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Geotechnical Engineering: Particle Size Distribution of Layered Glacial Lake Columbia and Ice Age Flood Deposits in Latah Valley, Spokane, WA

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Abstract

We collected samples from the Latah Valley in Spokane, Wa, of Missoula Flood deposits interbedded with Glacial Lake Columbia Sediments. We conducted tests on these soils according to ASTM standards. We performed Specific Gravity tests according to ASTM D854, and determined particle size distribution for these soils by conducting sieve and hydrometer analyses according to ASTM D422. We then plotted these data to create particle size distribution curves. Specific Gravities for the all of the samples collected range from 2.36 to 2.67. The flood deposits are dominated by coarse sand and gravel and the Glacial Lake Columbia deposits are dominated by finer grain silts.

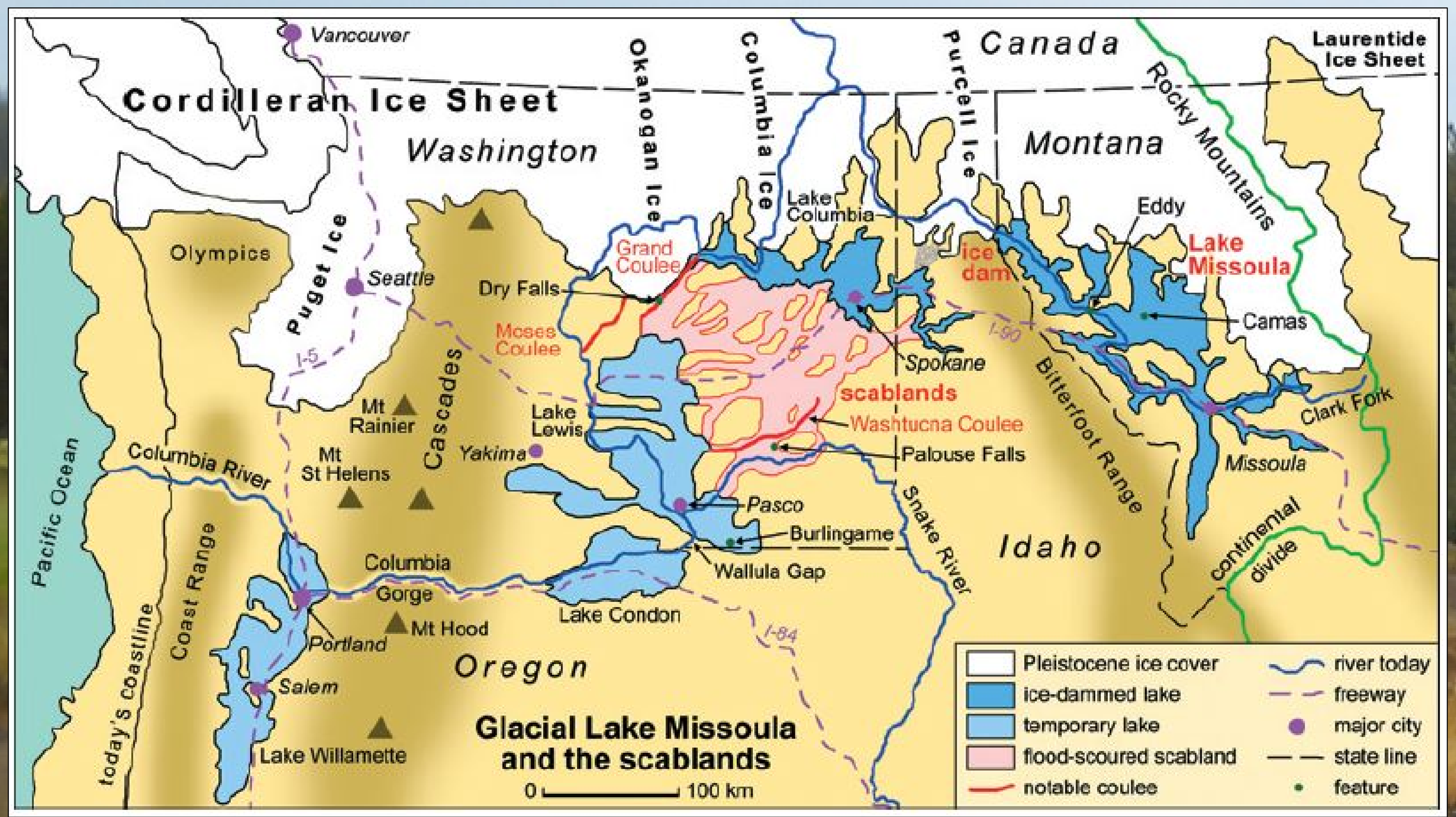
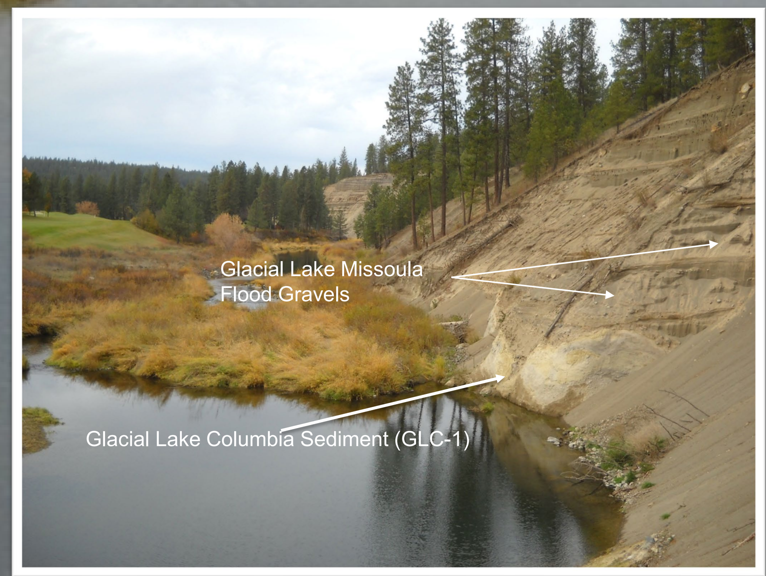


Fig. 1. A simplified map of Glacial Lake Missoula showing the temporary lakes and Glacial Lake Columbia (Waltham 2010).

Introduction

Glacial Lake Columbia formed when the Okanagan Lobe of the Cordilleran Ice Sheet blocked the Columbia River at the end of the Pleistocene. Further to the east, the Purcell Lobe of the Cordilleran Ice Sheet extended south into the Clark Fork Valley and dammed the Clark Fork to form Glacial Lake Missoula. When the ice dam holding back Glacial Lake Missoula broke, this water flooded to the west and southwest tearing up soil, sediment, and rock on its journey to the Pacific Ocean. Evidence of this gigantic flood and its interaction with Glacial Lake Columbia can be found in a number of locations in eastern Washington.

We collected Glacial Lake Columbia sediment interbedded with Missoula Flood deposits from the cut bank on an outside meander bend of Latah Creek at The Creek at Qualchan Golf Course in Eastern Washington. The sediments in the area consist of well-graded, reworked, Pleistocene glacial flood deposits of sand, silt and gravel interbedded with well-graded fine-grained silts and clays from Glacial Lake Columbia. There was evidence of active slope failure on this cut bank and others along the east side of the creek in several locations. There was also evidence of recent flooding in the form of organic debris wrapped around the trees and shrubs on the lower terrace opposite the study area. We tested these soils according to the American Society for Testing and Materials, ASTM, to determine the specific gravity (ASTM D854) and particle size distribution (ASTM D422) of each sample collected.



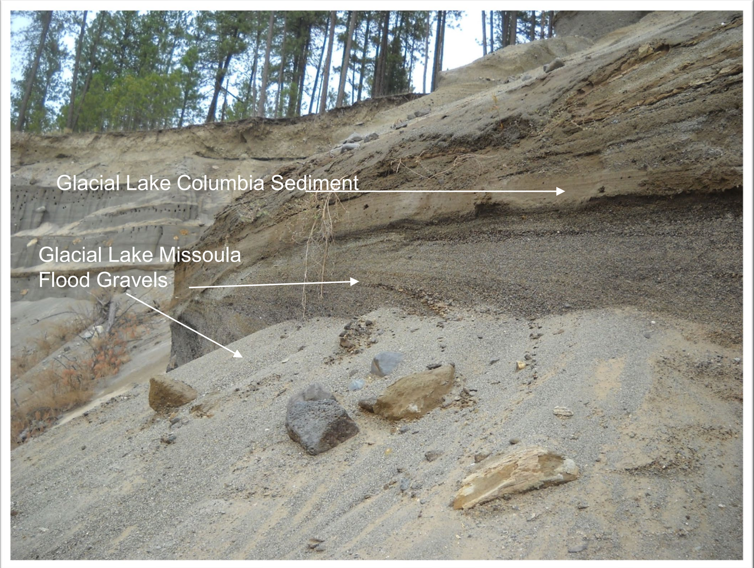


Fig. 2 (left). Glacial Lake Columbia (over 2 meters exposed) interbedded with the Glacial Lake Missoula Flood Gravels exposed along Hangman Creek (AKA Latah Creek). Fig. 3 (right). Close up of the Flood Gravels and the large boulders that are part of the well graded flood gravels. This is overlain by the fine grain silts and clays of the Glacial Lake Columbia sediments that accumulated between floods.

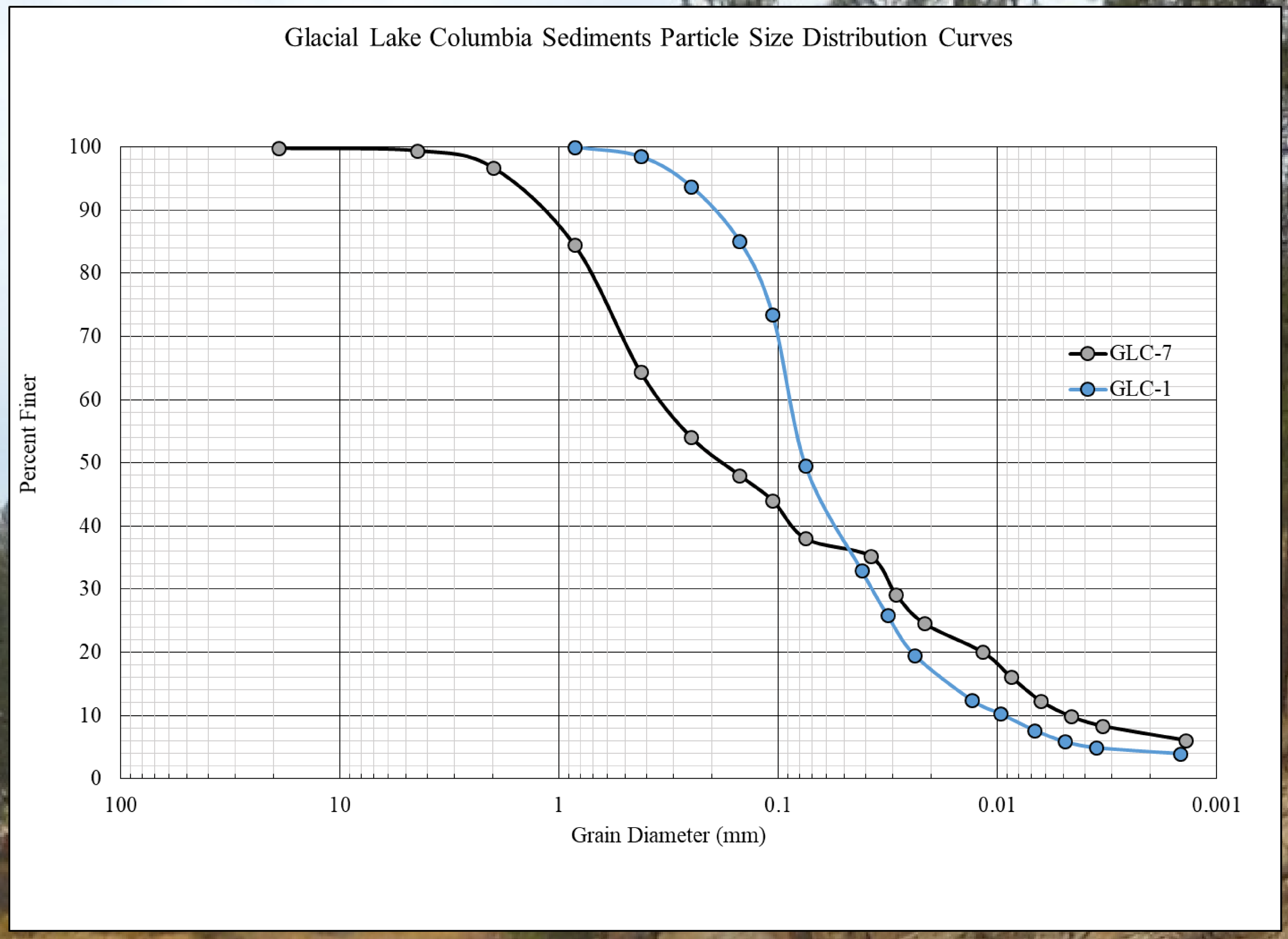


Fig. 4. Particle size distribution curve for 2 of the Glacial Lake Columbia samples. GLC-1 is interpreted to be the original lake deposits and represents the lakebed sediments prior to the first flood from Glacial Lake Missoula. GLC-7 is higher in the stratigraphic record of the interbedded GLC deposits and flood gravels (FG) separated from GLC-1 by 2 beds of Glacial Lake Columbia sediments and 3 beds of coarser flood gravels.

Methods

We collected multiple samples of the Glacial Lake Columbia sediments and interbedded Glacial Lake Missoula Flood deposits. We first determined the specific gravity of each sample according to ASTM standard D854. We conducted a particle size analysis on each sample according to ASTM D422. This test is composed of a sieve analysis followed by a hydrometer analysis, which determines the distribution of fines in each sample.

For each sieve analysis, we disaggregated the soil, weighed out at least 500g, and added it to the set of properly stacked sieves. We put the sieves on a standard sieve shaker and allowed it to shake for ten minutes. When complete we removed the sieves from the shaker, weighed the contents of each sieve, and recorded the data. We used this data to then calculate the percent finer for each sieve and plotted this data on a particle size distribution chart (figure 4 and 5). For each hydrometer analysis (GLC-1 GLC-7) we weighed out 50g of the particles that passed through the #200 sieve (0.075 mm grain diameter). We added 5g of the dispersing agent sodium hexa-metaphosphate to 150ml of water and heated until the dispersing agent dissolved. We added both the 50g of soil and the 150ml solution to a soil dispersion cup and filled the cup halfway with water. We used the soil dispersion tool for one minute, rinsed the blade into the cup, and emptied the contents of the cup into a 1L hydrometer jar. We filled the jar to the 1L mark and agitated it to ensure that all the particles were in suspension. We then began taking temperature and hydrometer readings at 1, 2, 4, 15, 30, 60, 120, and 1440 minutes of elapsed time and recorded the data. We used this data to determine the percent finer and corresponding grain diameter at each interval of time, then plotted the data on the particle size distribution chart seen in Figure 4.

Results and Conclusions

Based on the test results thus far, we have determined that the specific gravities for the all of the samples collected range from 2.36 to 2.67. The flood deposits are dominated by coarse sand and gravel and the Glacial Lake Columbia deposits are dominated by fine sands and silt/clay as seen in Table 1. Table 2 shows the calculated coefficients of uniformity and coefficients of curvature for the samples. Due to the COVID-19 Pandemic and the restrictions put in place, we were unable to continue with the hydrometer analyses for the remainder of the samples.

The Lake Missoula flood deposits show remarkable consistency in this sample area as evidenced by the tight clustering of particle size distribution curves. There is more variability in the Glacial Lake Columbia deposits. This may be due to suspension of silt that was brought into Lake Columbia by the Lake Missoula floods; these silts may have settled out more slowly than the sand and gravel, resulting in mixing with the Lake Columbia deposits that formed shortly after flood intervals.

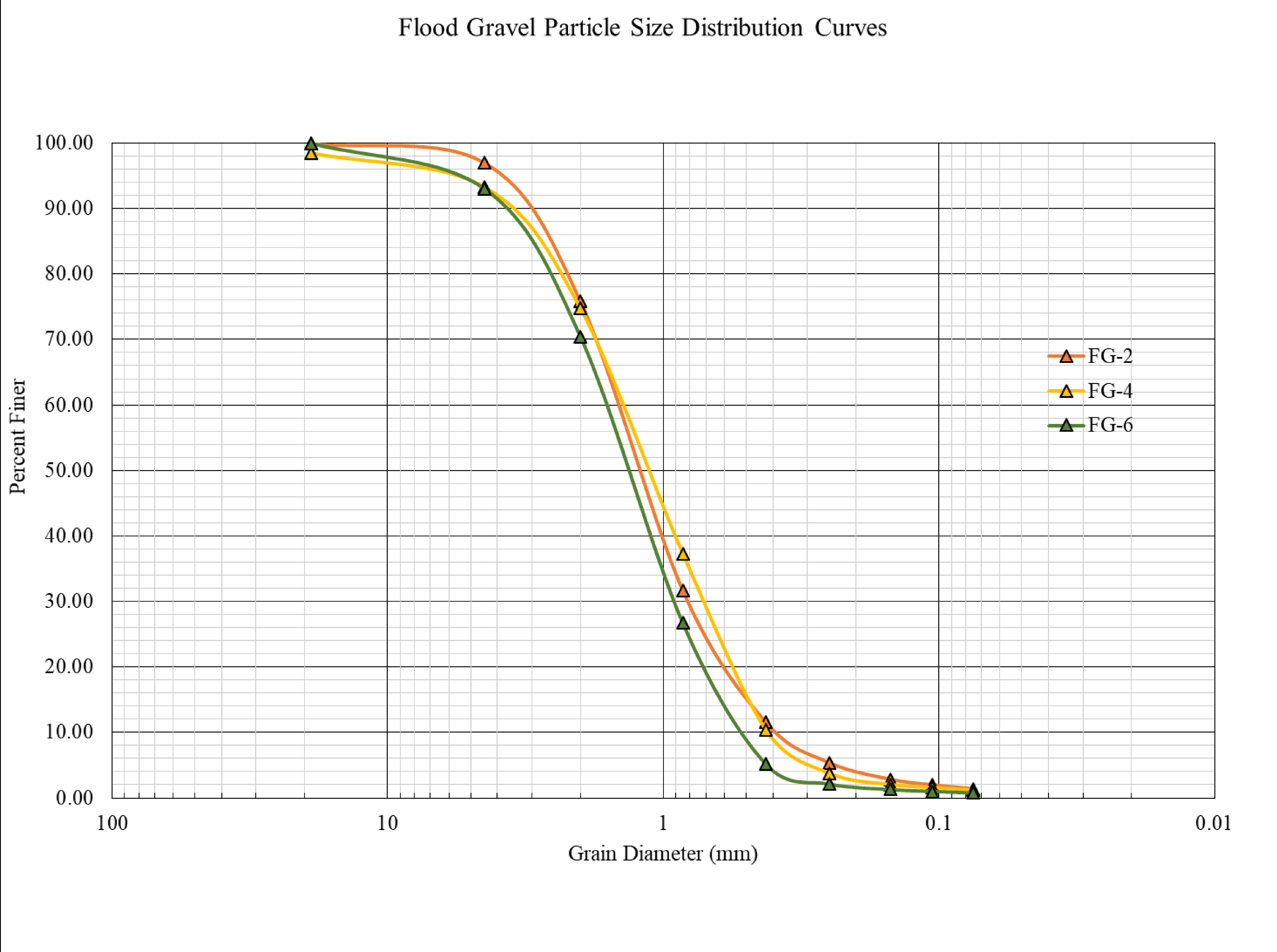


Fig. 5. Particle size distribution curve for 3 of the Glacial Lake Missoula Flood Gravels. FG-2 is directly above the basal (and likely original "pre-flood") Glacial Lake Colombia Lakebed sediments and is interpreted to be the deposits from the first of many Missoula Lake floods. This shows that the particle size characteristics of the flood gravels are very similar to each other, however they differ drastically from the GLC sediments.

Soil	% Gravels	% Sands	% Fines
GLC-1	0	50.53	49.47
GLC-7	0.56	61.45	37.99
FG-2	3.05	95.55	1.4
FG-4	6.73	92.05	1.22
FG-6	7	92.25	0.75

Table 1. This table shows the percent gravels, sands and fines for each of the samples tested to date.

Soil	C_u	C_c
GLC-1	9.47	1.69
GLC-7	74.47	0.53
FG-2	4.25	0.94
FG-4	3.69	0.75
FG-6	2.83	1.02

Table 2. This table shows the coefficient of curvature and coefficient of uniformity for each sample.

Future Work

As stated above, the ability to test samples was impacted by the restrictions that were put in place to help stop the spread of the COVID-19 virus. Soil tests require individuals to work together as a team, which is impossible under current state regulations. As such, once restrictions have been eased and we are able to get back in the lab, we will complete the hydrometer analyses for the remainder of the samples.

Acknowledgement

Thank you, Spokane Parks and Recreation Department, for permission to sample soil from The Creek at Qualchan Golf Course.

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