SANBORN HEAD
Building Trust. Engineering Success.

Weston Zoning Board of Appeals
11 Town House Road
Weston, MA 02493

May 18, 2022
4591.00

Re: 518 and 540 South Avenue Comprehensive Permit
Responses to Review Comments on Groundwater Mounding

Dear Chair and Board Members,

On behalf of Hanover R.S. Limited Partnership, Sanborn Head & Associates, Inc. (Sanborn Head) has prepared the following responses to comments raised regarding the above-referenced project.

Response to J. Matthew Davis & Associates, LLC memorandum of April 28, 2022

Introduction

Comment: *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.*

Response: We agree significant effort has gone into the site investigation and development of the MODFLOW model. We do not agree with the assertion that "the model is based on a limited number of observations…with data concentrated over a small portion of the site." In fact, there were over 60 test pits excavated across the entire site with 21 borings drilled and eight monitoring wells installed. In addition, 40 permeameter tests were conducted. Groundwater measurements were taken over two years. The extent of site investigation is illustrated on Figure 2 of Sanborn Head's March 2022 Groundwater Model Report.

Introduction (cont.)

Comment*:* *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.*

Response: This could be said of any development which efficiently uses the developable area of a site and where a groundwater model is used to evaluate post-development conditions. The modeling approach taken, however, meets or exceeds the standard of practice and the standard of care in Massachusetts. Use of a groundwater model is consistent with requirements for post-development assessment of groundwater conditions included in applicable guidance and, numerical modeling (MODFLOW) is accepted by MA DEP regulators.

The purpose of the MODFLOW model was to evaluate mounding under the treated wastewater leaching field. The model is well calibrated and has undergone robust transient verification testing where model groundwater responses matched those measured during Tropical Storm Ida. This level of calibration and verification certainly meets, and likely exceeds in most cases, the accepted standard of practice for this type of analysis.

The results of the groundwater model have been used to set the base of the treated wastewater leaching fields with a minimum separation of four feet above the mounded groundwater surface under the design condition of 80 percent wastewater discharge for 90-days followed by application of a 10-year design storm in the nearby stormwater infiltration areas at a starting groundwater elevation in full compliance with the MA "Guidelines for the Design, Construction, Operation, and Maintenance of Small Wastewater Treatment Facilities with Land Disposal"; no further work is required to comply with MADEP regulations.

During normal operating conditions – those expected the majority time – the groundwater mound beneath the leaching field is less than one foot high. When the mound is added to the ambient groundwater (approximately El. 212 ft), the mounded groundwater would not exceed approximate El. 213 ft. The bottom of the leaching field bed is set at El. 222.0 feet. Therefore, almost all the time, the base of the leaching field will be about 9 feet above the mounded groundwater elevation, when only 4 feet of separation is required. This is not a matter of a "few tenths of a foot."

Uncertainty is an accepted fact associated with any groundwater model. For this reason, MA DEP imposes a conservative scenario to include in the model analysis. In this case, it involves calculating the mound that will form on top of the seasonally high groundwater elevation assuming that 80 percent of the design wastewater flow is applied for 90 days following which a 10-year storm is added to the nearby stormwater basins. Even with these very conservative assumptions, the maximum mound height is projected to be approximately 4.0 feet, inclusive of the effects from infiltrating stormwater. When this mound is added to the seasonally high groundwater elevation, it reaches a predicted maximum of approximately El.

216.8 feet. This is 5.2 feet below the base of the proposed treated wastewater leaching field. This continues to meet the four feet of separation requirement by over a foot. Even under this very conservative scenario, this is still not a matter of a "few tenths of a foot."

Issue 1: Recharge Rates in Leach Field

Comment: *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 Leachfield 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.*

Response: In response to this comment, and a comment in the referenced MMA review (McDonald Morrissey Associates, Inc., April 21, 2022) that asserted: "*The SHA Groundwater Report states infiltration from the primary wastewater disposal area was represented as 80% of the proposed design rate of 33,000 gallons per day (GPD). However, based on MMA's review, the actual rate modeled as part of the Scenario 1 simulation appears to be erroneously low at approximately 67% of the proposed design rate during day 91 (i.e., instead of using 26,400 GPD or 80%, the SHA model uses 22,150 GPD or 67%),*" we rechecked inputs to the model. We found no error in the input either to Stress Period 1 or subsequent stress periods. Regarding specifically MMA's comment, the wastewater loading to the leaching field on day 91 was input to the model as:

- (total leaching field loading) – (rainfall from 10-year storm falling on the leaching field less impervious area) * (the area of the leaching field) = wastewater loading rate; or

- (0.555354 ft/day) – (0.126776 ft/day) * (7.48 gal/ft^3) * (8,235.2 ft^2) = 26,400 gal/day

Regarding the more general comment about volumetric flow rates, there is a slight difference in precipitation-based recharge rates between the November 2021 and March 2022 versions of the model. There are two reasons for this. First, the area over which recharge is applied in the November 2021 model was larger than in the March 2022 version of the model due to the addition of constant head and no flow boundary cells; MODFLOW does not apply recharge to these types of cells. Second, for the November 2021 report, precipitation-based recharge was added to the entire surface of the primary leaching field, reserve leaching field and three stormwater infiltration areas (see Section 4.3.1.2) even though portions of these areas would be covered by impervious materials. For the March 2022 version of the model, the recharge rates were modified to account for the presence of these impervious areas.

Exhibit A summarizes the cumulative recharge after 90 days for each recharge zone in the November 2021 and March 2022 simulations.

Exhibit A – Cumulative Recharge After 90 Days

Recharge Zone	Cumulative Recharge After 90 Days (ft^3)		Difference in Recharge (ft^3)
	Mar-22	**Nov-21**	
1	658,117	707,186	49,069
3	4,475	4,475	-
4	5,812	5,812	-
5	322,047	322,047	-
6	2,200	2,200	-
7	10,021	12,981	2,961
8	6,061	6,005	(56)
9	68	52	(16)
11	4,346	4,346	-
12	19,862	27,553	7,692
13	47,453	46,894	(559)
14	49,652	35,871	(13,781)
Total	**1,130,113**	**1,175,423**	**45,309**

Issue 2: So-Called "Extreme Design Conditions"

Comment: *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'.*

Response: As noted in the response to the Introductory Comments above, uncertainty is an accepted fact associated with any groundwater model. For this reason, MA DEP imposes a conservative scenario to include in the model analysis. Further as noted, in this case it involves calculating the mound that will form on top of the seasonally high groundwater elevation assuming that 80 percent of the design wastewater flow is applied for 90 days following which a 10-year storm is added to the nearby stormwater basins. Dr. Davis notes this in his comments and further concludes: "*Collectively, these [input assumptions] enable a simplified analysis and represent reasonably conservative mound heights*." We agree.

Regarding the more general comment about "*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*," there are six zones used within the model reflective of hydrogeologic properties within that zone based on the extensive field data summarized above. This is well within, and likely exceeds, the standard of practice for this kind of modeling analysis.

We note that the term "extreme design condition" was used to refer to the unlikely confluence of 80 percent wastewater loading for 90 days followed by a 10-year storm at the exact time of seasonally high groundwater throughout the entire time. We regard this as a very conservative scenario and was accepted by MA DEP regulators.

Issue 2: So-Called "Extreme Design Conditions" (cont.)

Comment: *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. 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. 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.

Response: Dr. Davis believes that contrary to a probability estimate for the design event, that such a probability cannot be estimated because the process is "binary". Probabilities for binary processes may be estimated and there is a rich and full body of literature on this topic. To come up with such a binary probability at the 518 Weston site would require many years of data. In lieu of years of site data, another way of developing risk probability is through joint probability analysis, and that is what was used by the applicant. There is also a rich body of literature on joint probability analysis, especially as it applies to hydrology, for example FEMA, 2016, Guidance for Flood Risk Analysis and Mapping Coastal Flood Frequency and Extreme Value Analysis or USBR, Hydrologic Hazard Curve Estimating Procedures, Research Report DSO-04-08. Joint probability analysis is the foundation of the Drake equation which estimates the number of civilizations in our galaxy with which communication might be possible (colloquially interpreted as "life on other planets"). The fact that we are able to estimate life on other planets with little information on many of the individual probabilities does not make the estimate impossible. Even this type of event may be viewed as "binary": a planet either has life or it does not. What may be debated about the applicants' estimate of the probability of the design event are the specific probabilities used in the calculation. However, what is being lost in all of this is the reason for the calculation: as public discussions of the 518 South Avenue proceeded since 2021, the design condition was being portrayed as a common condition, ultimately one that would have many significant, long term, adverse consequences, for example wetland hydrology. The fact remains that the design event is a rare occurrence. The design event does not dictate wetland hydrology. Wetlands are themselves a symphony of interactions of natural variables: climate, soils, biota, and the physicochemical environment. Wetland systems of the northeast United States are driven more by long term characteristics rather than very infrequent events. The design event was modeled (mounding) as outlined in guidance documents: the estimation of its occurrence probability was never to imply that the event was unworthy of consideration, as Dr. Davis states in a subsequent comment (a posture never supported by the applicant), rather to place it in the context of the many different aspects of the project the Board considers: extreme events and typical conditions. As is very common in engineering designs, designs (bridges, wastewater treatment, stormwater management, etc.) are framed around extreme conditions that rarely happen. This promotes successful performance over the vast majority of service life.

Issue 3: Groundwater Mounding Associated with Stormwater Infiltration

Comment: *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 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. 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.

Response: The Applicant has added storage to mitigate the effects of mounding from the 10-year storm in response to reviewer's comments at no small cost to the project. Nowhere is it asserted or implied that "*the Board should consider [the extreme design condition] to be an extremely unlikely event, presumably not worthy of consideration.*" Analysis of the "extreme" design condition is required by MA DEP and we agree that it is appropriate to include this condition as a measure of conservatism in the analysis. That said, we are not wrong to point out that this would be a very unusual event as it requires:

- Full occupancy of the residences to their capacity continuously for 90 days;
- A 10-year storm to occur at the end of the 90-day period; and
- The 10-year storm to occur precisely at the time of seasonally high groundwater when storms of this type are more likely to be tropical and therefore not springtime events.

This all said, the effects of this conservative design scenario are very transient. Even if all of the above conditions were to occur at the same time, the effects would last over a period of only a few days.

Issue 3: Groundwater Mounding Associated with Stormwater Infiltration (cont.)

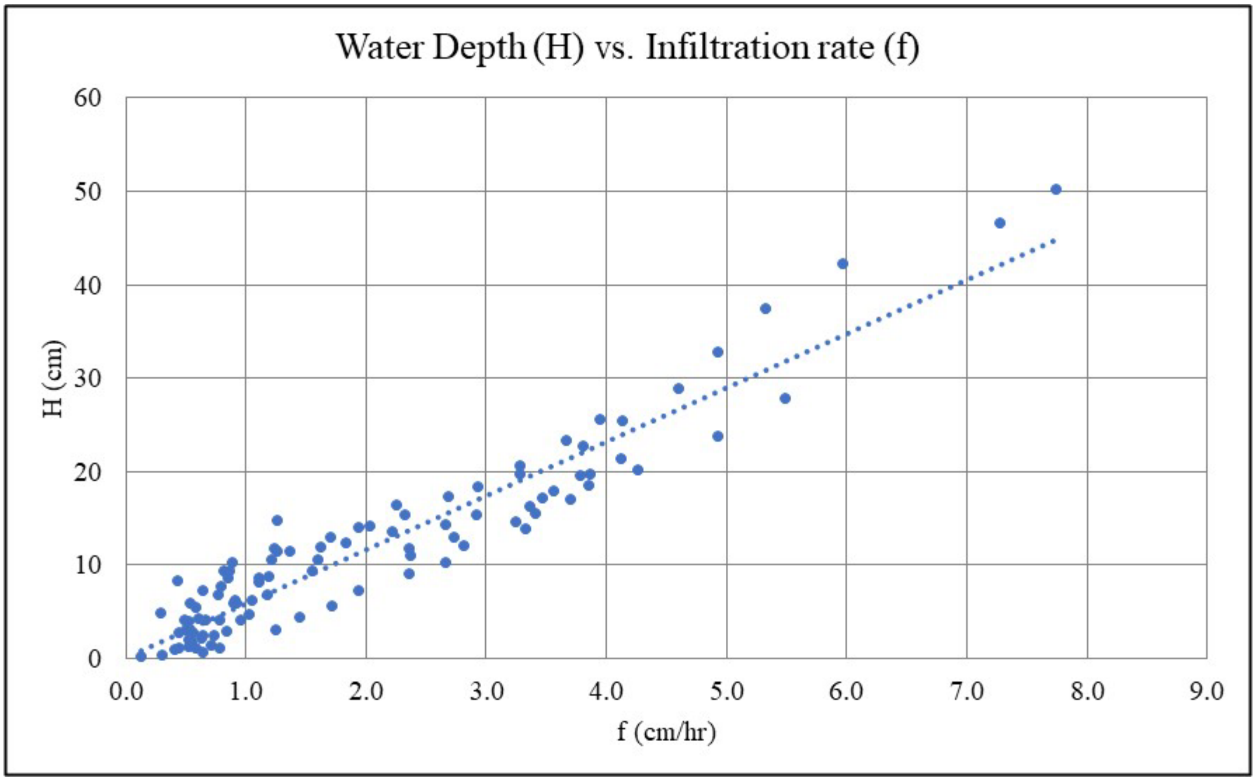
Comment: *The second argument focuses on the apparent assertion that the mounding heights simulated by the MODFLOW model overestimate the actual mounding as the model does not account for the 'bulb shaped wetting front' that would occur in the unsaturated zone, enabling both horizontal and vertical flow. 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. 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. 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.

Response: The Massachusetts Stormwater Handbook which establishes the standard of practice for design of the stormwater basins does not prohibit the groundwater mound from rising into the chambers and Dr. Ballestero has pointed out in detail why the function of the chambers is not compromised should this occur.

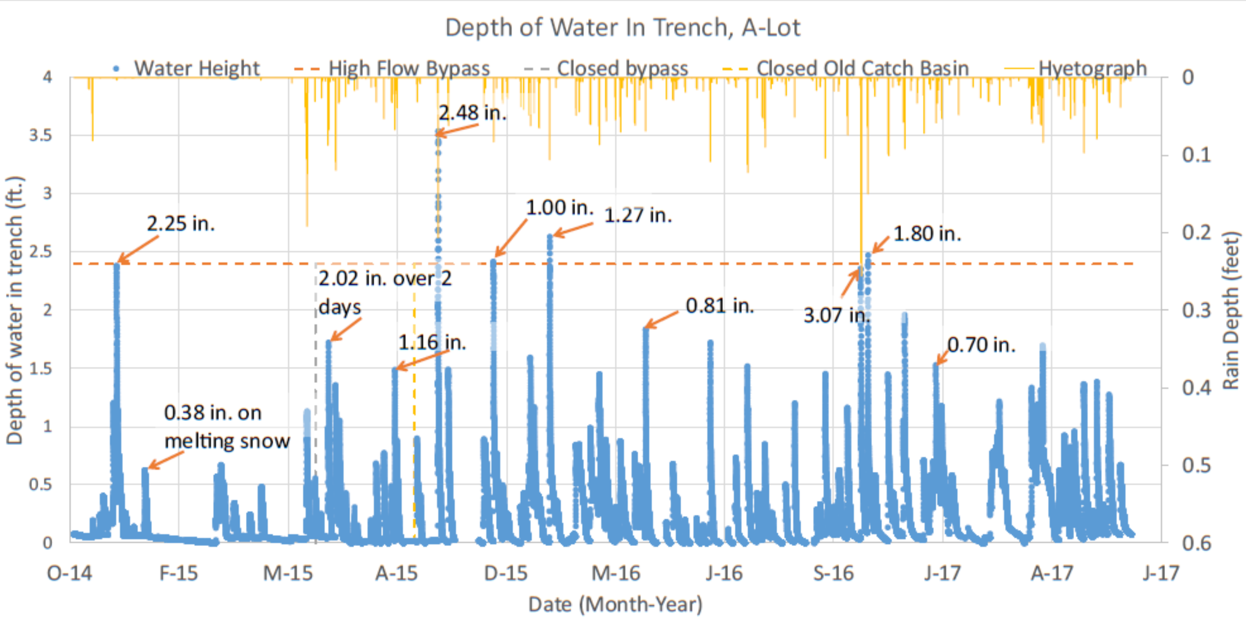
On previous occasions the Board was presented infiltration data from the Horne Street, Dover, NH bioretention system (Macadam Thesis, UNH) that demonstrated significant lateral infiltration, especially as water in the system built up. Peer reviewers continue deny this fact of stormwater infiltration systems yet offer nothing more than opinion. The following are data from two more stormwater systems.

The Grove Street, Dover, NH system is a gravel trench constructed below a road. Stormwater runoff enters the system via street catch basins. The primary outlet for the stormwater is infiltration. Should the system fill-up, there is an overflow pipe that leads to a nearby stream where stormwater flowed unabated prior to the installation of the gravel trench system. Water level monitoring data indicated that the infiltration rate increased dramatically as water ponded in the system. Estimates of infiltration using various models indicate that on average, 84 percent of the water infiltrated out the sides rather than the bottom of the system (Ely Thesis, UNH)

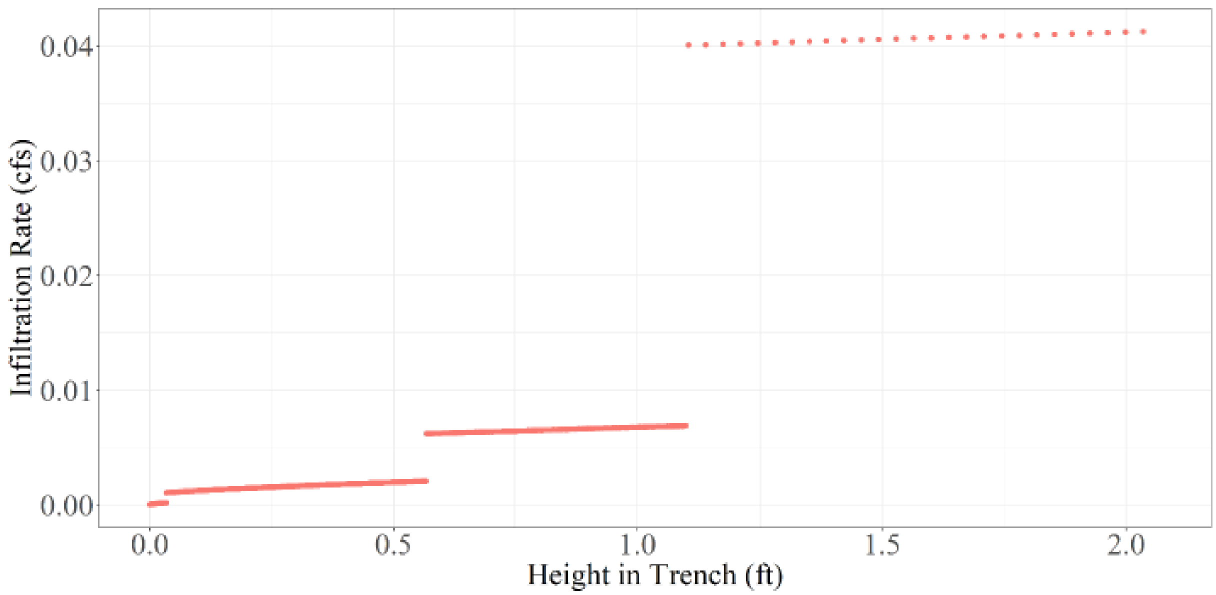


Grove Street, Dover, NH - Gravel Trench Water Depth (H) versus Infiltration Rate (f)

Another gravel trench system was constructed at the A-Lot commuter parking area on the University of New Hampshire campus. This site is an extreme example of the significance of horizontal infiltration because the infiltration rate at the bottom of the system was so low, it required an underdrain to drain the system. However, the underdrain was never plumbed to drain the system, with the intent being specifically to study the system drainage characteristics via solely infiltration. The volume of the gravel was sized to hold the runoff from one-inch of precipitation. As may be seen in the next figure, the system routinely manages upwards of twice the design rainfall depth: this is because of horizontal infiltration in addition to static design (instantaneously place the runoff in the system) versus dynamic performance (inflow and outflow occur at the same time). From this water level data, infiltration rates could be estimated, as presented in the subsequent figure, where system infiltration rate increases by over one order of magnitude: this can only be explained by horizontal infiltration.



A-Lot, UNH - Gravel Trench Water Level (left vertical axis) versus Time; and,
15-minute Rainfall Depth (right vertical axis) versus Time



A-Lot, UNH – Infiltration Rate versus Water Height

The dramatic change in infiltration rate with water depth in the A-Lot gravel trench is a direct result of horizontal infiltration. The estimated horizontal infiltration volume from this system over a 2-year period is 82 percent (Tarushka Thesis, UNH).

Aside from the dramatic amount of stormwater that does move laterally from stormwater infiltration systems, even when water is ponding in the systems due to groundwater below rising into the systems, vertical infiltration does occur. As long as the water depth in the

stormwater infiltration chamber is higher than that of the MODFLOW-simulated groundwater elevation in the soil below, there is downward flow.
It has been the contention by various peer reviewers that the MODFLOW infiltration rate is not the same (much lower) as the HydroCAD rate and that groundwater mounding into the stormwater systems will prevent any stormwater infiltration out the bottom of the systems. The peer reviewer posture that the stormwater infiltration rate used in HydroCAD is larger than MODFLOW, and therefore the MODFLOW results are not realistic is rejected: the stormwater infiltration rates in MODFLOW are representative of the HydroCAD stormwater infiltration rates and can be demonstrated by cell-to-cell head differential calculations.

Issue 3: Groundwater Mounding Associated with Stormwater Infiltration (cont.)

Comment: *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 infiltration systems. They go on to assert that 'the groundwater model demonstrates compliance with the [Massachusetts Stormwater] Handbook'. 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.

Response: For reasons clearly documented in Sanborn Head's March 2022 Groundwater Model Report, the ESHGW, based on documented redoximorphic features in test pits excavated within the storm basin area, was set at 215.3, over 4-feet below the crushed stone at the base of the stormwater chambers. Accordingly, by the Massachusetts Stormwater Handbook a mounding analysis is not required.

The MMA models of 25-year and 100-year rainfall events were admitted by MMA to be "unrealistic" because the mounds they predicted would result with water flowing to the outlet conveyance (which MMA did not model).

Issue 3: Groundwater Mounding Associated with Stormwater Infiltration (cont.)

Comment: *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.*

Response: As previously noted, the condition of the groundwater mounding analysis is the result of the wastewater hydrogeological evaluation as accepted by MADEP regulators. The stormwater evaluation does not require the completion of a mounding analysis and the TetraTech plans and documents demonstrate a design that meets the applicable regulations, including such design elements as collection, storage/detention, and discharge through combination of exfiltration and outlet conveyance. As discussed, the 25-year and 100-year storm events engage a greater percentage of the system discharge as outlet conveyance than the 10-year and smaller storms, as would be expected for any similar stormwater system with the same objectives.

Other Issues raised by MMA

Comment: *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.*

Response: The Tropical Storm Ida variable rainfall intensity was used solely for pre-development transient verification of the MODFLOW model. The Ida simulation shows that the groundwater flow model developed for the Site is able to predict groundwater mounding as evidenced by the very good agreement between the water levels measured at the site during Tropical Storm Ida and the water levels calculated by the groundwater flow model (Exhibits D-F in the March 2022 Sanborn Head Report). The application of the 10-year storm in the post-development model was applied uniformly – as is the standard of practice – to areas of the model not covered by impervious surfaces. Rain falling on areas covered with impervious surfaces was directed to the stormwater basins according to hydrographs provided by TetraTech.

Other Issues raised by MMA (cont.)

Comment:

- *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.*

Response: We understood from remarks made by Dr. Davis in the ZBA meeting of March 8, 2022, that he agreed with the ESHGW of 215.3 selected for the stormwater basin area. The comment above seems more a response to MMA than to the Sanborn Head report. We nonetheless note, as described in Section 5.2 of the March 2022 Groundwater Model Report, that on February 9, 2022, in response to comments made about ESHGW in this area of the site, two additional test pits, TP-519 and TP-520, were excavated to further review this matter. Test pit TP-519 was excavated in the corner of the proposed Infiltration Area 1 and test pit TP-520 was excavated between test pits DTH-3 and DTH-4.

Observations in test pit TP-519 indicated very similar geologic conditions to the other test pits excavated within proposed Stormwater Infiltration Area 1, and for that matter beneath the entire stormwater infiltration area and leaching field area – that is, free-draining sand and gravel below the organic surface soils. Groundwater was observed entering test pit TP-519 at an elevation of 212.5 ft, consistent with groundwater levels in the free-draining sand and gravel elsewhere throughout the stormwater basin and leaching field area (there is very little groundwater gradient in this area of the site as is well illustrated by an examination of data on Table 1 of the Groundwater Model Report).

Also as illustrated by examination of data on Table 1 of the Groundwater Model Report, there is less than 3-feet of groundwater fluctuation in this geologic deposit over time. This considers the effects of Tropical Storm Ida, which by comparison of the groundwater response measured at monitoring well MW-207W to redox features in adjacent test pit TP-506, both located within Stormwater Infiltration Area 2, match within 0.1 foot, indicating that Ida produced groundwater levels equivalent to ESHGW. Even adding 3-feet to the observed groundwater level in SH-TP-519 yields a groundwater elevation of 215.5. We find no basis for assuming ESHGW is higher than this in this area.

Response to McDonald Morrissey Associates, LLC memorandum of April 21, 2022

Note: Many of MMA's comments have been responded to in responses provided to J. Matthew Davis & Associates, LLC memorandum of April 28, 2022 ("Davis Memo").

Item 1 Summary Points:
Comment: *MMA's review of the Applicant's MODFLOW model files identified apparent errors in inputted wastewater and stormwater infiltration rates (both lower than reported).*

Response: As noted in the response to the Davis Memo, we rechecked inputs to the model. We found no error in the input either to Stress Period 1 or subsequent stress periods. Regarding specifically MMA's comment, the wastewater loading to the leaching field on day 91 was input to the model as:

- (total leaching field loading) – (rainfall from 10-year storm falling on the leaching field less impervious area) * (the area of the leaching field) = wastewater loading rate; or

- (0.555354 ft/day) – (0.126776 ft/day) * (7.48 gal/ft^3) * (8,235.2 ft^2) = 26,400 gal/day

Similarly, we found no errors in inputted stormwater rates.

Comment: *When used to simulate groundwater mounding based on infiltration inputs representative of the 25-year and 100-year RP design (rainfall) events, the Applicant's model predicts severe groundwater mounding that breaks out above the land surface over significant portions of the site and off-site areas.*

Response: Please refer to responses to the Davis Memo.

Comment: *These physically unrealistic results are demonstrative of the ongoing, unaddressed "disconnect" between the Applicant's HydroCAD and MODFLOW models, thus reinforcing concern relative to the Applicant's proposed design.*

Response: The groundwater mounding analysis presented by Sanborn Head considers the 10-year storm in accordance with the wastewater hydrogeological evaluation as accepted by MADEP regulators and is considered physically realistic. We agree that the modeling performed by MMA produces "*unrealistic results*" and consequently does not bear additional consideration. As discussed, the 25-year and 100-year storm events engage a greater percentage of the stormwater system discharge as outlet conveyance to the wetland when compared to the 10-year and smaller storms, as would be expected for any similar stormwater system with the same objectives.

Item 2 Summary Points:

Comment: *Without providing a basis for doing so, the Applicant appears to be omitting a significant amount of their own reported information from their process of developing an estimated seasonal high groundwater (ESHGW) condition for the site vicinity*

Response: We disagree. Please refer to responses to the Davis Memo. In an earlier ZBA meeting, Dr. Davis was in agreement with the ESHGW used by the applicant.

Comment: *The information reported by the Applicant, when considered as a whole, appears to invalidate the Applicant's claim that a stormwater-focused groundwater mounding analysis is not required as per the parameters defined within the Massachusetts Stormwater Handbook (MSH)*

Response: We disagree, and irrespective, a mounding analysis was performed and is well documented in the March 2022 Groundwater Model Report.

Comment: *The omitted information appears to be particularly consequential in certain areas, including the southern portion of the site where porous pavement sections appear to be proposed at elevations that would reside below ESHGW, as reported by the Applicant, in this area.*

Response: Please refer to responses to the Davis Memo.

Item 3 Summary Points:

Comment: *By not addressing the "disconnect" between their HydroCAD and MODFLOW models, the Applicant's groundwater mounding analysis does not appear to be complete relative to the requirements described within the MSH.*

Response: We disagree. The MSH does not require linking HydroCAD and MODFLOW, and this is not the standard of practice. That said, there is good agreement between the infiltration rates between MODFLOW and HydroCAD (see response to the Davis Memo).

Comment: *Even with the "disconnect" between HydroCAD and MODFLOW, the Applicant's groundwater mounding analysis appears to directly violate the outcome requirements listed in the MSH (e.g., predicting new areas of groundwater breakout in the wetland vicinity under post-development conditions).*

Response: We disagree. Section 6.0 and Appendix F of the Groundwater Model Report contains a detailed analysis of groundwater seepage to the wetland. There is no material change between post-development and pre-development conditions in the wetland.

Comment: *Tropical Storm Ida and the 10-year RP design (rainfall) event have different modeled precipitation rates that produce different groundwater mounding predictions; therefore, comparisons of these events presented by the Applicant are inappropriate and do not provide a reliable basis for interpreting changes attributable to the proposed project.*

Response: As noted in the response to the Davis Memo, the Tropical Storm Ida variable rainfall intensity was used solely for pre-development transient verification of the MODFLOW model. Because of the availability of actual rainfall intensity data and actual continuous groundwater level transducer data, this was the appropriate approach to take. The application of the 10-year storm in the post-development model was applied uniformly – as is the standard of practice – to areas of the model not covered by impervious surfaces. Rain falling on areas covered with impervious surfaces was directed to the stormwater basins within the model according to hydrographs provided by TetraTech.

Further comparisons of Ida in the March 2022 Groundwater Model Report to the 10-year storm are made in the context of cumulative rainfall over a 24-hour period, which as MMA points out, in this context, is appropriate. There is no way to predict exactly how a 10-year storm event would unfold. It is likely that it would not produce uniform rainfall over a period of 24-hours. Rather it is likely that a 10-year 24-hour storm would come as rainfall "bands" just as it did during Ida, so in this context, comparisons to Ida are reasonable. But, because this can't be known ahead of time the standard of practice is to model the event uniformly over 24-hours, which was done.

In the context of the evaluation of "breakout" to the wetland (Section 6.2 and Appendix F of the March 2022 Groundwater Model Report), it is reasonable to compare a pre-development scenario that is *approximately* equal in conservatism to that imposed on the post-development scenario. In this regard, observations of groundwater levels made during Ida were added to the "starting groundwater elevation" in a pre-development scenario and compared to the model prediction of the design scenario imposed by the MA DEP guidance (80 percent wastewater discharge for 90 days + 10-year storm + groundwater starting elevation). We stand by the analysis presented that there would be no material difference between the pre-development and post-development condition, especially in the context that: 1.) these scenarios would be rare occurrences, either pre- or post-development, and 2.) the effects of these conservative scenarios are very transient. Even if all of the above conditions were to occur at the same time, the effects would last over a period of only a few days. This is not going to adversely impact the wetlands.

Very truly yours,
SANBORN, HEAD & ASSOCIATES, INC.

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Project Director

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