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Hydrogeological and Infiltration Report

SAMMAMISH 18TH ASSEMBLAGE - PARCELS 2625069-033, -048, and -090

King County, Washington
King County Application No. PLAT18-0009

Prepared For:

TOLL BROS., INC.

Project No. 180351E001
September 24, 2018

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September 24, 2018
Project No. 180351E001

Toll Bros., Inc.
8815 122nd Avenue NE, Suite 200
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Attention: Mr. Jeff Peterson

Subject: Hydrogeological and Infiltration Report
Sammamish 18th Assemblage - Parcels 2625069-033, -048, and -090
King County, Washington
King County Application No. PLAT18-0009

Dear Mr. Peterson:

We are pleased to present the enclosed copy of the subject report. This report summarizes the results of our hydrogeological and infiltration studies and offers recommendations for the design and development of the proposed project.

We have enjoyed working with you on this study and are confident that the recommendations presented in this report will aid in the successful completion of your project. If you should have any questions, or if we can be of additional help to you, please do not hesitate to call.

Sincerely,
ASSOCIATED EARTH SCIENCES, INC.
Kirkland, Washington

Kurt D. Merriman, P.E.
Senior Principal Engineer

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I. PROJECT AND SITE CONDITIONS

1.0 INTRODUCTION

This report presents the results of our hydrogeological and infiltration study for the proposed new residential subdivision known as the Sammamish 18th Assemblage (King County Application No. PLAT18-0009). The site location is shown on the "Vicinity Map," Figure 1. The approximate locations of explorations completed for this study are shown on the "Site and Exploration Plan," Figure 2. This report is based on a site plan by D.R. Strong Consulting Engineers (D.R. Strong) titled "Delappe Sheehan, Preliminary Subdivision Layout, Infiltration Vault Option," dated June 28, 2018 and our earlier report "Subsurface Exploration, Geologic Hazard, Preliminary Geotechnical Engineering, and Preliminary Infiltration Report," dated August 20, 2018.

Interpretive exploration logs (Appendix A), infiltration testing (Appendix B), laboratory test results (Appendix C), groundwater mounding analyses results (Appendix D), and data from the project civil engineer (Appendix E) are included with this report. The conclusions and recommendations contained in this report should be reviewed and modified, or verified, if project plans change substantially.

1.1 Purpose and Scope

The purpose of this study was to provide subsurface data to be used in the design of the surface water infiltration facility for the project. Our study included a review of selected geologic literature, our earlier explorations/testing documented in our June and August reports, and observation of the excavation of one supplemental exploration pit and one additional test pit, and geologic studies to assess the type, thickness, distribution, and physical properties of the subsurface sediments and shallow groundwater. Groundwater mounding analyses were performed to assess the feasibility of surface water infiltration at the site. This report summarizes our fieldwork to date and offers recommendations for development based on our present understanding of the project. We recommend that we be allowed to review any revisions to project plans and update the recommendations in this report as needed.

1.2 Authorization

This report has been prepared for the exclusive use of Toll Bros., Inc. and its agents for specific application to this project. Our work was performed in accordance with our scope of work and cost proposal, dated August 21, 2018. We were authorized to proceed by means of a change order.

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.

2.0 PROJECT AND SITE DESCRIPTION

The subject site consists of three residential parcels located at 24403, 24407, and 24515 NE 18th Street in Sammamish, Washington (King County Parcels 2625069-033, -048, and -090). The roughly rectangular-shaped site is approximately 5.4 acres in area and bounded on the north by NE 18th Street, to the east and south by single-family residential development, and to the west by 244th Avenue NE. The properties are developed with three existing, single-family residences and various small, auxiliary buildings. The unbuilt areas are vegetated with grass lawns areas, landscaping shrubs and trees, and stands of mature conifer trees. Topography generally slopes downward to the southeast, south, and southwest from a high point near the property boundary between the middle and eastern parcel. Slopes generally range in inclination from gentle to moderate, with an isolated steeper slope on the western parcel. Overall vertical site relief is on the order of 36 feet.

We understand that the development will consist of constructing 32 new single-family residences, a surface water infiltration facility, interior streets, sidewalks, and other miscellaneous site improvements.

3.0 SUBSURFACE EXPLORATION, TESTING, AND FIELD INVESTIGATION

Our field studies from past and current site work included excavating ten exploration pits, drilling two exploration borings, installing one well and one piezometer, performing two field infiltration tests, performing several grain-size distribution tests, and water level monitoring. On the "Site and Exploration Plan" (Figure 2), the locations of the exploration pits EP-1 through EP-5, infiltration test pit IT-1, and exploration borings EB-1W and EB-2 were surveyed by Toll Bros., Inc., and the locations of exploration pits EP-6 through EP-10 and IT-2 were measured from known site features. Interpretive exploration logs are presented in Appendix A.

The various types of sediments, as well as the depths where characteristics of the sediments changed, are indicated on the exploration logs. The depths indicated on the logs where conditions changed may represent gradational variations between sediment types in the field.

The conclusions and recommendations presented in this report are based on the explorations completed for this study. The number, locations, and depths of our explorations were completed within site and budgetary constraints. Because of the nature of exploratory work

below ground, extrapolation of subsurface conditions between field explorations is necessary. It should be noted that differing subsurface conditions may sometimes be present due to the random nature of deposition and the alteration of topography by past grading and/or filling. The nature and extent of any variations between the field explorations may not become fully evident until construction. If variations are observed at that time, it may be necessary to re-evaluate specific recommendations in this report and make appropriate changes.

3.1 Exploration Pits

Associated Earth Sciences, Inc. (AESI) observed the excavation of ten exploration pits; all exploration pits were excavated with a track-mounted excavator. Exploration pits EP-1 through EP-4 were excavated on March 2nd by an excavator provided by Toll Bros., Inc., exploration pit EP-5 was excavated on March 27th by an excavator subcontracted to AESI, exploration pits EP-6 through EP-9 were excavated on July 16th by an excavator subcontracted to AESI, and exploration pit EP-10 was excavated on September 6th by an excavator subcontracted to AESI. The pits permitted direct, visual observation of subsurface conditions. Materials encountered in the exploration pits were studied and classified in the field by an engineer from our firm. All exploration pits were backfilled after examination and logging. Selected samples were then transported to our laboratory for further visual classification and testing, as necessary.

3.2 Piezometer

AESI installed one groundwater piezometer in exploration pit EP-1 in an area proposed for stormwater infiltration (Figure 2). The piezometer consisted of a 10-foot-long, 1¼-inch polyvinyl chloride (PVC) pipe with hand-drilled perforations in the lower 2½ feet set at the bottom of the exploration pit before backfilling. The piezometer extended about 2½ inches above the backfilled ground surface, and the end was covered with a slip cap.

3.3 Infiltration Testing

In order to evaluate stormwater infiltration feasibility and to obtain a representative infiltration rate, two infiltration tests, IT-1 and IT-2, were completed at the locations shown on Figure 2. The tests were conducted in general accordance with the small-scale Pilot Infiltration Test (PIT) procedure outlined in the 2016 *King County Surface Water Design Manual* (KCSWDM). Infiltration test pit IT-1 was excavated on March 27th and IT-2 was excavated September 6th, both by an excavator subcontracted to AESI. A continuous water source was supplied to the test by a water truck subcontracted to AESI.

The infiltration test procedure consisted of excavating the test pits IT-1 and IT-2 with relatively flat bottoms to the test depths of 5 feet and 4.5 feet, respectively. A staff gauge was installed in the test base to measure water level rise (head) to the nearest 0.01 feet. Water was introduced to the test area through a hose attached to a digital, propeller-type, flow meter

assembly with instantaneous flow rate and total flow volume readouts. The discharge hose was equipped with a diffuser to minimize turbulence and scouring of the test bottom. Water was discharged into the test area for a "soaking period" of at least 6 hours to saturate the receptor soils in the immediate vicinity of the pit. After the soaking period, the "constant-head" period of the test began and water was discharged into the test area at a constant rate for about 1 hour in IT-1 and for about 50 minutes in IT-2. After the constant-head period, water flow into the test area IT-1 was shut off and the "falling-head" period began. After the constant-head period, water flow into the test area IT-2 was depleted and the falling-head period of the test began.

Readings of the instantaneous flow rate, total flow volume, and water level were recorded at approximately 5- to 15-minute intervals throughout the soaking and constant-head periods of the test. The water level and wetted area were recorded frequently as the water receded during the falling-head periods of the test. Infiltration test data were recorded by hand in the field and subsequently transferred to electronic spreadsheets. Infiltration test data sheets are included in Appendix B.

Upon completion of the infiltration tests, the test pits were deepened to document the types of soils through which the water infiltrated and identify any soil layers that would restrict the downward flow of water. During excavation of the test pit IT-1 after testing, AESI observed seepage at depths of about 6.5 feet and 9 feet below the ground surface. During excavation of the test pit IT-2 after testing, AESI observed seepage at a depth of about 7.5 feet below the ground surface. We interpret this seepage as return flow from infiltration testing due to perching on lower-permeability layers beneath the test depth. Pooling was observed at a depth of 11 feet below the ground surface in both tests. This pooling was interpreted as shallow groundwater not related to testing.

A summary of test results and stormwater infiltration recommendations are presented in the "Infiltration Feasibility" section of this report.

3.4 Exploration Borings

Exploration borings EB-1W and EB-2 were drilled on March 28 and March 29, 2018, by a track-mounted, hollow-stem auger drill rig subcontracted to AESI. During the drilling process, samples were obtained at 2.5- and 5-foot intervals. The borings were continuously observed and logged by a field engineer from our firm. The interpretive exploration logs presented in Appendix A are based on the field logs, drilling action, and observation of the samples collected.

Disturbed, but representative samples were obtained by using the Standard Penetration Test (SPT) procedure in accordance with *American Society for Testing and Materials* (ASTM) D-1586. This test and sampling method consists of driving a standard, 2-inch outside-diameter,

split-barrel sampler a distance of 18 inches into the soil with a 140-pound hammer free-falling a distance of 30 inches. The number of blows for each 6-inch interval is recorded, and the number of blows required to drive the sampler the final 12 inches is known as the Standard Penetration Resistance ("N") or blow count. If a total of 50 blows is recorded at or before the end of one 6-inch interval, the blow count is recorded as the number of blows for the corresponding number of inches of penetration. The resistance, or N-value, provides a measure of the relative density of granular soils or the relative consistency of cohesive soils. These values are plotted on the attached boring logs.

The samples obtained from the split-barrel sampler were classified in the field and representative portions placed in water-tight containers. The samples were then transported to our laboratory for further visual classification and geotechnical laboratory testing, as necessary.

The various types of soil and groundwater elevations, as well as the depths where soil and groundwater characteristics changed, are indicated on the exploration boring logs presented in Appendix A of this report. The locations of our explorations were approximated by measuring from known site features.

3.5 Monitoring Well

Following drilling, one groundwater monitoring well was installed in exploration boring EB-1W to allow for longer-term monitoring of groundwater levels below the site. The well consisted of a 2-inch-diameter, PVC Schedule-40 well casing with threaded connections. The lower 10 feet of the well was a finely-slotted (0.010-inch machine slot) well screen to permit water inflow. The annular space around the well screen was backfilled with silica sand, and the upper portion of annulus was sealed with bentonite grout and chips. A steel, flush-mount monument was set in concrete over the top of the wellhead for protection. The as-built configuration of the well is illustrated on the associated boring log included in Appendix A. The well was developed with a plastic Mini Typhoon pump and $^{3}/_{8}$-inch, inside-diameter poly tube assembly. The entire length of the well screen was surged incrementally from the top down at a rate of about 1 minute per foot of screen. Following surging, approximately 35 gallons of water were pumped from the well in EB-1W.

A water level data logger was installed in the well on March 30, 2018. We will collect continuous water level measurements for the next several months and up to 1 year, depending on the need for water level data during design development. Off-site groundwater depths and elevations were also obtained from an adjacent project. Off-site well locations are shown on Figure 1.

3.6 Water Level Monitoring

Several water level monitoring stations have been installed on or near the subject property. Off-site monitoring station locations are shown on Figure 1. Table 1 summarizes the monitoring stations, seasonal high water level data, and source of the data collected to date.

Table 1
Seasonal High Water Depth and Elevation at On-Site and Off-Site Monitoring Stations

Water Level Monitoring Station	Surface Water Elevation (feet)	Depth to Groundwater (feet)	Groundwater Elevation (feet)	Date
EB-1W, onsite	n/a	10.17	333.37	April 18, 2018
WP-1, onsite	n/a	8.87	332.33	April 25, 2018
MW-1, Mystic Lake	n/a	37.59	334.44	April 29, 2013
MW-1, 16th Street	n/a	2.46	336.73	April 29, 2013
Staff Gauge, 16th Street	337	n/a	n/a	May 22, 2017
Mystic Lake	354	n/a	n/a	May 22, 2017
Allen Lake	343	n/a	n/a	May 22, 2017
B-1, Terra	n/a	3.48	334.45	January 25, 2018
B-2, Terra	n/a	28.43	346.79	January 12, 2018
B-101, Terra	n/a	19.50	330.85	May 1, 2018

n/a = not applicable

4.0 SUBSURFACE CONDITIONS

Subsurface conditions at the project site were inferred from the field explorations accomplished for this study, visual reconnaissance of the site, and review of selected geologic literature. The general distribution of geologic units is shown on the exploration logs. The explorations generally encountered native sediments, consisting of Vashon recessional outwash, ice-contact deposits, Vashon lodgement till, and Vashon advance outwash, overlain by thin deposits of topsoil and fill soils locally.

4.1 Stratigraphy

The following sections present more detailed subsurface information organized from the youngest (shallowest) to the oldest (deepest) sediment types.

Existing Fill

Fill soils (those not naturally placed) were encountered in exploration pits EP-1, EP-2, EP-6, EP-7, and IT-2 to depths of 1 feet to 3.5 feet. Artificial fill should be expected in other developed areas of the site, such as around existing utilities and foundations. Observed fill was

variable in nature, but generally consisted of gravel or silt with some sand and organic material such as roots and decaying particles. Waste materials, including wires and plastic, were observed in EP-6. Abundant wood debris, interpreted as a buried stump, was encountered in the fill in IT-2.

Due to the variable organic and waste content, existing fill is not considered suitable for foundation support or reuse in structural fills.

Sod/Forest Duff/Topsoil

A surficial soil layer consisting of soft, dark brown, sandy silt with some gravel and abundant organics was encountered in all explorations except EP-1, EP-2, and EP-7. This soil is interpreted as topsoil and was observed in thicknesses ranging from approximately 3 to 18 inches. In EP-10 and IT-2, the topsoil included 1 to 2 inches of sod.

Due to their high organic content, topsoil materials are not considered suitable for foundation, roadway, or slab-on-grade floor support, or for use in a structural fill.

Vashon Recessional Outwash

Underlying the topsoil or fill in explorations EB-1, EB-2, EB-4, EB-5, IT-1, EB-1W, EP-10, and IT-2, sediments encountered typically consisted of medium dense, gravelly, medium to coarse sand with silt interbeds interpreted as Vashon recessional outwash. Recessional outwash was observed to depths of approximately 2.5 to 9.5 feet below the ground surface. In all explorations except IT-2, the upper 1 to 2 feet of recessional outwash was weathered, characterized by an orange or tan color, loose to medium density, higher silt content, and the presence of fine roots. Vashon recessional outwash sediments were deposited by meltwater streams flowing from the receding Vashon glacier more than 10,000 years ago. The weathered condition was created by natural processes of freeze-thaw and bioturbation by roots and animals.

Recessional outwash is typically suitable for support of light to moderately loaded foundations and, where it occurs in sufficient, unsaturated thickness, may serve as a receptor for surface water infiltration.

Vashon Ice-Contact Deposit

Sediments encountered below the recessional outwash in explorations EP-1, EP-2, EP-5, IT-1, and EB-1W, and below the topsoil in EB-2, generally consisted of medium dense to very dense, silty, gravelly, medium to coarse sand with occasional interbeds of cleaner and siltier sands. We interpret these sediments to have been deposited in close contact with debris-laden glacial ice during the Vashon Stade of the Fraser Glaciation, approximately 12,500 to 17,500 years

ago. Ice-contact deposits were encountered to depths of 15 to 22 feet below the ground surface in EB-1W and EB-2, respectively, and extended beyond the maximum depths explored of 10 to 12 feet in EP-1, EP-2, EP-5, and IT-1.

With proper preparation, the ice-contact deposits are suitable for foundation support due to their dense configuration. The high fines content and low permeability of these sediments are not favorable for stormwater infiltration.

Vashon Lodgement Till

Underlying the topsoil and fill in explorations EP-3 and EP-6 through EP-9, and underlying the recessional outwash in EP-4, we encountered medium dense to very dense, very silty, gravelly fine sand with occasional cobbles and boulders interpreted as Vashon-age lodgement till. In these explorations, lodgement till was encountered to the full depths explored of 6 to 8.5 feet below the ground. In all explorations except EP-6, the upper 1.5 to 2 feet of lodgement till was weathered, characterized by an orange or tan color, a loose to medium dense consistency, and the presence of fine roots. The lodgement till was deposited at the base of an active ice sheet and was subsequently compacted by the weight of the overlying glacial ice.

Excavations into the lodgement till should be prepared to encounter large cobbles and boulders at random. Lodgement till typically possesses high-strength and low-compressibility attributes that are favorable for support of foundations, floor slabs, and paving, with proper preparation. Lodgement till soils are typically low permeability due to their high silt content and consolidated consistency and are therefore not considered suitable for infiltration.

Vashon Advance Outwash

Underlying the ice-contact deposits in EB-1W and EB-2 and underlying the recessional outwash in EP-10 and IT-2, dense to very dense, medium to coarse sand with silty and gravelly interbeds extended to full depths explored of 31.5, 34, 11, and 11.5 feet, respectively. Scattered cemented clasts were observed in EP-10. We interpret these sediments as Vashon advance outwash. Vashon advance outwash sediments were deposited by flowing water from the base of the southward advancing Vashon glacial front. Subsequent to deposition, the advance outwash was overridden by approximately 3,000 feet of glacial ice, resulting in the very dense condition of this unit. In EB-1W, EB-2, and IT-2, this unit was saturated. In EP-10, the advance outwash graded from moist to wet.

In an undisturbed condition, the advance outwash is suitable for support of light to heavy foundation loads and for roadway subbase material. Due to the presence of groundwater in this unit, the advance outwash is not considered suitable for stormwater infiltration at the project site.

4.2 Published Geologic Literature

We reviewed the published *Geologic Map of the Issaquah 7.5' Quadrangle, King County, Washington*, by D.B. Booth and J.P. Minard, 1992. This map indicates that the site is underlain by recessional outwash and lodgement till sediments and our interpretations of subsurface conditions onsite generally agree.

4.3 Laboratory Testing

As a part of our study of the infiltration potential of the site soils, we completed four laboratory grain-size analyses. We performed grain-size analyses on representative samples of the recessional outwash collected at depths of about 5 feet in IT-1 and 4.5 feet in IT-2, and on the Vashon ice-contact deposits collected from depths of about 7.5 to 8 feet in EP-1 and 9 to 10 feet in EP-2. Copies of the grain-size analyses reports are included in Appendix C.

4.4 Hydrology

Our understanding of the hydrologic conditions at the site is based on our explorations and water level monitoring data, including:

- Groundwater encountered in our borings at the time of our explorations;
- Water level data from the data logger in our on-site well EB-1W, last download August 29, 2018;
- Manual water level measurements in our piezometer WP-1;
- Groundwater monitoring records from the well MW-1 and surface water monitoring records from the staff gauge in the NE 16th Street Assemblage about ¼ mile to the south of the site;
- Groundwater monitoring records from the well MW-1 and surface water records in the Mystic Lake development about $^{1}/_{10}$ mile to the southwest of the site;
- Surface water elevations of Allen Lake about $^{3}/_{4}$ mile to the south of the site; and
- Off-site water level data obtained for other projects.

Intermittent perched groundwater or "interflow" is expected to accumulate at the upper surface of fine-grained native sediments, such as glacial till, and minor amounts of seepage may be expected seasonally. Interflow would tend to flow downslope along the top of the till and recharge underlying aquifers. It should be noted that the depth and occurrence of groundwater seepage may vary in response to changes in season, amount of precipitation, on- and off-site land use, and other factors. Explorations for this study were conducted on March 2nd, 27th, and 28th, July 16th, and September 6th of 2018, and did not encounter perched groundwater.

Groundwater seepage was encountered within the advance outwash deposits at about 15.5 feet in EB-1W, 21 feet in EB-2, and 11 feet in both IT-1 and IT-2. This groundwater is interpreted to represent the shallow aquifer underlying the site and vicinity. Groundwater within the advance outwash may interact with surface water features near the site, including the wetland within the 16th Street Assemblage to the south. Recharge to the unconfined aquifer is primarily through rainfall and from surface water features. Recharge also occurs due to infiltration of interflow and surface runoff from surrounding till uplands, which infiltrates along the upland margins into the surrounding outwash deposits.

Table 1 presents seasonal high groundwater data of the shallow aquifer from the site and nearby projects. Based on this data, we interpret the regional groundwater flow direction in the project area is to the north. Continuous groundwater level data collected from March 30 to July 19, 2018, indicates seasonal high groundwater for the 2017-2018 winter season near the proposed infiltration facility was 334.5 feet elevation.

II. PRELIMINARY DESIGN RECOMMENDATIONS

5.0 INTRODUCTION

Our exploration indicates that, from a geotechnical engineering standpoint, the proposed stormwater infiltration facility in the northwest area of the site is feasible provided the recommendations contained herein are properly followed.

Geotechnical engineering recommendations, including recommendations for site preparation, grading, foundations, floor support, drainage, paving, and stormwater vault construction, were provided in our earlier report, "Subsurface Exploration, Geologic Hazard, Preliminary Geotechnical Engineering, and Preliminary Infiltration Report," dated August 20, 2018.

6.0 INFILTRATION FEASIBILITY

The feasibility of stormwater infiltration depends upon the presence of a suitable receptor soil of sufficient thickness, extent, permeability, and vertical separation from groundwater. Of the soils encountered onsite, only the outwash deposits are typically permeable enough for stormwater infiltration. Due to the presence of groundwater within the advance outwash encountered in EB-1W, EB-2, EP-10, and IT-2, this deposit is not considered a suitable infiltration receptor. The recessional outwash observed in EP-2 and EP-4 was present in relatively thin deposits of about 1.5 feet thick each and is not considered a suitable infiltration receptor. Recessional outwash encountered in EP-1, EP-10, and IT-2 in the northwest area of the site and in EP-5, IT-1, and EB-1W in the southwest area of the site was observed in unsaturated thicknesses of about 3 to 5 feet, and stormwater infiltration is considered feasible.

6.1 Laboratory Test Results

Laboratory grain-size analyses were performed on selected soil samples; see Table 2 for details. Complete test results are presented in Appendix C.

Table 2
Sample Source, Depth Below Ground Surface, and Grain-Size Description

Sample Source	Sample Depth (feet bgs)	Description
EP-1	7.5 to 8	Very sandy GRAVEL, trace silt
EP-2	9 to 10	Very gravelly, silty, SAND
IT-1	5	Very sandy GRAVEL, some silt
IT-2	4.5	Very gravelly SAND, some silt

bgs = below ground surface

6.2 Infiltration Test Results

Infiltration testing was performed in the southwest and northwest areas of the site as described in the "Subsurface Exploration" section of this report. A summary of test results is presented in Table 3.

Table 3
Summary of Field Infiltration Test Data

Test No.	Test Depth (feet)	Total Water Used (gallons)	Wetted Area (square feet)	Constant-Head Flow Rate (gallons/minute)	Field-based Constant-Head Infiltration Rate (inches/hour)	Field-based Falling-Head Infiltration Rate (inches/hour)
IT-1	5	662	13.5	2.1	14.9	15.1
IT-2	4.5	3,882	19	9.2	48.5	47.6

6.3 Preliminary Design Infiltration Rate

Based on the subsurface conditions at the site and the results of our field and laboratory testing, we recommend a shallow infiltration facility, such as the proposed bottomless vault, that uses the recessional outwash deposit in the northwest area of the site as a stormwater receptor. Sufficient vertical separation must be maintained between the bottom of the facility and the seasonal high groundwater. Because the infiltration receptor sediments are thin and the anticipated seasonal high groundwater is shallow, we performed a groundwater mounding analysis to evaluate the impact of infiltrated surface water on the receptor as described in the "Groundwater Mounding Analysis" section of this report. Subsurface conditions are expected to vary within the footprint of a future infiltration facility. Actual subsurface conditions are expected to vary from those encountered in IT-1, EP-10, and IT-2. Therefore, we recommend using a conservative design infiltration rate for facility sizing as described in the following sections.

As described in the 2016 KCSWDM, the design infiltration rate for infiltration facilities is derived using the correction factors for testing, facility geometry, and plugging, per the following formula:

$$I_{design} = I_{measured} \times F_{testing} \times F_{geometry} \times F_{plugging}$$

Where I_{design} and $I_{measured}$ are the design and measured infiltration rates, respectively. As stated in the "Infiltration Test Results" section, the field infiltration rate was approximately 15 inches per hour (in/hr) in IT-1 and approximately 48 in/hr in IT-2.

The correction factor $F_{testing}$ accounts for uncertainties in the testing methods. This factor is defined as 0.50 for small-scale PITs.

The $F_{geometry}$ correction factor accounts for the influence of facility geometry and depth to the water table or impervious strata on the field-based infiltration rate. The KCSWDM states that this factor must be between 0.25 and 1.0, as determined by the following equation:

$$F_{geometry} = 4\ D/W + 0.05$$

Where D = Depth from the bottom of the proposed facility to the maximum wet season water table or nearest impervious layer, whichever is less; and

W = Width of the facility.

Based on the preliminary site plan identified earlier, we understand D will be equal to 3 feet and W will be equal to approximately 80 feet. Therefore, $F_{geometry}$ can be taken as the minimum required 0.25.

The plugging factor ($F_{plugging}$) is based on the grain size of the materials tested. For coarse sands to cobbles, such as those encountered in EP-1 at 7.5 feet and IT-1 at 5 feet, $F_{plugging}$ can be taken as 1.0. For medium sands, $F_{plugging}$ can be taken as 0.9. If the facility is preceded by a water quality treatment best management practice (BMP), such as the proposed pre-settling vault, the plugging factor is 1.0.

The resulting preliminary design infiltration rates are therefore 1.9 in/hr in IT-1 and 5.6 in/hr in IT-2. We recommend the design infiltration rate of 1.9 in/hr be used to size the facility even though the higher infiltration rate was obtained from the footprint of the proposed facility. Maximizing the infiltration facility dimensions is warranted, in our opinion, due to the uncertainties related to: 1) the thin receptor horizon, 2) depth to shallow groundwater which is pending documentation of seasonal high (our current estimate is based on correlation to on-site data with historical data from other locations), and 3) the potential cumulative impacts of existing and proposed off-site facilities.

7.0 GROUNDWATER MOUNDING ANALYSIS

The groundwater mounding analysis was completed to simulate the maximum groundwater mound height and compare it to the design high water elevation (DHWE) in the proposed infiltration facility. The MODRET program utilizes the Greene Ampt method for unsaturated conditions and the U.S. Geological Survey (USGS) MODFLOW finite-difference model for saturated conditions. Groundwater mounding can occur when water is introduced into an infiltration facility at a higher rate than can be dispersed in the subsurface away from the area beneath the facility. The introduced water can “mound” on the groundwater table or on a less-permeable layer underlying the receptor sand and gravel during a storm event. When the storm event is over and water is not being introduced into the system, the mound will normally

dissipate. The mounding analysis was used to simulate the maximum groundwater mound beneath the facility during design storm series.

The MODRET computer program was used to model potential groundwater mounding beneath the proposed infiltration facility under two design time series. D.R. Strong provided two 30-day hydrographs extracted from the 2012 Western Washington Hydrology Model (WWHM) modeling software for use in the mounding analysis, one from a period of maximum flow rate and one from a period of maximum volume. The maximum flow rate hydrograph contains the day with the highest average single-day flow rate (October 20, 2003) and includes the 15 days before and after (date range October 5, 2003 through November 4, 2003). The maximum volume hydrograph runs from November 2, 2006 through December 1, 2006, and is characterized as the 30-day period with the highest total volume inflow of the 61-year period of record. Per D.R. Strong's letter, "Delappe Sheehan Infiltration Vault Design Parameters," dated August 30, 2018 (D.R. Strong, 2018), influent flows include runoff from approximately 3.4 acres.

MODRET requires input of two hydraulic conductivity values: saturated horizontal hydraulic conductivity (Khs) and unsaturated vertical hydraulic conductivity (Kvu). Hydraulic conductivity values were derived from the factored field-calculated infiltration rate in infiltration test IT-2, conducted in the footprint of the proposed vault.

The design infiltration rate factor criteria presented beginning on page 5-45 of the 2016 KCSWDM contains the following note: *When conducting a mounding analysis, apply $F_{geometry}$ in the mounding analysis only if facility geometry is not captured in the groundwater model inputs.* MODRET includes facility geometry, so the $F_{geometry}$ factor (0.25) was not used. Without this factor, the infiltration rate used as a basis for the mounding analysis was 22.5 in/hr, which is equivalent to 45 feet per day (ft/day) and is assumed to represent the vertical saturated hydraulic conductivity (Kvs).

To derive a value for Khs, we used the relationship of Khs = 3 times the Kvs. This value is generally considered conservative, within the range of published hydraulic conductivity ratio values for sediments deposited by flowing water, and is required by jurisdictions such as King County (in Section 5.2.1 of the 2016 KCSWDM). Kvu is assumed to be two-thirds the value of Kvs (Andreyev and Wiseman, 1989).

Table 4 presents the basis for MODRET input values for the infiltration facility. The results of the MODRET simulation are included in Appendix D. Data from the civil engineer is included in Appendix E.

Table 4
MODRET Input Parameter Summary

Parameter	Value	Basis
Facility Bottom Area	8,000 ft^2	D.R. Strong
Facility Volume Between Bottom and DHWE	48,000 ft^2	D.R. Strong
Facility Length to Width Ratio	1.25	D.R. Strong
Elevation of Effective Aquifer Base	330 ft	AESI based on lowest elevation explored in area (IT-2, EP-10). See text.
Elevation of Seasonal High Ground Water Table	334.5 ft	AESI. Correlation of on-site data with historic off-site data. See text.
Elevation of Starting Water Level	337.5 ft	Facility bottom elevation (D.R. Strong).
Elevation of Facility Bottom	337.5 ft	D.R. Strong
DHWE	343.5 ft	D.R. Strong
Storage Coefficient of Soil for Unsaturated Analysis	0.25	AESI - Within range of published values for the soil types present.
Unsaturated Vertical Hydraulic Conductivity (Kvu) (ft/day)	30 ft/day	Based on field rate with $F_{testing}$ and $F_{plugging}$ factors applied, per 2016 *King County Surface Water Design Manual*. (2/3 x Kvs). See text.
Factor of Safety	2	Standard value.
Saturated Horizontal Hydraulic Conductivity (Khs) (ft/day)	135 ft/day	3 x Kvs. See text.
Storage Coefficient of Soil for Saturated Analysis	0.25	AESI - Within range of published values for the soil types present.
Average Effective Storage Coefficient of Pond/Exfiltration Trench	1.0	D.R. Strong
Time Increment During Storm Event (hours)	24	Increments match hydrograph time steps.
Time Increment After Storm Event (hours)	24	Increments match hydrograph time steps.
Total Number of Increments After Storm Event	6	Program default.

D.R. Strong = D.R. Strong Consulting Engineers
AESI = Associated Earth Sciences, Inc.
DHWE = design high water elevation
ft = feet
ft^2 = square feet
ft/day = feet per day
Kvs = vertical saturated hydraulic conductivity

7.1 Groundwater Mounding Analysis Results

The results of the MODRET simulation are included in Appendix D and indicate that the modeled infiltration facility will have the capacity to infiltrate all of the stormwater runoff routed to the facility during the design storm time series hydrographs provided by D.R. Strong, without exceeding the DHWE. Under the peak flow hydrograph, the maximum groundwater

mound reached an elevation of 339.5 feet. The maximum volume hydrograph yielded a maximum groundwater mound elevation of 339.9 feet. These elevations are below the DHWE for the facility, 343.5 feet.

8.0 PROJECT DESIGN AND CONSTRUCTION MONITORING

This report is based on a site plan that was current at the time this report was written. We are available to provide additional geotechnical consultation as the project design develops and possibly changes from that upon which this report is based. We recommend that AESI perform a geotechnical review of the plans prior to construction. In this way, our hydrogeological recommendations may be properly interpreted and implemented in the design.

We are also available to provide geotechnical engineering and monitoring services during construction. The performance of the infiltration facility 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. Construction monitoring services are not part of the current scope of work. If these services are desired, please let us know, and we will prepare a cost proposal.

We have enjoyed working with you on this study and are confident 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

Nicki Shobert, E.I.T.
Senior Staff Engineer

Kurt D. Merriman, P.E.
Senior Principal Engineer

State of Washington
Hydrogeologist
496
Licensed Geologist
9/24/18
Curtis J. Koger

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Senior Principal Geologist/Hydrogeologist

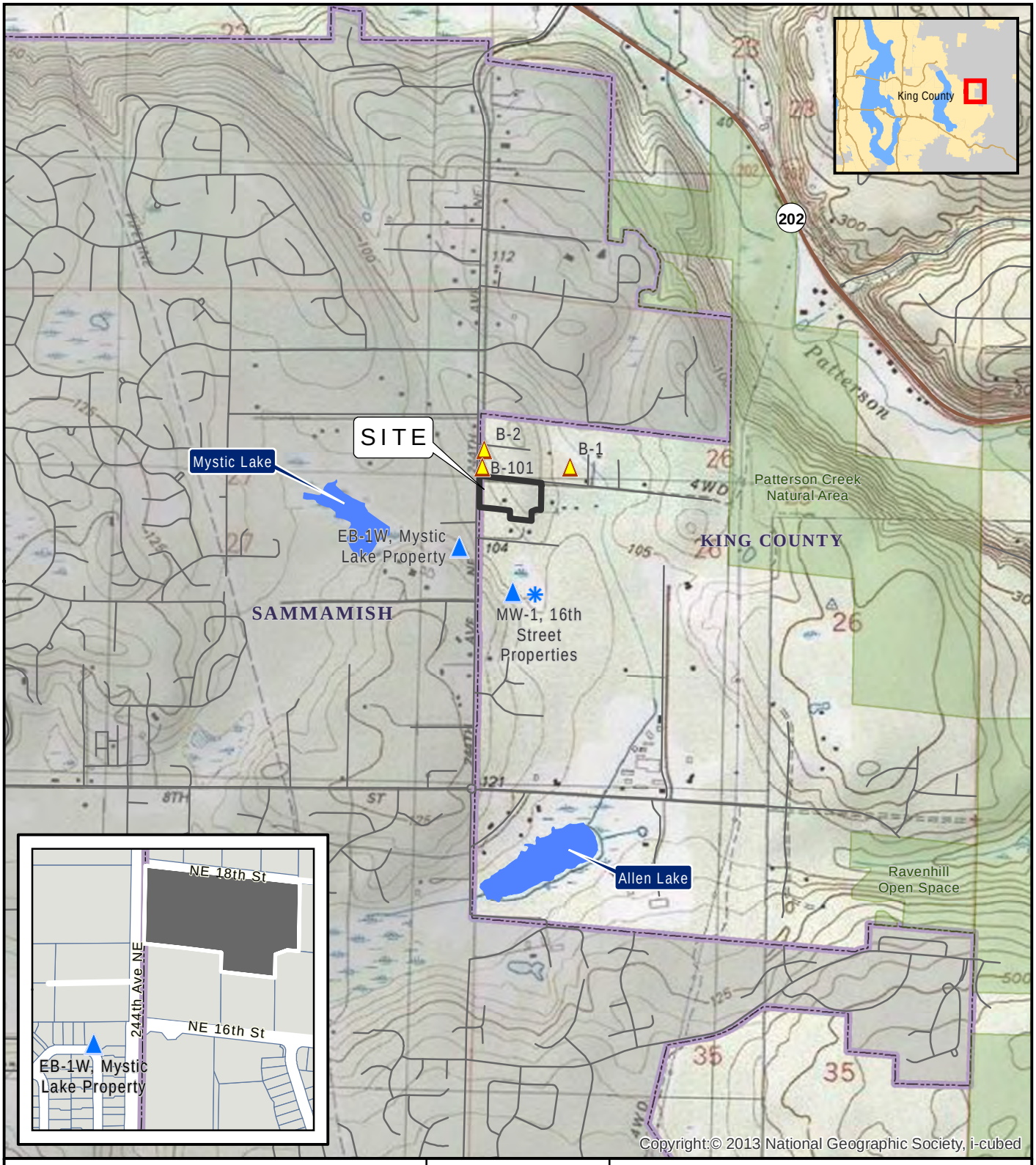
Attachments:

	Figure 1:	Vicinity Map
	Figure 2:	Site and Exploration Plan
	Appendix A:	Exploration Logs
	Appendix B:	Infiltration Test Data Sheets
	Appendix C:	Laboratory Test Results
	Appendix D:	Groundwater Mounding Analysis
	Appendix E:	Data from Civil Engineer

9.0 REFERENCES

Andreyev, N.E. and Wiseman, L.P., 1989, Stormwater retention pond infiltration analysis in unconfined aquifers: Prepared for Southwest Florida Water Management District, Brooksville, Florida.

King County Department of Natural Resources, 2016, Surface water design manual: April 24, 2016.



▲ MONITORING WELL, AESI

▲ MONITORING WELL, TERRA ASSOC. 2017

✱ STAFF GAUGE

DATA SOURCES / REFERENCES:
USGS: 7.5' SERIES TOPOGRAPHIC MAPS, ESRI/I-CUBED/NGS 2013
KING CO: STREETS, PARCELS, CITY LIMITS 1/18
TERRA ASSOC. REPORT KENSINGTON ENCLAVE, 12/17, REVISED 7/27/18

LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE

N

0 750 1500

FEET

NOTE: BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION

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VICINITY MAP

SHEEHAN PROPERTY
KING COUNTY, WASHINGTON

PROJ NO.	DATE:	FIGURE:
180351E001	3/18	1

Document Path: G:\GIS_Projects\aaY2018\180351 Sheehan Property\mxd\180351E001 F1 VM_Sheehan.mxd

LEGEND:

EB	EXPLORATION BORING - MARCH 2018
EBW	MONITORING WELL - MARCH 2018
EP	EXPLORATION PIT - MARCH 2018
IT	INFILTRATION TEST - MARCH 2018
	PIEZOMETER - MARCH 2018
EP	EXPLORATION PIT - JULY 2018
IT	INFILTRATION TEST - SEPTEMBER 2018
EP	EXPLORATION PIT - SEPTEMBER 2018

CONTOUR INTERVAL = 2'

NOTE: LOCATION AND DISTANCES SHOWN ARE APPROXIMATE.

NOTES:
1. BASE MAP REFERENCE: D.R. STRONG CONSULTING ENGINEERS, DELAPPE SHEEHAN / PRELIMINARY SUBDIVISION LAYOUT INFILTRATION VAULT OPTION, SHEET 1 OF 1, 6/28/18

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SITE AND EXPLORATION PLAN

DELAPPE SHEEHAN ASSEMBLAGE
KING COUNTY, WASHINGTON

PROJ NO.	DATE:	FIGURE:
180351H001	9/18	2

180351 Delappe Sheehan \ 180351H001 F2 S-E Plan.cdr

APPENDIX A

Exploration Logs

Coarse-Grained Soils - More than 50% [1] Retained on No. 200 Sieve	Gravels - More than 50% [1] of Coarse Fraction Retained on No. 4 Sieve	≤5% Fines [5]	GW	Well-graded gravel and gravel with sand, little to no fines
			GP	Poorly-graded gravel and gravel with sand, little to no fines
		≥12% Fines [5]	GM	Silty gravel and silty gravel with sand
			GC	Clayey gravel and clayey gravel with sand
	Sands - 50% [1] or More of Coarse Fraction Passes No. 4 Sieve	≤5% Fines [5]	SW	Well-graded sand and sand with gravel, little to no fines
			SP	Poorly-graded sand and sand with gravel, little to no fines
		≥12% Fines [5]	SM	Silty sand and silty sand with gravel
			SC	Clayey sand and clayey sand with gravel
Fine-Grained Soils - 50% [1] or More Passes No. 200 Sieve	Silts and Clays Liquid Limit Less than 50		ML	Silt, sandy silt, gravelly silt, silt with sand or gravel
			CL	Clay of low to medium plasticity; silty, sandy, or gravelly clay, lean clay
			OL	Organic clay or silt of low plasticity
	Silts and Clays Liquid Limit 50 or More		MH	Elastic silt, clayey silt, silt with micaceous or diatomaceous fine sand or silt
			CH	Clay of high plasticity, sandy or gravelly clay, fat clay with sand or gravel
			OH	Organic clay or silt of medium to high plasticity
Highly Organic Soils			PT	Peat, muck and other highly organic soils

Terms Describing Relative Density and Consistency

	Density	SPT [2] blows/foot
Coarse-Grained Soils	Very Loose	0 to 4
	Loose	4 to 10
	Medium Dense	10 to 30
	Dense	30 to 50
	Very Dense	>50
	Consistency	**SPT [2] blows/foot**
Fine-Grained Soils	Very Soft	0 to 2
	Soft	2 to 4
	Medium Stiff	4 to 8
	Stiff	8 to 15
	Very Stiff	15 to 30
	Hard	>30

Test Symbols

G = Grain Size
M = Moisture Content
A = Atterberg Limits
C = Chemical
DD = Dry Density
K = Permeability

Component Definitions

Descriptive Term	Size Range and Sieve Number
Boulders	Larger than 12"
Cobbles	3" to 12"
Gravel	3" to No. 4 (4.75 mm)
Coarse Gravel	3" to 3/4"
Fine Gravel	3/4" to No. 4 (4.75 mm)
Sand	No. 4 (4.75 mm) to No. 200 (0.075 mm)
Coarse Sand	No. 4 (4.75 mm) to No. 10 (2.00 mm)
Medium Sand	No. 10 (2.00 mm) to No. 40 (0.425 mm)
Fine Sand	No. 40 (0.425 mm) to No. 200 (0.075 mm)
Silt and Clay	Smaller than No. 200 (0.075 mm)

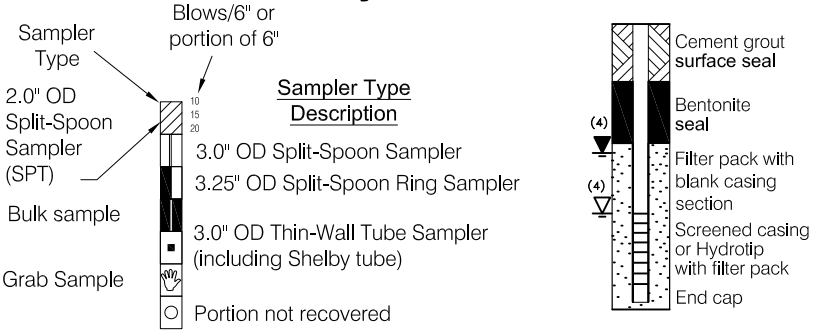
[3] Estimated Percentage

Component	Percentage by Weight
Trace	<5
Some	5 to <12
Modifier (silty, sandy, gravelly)	12 to <30
Very *modifier* (silty, sandy, gravelly)	30 to <50

Moisture Content

Dry - Absence of moisture, dusty, dry to the touch
Slightly Moist - Perceptible moisture
Moist - Damp but no visible water
Very Moist - Water visible but not free draining
Wet - Visible free water, usually from below water table

Symbols



(1) Percentage by dry weight
(2) (SPT) Standard Penetration Test (ASTM D-1586)
(3) In General Accordance with Standard Practice for Description and Identification of Soils (ASTM D-2488)
(4) Depth of ground water
▼ ATD = At time of drilling
▽ Static water level (date)
(5) Combined USCS symbols used for fines between 5% and 12%

Classifications of soils in this report are based on visual field and/or laboratory observations, which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field or laboratory testing unless presented herein. Visual-manual and/or laboratory classification methods of ASTM D-2487 and D-2488 were used as an identification guide for the Unified Soil Classification System.

LOG OF EXPLORATION PIT NO. EP-1

Depth (ft)

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.

DESCRIPTION

Fill

1 Loose, very moist, dark brown, silty, SAND, some gravel; areas of (5/8 inch) minus crushed rock; abundant roots (SM).

Weathered Vashon Recessional Outwash

2 Loose to medium dense, moist to very moist, reddish brown, gravelly, silty, SAND; abundant roots (SM).

3

Vashon Recessional Outwash

4 Medium dense, moist, grayish tan, very gravelly, fine to medium SAND; contains pockets of clayey, gravelly, sand (SP/SM).

Sand becomes medium to coarse grained, trace silt (SP).

5

6

Vashon Ice-Contact

7 Dense, moist, grayish tan, very gravelly, silty, SAND; cemented (SM).

8 Dense, moist, tan gray, very gravelly, medium to coarse SAND, trace silt; contains thin (<3 inches thick) silty lenses from 7 to 7.5 feet (till-like) (SP).

9

10 Becomes wet.

11 Bottom of exploration pit at depth 10 feet
Slow seepage at 10 feet. No caving.

12

13 Note: Installed a 1.25 inch piezometer to 10 feet; piezometer hand drilled (perforated) 7.5 to 10 feet.
Top of casing at 2.5 inches above ground surface.
Depth to water in piezometer is 9.4 feet below top of casing.

14

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Eiseles Delappe Assemblage
King County, WA

Logged by: NS

Approved by: JHS

associated earth sciences incorporated

Project No. 180096E001

3/2/18

KCTP3 180096.GPJ March 23, 2018

LOG OF EXPLORATION PIT NO. EP-2

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.

Depth (ft)	DESCRIPTION
	Fill
1	Loose to medium dense, very moist, dark brown, gravelly, very silty, SAND (SM).
	Weathered Vashon Recessional Outwash
2	Loose to medium dense, very moist, reddish brown, gravelly, silty, SAND; abundant roots (SM).
	Vashon Ice-Contact
3	Medium dense, moist, grayish tan, very gravelly, medium to coarse SAND, some silt; scattered cobbles (SM/SP).
4	
5	Becomes denser.
6	Trace silt. Contains pockets/lenses of silty, very gravelly, SAND up to 12 inches thick (till-like).
7	
8	Some silt (SP/SM).
9	Silty, till-like lenses becomes more frequent below 8 feet.
10	
11	Bottom of exploration pit at depth 10 feet No seepage. No caving.
12	
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Eiseles Delappe Assemblage
King County, WA

Logged by: NS
Approved by: JHS

associated earth sciences incorporated

Project No. 180096E001

3/2/18

KCTP3 180096.GPJ March 23, 2018

LOG OF EXPLORATION PIT NO. EP-3

Depth (ft)

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.

DESCRIPTION

Forest Duff / Topsoil - 3 inches

Weathered Vashon Lodgement Till

1 Loose to medium dense, moist, reddish brown, very silty, gravelly, SAND; abundant roots; wet at base (SM).

2

Vashon Lodgement Till

3 Very dense, moist, grayish tan, very silty, fine SAND; nonstratified (SM).

4 Becomes very moist below 4 feet.

5

6

7

Bottom of exploration pit at depth 7 feet
8 Slow, discontinuous seepage at ~1.5 feet. No caving.

9

10

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Eiseles Delappe Assemblage
King County, WA

Logged by: NS
Approved by: JHS

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Project No. 180096E001

3/2/18

KCTP3 180096.GPJ March 23, 2018

LOG OF EXPLORATION PIT NO. EP-4

Depth (ft)

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.

DESCRIPTION

Forest Duff / Topsoil - 4 inches

Weathered Vashon Recessional Outwash

1 Loose to medium dense, very moist, reddish brown, gravelly, silty, SAND; abundant roots (SM).

2

Vashon Recessional Outwash

3 Medium dense, moist, tan gray, very gravelly, medium to coarse SAND; contains thin (<1 inch thick) lenses of silty, fine sand (SP).

Vashon Lodgement Till

4 Very dense, moist, grayish tan, very silty, gravelly, SAND; scattered cobbles and boulders; nonstratified (SM).

5

6

7

Bottom of exploration pit at depth 7 feet
8 No seepage. No caving.

9

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Eiseles Delappe Assemblage
King County, WA

Logged by: NS

Approved by: JHS

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Project No. 180096E001

3/2/18

KCTP3 180096.GPJ March 23, 2018

LOG OF EXPLORATION PIT NO. IT-1

Depth (ft)

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.

DESCRIPTION

Topsoil / Forest Duff

Loose, moist, dark brown, very silty, medium SAND, some gravel; abundant organics (SM).

Weathered Vashon Recessional Outwash

Loose, moist, orangish brown, silty, fine SAND, some roots, trace gravel (SM).

Vashon Recessional Outwash

Loose to medium dense, moist, gray with faint iron oxide staining, gravelly, medium to coarse SAND, trace silt; occasional cobbles; faintly bedded with gravel (~1 to 2 inches thick) every 6 inches to 1 foot (SW).

Vashon Ice-Contact

Clasts of silty, coarse SAND; unsorted.

Difficult digging, very hard in eastern wall of pit, some bedding (3 to 6 inches thick) of alternating silty, SAND and sandy, SILT.
Occasional roots up to 7 feet.
Medium dense to dense, very moist, light brown, very silty, coarse SAND (SM).

Bottom of exploration pit at depth 11 feet
Slow seepage at 6.5 feet and slow to moderate seepage at 9.5 feet interpreted as return flow from infiltration test; pooling at 11 feet. Minor to moderate caving 2.5 to 5.5 feet. Infiltration test performed at 5 feet.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

Eisles Delappe Assemblage
King County, WA

Logged by: NS

Approved by: CJK

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Project No. 180096E002

3/27/18

KCTP3 180096E002.GPJ April 6, 2018

LOG OF EXPLORATION PIT NO. EP-5

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.

Depth (ft)	DESCRIPTION
	Topsoil
1	Loose, moist, dark brown, silty, SAND, trace gravel; abundant organics (SM).
	Weathered Vashon Recessional Outwash
2	Loose, moist, orangish brown, very silty, SAND, some gravel; abundant roots (SM).
	Vashon Recessional Outwash
3	Loose, moist, gray with iron oxide, gravelly, medium to coarse SAND, trace silt (SP). Loose to medium dense.
4	Excavator notes tighter at 4 feet, trace to some silt.
5	Excavator notes medium dense at 5 feet.
6	Silty beds (1 to 2 inches thick); clasts of medium dense, moist, light brown, SILT, some sand to sandy. Till-like clasts of very sandy, SILT with heavy iron oxide staining.
7	Increasing silt content.
	Vashon Ice-Contact
8	Difficult digging. Medium dense to dense, moist, light brown, very silty, medium SAND, some gravel (SM); contains clasts of sandy, SILT (ML); unsorted.
9	Medium dense to dense, very moist, brownish gray, medium SAND, some silt, trace gravel; some lightly consolidated clasts (SM).
10	
11	Medium dense to dense, very moist, light grayish brown, very silty, medium SAND, some gravel; slightly tacky (SM).
12	
13	Bottom of exploration pit at depth 12 feet No seepage. Minor to moderate caving 2.5 to 4.5 feet, very minor caving 4.5 to 7 feet.
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Eisles Delappe Assemblage
King County, WA

Logged by: NS
Approved by: CJK

associated earth sciences incorporated

Project No. 180096E002

3/27/18

KCTP3 180096E002.GPJ April 6, 2018

associated earth sciences incorporated

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
180096E002	EB-1W	1 of 1

Project Name	Eiseles Delappe Assemblage	Location	King County, WA
Elevation (Top of Well Casing)	343.18	Surface Elevation (ft)	343.36
Water Level Elevation	15.5	Date Start/Finish	3/28/18,3/29/18
Drilling/Equipment	Environmental Drilling / B53	Hole Diameter (in)	6 inches
Hammer Weight/Drop	140# / 30"		

Depth (ft)	Water Level	WELL CONSTRUCTION	ST	Blows/ 6"	Graphic Symbol	DESCRIPTION
		Flush Mount Monument Concrete Seal 0 to 2 feet				**Topsoil / Forest Duff** Loose, moist, dark brown, very silty, SAND, trace gravel; abundant organics (SM).
		Bentonite 2 to 17 feet		5 34 50/2"		**Vashon Recessional Outwash** Very dense, moist, gray with faint iron oxide, gravelly, silty, coarse SAND; contains broken rocks (SM).
5		2-inch I.D. Sch. 40 PVC well casing 0 to 20 feet		30 50/6"		Very dense, moist, gray, silty, gravelly, coarse SAND; difficult drilling with beds (1 inch thick) of light brown, sandy, silt, trace gravel (SM/ML).
				22 26 34		**Vashon Ice-Contact** Very dense, moist, light brown, very silty, coarse SAND, some gravel; cobbly drill chatter with beds (<1 inch thick) of very moist, gray, coarse SAND, trace silt; broken gravel; lightly consolidated (SM).
10				24 36 50/3"		Very dense, moist, gray, brown, silty, medium SAND, trace gravel; occasional large broken gravel; massive (SM).
				17 32 45		Very dense, very moist to wet, light brown, silty to very silty, medium SAND, trace to some gravel; occasional rounded gravel; one angular black fragment; slightly tacky (SM).
15	▼			28 50/3"		**Vashon Advance Outwash** Very dense, wet, dark gray, coarse SAND, some gravel to gravelly, some tan silt; massive (SP).
		10/20 Colorado silica sand pack 17 to 30 feet		50/6"		Very dense, very wet, tan, silty, coarse SAND, some gravel (SM).
						Very dense, wet, gray, SAND, some silt, trace gravel (SP).
20				47 50/3"		Very dense, wet, brown gray, coarse SAND, some silt, trace gravel; occasional interbeds (1 to 2 inches thick) of gravel (SP).
		2-inch I.D. Sch. 40 PVC well screen 20 to 30 feet		36 50/3"		Very dense, wet, gray, very gravelly, coarse SAND, trace silt; bedded (2 to 3 inches thick) with medium SAND, round, fine gravel, and occasional large gravel; some drill chatter (SP).
25				36 50/2"		Very dense, wet, gray, rounded, fine GRAVEL, some sand to sandy, trace silt; contains a thick bed of very coarse SAND in upper 1/3 of the spoon; driller notes blowcounts are overstated; looks pebbly???? (GP).
				37 50/5"		Very dense, wey brown gray, gravelly, coarse SAND, trace to some silt (SP). 2 inch thick bed of fine to medium SAND, trace to some silt. Moist, gray, silt clast in shoe.
30		Threaded end cap		26 32 50/4"		Very dense, wet, brownish gray, very sandy, rounded, fine GRAVEL, trace silt; thick bed of medium to coarse SAND in the top 1/3 of spoon (GP).
		Well Tag # BKH-531				Boring terminated at 31.5 feet. Well completed at 30 feet on 3/29/18. Groundwter encountered at 15.5 feet.
35						

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample

M - Moisture

- Water Level ()
- Water Level at time of drilling (ATD)

Logged by: NS

Approved by: CJK

NWWELL- B 180096.GPJ BORING.GDT 4/6/18

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Exploration Log

Project Number	Exploration Number	Sheet
180096E002	EB-2	1 of 1

Project Name	Eiseles Delappe Assemblage	Ground Surface Elevation (ft)	349.97
Location	King County, WA	Datum	NAVD88
Driller/Equipment	Environmental Drilling / B53	Date Start/Finish	3/28/18,3/29/18
Hammer Weight/Drop	140# / 30"	Hole Diameter (in)	6 inches

Depth (ft)	ST	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Water Level	Blows/6"	Blows/Foot (10 20 30 40)	Other Tests
				Topsoil / Forest Duff					
				Vashon Ice-Contact					
5		S-1		Very dense, moist, light brownish gray, silty, coarse SAND, some gravel to gravelly; broken gravel near shoe; some till like clasts (SM).			16 50/6"		50/6"
10		S-2		Very dense, moist, light brown, very silty, gravelly, medium to coarse SAND; slightly plastic; rock fragments in shoe, blowcounts likely overstated; non-bedded (SM).			50/6"		50/6"
		S-3		Very dense, moist, light grayish brown, silty, medium SAND, some gravel to gravelly; "jumbled"; non-bedded (SM).			50/6"		50/6"
15		S-4		Very dense, very moist, light gray brown, silty to very silty, medium SAND, some gravel; lightly consolidated; slightly plastic; driller notes rock while driving hammer; non-bedded (SM).			42 50/3"		50/3"
		S-5		Very dense, very moist, brownish gray, silty, medium SAND, trace fine gravel; faintly bedded (<1 inch thick); fine rounded gravel (SM).			50/6"		50/6"
20		S-6		Very dense, wet, light brown, silty, medium SAND, trace gravel; occasional large gravel; massive (SP).		▼	26 50/6"		50/6"
				Vashon Advance Outwash					
		S-7		Very dense, light brown and dark gray, medium to coarse SAND, trace to some silt, trace gravel; contains beds (1 inch thick) of rounded gravel and beds (3 inches thick) of fine to medium sand (SP-SM).			40 39 46		85
25		S-8		Very dense, wet, light brown and dark gray, slightly silty, very sandy, fine GRAVEL; faintly bedded (<1 inch thick) with alternating fine gravel and coarse sand; upper 1/3 of spoon is fairly clean medium sand, interpreted as slough (GP-GM).			5 16 50/5"		50/5"
		S-9		Very dense, wet, light brown and gray, slightly silty, medium to coarse SAND, trace gravel; driller suggests heave; contains a bed (4 inches thick) of silty, medium sand near bottom; black fragment in shoe (SP-SM).			5 7 50/3"		50/3"
30		S-10		Very dense, wet, dark gray, medium to coarse SAND, trace silt, trace gravel; contains bed (1 inch thick) of fine gravel near shoe (SP).			11 50/4"		50/4"
		S-11		Very dense, wet, dark gray, medium SAND, grading to coarse SAND to GRAVEL, trace silt (SP/GP).			39 50/2"		50/2"
35				Bottom of exploration boring at 34 feet Groundwter encountered at 21 feet.					

Sampler Type (ST):

- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample

M - Moisture

- Water Level ()
- Water Level at time of drilling (ATD)

Logged by: NS

Approved by: CJK

AESIBOR 180096.GPJ April 6, 2018

LOG OF EXPLORATION PIT NO. EP-6

Depth (ft)

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.

DESCRIPTION

Forest Duff / Organic Debris - 6 inches

Fill

1 — Medium stiff, dry, light brown, gravelly, sandy, SILT; occasional cobbles and rubbish (wires, metal, plastic) (ML).

2 —

Vashon Lodgement Till

Dense, slightly moist, light olive with faint iron oxide, very silty, gravelly, fine SAND; occasional cobbles; lightly cemented; unsorted (SM).

3 —

Roots 0 to 4 feet.

4 — As above, stiff to hard, less to no iron oxide, occasional cobbles; cemented.

5 —

6 —

Bottom of exploration pit at depth 6 feet
No seepage. No caving.

7 —

8 —

9 —

10 —

11 —

12 —

13 —

14 —

15 —

16 —

17 —

18 —

19 —

20 —

Sheehan Property
Sammamish, WA

Logged by: NS

Approved by: CJK

associated earth sciences incorporated

Project No. 180351E001

7/16/18

KCTP3 180351.GPJ July 25, 2018

LOG OF EXPLORATION PIT NO. EP-7

Depth (ft)

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.

DESCRIPTION

Fill

1 — Medium stiff, dry, light brown, gravelly, sandy, SILT (ML).

Weathered Vashon Lodgement Till

2 — Medium stiff, dry, light tan, gravelly, sandy, SILT; occasional cobbles; abundant roots (ML).

Vashon Lodgement Till

3 — Very dense, moist, light olive, very silty, gravelly, fine SAND; occasional cobbles; cemented; unsorted (SM).

4 — Roots 0 to 4 feet.

5

6 — Increasing moisture content, darker olive color.

7 — Increasing sand content.

8 — Very dense, moist, silty, gravelly, fine SAND; cemented; unsorted (SM).

9 — Bottom of exploration pit at depth 8.5 feet
No seepage. No caving.

10

11

12

13

14

15

16

17

18

19

20

Sheehan Property
Sammamish, WA

Logged by: NS
Approved by: CJK

associated earth sciences incorporated

Project No. 180351E001

7/16/18

KCTP3 180351.GPJ July 25, 2018

LOG OF EXPLORATION PIT NO. EP-8

Depth (ft)

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.

DESCRIPTION

Forest Duff / Topsoil - 4 inches

Weathered Vashon Lodgement Till

1 Soft, dry, orangish brown, gravelly, sandy, SILT; occasional cobbles; abundant roots (ML).

2

Vashon Lodgement Till

3 Medium dense, slightly moist, light olive, very silty, gravelly, fine SAND; occasional cobbles; occasional roots; cemented; unsorted (SM).

Grades to hard.

4 Roots 0 to 3.5 feet.

Very dense, slightly moist, light gray, silty, gravelly, fine SAND; occasional to frequent cobbles;

5 cemented; unsorted (SM).

6 Grades to moist.

7 Moist, as above.

8 Bottom of exploration pit at depth 7.5 feet
No seepage. No caving.

9

10

11

12

13

14

15

16

17

18

19

20

Sheehan Property
Sammamish, WA

Logged by: NS

Approved by: CJK

associated earth sciences incorporated

Project No. 180351E001

7/16/18

KCTP3 180351.GPJ July 25, 2018

LOG OF EXPLORATION PIT NO. EP-9

Depth (ft)

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.

DESCRIPTION

Forest Duff - 4 inches

Weathered Vashon Lodgement Till / Fill

1 Eastern half of pit: Medium stiff, slightly moist, orangish brown, gravelly, sandy, SILT (ML).

West half of pit: Lens of clean, well graded sand and fine gravel with occasional cut rock blocks.

2

Vashon Lodgement Till

Roots 0 to 3 feet.

3

4 Dense, moist, light gray, silty, gravelly, fine SAND; occasional cobbles; cemented; unsorted (SM).

5

6 Occasional boulders.

7 As above.

8 Bottom of exploration pit at depth 7.5 feet
No seepage. Minor caving 0 to ~2 feet.

9

10

11

12

13

14

15

16

17

18

19

20

Sheehan Property
Sammamish, WA

Logged by: NS

Approved by: CJK

associated earth sciences incorporated

Project No. 180351E001

7/16/18

KCTP3 180351.GPJ July 25, 2018

LOG OF EXPLORATION PIT NO. IT-2

Depth (ft)

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.

DESCRIPTION Elev: 341.5 ft

Sod - 1 inch

Fill

1 Dry, dark brown grading to tan, fine sandy, SILT; abundant wood debris (stump?); occasional cobbles (ML).

2

3

Vashon Recessional Outwash

4 Medium dense to dense, slightly moist, grayish brown, gravelly, medium to coarse SAND, trace to some silt; occasional cobbles; occasional till clasts (SP-SM).

5 Faintly to somewhat stratified 3.5 to 7 feet. Beds dipping slightly to north west.

6

7

Stratified 7 to 9.5 feet.

8

9

Vashon Advance Outwash

10 Dense, wet, brown, gravelly, medium to coarse SAND, some grading to trace silt: occasional cobbles; stratified (SP-SM).

11

12 Bottom of exploration pit at depth 11.5 feet
Moderate to rapid seepage at 8 feet interpreted as return flow from infiltration test. Groundwater pooling to 11 feet. No caving.
Infiltration test performed at 4.5 feet.

13

14

15

Sheehan Property
King County, WA

Logged by: NS

Approved by: CJK

associated earth sciences incorporated

Project No. 180351H001

9/6/18

KCTP3 180351H001.GPJ September 12, 2018

LOG OF EXPLORATION PIT NO. EP-10

Depth (ft)

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.

DESCRIPTION Elev: 342 ft

Sod - 2 inches

Topsoil

1

Weathered Vashon Recessional Outwash

Medium dense, slightly moist, orangish brown, very silty, gravelly, fine to medium SAND; scattered roots (SM).

2

Vashon Recessional Outwash

Medium dense, slightly moist, brownish gray, very gravelly, medium to coarse SAND, trace silt; occasional cobbles; stratified (SP).

3

4

Operator notes "tight"; contains till clasts.

5

6

Vashon Advance Outwash

Medium dense to dense, moist grading to wet, grayish brown to brown, silty, gravelly, medium to coarse SAND; slightly sticky grading to very sticky; occasional cemented clasts grading to none; stratified (SM).

7

8

9

10

11

Bottom of exploration pit at depth 11 feet
No seepage. No caving.

12

13

14

15

KCTP3 180351H001.GPJ September 12, 2018

Sheehan Property
King County, WA

Logged by: NS

Approved by: CJK

associated earth sciences incorporated

Project No. 180351H001

9/6/18

APPENDIX B

Infiltration Test Data Sheets

FIELD INFILTRATION TESTING DATA

Project Name	Eiseles Delappe Assemblage	**Water Source**	Water Truck
Project No.	180096E001	**Meter**	AESI FM XXXX
Date	3/27/2018	**Pit Area**	3ft x 4 1/2ft = 13 1/2 ft
Test No.	IT-1	**Test Depth**	5 ft
Performed By	SNS	**Test Material**	Recessional outwash

Time (24-hr)	Totalizer (gallon)	Flow Rate (gpm)	Stage (ft)	Comments
9:21:00	0.0	20.3	0.00	Flow on.
9:36:00	99.9	4.7	0.50	Decrease flow.
9:51:00	155.2	3.64	0.56	
10:08:00	214.0	3.36	0.60	Reduced flow
10:23:00	263.7	3.17	0.61	
10:38:00	307.8	3.06	0.62	
10:53:00	353.6	3.06	0.62	Minor sloughing at 3 1/2 to 4 1/2 feet.
11:08:00	399.5	3.04	0.63	
11:09:00	402.4	0	0.63	Switch flow meter. Water off.
11:13:00	402.4	2.02	0.54	Water on. Valve fully open.
11:28:00	432.1	2.03	0.50	
11:43:00	462.6	2.03	0.47	
12:01:00	494.8	2.03	0.44	
12:09:00		2.77		Pump on to increase pressure.
12:16:00	536.7	2.6	0.52	
12:31:00	575.7	2.38	0.54	
12:46:00	608.0	2.2	0.55	
13:01:00	640.8	2.21	0.55	
13:16:00	674.9	2.22	0.55	
13:33:00	711.8	2.23	0.55	
13:53:00	757.1	2.23	0.55	
13:58:00	767.2	2.22	0.55	Flow meter check with bucket. Flow stopped.
14:04:00	772.4	2.21	0.42	Flow on. Interim FH rate 15.6 iph
14:19:00	805.2	2.22	0.46	
14:35:00	840.9	2.22	0.48	
14:50:00	873.6	2.16	0.50	
15:05:00	905.6	2.13	0.50	
15:21:00	939.0	2.09	0.50	Begin last hour of constant head.
15:31:00	954.8	2.09	0.50	
15:41:00	980.9	2.09	0.50	
15:51:00	1001.7	2.09	0.50	
16:01:00	1022.6	2.09	0.50	
16:11:00	1043.6	2.09	0.50	
16:21:00	1064.1	2.09	0.50	Flow off, begin falling head
16:22:40			0.46	
16:24:10			0.44	
16:25:50			0.40	
16:27:45			0.36	Area decreasing, about 12.5 sf
16:29:50			0.32	
16:31:30			0.28	Area decreasing, about 11 sf
16:33:40			0.22	Area decreasing, about 10.5 sf
16:36:15			0.16	Wetted area not representative (22"x34" = 5.2 sf). Test terminated.

Project Name	Sheehan Property	**Water Source**	Water Truck
Project No.	180351 H001	**Meter**	NW Excavating 3 - 30 gmp
Date	9/6/2018	**Pit Area**	3' x 6'-4" = 19 sf
Test No.	IT-2	**Test Depth**	4.5
Performed By	SNS	**Test Material**	Vashon Recessional Outwash

Time (24-hr)	Totalizer (gallons)	Flow Rate (gpm)	Stage (ft)	Comments
8:45:00	0.0	12.71	0.00	water on
8:46:00	28.8	19.24	0.10	
8:48:00	68.7	19.04	0.30	test area flooded at 0.2 feet water
8:50:30	108.0	11.47	0.40	
8:52:00	121.5	8.63	0.40	
8:55:00	150.7	10.2	0.38	
9:00:00	199.7	10.2	0.39	decrease flow
9:05:00	245.7	9.13	0.38	increase flow
9:10:00	294.9	9.62	0.38	increase flow
9:15:00	342.0	9.7	0.38	
9:30:00	487.2	9.66	0.38	
9:45:00	632.1	9.66	0.39	decrease flow
10:01:30	790.6	9.61	0.39	
10:30:00	1066.0	9.56	0.39	
10:45:00	1207.9	9.56	0.40	
10:50:00	1253.6	9.56	0.40	calibration tests
10:53:40	1253.6	8.66	0.10	water on
11:00:00	1325.1	12.34	0.32	decrease flow
11:15:00	1480.0	9.38	0.40	
11:30:00	1620.9	9.48	0.40	
11:45:00	1765.4	9.68	0.41	decrease flow
12:00:00	1908.6	9.66	0.42	decrease flow
12:15:00	2051.8	9.58	0.42	
12:30:00	2195.3	9.58	0.43	decrease flow
12:45:00	2337.6	9.46	0.43	
13:00:00	2479.4	9.38	0.43	
13:20:00	2663.4	9.08	0.41	
13:30:00	2754.1	9.03	0.40	
13:45:00	2889.0	8.98	0.39	increase flow
13:47:00		9.4	0.39	
13:49:45		9.52		turn pump on
13:51:30	2949.2	9.54	0.40	adjust flow
14:00:00	3029.6	9.4	0.42	
14:15:00	3170.9	9.42	0.44	
14:30:00	3308.9	9.24	0.44	
14:45:00	3448.0	9.26	0.43	end soak period, begin constant head
15:00:00	3586.3	9.21	0.43	
15:10:00	3678.9	9.28	0.43	
15:20:00	3771.4	9.21	0.43	
15:30:00	3863.4	9.2	0.43	
15:32:07	3881.8	9.2	0.43	Out of water, end constant head
15:32:34	3881.8	0	0.36	begin falling head
15:32:52	3881.8	0	0.34	
15:33:09	3881.8	0	0.32	
15:33:24	3881.8	0	0.30	
15:33:59	3881.8	0	0.28	
15:34:21	3881.8	0	0.24	A = approx. 17 sf
15:34:53	3881.8	0	0.20	A = approx. 13 sf

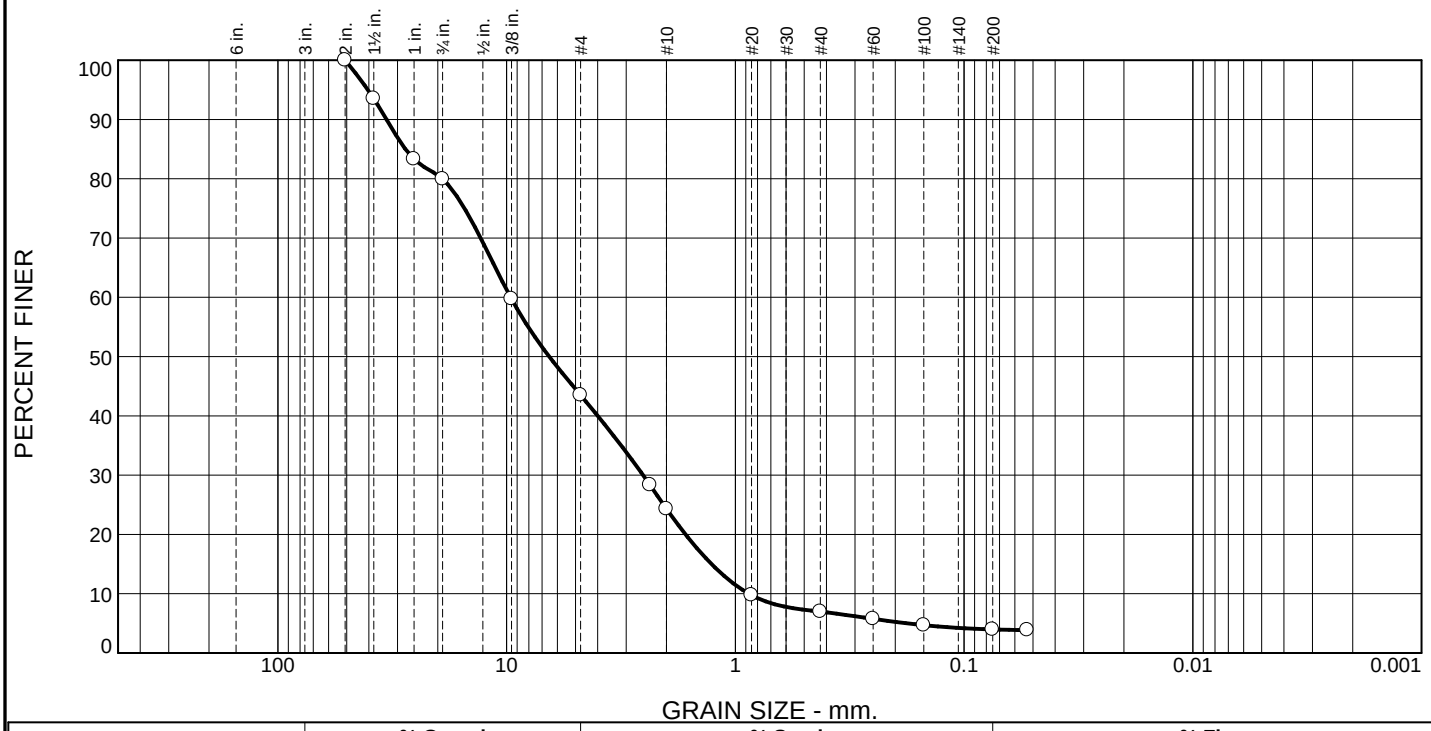
Project Name	Sheehan Property	**Water Source**	Water Truck
Project No.	180351 H001	**Meter**	NW Excavating 3 - 30 gmp
Date	9/6/2018	**Pit Area**	3' x 6'-4" = 19 sf
Test No.	IT-2	**Test Depth**	4.5
Performed By	SNS	**Test Material**	Vashon Recessional Outwash

Time (24-hr)	Totalizer (gallons)	Flow Rate (gpm)	Stage (ft)	Comments
15:35:16	3881.8	0	0.18	A = approx. 4 sf, end falling head

APPENDIX C

Laboratory Test Results

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	20.1	36.4	19.2	17.3	3.0	4.0	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2	100.0		
1.5	93.5		
1	83.3		
.75	79.9		
.375	59.7		
#4	43.5		
#8	28.3		
#10	24.3		
#20	9.8		
#40	7.0		
#60	5.8		
#100	4.7		
#200	4.0		
#270	3.8		

* (no specification provided)

Material Description

very sandy, GRAVEL, trace silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=**

Classification

USCS (D 2487)= GP **AASHTO (M 145)=** A-1-a

Coefficients

D_{90}= 33.5251 D_{85}= 27.7127 D_{60}= 9.6073
D_{50}= 6.5137 D_{30}= 2.5325 D_{15}= 1.2715
D_{10}= 0.8730 C_u= 11.00 C_c= 0.76

Remarks

Collected by: SNS

Date Received: 03/13/2018 **Date Tested:** 03/15/2018

Tested By: BN

Checked By: KDM

Title:

Location: Onsite
Sample Number: EP-1 **Depth:** 7.5'-8'

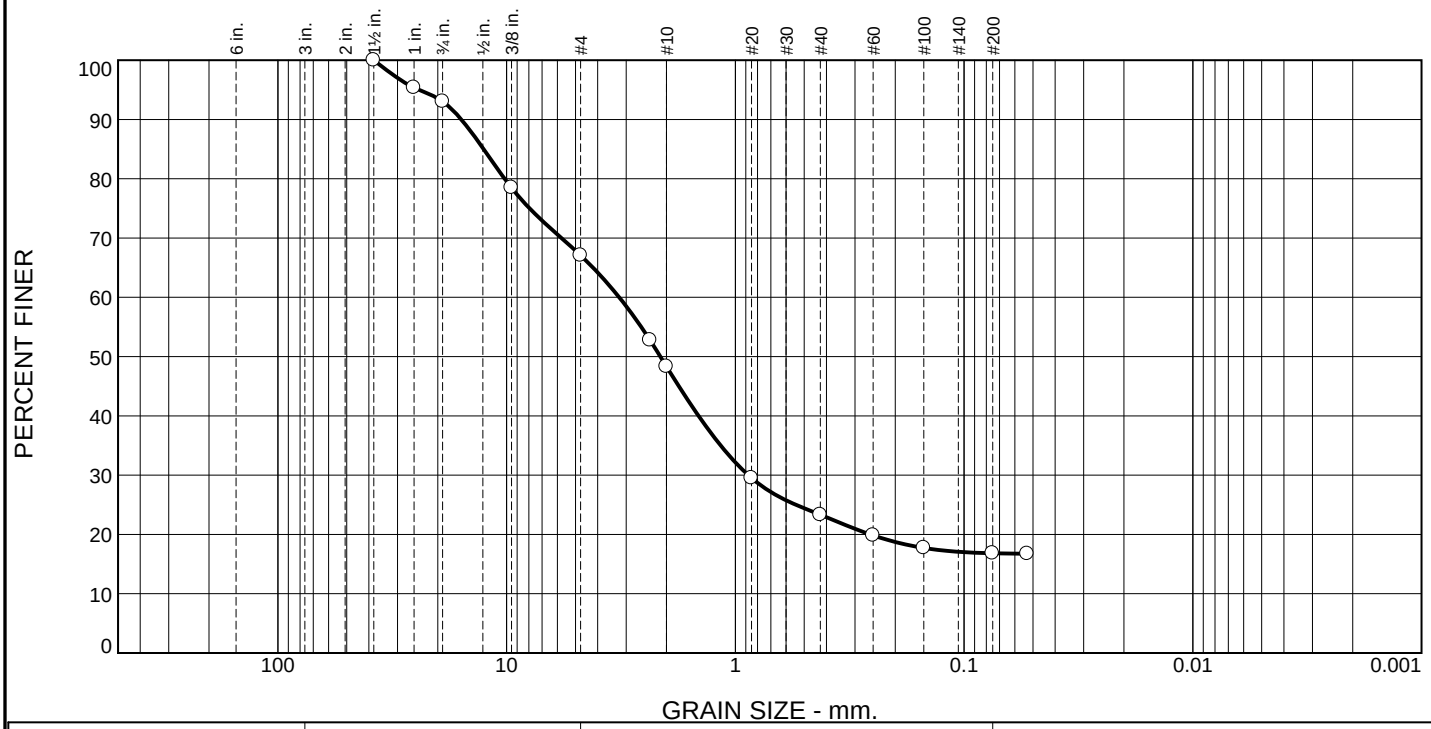
Date Sampled: 03/02/2018

associated earth sciences incorporated

Client: Toll Bros. Inc
Project: Eiseles Dleappe Assemblge

Project No: 180096 E001 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	7.0	25.9	18.8	25.0	6.5	16.8	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5	100.0		
1	95.4		
.75	93.0		
.375	78.5		
#4	67.1		
#8	52.8		
#10	48.3		
#20	29.5		
#40	23.3		
#60	19.8		
#100	17.7		
#200	16.8		
#270	16.7		

* (no specification provided)

Material Description

very gravelly, silty, SAND

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=**

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 15.7744 D_{85}= 12.6043 D_{60}= 3.2197
D_{50}= 2.1285 D_{30}= 0.8785 D_{15}=
D_{10}= C_u= C_c=

Remarks

Collected by: SNS

Date Received: 03/13/2018 **Date Tested:** 03/15/2018

Tested By: BN

Checked By: KDM

Title:

Location: Onsite
Sample Number: EP-2 **Depth:** 9'-10'

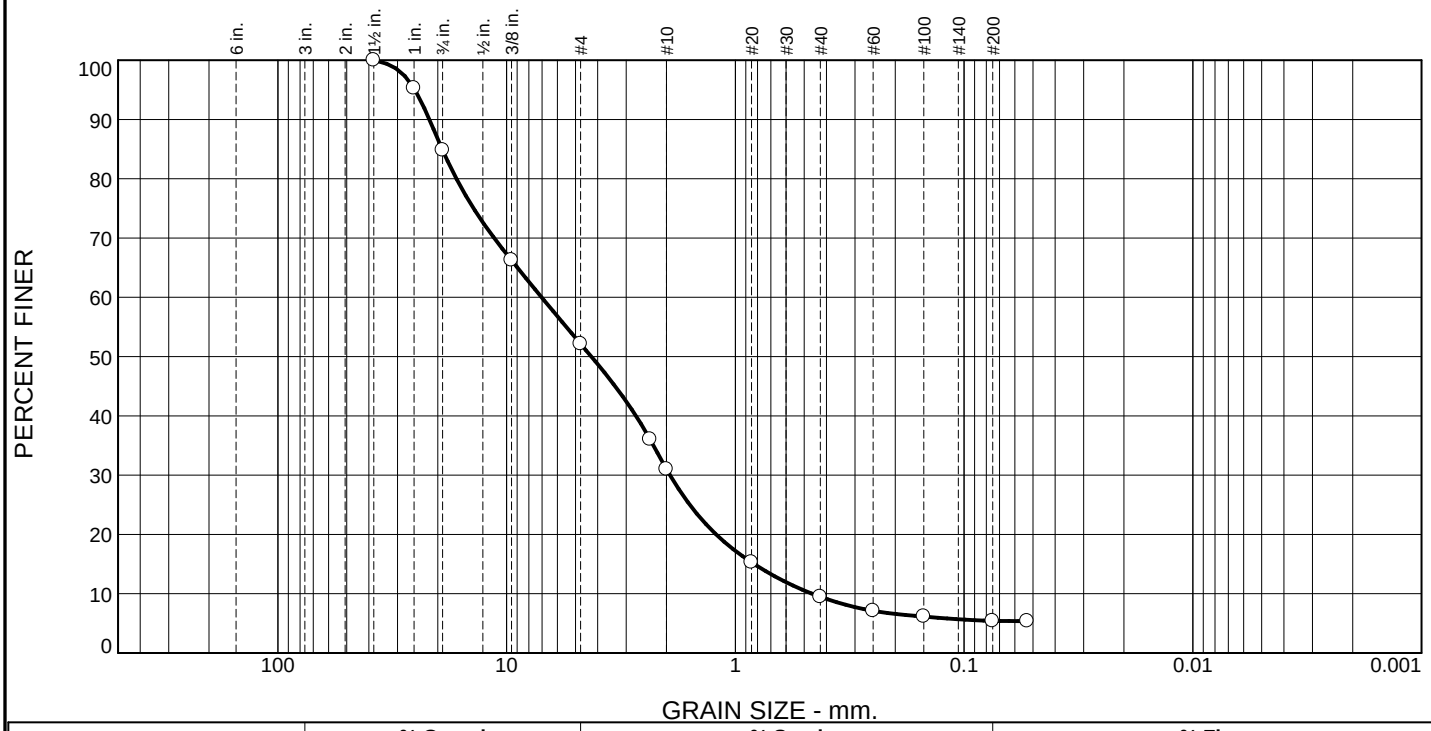
Date Sampled: 03/02/2018

associated earth sciences incorporated

Client: Toll Bros. Inc
Project: Eiseles Dleappe Assemblge

Project No: 180096 E001 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	15.2	32.7	21.1	21.5	4.1	5.4	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5	100.0		
1	95.3		
.75	84.8		
.375	66.3		
#4	52.1		
#8	36.0		
#10	31.0		
#20	15.3		
#40	9.5		
#60	7.1		
#100	6.1		
#200	5.4		
#270	5.4		

* (no specification provided)

Material Description

very sandy GRAVEL, some silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=**

Classification

USCS (D 2487)= GW-GM **AASHTO (M 145)=** A-1-a

Coefficients

D_{90}= 21.7650 D_{85}= 19.1423 D_{60}= 7.0325
D_{50}= 4.2633 D_{30}= 1.9319 D_{15}= 0.8272
D_{10}= 0.4626 C_u= 15.20 C_c= 1.15

Remarks

Collected by: SNS

Date Received: 08/01/2018 **Date Tested:** 08/03/2018

Tested By: BN

Checked By: KDM

Title:

Location: Onsite
Sample Number: IT-5 **Depth:** 5'

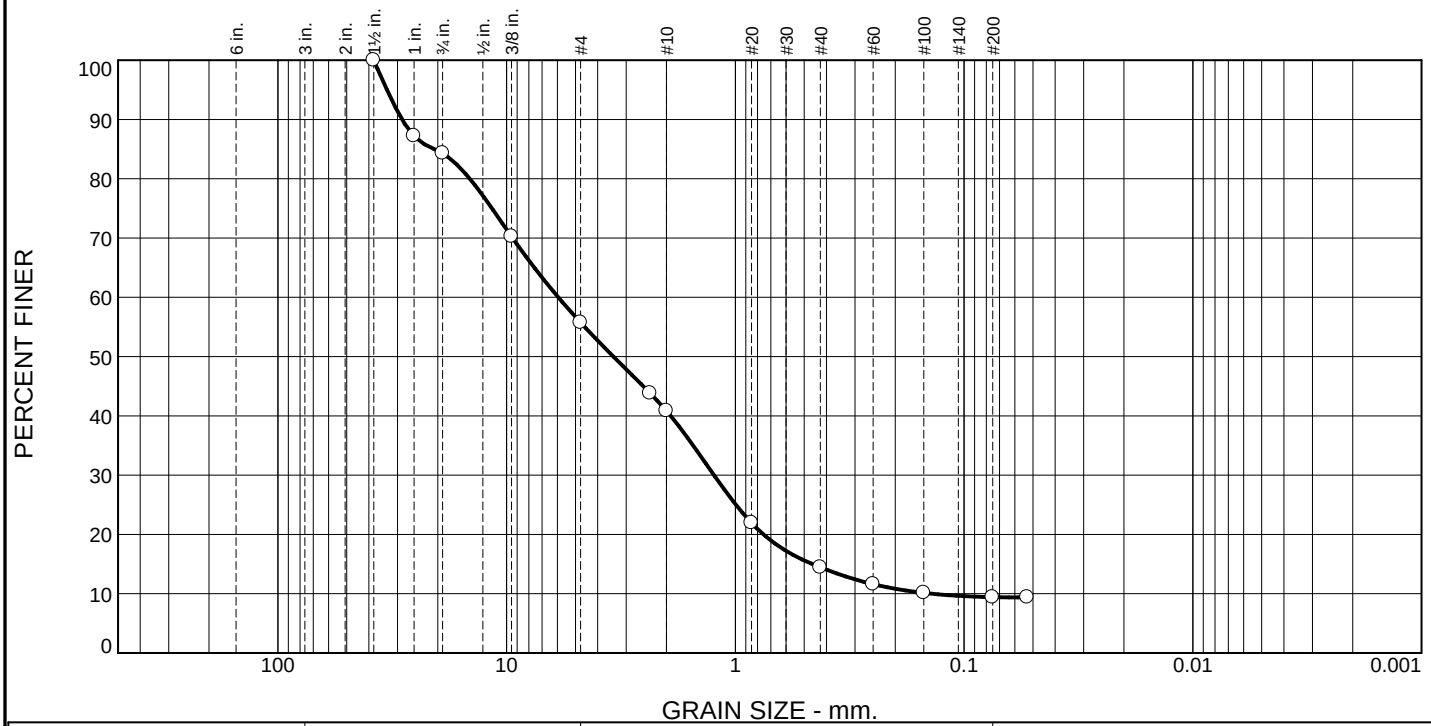
Date Sampled: 03/27/2018

associated earth sciences incorporated

Client: Toll Bros. Inc
Project: Eiseles Dleappe Assemblge

Project No: 180096 E001 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	15.7	28.6	14.9	26.4	5.0	9.4	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5	100.0		
1	87.2		
.75	84.3		
.375	70.3		
#4	55.7		
#8	43.8		
#10	40.8		
#20	21.9		
#40	14.4		
#60	11.6		
#100	10.1		
#200	9.4		
#270	9.4		

* (no specification provided)

Material Description

very gravelly SAND, some silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=**

Classification

USCS (D 2487)= SW-SM **AASHTO (M 145)=** A-1-a

Coefficients

D_{90}= 28.6406 D_{85}= 20.7144 D_{60}= 5.9457
D_{50}= 3.4117 D_{30}= 1.2402 D_{15}= 0.4607
D_{10}= 0.1386 C_u= 42.89 C_c= 1.87

Remarks

Collected by: SNS

Date Received: 09/07/2018 **Date Tested:** 09/11/2018

Tested By: BN

Checked By: KDM

Title:

Location: Onsite
Sample Number: IT-2 **Depth:** 4' 3"

Date Sampled: 09/06/2018

associated earth sciences incorporated

Client: Toll Brothers, Inc
Project: Sheehan

Project No: 180351 H001 **Figure**

APPENDIX D

Groundwater Mounding Analysis

MODRET

SUMMARY OF UNSATURATED & SATURATED INPUT PARAMETERS

PROJECT NAME : Sammamish 18th Assemblage - Peak Flow
HYDROGRAPH RUNOFF DATA USED
UNSATURATED ANALYSIS INCLUDED

Pond Bottom Area	8,000.00 ft²
Pond Volume between Bottom & DHWL	48,000.00 ft³
Pond Length to Width Ratio (L/W)	1.25
Elevation of Effective Aquifer Base	330.00 ft
Elevation of Seasonal High Groundwater Table	334.50 ft
Elevation of Starting Water Level	337.50 ft
Elevation of Pond Bottom	337.50 ft
Design High Water Level Elevation	343.50 ft
Avg. Effective Storage Coefficient of Soil for Unsaturated Analysis	0.25
Unsaturated Vertical Hydraulic Conductivity	30.00 ft/d
Factor of Safety	2.00
Saturated Horizontal Hydraulic Conductivity	135.00 ft/d
Avg. Effective Storage Coefficient of Soil for Saturated Analysis	0.25
Avg. Effective Storage Coefficient of Pond/Exfiltration Trench	1.00
Time Increment During Storm Event	24.00 hrs
Time Increment After Storm Event	24.00 hrs
Total Number of Increments After Storm Event	6.00

Runoff Hydrograph File Name: Sammamish 18th Assemblage Peak Flow

Time of Peak Runoff: 384.00 hrs

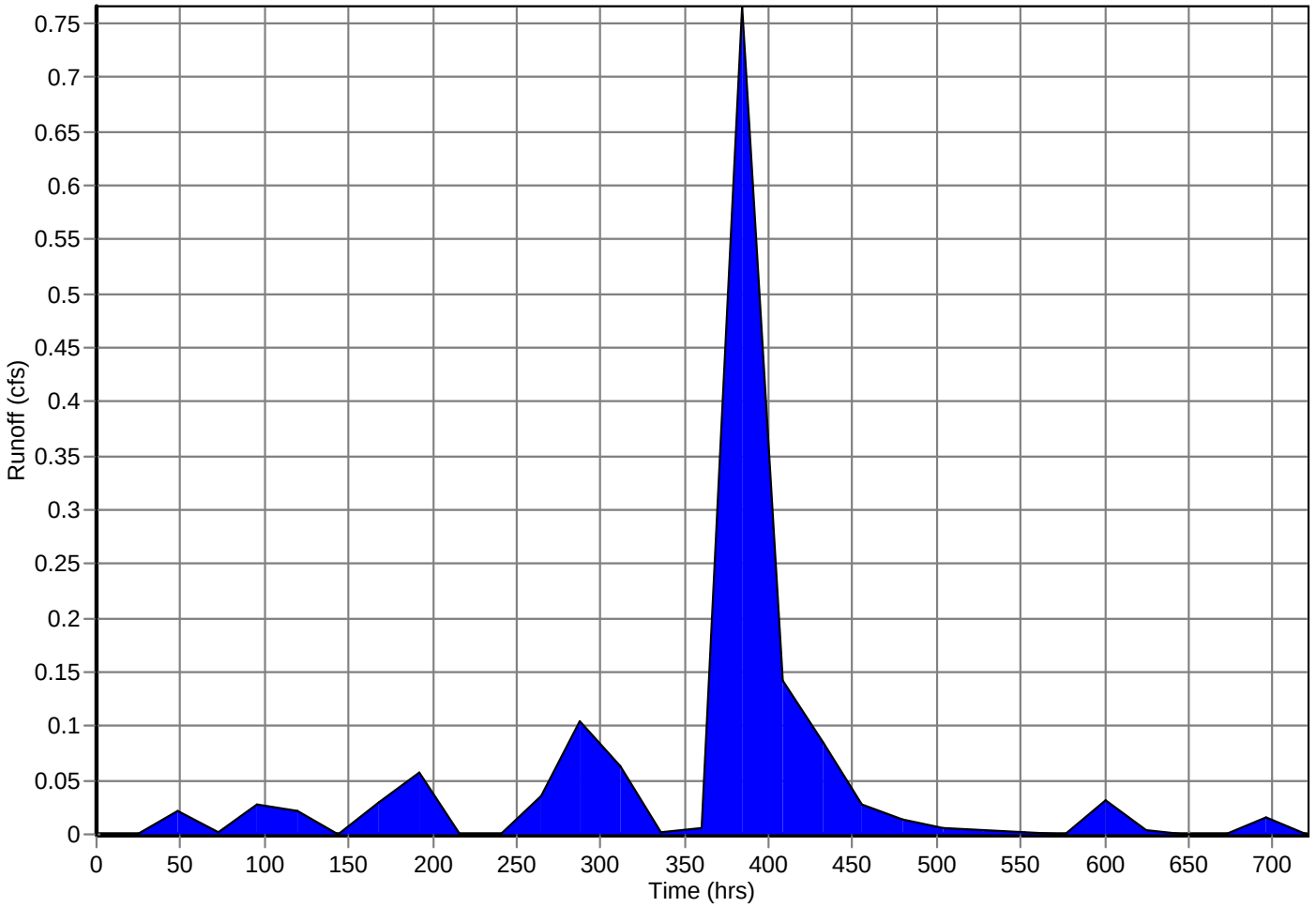
Rate of Peak Runoff: 0.77 cfs

Hydraulic Control Features:

	Top	Bottom	Left	Right
Groundwater Control Features - Y/N	N	N	N	N
Distance to Edge of Pond	0.00	0.00	0.00	0.00
Elevation of Water Level	0.00	0.00	0.00	0.00
Impervious Barrier - Y/N	N	N	N	N
Elevation of Barrier Bottom	0.00	0.00	0.00	0.00

Analysis Date: 9/24/2018

HYDROGRAPH : Sammamish 18th Assemblage Peak Flow



Qpeak: 0.7658 cfs Time of peak: 384.0 hrs Vtotal: 127,276 ft³

MODRET

SUMMARY OF RESULTS

PROJECT NAME : Sammamish 18th Assemblage - Peak Flow

CUMULATIVE TIME (hrs)	WATER ELEVATION (feet)	INSTANTANEOUS INFILTRATION RATE (cfs)	AVERAGE INFILTRATION RATE (cfs)	CUMULATIVE OVERFLOW (ft^3)
00.00 - 24.00	334.500	0.000 *		
			0.00000	
24.00	334.500	0.01537		
			0.03531	
168.00	337.500	0.05526		0.00
			0.05858	
192.00	337.500	0.05034		0.00
			0.04210	
216.00	337.500	0.03284		0.00
			0.02358	
240.00	337.500	0.02367		0.00
			0.02377	
264.00	337.500	0.03443		0.00
			0.04509	
288.00	337.500	0.05178		0.00
			0.05847	
312.00	337.500	0.05005		0.00
			0.04164	
336.00	337.500	0.03315		0.00
			0.02467	
360.00	337.500	0.11053		0.00
			0.19639	
384.00	337.802	0.24892		0.00
			0.30145	
408.00	339.450	0.23591		0.00
			0.17036	
432.00	338.837	0.14037		0.00
			0.11037	
456.00	338.257	0.09078		0.00

Analysis Date: 9/24/2018

MODRET

SUMMARY OF RESULTS

PROJECT NAME : Sammamish 18th Assemblage - Peak Flow

CUMULATIVE TIME (hrs)	WATER ELEVATION (feet)	INSTANTANEOUS INFILTRATION RATE (cfs)	AVERAGE INFILTRATION RATE (cfs)	CUMULATIVE OVERFLOW (ft^3)
			0.07119	
480.00	337.715	0.06034		0.00
			0.04949	
492.19	337.500	0.04277		0.00
			0.03605	
528.00	336.958	0.03167		0.00
			0.02729	
552.00	336.691	0.02428		0.00
			0.02127	
576.00	336.475	0.02284		0.00
			0.02441	
600.00	336.392	0.02456		0.00
			0.02471	
624.00	336.321	0.02086		0.00
			0.01700	
648.00	336.162	0.01507		0.00
			0.01313	
672.00	336.027	0.01372		0.00
			0.01430	
696.00	335.963	0.01410		0.00
			0.01390	
720.00	335.902	0.01179		0.00
			0.00968	
744.00	335.797	0.00880		0.00
			0.00792	
768.00	335.712	0.00732		0.00
			0.00671	
792.00	335.639	0.00628		0.00

Analysis Date: 9/24/2018

MODRET

SUMMARY OF RESULTS

PROJECT NAME : Sammamish 18th Assemblage - Peak Flow

CUMULATIVE TIME (hrs)	WATER ELEVATION (feet)	INSTANTANEOUS INFILTRATION RATE (cfs)	AVERAGE INFILTRATION RATE (cfs)	CUMULATIVE OVERFLOW (ft^3)
			0.00585	
816.00	335.576	0.00551		0.00
			0.00517	
840.00	335.520	0.00489		0.00
			0.00461	
864.00	335.470			0.00

Maximum Water Elevation: 339.450 feet @ 408.00 hours Recovery @ 492.192 hours

* Time increment when there is no runoff

Maximum Infiltration Rate: 3.256 ft/day

Analysis Date: 9/24/2018

MODRET

SUMMARY OF UNSATURATED & SATURATED INPUT PARAMETERS

PROJECT NAME : Sammamish 18th Assemblage - Max Volume
HYDROGRAPH RUNOFF DATA USED
UNSATURATED ANALYSIS INCLUDED

Pond Bottom Area	8,000.00 ft²
Pond Volume between Bottom & DHWL	48,000.00 ft³
Pond Length to Width Ratio (L/W)	1.25
Elevation of Effective Aquifer Base	330.00 ft
Elevation of Seasonal High Groundwater Table	334.50 ft
Elevation of Starting Water Level	337.50 ft
Elevation of Pond Bottom	337.50 ft
Design High Water Level Elevation	343.50 ft
Avg. Effective Storage Coefficient of Soil for Unsaturated Analysis	0.25
Unsaturated Vertical Hydraulic Conductivity	30.00 ft/d
Factor of Safety	2.00
Saturated Horizontal Hydraulic Conductivity	135.00 ft/d
Avg. Effective Storage Coefficient of Soil for Saturated Analysis	0.25
Avg. Effective Storage Coefficient of Pond/Exfiltration Trench	1.00
Time Increment During Storm Event	24.00 hrs
Time Increment After Storm Event	24.00 hrs
Total Number of Increments After Storm Event	6.00

Runoff Hydrograph File Name: Sammamish 18th Assemblage Max Volum

Time of Peak Runoff: 120.00 hrs

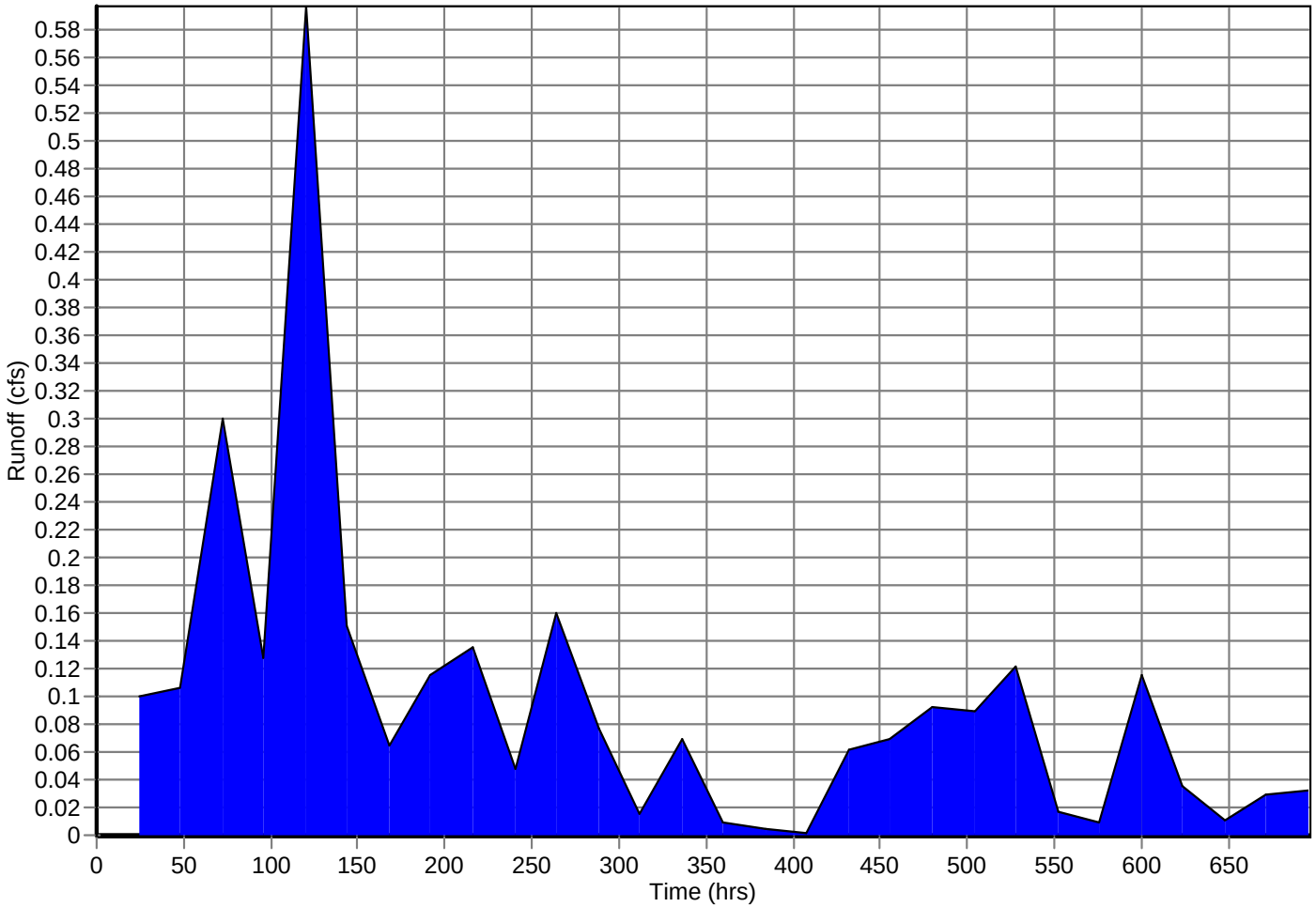
Rate of Peak Runoff: 0.60 cfs

Hydraulic Control Features:

	Top	Bottom	Left	Right
Groundwater Control Features - Y/N	N	N	N	N
Distance to Edge of Pond	0.00	0.00	0.00	0.00
Elevation of Water Level	0.00	0.00	0.00	0.00
Impervious Barrier - Y/N	N	N	N	N
Elevation of Barrier Bottom	0.00	0.00	0.00	0.00

Analysis Date: 9/24/2018

HYDROGRAPH : Sammamish 18th Assemblage Max Volume



Qpeak: 0.5970 cfs Time of peak: 120.0 hrs Vtotal: 237,600 ft³

MODRET

SUMMARY OF RESULTS

PROJECT NAME : Sammamish 18th Assemblage - Max Volume

CUMULATIVE TIME (hrs)	WATER ELEVATION (feet)	INSTANTANEOUS INFILTRATION RATE (cfs)	AVERAGE INFILTRATION RATE (cfs)	CUMULATIVE OVERFLOW (ft^3)
00.00 - 0.00	334.500	0.000 *		
			0.00000	
0.00	334.500	0.09407		
			0.12548	
72.00	337.500	0.15689		0.00
			0.16736	
96.00	337.778	0.20935		0.00
			0.25133	
120.00	338.973	0.27188		0.00
			0.29244	
144.00	339.854	0.23222		0.00
			0.17200	
168.00	339.157	0.15156		0.00
			0.13111	
192.00	338.713	0.13164		0.00
			0.13217	
216.00	338.641	0.12205		0.00
			0.11192	
240.00	338.415	0.11100		0.00
			0.11009	
264.00	338.344	0.11278		0.00
			0.11547	
288.00	338.377	0.09776		0.00
			0.08006	
312.00	338.009	0.07315		0.00
			0.06624	
336.00	337.747	0.06219		0.00
			0.05814	
360.00	337.546	0.04818		0.00

Analysis Date: 9/24/2018

MODRET

SUMMARY OF RESULTS

PROJECT NAME : Sammamish 18th Assemblage - Max Volume

CUMULATIVE TIME (hrs)	WATER ELEVATION (feet)	INSTANTANEOUS INFILTRATION RATE (cfs)	AVERAGE INFILTRATION RATE (cfs)	CUMULATIVE OVERFLOW (ft^3)
			0.03823	
363.32	337.500	0.03320		0.00
			0.02818	
408.00	336.947	0.03203		0.00
			0.03587	
432.00	336.906	0.04431		0.00
			0.05274	
456.00	337.043	0.05901		0.00
			0.06528	
480.00	337.208	0.07025		0.00
			0.07523	
504.00	337.373	0.08106		0.00
			0.08688	
528.00	337.574	0.08073		0.00
			0.07459	
552.00	337.519	0.05961		0.00
			0.04464	
576.00	337.177	0.05114		0.00
			0.05763	
600.00	337.230	0.06220		0.00
			0.06676	
624.00	337.329	0.05579		0.00
			0.04483	
648.00	337.099	0.04057		0.00
			0.03632	
672.00	336.928	0.03671		0.00
			0.03711	
696.00	336.862	0.02958		0.00

Analysis Date: 9/24/2018

MODRET

SUMMARY OF RESULTS

PROJECT NAME : Sammamish 18th Assemblage - Max Volume

CUMULATIVE TIME (hrs)	WATER ELEVATION (feet)	INSTANTANEOUS INFILTRATION RATE (cfs)	AVERAGE INFILTRATION RATE (cfs)	CUMULATIVE OVERFLOW (ft^3)
			0.02205	
720.00	336.624	0.01911		0.00
			0.01617	
744.00	336.449	0.01450		0.00
			0.01282	
768.00	336.311	0.01173		0.00
			0.01063	
792.00	336.196	0.00985		0.00
			0.00906	
816.00	336.098	0.00845		0.00
			0.00783	
840.00	336.014			0.00

Maximum Water Elevation: 339.854 feet @ 144.00 hours Recovery @ 363.317 hours

* Time increment when there is no runoff

Maximum Infiltration Rate: 3.158 ft/day

Analysis Date: 9/24/2018

APPENDIX E

Data from Civil Engineer

D. R. STRONG
CONSULTING ENGINEERS

August 30, 2018

Project No. 18009

Stan Thompson
Associated Earth Sciences
Via email: sthompson@aesgeo.com

Re: Delappe Sheehan
Infiltration Vault Design Parameters

Dear Mr. Thompson:

I have reviewed the WWHM analysis for the infiltration vault for the Delappe Sheehan project. Attached please find the peak flow and volume data (as Excel spreadsheets) extracted from the developed condition hydrograph.

I reviewed the daily peak flow rates and peak volumes flowing into the vault for the full 61-year period. The peak flow event was on October 20, 2003. The peak volume 30-day period was from November 2, 2006 to December 1, 2006. Separate hydrographs are included for the 31-day period surrounding the peak flow date (15 days prior-to and after) and for the peak volume period.

The following infiltration vault design parameters are included for your use as requested.

- Vault bottom area: 8,000 s.f. (includes two feet beyond tank perimeter)
- Vault volume between bottom and DHWL: 48,000 cu-ft.
- Vault length-to-width ratio: 1.25 to 1 (100 ft x 80 ft)
- Vault bottom elevation: 337.50 (3 ft min. separation from documented seasonal HWE)
- Vault DHWL: 343.50
- Avg. effective storage coefficient of Vault: 1.0
- Design infiltration rate: 1.9 in./hr.
- Total Impervious Area routed to the vault: 149,960 s.f. (3.443 acres)
- Stormwater Manual Used: 2016 King County Surface Water Design Manual
- Surface Water Model Used: Western Washington Hydrology Model 2012

Please contact me if you have any questions or need additional information.

Sincerely yours,
D. R. STRONG Consulting Engineers Inc.

Yoshio L. Piediscalzi, P.E.
Director of Engineering

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620 7th Ave.
Kirkland, WA 98033-5565
Phone: (425) 827-3063
Fax: (425) 827-2423
Toll Free: (800) 962-1402

Peak 31-day flow_18009

Date	Hour	CFS
10/5/2003	24	0.0000
10/6/2003	48	0.0210
10/7/2003	72	0.0021
10/8/2003	96	0.0281
10/9/2003	120	0.0222
10/10/2003	144	0.0009
10/11/2003	168	0.0287
10/12/2003	192	0.0565
10/13/2003	216	0.0004
10/14/2003	240	0.0001
10/15/2003	264	0.0363
10/16/2003	288	0.1044
10/17/2003	312	0.0622
10/18/2003	336	0.0017
10/19/2003	360	0.0066
10/20/2003	384	0.7658
10/21/2003	408	0.1423
10/22/2003	432	0.0850
10/23/2003	456	0.0283
10/24/2003	480	0.0137
10/25/2003	504	0.0069
10/26/2003	528	0.0034
10/27/2003	552	0.0017
10/28/2003	576	0.0009
10/29/2003	600	0.0325
10/30/2003	624	0.0037
10/31/2003	648	0.0009
11/1/2003	672	0.0005
11/2/2003	696	0.0161
11/3/2003	720	0.0004
11/4/2003	744	0.0001
		1.4733

Largest 30 day Volume_18009

Date	Hour	AC-FT	CU-FT	CFS (max vol)
11/2/2006	24	0.1981	8629	0.0999
11/3/2006	48	0.2101	9150	0.1059
11/4/2006	72	0.5952	25929	0.3001
11/5/2006	96	0.2527	11007	0.1274
11/6/2006	120	1.1833	51546	0.5966
11/7/2006	144	0.3001	13072	0.1513
11/8/2006	168	0.1267	5520	0.0639
11/9/2006	192	0.2303	10034	0.1161
11/10/2006	216	0.2683	11686	0.1353
11/11/2006	240	0.0936	4076	0.0472
11/12/2006	264	0.3167	13796	0.1597
11/13/2006	288	0.1530	6666	0.0772
11/14/2006	312	0.0304	1326	0.0153
11/15/2006	336	0.1372	5978	0.0692
11/16/2006	360	0.0202	880	0.0102
11/17/2006	384	0.0091	397	0.0046
11/18/2006	408	0.0045	197	0.0023
11/19/2006	432	0.1236	5386	0.0623
11/20/2006	456	0.1361	5929	0.0686
11/21/2006	480	0.1822	7937	0.0919
11/22/2006	504	0.1765	7689	0.0890
11/23/2006	528	0.2429	10582	0.1225
11/24/2006	552	0.0347	1510	0.0175
11/25/2006	576	0.0169	738	0.0085
11/26/2006	600	0.2296	10000	0.1157
11/27/2006	624	0.0708	3082	0.0357
11/28/2006	648	0.0221	964	0.0112
11/29/2006	672	0.0597	2600	0.0301
11/30/2006	696	0.0637	2775	0.0321
12/1/2006	720	0.0095	416	0.0048
				2.7719