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To: Zoning Board of Appeals, Town of Weston Massachusetts

Attn: Mr. John Field, PE
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From: J. Matthew Davis, PhD

Date: April 28, 2022

Subject: Peer review of groundwater mounding analysis for 518 South Ave project

This memo provides a summary of my concerns regarding the revised groundwater mounding analysis. New information reviewed for this report include:

- Groundwater Model Report, Hanover Weston, dated March 25, 2022, prepared by Sanborn Head and Associates, hereafter referred to as the SHA Report.
- McDonald Morrissey Associates (MMA) memorandum dated April 21, 2022, hereafter referred to as MMA Report.
- Hanover Weston Comprehensive Permit Package, revised date March 25, 2022, hereafter referred to as the CPP.
- Hanover Company memo, dated March 3, 2022, regarding Response to Peer Review and Other Comments – Stormwater/Wastewater/Civil, hereafter referred to as Executive Summary
- Stormwater Management Report, dated March 25, 2022, prepared by TetraTech, hereafter referred to as the TetraTech Report.
- Letters from Dr. Tom Ballestero regarding:
    - Wetland Hydrology and the Impacts resulting from the proposed 518 South Avenue project, and
    - The performance of infiltrating Green Stormwater Infrastructure, hereafter referred to

Introduction

The proposed development represents a significant alteration of the groundwater system. Significant effort has gone into the site investigation and development of the MODFLOW model for the groundwater mounding analysis. While the groundwater model appears to be a reasonable representation of the pre-development conditions, the model is based on a limited number of observations under current stress conditions with data concentrated over a small portion of the site. The primary source of water is recharge from precipitation and, under current conditions, is assumed to be uniformly distributed over the property. The proposed structures will eliminate recharge over a significant portion of the site and route that water to a set of stormwater storage tanks and infiltration chambers. The addition of domestic water that will be treated and discharged into the leach fields is another significant alteration. The extent of this hydrologic change and the uncertainty of the groundwater model are illustrated in the SHA Report Figures 9 and 14. Figure 9 shows the calibrated groundwater elevations with a prominent groundwater ridge along the southwest property boundary. Figure 14 shows the post-development steady-state condition with as much as 2.5 feet lowering of the water table along the same property boundary. A perturbation of this magnitude cannot be field tested to verify the groundwater model and, given the paucity of groundwater monitoring data along this property boundary, the long-term changes in hydrologic conditions at the site are uncertain. Given that there is no way to truly evaluate the post-development conditions until the site is developed, caution should be applied when interpreting the results of the post-development MODFLOW model, particularly when decisions are based on a few tenths of a foot change in groundwater elevations.

Below, I outline three issues of concern with the most recent groundwater mounding analysis as presented in the reports listed above, several of which overlap with those noted in the MMA Report, and then comment briefly on some of the additional comments noted in the MMA report.

Issue 1: Recharge Rates in Leach Fields

The MMA review reported an apparent discrepancy between the reported and simulated recharges rates applied to the leach fields. A cursory review of the Mass Balance tables in the MODFLOW output files also suggests that the Stress Period 1 recharge rate over the entire model domain in the November 2021 Primary Leachfield model is greater than the corresponding recharge rate in the March 2022 Primary Leachfiled model. The Mass Balance tables in the MODFLOW output files do not delineate recharge rates applied to different zones so it is not readily apparent where the recharge rates differ between the two model versions. To resolve this question, the Applicant is requested to provide a tabular accounting of the volumetric flow rates in the different recharge zones for Stress Period 1. Ideally, this would be done

through post-processing of the model cell-by-cell flow files using the Groundwater Vistas Boundary Reach Summary tool.

Issue 2: So-called 'extreme design conditions'

The groundwater mounding analysis uses a set of conservative conditions when assessing mound heights. These typically include 90-days of seasonal high groundwater and 80% of design flow into the leach fields. Collectively, these enable a simplified analysis and represent reasonably conservatively mound heights. Because of the presence of a large stormwater infiltration system in the vicinity of leach fields, the present analysis also includes the mounding associated with a 10-year 24-hour storm event with a uniform rainfall intensity. Each of these conditions is a relatively simple representation of expected conditions and these modeling assumptions are used for convenience, much like other modeling assumptions, such as the hydraulic conductivity is internally uniform (homogeneous) within a zone. Collectively, the Applicant refers to the three conditions noted above as the 'extreme design conditions'.

Dr. Ballestero chooses to assign probabilities to each of the model assumptions and reports the speculative joint probabilities in the context of the likelihood of the assumptions being met in any given year, or a recurrence interval. The applicant suggests that the low probability of these conditions all occurring at the same time limits the applicability of the mounding analysis to 'understand groundwater mounding at and near to [sic] the infiltration systems'[1].

The Applicant has also tended to conflate these 'extreme design condition' in assessing the significance of potential impacts[2]. Dr. Ballestero's calculation of the extreme design condition as a recurrence interval (twice in a million years) should not be confused with, or interpreted as, the common use of recurrence interval used to characterize extreme events, such as 100-year 24-hour storm[3]. Furthermore, the small joint probability of these model assumptions does not limit the applicability of the groundwater model any more than the infinitesimal probability of a host of other modeling assumptions that are used in the MODFLOW model.

Issue 3: Groundwater Mounding associated with Stormwater Infiltration

Several reviewers have expressed concern about the impact of the stormwater infiltration system on the groundwater mounding. In the revised package, the Applicant has mitigated some of the mounding associated with the 10-year 24-hour precipitation event with the addition of underground storage tanks. To the extent that the Board continues its effort to address the

[1] Ballestero, Wetland Hydrology and the Impacts resulting from the proposed 518 South Avenue project
[2] For example, Executive Summary, March 3, 2022, Section IV. Stormwater and Wastewater Breakout and Applicant presentation during ZBA meeting, March 8, 2022.
[3] For example, see McPhillips, L.E. and others, 2018, Defining extreme events: A cross-disciplinary review, Earth's Future, vol. 6, no. 3, p 441-455.

concerns raised by reviewer about larger storm events, it is important to address the Applicant's assessment of these concerns to reduce confusion moving forward.

In addition to asserting that a mounding analysis of the stormwater infiltration areas is not required, the Applicant uses two arguments to address the concerns about mounding in the stormwater chambers[4]. First, Ballestero suggests that because the 'extreme design condition' has a recurrence interval of 'twice in a million years' the Board should consider it to be an extremely unlikely event, presumably not worthy of consideration. This so-called 'extreme design condition' is addressed above and its low probability is related to the model assumptions rather its potential impact.

The second argument focuses on the apparent assertion that the mounding heights simulated by the MODFLOW model overestimate the actual mounding as the model does not account for the 'bulb shaped wetting front' that would occur in the unsaturated zone, enabling both horizontal and vertical flow. Ballestero provides a lengthy explanation of the vertical and horizontal infiltration that can occur in an unsaturated zone beneath a saturated stormwater infiltration system. However, the concern expressed by reviewers is in regard to the saturated conditions when the groundwater mound rises into the stormwater chambers and does not involve an underlying zone of unsaturated material.

Under the saturated conditions simulated in the MODFLOW model, horizontal infiltration is already accounted for, so simulated mound heights are not over-predicted, as Ballestero suggests. In MODFLOW, recharge is added to the active model cell and flow is simulated in both horizonal and vertical directions, depending on the conditions in the aquifer. There is nothing in the previous or current versions of the MODFLOW model that would inhibit the horizontal flow through the side-wall 'wheepholes' [sic] in the proposed stormwater chambers[5]. To model the infiltration chambers with hydraulically restrictive walls would require explicit treatment of the chambers as hydraulic barriers using, for example, the Horizontal Flow Barrier (HFB) package[6]. There is no reference in the SHA report that the HFB package is used to inhibit flow through the sides of the stormwater infiltration areas, so horizontal infiltration from the stormwater chambers is already accounted for in the groundwater model.

While the Applicant has been asked repeatedly to assess the groundwater mounding for the 25-year and 100-year 24-hour precipitation event, they assert that such an analysis is not required because there is at least 4 feet of separation between the ESHGW elevation and the bottom of the

[4] Ballestero, The performance of infiltrating Green Stormwater Infrastructure, March 25, 2022
[5] Hanover Weston Comprehensive Permit Package, Plate C-17
[6] Hsieh, P.A., and J.R. Feckleton, 1993, Documentation of a computer program to simulate horizontal-flow barriers using the U.S. Geological Survey's modular three-dimensional finite-difference ground-water flow model, USGS, Open-File Report, 92-477, https://pubs.usgs.gov/of/1992/0477/report.pdf

infiltration systems. They go on to assert that 'the groundwater model demonstrates compliance with the [Massachusetts Stormwater] Handbook'[7]. This assertion is based solely on their conclusion that the mounding associated with a 10-year storm event does not reach the ground surface. As noted in the MMA Report, if a mounding analysis were required, compliance with the Handbook would also require that the Applicant evaluates the mounding associated with the larger storm events that are part of the stormwater system design for the site (TetraTech Report).

To illustrate the potential impact of large storm events on groundwater mounding, the MMA Report includes simulations using the TetraTech design hydrographs as input to the groundwater mounding model and finds that predicted mounding significantly exceeds the ground surface elevation. As the MMA Report notes, the simulated mound heights of 25 and 44 feet (MMA Report Figures 1 and 2) are unrealistic because the mounding would cause the stormwater system, as designed, to fail. This failure would likely result in stormwater flowing to unknown locations in unknown quantities with an unknown dissipation time.

The SHA report concludes with: .

> *It is our overall opinion that the soils at the Site have adequate hydraulic capacity to accept treated wastewater and stormwater infiltration in accordance with the site plans and stormwater management system designed by TetraTech dated March 2022 and applicable regulations.*

However, as noted above, the basis for this opinion is not supported by the SHA report as the TetraTech stormwater management design includes analysis of both the 25-year and 100-year storm events, but the SHA groundwater mounding analysis does not.

Other Issues raised by MMA

The MMA report provides several other relevant observations, including:

- MMA provides a comparison of the highly variable rainfall intensity of Tropical Storm and the assumed uniform intensity of the 10-year 24-hour storm used in the post-development groundwater mounding analysis. They note that while the total rainfall over a 24-hour period is similar, the maximum mounding associated with a higher intensity storm, such as Tropical Storm Ida, is larger than the 10-year 24-hour design storm. While the applicant relies upon the characteristics of mounding associated with Tropical Storm Ida in their assessment of post-development mounding, the simulated mound heights are lower than what would result from a storm with Tropical Storm Ida's rainfall intensity.

[7] SHA Report, page 20, page 25

- MMA recommends that the Applicant interpolate ESHGW observations onto the entire stormwater infiltration areas rather than selecting a single value for each area. This would be consistent with Applicant's approach to consider the ESHGW at the corners of the leach fields. However, even though it appears that such an interpolation of ESHGW across the stormwater infiltration areas would result in less than four feet of separation between the ESHGW and the base of the stormwater chamber, it is likely that the Applicant would simply raise the base of the chamber before conducting the complete mounding analysis of the stormwater system that has been requested.