



April 11, 2022

Simon Simon
ImarArch Solutions

**RE: Groundwater Mounding Analysis
Cascade Mixed Use
XXX173rd Street Northeast
Arlington, Washington
RGI Job No. 2022-194-1**

The Riley Group, Inc. (RGI) is pleased to present this report documenting the groundwater mounding analysis for the proposed stormwater infiltration trench at the Cascade Mixed use Site.

RGI reviewed the following reports prepared for the site:

“Geotechnical Engineering Investigation, Cascade Mixed-Use Building Parcel #31052100307300, Arlington, Washington”, June 17th 2021, prepared by GEO Group Northwest, Inc.

“Addendum to Soil Grain Size & Cation Exchange Capacity Analysis, Cascade Mixed-Use Building, Parcel 31052100307300, Arlington, Washington”, July 29th, 2021, prepared by GEO Group Northwest, Inc.

“Piezometer Well Installation, Cascade Mixed-Use Building, Parcel 31052100307300, Arlington Washington”, February 14th, 2022, prepared by GEO Group Northwest, Inc.

“Well Monitoring Report, Cascade Mixed-Use, Arlington, Washington”, March 2, 2022, prepared by GEO Group Northwest, Inc.

Information regarding the infiltration trench and WWHM inflow volumes were provided by Harmsen Associates, LLC.

Subsurface Conditions

Geology

Review of the Geologic map of the Marysville quadrangle, Snohomish County Washington, by Minard J.P. (1985) indicates that the soil in the project vicinity is mapped as Vashon-age recessional outwash deposits Marysville Sand Member (Qvrm) which consists of well-drained outwash sand, a little fine gravel, and some beds of silt and clay deposited by streams and rivers emanating from the retreating ice sheet.

Hydrogeology

The hydrogeology in the area is described in “The Ground-Water System and Ground-Water Quality in Western Snohomish County, Washington, Thomas, B.E., et al, U.S. Geological Survey Water-Resources Investigations Report 96-4312.

GEO Group Northwest installed a monitoring well PZ-1 in January 2022. The ground surface elevation at the wellhead as reported by GEO Group is Elevation 125. The shallowest groundwater

level measurement was in February 2022 at approximately 5.42 feet below grade (Elevation 119.58)

Groundwater Mounding (MODFLOW)

Infiltration Trench

RGI understands an infiltration trench is proposed on the eastern portion of the site as shown in Figure 2. The infiltration trench dimension are 20 feet wide, 200 feet long, 1.5 feet deep. The bottom of the infiltration gallery is at Elevation 122.58.

Aquifer Framework

The aquifer underlying the Site is an unconfined aquifer comprised of the Vashon-age recessional Marysville Sand deposits. Marysville Sand was observed to the depth explored in the two geotechnical borings completed for the geotechnical engineering report and in the monitoring well boring completed by GEO Group Northwest in January 2022. Marysville Sand is noted on the geotechnical engineering borings to depths of 30 to 40 feet. Marysville Sand is noted on the monitoring well boring log to the depth drilled, 15 feet below grade.

Thomas et al, reports a thickness of the Marysville Sands ranging from 40 to 250 feet. An aquifer thickness of 40 feet was used in the mounding analysis.

Hydraulic Parameters

Hydraulic parameters for the Marysville Sand were estimated from hydraulic values presented by Thomas et al and grain size analyses of Site specific samples of the Marysville Sand from the site soil borings. Thomas et al, cites the median hydraulic conductivity in the Marysville Sand of 180 feet/day.

Grain size analysis of the Marysville Sand samples collect at the Site were evaluated by GEO Group Northwest using the grain method to estimate a soil infiltration rate (K_{sat} initial) of approximately 50 inches/hour (100 feet/day). This rate represents a vertical hydraulic conductivity (KVS). A correction factor of 1:1.5 was used to yield an initial horizontal hydraulic conductivity (KHS) of 150 feet/day, which was used for the aquifer hydraulic conductivity in the mounding analysis. The mounding analysis was also run using hydraulic conductivities of 50 feet/day and 100 feet/day to assess model sensitivity.

Porosity

A total porosity (n_t) for the recessional outwash deposits used in the mounding analysis was 0.25, with an effective porosity (n_e) of 0.20.

Groundwater Mounding Simulations

Inflow Hydrographs

Daily stormwater inflow to the infiltration trench used in the mounding analysis were provided by Harmsen Associates, LLC. Daily inflow rates to the infiltration trench were exported from the Western Washington Hydrology Model (WWHM). Inflow hydrograph for a 30-day period in which the one day peak maximum flow rate to the infiltration trench occurs for the period simulated in WWHM and the 30-day period in which the maximum flow volume occurs were simulated for the mounding analysis. Time series plots for the peak rate and cumulative highest 30-day volume events are attached.

Mounding Analysis (MODFLOW)

The USGS 3-Dimensional groundwater flow model MODFLOW was used to complete the mounding analysis. The inflow hydrographs are applied to the infiltration trench footprint “cells” in MODFLOW after being converted to recharge using the MODFLOW “recharge” module.

The MODFLOW model used in the mounding analysis is comprised of one layer and the grid dimensions are 3,000 feet (east-west) by 3,000 feet (north-south). The aquifer thickness in the model for the mounding simulations was 40 feet, as discussed above. The unconfined “water table” aquifer was simulated in MODFLOW using constant head cells around the perimeter of the model grid with assigned constant head values to simulate the groundwater aquifer beneath the site.

Daily stormwater inflow events for the two simulated events to the infiltration pond were input in daily time-steps. Mounded levels for each day of the 30 day simulations were evaluated to determine the maximum mounding condition beneath each infiltration trench.

Conclusions

Groundwater mounding simulations for the infiltration trenches for the peak one-day inflow rate and 30-day cumulative volume indicate that groundwater mounding did not inhibit infiltration in the trench for either simulated inflow event. Mounded conditions were the highest under the peak one day inflow simulations lesser mounded conditions were observed in the 30-day cumulative volume simulations. The groundwater mounding analysis shows over the range of hydraulic conductivities simulated (50 to 150 feet/day) under the maximum mounded condition the infiltration trench the mounded groundwater level remains below the base of the infiltration trench and the trench functionality will not be inhibited due to groundwater mounding.

Limitations

This report is the property of RGI, Cascade Mixed-use, and its designated agents. Within the limits of the scope and budget, the mounding analysis was completed in accordance with generally accepted geotechnical engineering practices in the area at the time this report was issued. This mounding analysis is intended for specific application to the Cascade Mixed-Use Site located at XXX173rd Street Northeast site in Arlington, Washington, and for the exclusive use of Cascade Mixed-Use and its authorized representatives.

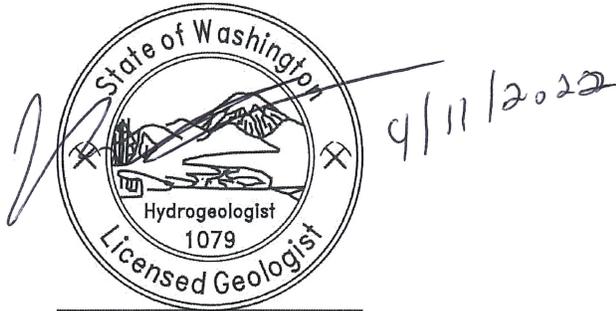
Please call us at (425) 415-0551 if you have any questions or need additional information.



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Respectfully submitted,

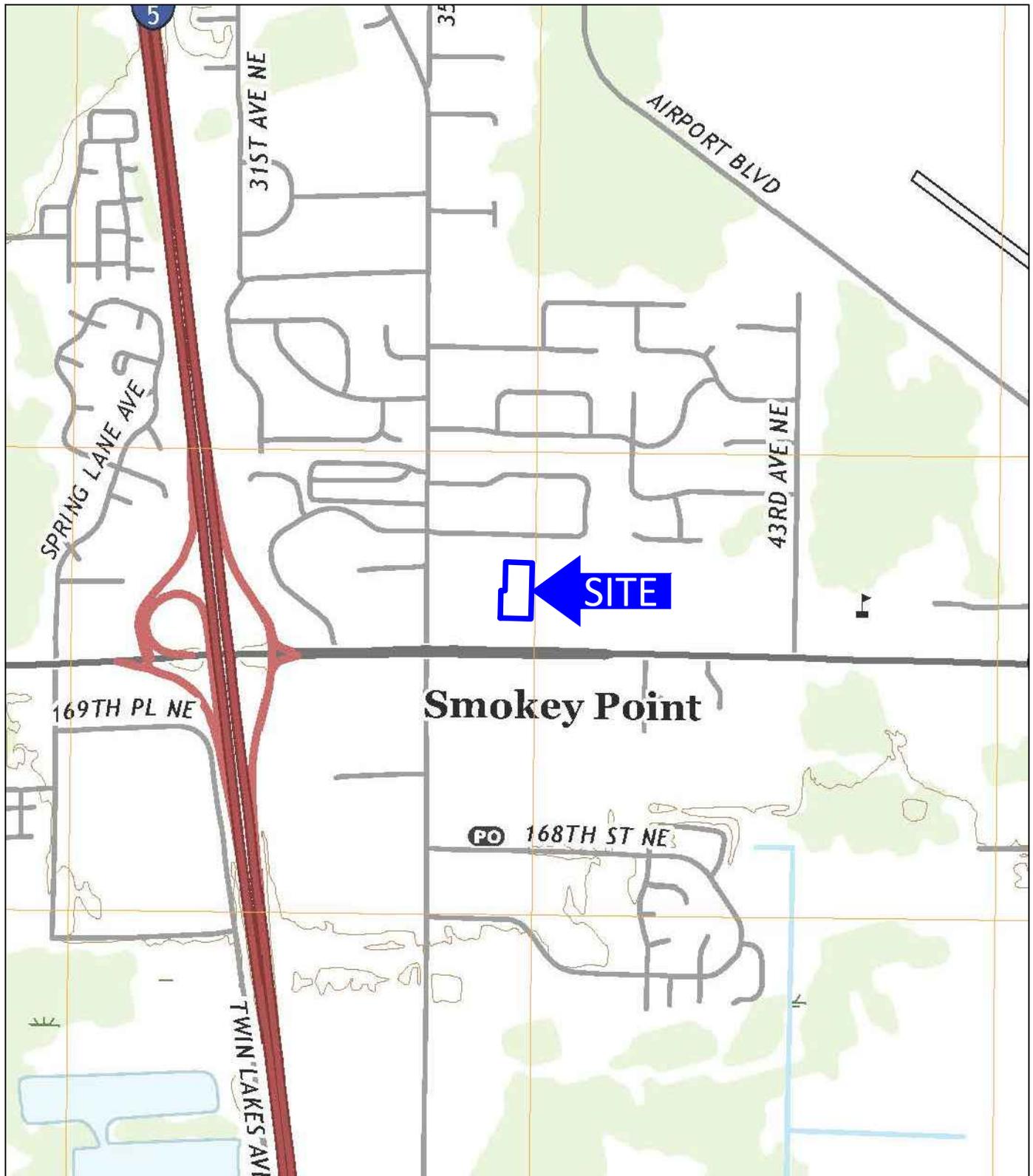
THE RILEY GROUP, INC.



David John Baumgarten

David J. Baumgarten, LHG
Associate Hydrogeologist

Attachments: Figure 1 Site Vicinity Map
 Figure 2 Site Plan
 Maximum Volume Event Hydrograph
 Peak Inflow Event Hydrograph



USGS, 2020, Arlington West, Washington
7.5-Minute Quadrangle

Approximate Scale: 1"=1000'



Corporate Office
17522 Bothell Way Northeast
Bothell, Washington 98011
Phone: 425.415.0551
Fax: 425.415.0311

Cascade Mixed Use

RGI Project Number:
2022-194-1

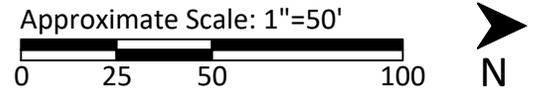
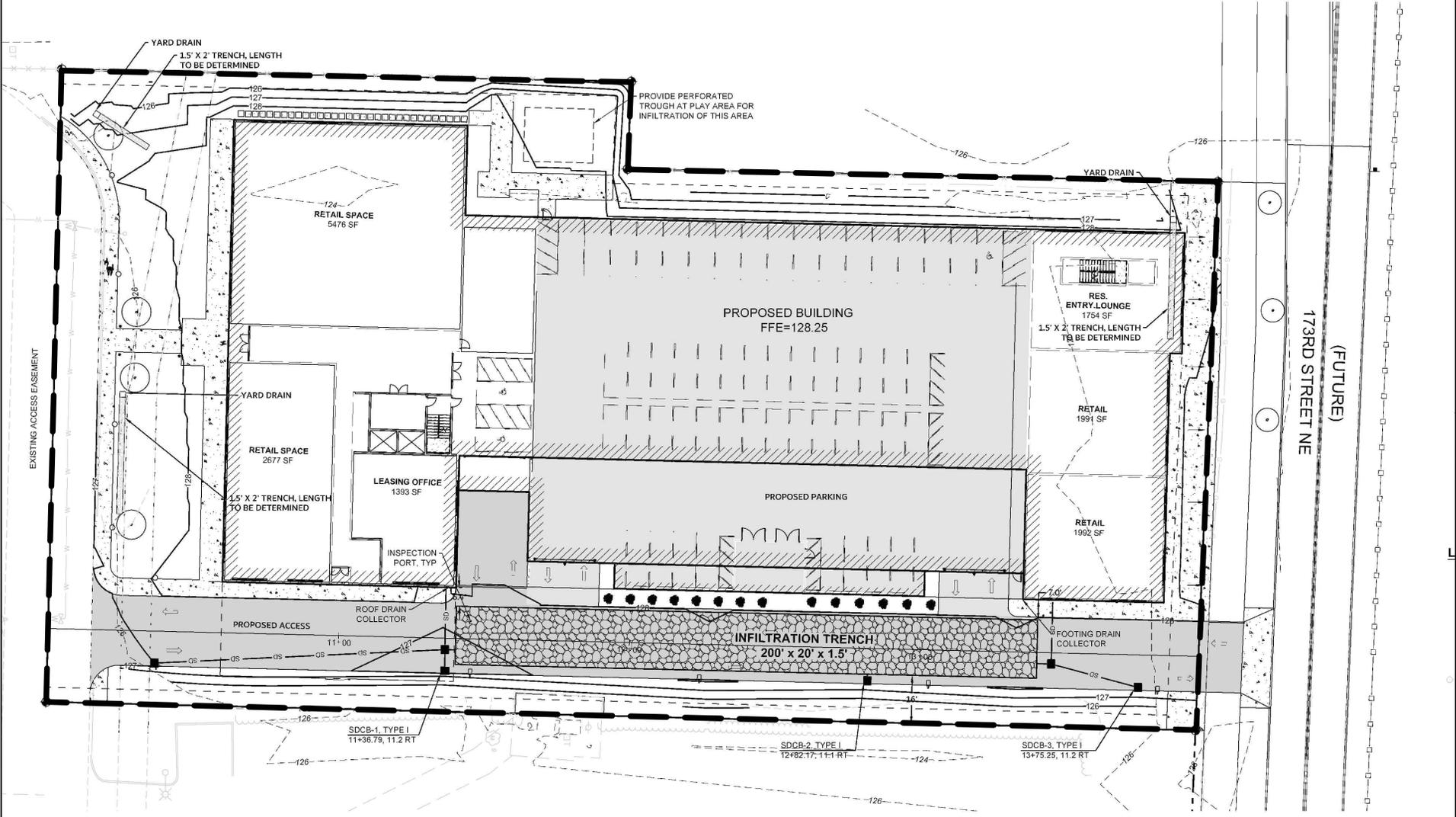
Site Vicinity Map

Figure 1

Date Drawn:
04/2022

Address: XXX 173rd Street Northeast, Arlington, Washington 98223

SECTION 21, TOWNSHIP 31 NORTH, RANGE 5 EAST, W.M.



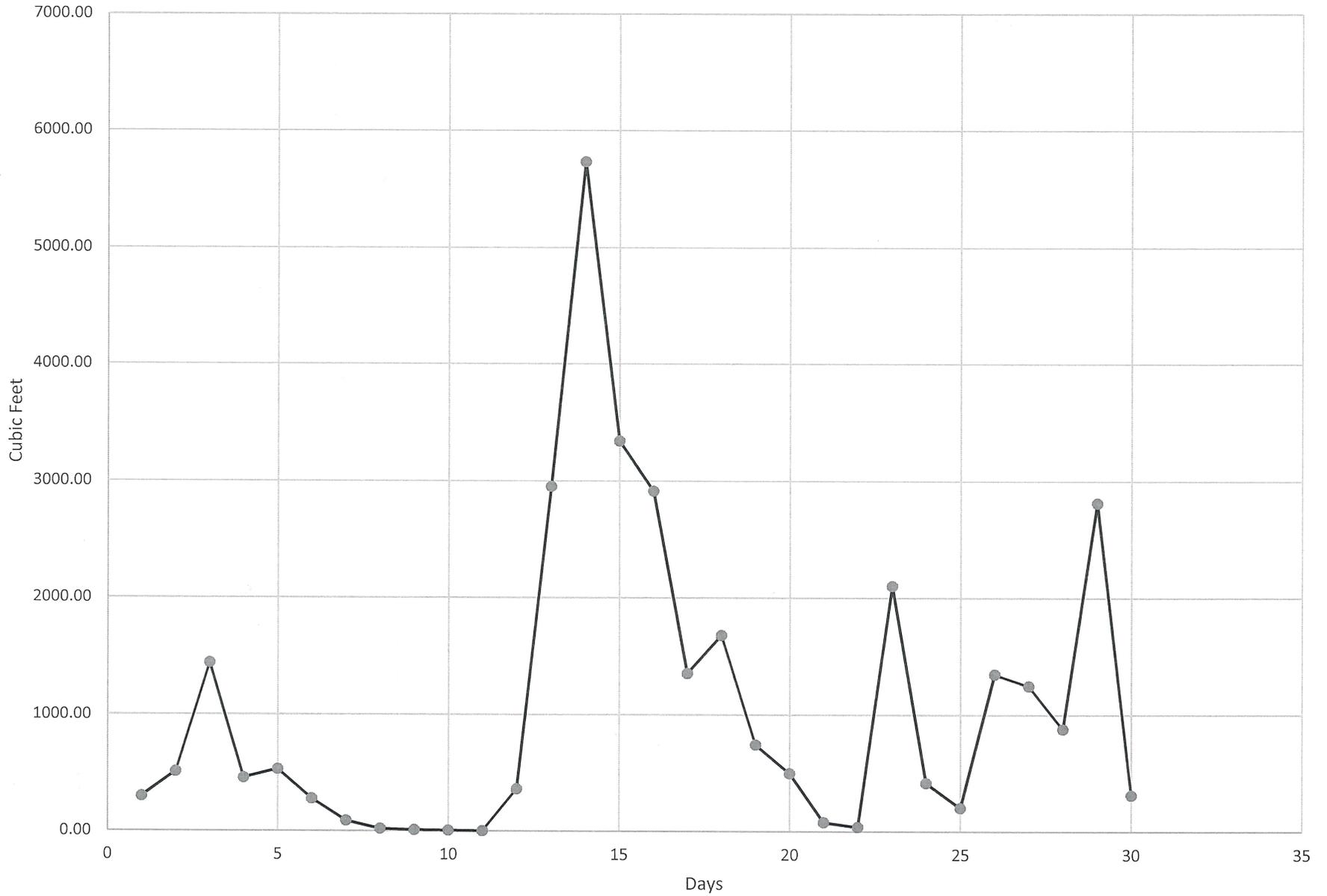
--- = Site boundary



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 17522 Bothell Way Northeast
 Bothell, Washington 98011
 Phone: 425.415.0551
 Fax: 425.415.0311

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|--|-------------------------------|------------------------|
| Cascade Mixed Use | | Figure 2 |
| RGI Project Number: 2022-194-1 | Geotechnical Exploration Plan | Date Drawn: 04/2022 |
| Address: XXX 173rd Street Northeast, Arlington, Washington 98223 | | |

Cascade Mixed Use: Maximum 30-Day Inflow Volume



Cascade Mixed Use Peak One-day Inflow Event

