MEMORANDUM

DATE: June 23, 2021

TO: Larry Covey, Department of Social and Health Services

FROM: Ken Nogeire, LHG, Senior Hydrogeologist

Ryan White, PE, GE (OR), Principal Geotechnical Engineer

SUBJECT: Groundwater Mounding Analysis
48 Bed Community RTF
16015 NE 50th Avenue
Vancouver, Washington
PBS Project 73200.011

The purpose of this memo is to summarize the preliminary groundwater mounding analysis for stormwater management at the proposed new facility located at 16015 NE 50th Avenue in Vancouver, Washington (property or site). Site-specific parameters included precipitation, subsurface conditions, and field-measured infiltration rates, which were used to calculate an order of magnitude estimate of groundwater mounding. This estimate was used to evaluate the stormwater infiltration feasibility and to aid in a detailed stormwater design.

PROJECT UNDERSTANDING

PBS understands the client plans to construct up to three 18,000-square-foot buildings, each with associated parking and landscape areas. The new buildings will be located on approximately the western third of the 20-acre site. The site is relatively flat and covered predominantly with grass and a few trees around the existing residence and barn and in the northeastern portion of the site.

The project design includes the on-site infiltration of stormwater. All infiltrating water would be from precipitation and does not include water that would not naturally exist, such as groundwater pumped from aquifers beneath the site or water from off-site properties. The planned buildings and parking areas will reduce the available, natural infiltration area and concentrate infiltration at the basin areas. However, the basin areas are spatially distributed and designed to be relatively shallow and laterally large for the purpose of allowing for infiltration similar to natural conditions.

Groundwater mounding is being evaluated due to the presence of relatively shallow groundwater at the site; shallow depths of 1.2 to 2.0 feet below the existing ground surface (bgs) were measured in February 2021.

MODELING GROUNDWATER MOUNDING

For the purpose of estimating groundwater mounding, PBS utilized the Hantush USGS SIR 2010-5102-110 model *Simulation of Groundwater Mounding Beneath Hypothetical Stormwater Infiltration Basins.*[1] The finite-difference groundwater-flow model MODFLOW-2000 (Harbaugh and others, 2000) is used to simulate the height and extent of groundwater mounds beneath infiltration basins with various aquifer characteristics, recharge conditions, and basin areas, depths, and shapes.

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[1] Carleton, G. B. (2010). Simulation of groundwater mounding beneath hypothetical stormwater infiltration basins: US Geological Survey Scientific Investigations Report 2010-5102, 64 p.

Primary Parameters

Basin Area

The current stormwater plan includes a total infiltration basin area of 101,000 square feet. The basins vary widely in location and lateral size. For this mounding estimate the basin areas were combined into one square-shaped basin of 318 by 318 feet (101,124 square feet). The geometry of the actual mound will likely be more complex than the one presented in this model; however, groundwater migrates toward equilibrium elevation. The approach utilized in this model is considered to be a good representation of a groundwater mound created beneath the new development during a severe storm event.

Infiltration Rate

The analysis was completed using an infiltration rate of 0.4 feet/day, or 0.2 inches/hour, based on field-measured infiltration rates with correction factors applied. Based on Isopluvial Maps for Washington State produced by the Western Regional Climate Center (WRCC) the total volume of precipitation water going to the basins for 24 hours during a 100-year storm event (118,000 cubic feet) exceeds the long-term infiltration rate. As a result, the basins will be designed to store water while it infiltrates (no overflow).

Secondary Parameters

Remaining parameters were estimated based on subsurface soil conditions observed during geotechnical explorations and summarized in the geotechnical engineering report for the project.

CONCLUSION

The groundwater mound resulting from stormwater infiltrating at the design infiltration rate lasting 24 hours would result in a **groundwater mound of approximately 1.14 feet** above the static groundwater elevation.

Based on this evaluation, on-site stormwater infiltration into relatively shallow but laterally large basins is considered feasible for the site. The infiltration basins are designed with the basin base elevation above the groundwater mound elevation. As such, groundwater mounding is not anticipated to adversely impact the performance of the stormwater infiltration system.

Attachment: Groundwater Mounding Model: 24-hour Storm Event

KN:RW:rg

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		
0.4000	***R***	**Recharge (infiltration) rate (feet/day)**
0.350	**Sy**	**Specific yield, Sy (dimensionless, between 0 and 1)**
12.00	**K**	**Horizontal hydraulic conductivity, Kh (feet/day)***
159.000	**x**	**1/2 length of basin (x direction, in feet)**
159.000	**y**	**1/2 width of basin (y direction, in feet)**
1.000	**t**	**duration of infiltration period (days)**
20.000	**hi(0)**	**initial thickness of saturated zone (feet)**

Conversion Table

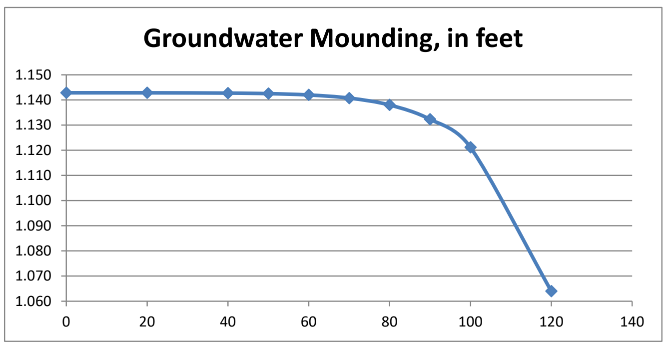
inch/hour	**feet/day**
0.67	1.33
2.00	4.00
hours	**days**
36	1.50

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).

21.143	**h(max)**	**maximum thickness of saturated zone (beneath center of basin at end of infiltration period)**
1.143	**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**
1.143	**0**
1.143	**20**
1.143	**40**
1.143	**50**
1.142	**60**
1.141	**70**
1.138	**80**
1.132	**90**
1.121	**100**
1.064	**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.