck loading areas. These walls should be designed as retaining walls. We recommend that retaining walls be designed for lateral pressures based on an equivalent fluid density of 35 pcf. If the tops of the walls will be structurally restrained, the walls should be designed for lateral pressures based on an equivalent fluid density of 55 pcf. Walls are assumed to be restrained if the top movement during backfilling is less than H/1000, where H is the height of the wall. Surcharge effects from equipment, traffic or floor loads should be considered where appropriate.

Backdrainage

The wall pressures presented above assume the walls are fully backdrained and hydrostatic pressures are prevented from building up behind the walls. This may be accomplished by placing a 24-inch-wide zone of free-draining sand and gravel containing less than 5 percent fines against the back of the walls. A 4-inch-diameter perforated heavy wall collector pipe should be installed within the free-draining material at the base of the wall. The pipe should be laid with a minimum slope of one percent and discharge into the stormwater collection system to convey the water off site. We recommend against discharging roof downspouts into the perforated pipe providing wall backdrainage. Alternatively, outside walls can be provided with weep holes to discharge water from the free-draining material. The weep holes should be 3-inch diameter, and spaced about every 6 feet center-to-center along the base of the walls. The weep holes should be backed with galvanized heavy wire mesh to prevent loss of the backfill material.

Construction Considerations

Measures should be taken to prevent overcompaction of the backfill behind the wall. This can be accomplished by placing the zone of backfill located within 5 feet of the wall in lifts not exceeding 6 inches in loose thickness and compacting this zone with hand-operated equipment such as a vibrating plate compactor.

In settlement-sensitive areas (e.g., beneath on-grade slabs), the upper 2 feet of backfill for retaining walls should be compacted to at least 95 percent of the maximum dry density determined in accordance with ASTM D-1557. At other locations and below a depth of 2 feet, wall backfill should be compacted to between 90 and 92 percent of ASTM D-1557.

PAVEMENT RECOMMENDATIONS

Asphalt Concrete Pavements

We recommend that the pavement subgrade be prepared in accordance with the previously described recommendations in "Earthwork" section of this report. The prepared subgrade should be evaluated by proofrolling with a grader or fully-loaded dump truck during dry weather or by probing during wet weather. Soft or loose areas that are disclosed during the evaluation should be recompacted, if practical, or the materials should be excavated to firm soils and replaced with compacted structural fill. We recommend that a qualified geotechnical engineer be present during the evaluation to aid in identifying any areas which may need additional compaction or other remedial work.

We recommend that pavement areas be underlain by a minimum thickness of 12 inches of structural fill which is essentially free of organic materials. We recommend a minimum pavement section of at least 2 inches of asphalt concrete over a minimum of 4 inches of densely compacted crushed surfacing for pavement areas limited to passenger vehicle parking and traffic and for the go-cart area. We recommend a minimum pavement section of at least 3 inches of asphalt concrete over at least 6 inches of densely compacted crushed surfacing for road access areas and truck traffic areas within the parking lot area.

The applicability of this pavement section is based on our recommendation that the subgrade preparation and pavement construction be done during a period of extended dry weather. We recommend that the asphalt concrete consist of Class A or B asphalt concrete as specified in the 1996 *Washington Department of Transportation Standard Specifications for Road, Bridge and Municipal Construction*. The crushed surfacing should conform to Section 9-03.9(3) of the 1996 WSDOT Specifications.

PCC Pavements

We expect that portland cement concrete (PCC) pavements may be used in the recreation areas such as the miniature golf course. PCC pavement should be underlain by a minimum thickness of 12 inches of structural fill which is essentially free of organic materials. We recommend that the upper 2 inches of the structural fill consist of crushed surfacing, conforming to Section 9-03.9(3) of the 1996 WSDOT Specifications, to provide uniform support and a working surface. PCC pavements may be designed using a value of 100 pounds per cubic inch (pci) for the modulus of subgrade reaction.

DRAINAGE CONSIDERATIONS

Temporary Drainage

We recommend that measures be implemented to remove surface water from proposed grading areas prior to the start of grading. Surface water runoff in graded areas should be controlled by careful control of grading to maintain positive gradients, strategic location of berms to divert flow to drainage swales and collection basins, as appropriate. We expect that zones of seepage from perched water in the fill soil may be encountered during grading, foundation installation and excavations. We anticipate that this water can be temporarily controlled during construction by ditching and pumping from sumps, as necessary.

Permanent Drainage

We recommend that all surfaces be sloped to drain away from the proposed building areas. Pavement surfaces and open space areas should be sloped such that surface water runoff is collected and routed to suitable discharge points.

We recommend that the perimeter footings be constructed with drains. The drains should consist of perforated pipe a minimum of 4 inches in diameter enveloped within a minimum thickness of 4 inches of washed gravel drain rock. A nonwoven geotextile fabric such as Mirafi 140N, Polyfelt TS600 or Trevira 1112 should be placed between the drain rock and the existing soils to prevent movement of fines into the drainage material.

All roof drains and footing drains should be connected to tightlines that discharge into the storm sewer disposal system. The roof drain pipes should be kept separate from the footing drain pipes.

SEISMICITY

General

The Puget Sound area is a seismically active region and has experienced thousands of earthquakes in historical time. Seismicity in this region is attributed primarily to the interaction between the Pacific, Juan de Fuca and North American plates. The Juan de Fuca plate is subducting beneath the North American Plate. Each year 1,000 to 2,000 earthquakes occur in Oregon and Washington. However, only 5 to 20 of these are typically felt because the majority of recorded earthquakes are smaller than Richter magnitude 3.

In recent years two large earthquakes occurred which resulted in some liquefaction in loose alluvial deposits and significant damage to some structures. The first earthquake, which was centered in the Olympia area, occurred in 1949 with a Richter magnitude of 7.1. The second earthquake, which occurred in 1965, was centered between Seattle and Tacoma and had a Richter magnitude of 6.5.

Uniform Building Code (UBC) Site Coefficients

The Puget Sound region is designated as a Seismic Zone 3 in the 1994 edition of the Uniform Building Code (UBC). For Zone 3 locations, a Seismic Zone Factor (Z) of 0.30 is applicable based on UBC Table 23-I. In our opinion, the soil profile at the site is best characterized as Type S_2, based on UBC Table 23-J. The Site Coefficient (S Factor) for this soil profile type is 1.2.

Design Earthquake Levels

The key seismic design parameters are the peak acceleration and the Richter magnitude of the earthquake. In general, a design earthquake is chosen based on a probability of exceedence (the probability that the design earthquake will not be exceeded over a given time period). The level of seismicity recommended in the 1994 edition of the UBC for human occupancy buildings is an earthquake with a 10 percent probability of exceedence in a 50-year period. The design earthquake event which corresponds to this probability of exceedence is an earthquake with a Richter magnitude of 7.5 and a peak horizontal ground acceleration of approximately 0.3g.

Liquefaction Potential

Liquefaction is a condition where soils experience a rapid loss of internal strength as a consequence of strong ground shaking. Ground settlement, lateral spreading and/or sand boils may result from soil liquefaction. Structures supported on liquefied soils can suffer foundation settlement or lateral movement that may be severely damaging to the structures.

Conditions favorable to liquefaction occur in loose to medium dense, clean to moderately silty sand, that is below the ground water level. Loose to medium dense sand below ground water is present at the site. Therefore, we performed an engineering evaluation of the liquefaction potential of the site soils.

The evaluation of liquefaction potential is dependent on numerous parameters including soil type and grain size distribution, soil density, depth to ground water, in-situ static ground stresses, and the earthquake induced ground stresses. Typically, the liquefaction potential of a site is evaluated by comparing the cyclic shear stress ratio induced by an earthquake with the cyclic shear stress ratio required to cause liquefaction. The cyclic shear stress ratio required to cause liquefaction was estimated using an empirical procedure based on the in-situ static ground stresses, the blow count data obtained during sampling in the borings, and the design earthquake magnitude.

To evaluate potential liquefaction at this site, we evaluated the earthquake induced cyclic shear stress ratio using the design earthquake event presented above. The results of our analyses indicate that the loose to medium dense sand below the ground water level has a moderate to high potential for liquefaction during an earthquake with a Richter magnitude of 7.5 or greater.

Ground Settlement

Because of the presence of potentially liquefiable soils at the site, ground settlement may be expected if liquefaction occurs. The potential ground settlement caused by liquefaction will vary depending on the actual levels of ground shaking, the duration of shaking, and site-specific soil conditions. We estimate that total liquefaction induced ground settlements may be on the order of 8 inches on Parcel 1 and on the order of 1 to 4 inches on Parcel 3. We estimate that differential settlements may be on the order of one-half of the total settlement because of the presence of an approximate 20-foot thick zone of non-liquefiable soils at the ground surface.

Lateral Spreading

Lateral spreading involves lateral displacements of large volumes of liquefied soil. Lateral spreading can occur on near-level ground as blocks of surface soils displace relative to adjacent blocks. Lateral spreading also occurs as blocks of surface soils are displaced toward a nearby slope (free face) by movement of the underlying liquefied soil. The bank of the Green River represents a free face condition for this site. Therefore, the topography of the site and underlying soil conditions indicate that lateral spreading is a possibility at the site.

We have used two simple models to predict free-field ground displacements which might be associated with lateral spreading at the site. Free-field ground displacements are those that are not impeded by structural resistance, ground modification, or a natural boundary. The first model is based on a single-degree-of-freedom system that incorporates the residual strength of the liquefied deposits. The primary parameters used in the analysis are the residual strength and limiting strain of the liquefied soil, the thickness of the liquefied zone and the slope angle measured between the structure and the toe of the free face (i.e., Green River). The residual shear strength and limiting shear strain of the liquefied soils were estimated using an empirical relationship that is based on the blow count data obtained from the explorations.

The second model is an empirical model that incorporates earthquake, geological, topographical and soil factors that affect ground displacement. The model was developed from compiled data collected at sites where lateral spreading was observed. The key parameters are the Richter magnitude, the horizontal ground acceleration, the thickness of the liquefied zone, the grain size distribution of the liquefied deposit, and the ratio of the free face height to the distance between the structure and the toe of the free face.

The results of our analysis indicate that lateral spreads may develop in the loose to medium dense sand below the site during an earthquake with a Richter magnitude of 7.5 or greater. We estimate that free-field lateral displacements at the proposed restaurant building may be on the order 10 feet or more. We estimate that free-field lateral displacements at the proposed Family Fun Center building may be on the order of 4 to 6 feet.

Conclusions and Recommendations Regarding Seismicity

The potential for liquefaction and lateral spreading at the site is moderate to high during an earthquake event with a Richter magnitude of 7.5 and a peak horizontal ground acceleration of approximately 0.3g. Liquefaction and lateral spreading may result in structural damage to the buildings.

Several mitigation techniques are available to reduce the potential for structural damage. These measures should be given consideration in the design of the buildings. However, it should be noted that these measures will not mitigate all of the potential liquefaction and lateral spreading damages and do not preclude damage to the building resulting from other earthquake characteristics, such as inertial forces during severe ground shaking.

Several measures are available to reduce differential settlements below footings and floor slabs caused by liquefaction at depth and to reduce damage to the building resulting from liquefaction and lateral spreading. One alternative is to support the footings and floor slab on several feet of clean crushed rock placed over a strong geotextile. The crushed rock pad and geotextile provides a more rigid base for the foundations and thus reduces the effects of differential settlement. It also allows pore water pressures from the lower soil units to dissipate in the zone of crushed rock thus reducing the potential for loss of strength of the near-surface soils.

A second alternative is to structurally connect the individual column footings and continuous footings using grade beams or a continuous mat foundation. This will also further increase the rigidity of the foundation system for the building. This option is particularly recommended for the restaurant building where relatively large liquefaction induced ground settlement may be expected. Placement of a crushed rock pad and/or use of grade beams or mat foundation as recommended should reduce the effects of liquefaction settlement on the building and provide increased rigidity to the foundation system to reduce the damage associated with lateral spreading. However, differential ground settlement and lateral displacements will likely still occur during a design level earthquake and some damage to the floor slabs and/or structure should be expected.

A third alternative is to support the building foundations and floor slabs on deep foundations. This will significantly reduce the amount of differential settlement and to some extent lateral spreading. At the restaurant site, piles may not significantly reduce lateral spreading unless a significant number of closely spaced piles are used.

If the potential for seismically induced structural damage is unacceptable, ground improvement techniques such as stone columns or soil densification can be implemented to alter the susceptibility of the underlying soils to liquefaction. We are available to assist in the evaluation of these options further.

OTHER CONSIDERATIONS

Methane Gas Collection

Borings GB-1 and GB-2 were monitored for methane gas using with a combustible gas indicator. Combustible vapors, presumed to be methane, were measured at concentrations of up to 1 percent, which is the upper level of significance of the equipment used, in boring GB-1. Combustible gas vapors were not detected in boring GB-2. Combustible gas concentrations in the range of 2.5 to 5 percent were reported in borings completed by others. The potential for during the work differ from those anticipated, and (3) evaluate whether or not earthwork and foundation installation activities comply with the contract plans and specifications.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in this area at the time the report was prepared. No warranty or other conditions, express or implied, should be understood.

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We trust this provides the information you require at this time. We appreciate the opportunity to be of service to you on this project. Please contact us should you have any questions concerning our findings or recommendations, or should you require additional information.

Respectfully submitted,

GeoEngineers, Inc.

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VICINITY MAP

FIGURE 1

06/24/97

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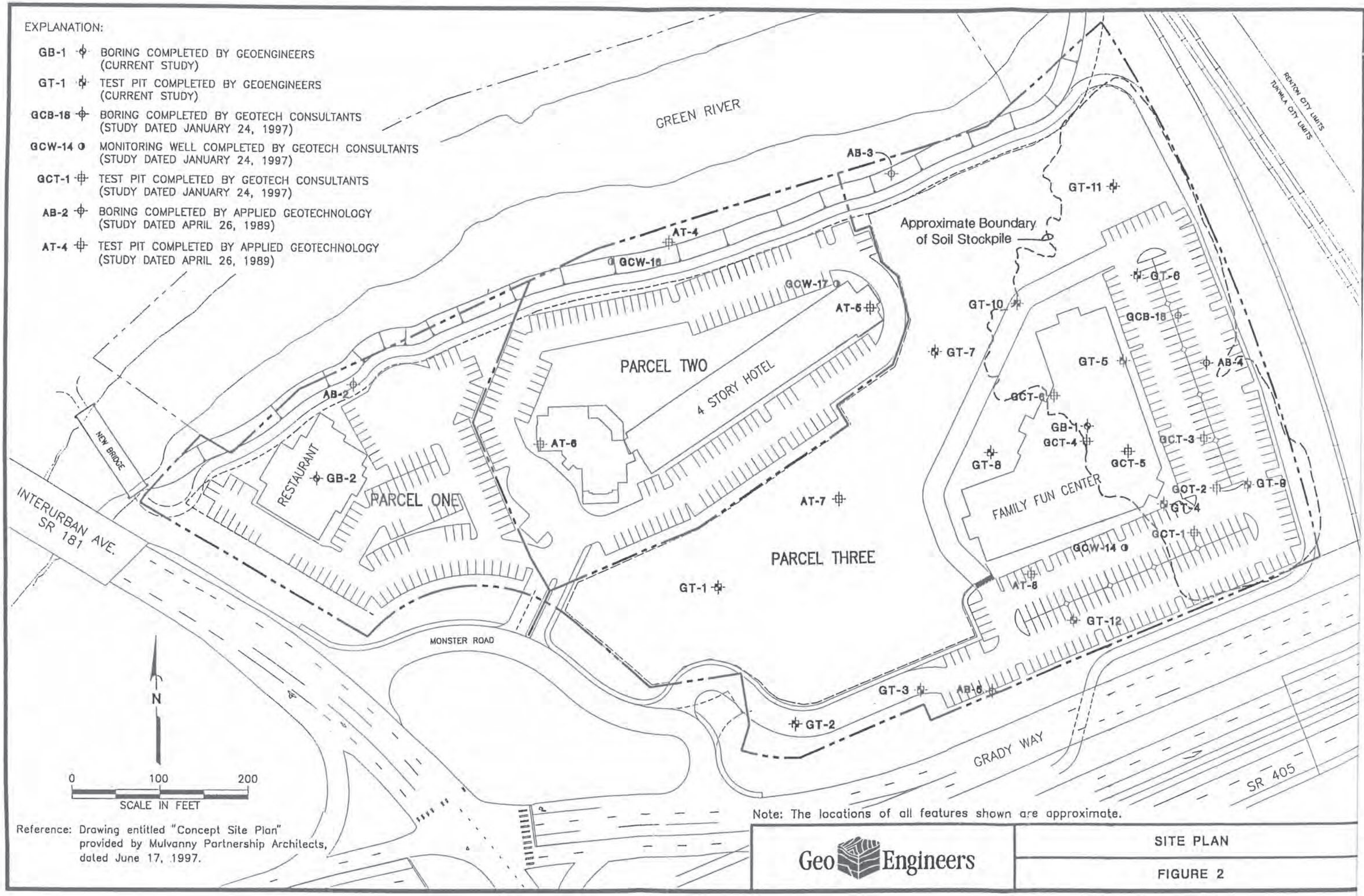

EXPLANATION:

GB-1 ⌖ BORING COMPLETED BY GEOENGINEERS (CURRENT STUDY)

GT-1 ⌖ TEST PIT COMPLETED BY GEOENGINEERS (CURRENT STUDY)

GCB-18 ⌖ BORING COMPLETED BY GEOTECH CONSULTANTS (STUDY DATED JANUARY 24, 1997)

GCW-14 ◑ MONITORING WELL COMPLETED BY GEOTECH CONSULTANTS (STUDY DATED JANUARY 24, 1997)

GCT-1 ⌖ TEST PIT COMPLETED BY GEOTECH CONSULTANTS (STUDY DATED JANUARY 24, 1997)

AB-2 ⌖ BORING COMPLETED BY APPLIED GEOTECHNOLOGY (STUDY DATED APRIL 26, 1989)

AT-4 ⌖ TEST PIT COMPLETED BY APPLIED GEOTECHNOLOGY (STUDY DATED APRIL 26, 1989)

Reference: Drawing entitled "Concept Site Plan" provided by Mulvanny Partnership Architects, dated June 17, 1997.

Note: The locations of all features shown are approximate.

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SITE PLAN

FIGURE 2

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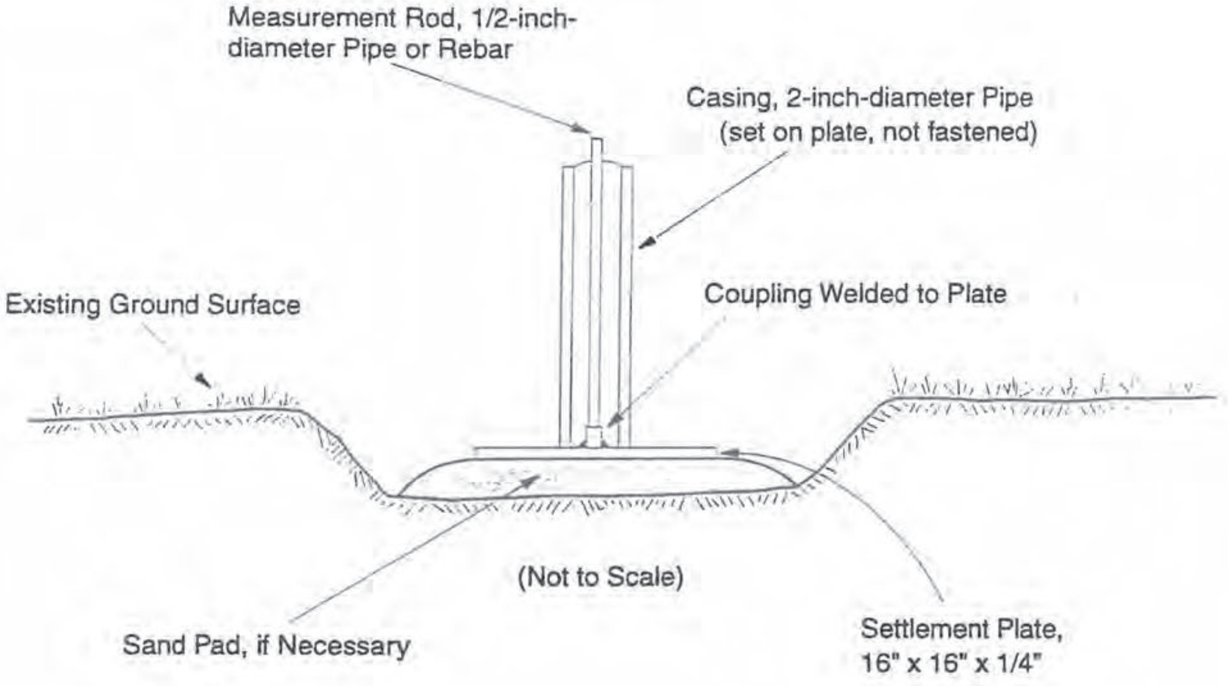

NOTES:

1. Install settlement plates on firm ground or on sand pads if needed for stability. Take initial reading on top of rod and at adjacent ground level prior to placement of any fill.
2. For ease in handling, rod and casing are usually installed in 5-foot sections. As fill progresses, couplings are used to install additional lengths. Continuity is maintained by reading the top of the measurement rod, then immediately adding the new section and reading the top of the added rod. Both readings are recorded.
3. Record the elevation of the top of the measurement rod at the recommended time intervals. Record the elevation of the adjacent fill surface every time a measurement is taken.
4. Record the elevation of the top of the measurement rod to the nearest 0.01 foot, or 0.005 foot, if possible. Record the fill elevation to the nearest 0.1 foot.
5. The elevations should be referenced to a temporary benchmark located on stable ground at least 100 feet from the area being filled.

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SETTLEMENT PLATE DETAIL

FIGURE 3

APPENDIX A

APPENDIX A

FIELD EXPLORATIONS AND GEOTECHNICAL LABORATORY TESTING

FIELD EXPLORATION

Subsurface conditions at the site were explored during the period of June 16, 1997 to June 17, 1997. Two borings designated GB-1 and GB-2 were drilled at the proposed location of the Family Fun Center building and restaurant building, respectively. The borings were drilled to depths ranging from about 44 to 49 feet below the existing ground surface using truck-mounted hollow-stem auger drilling equipment.

Twelve test pits designated GT-1 through GT-12 were excavated on Parcel 3 using a rubber-tired backhoe. The test pits were excavated to depths ranging from about 8.5 to 13.5 feet below the existing ground surface.

The locations of the explorations were determined in the field by taping distances from existing site features. Ground surface elevations indicated on the exploration logs are based on interpretation of topographic data provided by Mulvanny Partnership relative to the exploration locations. Locations of the explorations are shown on the Site Plan, Figure 2.

A geotechnical engineer or engineering geologist from our firm continuously observed the drilling and test pit excavations, prepared a detail log of the borings and test pits, and visually classified the soils encountered. Representative soil samples were obtained from the borings using a 2.4-inch-ID, split-barrel sampler driven into the soil using a 300-pound hammer falling approximately 30 inches. The number of blows required to drive the sampler the final 12 inches is recorded on the boring logs. Where hard driving conditions restricted penetration of the sampler to less than 18 inches, the blows are shown for the actual penetration distance. Grab samples were collected from the various soil horizons encountered in the test pits.

The exploration logs are based on our interpretation of the field and laboratory data and indicate the various types of soils encountered. They also indicate the depths at which these soils or their characteristics change, although the change might actually be gradual. If a change occurred between samples in the borings, it was interpreted. Soils were classified in general accordance with the classification system presented in Figure A-1. A key to the boring log symbols is presented in Figure A-2. Logs of the borings are presented in Figures A-3 and A-4. Logs of the test pits are presented in Figures A-5 through A-10.

GEOTECHNICAL LABORATORY TESTING

Soil samples obtained from the explorations were transported to our laboratory and examined to confirm or modify field classifications. Representative samples were selected for geotechnical laboratory testing including moisture content and dry density determinations, specific gravity tests and consolidation tests.

The results of the moisture content and dry density determinations performed on sample from the borings are presented on the boring logs. The results of the moisture content determinations performed on samples from the test pits are presented in Figure A-11. The consolidation test results are presented in Figure A-12.

SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE GRAINED SOILS More Than 50% Retained on No. 200 Sieve	GRAVEL More Than 50% of Coarse Fraction Retained on No. 4 Sieve	CLEAN GRAVEL	GW	WELL-GRADED GRAVEL, FINE TO COARSE GRAVEL
			GP	POORLY-GRADED GRAVEL
		GRAVEL WITH FINES	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	SAND More Than 50% of Coarse Fraction Passes No. 4 Sieve	CLEAN SAND	SW	WELL-GRADED SAND, FINE TO COARSE SAND
			SP	POORLY-GRADED SAND
		SAND WITH FINES	SM	SILTY SAND
			SC	CLAYEY SAND
FINE GRAINED SOILS More Than 50% Passes No. 200 Sieve	SILT AND CLAY Liquid Limit Less Than 50	INORGANIC	ML	SILT
			CL	CLAY
		ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY
	SILT AND CLAY Liquid Limit 50 or More	INORGANIC	MH	SILT OF HIGH PLASTICITY, ELASTIC SILT
			CH	CLAY OF HIGH PLASTICITY, FAT CLAY
		ORGANIC	OH	ORGANIC CLAY, ORGANIC SILT
HIGHLY ORGANIC SOILS			PT	PEAT

NOTES:

1. Field classification is based on visual examination of soil in general accordance with ASTM D2488-90.
2. Soil classification using laboratory tests is based on ASTM D2487-90.
3. Descriptions of soil density or consistency are based on interpretation of blow count data, visual appearance of soils, and/or test data.

SOIL MOISTURE MODIFIERS:

Dry - Absence of moisture, dusty, dry to the touch

Moist - Damp, but no visible water

Wet - Visible free water or saturated, usually soil is obtained from below water table

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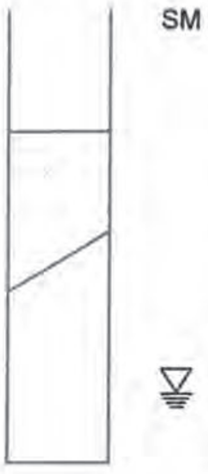
SOIL CLASSIFICATION SYSTEM

FIGURE A-1

LABORATORY TESTS

AL	Atterberg Limits
CP	Compaction
CS	Consolidation
DS	Direct shear
GS	Grain size
%F	Percent fines
HA	Hydrometer Analysis
SK	Permeability
SM	Moisture Content
MD	Moisture and density
SP	Swelling pressure
TX	Triaxial compression
UC	Unconfined compression
CA	Chemical analysis

SOIL GRAPH:



SM Soil Group Symbol (See Note 2)

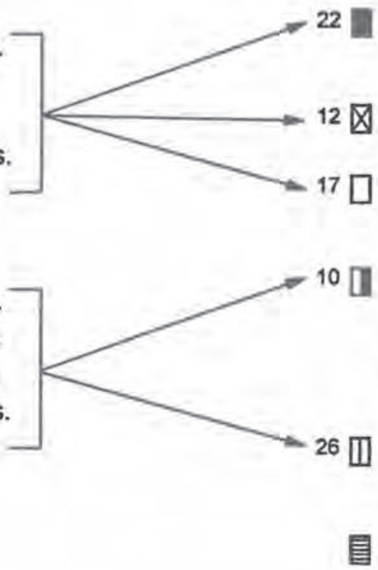
Distinct Contact Between Soil Strata

Gradual or Approximate Location of Change Between Soil Strata

Water Level

Bottom of Boring

BLOW COUNT/SAMPLE DATA:



Blows required to drive a 2.4-inch I.D. split-barrel sampler 12 inches or other indicated distances using a 300-pound hammer falling 30 inches.

22 ■ Location of relatively undisturbed sample

12 ☒ Location of disturbed sample

17 □ Location of sampling attempt with no recovery

Blows required to drive a 1.5-inch I.D. (SPT) split-barrel sampler 12 inches or other indicated distances using a 140-pound hammer falling 30 inches.

10 ◨ Location of sample obtained in general accordance with Standard Penetration Test (ASTM D-1586) procedures

26 ◫ Location of SPT sampling attempt with no recovery

▤ Location of grab sample

"P" indicates sampler pushed with weight of hammer or against weight of drill rig.

NOTES:

1. The reader must refer to the discussion in the report text, the Key to Boring Log Symbols and the exploration logs for a proper understanding of subsurface conditions.
2. Soil classification system is summarized in Figure A-1.

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KEY TO BORING LOG SYMBOLS

FIGURE A-2

BORING GB-1

TEST DATA

DESCRIPTION

Surface Elevation (ft.): 29.0

DEPTH IN FEET

Lab Tests	Moisture Content (%)	Dry Density (pcf)	Blow Count	Samples	Group Symbol	Description
					GM	Gray to brown silty coarse gravel with sand (dense, moist) (fill)
					XX	Slag with fine to coarse sand (fill)
					GM	Brown silty fine to coarse gravel with fine to coarse sand and occasional wood chips (dense, moist) (fill)
MD	9	129	50/4"	■		
					SM	Brown silty fine to medium sand with occasional gravel (dense, moist) (fill)
			34	■		
					ML	Brown fine sandy silt (soft, moist) (fill)
MD	15	83	3	■		
					SP-SM	Brown fine to medium sand with silt (very loose, moist) (fill?)
			2	■		
					ML	Brown mottled fine sandy silt (very soft, moist)
MD	44	78	2	■		
MD	37	83	2	■		Becomes wet
					ML	Gray silt with a trace of fine sand (very soft, wet)
MD, CS	44	78	1	■		
					SP	Black fine to medium sand (loose, wet)
			9	□		
MD	19	105	38	■		Becomes dense

Note: See Figure A-2 for explanation of symbols

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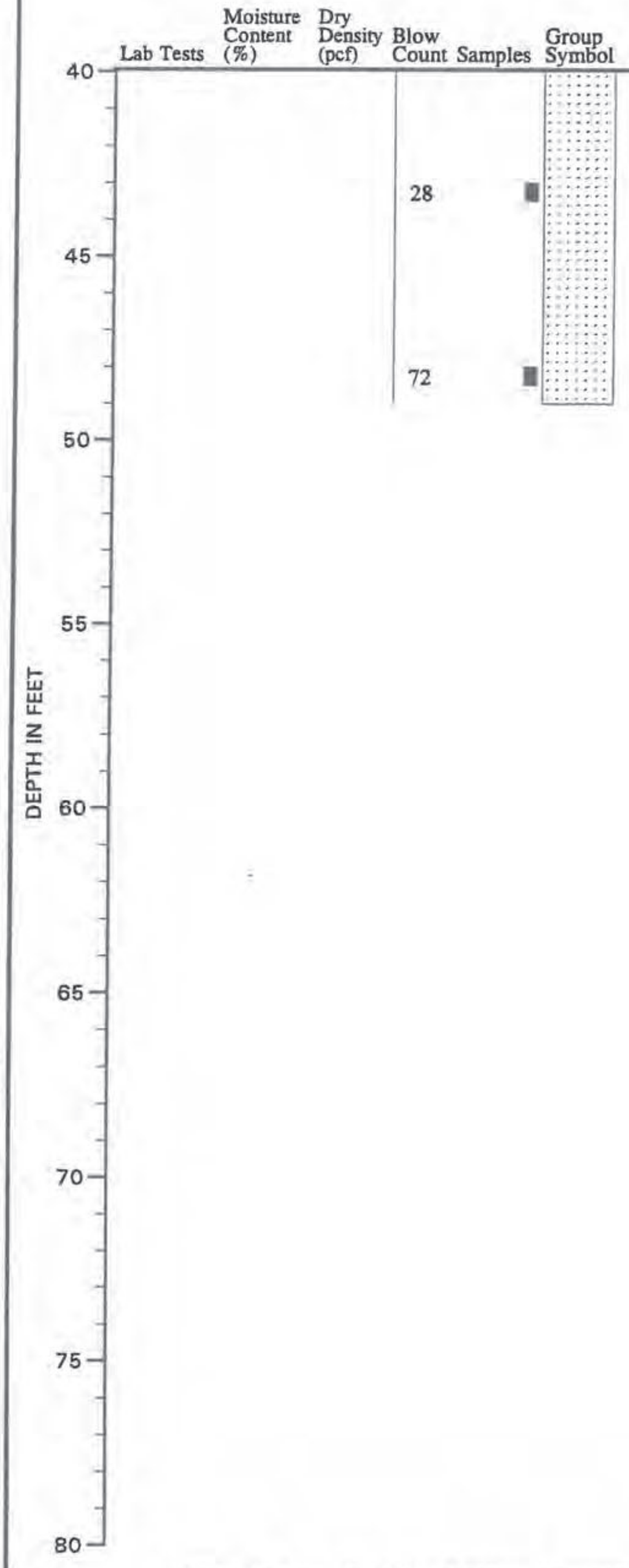
LOG OF BORING

FIGURE A-3

TEST DATA

BORING GB-1
(Continued)

DESCRIPTION



Boring completed at 49.0 feet on 06/16/97
Perched ground water encountered at 2.0 feet during drilling
Ground water encountered at 23.0 feet during drilling

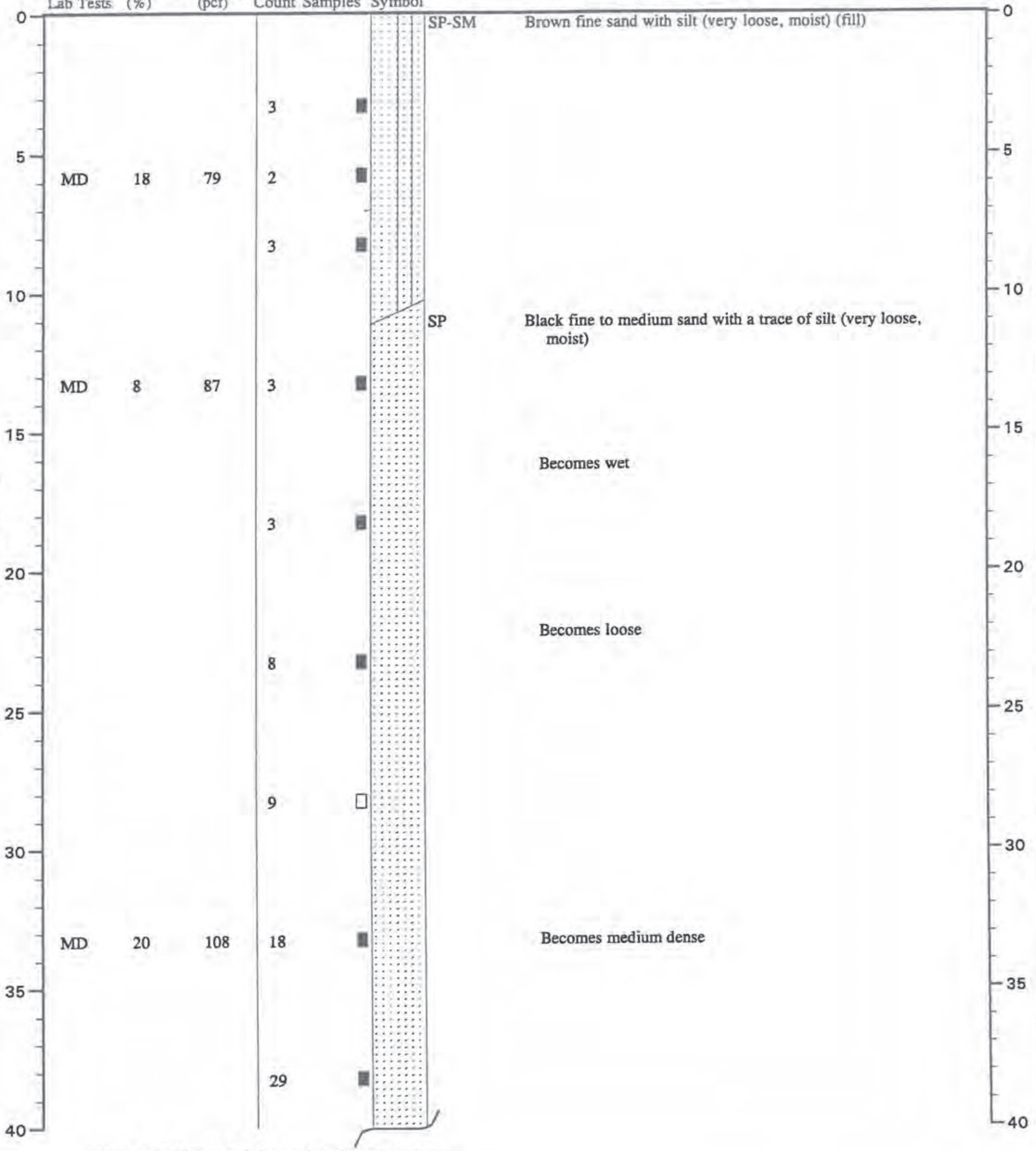
Note: See Figure A-2 for explanation of symbols

BORING GB-2

TEST DATA

DESCRIPTION

Surface Elevation (ft.): 21.0



Lab Tests	Moisture Content (%)	Dry Density (pcf)	Blow Count	Samples	Group Symbol	Description
					SP-SM	Brown fine sand with silt (very loose, moist) (fill)
			3	■		
MD	18	79	2	■		
			3	■		
					SP	Black fine to medium sand with a trace of silt (very loose, moist)
MD	8	87	3	■		
						Becomes wet
			3	■		
						Becomes loose
			8	■		
			9	☐		
MD	20	108	18	■		Becomes medium dense
			29	■		

Note: See Figure A-2 for explanation of symbols

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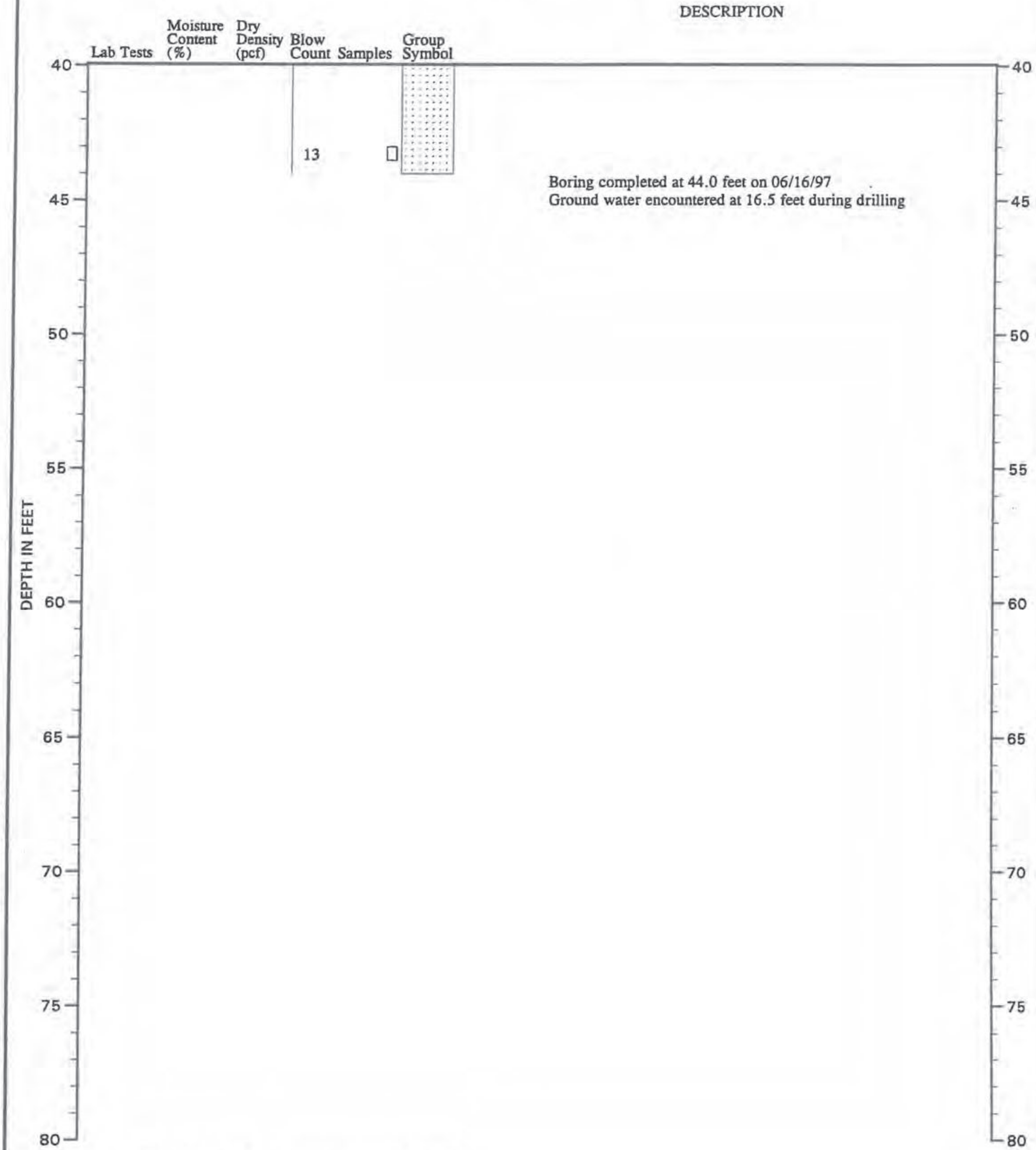
LOG OF BORING

FIGURE A-4

TEST DATA

BORING GB-2
(Continued)



Boring completed at 44.0 feet on 06/16/97
Ground water encountered at 16.5 feet during drilling

Note: See Figure A-2 for explanation of symbols

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LOG OF BORING

FIGURE A-4

LOG OF TEST PIT

DEPTH BELOW GROUND SURFACE (FEET)	SOIL GROUP CLASSIFICATION SYMBOL	DESCRIPTION
		TEST PIT GT-1
		Approximate ground surface elevation: 22.0 feet
0.0 - 7.0	ML	Brown silt with a trace of fine sand (soft, moist) (fill?)
7.0 - 8.5	ML	Brown silt with sand (soft, moist) (fill?)
8.5 - 11.5	SM	Brown silty fine sand (loose, moist) (fill?)
11.5 - 12.5	SP	Brown fine to medium sand with a trace of silt (loose, moist)
		Test pit completed at 12.5 feet on 06/17/97
		No ground water seepage observed
		No caving observed
		TEST PIT GT-2
		Approximate ground surface elevation: 20.0 feet
0.0 - 1.0		Sod and topsoil
1.0 - 2.0	SM	Brown silty fine sand (loose, moist) (fill)
2.0 - 12.5	ML	Brown silt with a trace of fine sand (soft, moist) (fill?)
12.5 - 13.0	SP-SM	Brown fine sand with silt (medium dense, wet)
		Test pit completed at 13.0 feet on 06/17/97
		Slow ground water seepage observed at 13.0 feet
		No caving observed
		Disturbed soil samples obtained at 1.0 and 3.0 feet

THE DEPTHS ON THE TEST PIT LOGS, ALTHOUGH SHOWN TO 0.1 FOOT, ARE BASED ON AN AVERAGE OF MEASUREMENTS ACROSS THE TEST PIT AND SHOULD BE CONSIDERED ACCURATE TO 0.5 FOOT.

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LOG OF TEST PIT

FIGURE A-5

LOG OF TEST PIT

DEPTH BELOW GROUND SURFACE (FEET)	SOIL GROUP CLASSIFICATION SYMBOL	DESCRIPTION
		<u>**TEST PIT GT-3**</u>
		Approximate ground surface elevation: 20.0 feet
0.0 - 3.0	ML	Brown silt with sand (soft, moist) (fill)
3.0 - 8.0	SP	Brown fine sand with a trace of silt (loose, moist) (fill?)
8.0 - 8.5	SM	Brown silty fine sand (loose, wet)
8.5 - 10.0	ML	Gray silt with fine sand (medium stiff, wet)
10.0 - 13.5	SM	Gray silty fine to coarse sand (loose, wet)
		Test pit completed at 13.5 feet on 06/17/97
		Slow ground water seepage observed at 8.0 feet
		Slight caving observed at 2.0 to 6.0 feet
		Disturbed soil samples obtained at 1.0, 2.0, 3.5, 4.5, 8.0 and 10.0 feet
		<u>**TEST PIT GT-4**</u>
		Approximate ground surface elevation: 35.0 feet
0.0 - 5.0	GM	Gray silty fine to coarse gravel with fine to coarse sand, a trace of fine organic matter and occasional 12-inch to 24-inch concrete debris (medium dense, moist) (fill)
5.0 - 8.0	SM	Black and brown silty fine to medium sand with fine gravel, abundant fine organic matter and occasional 12-inch to 24-inch concrete debris (medium dense, moist) (fill)
8.0 - 13.0	ML	Gray silt with fine to medium sand, occasional fine to coarse gravel, fine organic matter and occasional 12-inch to 24-inch concrete debris (stiff, moist) (fill)
		Test pit completed at 13.0 feet on 06/17/97
		No ground water seepage observed
		No caving observed
		Disturbed soil samples obtained at 2.0, 5.0 and 8.0 feet

THE DEPTHS ON THE TEST PIT LOGS, ALTHOUGH SHOWN TO 0.1 FOOT, ARE BASED ON AN AVERAGE OF MEASUREMENTS ACROSS THE TEST PIT AND SHOULD BE CONSIDERED ACCURATE TO 0.5 FOOT.

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LOG OF TEST PIT

FIGURE A-6

LOG OF TEST PIT

DEPTH BELOW GROUND SURFACE (FEET)	SOIL GROUP CLASSIFICATION SYMBOL	DESCRIPTION
		TEST PIT GT-5
		Approximate ground surface elevation: 45.0 feet
0.0 - 0.5	SM	Gray silty fine to coarse sand with gravel (dense, moist) (fill)
0.5 - 1.0	PT	Brown fibrous wood matter (soft, moist) (fill)
1.0 - 4.0	GM	Gray silty fine to coarse gravel with fine to coarse sand with abundant fine organic matter (dense, moist) (fill)
4.0 - 8.0	SM	Brown silty fine to medium sand with gravel, coarse sand and fine organic matter (dense, moist) (fill)
8.0 - 11.0	ML	Gray fine sandy silt with fine organic matter (very stiff, moist) (fill)
11.0 - 12.5	SM	Gray silty fine to medium sand with abundant fine organic matter (medium dense, moist) (fill)
		Test pit completed at 12.5 feet on 06/16/97
		No ground water seepage observed
		No caving observed
		Disturbed soil samples obtained at 1.0, 2.0, 4.0, 8.0 and 12.0 feet
		TEST PIT GT-6
		Approximate ground surface elevation: 50.0 feet
0.0 - 8.0	GM	Brown silty fine to coarse gravel with fine to coarse sand (dense, moist) (fill)
		Grades to green, occasional wood debris and wood fibers at 6.0 feet
8.0 - 9.0	SW-SM	Brown fine to coarse sand with silt, gravel and occasional fine wood debris (dense, moist) (fill)
9.0 - 12.5	SM	Brown silty fine to coarse sand with occasional gravel, cobbles and organic matter (dense, moist) (fill)
		Grades to gray at 10.5 feet
		Grades to yellow at 12.5 feet
		Test pit completed at 12.5 feet on 06/17/97
		No ground water seepage observe
		No caving observed
		Disturbed soil sample obtained at 1.0 foot

THE DEPTHS ON THE TEST PIT LOGS, ALTHOUGH SHOWN TO 0.1 FOOT, ARE BASED ON AN AVERAGE OF MEASUREMENTS ACROSS THE TEST PIT AND SHOULD BE CONSIDERED ACCURATE TO 0.5 FOOT.

LOG OF TEST PIT

DEPTH BELOW GROUND SURFACE (FEET)	SOIL GROUP CLASSIFICATION SYMBOL	DESCRIPTION
		<u>**TEST PIT GT-7**</u>
		Approximate ground surface elevation: 27.0 feet
0.0 - 2.0		Tree limbs, bricks, wire, concrete blocks, debris and boulders (loose, moist) (fill)
2.0 - 3.0	SM	Brown silty fine to medium sand with occasional gravel and abundant fine organic matter (medium dense, moist) (fill)
3.0 - 5.0	ML	Gray silt with fine to medium sand, occasional gravel and organic matter (soft, moist) (fill)
5.0 - 8.5	SM	Brown silty fine to coarse sand with gravel and concrete debris (medium dense, moist) (fill)
		Test pit completed at 8.5 feet on 06/17/97 due to refusal on concrete debris
		No ground water seepage observed
		No caving observed
		Disturbed soil samples obtained at 2.0, 3.0, 5.0 and 8.5 feet
		<u>**TEST PIT GT-8**</u>
		Approximate ground surface elevation: 26.0 feet
0.0 - 2.5	GW-GM	Brown fine to coarse gravel with silt and sand (dense, moist) (fill)
2.5 - 3.0	PT	Fibrous wood debris (soft, moist) (fill)
3.0 - 3.5	ML-SM	Yellow silt with fine sand (hard, moist) (fill)
3.5 - 4.0	SM	Brown silty fine to coarse sand (medium dense, moist) (fill)
4.0 - 9.0	ML	Brown silt with fine sand (stiff, moist) (fill)
9.0 - 12.0	SP	Brown fine sand with a trace of silt (loose, moist)
		Test pit completed at 12.0 feet on 06/17/97
		No ground water seepage observed
		No caving observed
		Disturbed soil samples obtained at 3.0 and 4.5 feet

THE DEPTHS ON THE TEST PIT LOGS, ALTHOUGH SHOWN TO 0.1 FOOT, ARE BASED ON AN AVERAGE OF MEASUREMENTS ACROSS THE TEST PIT AND SHOULD BE CONSIDERED ACCURATE TO 0.5 FOOT.

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LOG OF TEST PIT

FIGURE A-8

LOG OF TEST PIT

DEPTH BELOW GROUND SURFACE (FEET)	SOIL GROUP CLASSIFICATION SYMBOL	DESCRIPTION
		TEST PIT GT-9
		Approximate ground surface elevation: 51.0 feet
0.0 - 0.5	GP	Brown coarse gravel (dense, moist) (fill)
0.5 - 3.0	GM	Brown silty fine to coarse gravel with fine to coarse sand and occasional roots (dense, moist) (fill)
3.0 - 12.0	SM	Black silty fine to medium sand with gravel and abundant organic matter (medium dense, moist) (fill)
		Becomes wet at 7.0 feet
		Test pit completed at 12.0 feet on 06/17/97
		Slow ground water seepage observed at 7.0 feet
		No caving observed
		Disturbed soil samples obtained at 2.0 and 7.0 feet
		TEST PIT GT-10
		Approximate ground surface elevation: 24.0 feet
0.0 - 0.5		Wood debris (fill)
0.5 - 1.5	ML	Gray silt with fine sand, occasional gravel and fine organic matter (stiff, moist) (fill)
1.5 - 5.0	SM	Brown silty fine to coarse sand with gravel (medium dense, moist) (fill)
		4-foot-diameter concrete debris and wire encountered at 2.0 to 7.0 feet
5.0 - 6.0	SW-SM	Gray fine to coarse sand with silt and occasional gravel (medium dense, moist) (fill)
6.0 - 9.0	ML	Gray silt with fine sand (medium stiff, moist) (fill)
9.0 - 12.0	SM	Gray silty fine to medium sand (medium dense, moist)
		Test pit completed at 12.0 feet on 06/17/97
		Slow ground water seepage observed at 7.0 feet
		No caving observed
		Disturbed soil samples obtained at 2.0, 3.0 and 12.0 feet

THE DEPTHS ON THE TEST PIT LOGS, ALTHOUGH SHOWN TO 0.1 FOOT, ARE BASED ON AN AVERAGE OF MEASUREMENTS ACROSS THE TEST PIT AND SHOULD BE CONSIDERED ACCURATE TO 0.5 FOOT.

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LOG OF TEST PIT

FIGURE A-9

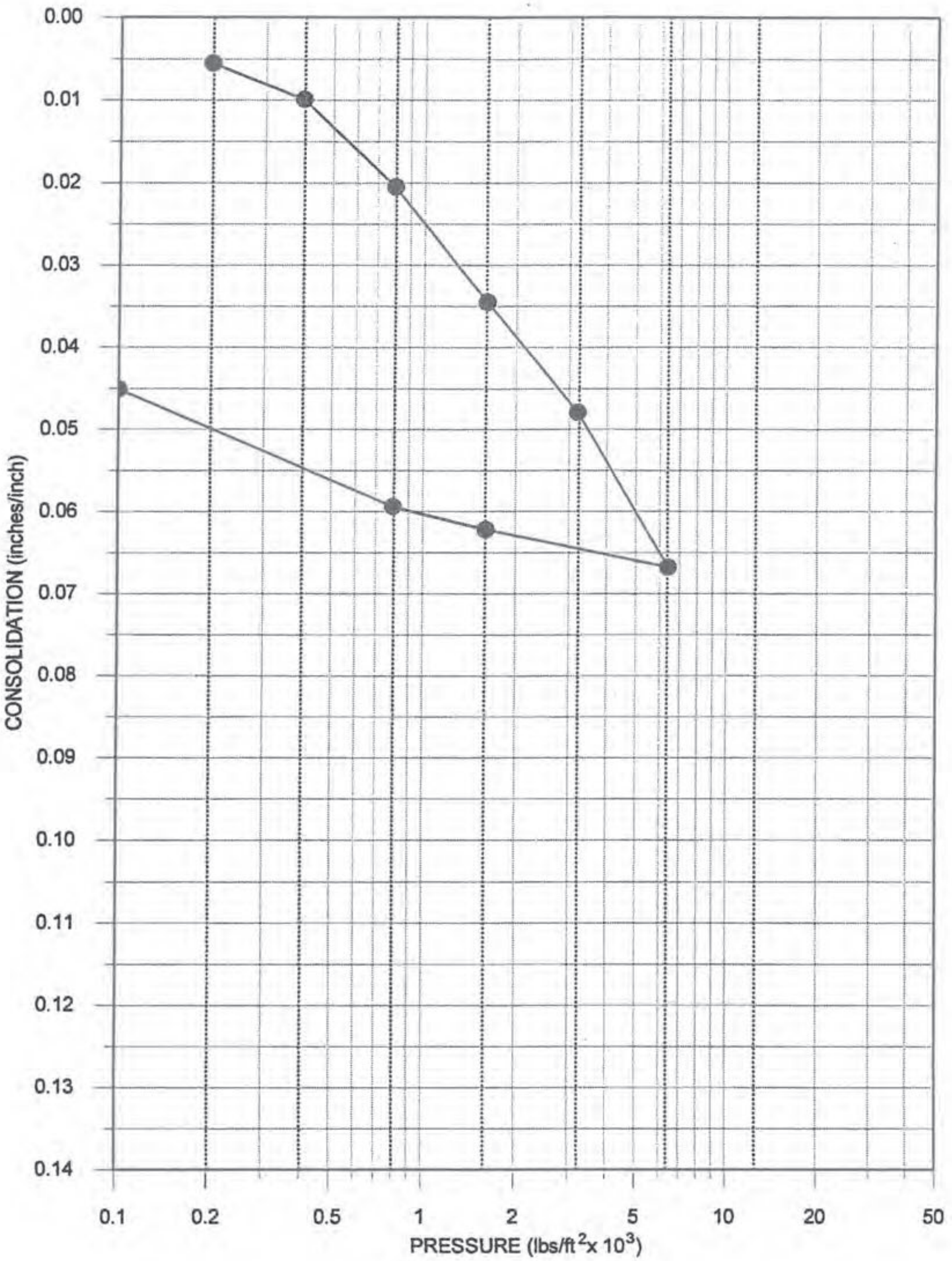
LOG OF TEST PIT

DEPTH BELOW GROUND SURFACE (FEET)	SOIL GROUP CLASSIFICATION SYMBOL	DESCRIPTION
		TEST PIT GT-11
		Approximate ground surface elevation: 48.0 feet
0.0 - 1.0	SP-SM	Brown fine to medium sand with silt and organic matter (loose, moist) (fill)
1.0 - 4.0	SM	Brown silty fine to medium sand with occasional organic matter (loose, moist) (fill)
4.0 - 6.0	SP	Brown fine to medium sand with a trace of silt, occasional gravel and occasional organic matter (medium dense, moist) (fill)
6.0 - 13.0	SM	Gray silty fine to medium sand with gravel and occasional organic matter (medium dense, moist (fill)
		Test pit completed at 13.0 feet on 06/17/97
		No ground water seepage observed
		No caving observed
		Disturbed soil samples obtained at 1.0 and 6.0 feet
		TEST PIT GT-12
		Approximate ground surface elevation: 21.0 feet
0.0 - 0.2		2 inches asphalt concrete
0.2 - 1.5	SP	Brown fine to medium sand (medium dense, moist) (fill)
1.5 - 3.0	SM	Brown silty fine sand with fine organic matter (medium dense, moist) (fill)
3.0 - 6.0	SM	Brown silty fine sand (medium dense, moist) (fill)
		Becomes wet at 5.5 feet
6.0 - 12.0	ML	Gray silt (soft, wet)
		Test pit completed at 12.0 feet on 06/17/97
		No ground water seepage observed
		Minor caving observed at 4.0 to 6.0 feet
		Disturbed soil samples obtained at 2.0, 4.0 and 6.0 feet

THE DEPTHS ON THE TEST PIT LOGS, ALTHOUGH SHOWN TO 0.1 FOOT, ARE BASED ON AN AVERAGE OF MEASUREMENTS ACROSS THE TEST PIT AND SHOULD BE CONSIDERED ACCURATE TO 0.5 FOOT.

MOISTURE CONTENT DATA

Test Pit Number	Depth of Sample (feet)	Soil Classification	Moisture Content (%)
2	3.0	ML	20
3	2.0	ML	22
4	2.0	GM	10
4	5.0	SM	20
5	2.0	GM	11
5	4.0	SM	15
5	8.0	ML	22
6	1.0	GM	11
7	8.0	SM	18
9	7.0	SM	17
10	3.0	SM	10
11	1.0	SM	21
12	4.0	SM	23
12	6.0	ML	44



KEY	BORING NUMBER	SAMPLE DEPTH (FEET)	SOIL CLASSIFICATION	INITIAL MOISTURE CONTENT	INITIAL DRY DENSITY (LBS/FT^3)
●	GB-1	28	Gray silt (ML) (very soft, wet)	44	78

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CONSOLIDATION TEST RESULTS

FIGURE A-12

SUMMARY OF SOIL FIELD SCREENING

Exploration Number[1]	Depth of Sample (feet)	Field Screening Results	
		Headspace Vapors (ppm)	Sheen
GB-1	1.0	--	SS
	5.0	--	SS
GB-2	18.0	--	NS
GT-1	3.0	--	SS
	7.0	--	SS
	9.0	--	SS
	11.5	--	SS
GT-3	0.5	--	NS
	1.0	--	NS
	3.5	--	NS
	4.5	--	NS
	8.5	<100	SS
	10.0	--	SS
GT-5	0.5	--	NS
	1.5	--	SS
	8.0	600	NS
	11.5	--	NS

Notes:

[1] Approximate exploration locations are shown on Figure 2.

ppm = part per million

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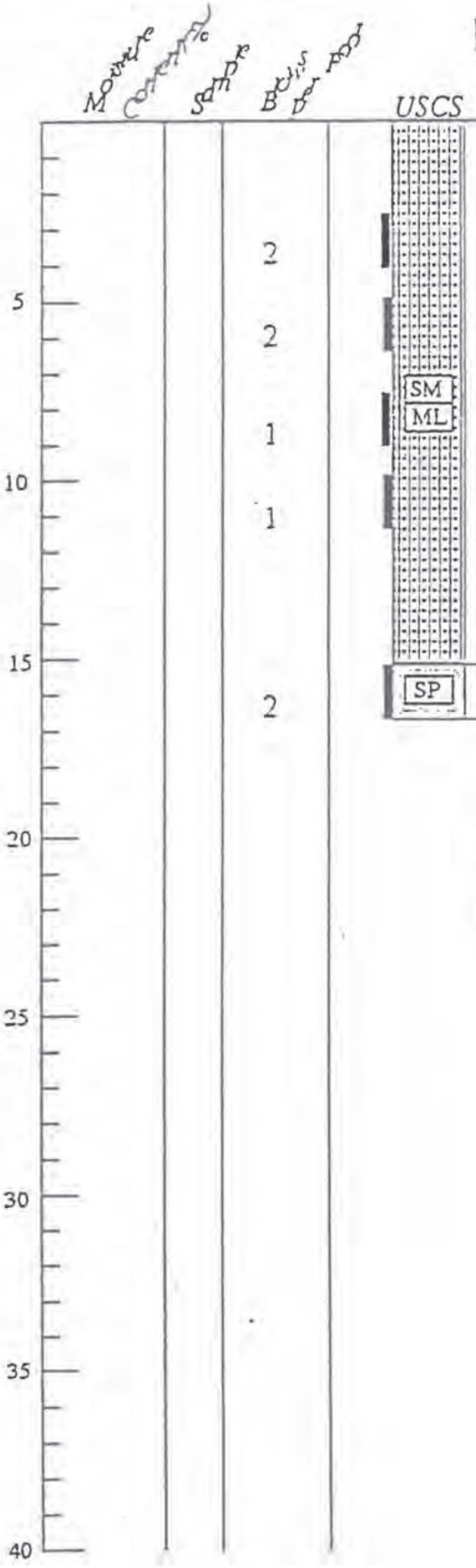
SUMMARY OF SOIL FIELD SCREENING

FIGURE A-13

APPENDIX B

BORING 14



Description

Gray to gray/brown SILT non-plastic & very fine-grained SAND in layers, moist, loose

ND

ND

ND

ND

ND Dark gray/black, fine-grained SAND, saturated, loose

Test boring was terminated at 16.5 feet below grade on 5-3-94 and completed as a monitoring well.

Note: -ND denotes non-detected hydrocarbon concentrations as measured during field work in the headspace of a glass jar with a combustible gas indicator.

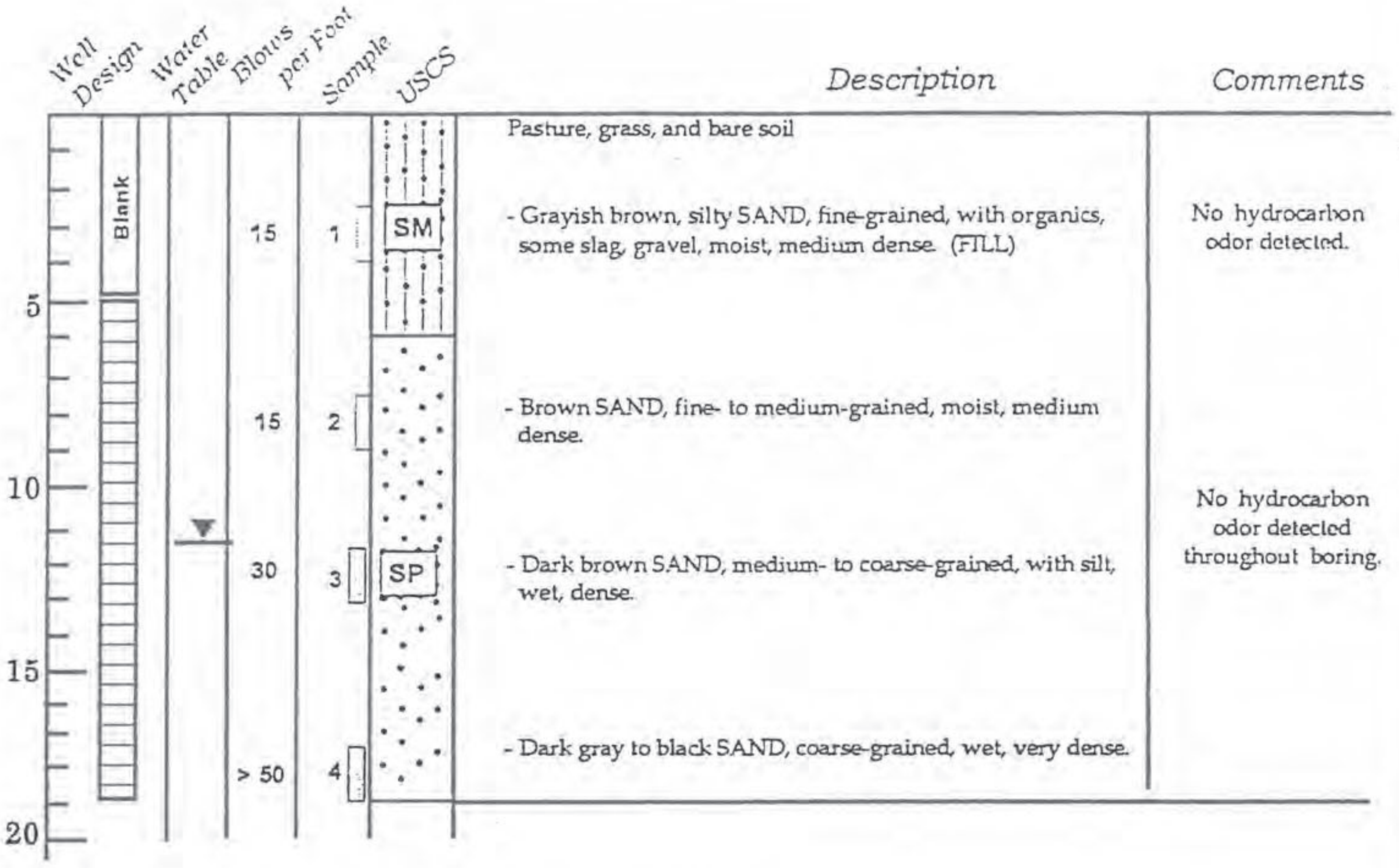
GEOTECH
CONSULTANTS, INC.

TEST BORING LOG

NIELSON PROPERTY
TUKWILA, WA

Job No:	Date:	Logged by:	Plate:
94158E	JUNE 1994	FC	6

BORING B-16/MW-16



Description

Pasture, grass, and bare soil

- Grayish brown, silty SAND, fine-grained, with organics, some slag, gravel, moist, medium dense. (FILL)
- Brown SAND, fine- to medium-grained, moist, medium dense.
- Dark brown SAND, medium- to coarse-grained, with silt, wet, dense.
- Dark gray to black SAND, coarse-grained, wet, very dense.

Comments

No hydrocarbon odor detected.

No hydrocarbon odor detected throughout boring.

* Boring drilled to 17.5 feet and sampled to 19.0 feet on November 1, 1996.

* No olfactory indication of contamination in soil.

* A monitoring well was completed in this boring.

* Groundwater depth measured at 11.52 feet below ground surface on November 4, 1996.

* Well completed with locking above-ground monument.

* Headspace measured using Photovac 2020 PID.

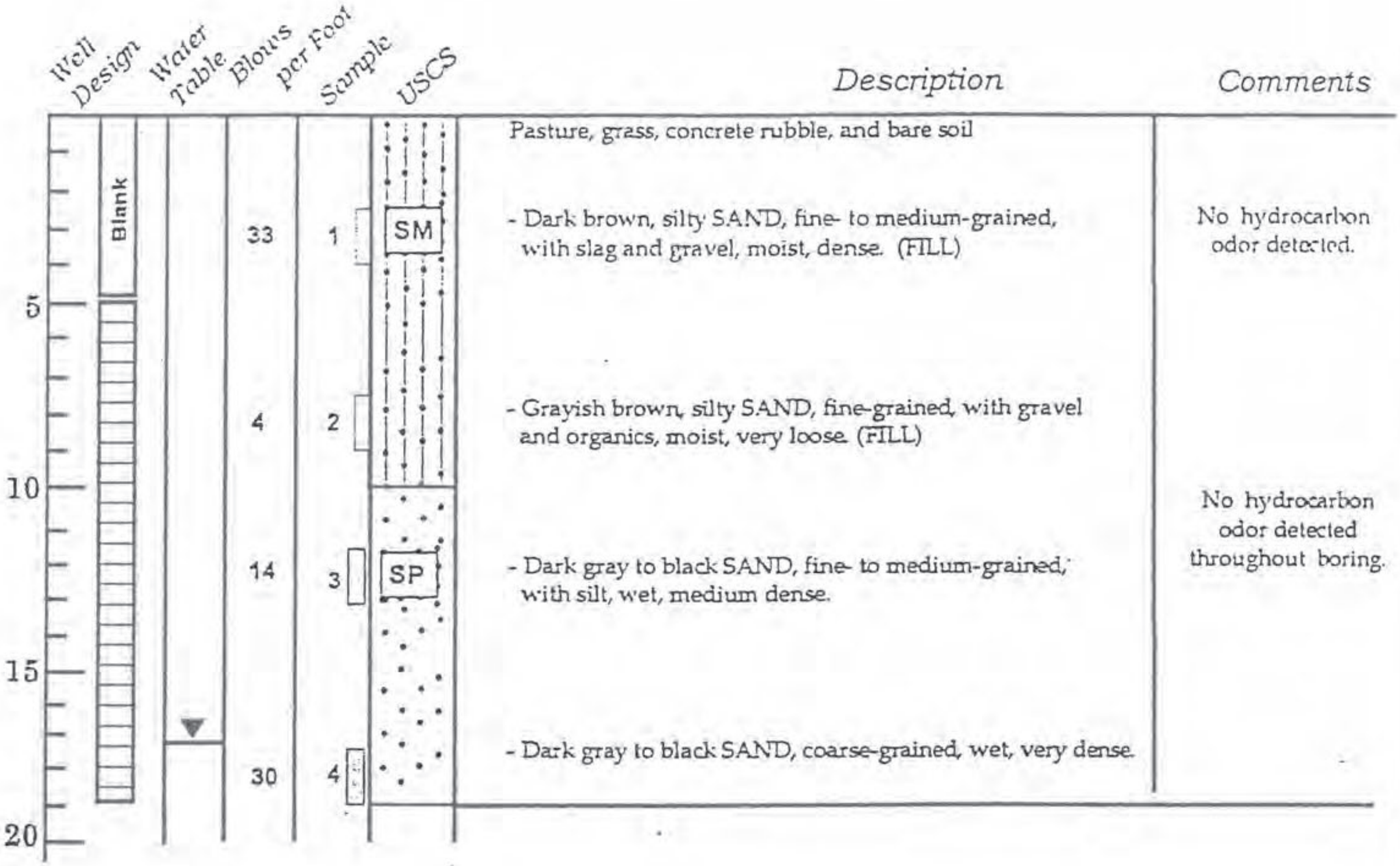
GEOTECH CONSULTANTS

BORING LOG B-16/MW-16

NIELSEN PROPERTY
SW GRADY WAY AT INTERURBAN AVE
TUKWILA, WASHINGTON

Job No:	Date:	Logged by:	Plate:
96387E	DEC 1996	TAJ	4

BORING B-17/MW-17



Pasture, grass, concrete rubble, and bare soil

- Dark brown, silty SAND, fine- to medium-grained, with slag and gravel, moist, dense. (FILL)

No hydrocarbon odor detected.

- Grayish brown, silty SAND, fine-grained, with gravel and organics, moist, very loose. (FILL)

No hydrocarbon odor detected throughout boring.

- Dark gray to black SAND, fine- to medium-grained, with silt, wet, medium dense.

- Dark gray to black SAND, coarse-grained, wet, very dense.

- Boring drilled to 17.5 feet and sampled to 19.0 feet on November 1, 1996.
- No olfactory indication of contamination in soil.
- A monitoring well was completed in this boring.
- Groundwater depth measured at 17.24 feet below ground surface on November 4, 1996.
- Well completed with locking above-ground monument.
- Headspace measured using Photovac 2020 PID.

GEOTECH
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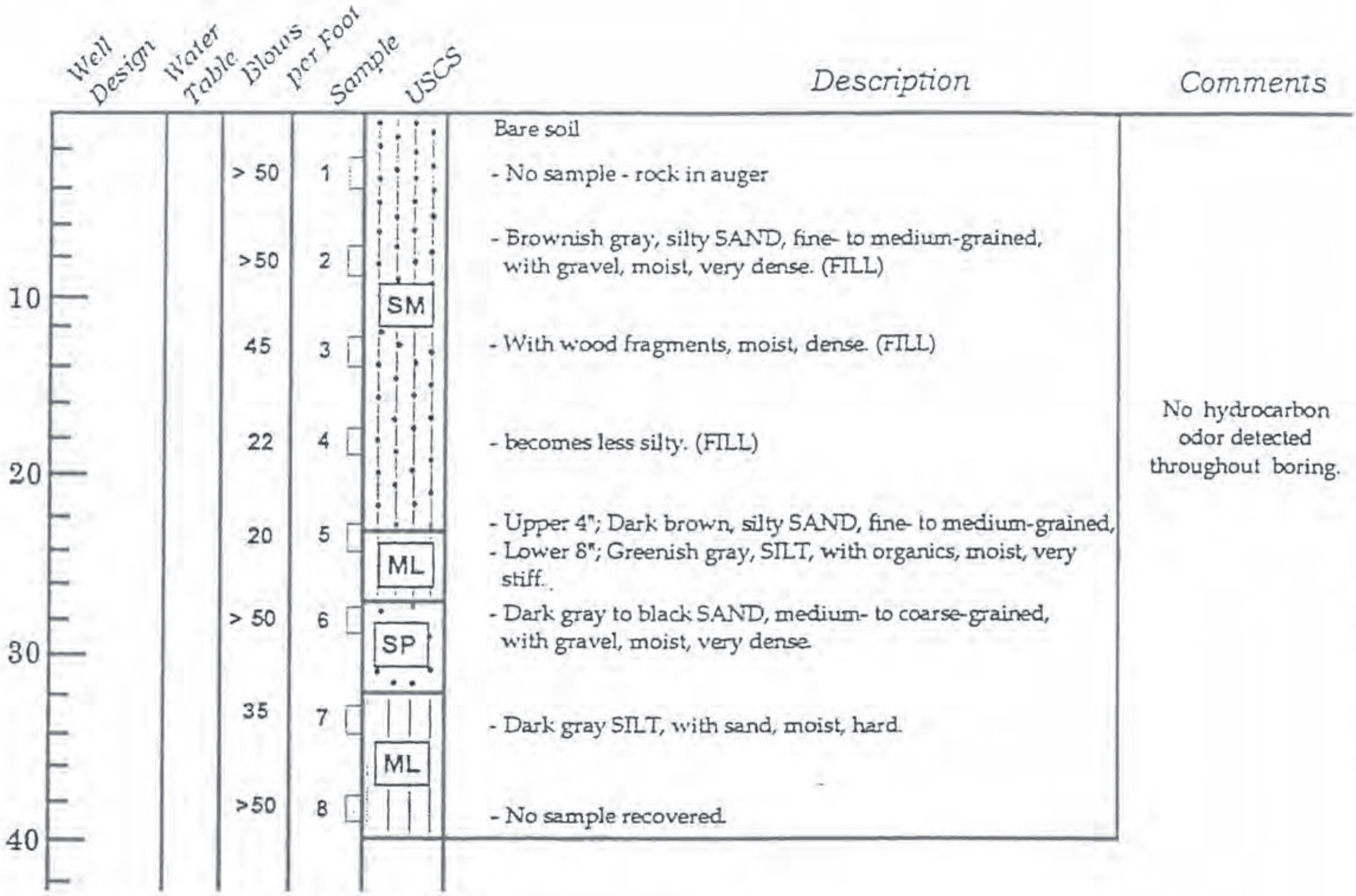
BORING LOG B-17/MW-17

NIELSEN PROPERTY
SW GRADY WAY AT INTERURBAN AVE
TUKWILA, WASHINGTON

Job No:	*Date:*	*Logged by:*	*Plate:*
96387E	DEC 1996	TAJ	5

BORING B-18



Well Design	Water Table	Blows per Foot	Sample	USCS	Description	Comments
					Bare soil	
		> 50	1		- No sample - rock in auger	
		>50	2		- Brownish gray, silty SAND, fine- to medium-grained, with gravel, moist, very dense. (FILL)	
				SM		
		45	3		- With wood fragments, moist, dense. (FILL)	No hydrocarbon odor detected throughout boring.
		22	4		- becomes less silty. (FILL)	
		20	5	ML	- Upper 4"; Dark brown, silty SAND, fine- to medium-grained, - Lower 8"; Greenish gray, SILT, with organics, moist, very stiff.	
		> 50	6	SP	- Dark gray to black SAND, medium- to coarse-grained, with gravel, moist, very dense.	
		35	7	ML	- Dark gray SILT, with sand, moist, hard.	
		>50	8		- No sample recovered.	

* Boring drilled to 37.5 feet and sampled to 38.5 feet on November 1, 1996.
* No visual or olfactory indication of contamination in soil.
* No groundwater encountered in boring.
* Headspace measured using Photovac 2020 PID.

GEOTECH CONSULTANTS

BORING LOG B-18
NIELSEN PROPERTY
SW GRADY WAY AT INTERURBAN AVE
TUKWILA, WASHINGTON

Job No:	Date:	Logged by:	Plate:
96387E	DEC 1996	TAJ	6

TEST PIT LOGS

TEST PIT 1

Depth (feet)	*Observations*
0.0 - 5.0	- Brown, gravelly, silty SAND, medium- to coarse-grained, with wood, concrete, and asphalt fragments, oil filter at 3 feet, moist. (FILL)
5.0 - 15.0	- Blue-gray, silty SAND, fine- to medium-grained, wood fragments, bricks, ceramic tile, black plastic fragments at 9 feet, wire fragments at 13 feet, moist. (FILL)
15.0 - 18.0	- Gray, silty SAND, coarse-grained, damp, peculiar odor, light-weight, moist. (FILL)
	- Test Pit terminated at 18 feet on 11/12/96. No groundwater noted, no caving. (FILL)

TEST PIT 2

Depth (feet)	*Observations*
0.0 - 5.0	- Brown, silty SAND, medium- to coarse-grained, with cobbles, rubber, sheet metal, and pipe fragments, moist. (FILL)
5.0 - 8.0	- Blue-gray, silty SAND, fine- to medium-grained, slight seepage at 7 feet. (FILL)
8.0 - 9.0	- Brown layer of chipped bark, moist. (FILL)
9.0 - 15.0	- Gray, gravelly, silty SAND, medium-grained, slight hydrocarbon odor at 10 feet, water at 13 feet. (FILL)
	- Test Pit terminated at 15 feet on 11/12/96. Groundwater noted at 13 feet, caving at 14 feet.

TEST PIT 3

Depth (feet)	*Observations*
0.0 - 8.0	- Brown, silty SAND, medium-to coarse-grained, with gravel and cobbles, one-foot-thick bark layers at 3 and 5 feet, slight seepage at 7 feet. (FILL)
8.0 - 13.0	- Gray-brown, silty SAND, fine- to medium-grained, concrete rubble, metal fragments at 10 feet, moist. (FILL)
	- Test Pit terminated at 13 feet on 11/12/96. No groundwater noted, no caving.

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TEST PIT LOGS

NIELSEN PROPERTY
SW GRADY WAY AT INTERURBAN AVE
TUKWILA, WASHINGTON

Job No: 96387E	***Date:*** DEC 1996	***Logged by:*** TAJ	***Plate:*** 7

TEST PIT LOGS

TEST PIT 4

Depth (feet)	*Observations*
0.0 - 5.0	- Gray-brown, gravelly SAND, medium-grained, moist. (FILL)
5.0 - 9.0	- Dark gray, silty SAND, fine- to medium-grained, with cobbles, moist. (FILL)
9.0 - 10.0	- Brown to black, WOOD CHIPS, 2"-diameter plastic pipe, damp. (FILL)
10.0 - 14.0	- Dark gray to black, silty SAND, fine- to medium-grained, with several plastic pails of lubricants, one 25-gallon drum of heavy lubricants, strong hydrocarbon odor. (FILL)
14.0 - 15.0	- Dark gray SILT with sand, slight hydrocarbon odor, moist. (FILL)
	- Test Pit terminated at 15 feet on 11/12/96. No groundwater noted, no caving.

TEST PIT 5

Depth (feet)	*Observations*
0.0 - 3.0	- Grayish brown SAND, medium-grained, with silt, moist. (FILL)
3.0 - 6.0	- Gray, silty SAND, fine- to medium-grained, with gravel, moist. (FILL)
6.0 - 7.0	- Brown layer of chipped bark, moist. (FILL)
7.0 - 11.0	- Brownish gray SILT, with sand and gravel, moist. (FILL)
	- Test Pit terminated at 11 feet on 11/12/96. No groundwater noted, no caving.

TEST PIT 6

Depth (feet)	*Observations*
0.0 - 7.0	- Brown, silty SAND, medium- to coarse-grained, with cobbles and wood fragments, some bricks, moist. (FILL)
7.0 - 13.0	- Brown WOOD CHIPS and wood fragments, metal fragments at 11 feet, moist. (FILL)
13.0 - 17.0	- Gray, silty SAND, medium- to coarse-grained, with cobbles and gravel, some bricks, asphalt, moist. (FILL)
	- Test Pit terminated at 17 feet on 11/12/96. No groundwater noted, no caving.

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TEST PIT LOGS

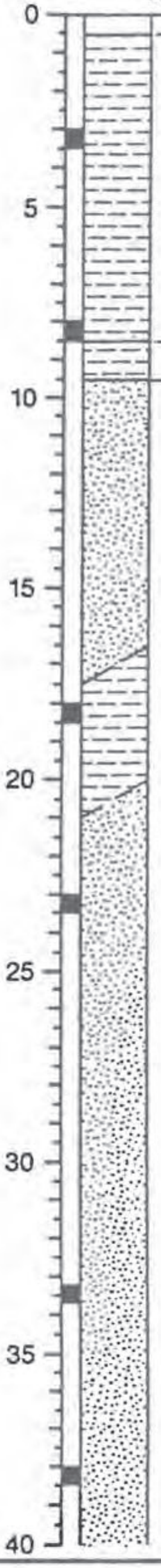
NIELSEN PROPERTY
SW GRADY WAY AT INTERURBAN AVE
TUKWILA, WASHINGTON

Job No:	*Date:*	*Logged by:*	*Plate:*
96387E	DEC 1996	TAJ	8

Equipment Mobile B-61

Elevation Not measured Date 3/30/89

Laboratory Tests	Blows/foot	Moisture Content (%)	Dry Density (pcf)
	7		
	3		
	7		
	3	51.2	72
	18	31.6	95
	50/6"*		
	21		
	26		



Sod.

BROWN SANDY SILT (ML) medium stiff, wet; with some silty sand layers (Fill?).

Becomes soft, wet to saturated, some organics.

GRAY-BROWN SILT (ML) very soft, saturated.

GRAY SAND (SP) loose, fine to medium grained.

GRAY AND BROWN SILT (ML) soft, saturated.

DARK GRAY SAND (SP) medium dense, saturated; fine to medium grained.

With trace fine gravel.

Becomes fine grained.

Applied Geotechnology Inc.
Geotechnical Engineering
Geology & Hydrogeology

Log of Boring B-5 (0-40')

Hillman Properties NW
Tukwila Development

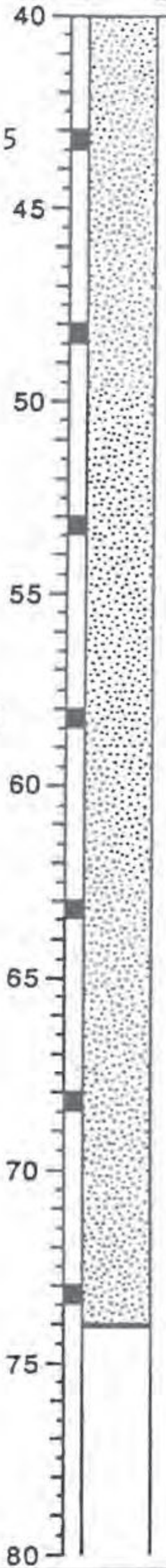
PLATE
8

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,339.002.01	ECR	SJO	12 April 89		

Equipment Mobile B-61

Elevation Not measured Date 3/30/89

Laboratory Tests	Blows/foot	Moisture Content (%)	Dry Density (pcl)	
	47*	17.5	115	Becomes medium dense to dense, medium to coarse grained, with some gravel.
	31			With trace silt.
	45*			Becomes fine to coarse grained, with some gravel.
	29	21.4	105	With occasional shell fragments.
	44*			
	74*			
	23			Becomes fine grained.



Groundwater encountered at approximately 9-foot depth during drilling.

*Blow counts may not be representative due to sand heave in auger.

Applied Geotechnology Inc.
Geotechnical Engineering
Geology & Hydrogeology

Log of Boring B-5 (40-74')

Hillman Properties NW
Tukwila Development

PLATE 9

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,339.002.01	ECR		12 April 89		

LOG OF TEST PITS
(Continued)

TEST PIT 4

Depth (Feet)	Classification	Description
0 to 5	ML	Brown Sandy Silt (ML); soft, moist to wet; fine to medium-grained, with some slag to 2-foot diameter, concrete to 5-foot diameter; bricks and wood debris (Fill).
5 to 9	SM/SP	Gray Silty Sand (SM); interlayered with Dark Brown Sand (SP); loose, wet; fine to medium-grained.
9 to 11	SP	Dark Brown Sand (SP); loose, wet; fine to medium-grained, with some silt.
		Test Pit completed April 3, 1989. Seepage noted at approximately 9-foot depth during excavation. Bulk samples obtained at 2- and 2-1/2-foot depths.

TEST PIT 5

Depth (Feet)	Classification	Description
0 to 5	SM/ML	Brown and Gray Sandy Silt and Silty Sand (SM/ML); soft, loose, wet; fine-grained, with trace gravel, concrete and slag to 6-inch diameter (Fill).
5 to 9	SM	Brown Silty Sand (SM); loose, saturated, fine to coarse-grained, with some gravel (Fill).
9 to 11	SM	Gray Silty Sand (SM); loose, saturated; with some gravel and concrete (Fill).
		Test Pit terminated due to caving April 3, 1989. Groundwater encountered at approximately 5-foot depth during excavation. Bulk sample obtained at 3-foot depth.

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Test Pits 4-5
Hillman Properties NW
Tukwila Development

PLATE
11

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,339.002	---	SGP	4/25/89		

LOG OF TEST PITS
(Continued)

TEST PIT 6

Depth (Feet)	Classification	Description
0 to 4.5	SM	Brown Silty Sand (SM); loose, moist to wet; fine to medium-grained, with some gravel, railroad ties, slag, and concrete (Fill).
4.5 to 9	SM	Gray Silty Sand (SM); loose, saturated; fine to medium-grained.
9 to 14	SP	Dark Gray to Black Sand (SP); loose, saturated; medium to coarse-grained.
		Test Pit completed April 3, 1989. Slight seepage noted at approximately 4-1/2-foot depth during excavation. Bulk sample obtained at 3-foot depth.

TEST PIT 7

0 to 4.5	SM	Brown Silty Sand (SM); loose, moist; fine-grained, with some organics.
4.5 to 8	SP	Brown Sand (SP); loose, moist; fine to medium-grained.
		Test Pit completed April 3, 1989. No groundwater encountered during excavation. Bulk sample obtained at 3-foot depth.

TEST PIT 8

0 to 4.5	ML	Brown Sandy Silt (ML); soft, moist to wet; with some organics.
4.5 to 7	SM	Brown Silty Sand (SM); loose, moist to wet; fine-grained.
7 to 9	SP	Dark Brown Sand (SP); loose, moist to wet; fine to medium-grained, with some silt.
		Test Pit completed April 3, 1989. No groundwater encountered during excavation. Bulk sample obtained at 5-foot depth.

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Test Pits 6-8
Hillman Properties NW
Tukwila Development

PLATE
12

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,339.002	---	STP	4/25/89		