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April 26, 2024

Arlington Land Trust, Inc.
Attn: Chris Leich
P.O. Box 492
Arlington, MA 02476
cmleich@comcast.net

RE: **Thorndike Place, Dorothy Road, Arlington, Massachusetts – Preliminary Review of Applicant's Groundwater Mounding Analysis**

Dear Mr. Leich,

McDonald Morrissey Associates, LLC (MMA) is providing this letter in response to your request for a preliminary technical review of the groundwater mounding calculations presented by BSC Group on behalf of Arlington Land Realty, LLC (collectively referred to herein as "the Applicant"). In conducting the review, MMA primarily focused on information presented in the following documents:

- *Stormwater Report – Thorndike Place, Dorothy Road, Arlington, MA*, prepared by BSC Group on behalf of Arlington Land Realty, LLC. Revised date: August 2021 (referred to herein as BSC's 2021 Report).

- Letter to the Town of Arlington Conservation Commission from Dominic Rinaldi of BSC Group, Inc. *RE: Response to Additional Peer Review Comments and Questions from the Commission – Thorndike Place Stormwater Peer Review*. Dated February 28, 2024 (referred to herein as BSC's 2024 Responses).

Minimum Vertical Separation Distance

BSC's 2021 Report states that a groundwater mounding analysis is necessary to address applicable requirements including those identified within the Massachusetts Stormwater Handbook (Mass. SW Handbook): "*As the infiltration system has more than 2-feet but less than 4-feet separation* [sic] *to estimated seasonal high groundwater, a mounding analysis has been performed…*". Based on MMA's review, this determination appears to be based on estimated seasonal high groundwater (ESHGW) elevations that are currently proposed by the Applicant but are subject to revision based on additional proposed/in-progress data collection and analysis. As noted in BSC's 2024 Responses, the ESHGW condition currently proposed by the Applicant would only provide 2.02 feet of separation at system INF-1 (i.e., currently only meeting the requirement by 0.02 feet without consideration of pending data and analysis), with even smaller vertical separation distances applying to the proposed infiltration systems near the townhomes (i.e., INF-2 through INF-6). Thus, MMA highlights the ESHGW condition as a significant remaining area of uncertainty relative to the proposed design that must be resolved by the Applicant to reliably demonstrate compliance with Mass. SW Handbook requirements.

Groundwater Mounding Analysis Design

Based on MMA's review, the Applicant appears to misinterpret guidance provided by the Mass. SW Handbook relative to conducting (groundwater) mounding analyses. Specifically, the Applicant incorrectly views a reference to *Required Recharge Volume* (RRV) used in the Mass. SW Handbook as a direct instruction for designing a specific loading scenario under which to evaluate resultant groundwater mounding. In the Mass. SW Handbook's discussion of mounding analysis requirements, the RRV is not being singularly used to define a specific volume of infiltration produced by an individual, hypothetical storm event, as the Applicant represents in their mounding analysis. Instead, the RRV term is being used in the Mass. SW Handbook to more generally refer to the volume of internal storage provided by the proposed infiltration practice that would fill during a storm and slowly drain via exfiltration/infiltration.

In MMA's experience, the common accepted practice for conducting mounding analyses that meet Mass. SW Handbook requirements is to use infiltration rates ***and durations*** representative of the largest (i.e., lowest probability) design events for which rate control is being provided. This approach is logical because, as acknowledged in BSC's 2021 Report, severe groundwater mounding can result in adverse hydraulic impacts that may reduce exfiltration/infiltration rates. This effect may, in turn, compromise the ability of a system to provide the intended rate control function. Our position on this matter is supported by the Mass. SW Handbook excerpts provided below, which generally refer to the need to illustrate full drainage of system storage under contemplated storm events, not just drainage capability under an artificial case based on the specific volume definition of the RRV:

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

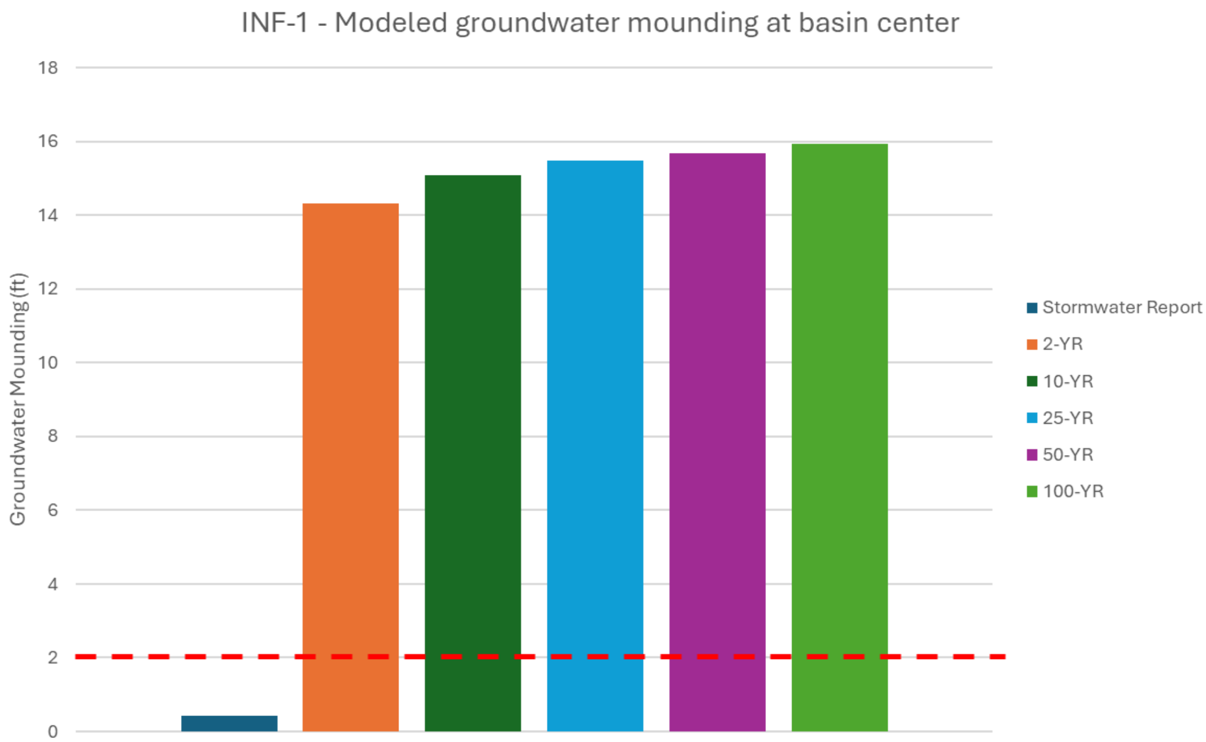
- "*Design the subsurface structure so that it drains within 72 hours after the storm event and completely dewaters between storms*". – Vol. 2, Ch. 2.

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

- "*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 that drains within the 72-hour period*". – Vol. 3, Ch. 1.

Ultimately, the Applicant's misinterpretation of Mass. SW Handbook guidance causes their mounding analysis to be conceptually flawed and unreliable in supporting key assumptions regarding system performance. In effect, the Applicant's analysis only provides an answer to a very specific and inappropriately narrow question: *can the proposed system exfiltrate/infiltrate a volume of water equal to the RRV without indications of adverse effects from groundwater mounding*? In actuality, the Mass. SW Handbook seeks answers to different questions that pertain more directly to evaluating proper system functionality, for example: *can the proposed system completely drain during storm events (i.e., within the required 72-hour period) in consideration of potential adverse effects from groundwater mounding, and is it valid to assume exfiltration/infiltration rates will not be adversely impacted during storm events by groundwater mounding when conducting HydroCAD simulations to evaluate rate control performance*?

Though MMA does not endorse the Applicant's modeling approach (i.e., utilization of the Hantush analytical model) or agree with certain inputs to the model used by the Applicant (e.g., assumed values of horizontal hydraulic conductivity and specific yield), the framework is *generally* useful for illustrating concerns relative to groundwater mounding potential associated with the proposed design. The figure below compares the Applicant's peak mounding height prediction (referred to as "Stormwater Report") for the INF-1 system to additional mounding height predictions based on estimated infiltration durations for the 2-, 10-, 25-, 50-, and 100-year, 24-hour storm event scenarios[1] evaluated using HydroCAD, which assumes no infiltration rate reductions due to groundwater mounding. All inputs to the model aside from the infiltration duration are unchanged (i.e., the same as those used in the "Stormwater Report" case). The dashed red line depicts the 2.02-feet of vertical separation between the bottom of INF-1 and the ESHGW elevation currently proposed by the Applicant.



[1] Infiltration durations were estimated by dividing the cumulative, event-specific discarded volumes reported by HydroCAD by the volumetric system infiltration rate (i.e., linear rate multiplied by the reported system exfiltration/bottom area). The resultant estimates are approximately 2.0, 2.1, 2.2, 2.2, and 2.3 days (47.4, 50.9, 52.7, 53.7, and 54.8 hours) for the 2-year, 10-year, 25-year, 50-year, and 100-year, 24-hour events, respectively. Note these estimates do not reflect consideration of groundwater mounding and associated infiltration rate reduction(s).

The Applicant predicts minimal mounding because they use the RRV to estimate the infiltration duration (0.051 days), and the resultant estimated duration is significantly shorter than infiltration durations estimated for the contemplated storm events (ranging from approximately 2 days for the 2-year event to approximately 2.3 days for the 100-year event). When the longer, storm-specific infiltration duration estimates are used instead, the Applicant's model predicts tremendous groundwater mounding with levels rising to unrealistic heights that significantly exceed the proposed system bottom. Consistent with the position expressed in the BSC 2021 Report, when groundwater is predicted to rise to this degree, it is an indication of a strong potential for adverse hydraulic effects that would extend system drainage times, thus warranting further analysis and potentially design adjustment. Due to the Applicant's misinterpretation of the Mass. SW Handbook, this potential—as well as the potential for other adverse effects associated with groundwater mounding—has simply not been recognized or addressed.

Groundwater Mounding Analysis Assumptions and Bases for Selected Inputs

While MMA views the aforementioned methodological flaw—including use of an erroneously short infiltration event duration—as the primary and most consequential concern relative to the Applicant's mounding analysis, our review did highlight several additional issues, including the following:

- The validity—and representativeness—of predictions yielded by the analytical model proposed by Hantush (1967) depends on conformance with the assumptions implicit in the mathematical formulation of the model itself. Of particular relevance to the Applicant's implementation is the assumption of infinite aquifer extent, which implies there are no barriers limiting horizontal flow. MMA understands the Applicant is proposing subsurface structures (e.g,. building foundations with impermeable liners) that would likely render the assumption of infinite aquifer extent invalid and lead the Hantush model to produce non-conservative peak mounding height predictions. Thus, the Applicant should justify their selection of the Hantush analytical model over the use of a more robust and flexible numerical modeling approach (e.g., MODFLOW) that can better represent physical complexity, including horizontal flow barriers and additive effects from simultaneous activity (i.e., exfiltration/infiltration) by multiple systems.

- The Applicant should provide bases for *all* assumed inputs to their mounding simulations, including assigned values of aquifer specific yield and initial saturated thickness, as these inputs do influence resultant mounding height and extent predictions.

- Regarding the assumed value of horizontal hydraulic conductivity, BSC's 2024 Responses present the following claim: "*The horizontal hydraulic conductivity selected* [1.04 feet per day] *is a typical value for silty materials converted from* 3.65×10^{-6} *meters per second to feet per day*". Additional information—namely a supporting literature reference or site-specific information source—should be provided by the Applicant to validate this claim. Based on MMA's review, this input appears to imply as assumption of a horizontal-to-vertical anisotropy ratio of approximately 1:1, which would be atypical based on industry-common ranges representative of the general character of subsurface materials present in the site vicinity (see Todd, 1980[2]).

The review described herein is preliminary and based on information made available to MMA as of the indicated transmittal date. MMA therefore reserves the right to amend and/or extend this commentary based on expanded review and/or review of new information provided by the Applicant or other interested parties.

Sincerely,

Michael Mobile, Ph.D., CGWP
President, McDonald Morrissey Associates, LLC

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[2] *Groundwater Hydrology, Second Edition, 1980*. Authored by David K. Todd.

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