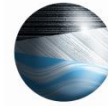


June 2, 2023



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GROUNDWATER SEEPAGE CUTOFF EVALUATION, U VILLAGE 3020 AND 3040 NORTHEAST 45TH STREET, SEATTLE, WASHINGTON

Dear Scott:

This letter presents the methods and results of a groundwater seepage evaluation at the proposed development at the University Village located at 3020 and 3040 Northeast 45th Street in Seattle, Washington. The mixed-use development will include construction of one partial level of parking below ground surface. Because the development will penetrate below the existing groundwater table, construction dewatering of the excavation will be required.

The site is located in a Category 2 Peat Settlement Environmentally Critical Area. In such areas within the City of Seattle, lowering of the groundwater table is restricted outside the boundaries of the development to protect existing structures and infrastructure from the risk of settlement due to lowering of the groundwater table. This letter presents the results of seepage evaluations related to construction of a proposed groundwater cutoff that is designed to mitigate lowering of the groundwater table outside of the property boundaries.

The site consists of an irregular shaped area with longest axis dimensions of about 540 by 560 feet. The groundwater gradient at the site is in a southwesterly direction with the highest water table elevation along Union Bay Place NE and sloping down to the southwest corner of the site. The current shoring concept is to install a low permeability secant pile wall to about elevation 8 feet. A secant pile wall consists of interconnected concrete columns; this is a relatively common shoring technique, and has been used frequently to form groundwater cutoffs. The secant pile wall will extend along much of the northeast building wall up to near Union Bay Place NE, the wall will then follow the building layout around the northeast part of the building, terminating where the building abuts near NE 45th Street.

The base of slab elevation for the structure will be elevation 31 feet. The base of excavation for the deeper footings will be elevation 26.5 feet. The target dewatering groundwater elevation is 25.5 feet.

Soil Conditions

The soil and groundwater conditions were provided by PanGEO in a geotechnical report titled: Geotechnical Report, Proposed Mixed-Use Development, 3020 and 3040 Northeast 45th Street, Seattle, Washington, dated February 2023. Your firm also provided updated figures and plots of groundwater levels measured at the site in late April 2023. Figure 1 shows the site and exploration plan.

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The site soil conditions consist of fill lying over peat and recent alluvium, which then overly Vashon Advance Outwash. Figure 2 shows a subsurface profile of the soil conditions (the profile location is shown in Figure 1). As shown, there is up to 15 feet of fill at the site, consisting of silty sand, sandy silt, and poorly graded sand with silt. Throughout much of the site about 7 feet of peat underlies the fill. In the eastern-central part of the site about 5 feet of medium stiff clay alluvium underlies the fill; this unit will exhibit low permeability. Advance outwash underlies these units; outwash was encountered directly beneath the fill in the easternmost area of the site, and then underlies the alluvium and peat in the remaining areas of the site. The outwash underlies the entire U Village development and can be a regional aquifer in Puget Sound, the outwash consists of fine to medium sand with varying amounts of silt and gravel.

The principal variable in groundwater flow calculations is hydraulic conductivity, also referred to as permeability. This variable essentially describes the ease of which groundwater can flow through the subsurface soils. The permeability of the fill was estimated to be 0.006 feet per minute (ft/min) based on pumping tests we performed at a site located to the northwest, and from other work we have performed in the area. The permeability of the peat was estimated to be 0.0005 ft/min, which based on experience is a conservatively high value (a higher permeability will generate greater predicted drawdown). The permeability of the alluvium was estimated to be 0.002 ft/min (also conservatively high). The permeability of the advance outwash was estimated to be 0.01 ft/min; this was based on the soil gradations performed for this project, and on what has been observed as about the average outwash permeability for many of the projects we have performed in the U Village area.

Groundwater levels at the site have been measured by you since December 2021. Groundwater levels have varied seasonally, but have also been significantly influenced by construction dewatering recently performed at a site directly to the east, across Union Bay Place NE; Figure 3 presents your measurements over time and indicates that groundwater levels at monitoring well PG-4 may have recovered about 5.5 feet since that dewatering system was decommissioned. Figure 4 presents the groundwater elevation contour plan, developed by you, over the subject site; this figure indicates that groundwater elevations in April 2023 were about 34 feet along Union Bay Place NE, dropping to about 25 feet in the southwest corner of the site. Based on this figure we estimate a hydraulic gradient of about 0.02 feet per foot.

Model Calculations

The seepage cutoff effects were modeled using MODFLOW, which is a three dimensional groundwater flow model that is considered to be the standard of the industry for complex groundwater flow calculations. The approach was to simulate the performance of the wall to cutoff groundwater flow into the site, and to extend the limits of the wall such that the groundwater drawdown outside the site was within reasonable limits, as defined by you.

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The model dimensions were 3,000 by 3,000 feet and incorporated 10 soil layers from the water table elevation down to elevation -30 feet. The smallest grid size in the model was 7 by 7 feet. Constant head boundaries were incorporated in to the north and south model limits to generate a static water level gradient similar to that shown on Figure 4; Figure 5 shows the calculated static groundwater gradient by the model (prior to placement of the secant pile wall). The soil layers shown in Figure 2 were incorporated into individual model layers. The secant pile wall was simulated using the Horizontal Flow Barrier package with secant pile permeabilities equal to 1×10^{-6} ft/min. Two simulated monitoring wells were incorporated into the model, one on the north side (MW-1), and one monitoring well on the west side (MW-2). Model simulations were run for 180 days.

Dewatering of the site was simulated using drains using MODFLOW's Drain Package; these essentially act as trench drains located just below subgrade elevation. This approach does not suggest that the site should be dewatered using this method; we use these drains for they force a uniform groundwater drawdown across the site, and will provide a strong hydraulic gradient from outside the site limits to inside the area shored by the secant piles. Figure 6 shows the final limits of the secant pile wall and trench drains.

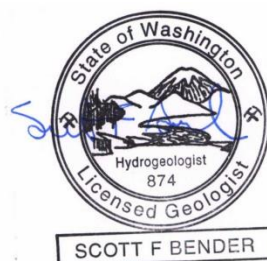
Figure 7 shows the calculated groundwater elevations after a drawdown period of 180 days. Figure 8 shows the groundwater elevations at MW-1 and MW-2, and indicates that less than 3.5 feet of drawdown would occur at MW-1 and less than 3 feet of drawdown would occur at the MW-2 location. Calculated flow rates from the drains were 90 gpm after two weeks and then gradually declining to 60 gpm after 50 days, and to 50 gpm after 180 days.

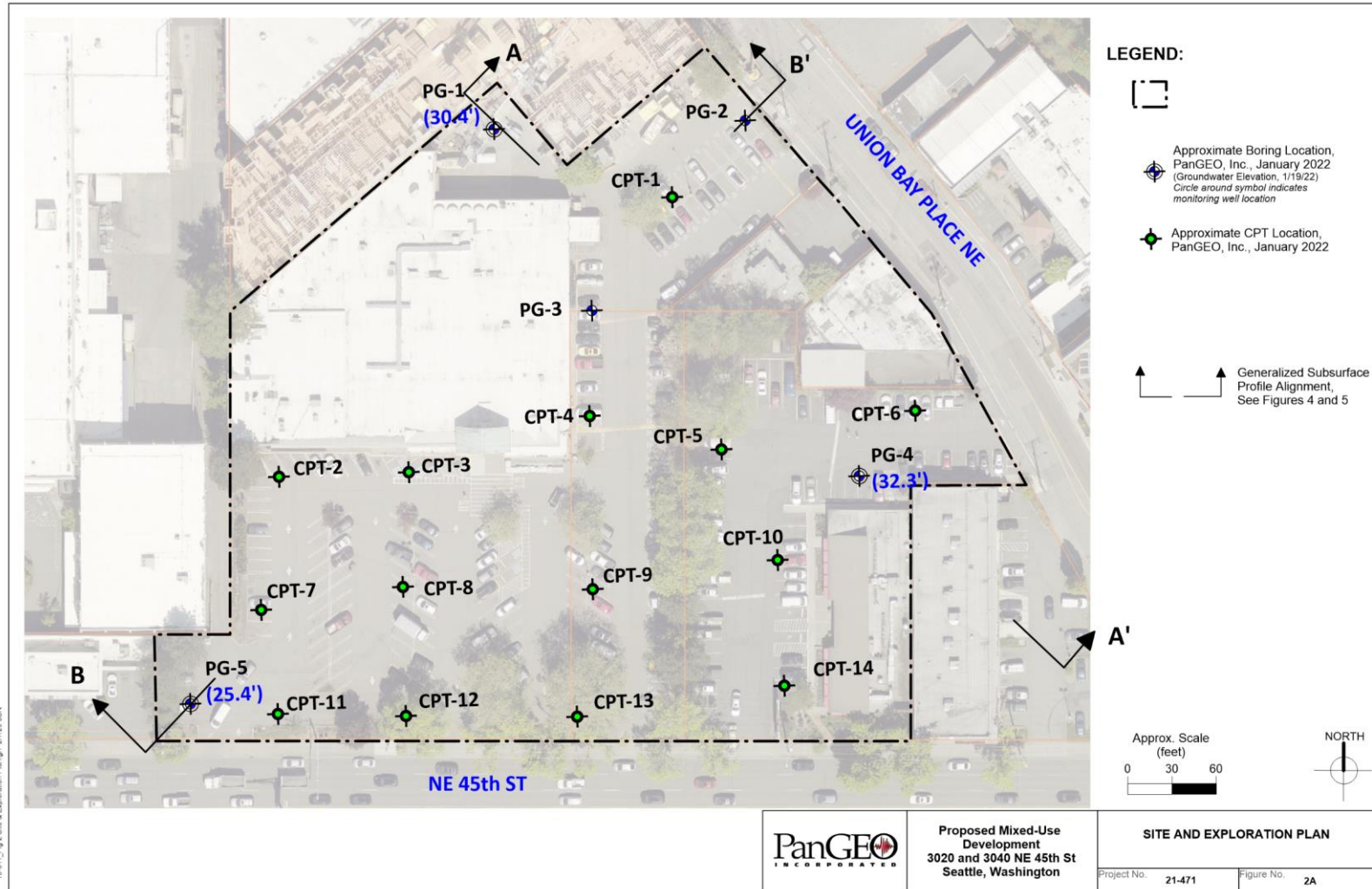
A second calculation was performed assuming groundwater recharge was performed on the north side of the excavation using a 330-foot long infiltration trench located about 50 feet from the north wall of the building. Recharge was simulated using 7 injection wells, each injecting at a rate of 7.5 gpm; roughly equal to the dewatering drain discharge rates discussed above of about 50 gpm. Figures 9 and 10 provide the results of this calculation, and shows that there was a significant decrease in groundwater drawdown in the vicinity of the site with the use of infiltration.

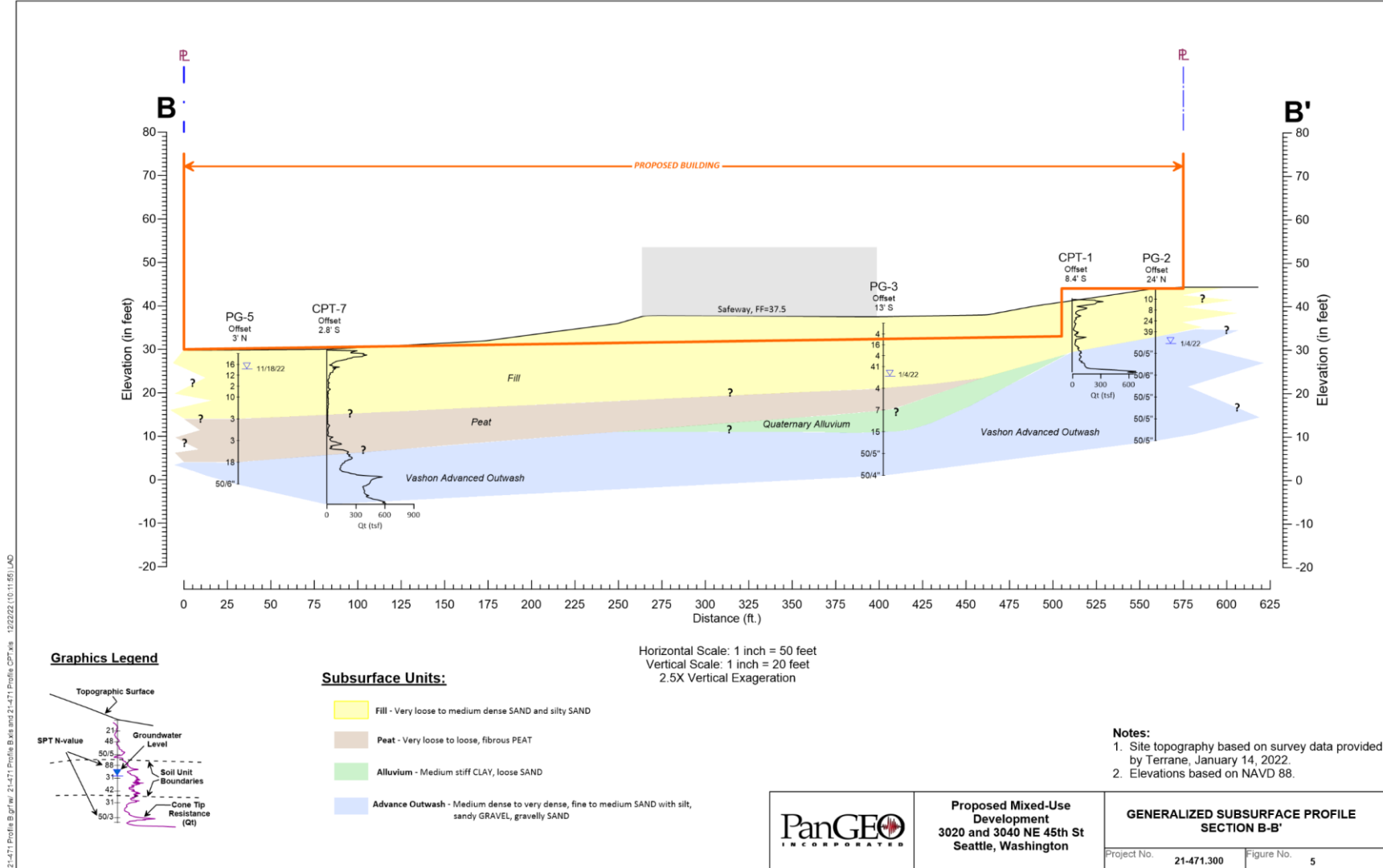
Thank you for the opportunity to be of service. Please call us at (360) 631-5600 should you have any questions or comments.

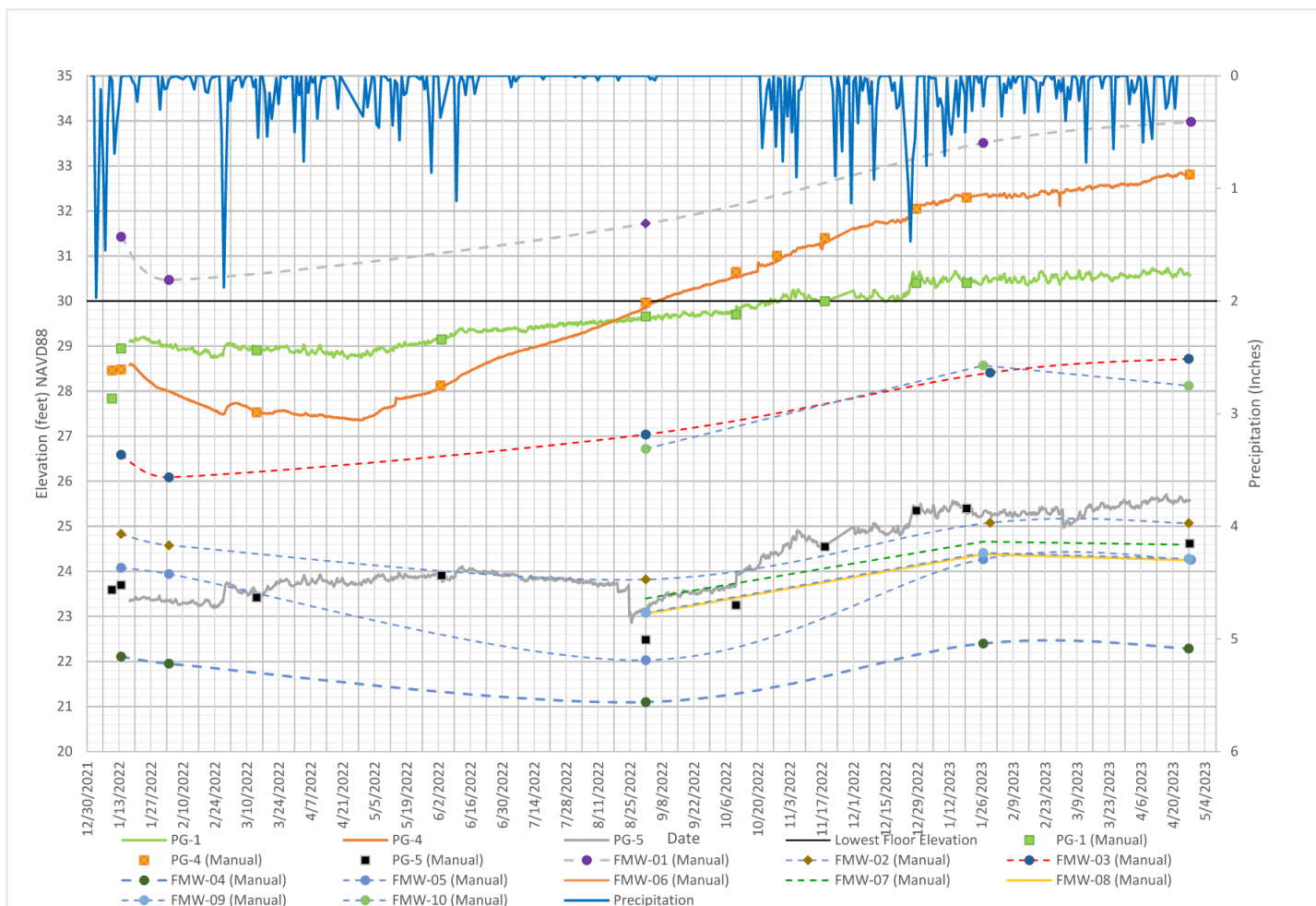
Sincerely,

Scott F. Bender L.H.G., C.G.W.P.









U-Village
3020 and 3040 NE 45th St
Seattle, Washington

Groundwater Elevations and Precipitation
Site Monitoring Wells

Project No. 21-471.300

Figure No. 6



3020 NE 45th
Drawdown Analyses
PanGEO Inc.

Groundwater Monitoring Well Hydrographs

Project Number
2318-01

Figure 3

