Geotechnical Engineering Services Report

Holmes Point Drive Storm Drain Replacement
Kirkland, Washington

for
KPFF Consulting Engineers

May 26, 2016

GeoEngineers
Earth Science + Technology

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File No. 0231-089-00

May 26, 2016

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Table of Contents

INTRODUCTION **1**

PROJECT UNDERSTANDING **1**

SCOPE OF SERVICES **1**

SITE CONDITIONS **2**

Geology Review 2
Surface Conditions 3
Subsurface Explorations 3
Subsurface Conditions 4
- Soil Conditions 4
- Groundwater 4

CONCLUSIONS AND RECOMMENDATIONS **4**

General 4
Site Preparation and Earthwork 4
- General 4
- Clearing and Grubbing 5
- Temporary Cut Slopes 5
- Permanent Cut and Fill Slopes 5
- Wet-Weather Considerations 6

Structural Fill 6
- Select Granular Fill 7
- Pipe Bedding Material 7
- Trench Backfill 7
- Use of On-site Soils 7
- Fill Placement and Compaction 7
- Pipe Bedding 8

Pavement Considerations 8
- Subgrade Preparation 8
- Pavement Section Considerations 8

Site Drainage Considerations 9
Slope Stability Considerations 9

LIMITATIONS **9**

LIST OF FIGURES

Figure 1. Vicinity Map
Figure 2. Site Plan

APPENDICES

Appendix A. Field Exploration and Laboratory Testing
- Figure A-1 – Key to Exploration Logs
- Figures A-2 through A-4 – Log of Borings
- Figures A-5 through A-7 – Sieve Analysis Results

Appendix B. Report Limitations and Guidelines for Use

INTRODUCTION

This report summarizes the results of our geotechnical engineering services in support of the Holmes Point Drive Storm Drain Replacement project in Kirkland, Washington. Our services have been provided in accordance with our signed agreement with KPFF Consulting Engineers (KPFF) dated January 19, 2016. The site is located approximately as shown on the Vicinity Map, Figure 1. The existing site layout is shown on the Site Plan, Figure 2. We previously provided a draft report for review on March 16, 2016. This final report incorporates review comments.

PROJECT UNDERSTANDING

Our project understanding is based on conversations with the City of Kirkland and KPFF during project meetings, our experience with similar drainage and seepage projects, and information provided. The project consists of replacing an existing buried storm sewer pipe, and collecting and re-routing surface drainage along Holmes Point Drive. The new stormwater conveyance will connect to an existing outfall to Lake Washington. The project may also incorporate providing a connection stub out for a future development within the NE 118th Street right-of-way (ROW).

We understand that the new conveyance would generally be located within 10 feet of existing site grades. We also understand that City of Kirkland and local residents have observed areas of seepage that combine with surface runoff to accumulate along the east side of the roadway adjacent to the existing slope. For the purposes of discussion in this report, the seepage has been separated into three distinct areas (north, central and south). At times, the water crosses the roadway, and City of Kirkland would like this project to address potential remedies to prevent water from affecting the roadway.

SCOPE OF SERVICES

The purpose of our services is to review available information and evaluate subsurface soil and groundwater conditions as a basis for developing geotechnical recommendations in support of project design and construction. Specifically, our scope of services for this project includes:

1. Attend up to two meetings with the project team, including an initial site walk and a project design charrette.
2. Review available relevant information including previous geotechnical studies and explorations, geologic and topographic mapping, and available construction documents.
3. Complete a reconnaissance of the existing slope to identify areas of groundwater seepage and check for signs of potential slope instability.
4. Contact the Washington Utilities Coordinating Council “One Call” service to locate utilities in the project area. Develop a field exploration and traffic control plan for approval prior to drilling.
5. Evaluate soil conditions at the site by advancing three hollow-stem auger soil borings to a depth of about 11.5 feet below ground surface (bgs). Soil sampling was performed at 2.5-foot depth intervals using Standard Penetration Testing (SPT) methods, in general accordance with ASTM International (ASTM) D 1586.

6. Perform geotechnical laboratory testing, including grain-size analyses and moisture content determinations on select samples obtained from the borings.
7. Describe surface conditions, including seepage and surface water observations from our reconnaissance, and subsurface soil and groundwater observations in our explorations.
8. Provide recommendations for earthwork and site grading, including temporary slopes and trench excavation. Also provide construction dewatering considerations, recommendations for reuse of on-site materials, pipe bedding and trench backfill materials, and fill placement and compaction criteria.
9. Provide recommendations and considerations for collecting and directing hillside seepage and surface water.
10. Provide layer thickness recommendations for an asphalt concrete pavement design section. If needed, our recommended pavement section can be modified during final design based on specific traffic data provided by City of Kirkland.
11. Provide limited geotechnical consultation during final design. We anticipate that final design consultation could include reviewing plans and specifications, attending project meetings and providing miscellaneous geotechnical consultations. We will provide this element of service upon request.

SITE CONDITIONS

Geology Review

Holmes Point Drive is located above the northeast shore of Lake Washington on the slope between the upland till cap and the lake. Geologic maps of the area (Minard, 1983) indicate the roadway was likely constructed in several geologic units, transitioning from advance outwash in the higher elevations, to transitional deposits in much of the roadway grade, and to recessional outwash below the road. Groundwater seeps are common in the glacial deposits and transitional layers as groundwater tends to infiltrate down and through the more permeable sand layers and becomes perched on the silt layers.

Advance outwash is mapped in the upper slope areas, underlying the upland till cap, and typically consists of sand with limited silt content and some gravel. The advance outwash was deposited during glacial advance and is, therefore, typically dense to very dense.

Transitional deposits are mapped beneath the advance outwash. These deposits are both glacial and non-glacial and consist mostly of laminated clay and silty clay in the lower part, grading up into silt to very fine-grained massive sand in the upper part. Transitional deposits are often unstable in steep slopes (when inclined greater than about 1½H:1V (horizontal to vertical), particularly where seepage flows in the cleaner sand layers and emerges on the slope face.

Recessional outwash is mapped in portions of the lower slope, consisting mostly of stratified sand, gravel, and cobbles deposited during glacial retreat.

Subsurface soils encountered in our borings are consistent with the mapped geology. We interpret the soils encountered in the borings to likely consist of transitional deposits and recessional outwash. Surficial fill is also present at the site associated with previous roadway construction. Detailed descriptions of the soil conditions encountered in our borings are described in the following section “Soil Conditions.”

Based on review of City of Kirkland environmentally sensitive areas maps, portions of the project are within a mapped landslide hazard area.

Surface Conditions

The project site is located in northwestern Kirkland, near the shoreline of Lake Washington. Overall site topography slopes downward from east to west, grading toward Lake Washington. The road grade typically rises relatively gently from north to south.

The roadway is surfaced with asphalt concrete pavement. The northbound (upslope) shoulder is also paved with asphalt concrete where present. The southbound (downslope) shoulder is typically surfaced with crushed rock and bark. Vegetation along the alignment typically consists of trees and landscaped plants and bushes along the roadway.

During a site visit on January 28, 2016 we observed two areas where water was seeping from the slope on the east side of Holmes Point Drive NE. One seep (central seep) was located near the mailbox of 11733 Holmes Point Drive NE. An estimated 2 to 3 gallons per minute (gpm) was observed flowing through some quarry spall fill behind the ivy, continuing down the edge of the asphalt and beyond the mailbox of 11804 as shown in the photograph to the right.

Looking North from Central Seep

The other seep (north seep) was located near 11818 Holmes Point Drive NE. Seepage in this area had saturated the yard area above the roadway, and was collecting along the shoulder near the fire hydrant. These approximate seep locations are also shown on Figure 2. We understand a south seep has also been reported by local residents but was not observed during our reconnaissance.

Looking North from North Seep

We did not observe ground cracking, scarps, pistol-butted trees, hummocky terrain, significant areas of exposed soil, or other signs of slope instability during our reconnaissance.

Subsurface Explorations

We explored subsurface conditions at the site on February 26, 2016 by drilling three borings (GEI-1 through GEI-3) near the proposed replacement pipe alignment. The approximate locations of the explorations are shown on Figure 2. A brief description of the subsurface conditions encountered in the explorations is

provided in the following paragraphs. More detailed descriptions of our field exploration program and laboratory test results are presented in Appendix A. Summary logs of the borings are presented in Appendix A.

Subsurface Conditions

Soil Conditions

All three explorations within the subject alignment were advanced in the center of the northbound lane of Holmes Point Drive NE. The thickness of the asphalt cores ranged from 4.5 to 6 inches. The asphalt section consisted of an original asphalt layer that ranged from 2.5 to 3 inches thick and an asphalt overlay that ranged from 2 to 3 inches thick. Approximately 1 foot of crushed surfacing base course was encountered below the asphalt in each boring.

Below the asphalt and base course, we encountered about 3 feet of medium dense sand, sand with silt and silty sand that we interpret to be fill, which may also include reworked native soil. Below the fill, we observed dense to very dense sand with silt and silty sand deposits, which we interpret to be transitional deposits. All of the explorations were terminated within very dense native glacially consolidated soils.

Groundwater

We did not observe groundwater in our explorations, however, we anticipate areas of perched water could be encountered during excavation activities for the pipe replacement, and is likely to be encountered in excavations for the drainage system to collect seepage, if such excavations are necessary. Perched groundwater is common in interlayered glacial deposits where relatively permeable soil is underlain by less permeable soil. We expect the depth to groundwater will vary seasonally and with precipitation. Groundwater elevations are typically higher during the wetter winter and spring months and lower during the summer and fall.

CONCLUSIONS AND RECOMMENDATIONS

General

In our opinion, the proposed storm drain replacement project is geotechnically feasible provided that the considerations and recommendations presented in this report are incorporated into design and construction. The following sections provide detailed conclusions and recommendations to support design and construction of this project.

Site Preparation and Earthwork

General

Excavations on the order of 5 to 10 feet deep may be required to install the replacement pipe. Excavations may also be required to collect and direct surface water and seepage. Static groundwater was not observed in our explorations. However, we anticipate that perched groundwater could be encountered within the excavation limits and should be expected during excavation activities.

Materials encountered in our explorations generally consist of medium dense fill and dense to very dense glacially consolidated soils. We anticipate that earthwork can be accomplished with conventional

excavation equipment. However, occasional cobbles were also encountered and boulders can sometimes be present in glacial deposits. The contractor should be prepared to deal with these conditions.

Clearing and Grubbing

In previously undeveloped areas, we anticipate clearing of vegetation and stripping on the order of 6 inches will be required to remove near-surface and organic-rich soil. Greater stripping depths may be required to remove localized zones of loose or organic-rich soil. In addition, the primary root systems of shrubs should be completely removed. Stripped material should be transported off site.

Temporary Cut Slopes

Excavations deeper than 4 feet should be shored or laid back at a stable slope if workers are required to enter. Shoring and temporary slope inclinations must conform to the provisions of Title 296 Washington Administrative Code (WAC), Part N, "Excavation, Trenching and Shoring." Regardless of the soil type encountered in the excavation, shoring, trench boxes or sloped sidewalls will be required under Washington Industrial Safety and Health Act (WISHA). The contract documents should specify that the contractor is responsible for selecting excavation and dewatering methods, monitoring the excavations for safety and providing shoring, as required, to protect personnel and structures.

In general, temporary cut slopes should be inclined no steeper than about 1-1/2H to 1V (horizontal to vertical) in the fill soils observed up to about 4 feet bgs. For cuts in dense to very dense glacially consolidated soil (below about 4 feet bgs), a temporary cut slope of 1H to 1V may be feasible. This guideline assumes that all surface loads are kept at a minimum distance of at least one-half the depth of the cut away from the top of the slope and that seepage is not present on the slope face. Flatter cut slopes will be necessary where seepage occurs or if surcharge loads are anticipated. Temporary covering with heavy plastic sheeting should be used to protect these slopes during periods of wet weather.

Based on our explorations, we do not expect groundwater to be a major factor during shallow excavations. However, some perched groundwater could be present depending on the time of year of construction. Based on our interpretation of the soil conditions and our experience, the interface between the fill material and the native soils and contacts between sand and silt materials are likely locations for accumulation of perched groundwater. Groundwater handling needs are typically lower during the late summer and early fall months. We anticipate that shallow perched groundwater can typically be handled adequately with sumps, pumps, and/or gravel-lined diversion ditches, as necessary. The excavation for the sump and the drainage trenches should be backfilled with clean gravel or crushed rock to reduce the amount of sediment in the water pumped from the sump (i.e., to serve as a filter). Ultimately, we recommend that the contractor performing the work be made responsible for controlling and collecting groundwater encountered.

Permanent Cut and Fill Slopes

Where permanent slopes are necessary we recommend they be constructed at a maximum inclination of 2H to 1V. Where 2H to 1V permanent slopes are not feasible, protective facings and/or retaining structures should be designed.

To achieve uniform compaction, we recommend that fill slopes be overbuilt slightly and subsequently cut back to expose well-compacted fill. Fill placement on slopes steeper than 5H to 1V should be benched into

the slope face. The configuration of benches depends on the equipment being used. Bench excavations should be level and extend into the slope face.

Exposed areas should be re-vegetated as soon as practical to reduce the surface erosion and sloughing. Temporary protection should be used until permanent protection is established.

Wet-Weather Considerations

Disturbance of near-surface soils should be expected if earthwork is completed during periods of wet weather. During dry weather, the soils will: 1) be less susceptible to disturbance, 2) provide better support for construction equipment and 3) be more likely to meet the required compaction criteria.

The wet weather season in western Washington generally begins in October and continues through May; however, periods of wet weather may occur during any month of the year. For earthwork activities during wet weather, we recommend that the following steps be taken.

- The ground surface in and around the work area should be sloped so that surface water is directed away from the work area. The ground surface should be graded so that areas of ponded water do not develop. The contractor should take measures to prevent surface water from collecting in excavations and trenches. Measures should be implemented to remove surface water from the work area.
- Earthwork activities should not take place during periods of moderate to heavy precipitation.
- Slopes with exposed soils should be covered with plastic sheeting.
- The contractor should take necessary measures to prevent on-site soils and imported soils to be used as fill from becoming wet or unstable. These measures may include the use of plastic sheeting and grading stockpiles to drain surface runoff. The site soils should not be left uncompacted and exposed to moisture. Sealing the surficial soils by rolling with a smooth-drum roller prior to periods of precipitation will help reduce the extent that these soils become wet or unstable.
- The contractor should cover all soil stockpiles that will be used as structural fill with plastic sheeting.
- Construction traffic should be restricted to specific areas of the site, preferably areas that are surfaced with existing asphalt or working pad materials not susceptible to wet weather disturbance.
- Construction activities should be scheduled so that the length of time that soils are left exposed to moisture is reduced to the extent practicable.

Structural Fill

Material used for structural fill should be free of debris, organic contaminants and rock fragments larger than 3 inches. We recommend that structural fill material consist of material similar to “Select Borrow” or “Gravel Borrow” as described in Section 9-03.14 of the Washington State Department of Transportation (WSDOT) Standard Specifications.

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 increases, soil becomes increasingly sensitive to small changes in moisture content. We recommend that crushed rock or select granular fill, as described below, be used for structural fill during the rainy season. If prolonged dry weather prevails during the earthwork phase of construction, materials with a somewhat higher fines content may be acceptable.

Select Granular Fill

Select granular fill should consist of well-graded sand and gravel or crushed rock with a maximum particle size of 3 inches and less than 5 percent fines by weight based on the minus 3/4-inch fraction. Organic matter, debris or other deleterious material should not be present. In our opinion, material with gradation characteristics similar to WSDOT Specification 9-03.9 (Aggregates for Ballast and Crushed Surfacing), or 9-03.14 (Borrow) is suitable for use as select granular fill, provided that the fines content is less than 5 percent (based on the minus 3/4-inch fraction) and the maximum particle size is 3 inches.

Pipe Bedding Material

Trench backfill for the bedding and pipe zone should consist of well-graded granular material similar to "gravel backfill for pipe zone bedding" described in Section 9-03.12(3) of the WSDOT Standard Specifications. The material must be free of roots, debris, organic matter and other deleterious material.

Trench Backfill

Trench backfill must be free of debris, organic material and rock fragments larger than 3 inches. We recommend that trench backfill material consist of material similar to "Select Borrow" or "Gravel Borrow" as described in Section 9-03.14 of the WSDOT Standard Specifications.

Use of On-site Soils

Existing fill soils and native soil at the site may be considered for use as structural fill and trench backfill provided that the material can be adequately moisture conditioned and placed and compacted as recommended, and does not contain organic or other deleterious material.

Based on the results of our laboratory testing, the moisture content of the existing fill and native soils is near the optimum required for compaction. However, based on our experience with soils similar to those found on this site, the silty sand and sand with silt materials are moisture sensitive and may be difficult to properly compact when wet. If earthwork occurs during a typical wet season, or if the soils are persistently wet and cannot be dried back due to prevailing wet weather conditions, we recommend the use of imported structural fill or select granular fill, as described above.

Fill Placement and Compaction

Structural fill should be mechanically compacted to a firm, non-yielding condition. Structural fill should be placed in loose lifts not exceeding 12 inches in thickness. The actual thickness will be dependent on the structural fill material used and the type and size of compaction equipment. Each lift should be conditioned to the proper moisture content and compacted to the specified density before placing subsequent lifts. Structural fill should be compacted to the following criteria:

1. Structural fill in new pavement and hardscape areas, including utility trench backfill, should be compacted to at least 95 percent of the maximum dry density (MDD) determined in general accordance with ASTM D 1557. Fill placed below 2 feet of final subgrade should be compacted to at least 90 percent of the MDD.
2. Structural fill placed as crushed surfacing base course below pavements should be compacted to 95 percent of the MDD estimated in general accordance with ASTM D 1557.

3. Non-structural fill, placed outside the roadway in level areas, should be compacted to at least 85 percent of the MDD estimated in general accordance with ASTM D 1557. In areas intended for future development or in permanent slope areas, a higher degree of compaction of 95 percent should be accomplished to reduce the risk of future settlement or slope instability.

Pipe Bedding

Utility pipes should be supported on bedding material that meets the pipe manufacturer specifications and the requirements of the City of Kirkland. Placement of bedding material is particularly important for gravity sewers where precise grade control may be required. "Gravel Backfill for Pipe Zone Bedding" as specified in the WSDOT Standard Specifications Section 9-03.12(3) should be suitable pipe bedding material.

The initial lift of fill over the pipe should be thick enough to reduce the potential for damage during compaction but generally should not be greater than about 18 inches. In addition, rock fragments greater than about 1 inch in maximum dimension should be excluded from this lift. The remainder of the utility excavations should be backfilled with compacted structural fill as recommended previously.

Pavement Considerations

Subgrade Preparation

Following trench backfill and preparation of pavement subgrade, we recommend that the uniformity of the subgrade be checked by thorough proofrolling with heavily-loaded, rubber-tired construction equipment or by probing. Any soft, loose or otherwise unsuitable zones identified during proofrolling should be recompacted, if possible, or removed and replaced with structural fill. A member of our staff should observe the proofrolling of subgrade areas and the repair of unsuitable zones.

Pavement Section Considerations

We understand City of Kirkland standard paving sections will be utilized in design. We can also provide pavement design sections based on traffic data collected on Holmes Point Drive, if desired. The standard pavement section is shown below.

TABLE 1. TYPICAL CITY OF KIRKLAND ROADWAY SECTIONS

½-inch HMA PG-64-22 Asphalt (inches)	ATB (inches)	CSBC[1] (inches)
2	4	5

Note:

1. Crushed surfacing base course per WSDOT Standard Specification 9-03.9(3).

The above design section should be placed on subgrade compacted to 95 percent of the maximum dry density per ASTM D-1557. Where soft subgrade soils are present, we recommend excavation and replacement with structural fill as previously described in this report. Based on the conditions observed in our explorations, we anticipate that stable pavement subgrade may be achieved by excavating and replacing existing soft zones for a depth of 2 feet or less below the pavement section. Soft or loose zones should be replaced with structural fill as specified in this report. The condition of the subgrade and need for excavation and replacement should be evaluated by the geotechnical engineer following pavement removal. Where loose fill soils are encountered, geotextile fabric can be utilized to provide separation and stabilization. We recommend Mirafi 600X or equivalent for this purpose.

Site Drainage Considerations

We observed two areas where water was seeping from the slope, located near the addresses 11733 and 11818 Holmes Point Drive NE. These seepage areas appear to combine with surface water to cause water accumulation and pooling along the upslope (northbound) shoulder. Because we did not observe groundwater in our explorations, it appears that the accumulated water is not infiltrating directly beneath the roadway, but rather flowing along the shoulder to low points. However, the seepage is softening the subgrade along the edges of the pavement resulting in localized raveling. Based on our observations and experience, we provide the following possible drainage remedies as options for consideration. Other options may also be feasible.

- Installing small stormwater catch basins near the areas of water accumulation, and tying the catch basins into the new stormwater conveyance pipe. Small curbs could be installed in combination with catch basins to reduce the risk of water crossing the roadway if leaves or other debris block the catch basins.
- Installing gravel-filled "drywells" near the areas of water accumulation, to allow for infiltration of accumulated water. In order to avoid introducing water directly beneath the roadway section, we would recommend drywells be at least 4 to 5 feet deep. If used, drywells should be sized appropriately, in accordance with applicable stormwater infiltration regulations. Based on our explorations and sieve analysis results, we anticipate infiltration rates would be low (less than about 0.25 inch/hour), which could result in relatively large drywells. If this alternative is considered, we recommend GeoEngineers be retained to review the proposed configuration, evaluate potential impacts to slope stability, and perform additional infiltration analyses.
- Excavating a larger, more continuous ditch on the northbound shoulder, to collect accumulated water and direct it to existing stormwater catch basins. This would likely require installing small culverts or pipes at uphill driveway crossings, and small retaining walls where excavation is required into adjacent slopes. Alternatively, a subsurface infiltration trench can be considered along the shoulder.

Slope Stability Considerations

Portions of the project alignment are within an area mapped as a landslide hazard area. Provided the recommendations and considerations discussed in this report are followed, it is our opinion that this project will not have an adverse effect on the overall stability of slopes in the area. Specific sections of this report that address measures to protect slope stability include "Temporary Cut Slopes," "Permanent Cut and Fill Slopes," "Wet-Weather Considerations," and "Site Drainage Considerations."

LIMITATIONS

We have prepared this report for the exclusive use of KPFF Consulting Engineers, the City of Kirkland, and their authorized agents, for the Holmes Point Drive Storm Drain Replacement project in Kirkland, Washington.

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

Please refer to Appendix B titled “Report Limitations and Guidelines for Use” for additional information pertaining to use of this report.

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Feet

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. It is unlawful to copy or reproduce all or any part thereof, whether for personal use or resale, without permission.

Data Sources: Open Street Map 2015

Transverse Mercator, Zone 10 N North, North American Datum 1983
North arrow oriented to grid north

Vicinity Map

Holmes Point Dr Storm Drain Replacement
Kirkland, Washington

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Figure 1

Office: Redmond Path: P:\0\0231089\00\GIS\023108900_F1_VicinityMap.mxd Map Revised: 3/2/2016 EL

Legend

- Site Boundary
- Right -of-Way
- GEI-1 Boring by GeoEngineers, 2016

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FEET

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. Vertical Datum: NAVD 88.

Data Source: Google Earth Pro Imagery Dated: 4/19/2015

Site Plan

Holmes Point Storm Drain Replacement
Kirkland, Washington

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Figure 2

Dwg name: C:\Users\cvanslyke\Documents\CAD blocks_CAD standards\GEO\Borders & more\Sample 8.5x11 figure for evaluation.dwg TAB:Model User: cvanslyke Plot time: Dec-18-14 @ 9:47am

APPENDIX A
Subsurface Exploration and Laboratory Testing

APPENDIX A
SUBSURFACE EXPLORATION AND LABORATORY TESTING

Field Exploration

We explored subsurface conditions at the site on February 25, 2016 by drilling three borings near the proposed pipe alignment. Our representative located the explorations in the field by hand-taping and pacing from existing site features. Exploration locations should be considered approximate and are indicated on the Site Plan, Figure 2. A key to the symbols used on the boring logs is included as Figure A-1. The boring logs are included as Figures A-2 through A-4.

The borings were advanced by Geologic Drill Exploration, Inc. of Spokane, Washington, using a trailer-mounted hollow-stem auger drill rig under subcontract to GeoEngineers. The soil borings were advanced to a depths of 11.5 feet below existing site grade. Sample attempts were made at 2.5-foot-depth intervals using a 2 inch-inside-diameter SPT sampler. The sampler was driven into the soil using a 140-pound automatic hammer, free-falling 30 inches. The number of blows required to drive the sampler the last 12 inches, or other indicated distance, is recorded on the boring logs.

Our representative continuously monitored the borings, and maintained a log of the subsurface conditions encountered. The soils encountered were visually classified in general accordance with ASTM International (ASTM) D 2488 and the system described in Figure A-1.

Laboratory Testing

Soil samples obtained from the explorations were transported to our geotechnical laboratory for further evaluation. Representative samples were selected for laboratory testing. Laboratory testing included soil gradation analysis, in general accordance with ASTM 6913. Moisture content and percent fines are shown at the approximate test depth on the boring logs. Full soil gradation plots are shown on the Sieve Analysis Results presented as Figures A-5 through A-7.

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% RETAINED ON NO. 200 SIEVE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS
				SP	POORLY-GRADED SANDS, GRAVELLY SAND
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% PASSING NO. 200 SIEVE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS, ROCK FLOUR, CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS AND SILTS OF MEDIUM TO HIGH PLASTICITY
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: Multiple symbols are used to indicate borderline or dual soil classifications

ADDITIONAL MATERIAL SYMBOLS

SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
	AC	Asphalt Concrete
	CC	Cement Concrete
	CR	Crushed Rock/ Quarry Spalls
	TS	Topsoil/ Forest Duff/Sod

Groundwater Contact

Measured groundwater level in exploration, well, or piezometer

Measured free product in well or piezometer

Graphic Log Contact

Distinct contact between soil strata

Approximate contact between soil strata

Material Description Contact

Contact between geologic units

Contact between soil of the same geologic unit

Sampler Symbol Descriptions

2.4-inch I.D. split barrel

Standard Penetration Test (SPT)

Shelby tube

Piston

Direct-Push

Bulk or grab

Continuous Coring

Blowcount is recorded for driven samplers as the number of blows required to advance sampler 12 inches (or distance noted). See exploration log for hammer weight and drop.

A "P" indicates sampler pushed using the weight of the drill rig.

A "WOH" indicates sampler pushed using the weight of the hammer.

Laboratory / Field Tests

%F	Percent fines
%G	Percent gravel
AL	Atterberg limits
CA	Chemical analysis
CP	Laboratory compaction test
CS	Consolidation test
DS	Direct shear
HA	Hydrometer analysis
MC	Moisture content
MD	Moisture content and dry density
OC	Organic content
PM	Permeability or hydraulic conductivity
PI	Plasticity index
PP	Pocket penetrometer
PPM	Parts per million
SA	Sieve analysis
TX	Triaxial compression
UC	Unconfined compression
VS	Vane shear

Sheen Classification

NS	No Visible Sheen
SS	Slight Sheen
MS	Moderate Sheen
HS	Heavy Sheen
NT	Not Tested

NOTE: The reader must refer to the discussion in the report text and the logs of explorations for a proper understanding of subsurface conditions. Descriptions on the logs apply only at the specific exploration locations and at the time the explorations were made; they are not warranted to be representative of subsurface conditions at other locations or times.

KEY TO EXPLORATION LOGS

GEOENGINEERS

FIGURE A-1

Rev. 02/16

Drilled Start 2/26/2016 End 2/26/2016	Total Depth (ft) 11.5	Logged By ET Checked By MM	Driller Geologic Drill Explorations	Drilling Method Hollow Stem Auger
Surface Elevation (ft) 40 Vertical Datum NAVD88		Hammer Data 140 (lbs) / 30 (in) Drop		Drilling Equipment Trailer-mounted Rig
Easting (X) Northing (Y)		System Datum		Groundwater Date Measured / Depth to Water (ft) / Elevation (ft): Not Observed
Notes:				

Elevation (feet)	Depth (feet)	Interval Recovered (in)	Blows/foot (N_{60})	Collected Sample Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content, %	% Fines	REMARKS
	0						AC	5 inches asphalt concrete pavement (3 inches original, 2 inches overlay)			
							GP-GM	Gray fine to coarse gravel with silt and sand (medium dense, moist) (crushed surfacing base course)			Driller noted approximately 1 foot of sandy gravel below asphalt
							SP	Brown fine to coarse sand with trace silt (medium dense, moist) (fill)			
		13	16	1 SA					8	5	
							SM	Brown silty fine to medium sand with gravel (very dense, moist) (transitional deposits)			
35	5	12	100+	2 SA					5	27	Hard drilling, cobbles encountered at 5 feet
		0	100+					No recovery			Hard drilling
30	10	5	100+	3 SA					6	26	

Note: Please see Figure A-1 for explanation of symbols.

Log of Boring GEI-1

GeoEngineers

Project: Holmes Point Drive Storm Drain Replacement
Project Location: Kirkland, Washington
Project Number: 0231-089-00

Figure A-2
Sheet 1 of 1

Tacoma: Date:3/16/16 Path:P:\0\0231089\GINT\02310890O.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_STANDARD

Drilled Start 2/26/2016 End 2/26/2016	Total Depth (ft) 11.5	Logged By ET Checked By MM	Driller Geologic Drill Explorations	Drilling Method Hollow Stem Auger
Surface Elevation (ft) 50 Vertical Datum NAVD88		Hammer Data 140 (lbs) / 30 (in) Drop		Drilling Equipment Trailer-mounted Rig
Easting (X) Northing (Y)		System Datum		Groundwater: Date Measured / Depth to Water (ft) / Elevation (ft) — Not Observed
Notes:				

Elevation (feet)	Depth (feet)	Interval Recovered (in)	Blows/foot (N_{60})	Collected Sample: Sample Name / Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content, %	% Fines	REMARKS
	0						AC	4.5 inches asphalt concrete pavement (2.5 inches original, 2 inches overlay)			
							GP-GM	Gray fine to coarse gravel with silt and sand (medium dense, moist) (crushed surfacing base course)			Driller noted approximately 1 foot of sandy gravel below asphalt
							SP-SM	Brown fine to coarse sand with silt, gravel and trace organics (medium dense, moist) (fill)			
		9	29	1 SA					5	9	
							SP-SM	Brown fine to coarse sand with silt (dense, moist) (transitional deposits)			
45	5	15	34	2 SA					11	12	
											Hard drilling at 7 feet, cobbles encountered
		9	62	3				Grades to very dense			
40	10	6	100+	4 SA				Grades with gravel	7	9	

Note: Please see Figure A-1 for explanation of symbols.

Log of Boring GEI-2

GeoEngineers

Project: Holmes Point Drive Storm Drain Replacement
Project Location: Kirkland, Washington
Project Number: 0231-089-00

Figure A-3
Sheet 1 of 1

Tacoma: Date:3/16/16 Path:P:\0\0231089\GINT\023108900.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_STANDARD

Drilled Start 2/26/2016	End 2/26/2016	Total Depth (ft) 11.5	Logged By ET / Checked By MM	Driller Geologic Drill Explorations	Drilling Method Hollow Stem Auger
Surface Elevation (ft) 68 / Vertical Datum NAVD88		Hammer Data 140 (lbs) / 30 (in) Drop		Drilling Equipment Trailer-mounted Rig	
Easting (X) / Northing (Y)		System Datum		Groundwater: Date Measured / Depth to Water (ft) / Elevation (ft)	
Notes:				Not Observed	

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot (N_{60})	Collected Sample	Sample Name / Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content, %	% Fines	REMARKS
	0								AC	6 inches asphalt concrete pavement (3 inches original, 3 inches overlay)			
									GP-GM	Gray fine to coarse gravel with silt and sand (medium dense, moist) (crushed surfacing base course)			
									SM	Brown silty fine to coarse sand (medium dense, moist) (fill)			
65			14	15		1 SA					10	31	
									SM	Brown silty fine to coarse sand with gravel (very dense, moist) (transitional deposits)			
	5		8	100+		2 SA					5	16	Hard drilling from 5 to 10 feet Driller noted cobbles at 6 feet
60			0	80+						No recovery			
	10		12	79		3 SA				Brown silty fine to medium sand with gravel (very dense, moist)	9	28	

Note: Please see Figure A-1 for explanation of symbols.

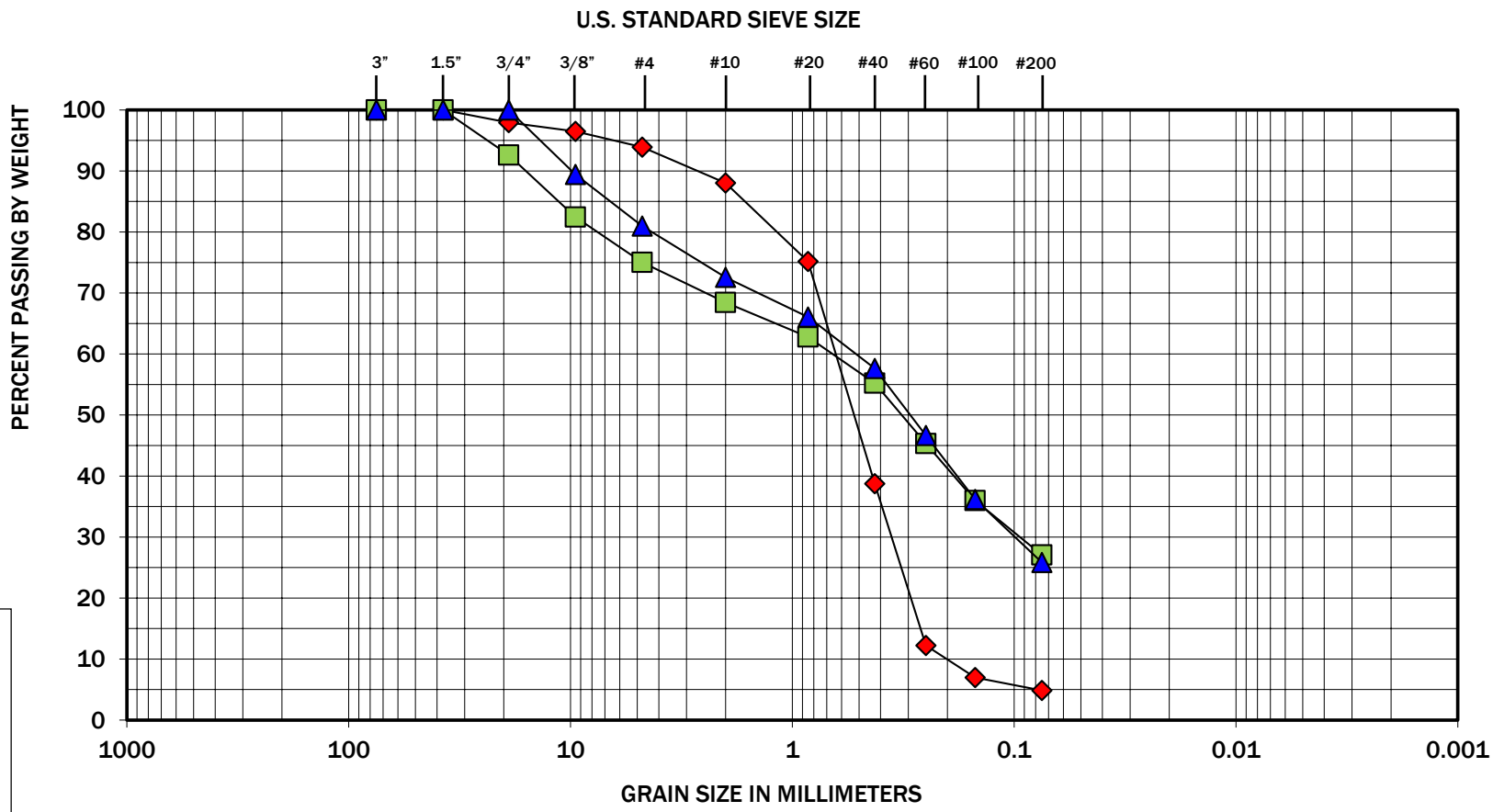
Log of Boring GEI-3

GeoEngineers

Project: Holmes Point Drive Storm Drain Replacement
Project Location: Kirkland, Washington
Project Number: 0231-089-00

Figure A-4
Sheet 1 of 1

Tacoma: Date:3/16/16 Path:P:\0\0231089\GINT\02310890O.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_STANDARD



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Symbol	Boring Number	Depth (feet)	Moisture (%)	Soil Description
◆	GEI-1	2.5	7.9	Poorly graded sand (SP)
■	GEI-1	5	5.2	Silty sand with gravel (SM)
▲	GEI-1	10	6.2	Silty sand with gravel (SM)

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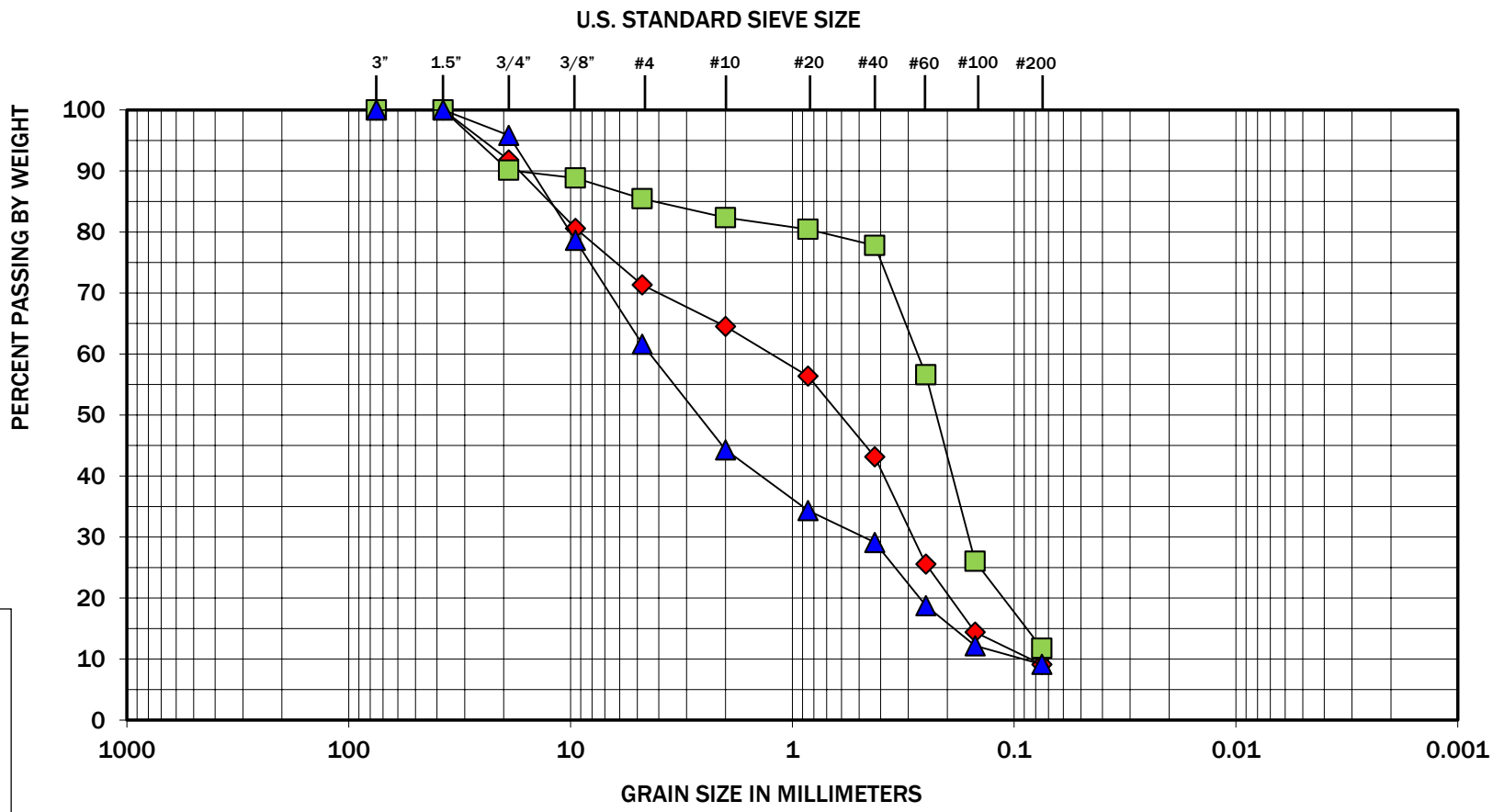
The grain size analysis results were obtained in general accordance with ASTM D 6913.

GEOENGINEERS

Figure A-5

Holmes Point Drive Storm Drain Replacement
Kirkland, Washington

Sieve Analysis Results



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Symbol	Boring Number	Depth (feet)	Moisture (%)	Soil Description
◆	GEI-2	2.5	5.0	Poorly graded sand with silt and gravel (SP-SM)
■	GEI-2	5	11.2	Poorly graded sand with silt (SP-SM)
▲	GEI-2	10	6.5	Poorly graded sand with silt and gravel (SP-SM)

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The grain size analysis results were obtained in general accordance with ASTM D 6913.

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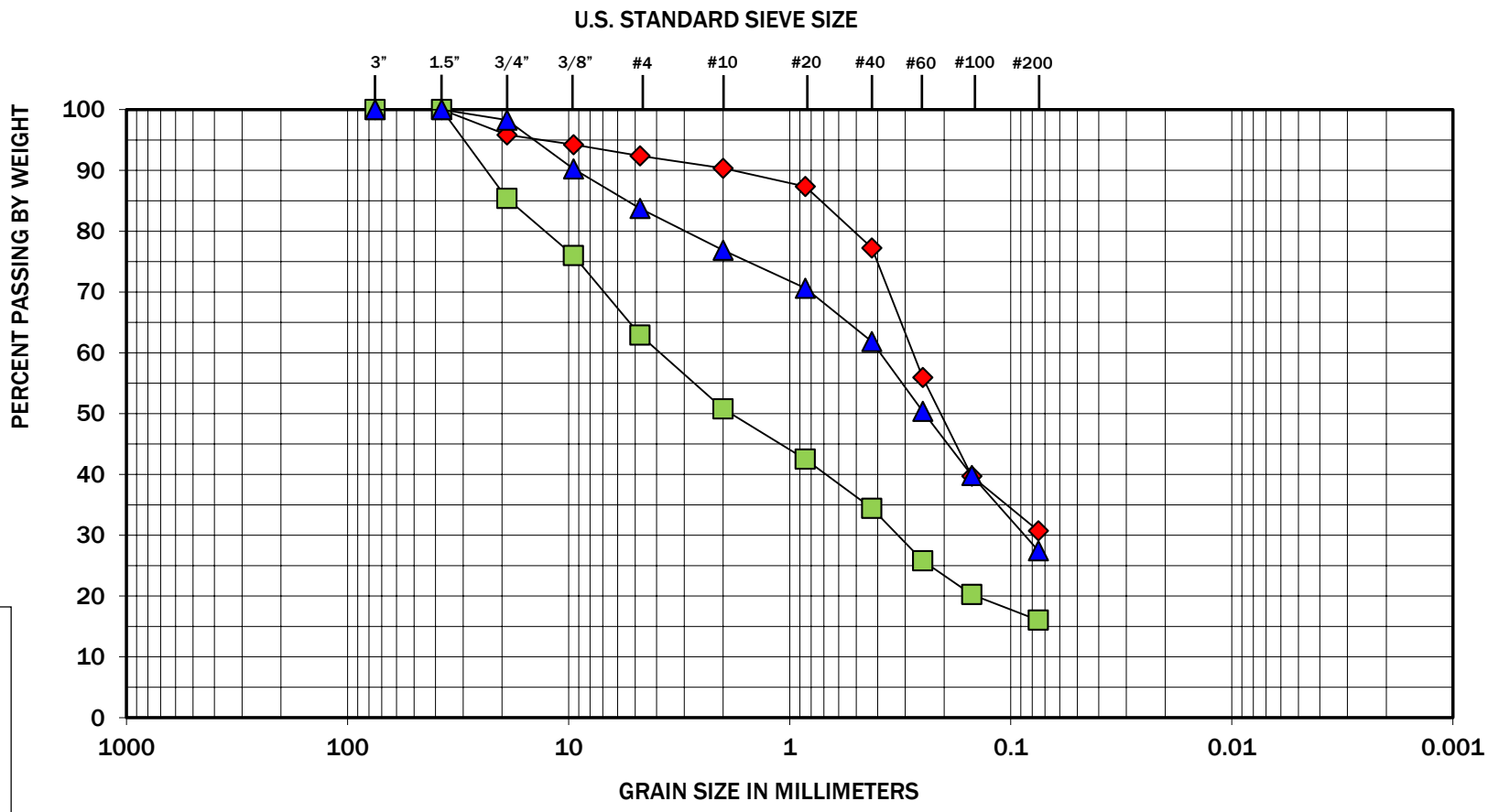
Figure A-6

Holmes Point Drive Storm Drain Replacement
Kirkland, Washington

Sieve Analysis Results



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Symbol	Boring Number	Depth (feet)	Moisture (%)	Soil Description
◆	GEI-3	2.5	10.2	Silty sand (SM)
■	GEI-3	5	4.4	Silty sand with gravel (SM)
▲	GEI-3	10	8.6	Silty sand with gravel (SM)

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The grain size analysis results were obtained in general accordance with ASTM D 6913.

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Holmes Point Drive Storm Drain Replacement
Kirkland, Washington

Sieve Analysis Results

Figure A-7

APPENDIX B
Report Limitations and Guidelines for Use

APPENDIX B
REPORT LIMITATIONS AND GUIDELINES FOR USE[1]

This appendix provides information to help you manage your risks with respect to the use of this report.

Geotechnical Services are Performed for Specific Purposes, Persons and Projects

This report has been prepared for the exclusive use of KPFF Consulting Engineers and the City of Kirkland and their authorized agents. This report may be made available to others for review. This report is not intended for use by others, and the information contained herein is not applicable to other sites.

GeoEngineers structures our services to meet the specific needs of our clients. For example, a geotechnical or geologic study conducted for a civil engineer or architect may not fulfill the needs of a construction contractor or even another civil engineer or architect that are involved in the same project. Because each geotechnical or geologic study is unique, each geotechnical engineering or geologic report is unique, prepared solely for the specific client and project site. Our report is prepared for the exclusive use of our Client. No other party may rely on the product of our services unless we agree in advance to such reliance in writing. This is to provide our firm with reasonable protection against open-ended liability claims by third parties with whom there would otherwise be no contractual limits to their actions. Within the limitations of scope, schedule and budget, our services have been executed in accordance with our Agreement with the Client and generally accepted geotechnical practices in this area at the time this report was prepared. This report should not be applied for any purpose or project except the one originally contemplated.

A Geotechnical Engineering or Geologic Report is Based on a Unique Set of Project-Specific Factors

This report has been prepared for the Holmes Point Drive Storm Drain Replacement project in Kirkland, Washington. GeoEngineers considered a number of unique, project-specific factors when establishing the scope of services for this project and report. Unless GeoEngineers specifically indicates otherwise, do not rely on this report if it was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

For example, changes that can affect the applicability of this report include those that affect:

- the function of the proposed structure;
- elevation, configuration, location, orientation or weight of the proposed structure;
- composition of the design team; or

[1] Developed based on material provided by ASFE, Professional Firms Practicing in the Geosciences; www.asfe.org.

- project ownership.

If important changes are made after the date of this report, GeoEngineers should be given the opportunity to review our interpretations and recommendations and provide written modifications or confirmation, as appropriate.

Subsurface Conditions Can Change

This geotechnical or geologic report is based on conditions that existed at the time the study was performed. The findings and conclusions of this report may be affected by the passage of time, by manmade events such as construction on or adjacent to the site, or by natural events such as floods, earthquakes, slope instability or groundwater fluctuations. Always contact GeoEngineers before applying a report to determine if it remains applicable.

Topsoil

For the purposes of this report, we consider topsoil to consist of generally fine-grained soil with an appreciable amount of organic matter based on visual examination, and to be unsuitable for direct support of the proposed improvements. However, the organic content and other mineralogical and gradational characteristics used to evaluate the suitability of soil for use in landscaping and agricultural purposes was not determined, nor considered in our analyses. Therefore, the information and recommendations in this report, and our logs and descriptions should not be used as a basis for estimating the volume of topsoil available for such purposes.

Most Geotechnical and Geologic Findings are Professional Opinions

Our interpretations of subsurface conditions are based on field observations from widely spaced sampling locations at the site. Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. GeoEngineers reviewed field and laboratory data and then applied our professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ, sometimes significantly, from those indicated in this report. Our report, conclusions and interpretations should not be construed as a warranty of the subsurface conditions.

Geotechnical Engineering Report Recommendations are Not Final

Do not over-rely on the preliminary construction recommendations included in this report. These recommendations are not final, because they were developed principally from GeoEngineers' professional judgment and opinion. GeoEngineers' recommendations can be finalized only by observing actual subsurface conditions revealed during construction. GeoEngineers cannot assume responsibility or liability for this report's recommendations if we do not perform construction observation.

Sufficient monitoring, testing and consultation by GeoEngineers should be provided during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions revealed during the work differ from those anticipated, and to evaluate whether or not earthwork activities are completed in accordance with our recommendations. Retaining GeoEngineers for construction observation for this project is the most effective method of managing the risks associated with unanticipated conditions.

A Geotechnical Engineering or Geologic Report Could be Subject to Misinterpretation

Misinterpretation of this report by other design team members can result in costly problems. You could lower that risk by having GeoEngineers confer with appropriate members of the design team after submitting the report. Also retain GeoEngineers to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering or geologic report. Reduce that risk by having GeoEngineers participate in pre-bid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Exploration Logs

Geotechnical engineers and geologists prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering or geologic report should never be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproductions are acceptable, but recognize that separating logs from the report can elevate risk.

Give Contractors a Complete Report and Guidance

Some owners and design professionals believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering or geologic report, but preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with GeoEngineers and/or to conduct additional study to obtain the specific types of information they need or prefer. A pre-bid conference can also be valuable. Be sure contractors have sufficient time to perform additional study. Only then might an owner be in a position to give contractors the best information available, while requiring them to at least share the financial responsibilities stemming from unanticipated conditions. Further, a contingency for unanticipated conditions should be included in your project budget and schedule.

Contractors are Responsible for Site Safety on Their Own Construction Projects

Our geotechnical recommendations are not intended to direct the contractor's procedures, methods, schedule or management of the work site. The contractor is solely responsible for job site safety and for managing construction operations to minimize risks to on-site personnel and to adjacent properties.

Read These Provisions Closely

Some clients, design professionals and contractors may not recognize that the geoscience practices (geotechnical engineering or geology) are far less exact than other engineering and natural science disciplines. This lack of understanding can create unrealistic expectations that could lead to disappointments, claims and disputes. GeoEngineers includes these explanatory "limitations" provisions in our reports to help reduce such risks. Please confer with GeoEngineers if you are unclear how these "Report Limitations and Guidelines for Use" apply to your project or site.

Geotechnical, Geologic and Environmental Reports Should Not be Interchanged

The equipment, techniques and personnel used to perform an environmental study differ significantly from those used to perform a geotechnical or geologic study and vice versa. For that reason, a geotechnical engineering or geologic report does not usually relate any environmental findings, conclusions or

recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. Similarly, environmental reports are not used to address geotechnical or geologic concerns regarding a specific project.

Biological Pollutants

GeoEngineers' Scope of Work specifically excludes the investigation, detection, prevention or assessment of the presence of Biological Pollutants. Accordingly, this report does not include any interpretations, recommendations, findings, or conclusions regarding the detecting, assessing, preventing or abating of Biological Pollutants and no conclusions or inferences should be drawn regarding Biological Pollutants, as they may relate to this project. The term "Biological Pollutants" includes, but is not limited to, molds, fungi, spores, bacteria, and viruses, and/or any of their byproducts.

If Client desires these specialized services, they should be obtained from a consultant who offers services in this specialized field.