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RESOURCE STEWARDSHIP

Geotechnical Report
Littlerock Elementary School Replacement
Tumwater, Washington

August 6, 2015

Prepared for

Tumwater School District
Tumwater, Washington

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1.0 INTRODUCTION

This report presents the results of our field investigations and provides geotechnical engineering conclusions and recommendations for the proposed Littlerock Elementary School Replacement project located at 12710 Littlerock Road Southwest (SW) in Tumwater, Washington (site). The purpose of this investigation is to review and compile available subsurface information for the project area, complete site explorations to characterize subsurface soil and groundwater conditions, and to develop geotechnical conclusions and recommendations to support design of the proposed improvements.

The general project location is shown on the Vicinity Map, Figure 1. Figure 2 presents the Site and Exploration Plan, and Figure 3 presents the conceptual layout of the proposed site improvements. Appendix A presents a description of the field explorations and summary logs of conditions observed as part of this study. Appendix B summarizes the results of the laboratory testing program we performed. Appendix C summarizes the results of our groundwater monitoring program.

This report has been prepared based on our discussions with Tumwater School District (TSD) and preliminary site layout information provided by TSD.

1.1 PROJECT UNDERSTANDING AND BACKGROUND

We understand the project replaces the 1957 vintage administration, library, and classroom and kindergarten buildings with a new structure that will be built around the existing buildings. The project also includes new onsite parking and bus and parent drop off areas. We understand that a large-scale infiltration facility will not be utilized for this project. Stormwater management will likely consist of a lined pond or retention vault in the northern portion of the site to handle the majority of stormwater produced on site and a small infiltration trench in the southwest will manage the stormwater generated by the roof drains of the existing gymnasium building.

The project site is located within the Salmon Creek Basin, an area of Thurston County (County) where development is particularly regulated due to high groundwater conditions. The County requires that a detailed groundwater/hydrogeologic model be completed to support this project.

1.2 SCOPE OF SERVICES

Landau Associates was contracted by TSD to provide geotechnical engineering services to support the project. Our services were provided in accordance with our *Proposal for Geotechnical Engineering and Hydrogeologic Services* signed by TSD on June 13, 2014. Our scope of services included the following specific services:

- Reviewed available published geologic maps and geotechnical reports for the project area.

- Coordinated the clearance of underground utilities at our proposed exploration areas.
- Explored the subsurface soil and groundwater conditions by advancing both direct-push and auger-drilled borings, and performing Standard Penetration Test sampling. Landau Associates' personnel monitored the borings, collected representative soil samples, and maintained detailed boring logs of the conditions observed.
- Conducted a geotechnical laboratory testing program consisting of natural moisture content determinations and grain size analyses on select samples from the explorations.
- Provided recommendations for earthwork and grading, including stripping of unsuitable material, subgrade preparation, utility trench excavation, construction dewatering, the reuse of onsite materials and structural fill, and structural fill placement and compaction.
- Provided seismic design parameters (i.e., site class and spectral acceleration coefficients) for the proposed structure using map-based methods in accordance with the 2012 International Building Code [(IBC), International Code Council (ICC) 2011].
- Provided geotechnical recommendations for shallow foundation support of the proposed structure.
- Provided geotechnical recommendations for slab-on-grade support.
- Provided geotechnical recommendations related to the design of retaining walls.
- Provided recommendations for a design pavement section. We provide a heavy-duty section for high traffic and bus areas and a standard-duty section for parking areas.
- Evaluated the feasibility of infiltrating stormwater at the site.
- Prepared this geotechnical engineering report, which presents our conclusions and recommendations along with supporting data.

2.0 EXISTING CONDITIONS

The following sections describe the existing surface conditions observed during completion of field explorations, a description of the geologic setting, a brief description of the field exploration and laboratory testing programs, and a summary of the subsurface soil and groundwater conditions observed in the borings.

2.1 SURFACE CONDITIONS

The site is located at 12710 Littlerock Road SW in Tumwater, Washington. The western half of the site is generally occupied by the existing school buildings and pavements, with interspersed grass-covered areas. The eastern half of the site is covered by grass playfields. The site is generally flat, with topographic variations on the order of a few feet (ft) or less. We did not observe standing water on the site during our June 2014 and January 2015 site visits.

2.2 GEOLOGIC SETTING

General geologic information for the project area was obtained from the *Hydrology and Quality of Ground Water in Northern Thurston County, Washington* (Drost et al. 1998). According to the above reference, subsurface deposits in the vicinity of the proposed development consist of Vashon-aged recessional outwash. Recessional outwash deposits generally consist of unconsolidated, stratified, and interbedded deposits of sand with silt and minor gravel. Recessional outwash was deposited by meltwater streams emanating from the face of a retreating glacier. Recessional outwash typically exhibits moderate to high permeability and moderate shear strength. The soil conditions encountered in our subsurface explorations at the project site are generally consistent with the mapped geology.

2.3 FIELD EXPLORATION PROGRAM

Subsurface conditions at the site were explored on June 17 and 18, 2014 by advancing and sampling 12 soil borings, designated as B-1 through B-3 and MW-1 through MW-9. An additional site exploration program was conducted on January 19, 2015 by advancing and sampling seven soil borings, designated B-4 through B-6 and MW-10 through MW-13. Borings designated with a "B" were advanced using a hollow-stem auger technique or a direct-push probe rig. Borings designated with a "MW" (i.e., monitoring well) were advanced using a direct-push probe rig, after which a piezometer was installed to monitor groundwater levels. The soil borings were advanced by Holocene Drilling, Inc., of Puyallup, Washington under subcontract to Landau Associates. The borings were advanced to depths of between 8 and 20 ft below ground surface (BGS). The approximate locations of the borings are shown on Figures 2 and 3. A discussion of field exploration procedures and summary logs of the explorations are presented in Appendix

A. Appendix B summarizes the results of the laboratory testing program we performed on selected soil samples obtained from the borings.

2.4 SUBSURFACE SOIL CONDITIONS

The materials observed in the explorations are characterized in four general units, as described below:

- **Sod/Topsoil:** Sod/topsoil was encountered in each of the borings except B-1, which was advanced in an area of existing pavement. The combined sod/topsoil thickness was 2 to 6 inches at the locations explored.
- **Fill/Weathered Recessional Outwash:** Fill/weathered recessional outwash was encountered in each of the borings except B-1, typically extending to depths of 1 to 5 ft BGS. The fill/weathered recessional outwash generally consists of brown to dark brown, silty, fine to coarse sand with gravel and sandy gravel with silt. The fill/weathered recessional outwash is typically in a medium dense condition.
- **Recessional Outwash:** Recessional outwash was observed either directly beneath the pavement section (boring B-1) or below the sod/topsoil and fill/weathered recessional outwash deposits in each of our explorations. This material typically consists of sandy gravel/sandy gravel with silt; fine to coarse sand with silt and gravel; or silty, fine to medium sand. The recessional outwash is typically in a medium dense to dense condition.
- **Glacially Consolidated Deposits:** Glacially consolidated deposits were observed underlying the recessional outwash in 11 of our explorations. This material generally consists of very stiff to hard or dense, sandy silt or silty sand with gravel. These deposits generally exhibit very low permeability and represent an aquitard.

The soils encountered in our explorations are generally well suited for support of structures and pavements, provided the procedures and conditions described in Section 3.0 are followed.

2.5 GROUNDWATER

Groundwater was encountered in all of our borings completed for this investigation. The groundwater encountered during our explorations was observed at depths of 3.5 to 13 ft BGS. The project area is known to have a high groundwater table during the wet season, typically late winter and early spring, and we anticipate that groundwater conditions will vary from our observations at the time of drilling. The groundwater levels in monitoring wells MW-1 through MW-13 were measured over the winter of 2014/2015. A discussion of our groundwater monitoring program, a groundwater summary table, and associated figures illustrating our findings related to groundwater conditions at the site are presented in Appendix C.

3.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the field explorations, laboratory testing, and engineering analyses, it is our opinion that subsurface conditions at the project site are suitable for the proposed improvements provided the recommendations contained herein are incorporated into the project design. The following sections of this report provide design considerations and geotechnical engineering conclusions and recommendations related to earthwork; underground utilities; structures including seismic design criteria, allowable bearing capacity, foundation settlement, resistance to lateral loads, foundation drainage, slab-on-grade floors; retaining walls; asphalt pavement sections; and stormwater management.

3.1 EARTHWORK

Site grading activities are expected to consist of site preparation, subgrade preparation, and placement and compaction of structural fill.

3.1.1 WET WEATHER CONSIDERATIONS

Earthwork-related construction will be influenced by weather conditions. Some of the near-surface soil at the site contains a significant amount of fines and is considered to be moisture sensitive. Site grading activities using moisture-sensitive soil should ideally occur during the relatively warmer and drier period between mid-summer to early fall (July through early October). Completing earthwork-related activities outside of this ideal construction window could lead to an increase in construction costs due to weather-related delays, the need to repair disturbed areas, and the increased use of "all-weather" import fill materials. Completing underground utility construction during the summer, when groundwater levels are at their lowest level, would also provide a benefit to the project budget.

3.1.2 SITE PREPARATION ACTIVITIES

Clearing and grubbing of existing vegetation within the footprint of the proposed improvements should be in accordance with the requirements in Section 2-01 of the 2014 Washington State Department of Transportation (WSDOT) *Standard Specifications for Road, Bridge, and Municipal Construction* (WSDOT Standard Specifications, WSDOT 2014). Material generated during clearing and grubbing should be properly disposed of at an approved offsite location. Topsoil, and/or other organic-rich soil, should be stripped to expose the underlying inorganic soil. Removal of the existing sod, topsoil, and organic-rich soil should extend a minimum 10 ft beyond areas to be developed. Stripped material is not considered suitable for use as structural fill. Stripped material should either be wasted off site at an approved location or stockpiled for later use as topsoil.

Any utilities that will be abandoned that are less than 3 ft deep should be removed and disposed of at an approved offsite location. Deeper utilities may be left in place, but should be grouted full with controlled density fill, meeting the requirements in Section 2-09.3(1)E of the 2014 WSDOT Standard Specifications, in order to reduce the potential for differential settlement resulting from collapsed pipes and/or erosion. All incidental excavations associated with the removal of the existing improvements should be backfilled in accordance with the recommendations in Section 3.1.5 of this report.

3.1.3 SUBGRADE PREPARATION

Following clearing, stripping, and any required overexcavation to remove unsuitable material, and before placement of any structural fill to establish planned subgrade elevations, the upper 6 to 9 inches of exposed soil should be scarified, moisture conditioned, and compacted as described in Section 3.1.5 of this report. The prepared subgrade should be proof-rolled with a loaded dump truck, large self-propelled vibrating roller, or equivalent piece of equipment in the presence of a qualified geotechnical or civil engineer to check for the presence of soft, loose, and/or disturbed areas. If any soft, loose, and/or disturbed areas are revealed during proof-rolling, these areas should either be moisture conditioned and recompacted to the required density, or removed and replaced with imported structural fill, meeting the requirements in Section 3.1.4 of this report, compacted to the required density. Areas of limited access that cannot be proofrolled can be evaluated using a steel t-probe. Overexcavation of unsuitable subgrade material should be in accordance with Section 2-03.3(14)E of the 2014 WSDOT Standard Specifications. Completion of a proofroll of the compacted subgrade should be included as a note on the construction drawings.

3.1.4 STRUCTURAL FILL

The suitability of excavated soil or imported soil for use as structural fill will depend on the gradation and moisture content of the soil when it is placed. As the amount of fines increases, the soil becomes increasingly sensitive to small changes in moisture content and adequate compaction becomes more difficult to achieve. Soil containing more than about 5 percent fines (material passing the U.S. Standard No. 200 sieve, by weight) cannot consistently be compacted to a dense, non-yielding condition when the water content is greater than about 2 to 3 percent above or below optimum moisture content. Optimum moisture content is the moisture content at which the greatest compacted dry density can be achieved. In general, onsite soil with less than about 30 percent fines will be suitable for use as fill when the moisture content can be maintained near optimum.

If the onsite soil cannot be utilized for structural fill or if additional material is needed, import structural fill will be required. Import structural fill should meet the requirements for Select Borrow in Section 9-03.14(2) of the 2014 WSDOT Standard Specifications. If wet weather construction is anticipated,

the amount of fines should not exceed 5 percent, by dry weight, based on a wet sieve analysis of that portion passing the ¾-inch sieve.

3.1.5 BACKFILL AND COMPACTION REQUIREMENTS

Structural fill should be placed and compacted in accordance with Section 2-03.3(14)C, Method C of the 2014 WSDOT Standard Specifications. Compaction and moisture control tests should be done in accordance with Section 2-03.3(14)D of the 2014 WSDOT Standard Specifications. The maximum dry density and optimum moisture content may also be determined by the ASTM International (ASTM) D1557 test procedure.

3.2 SITE UTILITIES

The following sections provide geotechnical recommendations for design and construction of new site utilities. Geotechnical recommendations are provided for trench excavation and support, construction dewatering, pipe foundation support, pipe bedding and initial backfill, and trench backfill and compaction criteria.

3.2.1 TRENCH EXCAVATION AND SUPPORT

We anticipate that excavations for underground utilities will primarily be within medium dense sand and gravel. A heavy-duty, hydraulic excavator with sufficient reach should be able to excavate the proposed trenches to the expected depths. Upon reaching the trench bottom, we suggest that a smooth-bladed bucket be used to clean the trench bottom of loose and/or disturbed soil. The final trench bottom should be firm and free of loose and disturbed soil.

Trench configurations and maintenance of safe working conditions, including temporary excavation stability, should be the responsibility of the contractor. All applicable local, state, and federal safety codes should be followed. Temporary excavations for utilities should be sloped no steeper than $1^1/_2$H:1V (horizontal:vertical), based on the governing regulations for safe excavation practice in the State of Washington [Chapter 296-155 Washington Administrative Code (WAC)]. If groundwater seepage is present, flatter slopes, temporary shoring, and/or dewatering may be required.

Trench boxes should provide adequate support for shallow excavations, provided the trench is properly dewatered and settlement-sensitive structures and utilities are not situated immediately adjacent to the excavation. Trench boxes should meet the requirements in *Safety Standards for Construction Work, Part N* (Chapter 296-155 WAC).

3.2.2 CONSTRUCTION DEWATERING

We anticipate that underground utilities at the site could encounter groundwater during installation. We recommend that layout and design of underground utilities consider utilizing minimum pipe cover in order to avoid encountering groundwater during construction. Depth to groundwater information is provided in Appendix C of this report. If dewatering is necessary, the contractor should be responsible for design, installation, monitoring, and maintenance of any required dewatering system(s).

3.2.3 PIPE FOUNDATION SUPPORT

Based on the conditions observed in our explorations, medium dense sand and gravel is expected to be present at the base of utility trenches. This soil type will provide adequate foundation support for utilities, provided the foundation soil remains in a relatively undisturbed condition. If the bottom of the trench becomes disturbed due to excavation and/or foot traffic during the laying of the pipe, the disturbed material should be overexcavated to expose undisturbed foundation soil. The overexcavation should be backfilled with suitable foundation material to provide a firm trench bottom. Foundation material should be free from roots, topsoil, lumps of silt and clay, and organic and inorganic debris.

3.2.4 PIPE BEDDING AND INITIAL BACKFILL

To provide uniform support of buried utility pipes, the pipe should be bedded in accordance with Section 7-08.3(1)C of the 2014 WSDOT Standard Specifications and WSDOT Standard Plan B-55.20-00 (WSDOT 2013). Because of the potential for encountering oversized material, material excavated from the trenches would likely need to be processed (i.e., all particles greater than 3 inches should be removed) in order to be suitable for use as pipe-zone backfill. Therefore, we recommend that material excavated from the trench not be utilized as pipe-zone backfill. Bedding material for buried utility pipes should consist of Gravel Backfill for Pipe Zone Bedding per the requirements in Section 9-03.12(3) of the 2014 WSDOT Standard Specifications.

Pipe-bedding material and pipe-zone backfill should be brought up evenly around the pipe in relatively horizontal lifts not exceeding 6 inches, and worked under the haunches of the pipe by slicing with a shovel, vibration, or other approved procedures. Pipe-zone backfill should extend 6 inches above the crown of the pipe. Pipe bedding and pipe-zone backfill should be compacted to at least 90 percent of the maximum dry density determined in accordance with Section 2-03.3(14)D of the 2014 WSDOT Standard Specifications. The maximum dry density may also be determined by the ASTM D1557 test procedure.

3.2.5 TRENCH BACKFILL AND COMPACTION

Onsite sand and gravel soils may be utilized for trench backfill, provided all soil particles greater than 4 inches in diameter are removed and the soil is properly moisture conditioned and compacted to the required density. If additional material is required for trench backfill, then imported material meeting the requirements in Section 3.1.4 of this report should be used. Trench backfill should be placed and compacted in accordance with Section 3.1.5 of this report.

3.3 STRUCTURES

The following sections provide geotechnical engineering conclusions and recommendations for foundation design of structures. Recommendations are provided for seismic design, allowable bearing capacity and settlement, resistance to lateral loads, drainage considerations, and slab-on-grade floors. The following table provides a summary of design parameters for the structural engineer. The design parameters should only be used along with the complete recommendations provided in this report.

SUMMARY DESIGN PARAMETERS FOR STRUCTURAL ENGINEER

Allowable Soil Bearing Pressure = 3,500 psf
Friction Coefficient (factored) = 0.34
Passive Resistance (factored, equivalent fluid design) = 320 pcf
Active Earth Pressure = 32 pcf
At-rest Earth Pressure = 52 pcf
Seismic Earth Pressure = 8*H psf
Minimum Foundation Width = 18 inches (continuous), 24 inches (isolated)
Maximum Foundation Width (for settlement considerations) = 8 ft (continuous), 16 ft (isolated)

psf = pounds per square foot
pcf = pounds per cubic foot
H = exposed height of wall measured in feet

3.3.1 SEISMIC DESIGN CONSIDERATIONS

We understand that seismic design will be performed using the 2012 IBC standards (ICC 2011). The following parameters may be used to compute seismic base shear forces:

2012 INTERNATIONAL BUILDING CODE SEISMIC DESIGN PARAMETERS

Spectral Response Acceleration at Short Periods (S_S) = 1.283 g
Spectral Response Acceleration at 1 Second Periods (S_1) = 0.543 g
Site Class = D
Site Coefficient (F_a) = 1.0
Site Coefficient (F_v) = 1.5

The site is directly underlain by medium dense, glacially derived soil deposits. On this basis, and despite the relatively high groundwater table, it is our opinion that there is a low risk for seismically-induced soil liquefaction or lateral spreading at the site. Because of the location of the site with respect to the nearest known active crustal faults and the presence of a relatively thick layer of glacial soil deposits, it is our opinion that the risk of ground rupture due to surface faulting is low.

3.3.2 FOOTING PREPARATION, BEARING CAPACITY, AND SETTLEMENT

Shallow footings should provide adequate support for the proposed improvements provided the recommendations provided herein are incorporated into the design.

We recommend that shallow foundations for this project extend through the near-surface soil that contains organics (i.e., extending through the topsoil). Alternatively, shallow foundations can be supported on properly compacted imported structural fill that is placed after the near-surface soil that contains organics is removed. Prior to placing structural fill or concrete formwork and reinforcing steel, the prepared subgrade should be observed by a qualified geotechnical engineer to check that suitable bearing soil is present. If unsuitable bearing soil is present on the subgrade, it should be overexcavated and replaced with structural fill. The overexcavation zone should extend a horizontal distance equal to at least one-half of the overexcavation depth on each side of the footing. For example, a 2-ft-wide footing with a 2-ft-deep overexcavation should have a 4-ft-wide overexcavation zone. The base of the overexcavation should be evaluated by the geotechnical engineer prior to placement of structural fill.

We recommend a minimum width of 18 inches for continuous wall footings and 24 inches for isolated column footings. For settlement considerations, we have assumed a maximum width of 8 ft for continuous wall footings and 16 ft for isolated column footings. Foundations should be founded a minimum of 18 inches below the lowest adjacent final grade for frost protection. Continuous or isolated spread

footings may be proportioned using a net allowable bearing pressure of 3,500 psf. The net allowable bearing pressure includes a factor of safety of at least 3 on the calculated ultimate bearing capacity. The term "Net Allowable Bearing Pressure" refers to the pressure that can be imposed on the soil at foundation level resulting from the total of all dead plus live loads (including snow loads), exclusive of the weight of the footing or any backfill placed above the footing. The net allowable bearing pressure can be increased by one-third for short term transient wind and seismic loads.

Settlement of shallow foundations depends on the foundation size and bearing pressure, as well as the strength and compressibility characteristics of the underlying bearing soil. Assuming construction is accomplished as previously recommended and for the maximum allowable soil bearing pressure recommended above, we estimate the settlement of continuous or isolated spread footings will be on the order of 1 inch or less. Differential settlement between similarly loaded foundation elements may be assumed to be on the order of ½ inch, or less. The soil response to applied stresses caused by structural and other loads is expected to be predominately elastic in nature, with most of the settlement occurring during construction as loads are applied.

3.3.3 Resistance to Lateral Loads

Resistance to lateral loads can be provided by friction acting on the base of footings and by passive lateral earth pressures acting against the sides of footings. An allowable coefficient of sliding resistance of 0.34, applied to the vertical dead loads only, may be used to compute frictional resistance. The allowable coefficient of sliding resistance includes a factor of safety of 1.5 on the calculated ultimate value. For design purposes, the passive resistance of properly compacted structural fill placed against the sides of foundations may be considered equivalent to a fluid with a density of 320 pcf. The value for the foundation passive earth pressure has been reduced by a factor of 1.5 to limit deflections to less than 2 percent of the embedded depth.

The passive earth pressure and friction components can be combined, provided that the passive component does not exceed two-thirds of the total. The top foot of soil should be excluded when calculating passive resistance unless the foundation perimeter area is covered by a slab-on-grade or pavement.

3.3.4 Foundation Drainage Considerations

We recommend that foundation drainage be provided for all below-grade footings and floor slabs that are lower than the adjacent exterior grade. The foundation drainage system should consist of a minimum 4-inch-diameter, smooth-walled, heavy-duty, minimum Schedule 40 PVC perforated pipe (with the perforations placed downward) in a minimum 12-inch-wide zone of 1-inch minus drain gravel. The drain gravel should completely surround the perforated drain pipe and be completely surrounded by a non-

woven geotextile such as Mirafi® 140N, or equivalent. The top of the perforated pipe should be no higher than the top of the adjacent footing. Foundation drains should discharge into the storm system or an approved location.

Roof downspouts should not be introduced into the footing drains, but discharged directly into the site stormwater system or other appropriate outlet by means of a tightline-type system. To reduce the possibility of water ponding and infiltrating into the subsurface near foundations, exterior grades should be sloped to promote runoff away from the structures.

3.3.5 SLAB-ON-GRADE FLOORS

Slab-on-grade floors should be established on a subgrade that consists of uniformly firm and unyielding soil. Slab-on-grade subgrades should be prepared as described in Section 3.1.3 of this report.

A modulus of vertical subgrade reaction (subgrade modulus) can be used to design the floor slabs. The subgrade modulus varies based on the dimensions of the slab and the magnitude of applied loads on the slab surface; slabs with larger dimensions and loads are influenced by soil to a greater depth. We recommend a subgrade modulus value of 150 pounds per cubic inch for the design of on-grade floor slabs with floor loads up to 500 psf. This subgrade modulus is for a 1-ft by 1-ft square plate, and is not the overall modulus of a larger area. We are available to provide alternate recommendations during design, based on any specific loading information available at that time.

We recommend that slabs-on-grade in interior spaces be underlain by a minimum 4-inch-thick capillary break layer to reduce the potential for moisture migration into the slab. The capillary break material should consist of well-graded sand and gravel containing less than 5 percent fines based on the fraction passing the ¾-inch sieve. If dry slabs are required (e.g., where adhesives are used to anchor carpet or tile to the slab), a waterproofing liner should be placed below the slab to act as a vapor barrier.

3.4 RETAINING WALLS

The following sections provide geotechnical engineering conclusions and recommendations for retaining walls. Recommendations are provided for lateral soil pressures, lateral resistance and foundation support, and wall drainage.

3.4.1 LATERAL SOIL PRESSURES

Lateral soil pressures acting on retaining walls will depend on the nature and density of the soil behind the wall, the amount of lateral wall movement that occurs as backfill is placed, and the inclination of backfill surface. For walls free to yield at the top at least one thousandth of the wall height (i.e., wall height times 0.001), we recommend that walls be designed using an equivalent fluid density of 32 pcf

(active pressures). Restrained walls (walls not allowed to rotate at least 0.001 times the wall height) should be designed using an equivalent fluid density of 52 pcf (at-rest pressures). For seismic loading conditions, a rectangular earth pressure equal to 8H psf, where H is the height of the wall, should be added to the active pressures provided above. This seismic earth pressure is based on the Mononobe-Okabe theory and assumes one-half of the peak ground surface acceleration for the site. If the walls are designed for at-rest conditions, but is assumed to move during seismic conditions, then it is appropriate to combine the seismic surcharge pressures with the active pressures (rather than the at-rest pressures).

The lateral soil pressures provided above do not include traffic surcharges, the effects of sloping backfill, or hydrostatic pressure. For uniform surcharge pressures, uniformly distributed lateral loads of 0.26 and 0.41 times the vertical surcharge pressure should be added for yielding and non-yielding walls, respectively. The recommended soil pressures also assume that the material behind the wall consists of structural fill or undisturbed native soil for a horizontal distance behind the wall equal to the wall height.

3.4.2 LATERAL RESISTANCE AND FOUNDATION SUPPORT

Foundation support and lateral resistance values for retaining wall footings should be designed in accordance with Sections 3.3.2 and 3.3.3 of this report, respectively.

3.4.3 WALL DRAINAGE

Drainage systems should be constructed to collect water and prevent the buildup of hydrostatic pressure against retaining walls. We recommend that wall drainage systems include a zone of free-draining backfill a minimum of 18 inches in width against the back of the wall. Free-draining backfill should meet the requirements for Gravel Backfill for Walls in Section 9-03.12(2) of the 2014 WSDOT Standard Specifications. The free-draining backfill zone should extend to within 1 ft of the top of the wall. A perforated, rigid, smooth-walled drain pipe with a minimum diameter of 4 inches should be placed along the base of the wall within the free-draining backfill and extend for the entire wall length. The drainpipe should be sloped to drain by gravity to an approved discharge location.

3.5 PAVEMENT

Pavement sections should be constructed on a subgrade that consists of uniformly firm and unyielding soil. Pavement subgrades should be prepared as described in Section 3.1.3 of this report. Pavement section recommendations provided below assume a 20-year design life and a maximum equivalent single-axle loads of 50,000 for the standard-duty section and 500,000 for the heavy-duty section.

RECOMMENDED ASPHALT PAVEMENT DESIGN SECTIONS

Pavement Section Type	Asphalt Concrete Pavement Thickness	Crushed Surfacing Thickness
Standard Duty	3 inches	6 inches
Heavy Duty	4 inches	8 inches

Asphalt concrete should be Class B aggregate material or hot-mix asphalt Class ½ inch, PG64-22 conforming to Section 5-04 of the 2014 WSDOT Standard Specifications. The asphalt should be compacted to at least 91 percent of the Rice density. Base course material should be compacted to at least 95 percent of the maximum dry density (ASTM D1557) and meet the requirements for Crushed Surfacing Base Course in Section 9-03.9(3) of the 2014 WSDOT Standard Specifications. The upper 2 inches of crushed surfacing could consist of Crushed Surfacing Top Course to facilitate fine grading of the surface. Prevention of road-base saturation is essential for pavement durability; thus, efforts should be made to limit the amount of water entering the base course.

3.6 STORMWATER MANAGEMENT

Seasonal groundwater measurements were recorded over the winter of 2014/2015. Soils observed in our explorations generally have high infiltration potential, however due to the presence of high groundwater the infiltration capacity of these soils is greatly reduced. Based on the groundwater data collected and site constraints, the design team concluded that a large-scale infiltration facility would not be feasible for this project. It is our understanding that the majority of the stormwater produced on site will be managed by a lined pond or retention vault in the northern portion of the site or a stormwater tank in the southern portion of the site. A small infiltration trench in the southwest portion of the site will manage the stormwater generated by the roof drains of the existing gymnasium building. Given the limited size of the contributing area to the infiltration trench, we do not believe a mounding analysis is necessary.

4.0 DOCUMENT REVIEW AND CONSTRUCTION OBSERVATIONS

Landau Associates recommends that we review the geotechnical-related portions of the project plans and specifications in advance of project bidding. The purpose of the review is to verify that the recommendations presented in this geotechnical report have been properly interpreted and implemented in the design and project specifications. We recommend that monitoring, testing, and consultation be provided during construction to confirm that the conditions encountered are consistent with those indicated by our explorations, to provide expedient recommendations should conditions be revealed during construction that differ from those anticipated, and to evaluate whether geotechnical-related activities comply with project plans and specifications and the recommendations contained in this report. Such geotechnical-related activities include observation of foundation subgrades, compaction testing of structural fill, observation of the prepared slab and pavement subgrades, and other geotechnical activities. The purpose of these services would be to observe compliance with the design concepts, specifications and recommendations of this report, and in the event subsurface conditions differ from those anticipated before the start of construction, provide revised recommendations appropriate to the conditions revealed during construction. Landau Associates would be pleased to provide these services for you.

5.0 USE OF THIS REPORT

This report was prepared for the exclusive use of the Tumwater School District and their authorized agents for specific application to the proposed Littlerock Elementary School Replacement project in Tumwater, Washington. The use of this report by others, or for purposes other than intended, is at the user's sole risk. Within the limitations of scope, schedule, and budget, the conclusions and recommendations presented in this report were prepared in accordance with generally accepted geotechnical engineering principles and practices in the area at the time the report was prepared. We make no other warranty, either express or implied.

There may be some variation in subsurface soil and groundwater conditions at the site, and the nature and extent of the variations may not become evident until construction. Accordingly, a contingency for unanticipated conditions should be included in the construction budget and schedule. We should be contacted if variations in subsurface conditions are encountered during construction.

* * * * *

We appreciate the opportunity to provide geotechnical engineering services on this project and look forward to assisting you as the project progresses. If you have any questions or comments regarding the information contained in this report, or if we may be of further service, please call the undersigned at (360) 791-3178.

LANDAU ASSOCIATES, INC.

Jeff Whitman
Project Geotechnical Engineer

Steven R. Wright, P.E.
Principal

8/6/15

JRW/SZW/bar

6.0 REFERENCES

Drost, B.W., G.L. Turney, N.P. Dian, and M.A. Jones.1998. *Hydrology and Quality of Groundwater in Northern Thurston County, Washington.* U.S. Geologic Survey, Geologic Map WRI-72-4109.

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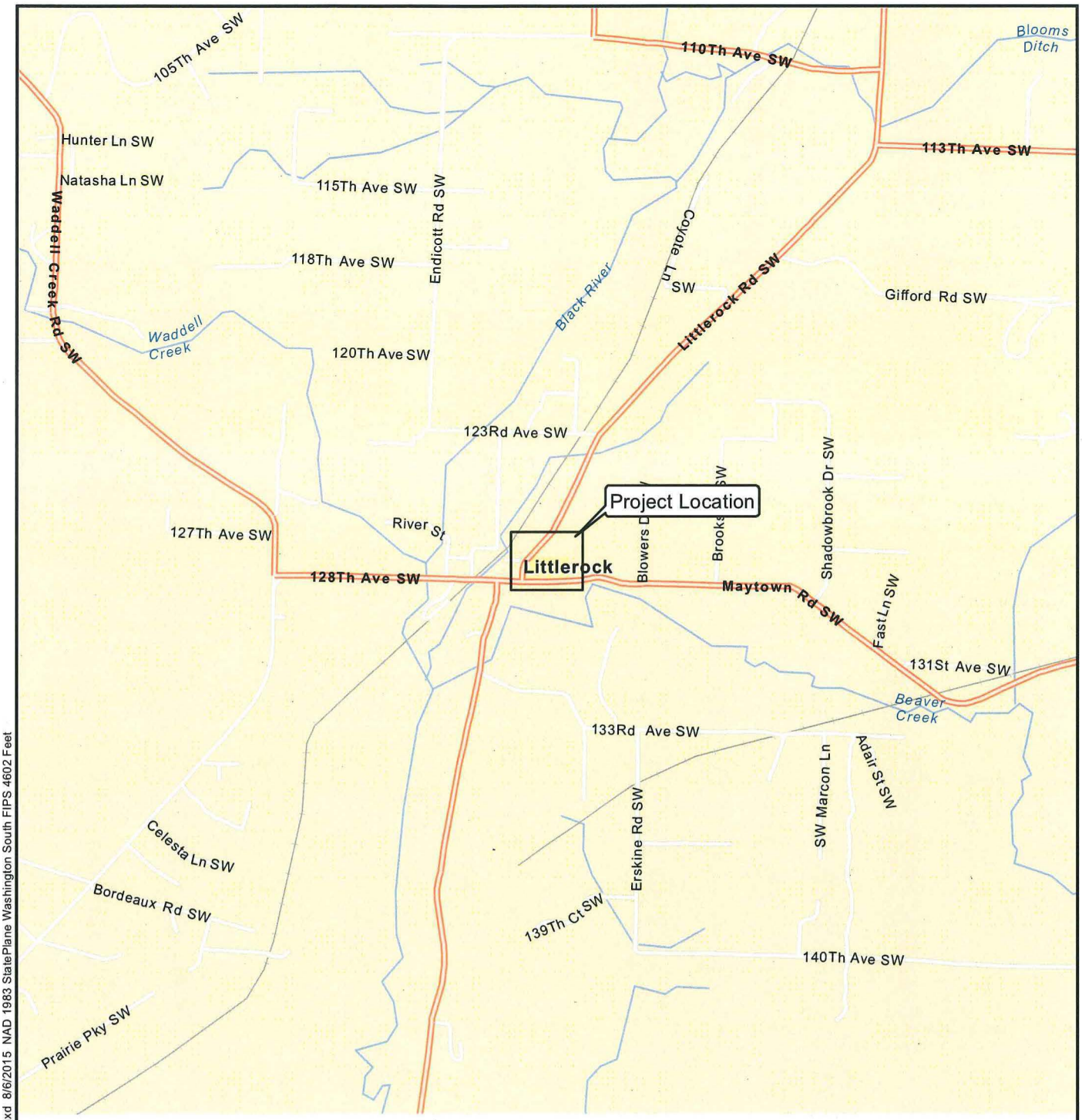

N

0 0.5 1
Miles

Data Source: Esri 2012

G:\Projects\1467\002\010\011\Littlerock\F01VicMap.mxd 8/6/2015 NAD 1983 StatePlane Washington South FIPS 4602 Feet

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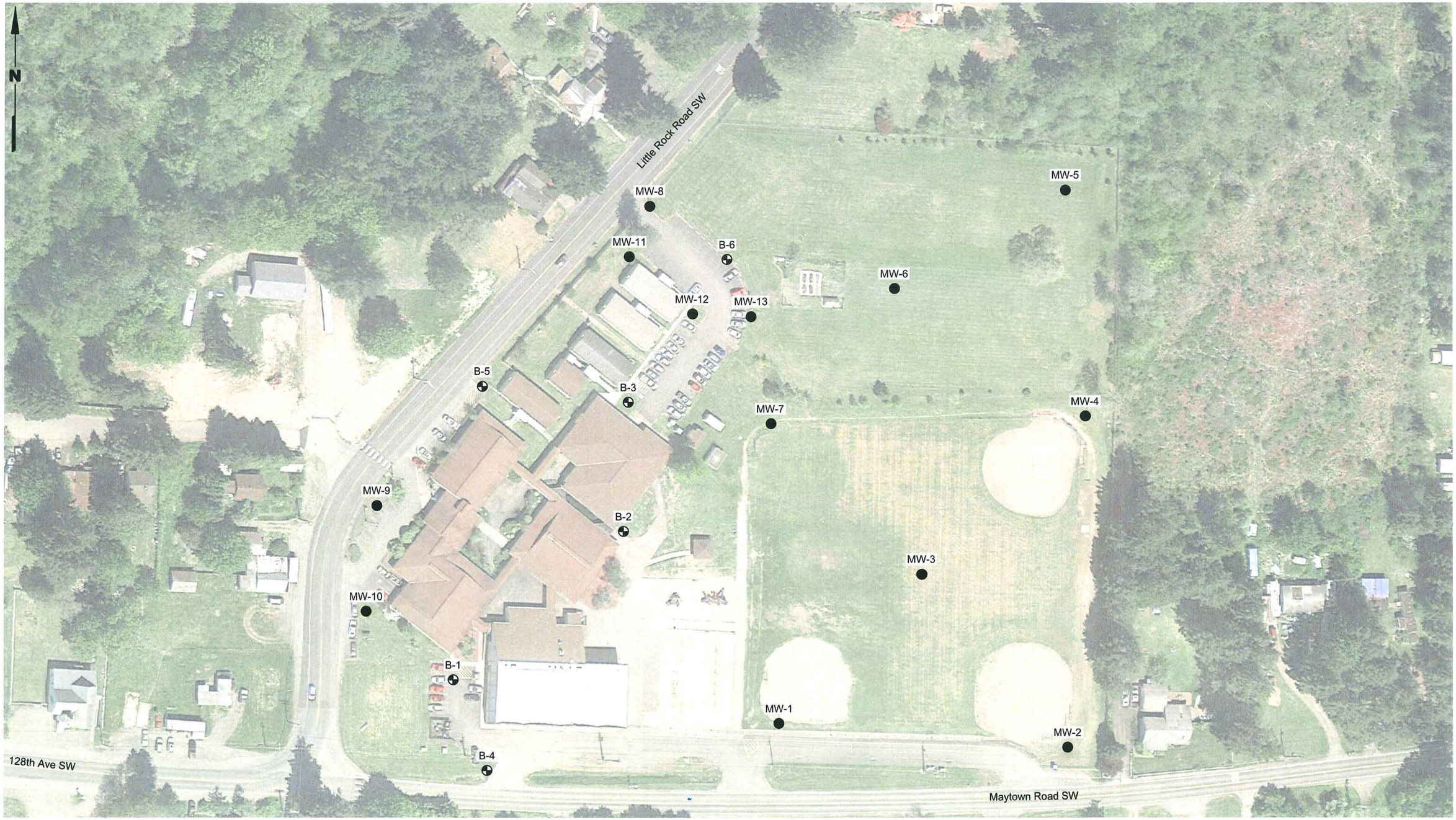
Littlerock Elementary School Replacement Tumwater, Washington	**Vicinity Map**	Figure 1



LANDAU ASSOCIATES, INC. | G:\Projects\1467\002\010\011\Littlerock\F02-03SEPLAN.dwg (A) "Figure 2" 8/7/2015

Legend

B-1 Boring Location and Designation

MW-1 Monitoring Well Location and Designation

Note

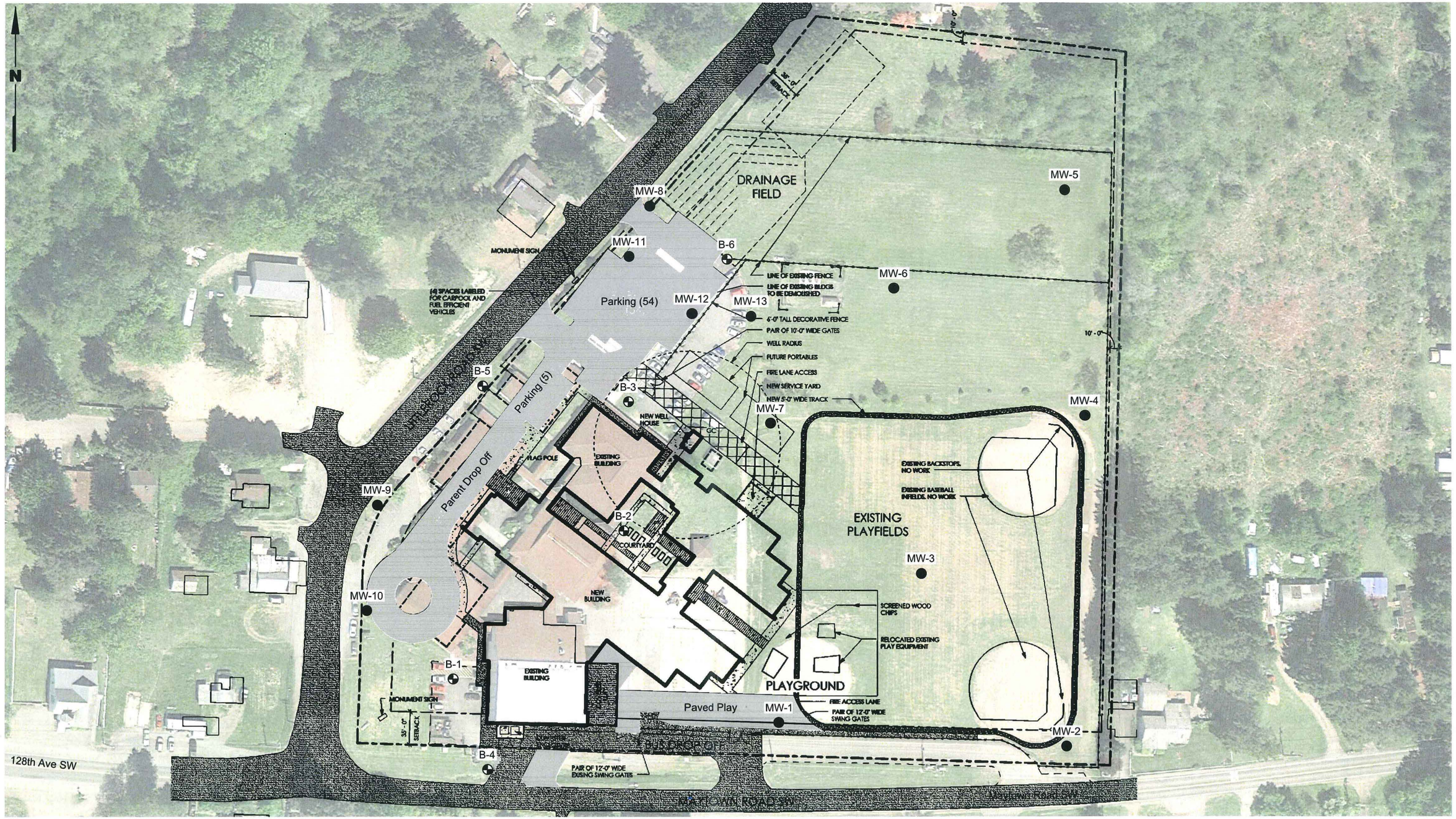
1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 100 200
Scale in Feet

Source: Thurston County GIS, Google Earth 2013

LANDAU ASSOCIATES

Littlerock Elementary School Replacement Tumwater, Washington	**Site and Exploration Plan**	Figure 2



LANDAU ASSOCIATES, INC. | G:\Projects\1467\002\010\011\Littlerock\F02-03SEPLAN.dwg (A) "Figure 3" 8/7/2015

Legend

B-1 Boring Location and Designation

MW-1 Monitoring Well Location and Designation

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 100 200
Scale in Feet

Source: Thurston County GIS, Tumwater School District 2014

LANDAU ASSOCIATES

Littlerock Elementary School Replacement Tumwater, Washington	**Conceptual Site Plan**	Figure 3

APPENDIX A

Field Explorations

APPENDIX A
FIELD EXPLORATIONS

Subsurface conditions within the limits of the project area were explored on June 17 and 18, 2014 by advancing and sampling 12 soil borings, designated as B-1 through B-3 and MW-1 through MW-9. An additional site exploration program was conducted on January 19, 2015 by advancing and sampling seven soil borings, designated B-4 through B-6 and MW-10 through MW-13. Borings designated with a "B" were advanced using the hollow-stem auger technique or a direct-push probe rig. Borings designated with a "MW" (i.e., monitoring well) were advanced using a direct-push probe rig, after which a piezometer was installed to monitor groundwater levels. The soil borings were advanced by Holocene Drilling, Inc., of Puyallup, Washington under subcontract to Landau Associates. The borings were advanced to depths of between 8 and 20 feet below ground surface. The explorations were located approximately in the field by referencing existing physical features.

The field exploration program was coordinated and monitored by Landau Associates' personnel, who also obtained representative soil samples, maintained a detailed record of the observed subsurface soil and groundwater conditions, and described the soil encountered by visual and textural examination. Each representative soil type observed in our exploratory borings was described using the soil classification system shown on Figure A-1, in general accordance with ASTM International D2488, *Standard Recommended Practice for Description of Soils (Visual-Manual Procedure)*. Logs of the exploratory borings are presented in Figures A-2 through A-20. These boring logs represent our interpretation of subsurface conditions identified during the field exploration program. The stratigraphic contacts shown on the individual logs represent the approximate boundaries between soil types; actual transitions may be more gradual. The soil and groundwater conditions depicted are only for the specific dates and locations reported and, therefore, are not necessarily representative of other locations and times. A further discussion of the soil and groundwater conditions observed is contained in the text portion of this report.

Disturbed soil samples from the borings were obtained at frequent intervals. In the hollow-stem auger borings, samples were taken using a 1.5-inch, inside-diameter Standard Penetration Test split-spoon sampler. The sampler was driven up to 18 inches into the undisturbed soil ahead of the auger bit with a 140-pound automatic hammer falling a distance of approximately 30 inches. The number of blows required to drive the sampler for the final 12 inches (or portion thereof) of soil penetration is noted on the boring logs adjacent to the appropriate sample notation. Upon completion of drilling and sampling, the boreholes were decommissioned in general accordance with the requirements of Chapter 173-160 Washington Administrative Code.

Soil Classification System

MAJOR DIVISIONS			GRAPHIC SYMBOL	USCS LETTER SYMBOL[1]	TYPICAL DESCRIPTIONS [2][3]
COARSE-GRAINED SOIL (More than 50% of material is larger than No. 200 sieve size)	GRAVEL AND GRAVELLY SOIL (More than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVEL (Little or no fines)		GW	Well-graded gravel; gravel/sand mixture(s); little or no fines
				GP	Poorly graded gravel; gravel/sand mixture(s); little or no fines
		GRAVEL WITH FINES (Appreciable amount of fines)		GM	Silty gravel; gravel/sand/silt mixture(s)
				GC	Clayey gravel; gravel/sand/clay mixture(s)
	SAND AND SANDY SOIL (More than 50% of coarse fraction passed through No. 4 sieve)	CLEAN SAND (Little or no fines)		SW	Well-graded sand; gravelly sand; little or no fines
				SP	Poorly graded sand; gravelly sand; little or no fines
		SAND WITH FINES (Appreciable amount of fines)		SM	Silty sand; sand/silt mixture(s)
				SC	Clayey sand; sand/clay mixture(s)
FINE-GRAINED SOIL (More than 50% of material is smaller than No. 200 sieve size)	SILT AND CLAY (Liquid limit less than 50)			ML	Inorganic silt and very fine sand; rock flour; silty or clayey fine sand or clayey silt with slight plasticity
				CL	Inorganic clay of low to medium plasticity; gravelly clay; sandy clay; silty clay; lean clay
				OL	Organic silt; organic, silty clay of low plasticity
	SILT AND CLAY (Liquid limit greater than 50)			MH	Inorganic silt; micaceous or diatomaceous fine sand
				CH	Inorganic clay of high plasticity; fat clay
				OH	Organic clay of medium to high plasticity; organic silt
	HIGHLY ORGANIC SOIL			PT	Peat; humus; swamp soil with high organic content

OTHER MATERIALS	GRAPHIC SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
PAVEMENT		AC or PC	Asphalt concrete pavement or Portland cement pavement
ROCK		RK	Rock (See Rock Classification)
WOOD		WD	Wood, lumber, wood chips
DEBRIS		DB	Construction debris, garbage

Notes:
1. USCS letter symbols correspond to symbols used by the Unified Soil Classification System and ASTM classification methods. Dual letter symbols (e.g., SP-SM for sand or gravel) indicate soil with an estimated 5-15% fines. Multiple letter symbols (e.g., ML/CL) indicate borderline or multiple soil classifications.
2. Soil descriptions are based on the general approach presented in the Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), outlined in ASTM D 2488. Where laboratory index testing has been conducted, soil classifications are based on the Standard Test Method for Classification of Soils for Engineering Purposes, as outlined in ASTM D 2487.
3. Soil description terminology is based on visual estimates (in the absence of laboratory test data) of the percentages of each soil type and is defined as follows:

Primary Constituent:	> 50% - "GRAVEL," "SAND," "SILT," "CLAY," etc.
Secondary Constituents:	> 30% and ≤ 50% - "very gravelly," "very sandy," "very silty," etc.
	> 15% and ≤ 30% - "gravelly," "sandy," "silty," etc.
Additional Constituents:	> 5% and ≤ 15% - "with gravel," "with sand," "with silt," etc.
	≤ 5% - "with trace gravel," "with trace sand," "with trace silt," etc., or not noted.

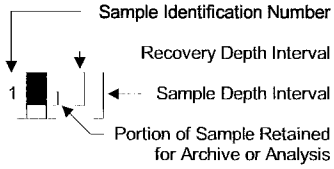
4. Soil density or consistency descriptions are based on judgement using a combination of sampler penetration blow counts, drilling or excavating conditions, field tests, and laboratory tests, as appropriate.

Drilling and Sampling Key

SAMPLER TYPE

Code	Description
a	3.25-inch O.D., 2.42-inch I.D. Split Spoon
b	2.00-inch O.D., 1.50-inch I.D. Split Spoon
c	Shelby Tube
d	Grab Sample
e	Single-Tube Core Barrel
f	Double-Tube Core Barrel
g	2.50-inch O.D., 2.00-inch I.D. WSDOT
h	3.00-inch O.D., 2.375-inch I.D. Mod. California
i	Other - See text if applicable
1	300-lb Hammer, 30-inch Drop
2	140-lb Hammer, 30-inch Drop
3	Pushed
4	Vibrocore (Rotosonic/Geoprobe)
5	Other - See text if applicable

SAMPLE NUMBER & INTERVAL



Field and Lab Test Data

Code	Description
PP = 1.0	Pocket Penetrometer, tsf
TV = 0.5	Torvane, tsf
PID = 100	Photoionization Detector VOC screening, ppm
W = 10	Moisture Content, %
D = 120	Dry Density, pcf
-200 = 60	Material smaller than No. 200 sieve, %
GS	Grain Size - See separate figure for data
AL	Atterberg Limits - See separate figure for data
GT	Other Geotechnical Testing
CA	Chemical Analysis

Groundwater

▽ Approximate water level at time of drilling (ATD)

▼ Approximate water level at time other than ATD

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Littlerock Elementary School Replacement
Tumwater, Washington

Soil Classification System and Key

Figure A-1

B-1

SAMPLE DATA						SOIL PROFILE				
Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Hollow-Stem Auger Ground Elevation (ft): Not Measured Drilled By: Holocene Drilling Inc. Logged By: JTM Date: 06/18/14	Groundwater	Moisture Content (%) Plastic Limit 20 40 60 80 Liquid Limit ▲ SPT N-Value ▲ △ Non-Standard N-Value △ 20 40 60 80 × Fines Content (%) × 20 40 60 80
0							AC	Asphalt concrete		
							CR	Crushed rock (dense, moist)		
2							GP-GM	Gray-brown, sandy, fine to coarse GRAVEL with silt (medium dense, moist) **(RECESSIONAL OUTWASH)**		
		S-1	b2	12						▲
4							SM	Red-brown, silty fine to coarse SAND with gravel (medium dense, moist)	5.0 ft ATD	
		S-2	b2	39			SP-SM	Brown, fine to coarse SAND with silt and gravel (dense, wet)		▲
6										
8										
10										
12										
14										
16										
18										
20										

Boring Completed 06/18/14
Total Depth of Boring = 10.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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B-2

SAMPLE DATA						SOIL PROFILE			Groundwater	Moisture Content (%) / SPT N-Value / Fines Content (%)
Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Hollow-Stem Auger Ground Elevation (ft): Not Measured Drilled By: Holocene Drilling Inc. Logged By: JTM Date: 06/18/14		Plastic Limit 20 40 60 80 Liquid Limit ▲ SPT N-Value ▲ △ Non-Standard N-Value △ 20 40 60 80 × Fines Content (%) × 20 40 60 80
0							SM	Brown, silty, fine to medium SAND with organics (loose, moist)		
							SM	**(TOPSOIL)**		
2								Brown, silty, fine to coarse SAND with gravel (medium dense, moist) **(FILL / WEATHERED RECESSIONAL OUTWASH)**		
		S-1	b2	39			GP-GM	Brown, fine to coarse GRAVEL with sand and silt (dense, moist) **(RECESSIONAL OUTWASH)**		▲
4										
6			b2	18	Tip of sampler wet Drilling less gravelly			- becomes medium dense	▽ 6.0 ft ATD	▲
8										
10							ML	Gray, sandy SILT (hard, wet) **(GLACIALLY CONSOLIDATED DEPOSITS)**		
		S-2	b2	36						▲
12										
14										
16										
18										
20										

Boring Completed 06/18/14
Total Depth of Boring = 11.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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B-3

SAMPLE DATA

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data
0					
2					
		S-1 S-2	b2	20	
4					
		S-3	b2	45	
6					
8					Less gravelly drilling
10					
		S-4 S-5	b2	20	
12					
14					
16					
18					
20					

SOIL PROFILE

Drilling Method: Hollow-Stem Auger
Ground Elevation (ft): Not Measured
Drilled By: Holocene Drilling Inc.
Logged By: JTM Date: 06/18/14

Graphic Symbol	USCS Symbol	Description
	SM	Brown, silty, fine to medium SAND with organics (medium dense, moist) **(TOPSOIL)**
	GP-GM	Brown, sandy, fine to coarse GRAVEL with silt and organics (medium dense, moist) **(FILL / WEATHERED RECESSIONAL OUTWASH)**
	SM	Dark brown, silty, fine to coarse SAND with gravel (medium dense, moist)
	SP-SM	Brown, gravelly, fine to coarse SAND with silt (medium dense, moist) **(RECESSIONAL OUTWASH)**
	SP-SM	Brown, fine to coarse SAND with gravel and silt (dense, moist)
	ML	Brown, sandy SILT (very stiff, wet) **(GLACIALLY CONSOLIDATED DEPOSITS)**

Groundwater: ▽ 9.5 ft ATD

Moisture Content (%) — Plastic Limit 20 40 60 80 Liquid Limit
▲ SPT N-Value ▲
△ Non-Standard N-Value △ — 20 40 60 80
× Fines Content (%) × — 20 40 60 80

Boring Completed 06/18/14
Total Depth of Boring = 11.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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B-4

SAMPLE DATA						SOIL PROFILE				
Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Direct Push Ground Elevation (ft): Not Measured Drilled By: Holocene Drilling Inc. Logged By: BDL Date: 01/19/15	Groundwater	Moisture Content (%) Plastic Limit 20 40 60 80 Liquid Limit ▲ SPT N-Value ▲ △ Non-Standard N-Value △ 20 40 60 80 × Fines Content (%) × 20 40 60 80
0							GM	Black, sandy, silty, fine to coarse GRAVEL (medium dense, moist)		
							GM	**(TOPSOIL)**		
2			i3					Brown, very silty, fine to coarse GRAVEL with sand **(FILL / WEATHERED RECESSIONAL OUTWASH)**		
4			i3				GM	Brown, silty, fine to coarse GRAVEL (medium dense, moist) **(RECESSIONAL OUTWASH)**		
		S-1	d						ATD	
6							ML	- becomes wet Gray, SILT (soft, moist) **(GLACIALLY CONSOLIDATED DEPOSITS)**		
			i3							
		S-2	d							
8		S-3	d							
		S-4	d							
		S-5	i3 d							
10										
12										
14										
16										
18										
20										

Boring Completed 01/19/15
Total Depth of Boring = 10.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Littlerock Elementary School Replacement
Tumwater, Washington

Log of Boring B-4

Figure A-5

B-5

SAMPLE DATA						SOIL PROFILE				
Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Direct Push Ground Elevation (ft): Not Measured Drilled By: Holocene Drilling Inc. Logged By: BDL Date: 01/19/15	Groundwater	Moisture Content (%) Plastic Limit 20 40 60 80 Liquid Limit ▲ SPT N-Value ▲ △ Non-Standard N-Value △ 20 40 60 80 × Fines Content (%) × 20 40 60 80
0							SM	Black, silty fine to coarse SAND with gravel (medium dense, moist) **(TOPSOIL)**		
2		S-1	d i3				GP-GM	Brown, sandy, fine to coarse GRAVEL with silt (medium dense, moist) **(FILL / WEATHERED RECESSIONAL OUTWASH)**		
4		S-2	d i3				SP-SM	Brown, very gravelly, fine to coarse SAND with silt (medium dense, moist) **(RECESSIONAL OUTWASH)**	ATD	
6								- becomes wet		
8		S-3	d i3							
10							ML	Gray, sandy SILT with gravel (stiff, wet) **(GLACIALLY CONSOLIDATED DEPOSITS)**		
12										
14										
16										
18										
20										

Boring Completed 01/19/15
Total Depth of Boring = 10.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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B-6

SAMPLE DATA						SOIL PROFILE				
Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Direct Push Ground Elevation (ft): Not Measured Drilled By: Holocene Drilling Inc. Logged By: BDL Date: 01/19/15	Groundwater	Moisture Content (%) Plastic Limit 20 40 60 80 Liquid Limit ▲ SPT N-Value ▲ △ Non-Standard N-Value △ 20 40 60 80 × Fines Content (%) × 20 40 60 80
0							SP-SM SM	Blackish-brown, gravelly, fine SAND with silt (medium dense, moist) **(TOPSOIL)**		
2			i3					Dark brown, gravelly, silty, fine to medium SAND (medium dense, moist) **(FILL / WEATHERED RECESSIONAL OUTWASH)**		
4								- becomes brown		
6			i3				GM	Brown, silty, sandy, fine to coarse GRAVEL (medium dense, moist) **(RECESSIONAL OUTWASH)** - becomes reddish-brown and damp		
8		S-1	d				SP-SM	Brown, gravelly, fine to coarse SAND with silt (medium dense, damp)		
10			i3							
12							ML	Dark brown, gravelly, sandy SILT (stiff, moist)	▽ ATD	
							SP-SM	Brown, fine to medium SAND with silt (medium dense, wet)		
		S-2	d				GP-GM	Brown, sandy, fine to coarse GRAVEL with silt (medium dense, wet)		
14			i3				ML	Brown, gravelly, sandy SILT (very stiff, moist) **(GLACIALLY CONSOLIDATED DEPOSITS)** - grades to grayish-brown and with gravel		
		S-3	d							
16										
18										
20										

Boring Completed 01/19/15
Total Depth of Boring = 16.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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MW-1

SAMPLE DATA | **SOIL PROFILE**

Drilling Method: Direct Push
Ground Elevation (ft): Not Measured
Drilled By: Holocene Drilling Inc.
Logged By: JTM Date: 06/17/14

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Description
0							SM / SM	Brown, silty, fine to medium SAND with organics (loose, moist) **(TOPSOIL)**
								Dark brown, silty, fine to coarse SAND with gravel (medium dense, moist) **(FILL / WEATHERED RECESSIONAL OUTWASH)**
2		S-1	i3					
		S-2			W = 12 GS		SP-SM	Brown, very gravelly, fine to coarse SAND with silt (medium dense, wet) **(RECESSIONAL OUTWASH)**
4								
6			i3				GP-GM	Brown, sandy, fine to coarse GRAVEL with silt (medium dense, wet)
		S-3			W = 7 GS			
8							ML	Gray-brown, sandy SILT with trace gravel (very stiff, wet) **(GLACIALLY CONSOLIDATED DEPOSITS)**
		S-4	i3					
10		S-5	i3				SM	Gray-brown, silty, fine to coarse SAND with gravel (dense, dry to moist)
12								
14								
16								
18								
20								

WELL DETAIL (DOE#: BIP-340)

4.5 ft 4.5 ft ATD

Moisture Content (%) — Plastic Limit 20 40 60 80 Liquid Limit

▲ SPT N-Value ▲ — △ Non-Standard N-Value △ — 20 40 60 80

× Fines Content (%) × — 20 40 60 80

Boring Completed 06/17/14
Total Depth of Boring = 10.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Littlerock Elementary School Replacement
Tumwater, Washington

Log of Boring MW-1

Figure A-8

MW-2

SAMPLE DATA						SOIL PROFILE			WELL DETAIL (DOE#: BIP-338)	Moisture Content (%) Plastic Limit 20 40 60 80 Liquid Limit; ▲ SPT N-Value ▲ △ Non-Standard N-Value △ 20 40 60 80; × Fines Content (%) × 20 40 60 80
Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Direct Push Ground Elevation (ft): Not Measured Drilled By: Holocene Drilling Inc. Logged By: JTM Date: 06/17/14		
0							SM	Brown, silty, fine to medium SAND with organics (loose, moist) **(TOPSOIL)**		
							SM	Dark brown to brown-red, silty, fine to coarse SAND with gravel (medium dense, moist) **(FILL / WEATHERED RECESSIONAL OUTWASH)**		
2		S-1	i3							
		S-2	i3				SP-SM	Brown-gray, gravelly, fine to coarse SAND with silt (medium dense, moist) **(RECESSIONAL OUTWASH)**		
4										
6									7.0 ft 7 ft ATD	
		S-3	i3				GP	Brown-gray, sandy, fine to coarse GRAVEL (dense, wet)		
8										
10										
12										
14										
16										
18										
20										

Boring Completed 06/17/14
Total Depth of Boring = 10.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Littlerock Elementary School Replacement
Tumwater, Washington

Log of Boring MW-2

Figure A-9

MW-3

SAMPLE DATA						SOIL PROFILE			WELL DETAIL (DOE#: BIP-337)	Moisture Content (%) Plastic Limit – Liquid Limit 20 40 60 80 ▲ SPT N-Value ▲ △ Non-Standard N-Value △ 20 40 60 80 × Fines Content (%) × 20 40 60 80
Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Direct Push Ground Elevation (ft): Not Measured Drilled By: Holocene Drilling Inc. Logged By: JTM Date: 06/17/14		
0							SM	Brown, silty, fine to medium SAND with organics (loose, moist)		
							SM	**(TOPSOIL)**		
								Dark brown, silty, fine to coarse SAND with gravel and organics (medium dense, moist) **(FILL / WEATHERED RECESSIONAL OUTWASH)**	3.5 ft 3.5 ft ATD	
2		S-1	i3							
		S-2	i3				SP-SM	Brown, gravelly, fine to medium SAND with silt (medium dense, wet) **(RECESSIONAL OUTWASH)** - becomes red		
4										
6							GP	Brown, very sandy, fine to coarse GRAVEL (dense, wet)		
		S-3	i3		W = 8 GS					
8										
10										
12										
14										
16										
18										
20										

Boring Completed 06/17/14
Total Depth of Boring = 10.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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MW-4

SAMPLE DATA						SOIL PROFILE			WELL DETAIL (DOE#: BIP-339)	Moisture Content (%) Plastic Limit 20 40 60 80 Liquid Limit ▲ SPT N-Value ▲ △ Non-Standard N-Value △ 20 40 60 80 × Fines Content (%) × 20 40 60 80
Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Direct Push Ground Elevation (ft): Not Measured Drilled By: Holocene Drilling Inc. Logged By: JTM Date: 06/17/14		
0							SM SM	Brown, silty, fine to medium SAND with organics (loose, moist) **(TOPSOIL)**		
2								Brown, silty, fine to coarse SAND with gravel (medium dense, moist) **(FILL / WEATHERED RECESSIONAL OUTWASH)**		
4		S-1	i3				GP-GM	Brown, sandy, fine to coarse GRAVEL with silt (medium dense, wet) **(RECESSIONAL OUTWASH)**	5.5 ft 5.5 ft ATD	
6		S-2	i3		W = 4 GS					
8		S-3	i3							
10										
12										
14										
16										
18										
20										

Boring Completed 06/17/14
Total Depth of Boring = 10.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Tumwater, Washington

Log of Boring MW-4

Figure A-11

MW-5

SAMPLE DATA						SOIL PROFILE				
Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Direct Push Ground Elevation (ft): Not Measured Drilled By: Holocene Drilling Inc. Logged By: JTM Date: 06/17/14	WELL DETAIL (DOE#: BIP-335)	Moisture Content (%) Plastic Limit 20 40 60 80 Liquid Limit ▲ SPT N-Value ▲ △ Non-Standard N-Value △ 20 40 60 80 × Fines Content (%) × 20 40 60 80
0		S-1	i3				SM SM	Brown, silty, fine to medium SAND with organics (loose, moist) **(TOPSOIL)** Brown, silty fine to coarse SAND with gravel and organics (medium dense, moist) **(FILL / WEATHERED RECESSIONAL OUTWASH)**		
2										
4		S-2	i3				GP-GM	Brown, very sandy, fine to coarse GRAVEL with silt (medium dense, wet) **(RECESSIONAL OUTWASH)**	5.5 ft 5.5 ft ATD	
6		S-3	i3		W = 6 GS					
8		S-4	i3				SP-SM	Gray-brown, fine to coarse SAND with gravel and silt (medium dense, wet)		
10										
12										
14										
16										
18										
20										

Boring Completed 06/17/14
Total Depth of Boring = 10.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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MW-6

SAMPLE DATA						SOIL PROFILE			WELL DETAIL (DOE#: BIP-336)	Moisture Content (%) Plastic Limit – Liquid Limit 20 40 60 80 ▲ SPT N-Value ▲ △ Non-Standard N-Value △ 20 40 60 80 × Fines Content (%) × 20 40 60 80
Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Direct Push Ground Elevation (ft): Not Measured Drilled By: Holocene Drilling Inc. Logged By: JTM Date: 06/17/14		
0							SM SM	Brown, silty, fine to medium SAND with organics (loose, moist) **(TOPSOIL)**		
2								Brown, silty, fine to coarse SAND with gravel and trace organics (medium dense, moist) **(FILL / WEATHERED RECESSIONAL OUTWASH)**		
4		S-1	i3				GP-GM	Gray-brown, sandy, fine to coarse GRAVEL with silt (medium dense, wet) **(RECESSIONAL OUTWASH)**	5.0 ft 5 ft ATD	
6		S-2	i3							
8		S-3	i3		W = 6 GS		GP	Gray-brown, very sandy, fine to coarse GRAVEL (medium dense, wet) - becomes brown		
10										
12										
14										
16										
18										
20										

Boring Completed 06/17/14
Total Depth of Boring = 10.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Tumwater, Washington

Log of Boring MW-6

Figure A-13

MW-7

SAMPLE DATA						SOIL PROFILE			WELL DETAIL (DOE#: BIP-341)	Moisture Content (%) Plastic Limit – Liquid Limit 20 40 60 80 ▲ SPT N-Value ▲ △ Non-Standard N-Value △ 20 40 60 80 × Fines Content (%) × 20 40 60 80
Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Direct Push Ground Elevation (ft): Not Measured Drilled By: Holocene Drilling Inc. Logged By: JTM Date: 06/17/14		
0							SM SM	Brown to red, silty, fine to medium SAND with organics (loose, moist) **(TOPSOIL)**		
								Dark brown, silty, fine to coarse SAND with gravel (medium dense, moist) **(FILL / WEATHERED RECESSIONAL OUTWASH)**		
2		S-1 S-2	i3				GP-GM	Brown-gray, very sandy, fine to coarse GRAVEL with silt (medium dense, wet) **(RECESSIONAL OUTWASH)**	5.0 ft 5 ft ATD	
4										
6		S-3	i3		W = 7 GS					
		S-4 S-5	i3 i3				SM ML	Brown, silty, fine to medium SAND with gravel (dense, dry to moist) **(GLACIALLY CONSOLIDATED DEPOSITS)**		
8								Gray, sandy SILT with gravel (very stiff, dry to moist)		
10										
12										
14										
16										
18										
20										

Boring Completed 06/17/14
Total Depth of Boring = 8.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Littlerock Elementary School Replacement
Tumwater, Washington

Log of Boring MW-7

Figure A-14

MW-8

SAMPLE DATA						SOIL PROFILE				WELL DETAIL (DOE#: BIP-334)	Moisture Content (%) Plastic Limit 20 40 60 80 Liquid Limit; ▲ SPT N-Value ▲ △ Non-Standard N-Value △ 20 40 60 80; × Fines Content (%) × 20 40 60 80
Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Direct Push Ground Elevation (ft): Not Measured Drilled By: Holocene Drilling Inc. Logged By: JTM Date: 06/17/14			
0							SM	Brown, silty, fine to coarse SAND with organics (loose, moist)			
							SM	**(TOPSOIL)**			
2								Brown, silty, fine to coarse SAND with gravel (medium dense, moist) **(FILL / WEATHERED RECESSIONAL OUTWASH)**			
		S-1	i3					- becomes red-brown			
4							SP	Brown, very gravelly, fine to coarse SAND (medium dense, moist) **(RECESSIONAL OUTWASH)**			
6		S-2	i3								
8											
10		S-3	i3		W = 2 GS		GP	Brown, very sandy, fine to coarse GRAVEL (dense, moist)		12.6 ft 12.6 ft ATD	
12											
14		S-4	i3					- becomes wet			
16											
18											
20											

Boring Completed 06/17/14
Total Depth of Boring = 15.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Log of Boring MW-8

Figure A-15

MW-9

SAMPLE DATA						SOIL PROFILE			WELL DETAIL (DOE#: BIP-333)	Moisture Content (%) Plastic Limit 20 40 60 80 Liquid Limit; ▲ SPT N-Value ▲ △ Non-Standard N-Value △ 20 40 60 80; × Fines Content (%) × 20 40 60 80
Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Direct Push Ground Elevation (ft): Not Measured Drilled By: Holocene Drilling Inc. Logged By: JTM Date: 06/17/14		
0							SM	Brown, silty, fine to medium SAND with organics (loose, moist)		
							SM	**(TOPSOIL)**		
		S-1	i3							
			i3				GP	Dark brown, silty, fine to coarse SAND with gravel (medium dense, moist)		
2		S-2						**(FILL / WEATHERED RECESSIONAL OUTWASH)**		
								Brown, sandy, fine to coarse GRAVEL (medium dense, moist)		
4								**(RECESSIONAL OUTWASH)**		
6			i3						8.5 ft 8.5 ft ATD	
		S-3			W = 1 GS					
8								- becomes wet		
							ML	Brown, sandy SILT (very stiff, wet)		
10								**(GLACIALLY CONSOLIDATED DEPOSITS)**		
		S-4	i3							
12										
14										
16										
18										
20										

Boring Completed 06/17/14
Total Depth of Boring = 12.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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MW-10

Drilling Method: Direct Push
Ground Elevation (ft): Not Measured
Drilled By: Holocene Drilling Inc.
Logged By: BDL Date: 01/19/15

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Soil Profile	Groundwater
0							SP-SM / SP-SM	Dark brown, very gravelly, fine to medium SAND with silt and organics (medium dense, moist) **(TOPSOIL)**	
2			i3					Brown, gravelly, fine to medium SAND with silt (medium dense, moist) **(FILL / WEATHERED RECESSIONAL OUTWASH)**	
4		S-1	d					- becomes dense	
			i3				SM	Brown, silty, gravelly, fine to coarse SAND (medium dense, moist) **(RECESSIONAL OUTWASH)**	
6									ATD
		S-2	i3 d				GM	Reddish-brown, silty, sandy, fine to coarse GRAVEL (medium dense, wet)	
8			i3						
10		S-3	d				ML	Gray, sandy SILT with gravel (medium stiff, moist) **(GLACIALLY CONSOLIDATED DEPOSITS)**	
		S-4	i3 d					- grades to gravelly and with sand	
12									
14									
16									
18									
20									

Moisture Content (%) — Plastic Limit 20 40 60 80 Liquid Limit
▲ SPT N-Value ▲ — △ Non-Standard N-Value △ — 20 40 60 80
× Fines Content (%) × — 20 40 60 80

Boring Completed 01/19/15
Total Depth of Boring = 12.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Tumwater, Washington

Log of Boring MW-10

Figure A-17

MW-11

SAMPLE DATA						SOIL PROFILE				
Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Direct Push Ground Elevation (ft): Not Measured Drilled By: Holocene Drilling Inc. Logged By: BDL Date: 01/19/15	Groundwater	Moisture Content (%) Plastic Limit 20 40 60 80 Liquid Limit ▲ SPT N-Value ▲ △ Non-Standard N-Value △ 20 40 60 80 × Fines Content (%) × 20 40 60 80
0							SM	Black, silty, fine SAND with gravel and organics (medium dense, moist)		
							SM	**(TOPSOIL)**		
2			i3					Brown, silty fine to medium SAND with gravel (medium dense, moist) **(FILL / WEATHERED RECESSIONAL OUTWASH)**		
4							SP-SM	Brown, very gravelly, fine to medium SAND with silt (medium dense, moist)		
							SP-SM	Brown, fine to medium SAND with silt (medium dense, moist) **(RECESSIONAL OUTWASH)**		
6		S-1	i3 d							
8								- becomes very gravelly		
10		S-2	i3 d							
12								-becomes wet	ATD	
							GP-GM	Brown, very sandy, fine to coarse GRAVEL with silt (dense, wet)		
14		S-3	i3 d							
16										
		S-4	d				ML	Gray, very gravelly SILT with sand (stiff, damp)		
18			i3					**(GLACIALLY CONSOLIDATED DEPOSITS)**		
		S-5	d					- grades to very sandy and without gravel - grades to with sand		
20										

Boring Completed 01/19/15
Total Depth of Boring = 20.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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MW-12

SAMPLE DATA | **SOIL PROFILE**

Drilling Method: Direct Push
Ground Elevation (ft): Not Measured
Drilled By: Holocene Drilling Inc.
Logged By: BDL Date: 01/19/15

Moisture Content (%) — Plastic Limit 20 40 60 80 Liquid Limit
▲ SPT N-Value ▲ — △ Non-Standard N-Value △ — 20 40 60 80
× Fines Content (%) × — 20 40 60 80

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Description	Groundwater
0							SP-SM / SP	Grayish-brown, very gravelly, fine SAND with silt (medium dense, moist) **(TOPSOIL)**	
								Brown, gravelly, fine SAND (medium dense, moist) **(FILL / WEATHERED RECESSIONAL OUTWASH)**	
2			i3				SP-SM	Brown, gravelly, fine to coarse SAND with silt (medium dense, moist)	
4									ATD
		S-1	d				GP-GM	Grayish-brown, sandy, fine to coarse GRAVEL with silt (medium dense, wet) **(RECESSIONAL OUTWASH)**	
6			i3						
8									
		S-1	d						
10			i3				GP-GM	Grayish-brown, sandy, fine to coarse GRAVEL with silt (medium dense, wet)	
		S-3	d						
12		S-4	d i3				ML	Brown, sandy SILT with gravel (stiff, moist) **(GLACIALLY CONSOLIDATED DEPOSITS)** - grades to gray and without sand or gravel	
14									
16									
18									
20									

Boring Completed 01/19/15
Total Depth of Boring = 12.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Littlerock Elementary School Replacement
Tumwater, Washington

Log of Boring MW-12

Figure A-19

MW-13

SAMPLE DATA						SOIL PROFILE				
Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Direct Push Ground Elevation (ft): Not Measured Drilled By: Holocene Drilling Inc. Logged By: BDL Date: 01/19/15	Groundwater	Moisture Content (%) Plastic Limit 20 40 60 80 Liquid Limit ▲ SPT N-Value ▲ △ Non-Standard N-Value △ 20 40 60 80 × Fines Content (%) × 20 40 60 80
0							SM	Dark brown, silty, fine to medium SAND (medium dense, moist)		
							GP-GM	**(TOPSOIL)**		
2			i3				SP-SM	Dark brown, sandy GRAVEL with silt (medium dense, moist) **(FILL / WEATHERED RECESSIONAL OUTWASH)**		
								Dark gray, very gravelly, fine to coarse SAND with silt (medium dense, moist)		
4							GM	Brown, silty, sandy, fine to coarse GRAVEL (medium dense, moist) **(RECESSIONAL OUTWASH)**		
		S-1	d							
6			i3						ATD	
8							SP-SM	Brown, gravelly, fine to coarse SAND with silt (dense, wet)		
		S-2	d							
10			i3							
		S-3	d							
12							ML	Brown, very gravelly SILT with sand (medium stiff, moist) **(GLACIALLY CONSOLIDATED DEPOSITS)**		
14										
16										
			i3							
18								- grades to gray and without sand or gravel		
20										

Boring Completed 01/19/15
Total Depth of Boring = 19.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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APPENDIX B

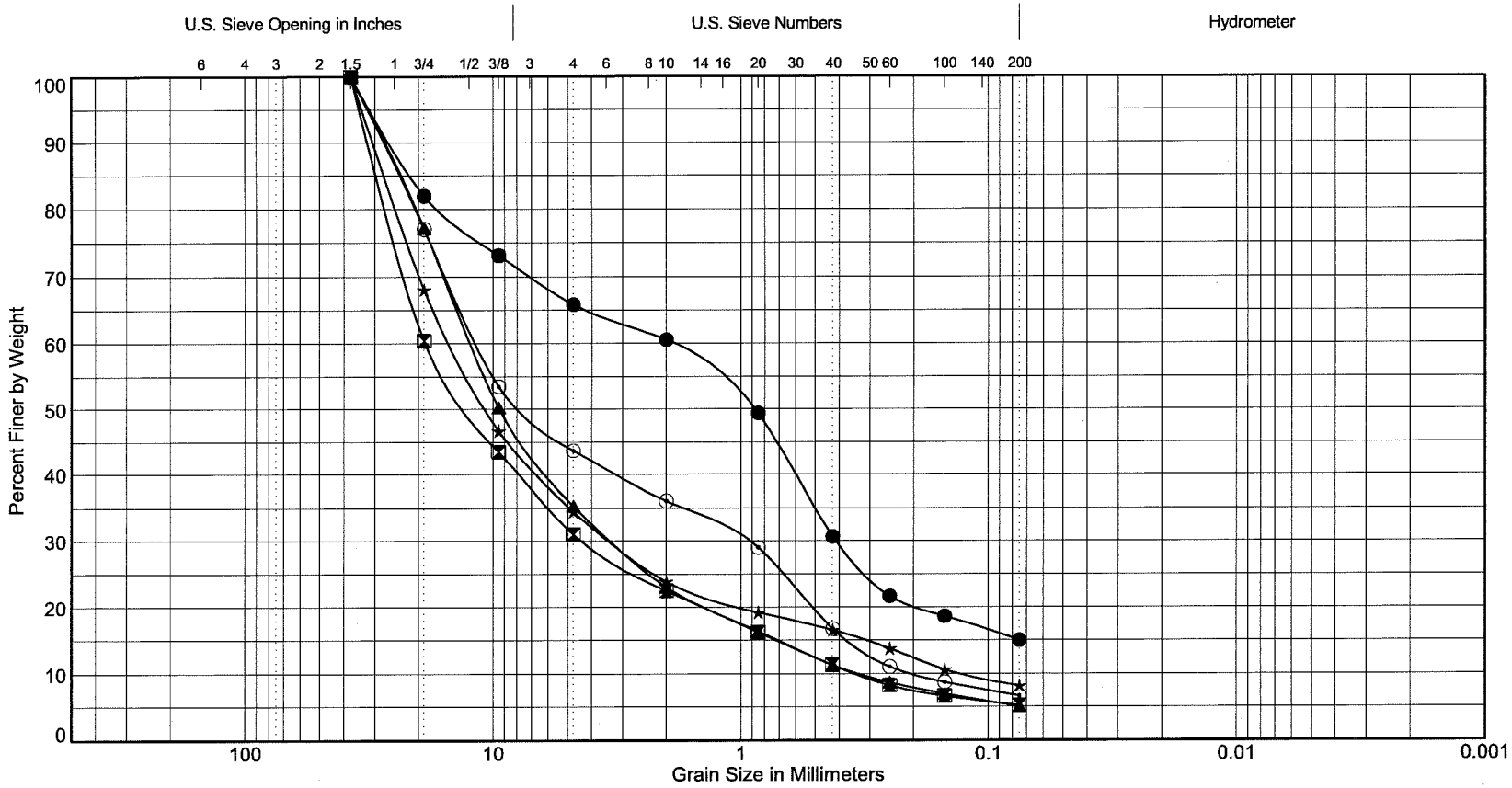
Laboratory Testing

APPENDIX B
LABORATORY TESTING

Natural moisture content determinations and sieve analyses were conducted in Landau Associates' laboratory on representative samples obtained from the explorations. Laboratory testing was performed in general accordance with the ASTM International (ASTM) standard test procedures described below. The samples were checked against the field log descriptions, which were updated where appropriate in general accordance with ASTM D2487, *Standard Test Method for Classification of Soils for Engineering Purposes*.

Natural moisture content determinations were performed on soil samples obtained from the borings in general accordance with ASTM D2216. The natural moisture content is shown as W=xx (percent of dry weight) at the respective sample depth in the column labeled "Test Data" on the summary logs in Appendix A. Please note the natural moisture contents reported may not accurately represent the *in situ* moistures of the samples due to the time between sampling and testing.

Sieve analyses were performed on representative soil samples obtained from the explorations in accordance with ASTM D422 to provide an indication of the grain size distribution. Samples selected for grain size analysis are designated with a "GS" in the column labeled "Test Data" on the summary boring logs on Figures A-2 through A-20 in Appendix A. The results of the grain size analyses are presented in the form of grain size distribution curves on Figures B-1 and B-2 in this appendix.



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Exploration Number	Sample Number	Depth (ft)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	MW-1	S-2	3.5	12	Very gravelly, SAND with silt	SP-SM
⊠	MW-1	S-3	6.5	7	Sandy, GRAVEL with silt	GP-GM
▲	MW-3	S-3	6.5	8	Very sandy, GRAVEL	GP
★	MW-4	S-2	6.5	4	Sandy, GRAVEL with silt	GP-GM
⊙	MW-5	S-3	5.0	6	Very sandy, GRAVEL with silt	GP-GM

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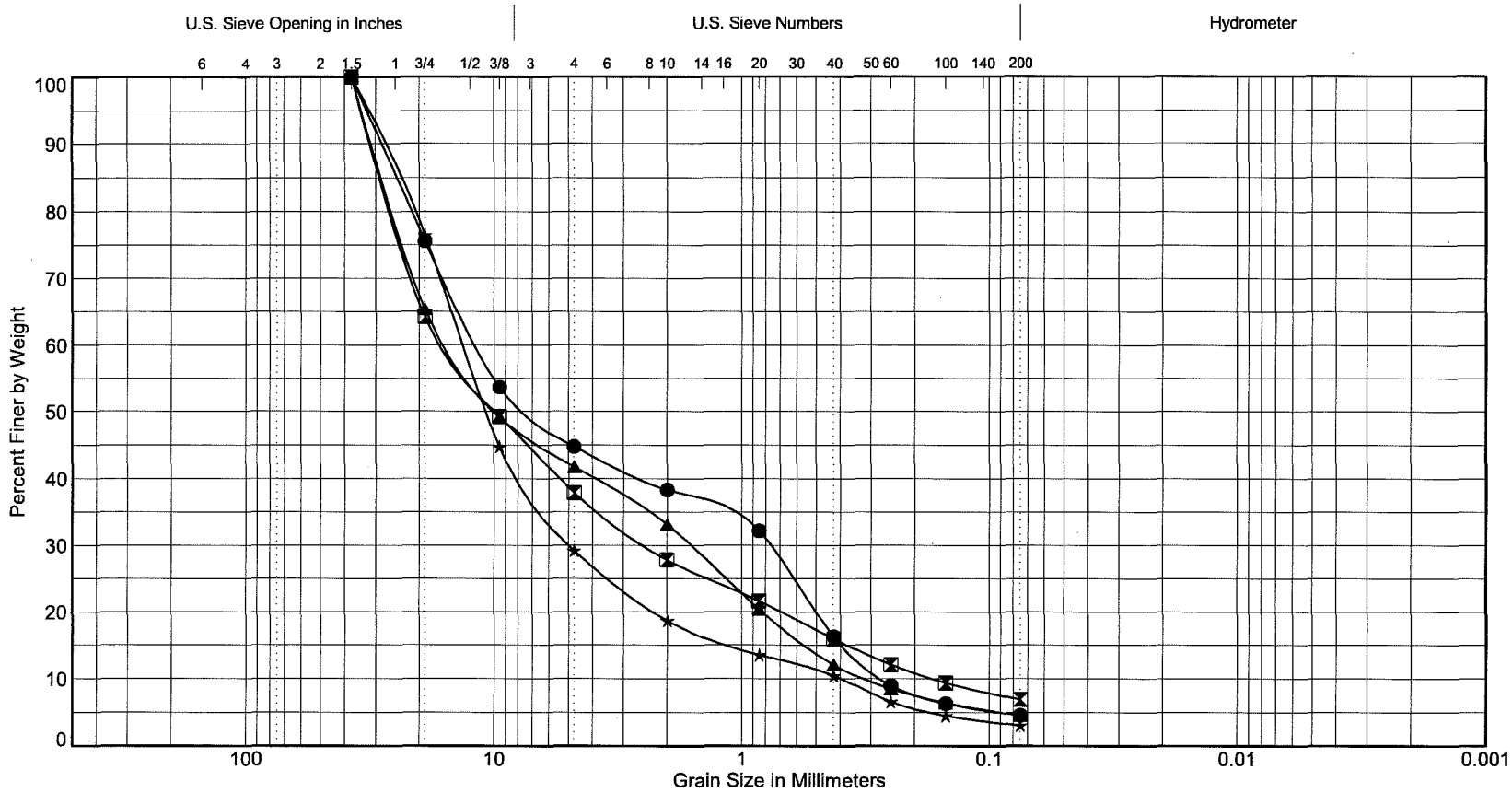
Tumwater, Washington

Grain Size Distribution

Figure B-1



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Exploration Number	Sample Number	Depth (ft)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	MW-6	S-3	6.5	6	Very sandy, GRAVEL	GP
⧗	MW-7	S-3	6.0	7	Very sandy, GRAVEL with silt	GP-GM
▲	MW-8	S-3	9.5	2	Very sandy, GRAVEL	GP
★	MW-9	S-3	6.5	1	Sandy, GRAVEL	GP

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Littlerock Elementary School Replacement
Tumwater, Washington

Grain Size Distribution

Figure
B-2

APPENDIX C

Groundwater Monitoring Program

APPENDIX C
GROUNDWATER MONITORING PROGRAM

Groundwater monitoring wells MW-1 through MW-9 were installed within the project area on June 17 and 18, 2014 and MW-10 through MW-13 on January 19, 2015. Recording of groundwater levels began in early fall of 2014 and continued through late spring of 2015. The groundwater data was collected with a data logger in three of the wells (MW-1, MW-4, and MW-8) to record water fluctuations over time. The groundwater levels in all wells were recorded monthly using an electronic water level indicator. The results of our groundwater monitoring program are summarized below in Table C-1. Figure C-1 of this appendix provides a topographic overlay of the project site for reference in regard to groundwater levels. Figures C-2 and C-3 of this appendix provide a graphical illustration of the groundwater levels in terms of groundwater contours for January 2015 and February 2015, respectively.

TABLE 1: GROUNDWATER MONITORING DATA

Well	Date	Time	Depth to Water (ft BGS)	Water Level Elevation (ft)*
MW-1	9/9/2014	10:13	2.07	157.22
	10/20/2014	13:08	1.80	157.49
	11/18/2014	14:56	1.67	157.62
	1/5/2015	14:38	A	159.29
	2/6/2015	10:15	0.73	158.56
	3/12/2015	9:34	1.67	157.62
	4/16/2015	13:20	1.61	157.68
	5/14/2015	13:10	1.80	157.49
MW-2	9/9/2014	10:17	4.00	157.84
	10/20/2014	13:05	3.64	158.20
	11/18/2014	15:06	3.28	158.56
	1/5/2015	13:35	0.43	161.41
	2/6/2015	10:25	1.90	159.94
	3/12/2015	9:45	3.22	158.62
	4/16/2015	13:33	3.17	158.67
	5/14/2015	13:22	3.48	158.36

MW-3	9/9/2014	10:22	2.82	157.91
	10/20/2014	13:02	2.47	158.26
	11/18/2014	15:09	2.11	158.62
	1/5/2015	13:40	A	160.73
	2/6/2015	10:34	0.73	160.00
	3/12/2015	9:40	2.05	158.68
	4/16/2015	13:29	1.99	158.74
	5/14/2015	13:17	2.33	158.4
MW-4	9/9/2014	10:27	3.93	158.09
	10/20/2014	13:12	3.56	158.46
	11/18/2014	15:12	3.15	158.87
	1/5/2015	13:45	0.20	161.82
	2/6/2015	10:40	1.69	160.33
	3/12/2015	9:53	3.05	158.97
	4/16/2015	13:37	2.97	159.05
	5/14/2015	13:25	3.36	158.66
MW-5	9/9/2014	10:29	4.27	159.18
	10/20/2014	13:16	3.60	159.85
	11/18/2014	15:19	2.88	160.57
	1/5/2015	13:53	0.18	163.27
	2/6/2015	10:45	0.67	162.78
	3/12/2015	10:16	2.73	160.72
	4/16/2015	13:45	2.63	160.82
	5/14/2015	13:32	3.19	160.26
MW-6	9/9/2014	10:42	3.35	157.93
	10/20/2014	13:18	2.68	158.60
	11/18/2014	15:21	2.02	159.26
	1/5/2015	13:51	A	161.28
	2/6/2015	10:51	0.07	161.21
	3/12/2015	10:12	2.18	159.1
	4/16/2015	13:48	2.12	159.16
	5/14/2015	13:34	2.53	158.75

MW-7	9/9/2014	10:46	3.33	157.79
	10/20/2014	13:20	2.98	158.14
	11/18/2014	15:23	2.69	158.43
	1/5/2015	13:47	0.38	160.74
	2/6/2015	10:55	1.41	159.71
	3/12/2015	10:00	2.66	158.46
	4/16/2015	13:51	2.61	158.51
	5/14/2015	13:37	2.84	158.28
MW-8	9/9/2014	12:28	12.21	149.26
	10/20/2014	13:23	12.03	149.44
	11/18/2014	15:26	11.91	149.56
	1/5/2015	14:03	7.81	153.66
	2/6/2015	11:15	11.38	150.09
	3/12/2015	10:35	11.95	149.52
	4/16/2015	14:01	11.87	149.6
	5/14/2015	13:44	12.03	149.44
MW-9	9/9/2014	10:51	8.91	147.13
	10/20/2014	12:58	5.72	150.32
	11/18/2014	15:34	4.82	151.22
	1/5/2015	14:33	2.99	153.05
	2/6/2015	11:30	4.83	151.21
	3/12/2015	10:51	6.54	149.50
	4/16/2015	14:10	6.10	149.94
	5/14/2015	13:51	6.67	149.37
MW-10	2/6/2015	11:25	4.45	151.84
	3/12/2015	10:54	6.50	149.79
	4/16/2015	14:14	5.95	150.34
	5/14/2015	13:52	6.69	149.60
MW-11	2/6/2015	11:23	11.74	149.97
	3/12/2015	10:42	12.31	149.40
	4/16/2015	14:08	12.22	149.49
	5/14/2015	13:47	12.38	149.33

MW-12	2/6/2015	11:11	4.97	156.35
	3/12/2015	10:31	5.70	155.62
	4/16/2015	13:56	5.61	155.71
	5/14/2015	13:41	5.75	155.57
MW-13	2/6/2015	11:05	1.06	160.12
	3/12/2015	10:45	2.67	158.51
	4/16/2015	13:54	2.65	158.53
	5/14/2015	13:39	3.01	158.17

*Water level elevation based on surveyed elevation (North American Vertical Datum of 1988) of north rim of well casing
"A" denotes artesian conditions
ft = feet
BGS = below ground surface

N

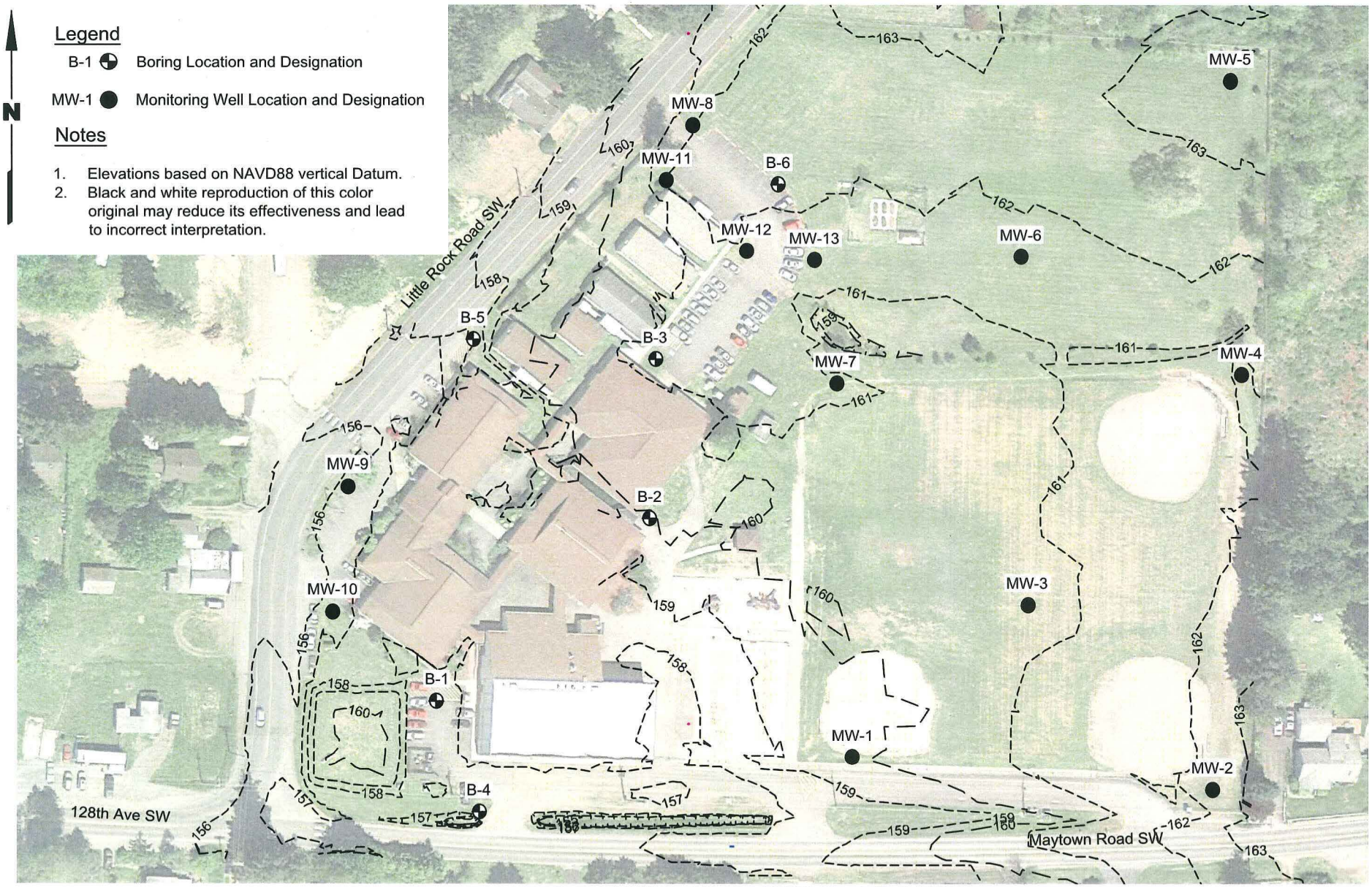
Legend

B-1 Boring Location and Designation

MW-1 Monitoring Well Location and Designation

Notes

1. Elevations based on NAVD88 vertical Datum.
2. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.



Source: MTN2Coast Survey, 1/26/15; Google Earth 2013

0 120 140

Scale in Feet

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Tumwater, Washington

Ground Surface Elevation

Figure C-1

Legend

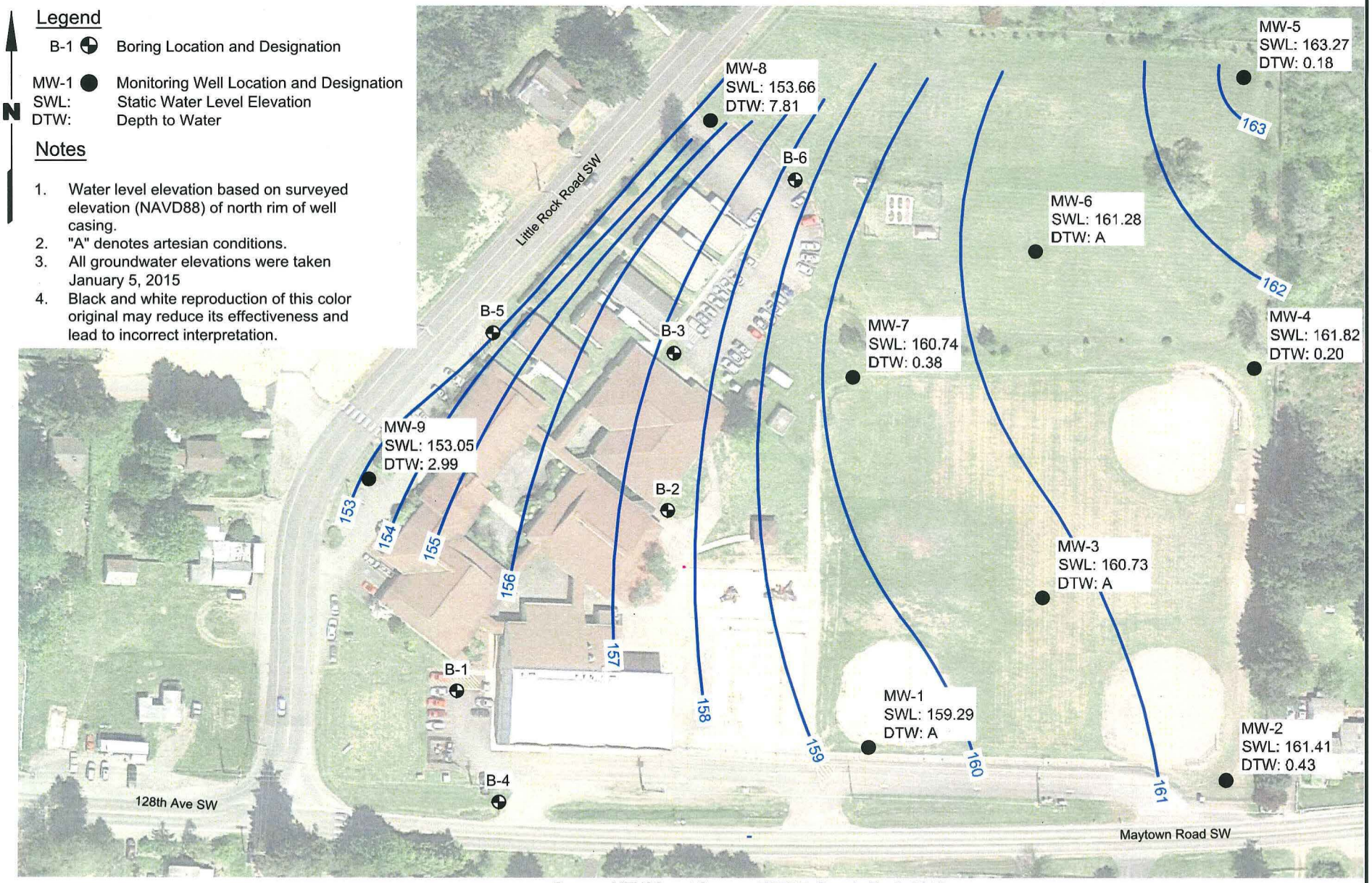
B-1 Boring Location and Designation

MW-1 Monitoring Well Location and Designation
SWL: Static Water Level Elevation
DTW: Depth to Water

N

Notes

1. Water level elevation based on surveyed elevation (NAVD88) of north rim of well casing.
2. "A" denotes artesian conditions.
3. All groundwater elevations were taken January 5, 2015
4. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.



Source: MTN2Coast Survey, 1/26/15; Google Earth 2013

0 120 140
Scale in Feet

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Littlerock Elementary School Replacement Tumwater, Washington	**Groundwater Elevations January 2015**	Figure C-2

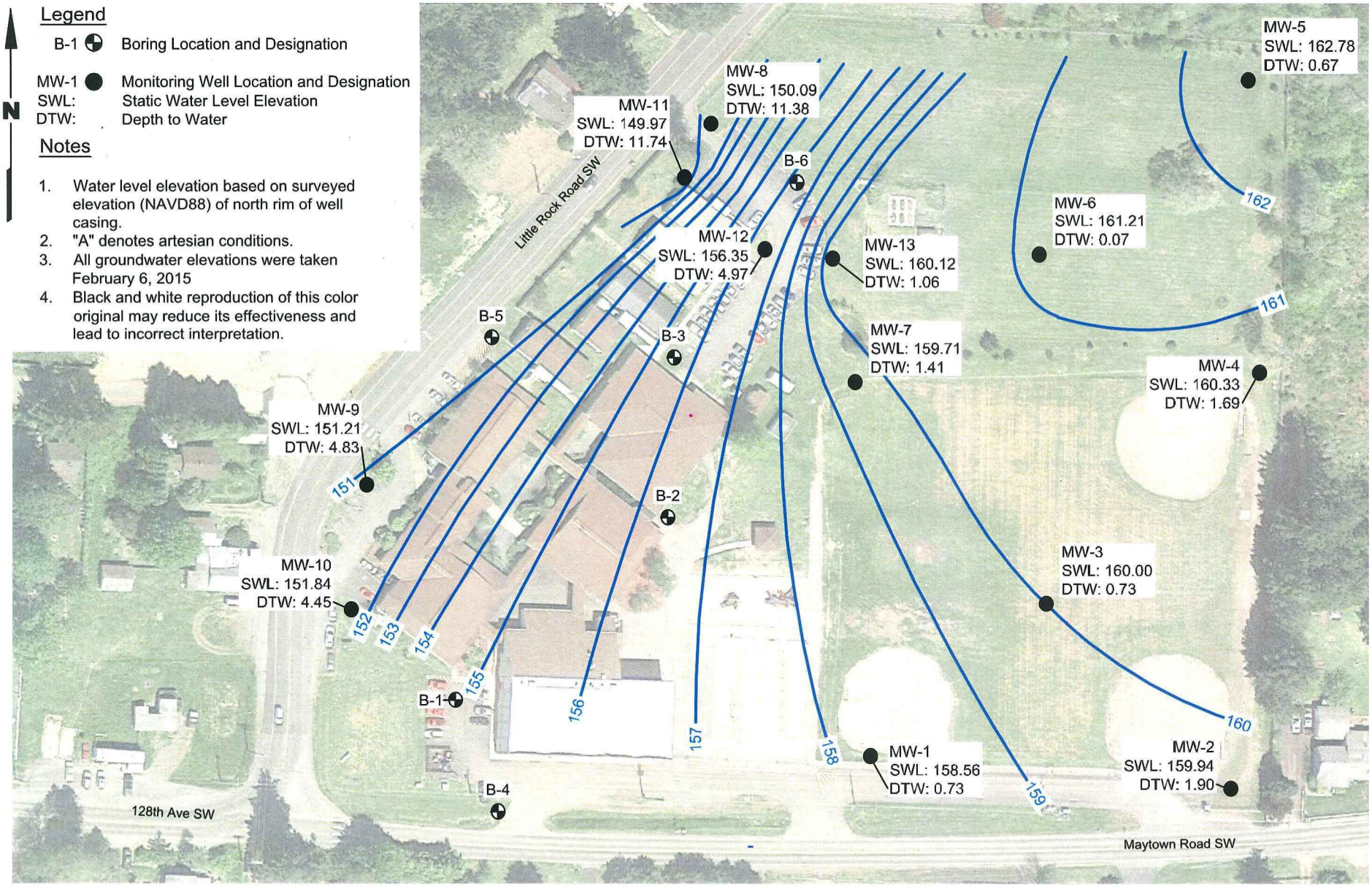
Legend

B-1 Boring Location and Designation

MW-1 Monitoring Well Location and Designation
SWL: Static Water Level Elevation
DTW: Depth to Water

Notes

1. Water level elevation based on surveyed elevation (NAVD88) of north rim of well casing.
2. "A" denotes artesian conditions.
3. All groundwater elevations were taken February 6, 2015
4. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.



Source: MTN2Coast Survey, 1/26/15; Google Earth 2013

0 120 140
Scale in Feet

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Tumwater, Washington

Groundwater Elevations February 2015

Figure C-3