July 6, 2021

Branch ENGINEERING Inc
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Ashlee Sorber
American Pacific International Capital
Via Email: asorber@apicincus.com

RE: GEOTECHNICAL EVALUATION OF GROUNDWATER HYDRAULICS
FLORENCE HOUSING DEVELOPMENT – SITE A
RHODODENDRON DRIVE AND 35TH STREET
FLORENCE, OREGON
BRANCH ENGINEERING INC. PROJECT NO. 19-510

Pursuant to your request, Branch Engineering Inc. (BEI) geotechnical engineering staff has collected information regarding the historic surface and subsurface flow of stormwater on and in the vicinity of the subject site (Site). The information contained herein is based on our geologic knowledge of the area, discussions with a long-time local excavation contractor, review of the December 2018 Stormwater Master Plan Update for the City of Florence, and discussions with City of Florence Public Works staff.

The Site, formerly a KOA campground prior to the year 2000, lies on the southern end of a north to south drainage path that begins in the open dune area north of Heceta Beach Road creating a series of shallow lakes between these open dunes and those located behind the Fred Meyer store on the north end of the Sand Pines Golf Course at which point the flow of water bends west towards the Siusalw River with various surface water outlets to the river and groundwater flow atop a cemented sand lense near low tide river level. It is our understanding the lakes within the golf course are lined manmade reservoirs.

Findings

Historically, several areas of Florence have experienced extended periods of standing surface water during times of heavily, sustained rainfall as is evidenced by conditions documented in 1996/1997 and 2016/2017. Continued improvements over the years by the City of Florence and developers have mitigated some of the high-water conditions, but it is our understanding that Federal agency oversight has limited the number of direct outfalls and flow volumes to the Siuslaw River requiring the implementation of detention/retention and infiltration systems to be employed.

Recent stormwater system improvements in the vicinity of the Site include:

- Construction of retention facilities in the Mariners Village development north of the Site;
- Installation of detention and flow control structures for stormwater in the Fairway Estates subdivision directly north of the Site; and

- Construction of the Siano Ditch and enhancement of Bud's Ravine on the south end of the Site to mitigate surface water that was directed onto the Site by development of the Sand Pines and Sand Pines West subdivision.

Our geotechnical site investigation in December 2019 did not encounter any groundwater the test pits that were excavated to a maximum depth of 10-feet below the surface grade nor was there oxidation staining of the sand that would indicate a fluctuating water level observed. No flowing surface water was present, although surface soil on the east side of the site, adjacent to the Sand Pines development, had a noticeably elevated moisture content and is believed to be yard and roof drain runoff from the adjacent houses.

The Site is currently forested with some remaining remnants of the former campground; since it appears that a majority of the surface water that had originally been diverted towards the Site has been mitigated, and the amount of precipitation falling on the Site cannot be controlled, we researched factors that may contribute to the pre- and post-development stormwater conditions. These factors include changes in vegetation cover and concentrated infiltration of stormwater from impervious surface areas. A United States Department of Agriculture[1] (USDA) study indicates tree canopies detain an average of 20% to 30% of the rainfall and that vegetation provides a reduction in water through transpiration. Modeling by the United States Geological Survey[2] (USGS) of groundwater mounding effects from concentrated infiltration basins indicates that mounding is most sensitive to the vertical hydraulic conductivity of the soil. Higher rates of infiltration show less mounding of groundwater levels in aquifers but increased lateral spread of the mounding effect.

In our initial July 24, 2020 report, the groundwater mounding was estimated using a hypothetical stormwater infiltration basin for a 10-acre site, for which the USGS had conducted numerous simulations using the finite difference model MODFLOW. The results of this modeling effort were presented in accordance with Reference 2, from which BEI chose the model simulation results with conditions of 40% impervious cover, a design storm of 1.25-inches, basin depth of 2-feet, with a square basin area of 9,075 square feet, aquifer thickness of 20-feet, and soil permeability of 5-inches/hour and a specific yield of 8.5%. This model simulation produced a maximum mounding height of 1.85-feet with a maximum extent of 185 feet for a mounding of 0.25-feet. For comparison, a simulation was run using the Hantush spreadsheet analysis provided as a link in Reference 2 with the similar input parameters as used in the MODFLOW model with an unrealistic mounding effect.

BEI has subsequently used the Hantush analysis using the following input parameters provided by 3J Consulting and BEI's site specific research:

Infiltration rate (ft/day)	12
Specific Yield	0.3
Hydraulic Conductivity (ft/Day)	12 (conservative est.)
Half basin length (ft)	2
Half basin width (ft)	87.5
Duration of Infiltration Period (day)	1
Aquifer thickness (ft)	50

The attached results show a mounding of 1.9-feet at the source with an attenuation to 0.25 at 80-feet away and 0.06-feet at 120-feet from the source. These results are comparable to our initial results presented from the USGS MODFLOW analysis.

In addition to above considerations associated with groundwater, in the unlikely event where groundwater extends all the way to the surface, mounding would be non-existent, and all infiltration facilities will surcharge. Similarly, during an intense rainfall event that produces surface water flow, the water will be conveyed to the designated flow path routes that includes driveways, alleys and roads where stormwater catch basins and inlets reside. Should the site stormwater system become overloaded, the alleys and roads will become the conveyance routes to Bud's Ravine, which is identified as the conveyance path to the Siuslaw River.

Conclusions

Based on our research of the hydraulics of the Site and general vicinity we conclude the following:

- Recent stormwater improvements in the area of the Site have reduced the flow of surface water onto the site.
- Groundwater mounding may occur as a result of concentrated infiltration of stormwater; however, the degree of mounding is expected to be negligible.

The proposed design for infiltration of Site stormwater is consistent with the area and local regulations, and does not appear it will have an adverse impact on the current subsurface flow of water on, or offsite, of the property.

Sincerely,
Branch Engineering Inc.

Ronald J. Derrick, P.E., G.E.
Principal Geotechnical Engineer

1: USDA Forest Service 1146, Urban Forest Systems and Green Stormwater Infrastructure, February 2020.

2: USGS, Simulation of Groundwater Mounding Beneath Hypothetical Stormwater Infiltration Basins, Scientific Investigations Report 2010-5102.

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				
12.0000	*R*	**Recharge (infiltration) rate (feet/day)**		
0.300	Sy	**Specific yield, Sy (dimensionless, between 0 and 1)**		
12.00	K	**Horizontal hydraulic conductivity, Kh (feet/day)***		
2.000	x	**1/2 length of basin (x direction, in feet)**		
87.500	y	**1/2 width of basin (y direction, in feet)**		
1.000	t	**duration of infiltration period (days)**		
50.000	hi(0)	**initial thickness of saturated zone (feet)**		

Conversion Table

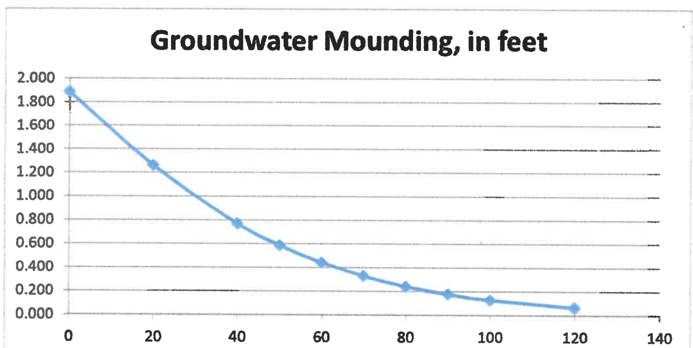
inch/hour	feet/day
0.67	1.33
2.00	4.00
hours	**days**
36	1.50

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).

51.885	h(max)	**maximum thickness of saturated zone (beneath center of basin at end of infiltration period)**
1.885	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
1.885	0
1.259	20
0.768	40
0.586	50
0.440	60
0.326	70
0.238	80
0.172	90
0.123	100
0.063	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.