PanGEO
INCORPORATED
Geotechnical & Earthquake
Engineering Consultants

March 4, 2014
Project No. 13-239

Ms. Stacey Clear, P.E.
Gray & Osborne, Inc.
3710 168th St. NE, Suite B210
Arlington, WA 98223

Subject: **Geotechnical Report**
First and Third Street Retrofit
Marysville, Washington
G&O IPN #13587

Dear Ms. Clear:

As requested, PanGEO completed a geotechnical engineering study to support the design of the proposed 1st Street and 3rd Street retrofit project in Marysville, Washington. The results of our study and our recommendations are summarized in the attached report.

In summary, based on the results of our study, it appears that the planned infiltration facilities are feasible. New pavements consisting of HMA over CSBC or HMA over ATB over CSBC may be used for street reconstruction. The existing asphalt pavement along 3rd Street may also be overlaid with at least 2 inches of new HMA and, if needed, the uppermost 2 inches of the existing asphalt may be removed prior to the overlay.

We appreciate the opportunity to assist you with this project. Should you have any questions, please do not hesitate to call.

Sincerely,

Siew L. Tan, P.E.
Principal Geotechnical Engineer

3213 Eastlake Avenue E, Ste B
Seattle, WA 98102
Tel (206) 262-0370
Fax (206) 262-0374

TABLE OF CONTENTS

List of Figures

List of Appendices

GEOTECHNICAL REPORT
1ST AND 3RD STREETS RETROIFT
MARYSVILLE, WASHINGTON

1.0 INTRODUCTION

PanGEO completed a geotechnical engineering study to support the design effort for the 1st and 3rd Streets Retrofit Project in the City of Marysville, Washington. Our service scope included conducting a site reconnaissance along the project alignment, advancing eight test borings and installing four groundwater monitoring wells, completing a laboratory test program, performing geotechnical engineering analysis, and developing the conclusions and recommendations presented in this report.

2.0 SITE AND PROJECT DESCRIPTION

The project alignment consists of 1st Street between Cedar Avenue and State Avenue, and 3rd Street between Columbia Avenue and 47th Avenue NE in the City of Marysville, Washington. The site vicinity map and the project alignment are shown in Figure 1. The 1st Street portion of the alignment is approximately 800 feet long, and is a two-lane paved roadway with angle parking on the north side and parallel parking on the south side of the street (see Figure 2A). This section of 1st Street has concrete sidewalk on the north side and a portion of the south side of the roadway. The 3rd Street portion of the alignment is approximately 1,900 feet long, and is also a paved two-lane roadway with angle parking for the western one quarter of the alignment and parallel parking for the remaining portion (see Figure 2) This section of the 3rd Street has landscape strips and concrete sidewalk on both sides of the roadway. The surface grade along 1st and 3rd Streets is relatively level. The typical existing pavement conditions along 1st and 3rd Street are shown in Plates 1 and 2 on Page 2.

We understand that the principle elements of proposed retrofit project include enhancing the road and pedestrian safety with traffic circles and crosswalks at the intersections, improving water quality using low impact design (LID) facilities at intersections and new medians, installing a new sewer line along 1st street and reconstructing the 1st Street roadway, and rehabilitating the existing pavement along 3rd Street. Installation of the new sewer line along 1st Street will require excavations up to about 13 feet.

Plate 1. Looking west along 1st Street near State Avenue. The drill rig is set up to drill boring B-3.

Plate 2. Looking west along 3rd Street near 47th Avenue NE. The drill rig is set up to drill boring B-8.

3.0 SUBSURFACE EXPLORATIONS

Eight test borings (B-1 through B-8) were drilled along the project alignment on November 25 and 26, 2013. The approximate boring locations were estimated from existing site features and are indicated on Figures 2A and 2B of this report. The borings were drilled to depths of about 14 and 16½ feet using a trailer-mounted drill rig owned and operated by Boretec Drilling, Inc. of Valleyford, Washington. The trailer-mounted drill rig was equipped with 8-inch outside diameter hollow stem augers. Two-inch diameter open-pipe piezometers were installed in borings B-1, B-2, B-4, and B-7 for long term groundwater level monitoring.

Soil samples were obtained from the borings at 2½-foot depth intervals in conjunction with Standard Penetration Test (SPT) sampling method in general accordance with ASTM test method D-1586, in which the samples are obtained using a 2-inch outside diameter split-spoon sampler. The sampler was driven into the soil a distance of 18 inches using a 140-pound weight falling a distance of 30 inches. The number of blows required for each 6-inch increment of sampler penetration was recorded. The number of blows required to achieve the last 12 inches of sample penetration is defined as the SPT N-value. The N-value provides an empirical measure of the relative density of cohesionless soil, or the relative consistency of fine-grained soils.

An engineering geologist from PanGEO was present during the field exploration to observe the drilling, to assist in sampling, to excavate the hand boring, and to describe and document the soil samples obtained from the borings. Summary boring logs are included in Appendix A, Figures A-2 through A-9. The soil samples were described using the system outlined on Figure A-1.

4.0 LABORATORY TESTING

Grain size distribution and natural moisture contents tests were conducted on selected soil samples obtained from the borings. Cation Exchange Capacity tests were also conducted on selected soil samples. The test results from the moisture content tests are indicated at the appropriate depths on the boring logs. The grain size distribution test results are included in Figures B-1 through B-4 of Appendix B. The summary results of Cation Exchange Capacity tests are presented in Figure B-5.

5.0 EXISTING PAVEMENT

Based on the results of pavement cores taken by the City and results of our borings, the existing pavement along 3rd Street between Columbia Avenue and 47th Avenue NE appear to consist of two distinct sections: the approximately 16-foot wide middle section of the roadway appears to consist of varying thickness of asphalt over a 6-inch thick concrete panel; while the concrete panel was not encountered along the edges of the roadway. The pavement conditions along 3rd Street are considered to be fair to good with some longitude and traverse cracks, mostly along the joints between concrete panels.

Along 1st Street, it appears that the existing pavement consists of asphalt placed directly on sand and gravel. The pavement conditions along 1st Street are considered in a relatively good condition with scattered minor cracks.

Borings B-1 through B-6, and B-8 were drilled through the existing roadway pavement to evaluate the existing roadway pavement thickness and the subgrade conditions. The City of Marysville conducted six additional cores through the existing pavement to determine the pavement thickness. The approximate locations of the test borings and pavement cores are indicated on the attached Figures 2A and 2B. A summary of the pavement thicknesses in the borings and cores are presented in Table 1, below:

Table 1 Summary of Pavement Thickness

Boring/Core Location	Approx. Offset from Center Line	Approximate Asphalt Thickness (inch)	Approximate Portland Cement Concrete Thickness (inch)
B-1	20’	6	-
B-2	10’	6	-
B-3	20’	9	-
B-4	16’	3	-
B-5	20’	5	-
B-6	21’	6	-
B-8	19’	5	-
Core #1	11’	7	-
Core #2	2’	7	-

Core #3	16’	1.5	6
Core #4	7.5’	3	6
Core #5	11’	7	-
Core #6	13’	7	-

Based on the results from Table 1, the asphalt pavement along 1st Street is about 6 to 9 inches thick. Along 3rd Street between State Avenue and Columbia Avenue, the existing pavement consisted of 1½inch of asphalt over about 6 inches of concrete. Along 3rd Street between Columbia Avenue and 47th Avenue NE, the existing pavement appear to consist of 3 inches of asphalt over 6-inch cement concrete for the center 16-foot strip, and about 3 to 7 inches of asphalt along the edges of the roadway, based on the results from the pavement cores and borings.

6.0 SUBSURFACE CONDITIONS

6.1 Soil

Two distinct soil units were encountered in our test borings: Fill and Recessional Outwash, as detailed below. Please refer to the summary boring logs (Figures A-2 through A-9) for additional details.

Fill – Fill was encountered below the asphalt pavement and road base in borings B-1 and B-3. The fill generally consisted of very loose to medium dense silty sand with trace to some gravel, and extended to a depth of about 7 feet below the surface in borings B-1 and B-3. The fill appeared to be reworked outwash sand during previous roadway construction. No significant amount of fill was encountered at other boring locations.

Recessional Outwash – A unit of very loose to medium dense silty sand and sand with trace to some silt was encountered below the pavement and fill, where present. We interpret this unit as Recessional Outwash deposit. This unit extended to at least the bottom of the borings at about 14 and 16½ feet below the surface.

6.2 Groundwater

Groundwater was encountered in all borings except in B-6 during drilling. Groundwater was measured at about 5.3 to 7½ feet in borings B-1 through B-3 along/near 1st Street, during drilling and one day after drilling. Groundwater was measured at about 10 to 16 feet during drilling in the borings located along 3rd street, except in B-6 where groundwater was not encountered within the drilling depth of 14 feet. Two-inch diameter open pipe piezometers were installed in two of the borings along 1st Street (B-1 and B-2) and two of the borings along 3rd Street (B-4, and B-7), and data loggers were installed in B-1, B-2, and B-4 to continuously monitor groundwater fluctuations. Data logger was not installed in B-7 due to the dry condition one day after the well was installed. A summary of groundwater depth is presented in Table 2 below. The groundwater levels in B-1, B-2, and B-4 measured between November 27, 2013 and January 8, 2014 are shown in Figure 3.

It should be noted that groundwater elevations may vary depending on the season, local subsurface conditions, and other factors. Groundwater levels are normally highest during the winter and early spring.

Table 2 – Summary of Groundwater Depth

Boring No.	**Date Drilling and Well Completed**	**Groundwater Depth below Surface (ft)**	
		During Drilling	After Drilling
B-1	Nov. 25,2013		6.6 - 7.8 (11/27/2013 – 01/08/2014)
B-2	Nov. 25,2013		4.2 - 5.4 (11/27/2013 – 01/08/2014)
B-3	Nov. 25,2013	6.3	
B-4	Nov. 26, 013		9.2 – 10.5 (11/27/2013 – 01/08/2014)
B-5	Nov. 26, 013	12.3	
B-6	Nov. 25,2013	Not encountered	
B-7	Nov. 25,2013	16	Not present
B-8	Nov. 26, 013	14	

Note: Borings B-1, B-2, B-4, and B-7 were converted to groundwater monitoring wells. Data loggers were installed in B-1, B-2, and B-4 to continuously monitoring groundwater levels.

7.0 CONCLUSIONS AND RECOMMNEDATIONS

7.1 INFILTRATION RATES OF ON-SITE SOILS

Infiltration characteristics of the site soils were evaluated based on Soil Grain Size Analysis Method as outlined in the *Stormwater Management Manual for Western Washington* (Washington State Department of Ecology, 2012). Based on the results of the grain size distribution analysis (ASTM D-422) and the WSDOE Manual, it is our opinion the site soils have reasonably good infiltration capability. Based on the infiltration rate calculations as outlined in 2012 WSDOE Manual and the site conditions, we recommended the design long-term infiltration rates presented in the Table 3 below be used for infiltration facility design at the site:

Table 3 – Recommended Design Infiltration Rates Based on Grain Size Distribution
(WSDOE Storm Water Manual, 2012)

Infiltration Facility Location	Long Term (Design) Infiltration Rate (in./hr)
1st Street between Cedar Ave and State Ave	2.0
3rd Street & Columbia Ave (B-4)	2.5
3rd Street & Alder Ave (B-5)	1.0
3rd Street & Quinn Ave (B-6)	2.0
3rd Street & Union Ave (B-7)	4.0
3rd Street & 47th Ave NE (B-8)	1.5

Note – For infiltration facilities between the borings, an average infiltration rate may be used for design.

7.2 PAVEMENT DESIGN

We understand that a new sewer line will be installed along 1st Street and the therefore the existing roadway pavement will be replaced. Along 3rd Street, the existing pavement will be cut to install new medians and bulbouts at various intersections. As a result, new pavement will be needed in the areas where the existing concrete panels will be removed as part of median construction. We also understand that the entire roadway alignment along 3rd Street will be overlaid with HMA. The following sections outline our pavement design recommendations.

7.2.1 Design Traffic Level

Based on the traffic counts provided by the City of Marysville, along 1st Street, the average daily traffic (ADT) between January 14 and 22, 2014 was about 1,273 and 2,066 on the eastbound and westbound lanes, respectively. The average truck traffic was approximately 5 and 11 percent of the ADT on the eastbound and westbound lanes, respectively. For pavement design purposes, we used an ADT of 2,066 and a truck traffic of 11 percent (westbound traffic) in our analysis. The 18-kip Equivalent Single Axle Loads (ESAL) for a 20-year design period was estimated based on the ADT and truck traffic discussed above, an assumed annual truck traffic growth of 1%, and the estimated ESAL per axle class outlined in the WSDOT pavement design manual. Based on these parameters, the calculated total 20-year design ESAL for 1st Street is approximately 1,243,000.

For 3rd Street, the actual traffic information is not available. We understand that the vehicle traffic along 3rd Street is predominately passenger cars and light pickups with occasional trucks. For design purposes, we believe that it is reasonable to assume Class III (Urban minor collector Streets) traffic loading for the subject alignment, using the Asphalt Institute's (AI) classification. Based on AI's recommendation for Class III traffic and our traffic observations while we were onsite, we utilized a traffic level of 400,000 ESAL's (18-kip equivalent single axle loads) for design of the new pavement section. Required pavement thickness was determined based on this level of traffic which has a service life of 20 years.

It should be noted that for the pavement options described below, the pavement performance over the design period assumed in our analysis would depend on a number of factors, including the actual traffic loading conditions. The recommended pavement sections will need to be revised if the traffic level (ESALs) is significantly different from the estimated value discussed above.

7.2.2 Parameters for Pavement Design

The existing pavement subgrade soil generally consists of very loose to medium dense silty sand with variable amounts of gravel. Based on our prior experience with similar soil conditions, it is our opinion that a resilient modulus (M_R) of 5,000 pounds per square inch (psi) is appropriate for the existing subgrade soils.

In areas where new pavement will be constructed to widen the existing roadway, the existing subgrade soil at the site should be compacted to a dense condition. As such, a resilient modulus

(M_R) of 10,000 psi is considered appropriate for design. This value is based on the assumption that, during construction, the uppermost 12 inches of the subgrade will be compacted to at least 95% of its maximum dry density (ASTM D-1557 Modified Proctor).

The pavement analysis was performed using the 1993 AASHTO pavement design methodology using the following parameters:

Pavement Design life	20 years
Reliability	85%
Overall Standard Deviation	0.5
Design Serviceability Loss (ΔPSI)	1.5
Drainage Coefficient	1.0
Structural Coefficient: New HMA	0.44
Structural Coefficient: Existing HMA	0.35
Structural Coefficient: New ATB	0.30
Structural Coefficient: Crushed Surfacing	0.14
Elastic Modulus for Hot-Mix Asphalt	500,000 psi
Resilient Modulus for CSBC	30,000 psi (compacted to 95%)
Resilient Modulus for Subgrade Soil	5,000 psi (existing subgrade) 8,000 psi (firmly recompacted subgrade)

7.2.3 Pavement Sections

New HMA Pavement with Crushed Rock Base along 1st Street

Based on the design information and parameters discussed above and the 1993 AASHTO pavement design methodology, the new pavement for the 1st Street may consist of 7 inches of Hot-Mix Asphalt (HMA) and 4 inches of crushed surfacing base course (CSBC). Alternatively, a pavement section consisting of 3 inches of Hot-Mix Asphalt (HMA), 6 inches of Asphalt Treated Base (ATB), and 3 inches of crushed surfacing base course (CSBC) may also be used. The HMA should conform to the section 9-03.8(2) of the 2012 WSDOT *Standard Specifications*, for design ESAL's between the range of 0.3 to 3 million. ATB Crushed surfacing should conform to section 9-03.9(3) of the 2012 WSDOT *Standard Specifications*. The CSBC may be replaced with Crushed Surfacing Top Course (CSTC).

The pavement section recommended above is based on the assumption the existing pavement subgrade will be properly compacted. As a minimum, prior to placing the crushed rock base, the upper 12 inches of the subgrade should be compacted to at least 95% of its maximum dry density (Modified Proctor, ASTM D1557).

If the existing on-site asphalt concrete pavement is to be pulverized and re-used on-site, the pulverized asphalt should be blended with CSBC, in accordance with Section 9-03.21(2) of the 2012 WSDOT *Standard Specifications,* to be considered an equivalent to CSBC. Alternatively, the pulverized asphalt need not be blended if it is not going to be considered as CSBC in the pavement section.

New HMA Pavement with Crushed Rock Base along 3rd Street

Along 3rd Street where the existing concrete pavement will be removed, the new pavement may consist of 4 inches of Hot-Mix Asphalt (HMA) and 8 inches of crushed surfacing base course (CSBC). Alternatively, a pavement section consisting of 2 inches of Hot-Mix Asphalt (HMA), 6 inches of Asphalt Treated Base (ATB), and 3 inches of crushed surfacing base course (CSBC) may be used. The HMA should conform to the section 9-03.8(2) of the 2012 WSDOT *Standard Specifications,* for design ESAL's between the range of 0.3 to 3 million. Crushed surfacing should conform to section 9-03.9(3) of the 2012 WSDOT *Standard Specifications*. The pavement subgrade should be prepared as discussed in the previous section.

HMA Overlay along 3rd Street

Where the existing pavement will be overlaid, we recommend the existing asphalt pavement be planed/grind down a maximum 2 inches and apply a minimum 2 inch of HMA. The existing pavement should be cleaned and a tack coat should be applied prior to the overlay. Pavement overlays should be constructed in accordance with Section 5-04.3 of the 2012 WSDOT *Standard Specifications*.

It should be noted that the existing asphalt thickness ranges from about 3 inches (B-4) to 7 inches (cores # 5 and #6). From the constructability perspective, it is our opinion that at least 2½ to 3 inches of the existing pavement should be left in place for the overlay. In the areas that the remaining existing asphalt pavement is distressed or broken after upper 2 inches are grinded down, the remaining broken asphalt should be removed and fill depth new asphalt pavement should be constructed.

7.3 Subgrade Preparation for Pavements and Concrete Sidewalk

Based on the results of our test borings, we anticipate that loose to medium dense silty sand will be present below the existing pavement, sidewalk, and shoulder areas. All unsuitable soils at the subgrade level should be removed during stripping operations and either exported from the site, or stockpiled for later re-use in landscaping areas.

Following removal of the existing pavement and surficial unsuitable soils, the exposed subgrade should be moisture conditioned, if necessary, and compacted to a firm condition. The upper 12 inches of material should be compacted to at least 95 percent of the maximum dry density, as determined by test method ASTM D 1557 (Modified Proctor). Alternatively, a 10-ton vibratory roller with a minimum of four passes travel at no more than 5 miles per hour is also considered adequate.

Any soft, yielding, and pumping subgrade areas identified during the compaction or proof-rolling process should be over-excavated and backfilled with properly compacted CSBC (crushed surfacing base course), as described in Section 9-03.9(3) of the 2012 WSDOT *Standard Specifications*, or gravel borrow as described in Section 9-03.14 (1) of the *Standard Specifications*.

We recommend that a leveling course consists of at least 4 inches of crushed surfacing top course (CSTC), compacted to a dense condition, be placed directly below the driveways and concrete sidewalks to provide a level and firm uniform support.

7.4 New Sewer Line

7.4.1 Trench Excavation

The project will include installation of a new sewer line along 1st Street. We understand that the invert for the new sewer line will approximately match the existing line at about 7 to 13 feet deep. Based on our field exploration, the trench excavation is anticipated to encounter very loose to medium dense silty sand to sand with silt. Groundwater was encountered at about 6½ to 7½ feet below the surface during and after drilling in the borings B-1 and B-3 near the ends of the alignment. The groundwater level in boring B-2, located about 60 feet south of the 1st Street, is about 4½ to 6½ feet below the surface. As such, groundwater is anticipated to be present above the pipe inverts for the entire alignment of 1st Street. It should be noted that the groundwater level will vary depending on the seasonal precipitation, local subsurface conditions, and other factors. Groundwater levels and seepage rates are normally highest during the winter and early spring.

The excavation method and equipment should be determined by the contractor. It is our opinion that conventional excavators are capable of excavating the trenches based on the subsurface conditions encountered. Construction equipment, construction material, excavated soil, and vehicular traffic should not be allowed within a horizontal distance, measured from the edge of the excavation, equal to half the depth of the excavation, unless the shoring system has been designed for the surcharge. All excavations should be conducted in accordance with all applicable federal, state, and other local safety requirements.

7.4.2 Trench Excavation Support

It is the contractor's responsibility to maintain safe working conditions, including temporary excavation stability. All excavations should be conducted in accordance with all applicable federal, state, and other local safety requirements. All excavations should be sloped in accordance with Washington Administrative Code (WAC) 296-155, or be shored. Unsupported open cut excavations, if used, may be sloped 1½H:1V or flatter. Even if space is available for unsupported open cut excavations, we anticipate that near vertical trench excavations with proper excavation support will be used for the project to reduce the disruption to the roadway and adjacent properties.

In our opinion, trench boxes, steel plates with hydraulic braces, sheetpiles, or a combination of these systems are appropriate may be considered for the proposed project. As a minimum, all excavation shoring systems should be designed to withstand a lateral earth pressure of 35 pcf above groundwater table and 75 pcf below groundwater. Where appropriate, a uniform lateral pressure of 85 psf should be used to account for a traffic surcharge. Lateral loads due to construction equipment traffic or sloping ground conditions adjacent to the excavations should also be added to the recommended earth pressures for design purposes.

Lateral loads due to construction equipment traffic or sloping ground conditions adjacent to the excavations should also be added to the recommended earth pressures for design purposes. Construction equipment, construction material, excavated soil, and vehicular traffic should not be allowed within a horizontal distance, measured from the edge of the excavation, equal to half the depth of the excavation, unless the shoring system has been designed for the surcharge. These conditions will need to be evaluated on a case-by-case basis.

During construction, the ground adjacent to excavations should be continuously monitored for cracks or dips and other indications of movements and possible sloughing of the excavation walls. Such monitoring is particularly critical in areas adjacent to existing structures and utilities.

7.4.3 Construction Dewatering

As previously indicated, groundwater was encountered at depths of about 4½ and 7½ feet in borings B-1 through B-3 between November 25, 2013 and January 8, 2014. Therefore, based on the pipe invert depths of 7 to 13 feet, groundwater will likely be above the pipe inverts, particularly in the wet season, and construction dewatering will likely be needed to facilitate the trench excavation and pipe installation.

Control of groundwater and surface water is the responsibility of the contractor. The selection of equipment and methods of dewatering should be left up to the contractor. The dewatering method selected should have minimal impact on the groundwater level surrounding the proposed excavations. The dewatering operation should also be conducted so that it will not cause areal ground subsidence, which may cause potential damage to the adjacent utilities and existing structures. If needed, re-charging of the groundwater should be conducted to maintain the groundwater levels at the desired level at the structure locations.

The “Dewatering” item in the contract documents should include all works or systems required to lower the natural groundwater table and/or to exclude the water from the excavations, allowing for construction of the proposed sewer line under safe and dry conditions, and without causing areal ground subsidence. These works or systems may include, but may not be limited to, deep wells, well points, grouting, cut-off walls, tremie concrete plugs, or any combination of the above and/or possible methods. It should be realized that dewatering, if not performed appropriately, could cause ground settlement due to an increase in the effective stress of the dewatered soils. Possible effects on adjacent settlement-sensitive elements should be taken into consideration. Methods to minimize settlement should be used where appropriate, such as the use of a sheetpile cut-off as a barrier to lateral seepage.

Since the excavation dewatering will involve discharge of groundwater from the dewatering operation, the contractor should consult their independent consultant for the latest regulations and information pertaining to the permit application.

7.4.4 Trench/Pipe Subgrade

In general, we anticipate the subgrade soils at the pipe inverts to consist of wet, loose sand with silt to silty sand. We recommend the wet, loose sandy subgrade soil be over-excavated 12 inches and backfilled with Ballast (*9-03.9(1) of 2012 Standard Specifications*) before placing pipe bedding materials to create a stable subgrade. This Ballast should be wrapped with a layer of Geotextile for Separation or Soil Stabilization (*9-33.2(1) of 2012 Standard Specifications*).

7.4.5 Pipe Bedding

Pipe bedding material, placement, compaction, and shaping should be in accordance with the project specifications and the pipe manufacturer's recommendations. As a minimum, the pipe bedding material should meet the requirements for Gravel Backfill for Pipe Zone Bedding in section 9-03.12(3) of 2012 *Standard Specifications*.

Bedding material should be placed in accordance with the recommendations provided in *Standard Specifications* Section 7-08.3(1) for Pipe Zone Bedding to ensure proper pipe support and protection. For flexible pipes, the bedding material should extend at least 6 inches above the crown of the pipe; for rigid pipes, the bedding material should extend to at least the spring line of the pipe.

Contractor shall made special precaution when backfilling to 2 feet above the crown of the pipes. This may involve the use of vibratory compactors to vibrate the pipe bedding and backfill in place without applying a significant downward pressure that may overstress the pipe. Part of the bedding around the pipe may need to be placed by hand tools to ensure proper placement.

7.4.6 Trench Backfill and Compaction

In general, the placement of trench backfill should conform to WSDOT Section 7-08.3(3) of the 2012 *Standard Specifications*. In our opinion, Gravel Borrow conforming to WSDOT Section 9-03.14(1) of the 2012 *Standard Specifications* is considered appropriate as trench backfill.

In our opinion, the trench backfill may also consist of excavated on-site granular soils, provided that 95% compaction (ASTM D1557) can be achieved. The use of on-site granular soil should be evaluated and approved by the engineer during trench excavation. Where on-site sand will be used as trench backfill, it should be capped with at least 2 feet of granular material compacted to 95% of its relative compaction.

In general, the trench backfill should be placed in thin lifts not exceeding 8 inches in loose thickness with each lift mechanically compacted to a minimum 95 percent relative compaction in the upper 2 feet, and 90 percent relative compaction below 2 feet. Relative compaction should be determined in accordance with ASTM D 1557 (Modified Proctor).

7.5 GENERAL EARTHWORK RECOMMENDATIONS

7.5.1 Stripping and Subgrade Preparation

Site preparation should begin with removing existing pavement and other unsuitable soil, if encountered, from the area of the proposed improvements. Following removal of existing surficial materials or pavement structures, the exposed subgrade should be compacted to a dense condition. Any soft, yielding areas or organic-rich soils should be over-excavated and backfilled with properly compacted CSBC (Section 9-03.9(3) of the 2012 WSDOT *Standard Specifications*), or Gravel Borrow (Section 9-03.14 (1)). The subgrade preparation should be observed by an individual experienced with earthwork construction, to verify the adequacy of the prepared subgrade.

7.5.2 Structural Fill and Compaction

Imported structural fill should consist of well-graded, free-draining granular soils that are relatively free from organic matter or other deleterious materials. Such materials should be less than 4 inches in maximum dimension, with less than 7 percent fines (portion passing the U. S. Standard No. 200 sieve), as specified in Section 9-03.14(1) of the 2012 WSDOT *Standard Specifications for Road, Bridge, and Municipal Construction*. The fine-grained portion of structural fill soils should be non-plastic. A fines content greater than 7 percent but less than 10 percent may be acceptable if the earthwork is performed during relatively dry weather and the contractor’s methods are conducive to proper compaction of the soil. The use of material with a fines content greater than 7 percent should be approved by the engineer prior to use.

Structural fill soils should be moisture conditioned to within about 3 percent of optimum moisture content, placed in loose, horizontal lifts less than 8 tom 12 inches in thickness, and compacted to at least 95 percent maximum density, determined using ASTM D 1557 (Modified Proctor). The procedure to achieve proper density of a compacted fill depends on the size and type of compacting equipment, the number of passes, thickness of the layer being compacted, and certain soil properties. In areas where the size of the excavation restricts the use of heavy equipment, smaller equipment can be used, but the soil must be placed in thin enough layers to achieve the required relative compaction.

7.5.3 Earthwork Recommendations in the LID Facility Areas

Earthwork standards and requirements for LID facilities are generally different than typically earthwork construction. For example, typical compaction requirements will reduce the infiltration capacity of the soils and could lead to facility failure. Compromises need to be made between providing adequate support of structures and maintaining the intent of the LID implementation. We recommend using an earthwork contractor experienced with the successful implementation of earthwork construction on LID facilities. We also recommend the Low Impact Development: Technical Guidance Manual for Puget Sound, prepared by the Puget Sound Partnership (PSP, 2012) be consulted for specific earthwork construction methods for LID facilities. The following sections of this report provide additional recommendations for the earthwork construction in the Biorention and porous sidewalk areas.

Biorention Facilities:

- Excavation should not be allowed in wet or saturated conditions.
- Excavation equipment should be located outside of the biorention facilities and no heavy equipment with narrow tracks, narrow tires, or high pressure tires should be allowed on the bottom of the biorention facilities. Construction foot traffic should also be minimized to the maximum extent possible.
- Minimize compaction of the base and sidewalls of the biorention area.
- On-site soil mixing or placement should not be performed if soil is saturated. The biorention soil mixture should be placed and graded by excavator equipment operating adjacent to the biorention facilities.

Porous Sidewalk:

- The porous sidewalk subgrade should not be prepared during period of heavy precipitation that resulted in wet subgrade conditions.

- The subgrade should be scarified prior to placing fill to prevent sealing of the surface to be filled.

- Any soft, yielding areas or organic-rich soils identified during subgrade preparation process should be over-excavated and backfilled with granular native soils or an imported aggregate, such as open graded crushed base such as ASTM No. 57 aggregate or an approved equivalent.

- If fine grained sediment is deposited or tracked onto the subgrade, it should be removed using an excavator with a grade plate, small dozer or vacuum truck stationed outside of the sidewalk areas.

- The porous sidewalk subgrade should be compacted to between 90 and 92 percent of the maximum dry density, as determined by test method ASTM D 698 (Standard Proctor). Use of heavy compaction equipment and over-compaction of the subgrade shall be avoided.

- The construction or compaction equipment should be located outside of porous sidewalk areas to avoid over-compacting the subgrade. The subgrade should not subject to truck traffic.

- The aggregate base materials should be end-dumped at the edge of the fill area and the material pushed out over the subgrade.

7.5.4 Wet Weather Earthwork

In our opinion, the proposed construction may be accomplished during wet weather. However, it is likely more economical to perform the earthwork construction during the drier summer months. Winter/spring construction will require the implementation of best management erosion and sedimentation control practices to reduce the chance of off-site sediment transport. The on-site subgrade soils may become saturated and spongy, and difficult to compact due to rain in the wet season. Soft subgrade soil due to inclement weather, disturbance, and poor drainage will require removal and replacement with well-compacted structural fill. Additionally, groundwater levels are typically higher in the winter/spring seasons than in the summer. As a result, the sewer line installation in the wet season will likely require more dewatering efforts.

General recommendations relative to earthwork performed in wet weather or in wet conditions are presented below. These recommendations should be incorporated into the contract specifications.

- Earthwork should be performed in small areas to minimize exposure to wet weather. Excavation or the removal of unsuitable soil should be followed promptly by the placement and compaction of clean structural fill. The size and type of construction equipment used may have to be limited to prevent soil disturbance. Under some circumstances, it may be necessary to excavate soils with a backhoe to minimize subgrade disturbance caused by equipment traffic.

- During wet weather conditions, the allowable fines content of the gravel borrow should be reduced to no more than 5 percent by weight based on the portion passing ¾-inch sieve. The fines should be non-plastic.

- The ground surface within the construction area should be graded to promote run-off of surface water and to prevent the ponding of water.

- The ground surface within the construction area should be sealed by a smooth drum vibratory roller, or equivalent, and under no circumstances should soil be left uncompacted and exposed to moisture.

- Geotextile silt fences should be strategically located to control erosion and the movement of soil.

8.0 LIMITATIONS

We have prepared this report for Gray & Osborne, Inc., City of Marysville, and the project design team. Recommendations contained in this report are based on a site reconnaissance, a subsurface exploration program, review of pertinent subsurface information, and our understanding of the project. The study was performed using a mutually agreed-upon scope of work.

Variations in soil conditions may exist between the locations of the explorations and the actual conditions underlying the site. The nature and extent of soil variations may not be evident until construction occurs. If any soil conditions are encountered at the site that are different from those described in this report, we should be notified immediately to review the applicability of our recommendations. Additionally, we should also be notified to review the applicability of our recommendations if there are any changes in the project scope.

The scope of our work does not include services related to construction safety precautions. Our recommendations are not intended to direct the contractors' methods, techniques, sequences or procedures, except as specifically described in our report for consideration in design. Additionally, the scope of our work specifically excludes the assessment of environmental characteristics, particularly those involving hazardous substances.

This report has been prepared for planning and design purposes for specific application to the proposed project in accordance with the generally accepted standards of local practice at the time this report was written. No warranty, express or implied, is made.

This report may be used only by the client and for the purposes stated, within a reasonable time from its issuance. Land use, site conditions (both off and on-site), or other factors including advances in our understanding of applied science, may change over time and could materially affect our findings. Therefore, this report should not be relied upon after 24 months from its issuance. PanGEO should be notified if the project is delayed by more than 24 months from the date of this report so that we may review the applicability of our conclusions considering the time lapse.

It is the client's responsibility to see that all parties to this project, including the designer, contractor, subcontractors, etc., are made aware of this report in its entirety. The use of information contained in this report for bidding purposes should be done at the contractor's option and risk. Any party other than the client who wishes to use this report shall notify PanGEO of such intended use and for permission to copy this report. Based on the intended use of the report, PanGEO may require that additional work be performed and that an updated report be reissued. Noncompliance with any of these requirements will release PanGEO from any liability resulting from the use this report.

We appreciate the opportunity to be of service to you on this project. Please feel free to contact our office with any questions you have regarding our study, this report, or any geotechnical engineering related project issues.

Sincerely,

H. Michael Xue, P.E.	Siew L. Tan, P.E.
Senior Geotechnical Engineer	Principal Geotechnical Engineer

9.0 LIST OF REFERENCES

American Association of State Highway and Transportation Officials, (1993). *AASHTO Guide for Design of Pavement Structures*.

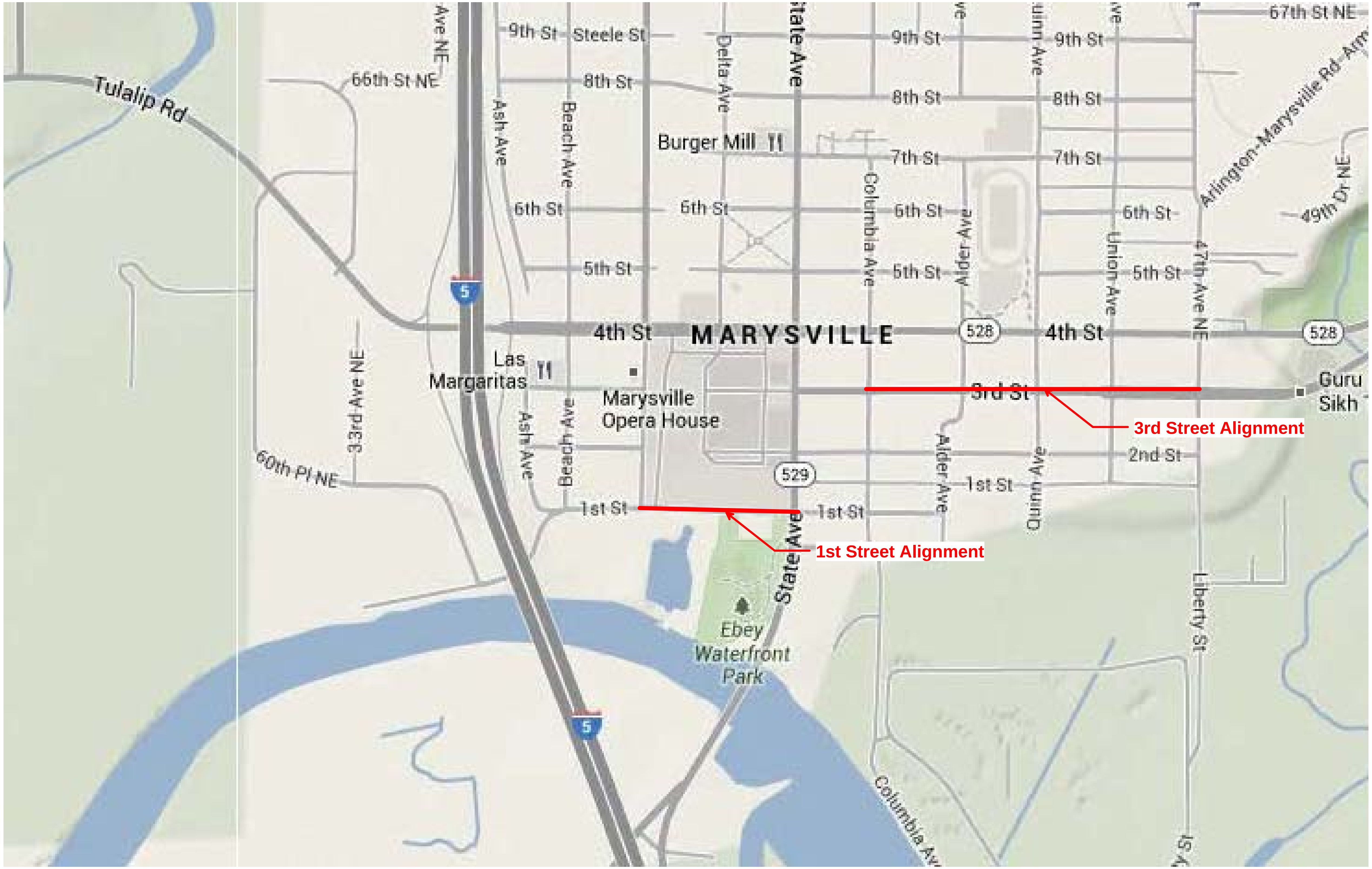
Asphalt Institute, (1981). *Asphalt Pavement Thickness Design,* Information Series No. 181.

Puget Sound Partnership (2012). *Low Impact Development: Technical Guidance Manual for Puget Sound.*

WSDOE, (2012). *Stormwater Management Manual for Western Washington (SWMMWW).*

WSDOT, (1995). *WSDOT Pavement Guide*.

WSDOT, (2012). *Standard Specifications for Road, Bridges, and Municipal Construction*.



Approx. Scale
1" = 600'

Note: Map provided by Google Maps.

PanGEO INCORPORATED

1st and 3rd Streets Retrofit
Marysville, WA

Vicinity Map

Project No.	Figure No.
13-239	1

Legend:

- **B-1** Approx. Borehole Location (PanGEO)
- **Core #1** Approx. Pavement Core Location (City of Marysville)

N

Approx. Scale
1" = 60'

Note: Base map modified from Aerial Map provided by City of Marysville.

PanGEO INCORPORATED	1st & 3rd Streets Retrofit Marysville, WA	SITE AND EXPLORATION PLAN 1ST STREET BETWEEN CEDAR AVENUE AND STATE AVENUE
		Project No. 13-239 / Figure No. 2A

file.grf w/ file.dat 1/30/14 (11:29) TEA2

Note: Base map modified from Aerial Map provided by City of Marysville.

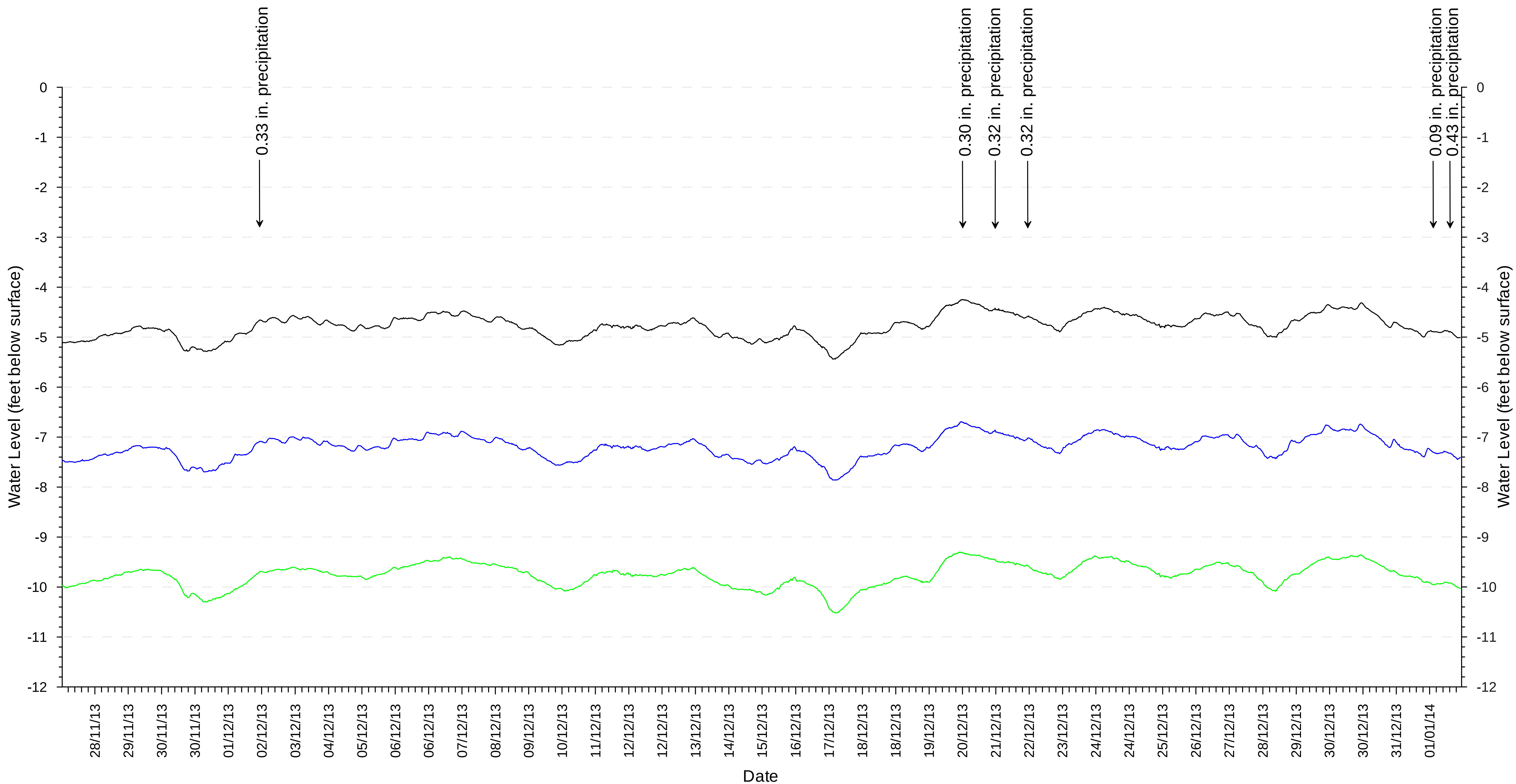
Legend:

B-1 Approx. Borehole Location (PanGEO)

Core #3 Approx. Pavement Core Location (City of Marysville)

PanGEO INCORPORATED	1st and 3rd Streets Retrofit Marysville, WA	SITE AND EXPLORATION PLAN 3RD STREET BETWEEN COLUMBIA AVENUE AND 47TH AVENUE NE
		Project No. 13-239 / Figure No. 2B

file.grf w/ file.dat 1/30/14 (11:33) TEA2



Legend:

B-1 Water Depth (feet)
B-2 Water Depth (feet)
B-4 Water Depth (feet)

Note: Monitoring well in B-7 was dry after drilling.
Rainfall data from Stanwood.

PanGEO INCORPORATED

1st & 3rd Streets Retrofit
Marysville, Washington

SUMMARY GROUNDWATER LEVEL BETWEEN NOVEMBER 27, 2013 AND JANUARY 8, 2014

Project No.	Figure No.
13-239	3

Pump Test Results 11-8-13.grf 2/3/14 (9:07) SHE

APPENDIX A

SUMMARY BORING LOGS

RELATIVE DENSITY / CONSISTENCY

SAND / GRAVEL			SILT / CLAY		
Density	SPT N-values	Approx. Relative Density (%)	Consistency	SPT N-values	Approx. Undrained Shear Strength (psf)
Very Loose	<4	<15	Very Soft	<2	<250
Loose	4 to 10	15 - 35	Soft	2 to 4	250 - 500
Med. Dense	10 to 30	35 - 65	Med. Stiff	4 to 8	500 - 1000
Dense	30 to 50	65 - 85	Stiff	8 to 15	1000 - 2000
Very Dense	>50	85 - 100	Very Stiff	15 to 30	2000 - 4000
			Hard	>30	>4000

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS		GROUP DESCRIPTIONS	
Gravel 50% or more of the coarse fraction retained on the #4 sieve. Use dual symbols (eg. GP-GM) for 5% to 12% fines.	GRAVEL (<5% fines)	GW	Well-graded GRAVEL
		GP	Poorly-graded GRAVEL
	GRAVEL (>12% fines)	GM	Silty GRAVEL
		GC	Clayey GRAVEL
Sand 50% or more of the coarse fraction passing the #4 sieve. Use dual symbols (eg. SP-SM) for 5% to 12% fines.	SAND (<5% fines)	SW	Well-graded SAND
		SP	Poorly-graded SAND
	SAND (>12% fines)	SM	Silty SAND
		SC	Clayey SAND
Silt and Clay 50%or more passing #200 sieve	Liquid Limit < 50	ML	SILT
		CL	Lean CLAY
		OL	Organic SILT or CLAY
	Liquid Limit > 50	MH	Elastic SILT
		CH	Fat CLAY
		OH	Organic SILT or CLAY
Highly Organic Soils		PT	PEAT

Notes:

1. Soil exploration logs contain material descriptions based on visual observation and field tests using a system modified from the Uniform Soil Classification System (USCS). Where necessary laboratory tests have been conducted (as noted in the "Other Tests" column), unit descriptions may include a classification. Please refer to the discussions in the report text for a more complete description of the subsurface conditions.

2. The graphic symbols given above are not inclusive of all symbols that may appear on the borehole logs. Other symbols may be used where field observations indicated mixed soil constituents or dual constituent materials.

DESCRIPTIONS OF SOIL STRUCTURES

Layered:	Units of material distinguished by color and/or composition from material units above and below	Fissured:	Breaks along defined planes
Laminated:	Layers of soil typically 0.05 to 1mm thick, max. 1 cm	Slickensided:	Fracture planes that are polished or glossy
Lens:	Layer of soil that pinches out laterally	Blocky:	Angular soil lumps that resist breakdown
Interlayered:	Alternating layers of differing soil material	Disrupted:	Soil that is broken and mixed
Pocket:	Erratic, discontinuous deposit of limited extent	Scattered:	Less than one per foot
Homogeneous:	Soil with uniform color and composition throughout	Numerous:	More than one per foot
		BCN:	Angle between bedding plane and a plane normal to core axis

COMPONENT DEFINITIONS

COMPONENT	SIZE / SIEVE RANGE	COMPONENT	SIZE / SIEVE RANGE
Boulder:	> 12 inches	Sand	
Cobbles:	3 to 12 inches	Coarse Sand:	#4 to #10 sieve (4.5 to 2.0 mm)
Gravel		Medium Sand:	#10 to #40 sieve (2.0 to 0.42 mm)
Coarse Gravel:	3 to 3/4 inches	Fine Sand:	#40 to #200 sieve (0.42 to 0.074 mm)
Fine Gravel:	3/4 inches to #4 sieve	Silt	0.074 to 0.002 mm
		Clay	<0.002 mm

TEST SYMBOLS

for In Situ and Laboratory Tests listed in "Other Tests" column.

ATT	Atterberg Limit Test
Comp	Compaction Tests
Con	Consolidation
DD	Dry Density
DS	Direct Shear
%F	Fines Content
GS	Grain Size
Perm	Permeability
PP	Pocket Penetrometer
R	R-value
SG	Specific Gravity
TV	Torvane
TXC	Triaxial Compression
UCC	Unconfined Compression

SYMBOLS

Sample/In Situ test types and intervals

- 2-inch OD Split Spoon, SPT (140-lb. hammer, 30" drop)
- 3.25-inch OD Spilt Spoon (300-lb hammer, 30" drop)
- Non-standard penetration test (see boring log for details)
- Thin wall (Shelby) tube
- Grab
- Rock core
- Vane Shear

MONITORING WELL

- Groundwater Level at time of drilling (ATD)
- Static Groundwater Level
- Cement / Concrete Seal
- Bentonite grout / seal
- Silica sand backfill
- Slotted tip
- Slough
- Bottom of Boring

MOISTURE CONTENT

Dry	Dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water

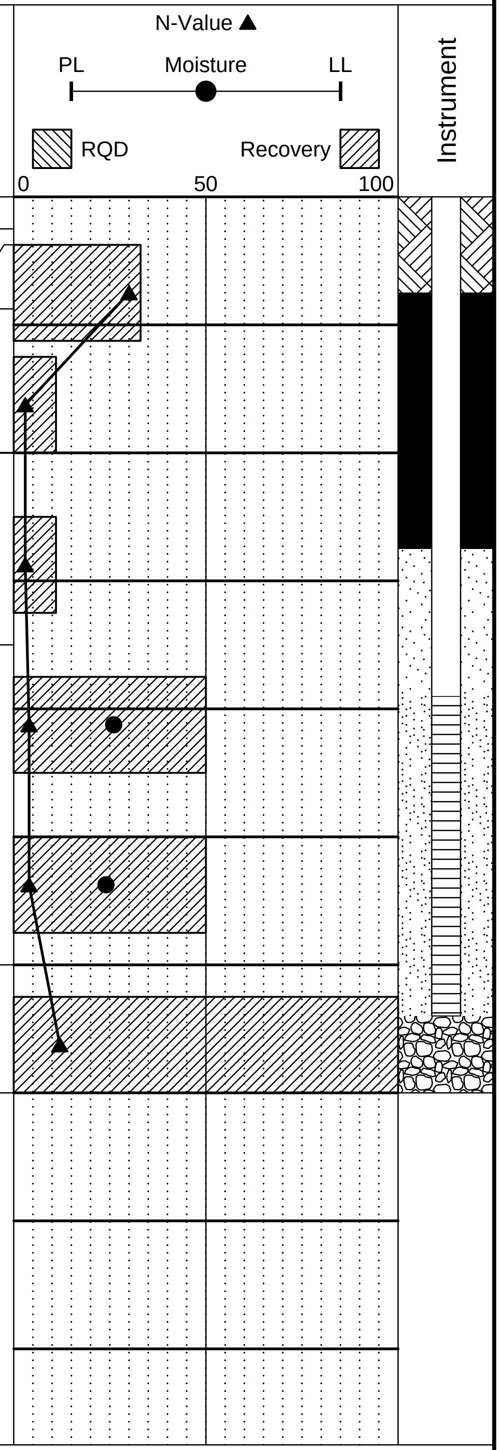
PanGEO INCORPORATED
Phone: 206.262.0370

Terms and Symbols for Boring and Test Pit Logs

Figure A-1

Project:	1st & 3rd Street Retrofit
Job Number:	13-239
Location:	1st and 3rd Streets, Marysville, WA
Coordinates:	Northing: , Easting:
Surface Elevation:	
Top of Casing Elev.:	
Drilling Method:	HSA
Sampling Method:	SPT

Depth, (ft)	Sample No.	Blows / 6 in.	Other Tests	MATERIAL DESCRIPTION
0				6 inches Asphalt.
				3 inches chip seal or similar.
	S-1	27 20 10		Approximately 12 inches of sand and gravel (Road Base).
2				Loose, brown, silty, fine to coarse SAND with gravel: moist, sub-angular gravel. (Fill).
	S-2	4 2 1		
4				Very loose, brown, fine to coarse SAND with silt: moist, abundant red cedar debris, non-plastic, poorly graded.
6	S-3	1 1 2		
8	S-4	1 1 3	GS	Loose, brown-gray, fine to medium SAND with some silt: wet, poorly graded, non-plastic, laminated. (Recessional Outwash).
10	S-5	2 1 3	GS	Becoming fine to coarse SAND, some silt.
12	S-6	3 5 7		Loose to medium dense, brown gray, silty, fine to medium SAND: wet, poorly graded, non-plastic, rapid dilatancy, homogeneous, laminated. (Recessional Outwash).
14				Boring terminated at about 14 feet below the surface. Groundwater was measured at about 7.6 feet below the surface on November 26, 2013.
16				
18				



Completion Depth:	14.0ft
Date Borehole Started:	11/25/13
Date Borehole Completed:	11/25/13
Logged By:	S. Evans
Drilling Company:	Bore Tec Drilling

Remarks: Groundwater measured in well installation on 11/26/13 at 12:31. Well was then developed by pumping with a down-hole pump until return water was nearly clear, about 5 minutes. Data logger installed in well following development. Logging was programed to begin at 12:00 noon, 11/27/13.

PanGEO INCORPORATED

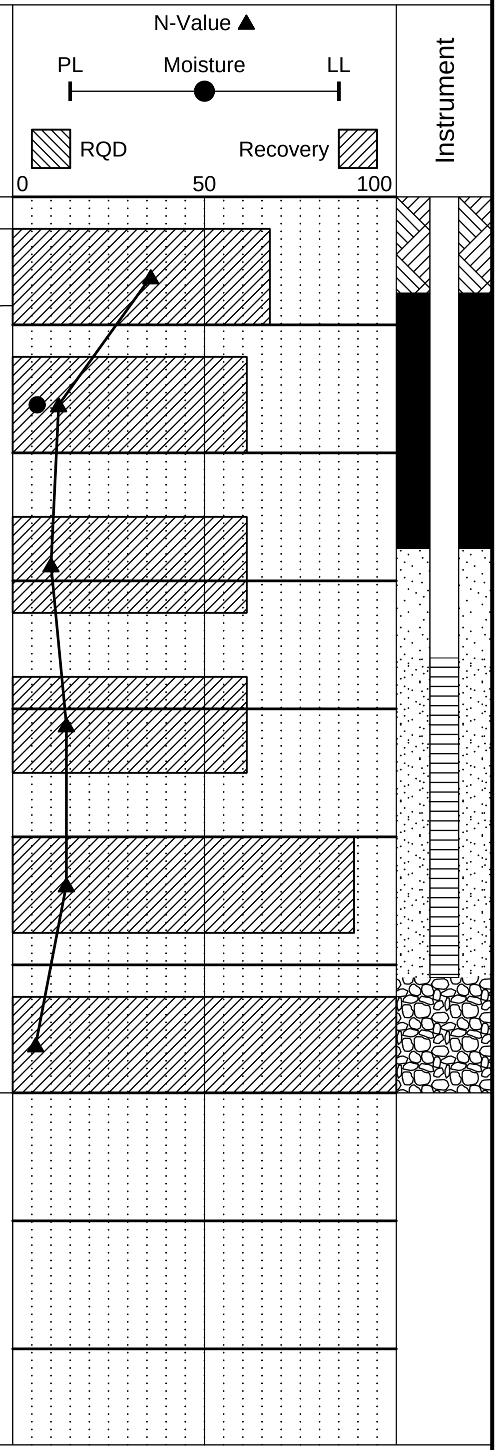
LOG OF TEST BORING B-1

Figure A-2

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	1st & 3rd Street Retrofit	Surface Elevation:	
Job Number:	13-239	Top of Casing Elev.:	
Location:	1st and 3rd Streets, Marysville, WA	Drilling Method:	HSA
Coordinates:	Northing: , Easting:	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0						6 inches of Asphalt.
	S-1		18 24 12			16 inches of Ballast/Base sand and gravel. Dense, brown and white, gravelly, fine to coarse SAND: moist some silt, layered, sub-rounded to sub-angular (Road Base).
2	S-2		5 6 6	GS		Medium dense, brown to gray, fine to medium SAND: moist becoming wet, trace to some silt, well and poorly graded, non-plastic fines, occasional organic material or woody debris, homogeneous, laminated. (Recessional Outwash).
4–6	S-3		4 5 5			Becoming wet.
8	S-4		5 7 7			Some woody debris, occasional gravel.
10	S-5		4 7 7			Becoming fine to medium.
12–14	S-6		2 2 4			Laminated with one brown silt laminae.
14						Boring terminated at about 14 feet below the surface. Groundwater was measured at about 5.3 feet below the surface on November 26, 2013.
16						
18						



Completion Depth:	14.0ft
Date Borehole Started:	11/25/13
Date Borehole Completed:	11/25/13
Logged By:	S. Evans
Drilling Company:	Bore Tec Drilling

Remarks: Groundwater measured in well installation on 11/26/13 at 12:52. Well was then developed by pumping with a down-hole pump until return water was nearly clear, about 5 minutes. Data logger and barometric pressure logger installed in well following development. Logging was programed to begin at 12:00 noon, 11/27/13.

PanGEO INCORPORATED

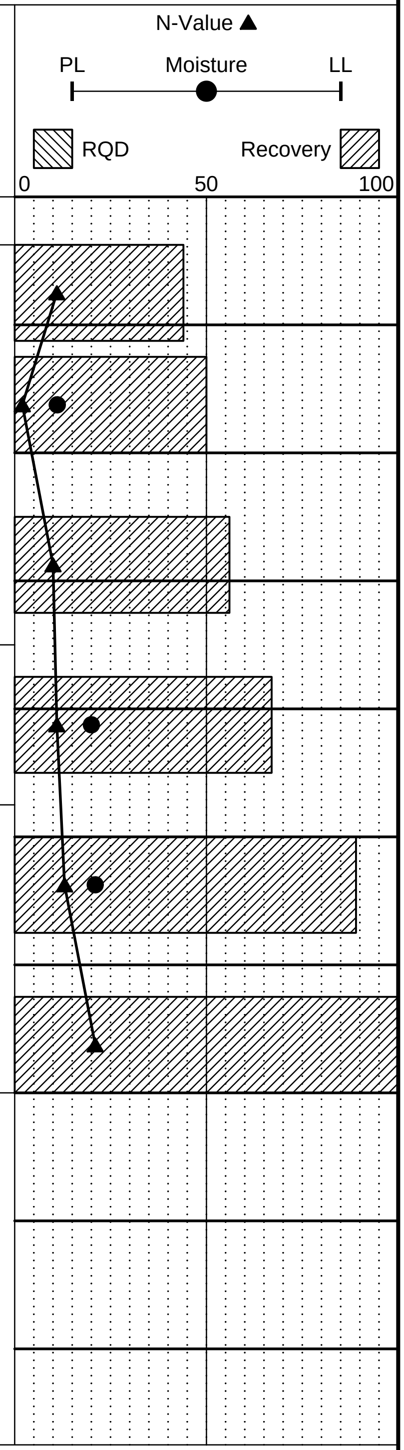
LOG OF TEST BORING B-2

Figure A-3

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	1st & 3rd Street Retrofit	Surface Elevation:	
Job Number:	13-239	Top of Casing Elev.:	
Location:	1st and 3rd Streets, Marysville, WA	Drilling Method:	HSA
Coordinates:	Northing: , Easting:	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0						9 inches of Asphalt, minimal base material.
1–2	S-1		5 8 3			Medium dense, dark gray to yellowish brown, silty, fine SAND: moist, poorly graded, non-plastic fines, trace gravel, homogeneous, laminated, trace of organics. (Fill).
2.5–4	S-2		2 1 1	GS		-Becomes very loose and with organic beds.
5–6.5	S-3		2 4 6			Organic pockets, becoming wet, silt pockets, yellow brown, grading to medium dense.
7.5–9	S-4		6 5 6	GS		Medium dense, brown-gray, fine to medium SAND with some silt: wet, poorly graded, laminated, with occasional silt beds. (Recessional Outwash). Medium stiff silt bed, wet, non-plastic, rapid dilatancy, laminated.
10–11.5	S-5		5 6 7	GS		Medium dense, brown-gray, fine to coarse SAND, some silt, wet, poorly and well graded beds, trace wood debris, laminated.
12.5–14	S-6		8 10 11			Fine to medium SAND, some silt.
14						Boring terminated at about 14 feet below the surface. Groundwater was estimated from groundwater level in an old well located 24' east of B-3 on November 25, 2013.



Depth scale (ft): 0, 2, 4, 6, 8, 10, 12, 14, 16, 18

Completion Depth:	14.0ft
Date Borehole Started:	11/25/13
Date Borehole Completed:	11/25/13
Logged By:	S. Evans
Drilling Company:	Bore Tec Drilling

Remarks: Groundwater level measured in an old monitoring well located 24 feet east of B-3 on 11/25/13.

PanGEO INCORPORATED

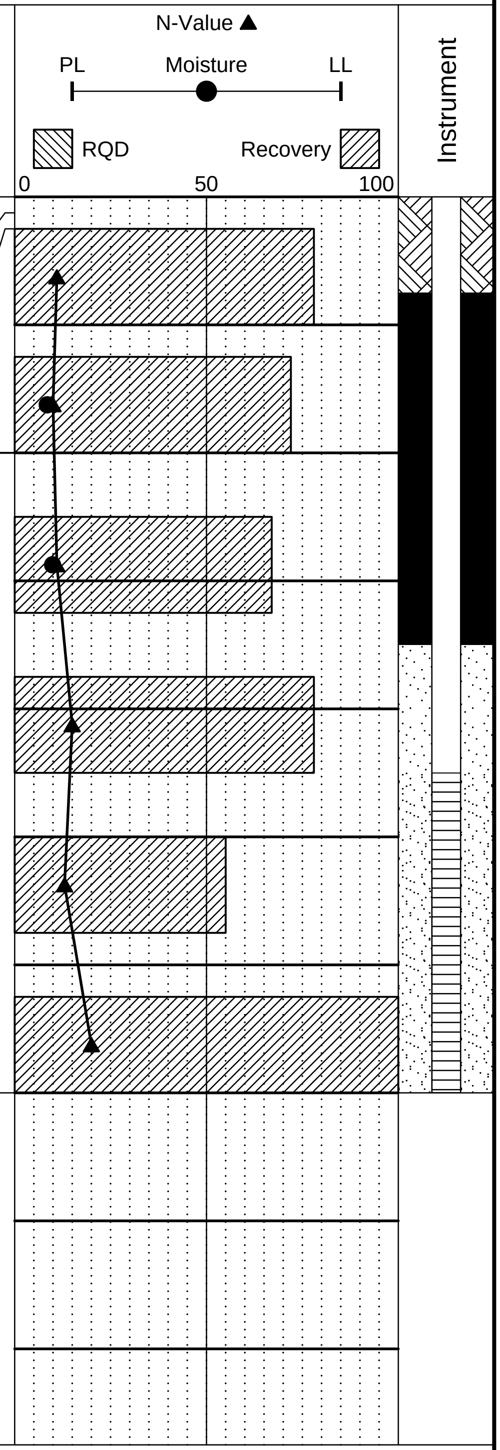
LOG OF TEST BORING B-3

Figure A-4

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	1st & 3rd Street Retrofit	Surface Elevation:	
Job Number:	13-239	Top of Casing Elev.:	
Location:	1st and 3rd Streets, Marysville, WA	Drilling Method:	HSA
Coordinates:	Northing: , Easting:	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0						3 inches of Asphalt.
						3 inches of Gravel base.
1	S-1		4 5 6			Medium dense, yellow brown, fine SAND: moist, poorly graded, some silt, non-plastic fines, occasional organic pocket at top, homogeneous, laminated. (Recessional Outwash).
2.5	S-2		3 5 5	GS		Grading to fine to coarse SAND with silt.
4						Medium dense, brown, silty, fine to coarse SAND: moist, some silt, occasional gravel, well graded, homogenous, laminated with occasional fine sand with silt interbeds.
5	S-3		4 6 5	GS		
7.5	S-4		4 7 8			Light gray brown, massive to indistinctly laminated.
10	S-5		3 6 7			Becoming wet, fine to medium SAND with silt, poorly graded.
12.5	S-6		5 8 12			Grading to brown, fine to coarse SAND, wet, some silt, non-plastic fines, occasional finer bed.
14						Boring terminated at about 14 feet below the surface. Groundwater was measured at about 7.6 feet below the surface on November 26, 2013.



Completion Depth:	14.0ft
Date Borehole Started:	11/26/13
Date Borehole Completed:	11/26/13
Logged By:	S. Evans
Drilling Company:	Bore Tec Drilling

Remarks: Groundwater measured in well installation on 11/26/13 at 13:16. Well was then developed by pumping with a down-hole pump until return water was nearly clear, about 5 minutes. Data logger installed in well following development. Logging was programed to begin at 12:00 noon, 11/27/13.

PanGEO INCORPORATED

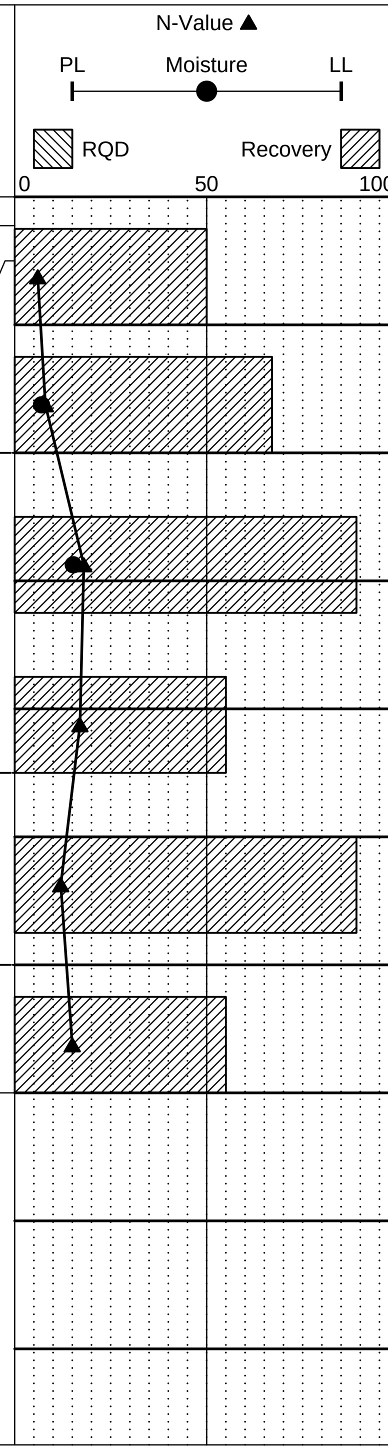
LOG OF TEST BORING B-4

Figure A-5

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	1st & 3rd Street Retrofit	Surface Elevation:	
Job Number:	13-239	Top of Casing Elev.:	
Location:	1st and 3rd Streets, Marysville, WA	Drilling Method:	HSA
Coordinates:	Northing: , Easting:	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0						5 inches of ASPHALT in two layers.
						6 inches of base. Medium dense, brown gray, silty, fine to coarse SAND with some gravel.
2	S-1		4 4 2			Loose, red brown to brown, fine SAND: moist, poorly graded, some silt, non-plastic fines, laminated with occasional rusty laminae, scattered charcoal organics. (Recessional Outwash).
4	S-2		2 3 5	GS		
						Medium dense, light gray, silty, fine to coarse SAND: moist, well graded, homogeneous, laminated with occasional rusty laminae, occasional fine gravel.
6	S-3		7 9 9	GS		
8	S-4		6 9 8			Grading to interbedded, light brown gray, silty, fine to medium SAND and fine to coarse SAND beds, laminated with occasional rusty laminae.
10						Medium dense, light brown, SILT with fine sand interbeds: very moist, non-plastic, laminated and fine bedded.
12	S-5		4 5 7			
						<medium dense, brown gray, fine to medium SAND with silt: wet, poorly graded, occasional fine to coarse sand interbed, homogeneous, laminated.
14	S-6		6 7 8			
16						Boring terminated at about 14 feet below the surface. Groundwater was estimated based on the soil sample moisture on November 26, 2013.
18						



Completion Depth:	14.0ft
Date Borehole Started:	11/26/13
Date Borehole Completed:	11/26/13
Logged By:	S. Evans
Drilling Company:	Bore Tec Drilling

Remarks: Groundwater observed in sample S-6 during drilling.

PanGEO INCORPORATED

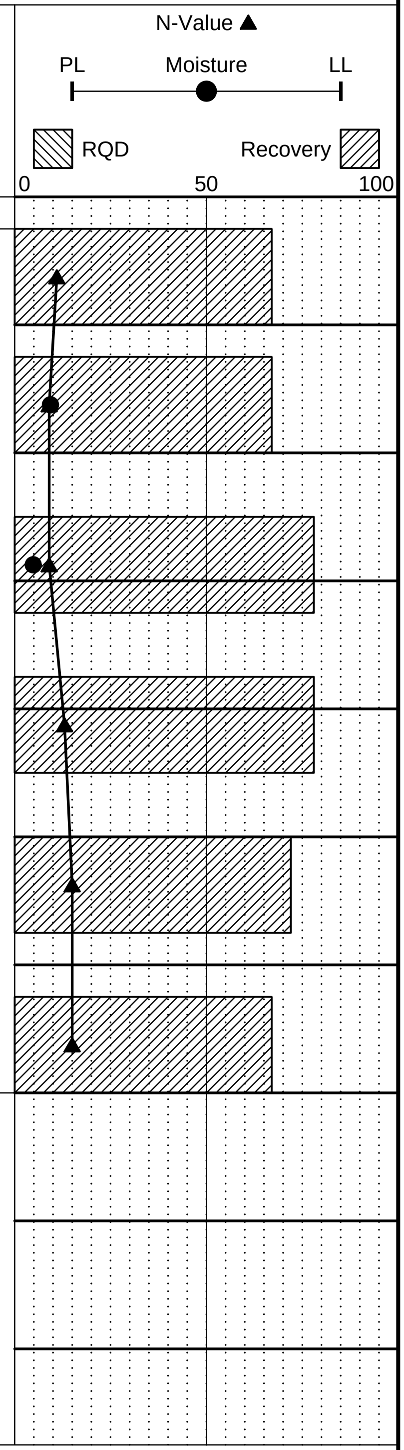
LOG OF TEST BORING B-5

Figure A-6

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	1st & 3rd Street Retrofit	Surface Elevation:	
Job Number:	13-239	Top of Casing Elev.:	
Location:	1st and 3rd Streets, Marysville, WA	Drilling Method:	HSA
Coordinates:	Northing: , Easting:	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0						6 inches of Asphalt, thin road base (<2 inches).
0.5–2	S-1	SPT	6, 6, 5			Loose to medium dense, yellow brown, silty, fine SAND to fine to medium SAND with silt: moist, poorly graded, non-plastic fines, trace gravel and organics at top, homogeneous, laminated. (Recessional Outwash).
2.5–4	S-2	SPT	4, 5, 4	GS		Grading to silty, fine to medium SAND, light brown gray.
5–6.5	S-3	SPT	2, 5, 4	GS		Grading to light gray, fine to medium SAND, some silt, occasional rusty laminae, finer and coarser beds.
7.5–9	S-4	SPT	4, 5, 8			Interbedded fine to coarse SAND, silty fine SAND and fine to medium SAND with silt, rusty laminae, finer beds brown, coarser are gray.
10–11.5	S-5	SPT	7, 7, 8			Homogeneous, fine to medium SAND, moist, trace silt, occasional rusty laminae.
12.5–14	S-6	SPT	6, 7, 8			Light gray, fine to medium SAND, moist, some silt, laminated to massive.
14						Boring terminated at about 14 feet below the surface. Groundwater was not observed during drilling.



Completion Depth:	14.0ft
Date Borehole Started:	11/25/13
Date Borehole Completed:	11/25/13
Logged By:	S. Evans
Drilling Company:	Bore Tec Drilling

Remarks: Groundwater not observed in SPT samples.

PanGEO INCORPORATED

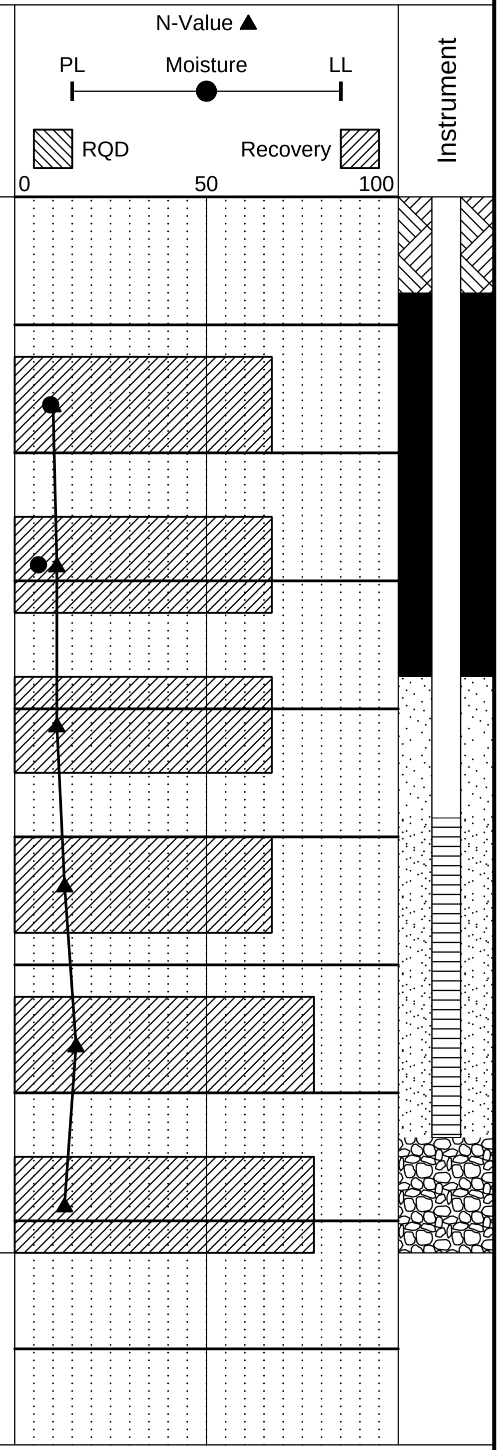
LOG OF TEST BORING B-6

Figure A-7

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	1st & 3rd Street Retrofit	Surface Elevation:	
Job Number:	13-239	Top of Casing Elev.:	
Location:	1st and 3rd Streets, Marysville, WA	Drilling Method:	HSA
Coordinates:	Northing: , Easting:	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0						Medium dense, light gray, fine to medium SAND: moist, some silt, poorly graded, homogeneous, massive to laminated, occasional orange pockets. (Recessional Outwash).
2.5–4	S-1	SPT	3 5 5	GS		Occasional organics.
5–6.5	S-2	SPT	5 5 6	GS		Trace to some silt.
7.5–9	S-3	SPT	5 5 6			
10–11.5	S-4	SPT	4 6 7			Laminated with occasional brown laminae.
12.5–14	S-5	SPT	5 8 8			Grading to light gray, fine SAND with silt.
15–16.5	S-6	SPT	5 6 7		∇	Grading to fine to medium SAND with silt.
16.5						Boring terminated at about 16.5 feet below the surface. Groundwater was estimated based on the soil sample moisture on November 26, 2013.



Completion Depth:	16.5ft
Date Borehole Started:	11/25/13
Date Borehole Completed:	11/25/13
Logged By:	S. Evans
Drilling Company:	Bore Tec Drilling

Remarks: Well dry when measured on 11/26/13. Groundwater estimated from SPT sample S-6 from 15 to 16.5 feet.

PanGEO INCORPORATED

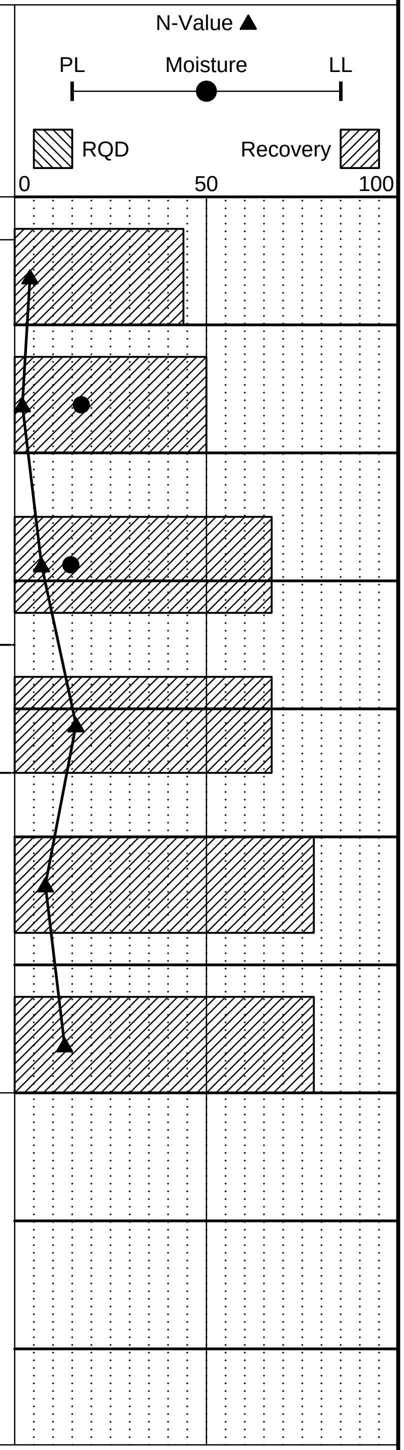
LOG OF TEST BORING B-7

Figure A-8

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	1st & 3rd Street Retrofit	Surface Elevation:	
Job Number:	13-239	Top of Casing Elev.:	
Location:	1st and 3rd Streets, Marysville, WA	Drilling Method:	HSA
Coordinates:	Northing: , Easting:	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	MATERIAL DESCRIPTION
0					5 inches Asphalt in two layers, 3 inches base.
					Loose, red brown, silty, fine SAND: moist, poorly graded, non-plastic, homogeneous, laminated. (Recessional Outwash).
	S-1	SPT	6, 3, 1		
2					
	S-2	SPT	2, 1, 1	GS	
4					
					Grading light brown-gray silty, fine SAND with silt lenses, very moist.
6	S-3	SPT	2, 2, 5	GS	
					Medium dense, light gray, fine to coarse SAND: wet, well graded, trace to some silt, homogeneous, laminated with occasional rusty laminae.
8	S-4	SPT	6, 7, 9		
					Loose to medium dense, light gray, silty, fine SAND: moist, poorly graded, non-plastic, laminated, trace of orange mottling.
10					
	S-5	SPT	3, 4, 4		
12					
					Grading to fine to medium SAND with silt.
	S-6	SPT	6, 6, 7		
14					Boring terminated at about 14 feet below the surface. Groundwater was estimated based on the soil sample moisture during drilling.
16					
18					



Completion Depth:	14.0ft
Date Borehole Started:	11/26/13
Date Borehole Completed:	11/26/13
Logged By:	S. Evans
Drilling Company:	Bore Tec Drilling

Remarks: Free water not observed in samples. Sample S-6 was observed to become very moist, indicating groundwater was close.

PanGEO INCORPORATED

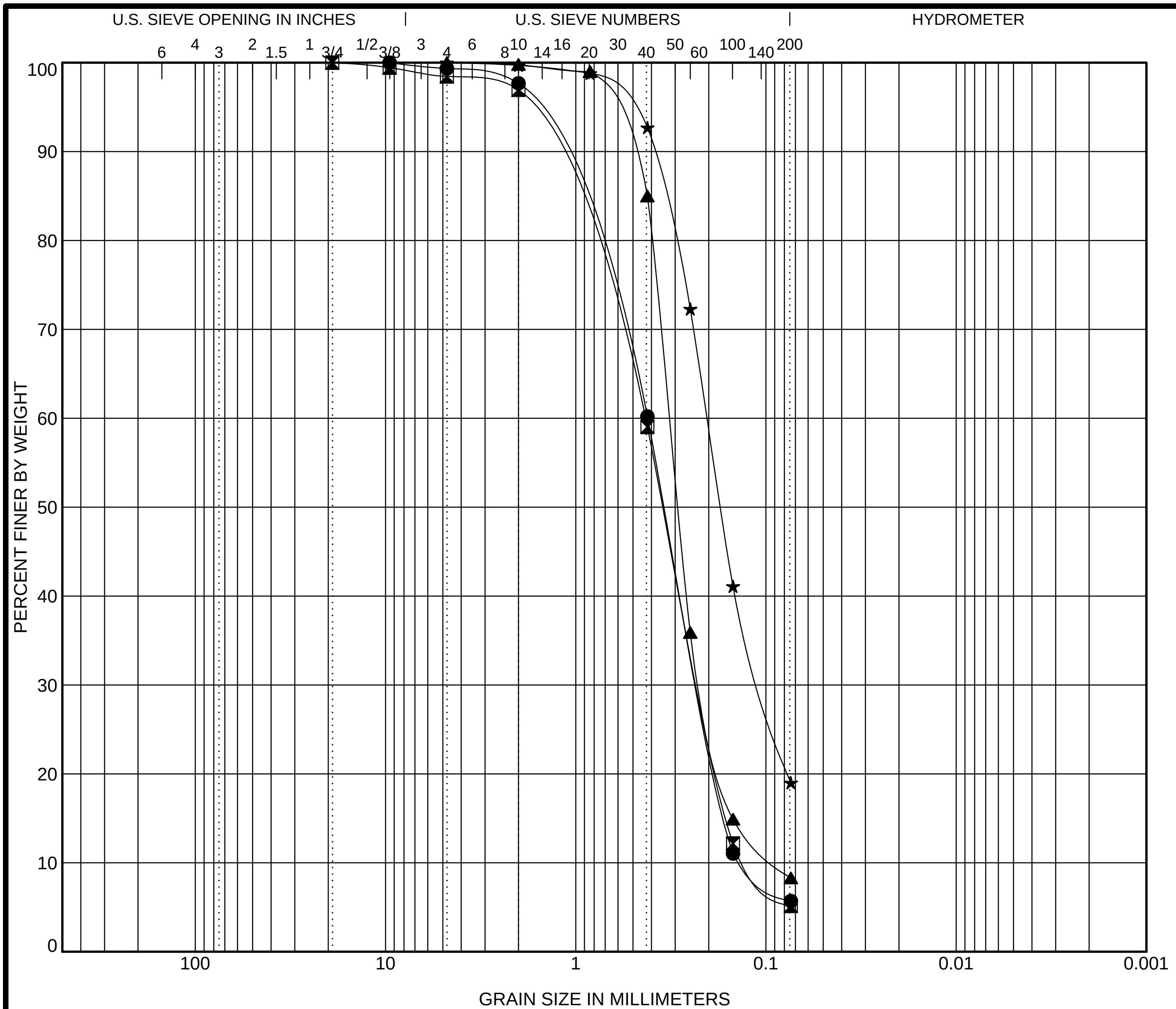
LOG OF TEST BORING B-8

Figure A-9

The stratification lines represent approximate boundaries. The transition may be gradual.

APPENDIX B

LABORATORY TEST RESULT



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	**B-1**	**@ 7.5 ft.**	**Browm-gray, fine to medium SAND, some silt**				**0.91**	**3.22**
⊠	**B-1**	**@ 10.0 ft.**	**Brown-gray, fine to coarse SAND, some silt**				**0.93**	**3.64**
▲	**B-2**	**@ 2.5 ft.**	**Brown-gray, fine to medium SAND, some silt**				**1.64**	**3.64**
★	**B-3**	**@ 2.5 ft.**	**Dark gray-yellowish brown, silty fine SAND**					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt / %Clay
●	**B-1**	**7.5**	**9.52**	**0.418**	**0.222**	**0.13**	**0.7**	**93.5**	**5.8**
⊠	**B-1**	**10.0**	**19.05**	**0.437**	**0.221**	**0.12**	**1.6**	**93.2**	**5.3**
▲	**B-2**	**2.5**	**4.76**	**0.322**	**0.216**	**0.089**	**0.0**	**91.6**	**8.4**
★	**B-3**	**2.5**	**4.76**	**0.204**	**0.105**		**0.0**	**80.6**	**19.4**

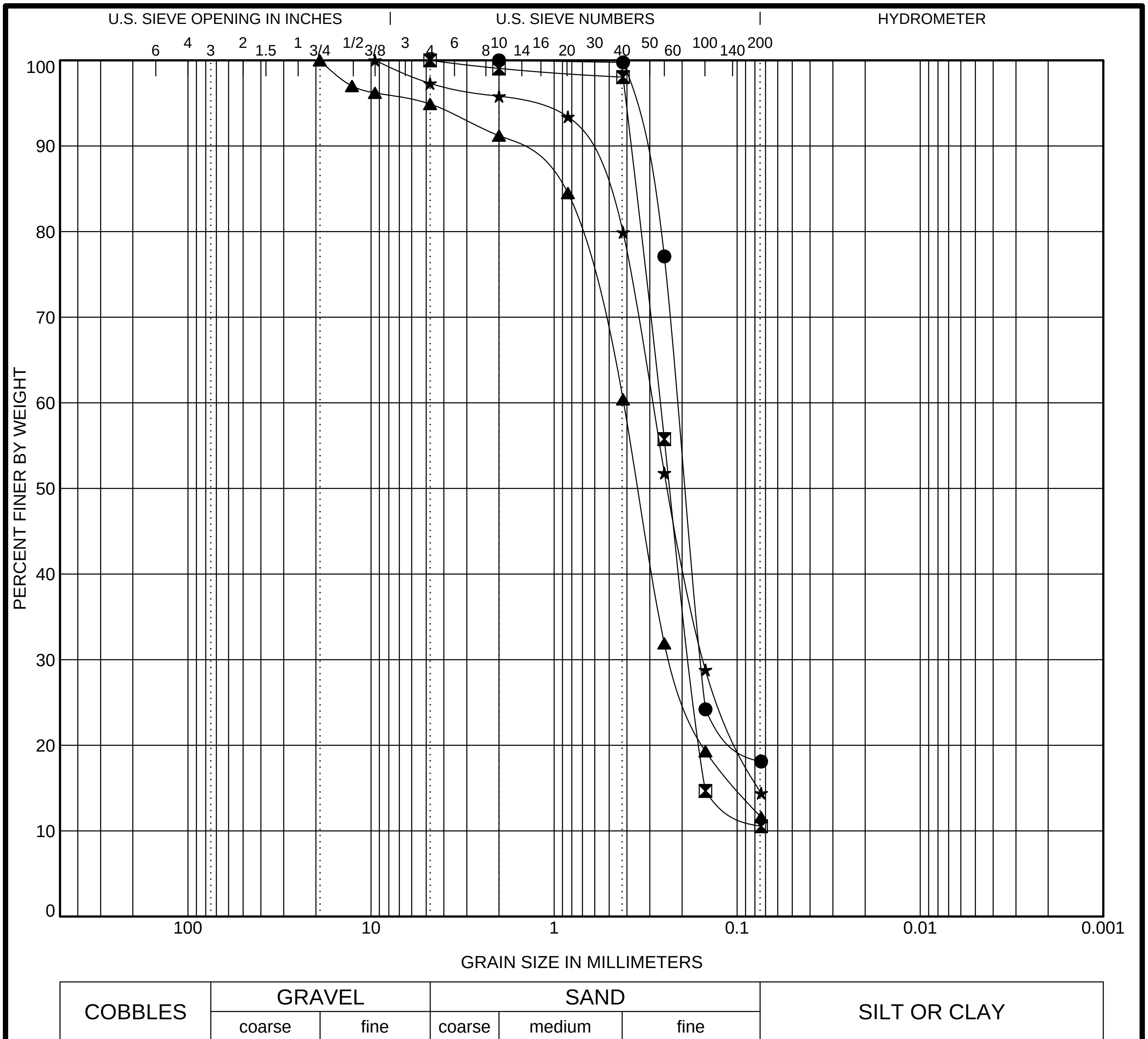
GRAIN SIZE DISTRIBUTION

PanGEO INCORPORATED
Phone: 206.262.0370

Project: 1st & 3rd Street Retrofit
Job Number: 13-239
Location: 1st and 3rd Streets, Marysville, WA

Figure B-1

GRAIN SIZE 13-239 3RD ST LOGS.GPJ PANGEO.GDT 1/30/14



	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	**B-3**	**@ 7.5 ft.**	**Brown-gray, silty fine to medium SAND**					
⊠	**B-3**	**@ 10.0 ft.**	**Brown-gray, fine to medium SAND, some silt**				**1.84**	**3.91**
▲	**B-4**	**@ 2.5 ft.**	**Yellow-brown, fine SAND, some silt**				**2.00**	**6.52**
★	**B-4**	**@ 5.0 ft.**	**Brown, silty fine to coarse SAND**					

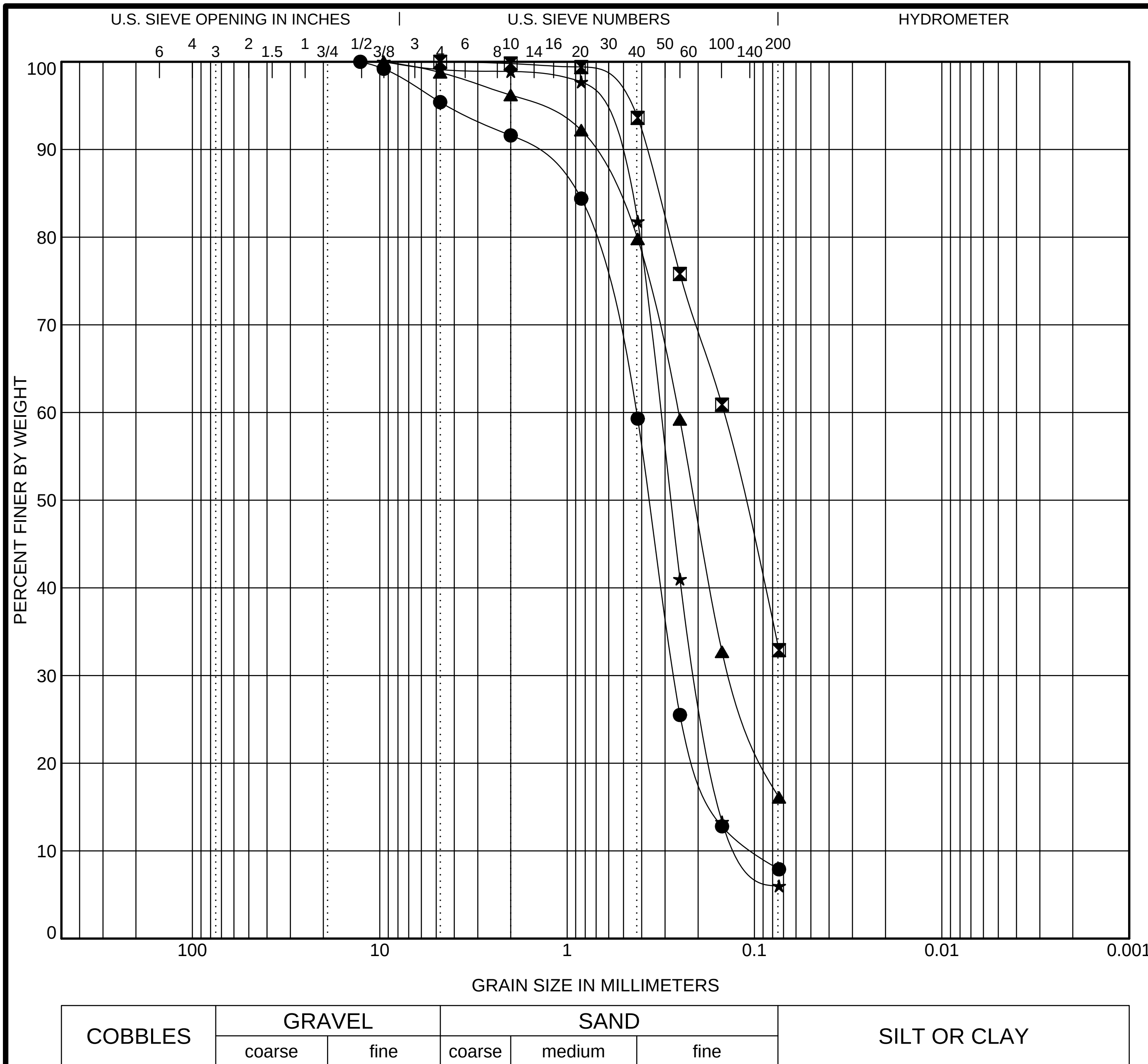
	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-3**	**7.5**	**2**	**0.211**	**0.158**		**0.0**	**81.8**	**18.2**	
⊠	**B-3**	**10.0**	**4.76**	**0.263**	**0.181**		**0.0**	**89.4**	**10.6**	
▲	**B-4**	**2.5**	**19.05**	**0.417**	**0.231**		**5.1**	**83.1**	**11.7**	
★	**B-4**	**5.0**	**9.52**	**0.291**	**0.153**		**2.7**	**82.6**	**14.7**	

PanGEO
INCORPORATED
Phone: 206.262.0370

GRAIN SIZE DISTRIBUTION

Project: 1st & 3rd Street Retrofit
Job Number: 13-239
Location: 1st and 3rd Streets, Marysville, WA

Figure B-2



	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	**B-5**	**@ 2.5 ft.**	**Red brown-brown, fine SAND, some silt**				**1.68**	**4.29**
⊠	**B-5**	**@ 5.0 ft.**	**Light gray, silty fine to medium SAND**					
▲	**B-6**	**@ 2.5 ft.**	**Yellow brown, silty fine to medium SAND**					
★	**B-6**	**@ 5.0 ft.**	**Light gray, fine to medium SAND, some silt**				**1.20**	**2.93**

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-5**	**2.5**	**12.7**	**0.428**	**0.268**	**0.1**	**4.6**	**87.4**	**8.0**	
⊠	**B-5**	**5.0**	**4.76**	**0.146**			**0.0**	**66.6**	**33.4**	
▲	**B-6**	**2.5**	**9.52**	**0.255**	**0.133**		**1.2**	**82.4**	**16.4**	
★	**B-6**	**5.0**	**9.52**	**0.318**	**0.204**	**0.109**	**0.9**	**93.0**	**6.1**	

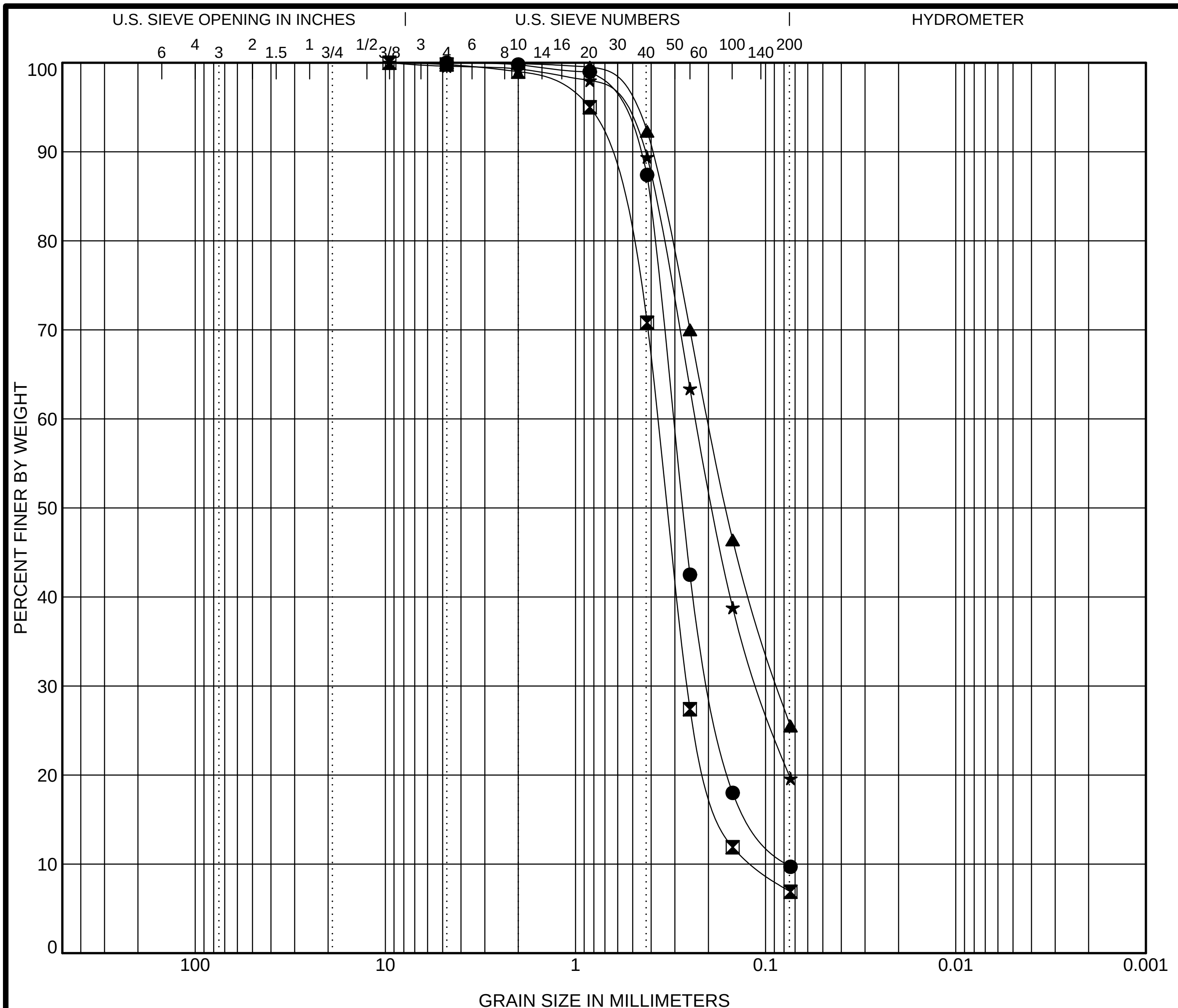
PanGEO
INCORPORATED
Phone: 206.262.0370

GRAIN SIZE DISTRIBUTION

Project: 1st & 3rd Street Retrofit
Job Number: 13-239
Location: 1st and 3rd Streets, Marysville, WA

Figure B-3

GRAIN SIZE 13-239 3RD ST LOGS.GPJ PANGEO.GDT 1/30/14



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	**B-7**	**@ 2.5 ft.**	**Light gray, fine to medium SAND, some silt**				**1.59**	**4.03**
⊠	**B-7**	**@ 5.0 ft.**	**Light gray, fine to medium SAND, trace to some silt**				**1.58**	**3.23**
▲	**B-8**	**@ 2.5 ft.**	**Red brown, silty fine SAND**					
★	**B-8**	**@ 5.0 ft.**	**Light brown-gray, silty fine SAND**					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt / %Clay
●	**B-7**	**2.5**	**4.76**	**0.306**	**0.192**	**0.076**	**0.0**	**90.1**	**9.9**
⊠	**B-7**	**5.0**	**9.52**	**0.369**	**0.258**	**0.114**	**0.2**	**92.8**	**7.0**
▲	**B-8**	**2.5**	**4.76**	**0.201**	**0.086**		**0.0**	**74.1**	**25.9**
★	**B-8**	**5.0**	**9.52**	**0.233**	**0.108**		**0.4**	**79.6**	**20.0**

PanGEO INCORPORATED

Phone: 206.262.0370

GRAIN SIZE DISTRIBUTION

Project: 1st & 3rd Street Retrofit
Job Number: 13-239
Location: 1st and 3rd Streets, Marysville, WA

Figure B-4

Summary Results of Cation Exchange Capacity Tests

Boring No.	B-2	B-3	B-4	B-5	B-6	B-7	B-8
Sample No.	S-1	S-1	S-1	S-1	S-1	S-1	S-1
Sample Depth	2.5-4'	2.5-4'	2.5-4'	2.5-4'	2.5-4'	2.5-4'	2.5-4'
Cation Exchange Capacity (meg/100g)	1.59	2.91	2.78	2.3	2.67	2.34	3.25