Preliminary Groundwater Mounding Analysis Review
Thorndike Place: Near Dorothy Road, Arlington

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May 2, 2024

MMA summary letter dated April 26, 2024
(*RE: Thorndike Place, Dorothy Road, Arlington, Massachusetts – Preliminary Review of Applicant's Groundwater Mounding Analysis*)

Groundwater Mounding Analysis Purpose and Design

MOUNDING ANALYSIS

Mounding analysis is required when the vertical separation from the bottom of an exfiltration system to seasonal high groundwater is less than four (4) feet *and* the recharge system is proposed to attenuate the peak discharge from a 10-year or higher 24-hour storm (e.g., 10-year, 25-year, 50-year, or 100-year 24-hour storm). In such cases, the mounding analysis must demonstrate that the *Required Recharge Volume* (e.g., infiltration basin storage) is fully dewatered within 72 hours (so the next storm can be stored for exfiltration). The mounding analysis must also show that the groundwater mound that forms under the recharge system will not break out above the land or water surface of a wetland (e.g., it doesn't increase the water sheet elevation in a Bordering Vegetated Wetland, Salt Marsh, or Land Under Water within the 72-hour evaluation period).

The Hantush[24] or other equivalent method may be used to conduct the mounding analysis. The Hantush method predicts the maximum height of the groundwater mound beneath a rectangular or circular recharge area. It assumes unconfined groundwater flow, and that a linear relation exists between the water table elevation and water table decline rate. It results in a water table recession hydrograph depicting exponential decline. The Hantush method is available in proprietary software and free on-line calculators on theWeb in automated format. If the analysis indicates the mound will prevent the infiltration BMP from fully draining within the 72-hour period, an iterative process must be employed to determine an alternative design that drains within the 72-hour period.

Mounding analysis is also needed when recharge is proposed at or adjacent to a site classified as contaminated, was capped in place, or has an Activity and Use Limitation (AUL) that precludes inducing runoff to the groundwater, pursuant to MGL Chapter 21E and the Massachusetts Contingency Plan 310 CMR 40.0000; or is a solid waste landfill pursuant to 310 CMR 19.000; or groundwater from the recharge location flows directly toward a solid waste landfill or 21E site. In this case, the mounding analysis must determine whether infiltration of the *Required Recharge Volume* will cause or contribute to groundwater contamination.

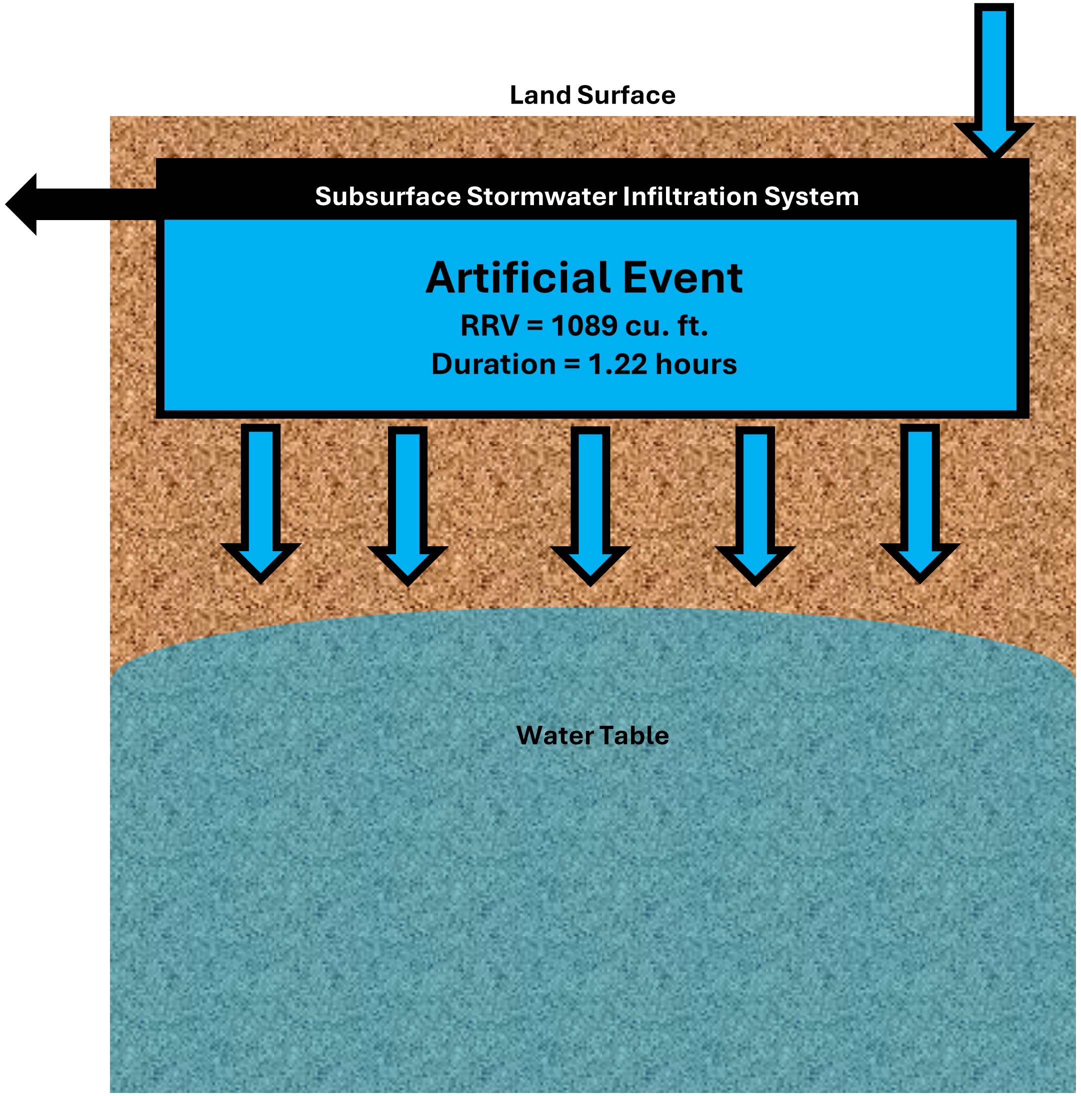
-Excepted from MSH, Vol.3, Ch.1, p.28

"*Infiltration structures must be able to **drain fully** within 72 hours.*" – MSH, Vol.1, Ch.1, p.7.

"*Design the subsurface structure so that it drains within 72 hours **after the storm event** and **completely dewaters between storms**.*" – MSH, Vol.2, Ch.2, p.105.

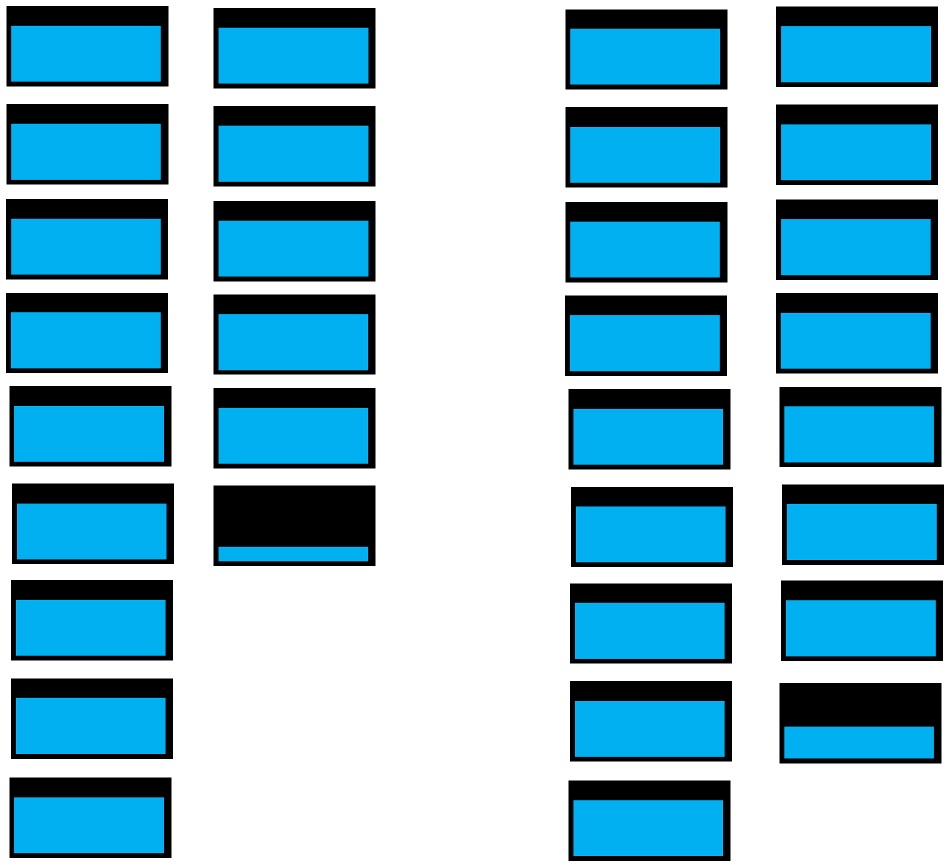
"*Design the system to **totally exfiltrate** within 72 hours.*" – MSH, Vol.2, Ch.2, p.105.

"*If the [mounding] analysis indicates the mound will **prevent the infiltration BMP from fully draining within the 72-hour period**, an iterative process must be employed to determine an alternative design…*"



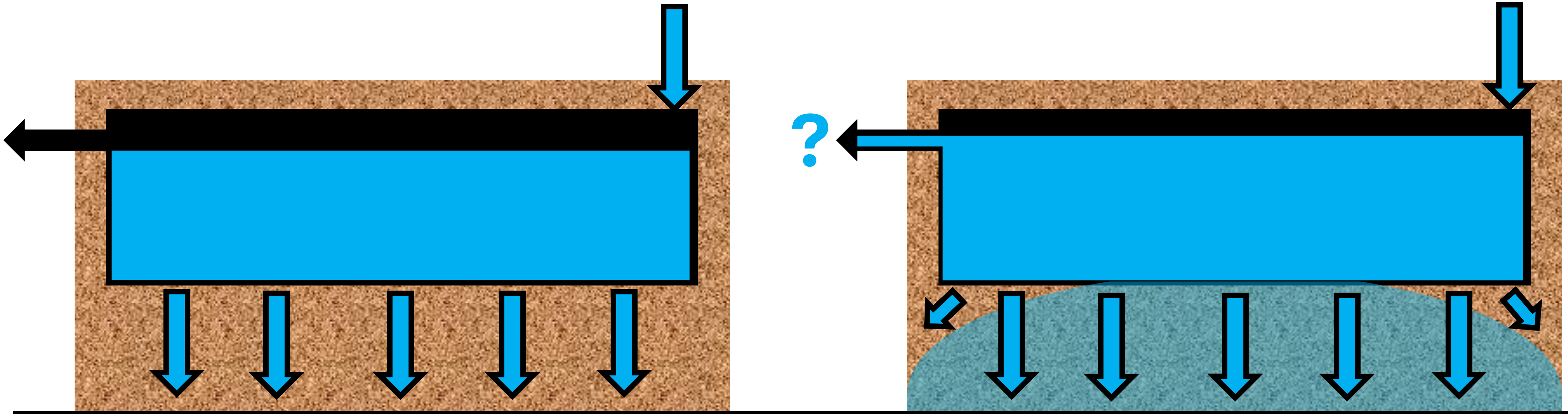
2-Year Event
(50% Chance)

100-Year Event
(1% Chance)



~14.2X the RRV
38.8X the duration

~16.5X the RRV
44.9X the duration



Potential Implications of Severe Groundwater Mounding

- **Can invalidate constant infiltration rate assumption (used by BSC in their HydroCAD analysis)**
- **HydroCAD: reduced infiltration rate → increased primary outflow rate, which may impact rate control predictions (Standard 2)**
- **Drainage Times: reduced infiltration rate → extended drainage times, which may impact predictions intended to address MSH requirement (72-hours)**

Consensus on Groundwater Mounding Effects

"*If groundwater mounding of the underlying water table reaches the bottom of the infiltration basin, the rate of infiltration out of the basin will decrease substantially*". – **U.S. Geological Survey (USGS)**.

"*…generally, once the groundwater table (or capillary fringe) intersects the bottom of the infiltration system due to short-term mounding, the infiltration pathway shifts from a downward flux through the unsaturated zone to a lateral flux out of the perimeter of the system (Bouwer, 2002; Petrides et al., 2015). This can significantly reduce overall drainage rates, as shown through extensive physical modeling and field observations (Bhaskar et al., 2018; Bouwer, 2002; Talebi and Pitt, 2014; Petrides et al., 2015)*". – **U.S. EPA**.

"*If the mounded groundwater reaches the bottom of the basin, the rate of infiltration out of the BMP* [best management practice] *is reduced and infiltration may stop*". – **New Jersey Department of Environmental Protection (NJDEP)**.

"*For the shallow groundwater sites, the possibility of groundwater mounding must be considered in designing infiltration facilities. This mounding will reduce the hydraulic gradient to a value that is often significantly less than 1.0, and the infiltration rate may be much less than the saturated* [vertical] *hydraulic conductivity*". – **Massman (2003). *A Design Manual for Sizing Infiltration Ponds*. Prepared for Washington State DoT in cooperation with the U.S. Department of Transportation.**

2.03 Stormwater Standard 3 – Groundwater Recharge

Groundwater recharge is provided on site via an underground structural infiltration system beneath the surface parking area to the north of the building, and smaller systems beneath each individual driveway of the duplex townhouses. Overall, the project will result in no loss of annual recharge to groundwater as required by Standard 3. Refer to Section 6.0 of this Report for groundwater recharge information.

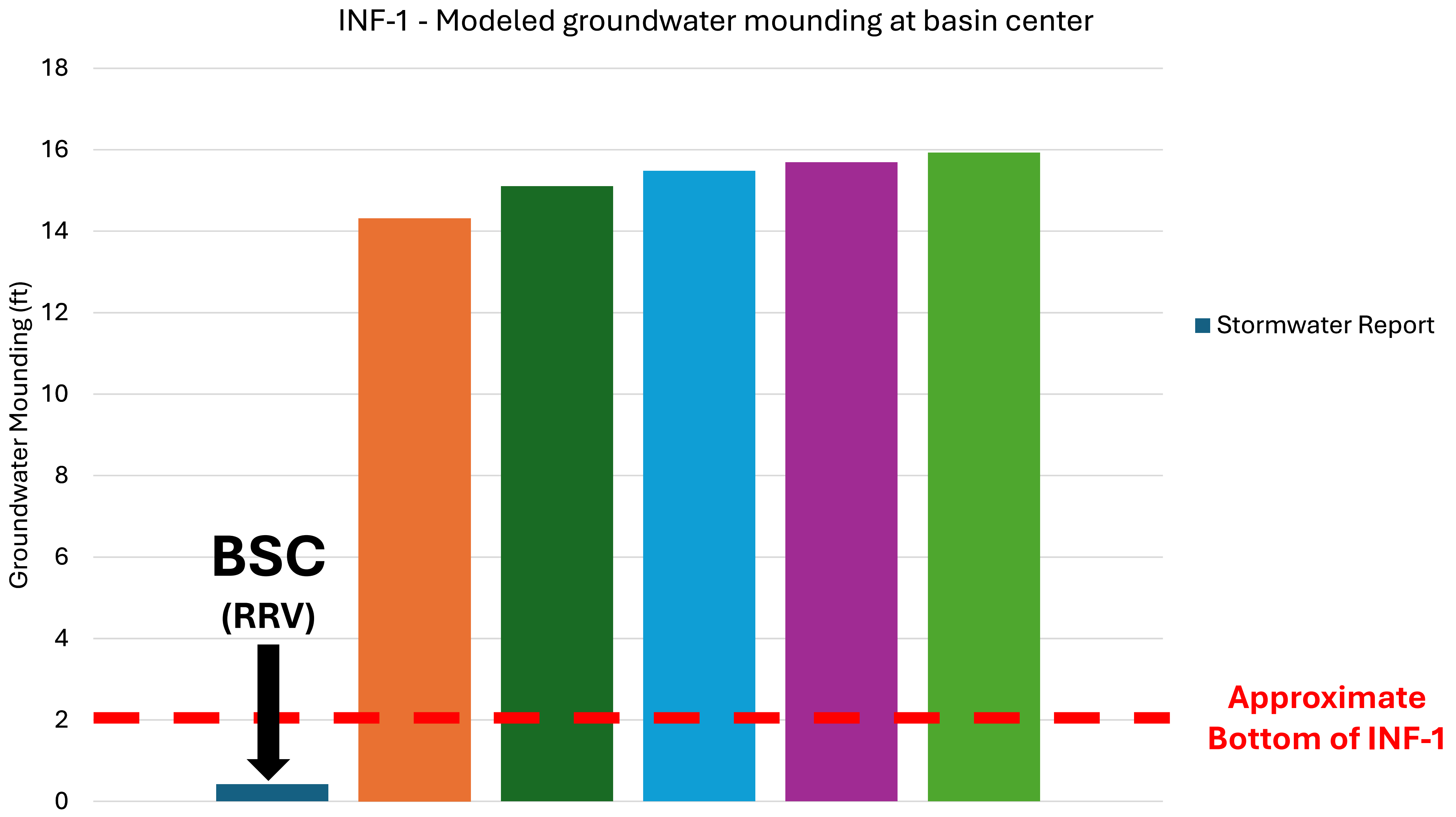
As the infiltration system has more than 2-feet but less than 4-feet separation to estimated seasonal high groundwater, a mounding analysis has been performed in accordance with the Hantoush Method to ensure that a groundwater mound does not extend into the bottom of the infiltration system preventing infiltration of the required recharge volume. This analysis is included in Section 6.0 of this Report.

2.04 Stormwater Standard 4 – TSS Removal

As a new development, the Project stormwater management system will achieve a TSS removal greater than 80%. The proposed stormwater management system has been designed to provide treatment of runoff in order to reduce suspended solids prior to discharge off-site through the implementation of the following best management practices:

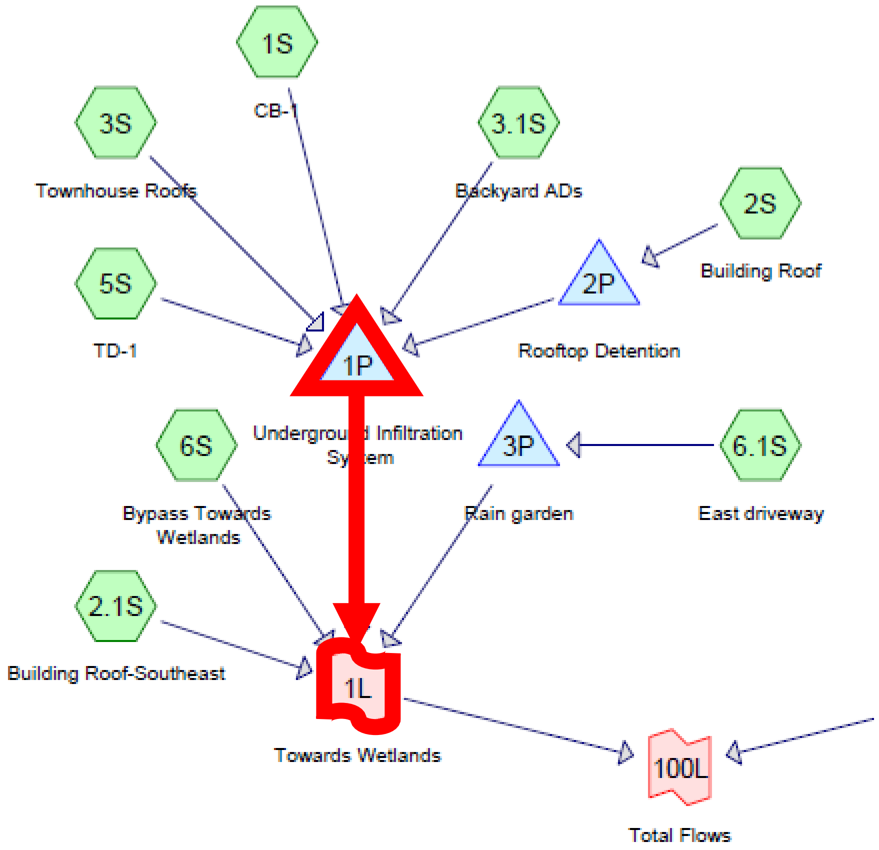
- Deep Sump Hooded Catch Basins
- Proprietary Hydrodynamic Separators
- Underground Stormwater Infiltration Systems

BSC GROUP



INF-1 - Modeled groundwater mounding at basin center
18
16
14
12
10
8
6
4
2
0
Groundwater Mounding (ft)
BSC
(RRV)
Stormwater Report
Approximate
Bottom of INF-1

Justification of Modeling Approach and Inputs



<u>Peak Flow Discharge Rates</u>

<u>Node 1L – Flow to Wetlands</u>

Storm Event	Pre-Development Peak Discharge Rate (cfs)	Post-Development Peak Discharge Rate (cfs)	Change in Peak Discharge Rate (cfs)
2-Year	2.9	2.9	0.0
10-Year	7.6	5.7	-1.9
25-Year	11.7	8.5	-3.2
50-Year	14.8	11.8	-3.0
100-Year	19.0	16.1	-2.9

Note: 1P/INF-1 Peak Exfiltration/Infiltration Rate = 0.1 cfs

Groundwater Mounding Analysis Review Summary

- Applicant's current analysis is not successful in demonstrating compliance with requirements (e.g., Standard 2, drainage time, etc.) because groundwater mounding effects have not been properly evaluated

- Major Issue: misinterpretation of MSH and event consideration
  - Common practice: largest event for which rate control is proposed (but 2-yr and 100-yr similar)

- Several secondary issues – letter details a few examples:
  - Appropriateness/applicability of the Hantush model versus improved representation (MODFLOW)
  - Justification for values of influential inputs (e.g., specific yield, initial saturated thickness)
  - Suggestion of 1:1 horizontal-to-vertical anisotropy (i.e., isotropy)

2024 Water Level History