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M E M O R A N D U M

DATE: September 6, 2023

TO: Robert Linscott

FROM: Khaled M. Shawish, PE
Alex Rinaldi, LG

RE: Groundwater Monitoring and Mounding Analysis
Linscott Short Plat
9622 – 48th Drive NE
Marysville, Washington
NGA File No. 13140B23

KHALED M. SHAWISH
STATE OF WASHINGTON
35215
REGISTERED
PROFESSIONAL ENGINEER
9.06.2023

This memorandum presents the results of our groundwater monitoring at the site of the proposed short plat development located at **9622 – 48th Drive NE in Marysville, Washington.**

INTRODUCTION

We previously prepared a geotechnical report for the site titled ***"Geotechnical Engineering Evaluation – Linscott Short Plat – 9622 - 48th Drive NE – Marysville, Washington," dated December 17, 2021.*** We did not encounter any groundwater or signs of groundwater in our explorations as described within this previous report. We understand that development plans require stormwater systems to infiltrate into site soils with numerous infiltration trenches planned within the site. These trenches are up to 4-feet in depth. We were not retained to revisit the site during the wet season to see if the site meets Suitability Criteria per the Washington State Department of Ecology's 2019 Stormwater Management Manual for Western Washington. However, based on our observations, experience with nearby sites, and monitoring performed onsite, we estimated a seasonal high groundwater elevation.

Additionally, we were requested to perform mounding analysis on a specific infiltration trench due to the base elevation of the proposed trench extending less than 5 feet from the assumed seasonal high groundwater elevation.

For use in preparing this memorandum we were provided with a drainage plan sheet titled "Linscott Short Plat," date July 25, 2023, and prepared by Omega Engineering.

GROUNDWATER MONITORING

We were not retained to provide wet-season groundwater monitoring for this site; however, we are able to reasonably estimate the suitability criteria from the results from our onsite explorations, which were done within the wet season.

The wet season is typically considered to be within October 1st and April 30th. We performed our field work on November 19, 2021 and returned to the site to check the groundwater level on January 25, 2022, both visits within the wet season, where no groundwater, or indications of groundwater, were observed. It is our opinion that any groundwater observed within the site would be related to the regional groundwater levels; therefore, groundwater levels are not expected to fluctuate substantially. While we did not observe any groundwater up to a depth of 11-feet, we estimate a possible margin of error of 0.5 feet. Therefore, we estimate that the seasonal high groundwater table is no higher than 10.5-feet below the existing ground surface within the site. It is our opinion, based on our findings onsite, that the seasonal high groundwater levels on this site should be no shallower than 10.5-feet below the existing ground surface.

DOCUMENT REVIEW AND GROUNDWATER MOUNDING ANALYSIS

Based on our review of the provided drainage plan, individual lot infiltration trenches are planned to collect roof runoff as well as two infiltration trenches to capture roadway runoff. We were requested to provide mounding analysis on Roadway Infiltration Trench #2 due to less than 5 feet of separation from the assumed, 10.5-foot depth, seasonal high groundwater elevation. We did not encounter groundwater within our previous explorations or in our groundwater monitoring reading. Therefore, based on our test pit explorations within the site and experience with other nearby projects, we have assumed that the seasonal high groundwater elevation should be no shallower than 10.5-feet below the existing ground surface, which correlates to an elevation of approximately 46 feet, per the drainage plans.

We performed a groundwater mounding analysis for the proposed Road Infiltration Trench #2 utilizing a spreadsheet generated by USGS solving the Hantush (1967) equation for groundwater mounding beneath an infiltration basin. A value of 6.14 feet per day (ft/day) (3.07 in/hr) was utilized for the recharge (infiltration) rate of site soils. The provided rate was generated from grain-size analyses on selected soil samples throughout the site based on the simplified approach per the 2019 DOE Stormwater Management Manual for Western Washington as discussed in our previous report. A specific yield of 0.222 was utilized for the granular site soils underlying the site at depth. Basin sizing specifications are based on the drainage details provided by Omega Engineering, Inc.

The duration of infiltration incorporated into the analyses was based on the duration of time that it would take the maximum ponding depth of the proposed infiltration systems to drain utilizing the recommended long-term design infiltration rate of 3.07 in/hr. The initial overall thickness of the saturated zone was estimated based on previous explorations within the site and the nearby vicinity and is likely thicker than 30 feet which was used in the analysis. The spreadsheet results of our groundwater mounding analyses is presented in Figure 1, attached to this letter. A summary of the mounding analyses is shown in **Table 1** below.

Table 1. Mounding Analyses Summary

Infiltration Trench ID	Trench Dimensions (ft)	Trench Bottom Elevation (ft)	Seasonal High Groundwater Elevation (ft)	Groundwater Mound (ft)
Roof Infiltration Trench #2	100Lx7Wx4D	49.4	46.0	1.3

CONCLUSIONS

Based on our groundwater mounding analyses, it appears that the groundwater mounds generated from a design level storm event below the proposed infiltration systems will rise approximately 1.3 feet above an assumed seasonal high groundwater elevation of 46 feet in the area of Road Infiltration Trench #2 (10.5 feet below the existing ground surface) within proposed infiltration system, allowing for approximately 2.1 feet of separation. Based on the mounding analyses, observations within the site, and experience in the area, it is our opinion that the performance of the proposed stormwater infiltration systems within the site should not be adversely impacted by subsurface groundwater mounding during storm events.

CLOSURE

We recommend that NGA be retained to provide monitoring and consultation services during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions revealed during the work differ from those anticipated, and to evaluate whether or not earthwork activities comply with contract plans and specifications. We trust this memorandum should satisfy your needs at this time. Please contact us if you have any questions or require additional services.

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One Figure Attached

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This spreadsheet will calculate the height of a groundwater mound beneath a stormwater infiltration basin. More information can be found in the U.S. Geological Survey Scientific Investigations Report 2010-5102 "Simulation of groundwater mounding beneath hypothetical stormwater infiltration basins".

The user must specify infiltration rate (R), specific yield (Sy), horizontal hydraulic conductivity (Kh), basin dimensions (x, y), duration of infiltration period (t), and the initial thickness of the saturated zone (hi(0), height of the water table if the bottom of the aquifer is the datum). For a square basin the half width equals the half length (x = y). For a rectangular basin, if the user wants the water-table changes perpendicular to the long side, specify x as the short dimension and y as the long dimension. Conversely, if the user wants the values perpendicular to the short side, specify y as the short dimension, x as the long dimension. All distances are from the center of the basin. Users can change the distances from the center of the basin at which water-table aquifer thickness are calculated.
Cells highlighted in yellow are values that can be changed by the user. Cells highlighted in red are output values based on user-specified inputs. The user MUST click the blue "Re-Calculate Now" button each time ANY of the user-specified inputs are changed otherwise necessary iterations to converge on the correct solution will not be done and values shown will be incorrect. Use consistent units for all input values (for example, feet and days)

use consistent units (e.g. feet & days **or** inches & hours)

Input Values		
6.1400	*R*	**Recharge (infiltration) rate (feet/day)**
0.222	Sy	**Specific yield, Sy (dimensionless, between 0 and 1)**
13.00	K	**Horizontal hydraulic conductivity, Kh (feet/day)***
50.000	x	**1/2 length of basin (x direction, in feet)**
3.500	y	**1/2 width of basin (y direction, in feet)**
0.325	t	**duration of infiltration period (days)**
30.000	hi(0)	**initial thickness of saturated zone (feet)**

Conversion Table

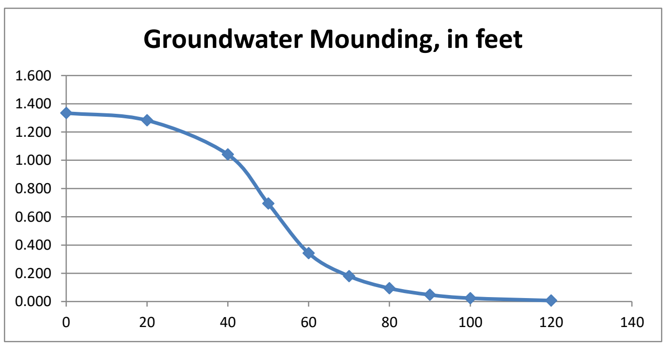
inch/hour	**feet/day**
0.67	1.33
2.00	4.00
hours	**days**
36	1.50

In the report accompanying this spreadsheet (USGS SIR 2010-5102), vertical soil permeability (ft/d) is assumed to be one-tenth horizontal hydraulic conductivity (ft/d).

31.334	h(max)	**maximum thickness of saturated zone (beneath center of basin at end of infiltration period)**
1.334	Δh(max)	**maximum groundwater mounding (beneath center of basin at end of infiltration period)**

Ground-water Mounding, in feet	**Distance from center of basin in x direction, in feet**
1.334	0
1.283	20
1.041	40
0.694	50
0.343	60
0.180	70
0.094	80
0.048	90
0.024	100
0.007	120

Re-Calculate Now



Disclaimer

This spreadsheet solving the Hantush (1967) equation for ground-water mounding beneath an infiltration basin is made available to the general public as a convenience for those wishing to replicate values documented in the USGS Scientific Investigations Report 2010-5102 "Groundwater mounding beneath hypothetical stormwater infiltration basins" or to calculate values based on user-specified site conditions. Any changes made to the spreadsheet (other than values identified as user-specified) after transmission from the USGS could have unintended, undesirable consequences. These consequences could include, but may not be limited to: erroneous output, numerical instabilities, and violations of underlying assumptions that are inherent in results presented in the accompanying USGS published report. The USGS assumes no responsibility for the consequences of any changes made to the spreadsheet. If changes are made to the spreadsheet, the user is responsible for documenting the changes and justifying the results and conclusions.