Technical Memorandum

TO: Mr. Bob Droll, President, Robert W. Droll, Landscape Architect, PS

FROM: Lance Levine, PE, and Calvin McCaughan, PE

DATE: July 28, 2020

RE: **Summary of Geotechnical Engineering Services**
Inspiring Kids Preserve
Olympia, Washington
Project No. 1444012.010.011

Introduction

This memorandum summarizes the results of geotechnical engineering services provided by Landau Associates, Inc. (LAI) in support of the Inspiring Kids Preserve project, located at 4849 Johnson Point Road Northeast near Olympia, Washington (site; Figure 1). Geotechnical services were provided in accordance with the scope outlined in LAI's December 6, 2019 proposal.

This memorandum was prepared with information provided by representatives of Robert W. Droll, Landscape Architect, PS, and with data collected during LAI's geologic review, field investigation, and geotechnical laboratory testing. The site plan (Figure 2) was developed with information provided by KPFF Consulting Engineers (project civil engineer).

Project Understanding

The 108-acre site consists of eight undeveloped parcels. Capitol Land Trust (CLT, project owner) proposes to develop a portion of the site along Johnson Point Road Northeast with a shelter, a restroom, trails, paved parking and roads, and one or more stormwater facilities.

Geologic Setting

Geologic information for the site and the surrounding area was obtained from the *Geologic Map of the Lacey 7.5-minute Quadrangle, Thurston County, Washington* (Logan 2003). Subsurface conditions at the site are mapped as Vashon till deposits (Qgt), a highly compact mixture of low-permeability clay, silt, sand, and gravel deposited directly by the glacier. During LAI's February 2020 field investigation, surficial site soils were observed to consist of silt with variable sand content. These soil conditions are consistent with the Vashon recessional outwash and minor silt (Qgos) mapped to the west of the site.

Subsurface Explorations

Site subsurface conditions were explored on February 25, 2020 by excavating five test pits (TP-1 through TP-5) at the approximate locations shown on Figure 2. Howard's Construction and Excavating, subcontracted by LAI, advanced the test pits 12.0 to 15.0 feet (ft) below ground surface (bgs).

LANDAU ASSOCIATES

955 Malin Lane SW, Suite B • Tumwater, Washington 98501 • (360) 791-3178

Table 1. 2018 International Building Code Seismic Design Parameters

Peak ground acceleration = 0.604
Spectral response acceleration at short periods (S_S) = 1.42g
Spectral response acceleration at 1-second periods (S_1) = 0.515g
Site class = D
Site coefficient (F_a) = 1.0
Site coefficient (F_v) = 1.785[(a)]

(a) The structural engineer must calculate the seismic response coefficient (C_S) in accordance with Section 11.4.8, Exception 2 of the American Society of Civil Engineers' *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (2017).
F_a, F_v = acceleration (0.2-second period) and velocity (1.0-second period) site coefficients, respectively
g = force of gravity
S_s, S_1 = 0.2-second and 1.0-second period spectral accelerations, respectively

Based on the subsurface conditions observed in LAI's February 2020 explorations, seismically induced soil liquefaction and lateral spreading are not likely to occur at the site. Given the distance between the site and the nearest known active crustal fault, the risk of ground rupture due to surface faulting is low.

Conclusions and Recommendations

Shallow site soils are soft, but will provide adequate support for shallow foundations and anticipated structural loads. Because they are fine grained and moisture sensitive, site soils are not suitable for reuse as structural fill. Earthwork should be avoided during heavy and/or extended precipitation events. A 1-ft-thick layer of import structural fill should be placed across structural footprints to limit soil disturbance and increase soil bearing capacity.

Foundation Support

In areas that will be developed with foundations and slabs-on-grade, at least 12 inches of fine-grained, moisture-sensitive soil should be overexcavated and replaced with Gravel Borrow. Gravel Borrow should meet the requirements in Section 9-03.14(1) of the Washington State Department of Transportation's *2020 Standard Specifications for Road, Bridge, and Municipal Construction* (*2020 WSDOT Standard Specifications*). Following overexcavation, the exposed subgrade should be sloped to allow runoff to drain away from the proposed structures. Gravel Borrow should be compacted to 95 percent of the maximum dry density, in accordance with ASTM standard test method D1557, *Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).*

The design parameters in Table 2 should be used in conjunction with the complete recommendations in this memorandum.

Slabs-On-Grade

A modulus of vertical subgrade reaction (subgrade modulus) can be used to design slabs-on-grade. The subgrade modulus will vary 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 soils at a greater depth. LAI recommends using a subgrade modulus of 125 pounds per cubic inch to design on-grade floor slabs. This subgrade modulus is for a 1-ft by 1-ft square plate, and is not the overall modulus of a larger area. When calculating the subgrade modulus, LAI assumed that on-grade slabs would be placed on a 1-ft-thick layer of Gravel Borrow.

Interior slabs-on-grade should include a vapor barrier and a capillary break layer, consistent with industry standards. The 1-ft-thick layer of Gravel Borrow placed beneath slabs to limit subgrade disturbance could double as a capillary break material, provided it is not contaminated with silty soils during construction.

Pavement Design

Pavement sections should be constructed on a uniformly firm, unyielding subgrade that consists of 1 ft of recompacted native soil or import structural fill. Native soils will not provide a suitable subbase for pavements constructed during the wet season. If wet weather construction is unavoidable, one foot of import structural fill should be placed beneath the pavement section.

When calculating the parameters in Table 3, LAI assumed a 20-year design life and maximum equivalent single-axle loads of 100,000 for the standard-duty pavement section and 1,000,000 for the heavy-duty section. For new pavement installed within public rights-of-way, local standards will supersede the recommendations provided herein.

Table 3. Recommended Asphalt Pavement Design Section

Pavement Section Type	Asphalt Pavement Thickness (inches)	Crushed Surfacing Thickness (inches)
Standard duty	2	4
Heavy duty	3	6

Base course material should be compacted to at least 95 percent of the maximum dry density (ASTM standard test method D1557), and should meet the requirements for Crushed Surfacing Base Course in Section 9-03.9(3) of the *2020 WSDOT Standard Specifications.* To facilitate fine grading of the surface, the upper 2 inches of crushed surfacing could consist of Crushed Surfacing Top Course. Prevention of road base saturation is essential for pavement durability, and efforts should be made to limit the amount of water entering the base course.

- **Fill placement and compaction:** Structural fill should be placed on an approved subgrade that consists of uniformly firm, unyielding, inorganic native soil, or on compacted structural fill extending to such soils. Structural fill should be placed and compacted in accordance with Section 2-03.3(14)C, Method C of the *2020 WSDOT Standard Specifications.* Method A is appropriate for non-structural areas, such as landscaping. Each layer of structural fill should be compacted to at least 95 percent of the maximum dry density, as determined using the compaction control tests described in Section 2-03.3(14)D of the *2020 WSDOT Standard Specifications.* Alternatively, maximum density can be determined using ASTM standard test method D1557.
- **Construction dewatering:** Perched groundwater zones may be encountered during the wet season, and the need for construction dewatering should be anticipated. LAI recommends dewatering temporary excavations to allow construction to be completed in the dry. Where groundwater seepage is encountered, conventional sumps and pumps should be sufficient. The contractor should be responsible for the design, monitoring, and maintenance of any dewatering system(s).
- **Temporary slopes:** Temporary excavations should be completed in accordance with Section 2-09 of the *2020 WSDOT Standard Specifications.* The contractor should be responsible for actual excavation configurations and the maintenance of safe working conditions, including temporary excavation stability. Temporary excavations in excess of 4 ft should be shored or sloped in accordance with the requirements outlined in Safety Standards for Construction Work, Part N (Washington Administrative Code Chapter 296-155). The soil likely to be exposed in the excavations should be considered Type C with a maximum allowable excavation inclination of 1½ horizontal to 1 vertical (1½H:1V). All applicable local, state, and federal safety codes should be followed.
- **Permanent slopes:** Permanent cut-or-fill slopes should be no steeper than 2H:1V. This design recommendation does not apply to stormwater pond slopes, which are typically 3H:1V or flatter. Stormwater pond slopes should be designed in accordance with local stormwater codes. Permanent and temporary slopes should be protected from erosion and reseeded or revegetated as soon as practical.
- **Obstructions:** During LAI's February 2020 field investigation, cobbles were observed in site soils. The contractor should be prepared to encounter cobbles and boulders in the excavations.

Construction Support Services

LAI should review the project plans and specifications to verify that geotechnical recommendations have been properly interpreted and implemented.

Monitoring, testing, and consultation should be provided during construction to confirm that site conditions are consistent with those observed in LAI's explorations, and to provide expedient recommendations should conditions differ from those anticipated. Construction monitoring activities would include compaction testing of structural fill and observation of slab, pavement, and structural foundation subgrade preparation. LAI would be pleased to provide construction monitoring services.

References

ASCE. 2017. *Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE/SEI 7-16).* American Society of Civil Engineers/Structural Engineering Institute.

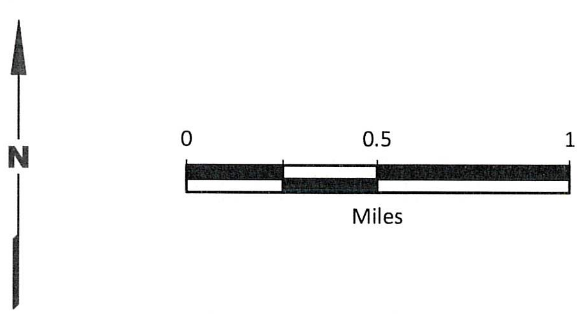
ASTM. 2017. Annual Book of ASTM Standards. In: *Soil and Rock (I).* West Conshohocken, PA: ASTM International.

ICC. 2017. 2018 International Building Code. International Code Council. August 31.

Logan, R.L., T.J. Walsh, H.W. Schasse, and M. Polenz. 2*003. Geologic Map of the Lacey 7.5-Minute Quadrangle, Thurston County, Washington.* Washington Division of Geology and Earth Resources, Washington State Department of Natural Resources.

Washington State Department of Labor and Industries. 2016. Construction Work. Chapter 296-155 WAC; Part N. Excavation, Trenching, and Shoring. Washington State Department of Labor and Industries. May 20.

WSDOT. 2019. *M41-10: Standard Specifications for Road, Bridge, and Municipal Construction 2020.* Washington State Department of Transportation.



Data Source: Esri 2012

Inspiring Kids Preserve Olympia, Washington	**Vicinity Map**	Figure 1

G:\Projects\1444\012\010\011\F01VicMap.mxd 3/3/2020 NAD 1983 StatePlane Washington South FIPS 4602 Feet

Legend

TP-1 ▣ Approximate Test Pit Location and Designation

Note

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

Source: Digital Globe 2020; KPFF 2020

0 200 400
Scale in Feet

Landau Associates

Inspiring Kids Preserve
Olympia, Washington

Site and Exploration Location Plan

Figure 2

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.

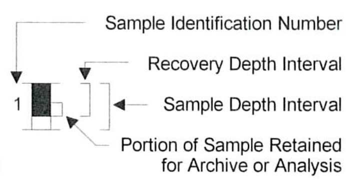
4. Soil density or consistency descriptions are based on judgement using a combination of sampler penetration blow counts, drilling or excavating conditions, field tests, and laboratory tests, as appropriate.

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 after drilling/excavation/well

LANDAU ASSOCIATES

Inspiring Kids Preserve
Olympia, Washington

Soil Classification System and Key

Figure 3

TP-3

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Test Data	USCS Symbol	Soil Profile	Groundwater
0					ML	3 inches of duff over 7 inches of dark brown	Groundwater not encountered.
		S-1	d	W = 33 AL	ML	SILT with sand and organics (soft, moist) **(TOPSOIL)**	
5						Brown SILT with sand (soft, moist) **(RECESSIONAL LACUSTRINE)**	
		S-2	d		SM	Brown, very silty, fine SAND (loose, moist)	
10					ML	Brown SILT (soft, moist)	
		S-3	d				

Excavation Method: Tracked Excavator
Ground Elevation (ft): Not measured
Excavated By: Howard's Construction and Excav.
Logged By: DAR

Test Pit Completed 02/25/20
Total Depth of Test Pit = 12.0 ft.

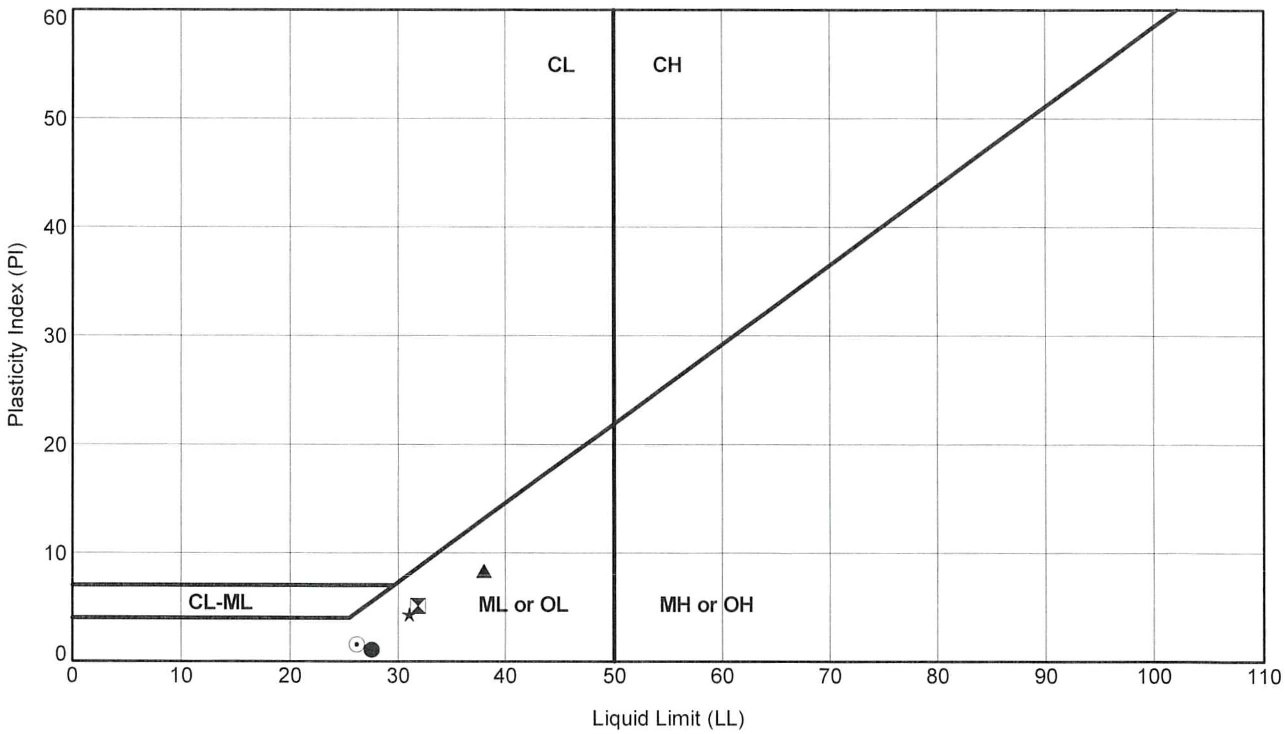
TP-4

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Test Data	USCS Symbol	Soil Profile	Groundwater
0					ML	3 inches of duff over 7 inches of dark brown	
		S-1	d	W = 33 AL	ML	SILT with sand and organics (soft, moist) **(TOPSOIL)**	
5		S-2	d		SM	Mottled orange/brown/gray SILT (soft, moist) **(RECESSIONAL LACUSTRINE)**	▽ Perched at 6 feet
					ML	Brown, silty, fine to coarse SAND with gravel (dense, moist) **(GLACIAL TILL)**	
10		S-3	d			Brown SILT (very stiff, moist)	
					SM	Brown, silty, fine to coarse SAND with gravel and cobbles (dense, moist)	
15		S-4	d				

Excavation Method: Tracked Excavator
Ground Elevation (ft): Not measured
Excavated By: Howard's Construction and Excav.
Logged By: DAR

Test Pit Completed 02/25/20
Total Depth of Test Pit = 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.



ATTERBERG LIMIT TEST RESULTS

Symbol	Exploration Number	Sample Number	Depth (ft)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	TP-1	S-1	2.0	28	26	2	28	SILT with sand	ML
⧗	TP-2	S-1	2.0	32	27	5	37	SILT	ML
▲	TP-3	S-1	2.0	38	30	8	33	SILT with sand	ML
★	TP-4	S-1	2.0	31	27	4	33	SILT	ML
⊙	TP-5	S-1	2.0	26	25	1	30	SILT with sand	ML

ASTM D 4318 Test Method

1444012.010.011 3/9/20 \\OLYMPIA1\PROJECTS\1444\012.010\T\1444012.010.GPJ ATTERBERG LIMITS FIGURE

LANDAU ASSOCIATES

Inspiring Kids Preserve
Olympia, Washington

Plasticity Chart

Figure 7