SUBSURFACE EXPLORATION AND GEOTECHNICAL ENGINEERING REPORT

KENT RIDGE

ARLINGTON, WASHINGTON

PREPARED FOR

Mr. Dave O'Connor

PROJECT NO. KE98280G

July 1998

CORPORATE OFFICE
911 Fifth Avenue, Suite 100
Kirkland, Washington 98033
(425) 827-7701
FAX (425) 827-5424

ASSOCIATED EARTH SCIENCES, INC

BAINBRIDGE ISLAND OFFICE
179 Madrone Lane North
Bainbridge Island, WA 98110
(206) 780-9370
FAX (206) 780-9438

SUBSURFACE EXPLORATION AND GEOTECHNICAL ENGINEERING REPORT
KENT RIDGE
MAPLE STREET AND STILLAGUAMISH
ARLINGTON, WASHINGTON

July 23, 1998
Project No. KE98280G

I. PROJECT AND SITE CONDITIONS

1.0 INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering study for the Kent Ridge development, a 15 lot residential plat. The approximate locations of the subsurface explorations for this study are presented in the Site and Exploration Plan, Figure 1. The conclusions and recommendations in this report should be reviewed and modified, or verified, as necessary if development plans change from those upon which this report is based.

1.1 Purpose and Scope

The purpose of this study was to provide shallow subsurface soil and ground water data to be utilized in the design and development of the proposed residential subdivision. Our study included reviewing available geologic literature, excavating exploration pits, and performing geologic studies to assess the type, thickness, distribution, and physical properties of the subsurface sediments and shallow ground water conditions. Geotechnical engineering studies were also completed to determine site preparation and structural fill recommendations, the type of suitable foundations, allowable foundation soil bearing pressures, anticipated foundation settlements, erosion considerations, and drainage considerations. This report summarizes our current field work and offers development recommendations based on our present understanding of the project

1.2 Authorization

Written authorization to proceed with this study was granted by Mr. Dave O'Connor. This report has been prepared for the exclusive use of Mr. O'Connor and his agents for specific application to this project. Within the limitations of scope, schedule, and budget, our services have been performed in accordance with generally accepted geotechnical engineering and engineering geology practices in effect in this area at the time our report was prepared. No other warranty, express or implied, is made. Our observations, findings, and opinions are a means to identify and reduce the inherent risks to the owner.

2.0 PROJECT AND SITE DESCRIPTION

This report was completed with an understanding of the project based on a site plan for the Kent Ridge plat, dated June 1998, and prepared by JBMF Consulting Engineer. The plan included topographic information.

Present plans call for development of 15 single-family residential lots. We anticipate the new houses will be 1-to-2-story wood-frame structures with attached multi-car garages. Some homes might use partial daylight basements. Slab-on-grade floors are anticipated for the garages and any basements. Access to the lots will be via private drives or from the existing streets. A storm water detention pond is planned in the lowest area of the property, located in the northwest corner of the site. Construction grading is anticipated to be minor, except for the detention pond, for which the details were not known at the time of this report writing.

The Kent Ridge property is located in the northeast quadrant of Maple Street and Stillaguamish Avenue in Arlington, Washington. The approximate 210 foot (north-south) by 640 foot (east-west) property was bordered on the north and east by residential lots, to the south by Maple Street and to the west by Stillaguamish Avenue. The north, central portion of the property was occupied by an existing home and several sheds/barns. The existing home will be part of the future development plans.

Topographically, the majority of the property was relatively level to gently sloping downward to the west. Total elevation change across the property from east to west was on the order of 40 feet.

Most of the property was covered with field grass. Deciduous and evergreen trees were located in the north, central portion of the property, with a few scattered fruit trees.

3.0 SITE EXPLORATION

The various types of sediments, as well as the depths where characteristics of the sediments changed, are indicated on the exploration pit logs presented in the Appendix of this report. Our explorations and reconnaissance were approximately located by measuring from known site features shown on the aforementioned map.

Because of the nature of exploratory work, extrapolation of subsurface conditions between and beyond field explorations is necessary. Differing subsurface conditions may sometimes be present due to the random nature of natural sediment deposition and the alteration of topography by past grading and filling. The nature and extent of any variations between the field explorations may not become fully evident until construction. If variations are observed at the time of construction, it may be necessary to re-evaluate specific recommendations in this report and make appropriate changes.

4.0 SUBSURFACE CONDITIONS

Subsurface conditions on the project site were inferred from the eight subsurface explorations conducted for this study, visual reconnaissance of the site, and review of applicable geologic literature. As shown on the field logs, most of the explorations encountered dense, glacially consolidated sediments overlain by loose to medium dense, silty sand to medium stiff sandy silt. Minor amounts of fill soils were also encountered in several areas. The following section presents more detailed subsurface information beginning from the youngest (shallow) to oldest (deeper) sediment types.

4.1 Stratigraphy

Fill

Approximately six inches to one foot of fill soil (material not naturally placed) was encountered in exploration pits EP-1, EP-3, and EP-7. Localized areas of fill/disturbed soil should also be expected around existing structures, underground utilities, and from past grading activities. The fill generally consisted of loose to medium dense, moist, brown and gray, gravelly, silty, fine to coarse sand with some small wood debris. The fill is considered unsuitable for foundation support.

Recessional Outwash

Underlying the fill or topsoil in many explorations was a zone of soft to medium stiff, moist to saturated with depth, black and brown sandy silt to loose to medium dense silty fine sand. This material extended to depths of 1½ to 4 feet in explorations EP-1, EP-2, EP-3, and EP-5 through EP-8. In EP-4, located near the highest point of the property, the material graded into a gray, gravelly, fine to coarse sand with depth and it extended to 6½ feet below the existing ground surface. This material has been interpreted as recessional outwash (Arlington gravel member) deposited less than 10,000 years ago in the retreating wake of the last ice sheet to occupy this region. The fine-grained material represented lacustrine deposition in a low energy environment such as a slow-moving stream or lake. The loose, non-organic outwash can generally be used for foundation support with additional recompaction, if it is not too wet.

Lodgement Till

Lodgement till was encountered underlying the recessional outwash in all of the explorations. In general, the lodgement till was first encountered at relatively shallow depths ranging from 1½ feet to 4 feet except in EP-4 where it was encountered at 6½ feet deep. The till consisted of dense, moist, gray, gravelly, silty, fine to coarse sand. The till sediments were deposited at the base of the Vashon-age ice sheet (glacier) approximately 12,000 year ago. This material was subsequently overridden by the ice sheet, which was about 3,500 feet thick in this area, and which resulted in a compact soil, possessing high strength, low compressibility, and low permeability characteristics. The lodgement till extended below the termination depths of all the exploration pits.

Geologic Map Review

As part of our study, we reviewed a geologic map of the East Arlington Quadrangle, Washington, prepared by James P. Minard in 1980. This map identified the subject area as lodgement till and recessional outwash. We concur with the mapped sediments.

4.2 Hydrology

Ground water seepages were encountered in EP-1, EP-3, EP-4, and EP-7 and ranged in depth from 4 feet to below 7 feet. The seepages were generally minor in nature except for EP-4 where the seepage ranged from minor to slightly moderate. The seepages represented a perched ground water condition where rain water infiltrates the upper soils and is slowed or trapped by the relatively impermeable till soil. Some of the seepages may also represent wet zones within the till where granular sediments were encountered such as in EP-7. Seepages may also be encountered in uncontrolled fill. It should be noted that fluctuations in the level of the ground water may occur due to the time of the year and variations in rainfall.

III. DESIGN RECOMMENDATIONS

7.0 INTRODUCTION

Our explorations and site reconnaissance indicate that, from a geotechnical standpoint, the parcel is suitable for the proposed development, provided that the recommendations outlined herein are properly followed. Our exploration pits encountered suitable foundation bearing strata (granular recessional outwash or dense lodgement till) at relatively shallow depths and conventional foundation construction techniques may be used. Foundation subgrades should extend below the organic topsoil and fill horizon. Loose, granular sand may be recompacted for foundation support as discussed herein. Some overexcavation may be necessary in the footing areas in order to remove soft, fine-grained or organic soils and expose the underlying firm, natural sediment.

8.0 SITE PREPARATION

Site preparation of areas to be developed should include removal of the existing sheds and barn and their foundations. Any buried utilities, which are not apart of future plans, should also be removed, as well as all trees, brush, debris, and any other deleterious material. Additionally, the organic topsoil should be removed and the remaining roots grubbed. Areas of loose, natural, granular soils should be recompacted to 95 percent of ASTM:D 1557 with a backhoe-mounted vibratory plate or a walk-behind vibratory roller and as subsequently recommended for structural fill placement.

8.2 Site Disturbance

The on-site soils contain a high percentage of fine-grained material, which makes them moisture-sensitive and subject to disturbance when wet. The contractor must use care during site preparation and excavation operations so that the underlying soils are not softened, particularly during wet weather conditions. If disturbance occurs, the softened soils should be removed and the area brought to grade with structural fill.

9.0 STRUCTURAL FILL

Structural fill will be necessary to backfill utility trenches and may be necessary to establish desired lot and roadway grades. All references to structural fill in this report refer to subgrade preparation, fill type, placement, and compaction of materials as discussed in this section.

9.1 Fill Placement

After stripping has been performed to the satisfaction of the geotechnical engineer/engineering geologist, the upper 12 inches of exposed ground should be recompacted to at least 90 percent of the modified Proctor maximum density, using American Society for Testing and Materials (ASTM) test designation D 1557 as the standard. If the subgrade contains too much moisture, adequate recompaction may be difficult or impossible to obtain and should probably not be attempted. In lieu of recompaction, the area to receive fill should be blanketed with washed rock or quarry spalls to act as a capillary break between the new fill and the wet subgrade.

After compaction of the exposed ground is tested and approved, or a free-draining rock course is laid, structural fill may be placed to attain desired grades. Structural fill is defined as non-organic soil, acceptable to the geotechnical engineer, placed in maximum 8 to 12 inch loose lifts (depending on the size and type of compaction equipment) with each lift being compacted to at least 95 percent of the modified Proctor maximum density, using ASTM:D 1557 as the standard.

The contractor should note that any proposed fill soils must be evaluated by AESI prior to their use in fills. This would require that we have a sample of the material 48 hours in advance to perform a Proctor test and determine its field compaction standard. Soils in which the amount of fine-grained material (smaller than U.S. number 200 sieve) is greater than approximately 5 percent (measured on the minus U.S. number 4 sieve size) should be considered moisture-sensitive. Use of moisture-sensitive soils in structural fills should be limited to favorable dry weather and dry subgrade conditions. The on-site soils generally contained significant amounts of silt and are considered moisture-sensitive. At the time of our exploration (July, 1998), the majority of the non-organic on-site soils were judged to be near their optimum moisture and suitable for use as structural fill. If fill is placed during wet weather or if proper compaction cannot be obtained, a select material consisting of a clean, free-draining gravel and/or sand should be used. Free-draining fill consists of non-organic soil with the amount of fine-grained material limited to 5 percent by weight when measured on the minus U.S. number 4 sieve fraction.

9.3 Construction Monitoring

A representative from our firm should inspect the stripped fill/topsoil subgrade and perform a representative number of in-place density tests on the fill material as it is placed. In this way, the adequacy of the earthwork may be evaluated as filling progresses and any problem areas may be corrected at that time. We are available to aid the owner in developing a suitable monitoring and testing program.

10.0 FOUNDATIONS

Conventional footings may be used for building support when founded on recompacted, natural sand (95 percent of ASTM:D 1557) or medium dense to dense lodgement till. As explained earlier, loose sands should be recompacted with vibrator plate attached to a backhoe or with a walk-behind vibratory roller. We recommend that an allowable bearing pressure of 2,000 pounds per square foot (psf) be utilized for design purposes, including both dead and live loads. An increase of one third may be used for short term wind or seismic loading. Perimeter footings should be buried at least 18 inches into the surrounding soil for frost protection. All footings must penetrate to the prescribed bearing stratum and no footing should be founded on loose, organic, or existing fill soils. All footings should have a minimum width of 14 inches for one-story structures and 16 inches for two-story structures.

It should be noted that the area bounded by lines extending downward at 1H:1V (Horizontal:Vertical) from any footing must not intersect another footing or intersect a filled area that has not been compacted to at least 95 percent of ASTM:D 1557

Anticipated settlement of footings founded on medium dense sand or approved structural fill should be on the order of 1 inch. However, disturbed soil not removed from footing excavations prior to footing placement could result in increased settlements. All footing areas should be inspected by AESI prior to placing concrete, to verify that the design bearing capacity of the soils has been attained and that construction conforms with the recommendations contained in this report. Such inspections may be required by the City of Arlington. Perimeter footing drains should be provided under section 13.0 Drainage Considerations.

11.0 LATERAL WALL PRESSURES

There is the possibility that some of the houses will use partial daylight basements. We do not anticipate that any basement walls would exceed 8 feet in height. All backfill behind a basement wall or around foundation units should be placed as per our recommendations for structural fill and as described in this section of the report.

Horizontally backfilled walls that are free to yield laterally at least 0.1 percent of their height may be designed using an equivalent fluid equal to 35 pounds per cubic foot (pcf). Fully restrained, horizontally backfilled rigid walls that cannot yield should be designed for an equivalent fluid of 55 pcf. If parking areas are adjacent to walls, a surcharge equivalent to 2 feet of soil should be added to the wall height in determining lateral design forces.

The lateral pressures presented above are based on the conditions of a uniform horizontal backfill consisting of on-site sand and gravel compacted to 90 percent of ASTM:D 1557. A higher degree of compaction is not recommended, as this will increase the pressure acting on the wall. Surcharges from adjacent footings, heavy construction equipment, or sloping ground must be added to the above values. Footing drains should be provided for all retaining walls as discussed under the section on Drainage Considerations.

It is imperative that proper drainage be provided so that hydrostatic pressures do not develop against the wall. This would involve installation of a minimum 1 foot wide blanket drain for the full wall height using imported, washed gravel against the walls.

11.1 Passive Resistance and Friction Factors

Retaining wall footings/keyways cast directly against undisturbed, dense soils in a trench may be designed for passive resistance against lateral translation using an equivalent fluid equal to

250 pounds per cubic foot. The passive equivalent fluid pressure diagram begins at the top of the footing; however, total lateral resistance should be summed only over the depth of the actual key (truncated triangular diagram). The passive resistance value includes a factor of safety equal to 3 in order to reduce the amount of movement necessary to generate passive resistance.

The friction coefficient for footings cast directly on undisturbed, dense soils may be taken as 0.35. This is an ultimate value and does not include a safety factor. Since it will be difficult to excavate these soils without disturbance, the soil under the footings must be recompacted to 95 percent of the above mentioned-standard for this value to apply.

12.0 FLOOR SUPPORT

Slab-on-grade floors may be used over structural fill or medium dense natural ground. A capillary break layer consisting of 4 inches of washed pea gravel and a polyethylene plastic vapor barrier should be used under floors likely to receive an impermeable floor finish or where passage of water vapor through the floor is undesirable. Based on American Concrete Institute recommendations, we suggest placing a two to three inch layer of clean sand over the vapor barrier to protect the vapor barrier and to allow some moisture loss through the bottom of the slab to aid in the finishing and curing process.

13.0 DRAINAGE CONSIDERATIONS

Traffic across the on-site soils when they are damp or wet will result in disturbance of the otherwise firm stratum. Therefore, during site work and construction, the contractor should provide surface drainage and subgrade protection as necessary.

All perimeter footing walls and any retaining walls should be provided with a drain at the footing elevation. Drains should consist of rigid, perforated, PVC pipe surrounded by washed pea gravel. The level of the perforations in the pipe should be set approximately 2 inches below the bottom of the footing and the drains should be constructed with sufficient gradient to allow gravity discharge away from the buildings. The perforations should be located on the lower portion of the drain pipe. Roof and surface runoff should not discharge into the footing drain system but should be handled by a separate, rigid tightline drain. Collected water should be discharged into the site storm drain system. Exterior grades adjacent to walls should be sloped downward away from the structure to achieve positive surface drainage. Ground surfaces should be sloped away from the homes.

14.0 EROSION CONSIDERATIONS

The on-site recessional soils are characterized as having a high potential for erosion. To mitigate potential erosion and off-site sediment transport the following recommendations should be followed.

1) Clearing beyond the areas to be developed should be avoided. Disturbed areas should be re-vegetated as soon as possible.

2) Temporary silt fences should be provided along the lower margins of graded areas.

3) Temporary stockpiles of soil should be protected from rain and erosion by covering with plastic sheeting, compacting and sealing the surface, or placing silt fences around the base.

4) Rock check dams and sediment traps should be used in drainage swales/ditches.

15.0 PROJECT DESIGN AND CONSTRUCTION MONITORING

We recommend that AESI perform a geotechnical review of the plans prior to final design completion. In this way, our recommendations may be properly interpreted and implemented in the design.

We are also available to provide geotechnical engineering and monitoring services during construction. The integrity of the earthwork and foundations depends on proper site preparation and construction procedures. In addition, engineering decisions may have to be made in the field in the event that variations in subsurface conditions become apparent.

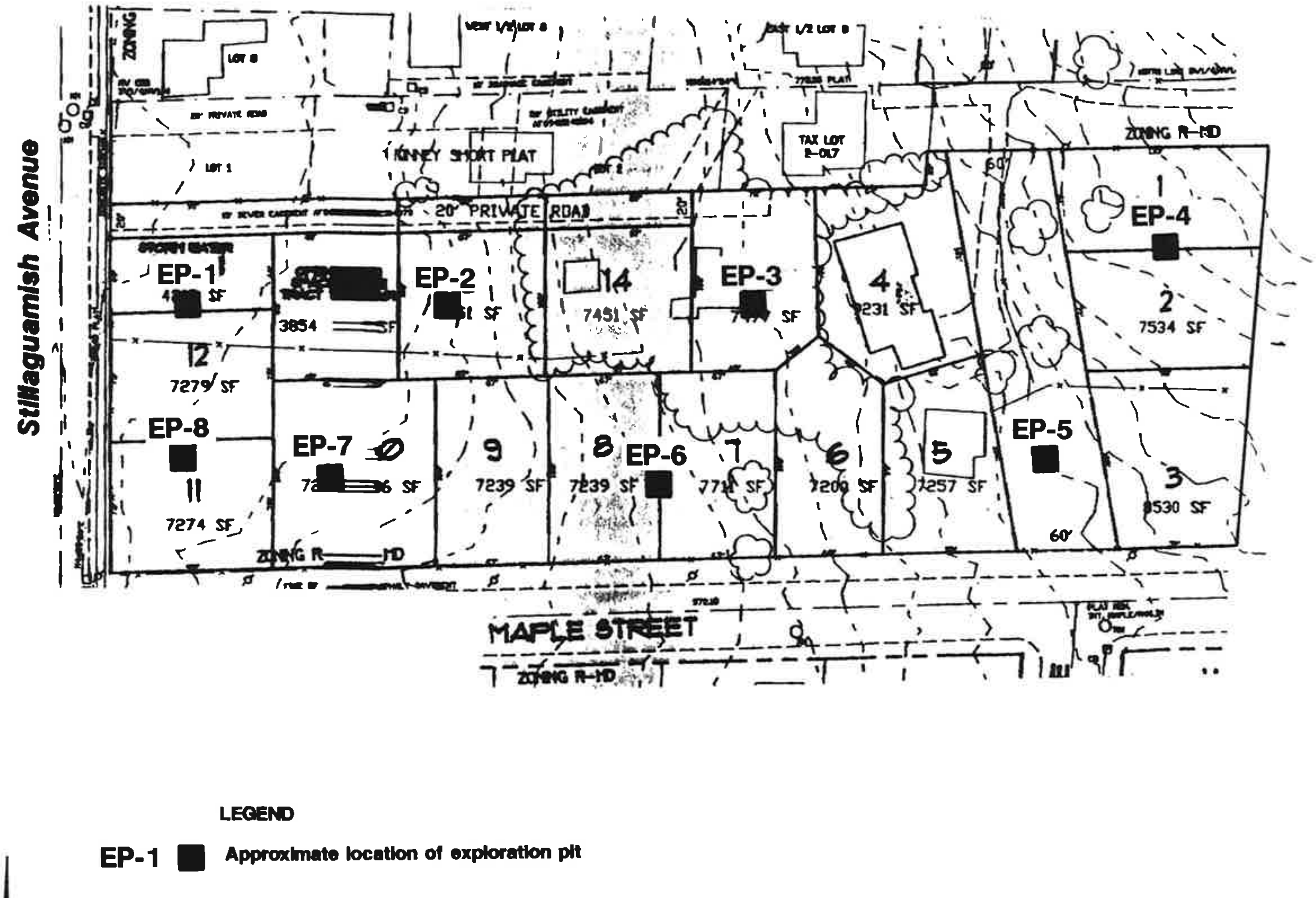
We have enjoyed working with you on this study and are confident that these recommendations will aid in the successful completion of your project. If you should have any questions, or require further assistance, please do not hesitate to call.

Sincerely,
ASSOCIATED EARTH SCIENCES, INC.
Kirkland, Washington

Scott R. Hannah
Senior Staff Geologist

Bruce L. Blyton, P.E.
Associate Engineer

SRH/lc - KE98280G1 -7/1/98 lc – W97



REFERENCE: BASE MAP PROVIDED BY CLIENT.

ASSOCIATED EARTH SCIENCES, INC

SITE AND EXPLORATION PLAN

KENT RIDGE
ARLINGTON, WASHINGTON

KE98280G	7/98	FIGURE 1

EXPLORATION PIT LOG

Number EP-1

Medium dense, moist, gray, gravelly, fine to coarse SAND. (Fill)

Medium stiff, moist, black, organic SILT. (Recessional Outwash)

Medium stiff, moist, tan, sandy SILT with pockets of silty, fine sand; upper 1' weathered light brown. (Recessional Outwash)

Dense, wet to saturated with depth, gray, clayey, silty, gravelly, fine to coarse SAND. (Lodgement Till)

BOH @ 9'
Note: Minor seepage below 7'; no caving.

Number EP-2

Topsoil.

Loose to medium dense, moist, light brown, silty, fine to medium SAND with some gravel. (Recessional Outwash)

Dense, moist to wet, gray, gravelly, silty, fine to coarse SAND with occasional boulders. (Lodgement Till)

BOH @ 7-1/2'
Note: No seepage; no caving.

Reviewed By SRH

Associated Earth Sciences, Inc.
911 Fifth Avenue, Suite 100
Kirkland, Washington 98033
Phone: 425-827-7701
Fax: 425-827-5424

Kent Ridge
Arlington, Washington
Project No. KE98280G
July 1998

EXPLORATION PIT LOG

Number EP-3

Loose, moist, brown, silty, fine to coarse SAND with occasional gravel and wood. (Fill)

Soft to medium stiff, wet, brown, sandy SILT with occasional organics. (Recessional Outwash)

Dense, moist, tan, gravelly, silty, fine to coarse SAND with tiny voids. (Weathered Lodgement Till)

Dense, moist to wet, gray, gravelly, silty, fine to coarse SAND. (Lodgement Till)

BOH @ 7-1/2'
Note: Minor seepage below 4'; no caving.

Number EP-4

Topsoil.

Loose to medium dense, moist to saturated with depth, light brown, silty, fine SAND grading into, gray, gravelly, fine to coarse SAND with depth. (Recessional Outwash)

Dense, moist, gray, gravelly, silty, fine to coarse SAND. (Lodgement Till)

BOH @ 8'
Note: Minor to slightly moderate seepage at 4-1/2'; no caving.

Reviewed By SRH

Associated Earth Sciences, Inc.
911 Fifth Avenue, Suite 100
Kirkland, Washington 98033
Phone: 425-827-7701
Fax: 425-827-5424

Kent Ridge
Arlington, Washington
Project No. KE98280G
July 1998

EXPLORATION PIT LOG

Number EP-5

Depth (ft)	Description
0	Topsoil.
	Loose, moist, brown, silty, fine to medium SAND with some gravel and occasional boulders.. (Recessional Outwash)
5	Very dense, moist, gray, gravelly, fine to coarse SAND; large boulder at 3' depth in west end of pit. (Lodgement Till)
	BOH @ 6' Note: No seepage; no caving.
10	
15	

Number EP-6

Depth (ft)	Description
0	Topsoil.
	Loose, moist, light brown, silty, fine to medium SAND with occasional charcoal. (Recessional Outwash)
5	Very dense, moist, gray, silty, gravelly, fine to coarse SAND. (Lodgement Till)
	BOH @ 7-1/2' Note: No seepage; no caving.
10	
15	

Reviewed By SRH

Associated Earth Sciences, Inc.
911 Fifth Avenue, Suite 100
Kirkland, Washington 98033
Phone: 425-827-7701
Fax: 425-827-5424

Kent Ridge
Arlington, Washington
Project No. KE98280G
July 1998

EXPLORATION PIT LOG

Number EP-7

Depth (ft)	Description
0	Loose, moist, gray, fine to medium SAND with occasional gravel. (Fill)
	Topsoil.
	Loose, moist, brown, silty, fine SAND with occasional gravel. (Recessional Outwash)
5	Dense, moist, gray, gravelly, silty, fine to coarse SAND; pocket of sand and gravel at 5'. (Lodgement Till)
	BOH @ 7-1/2' Note: Minor seepage 5' to 6-1/2' in gravel; no caving.
10	
15	

Number EP-8

Depth (ft)	Description
0	Topsoil.
	Loose, moist, brown, silty, fine to medium SAND with 1' and 2' diameter boulders. (Recessional Outwash)
5	Dense, moist, gray, gravelly, silty, fine to coarse SAND. (Lodgement Till)
	BOH @ 7' Note: No seepage; no caving.
10	
15	

Subsurface conditions depicted represent our observation at the time and location of this exploratory hole, modified by geologic interpretation, engineering analysis, and judgment. They are not necessarily representative of other times and locations. We will not accept responsibility for the use or interpretation by others of information presented on this log.

Reviewed By SRH

Associated Earth Sciences, Inc.
911 Fifth Avenue, Suite 100
Kirkland, Washington 98033
Phone: 425-827-7701
Fax: 425-827-5424

Kent Ridge
Arlington, Washington
Project No. KE98280G
July 1998