Scott Horsley
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February 22, 2024

VIA EMAIL

Mr. Brian Moore
49 Farm Road
Sherborn, MA
Re: Farm Road 40B, Sherborn, MA

Dear Brian:

At your request I have reviewed the most recent reports and groundwater modeling results prepared by Creative Land and Water Engineering (CLWE) associated with the proposed 40B development at Farm Road, Sherborn, MA. The proposed project is located adjacent to your property and is hydrologically upgradient from your property. I understand that you and several of your neighbors have private drinking water supply wells on your properties. I also understand that your property contains a jurisdictional wetland projected under the Massachusetts Wetlands Protection Regulations.

The Sherborn Health Regulations require a detailed review of water quality impacts of the proposed project. The Health Regulations also require an "Environmental Health Impact Report" for all developments that exceed 2000 gallons/day. The Regulations require *"Impact estimation shall be performed by employing a site-specific mass balance analysis of the area of impact (in accordance with MassDEP's Guidelines for Title 5 Aggregation of Flow and Nitrogen Loading [2/22/2016] associated with 310 CMR 15.216) or a comparable approach approved by the Board". The report shall meet the criteria required by this and all other applicable Board of Health regulations, and shall provide specific information relative to the operation of the proposed sewage treatment and disposal systems, including soil conditions, surface drainage calculations, hydrogeologic descriptions of groundwater resources and movement, effects of precipitation, and wastewater treatment methodology".*

The Applicant submitted a Hydrogeologic Evaluations Report prepared by Creative Land and Water Engineering (CLWE) dated December 11, 2023 and an Appendix Supplementary Data for Groundwater Mounding Analysis and Updated Groundwater Mounding Analysis and Nitrogen Loading Appendix dated February 2024. These reports include groundwater mounding analyses and nitrogen loading analyses that are based on methods inconsistent with MADEP guidelines and hydrologic assumptions that are not substantiated with onsite measurements.

1. Groundwater Mounding Comments

The CLWE groundwater mounding analysis is based upon permeability values calculated from Title 5 percolation tests (see figure 1). Percolation tests measure unsaturated infiltration rates above the water table. Groundwater mounding analysis requires saturated permeability (hydraulic conductivity)values from field tests below the water table.

7.2 Percolation and Permeability Test.

Creative Land & Water Engineering, LLC (CLAWE) has been conducting a hydrogeologic study of the site in accordance with 310 CMR15 for a common large Title 5 Septic system. CLAWE conducted eight deep hole soil observations successfully, 4 percolation testing to show consistent soil conditions throughout the SAS area. See Figure 6 for locations. Soil logs are presented in Appendix B. The tests were witnessed by Mr. Mark Oram of Sherborn Board of Health Agent. CLAWE's soil evaluation and percolation tests showed that the soil in the proposed SAS area has a percolation rate between 3 min/in to 5 min/in, which confirms the very permeable soil condition in this area. Based on the percolation rate, a permeability of 24 ft/day hydraulic conductivity is recommended to be used for groundwater mounding analysis. The detailed test results are attached in Appendices B and C.

Figure 1 – Excerpt from Hydrogeologic Report prepared by CLWE, December, 2023

The MADEP Stormwater Handbook clarifies this and states *"A Title 5 percolation test is not an acceptable test for saturated hydraulic conductivity. Title 5 percolation tests overestimate the saturated hydraulic conductivity rate".*

CLWE presents grain size analysis as another method to estimate hydraulic conductivity. However, the report simply presents the results of the grain size analysis, then selects the value of 24 feet/day which they calculated from the percolation tests (see Table S3 from the CLWE report below). The grain size analysis provides a broad range of hydraulic conductivity values that differ by an order of magnitude or more.

Table S3. Summary of hydraulic conductivity (permeability) analysis

Soil Sample	Location	estimated K, ft/day	Average K, ft/day	Typical K for silt/sand*	Design K	Soil texture per USDA
S1	lower edge of SAS	29-850	439	153	24	medium sand
S2	upper edge of SAS	4.39-76	40	28		medium loamy sand
SA1	Stormwater Basin A	0.52-8.5	4.51	28		medium sand loam

The most reliable method to determine hydraulic conductivity is to conduct an on-site, in-situ Permeability tests. The MADEP Stormwater Handbook (Volume 3, Chapter 1) provides clear guidance on how to properly conduct these tests as follows. To my knowledge CLWE did not apply these methods.

a. Field test methods to assess saturated hydraulic conductivity for the "Dynamic Field" method must simulate the "field-saturated" condition. See ASTM D5126-90 (2004) Standard Guide for Comparison of Field Methods for Determining Hydraulic Conductivity in the Vadose Zone. The saturated hydraulic conductivity analysis must be conducted by the Competent Soils Professional. Acceptable tests include:

i. Guelph permeameter - ASTM D5126-90 Method
ii. Falling head permeameter – ASTM D5126-90 Method
iii. Double ring permeameter or infiltrometer - ASTM D3385-035, D5093-026, D5126-90 Methods
iv. Amoozemeter or Amoozegar permeameter – Amoozegar 1992
1 MADEP Stormwater Handbook, Volume 3, Chapter 1, page 11.
c. A Title 5 percolation test is not an acceptable test for saturated hydraulic conductivity. Title 5 percolation tests overestimate the saturated hydraulic conductivity rate.

Another critical input to the groundwater mounding model is saturated thickness. This is the vertical dimension (or depth) of groundwater measured from the water table downward to the underlying bedrock (or other confining layer such as glacial till). The CLWE report misinterprets their test pit data and reports the saturated thickness as the depth from the land surface to the water table (instead of the water table downward to the bedrock or confining layer). On page 4 of the Nitrogen Loading Appendix the report states, "The saturated soil thickness of 14.5 ft will be used to update the groundwater mounding analysis". The 14.5 feet figure is the depth to water table and is reported on page 11 of the Hydrogeologic Evaluations Report. It states, "We made an extra effort to use large machinery and get to water in the two lower test pits, DHTP 55-10AN and DHTP 55-11AN, which had water at the depth of about 14.5 ft to 18 ft". This are not saturated thickness, it is the depth to the water table.

In fact, the actual test pit data provided by CLWE shows only a saturated thickness of 3.96 feet. Table 3.1 from the Hydrogeologic Evaluations Report (shown below) summarizes the test pit data and shows the estimated seasonal high groundwater (ESHGW) or water table and the bottom of hole (test pit) – the difference is the measured saturated thickness. Although I agree that there is likely to be additional saturated thickness beneath the test pit elevations, the selection of 14.5 feet or 20 feet (later in the report) as a saturated thickness is not supported by the data.

Table 3.1 - SAS Soil Testing Summary

Test Pit #	Test Date	GSE (ft)	Depth to pit bottom (ft)	Soil Texture	Adjusted Depth to HGW (ft)	Water adjustement, ft	EHGW, ft	Perc rate, mpi	Perc depth, in	Bottom Hole El, ft	Ledge Note: L=ledge;N=no ledge; U=unknown	
DHTP 55-10	4/23/2021	196.92	11.25	Co. M. L.S.	9.42		187.50			185.67	N	well installed,upslope, dry
DHTP 55-10An	4/23/2021	192.10	14.50	Co. M. L.S.	11.17		180.93			177.60	U	Well installed,lower SLP, some weeping
DHTP 55-11	4/23/2021	201.00	16.00	Co. M. L.S.	13.75	1.83	187.25	4.00	54.00	185.00	N	Well installed, upslope, dry
DHTP 55-11An	4/23/2021	193.92	18.00	Co. M. L.S.	14.42		179.50	3.00	54.00	175.92	U	Well installed, lower SLP, some weeping
DHTP-55-11B	4/23/2021	194.00	10.00	Co. M. L.S.	n/t		n/t			184.00	U	No well, confirm soil, mid slope, dry
DHTP 5-1	11/24/2021	195.04	14.50	Co. M. L.S.	10.54		184.50			180.54	N	Well installed, lower SLP, dry
DHTP 5-2	11/24/2021	200.77	17.49	Co. M. L.S.	12.86	2.38	187.91	5.00	64.00	183.28	N	well installed, upslope, dry
DHTP 5-3	11/24/2021	198.04	16.66	Co. M. L.S.	13.53		184.51	3.00	60.00	181.38	N	well insttalled, upslope, dry

maximum measured saturated thickness = 3.96'

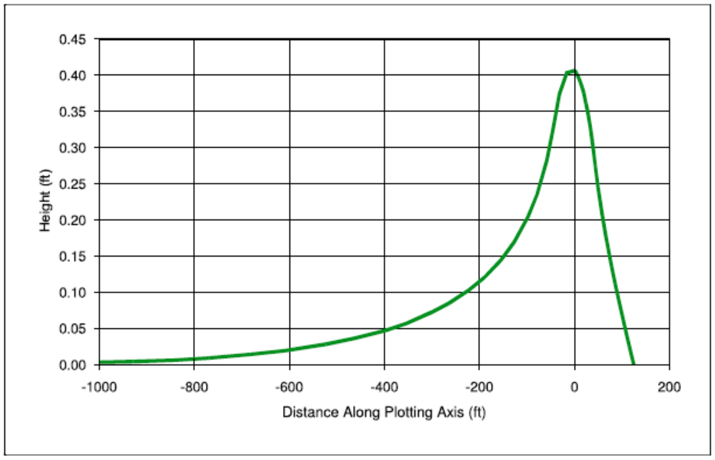
Note: 1. Nearby downgradient wetland is at elevation of 177-178, which is in line with the weeping water elevation in Test pits DHTP-11An and DHTP-10An; 2. Except the two test pits, other test pits were dry and no water measured and the water table based on the depth of hole is a conservative estimate and normally will not be considered.

Finally, and perhaps most importantly the CLWE groundwater mounding model places a constant head boundary at 125 feet from the wastewater disposal field (see figure 3 below). A constant head boundary means that water levels are fixed and cannot change as a result of the model.

The wetland adjacent to the wastewater system is approximately 125 feet from the wetland. This means that the model is constructed in a way that cannot predict any water level changes in the wetland. This defeats one of the principal purposes of the groundwater mounding analysis – to evaluate impacts on the adjacent wetland.

The MADEP Stormwater Handbook Volume 3, Chapter 1 (page 28) states, *"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)".* My experience indicates that MADEP does not allow more than a 0.1-foot alteration of water levels at wetland boundaries.

Groundwater Mounding Analysis (Hantush's Method using Glover's Solution)



COMPANY: CLAWE

PROJECT: Farm Road Homes - SAS 3

ANALYST: Desheng Wang

DATE: 2/2/2024 TIME: 10:54:47 AM

INPUT PARAMETERS

Application rate: 0.1 c.ft/day/sq. ft
Duration of application: 90 days
Fillable porosity: 0.26
Hydraulic conductivity: 24 ft/day
Initial saturated thickness: 14.5 ft
Length of application area: 82 ft
Width of application area: 46 ft
Constant head boundary used at: 125 ft
Plotting axis from Y-Axis: 0 degrees
Edge of recharge area:
positive X: 0 ft
positive Y: 41 ft
Total volume applied: 33948 c.ft

MODEL RESULTS

X (ft)	Y (ft)	Plot Axis (ft)	Mound Height (ft)
0	-1000	-1000	0
0	-841	-841	0.01
0	-681.9	-682	0.01
0	-522.9	-523	0.03
0	-397.9	-398	0.05
0	-301	-301	0.07
0	-221.8	-222	0.1
0	-154.9	-155	0.14
0	-96.9	-97	0.2
0	-58	-58	0.28
0	-31.5	-32	0.37
0	0	0	0.41
0	3.9	4	0.4
0	7.2	7	0.4
0	12.1	12	0.39
0	19.4	19	0.38
0	27.7	28	0.35
0	37.6	38	0.31
0	49.7	50	0.24
0	65.4	65	0.18
0	85.2	85	0.11
0	105.1	105	0.06
0	125	125	0

Figure 3 – Excerpt from CLWE report – Groundwater Mounding Analysis

2. Area of Impact (Plume) Comments

The CLWE analysis misinterprets their own groundwater mounding analysis and conflates predicted water table rises with groundwater flow directions. The model predicts small rises in the water table at a distance of 841 feet from the wastewater disposal area (see Figure 3 above). They have misinterpreted this as the outer lateral bounds of the Area of Impact (or plume). The groundwater mounding predictions must be integrated with the existing (pre-development) water table to determine post-development groundwater flow directions for the purpose of determining the Area of Impact.

The CLWE reports states, *"The groundwater mounding analysis shows that plum(e) will spread out 841 ft on each side of the SAS fields and will cover the entire western property line, which received ground water recharge from about 25.57 acres and 22.88 acres of land net for nitrogen loading excluding 53 and 55 Farm Road and including off site town conservation open space to the northeast"*. This grossly overstates the area of impact and inaccurately dilutes the wastewater effluent. It conflates groundwater mounding and groundwater flow net analysis.

3. Suggested Revisions to Groundwater Mounding Analysis

I have re-run the groundwater mounding model (Hantush) using more conservative values for hydraulic conductivity and saturated thickness but maintaining other inputs to the model in accordance with CLWE's estimates. Because there are no available in-situ permeability tests (as recommended by MADEP) I selected the most conservative hydraulic conductivity values presented in CLWE's Table S3 (shown below). I assumed a saturated thickness of 8 feet (twice the value that CLWE measured).

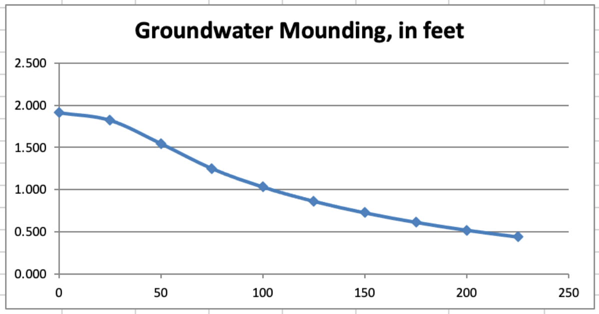
The results of the modelling shows significant groundwater mounding directly underneath the wastewater disposal field at 1.9 feet and 0.7 feet at the wetland. The results at the stormwater infiltration facility indicate groundwater mounding of 8.5 beneath the system and 2.0 feet at the wetland boundary. To my knowledge CLWE has not reported on groundwater mounding at the stormwater infiltration facility.

My analyses indicate that the groundwater mounding associated with the stormwater and wastewater facilities will overlap causing cumulative impacts. They need to be evaluated together. The stormwater mounding will redirect (or push) the wastewater effluent further south in the direction of the private wells on neighboring properties. The CLWE analysis does not provide groundwater mounding for the stormwater facility and clearly does not address the cumulative impacts between the stormwater and wastewater facilities.

0.0980	*R*	Recharge (infiltration) rate (feet/day)	0.67	1.33	
0.260	Sy	Specific yield, Sy (dimensionless, between 0 and 1)			
16.70	K	Horizontal hydraulic conductivity, Kh (feet/day)*	2.00	4.00	In the repo
46.000	x	1/2 length of basin (x direction, in feet)			SIR 2010-5
41.000	y	1/2 width of basin (y direction, in feet)	hours	days	assumed t
90.000	t	duration of infiltration period (days)	36	1.50	conductivit
8.000	hi(0)	initial thickness of saturated zone (feet)			
9.912	h(max)	maximum thickness of saturated zone (beneath center of basin at end of infiltration period)			
1.912	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
1.912	0
1.823	25
1.547	50
1.251	75
1.033	100
0.863	125
0.727	150
0.614	175
0.520	200
0.441	225

Re-Calculate Now



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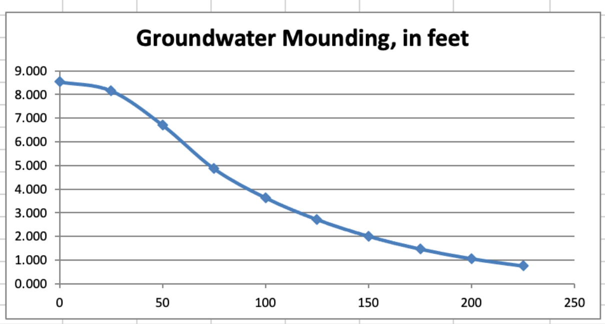
Input Values			inch/hour	feet/day	
0.4475	*R*	Recharge (infiltration) rate (feet/day)	0.67	1.33	
0.260	Sy	Specific yield, Sy (dimensionless, between 0 and 1)			
4.50	K	Horizontal hydraulic conductivity, Kh (feet/day)*	2.00	4.00	In the repo
50.000	x	1/2 length of basin (x direction, in feet)			SIR 2010-
15.000	y	1/2 width of basin (y direction, in feet)	hours	days	assumed t
90.000	t	duration of infiltration period (days)	36	1.50	conductivi
8.000	hi(0)	initial thickness of saturated zone (feet)			
16.540	h(max)	maximum thickness of saturated zone (beneath center of basin at end of infiltration period)			
8.540	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
8.540	0
8.163	25
6.713	50
4.870	75
3.638	100
2.719	125
2.013	150
1.471	175
1.061	200
0.757	225

Re-Calculate Now



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4.0 Nitrogen Loading Analysis

As part of my previous analysis and presented in my November 5, 2023 letter I applied the nitrogen loading method as outlined in MADEP's *"Guidelines for Title 5 Aggregation of Flows and Nitrogen Loading 310 CMR 15.216"* as required by the Sherborn Health Regulations. These guidelines stipulate that for proposed wastewater flows exceeding 2000 gallons per day adjacent to areas served by private drinking water wells that nitrate-nitrogen concentrations must be maintained below 10 mg/liter at the downgradient property boundary.

To determine groundwater flow directions on the subject property I plotted existing groundwater elevations provided by the applicant's consultant, Creative Land and Water Development. A series of test pits shown on the site plans provide estimated seasonal high groundwater (ESHGW) elevations. Utilizing this data I constructed a water table map (highlighting the 195-foot contour) which indicates groundwater flow in a westerly direction.

Based upon these groundwater flow directions I delineated two Areas of Impact (AOI). The northerly AOI is downgradient of the proposed 40B development septic system and the southerly AOI is downgradient of septic systems on two adjacent lots. The locations of the septic systems are shown on a basemap prepared by Creative Land Development dated September 28, 2023 (see figure 4).

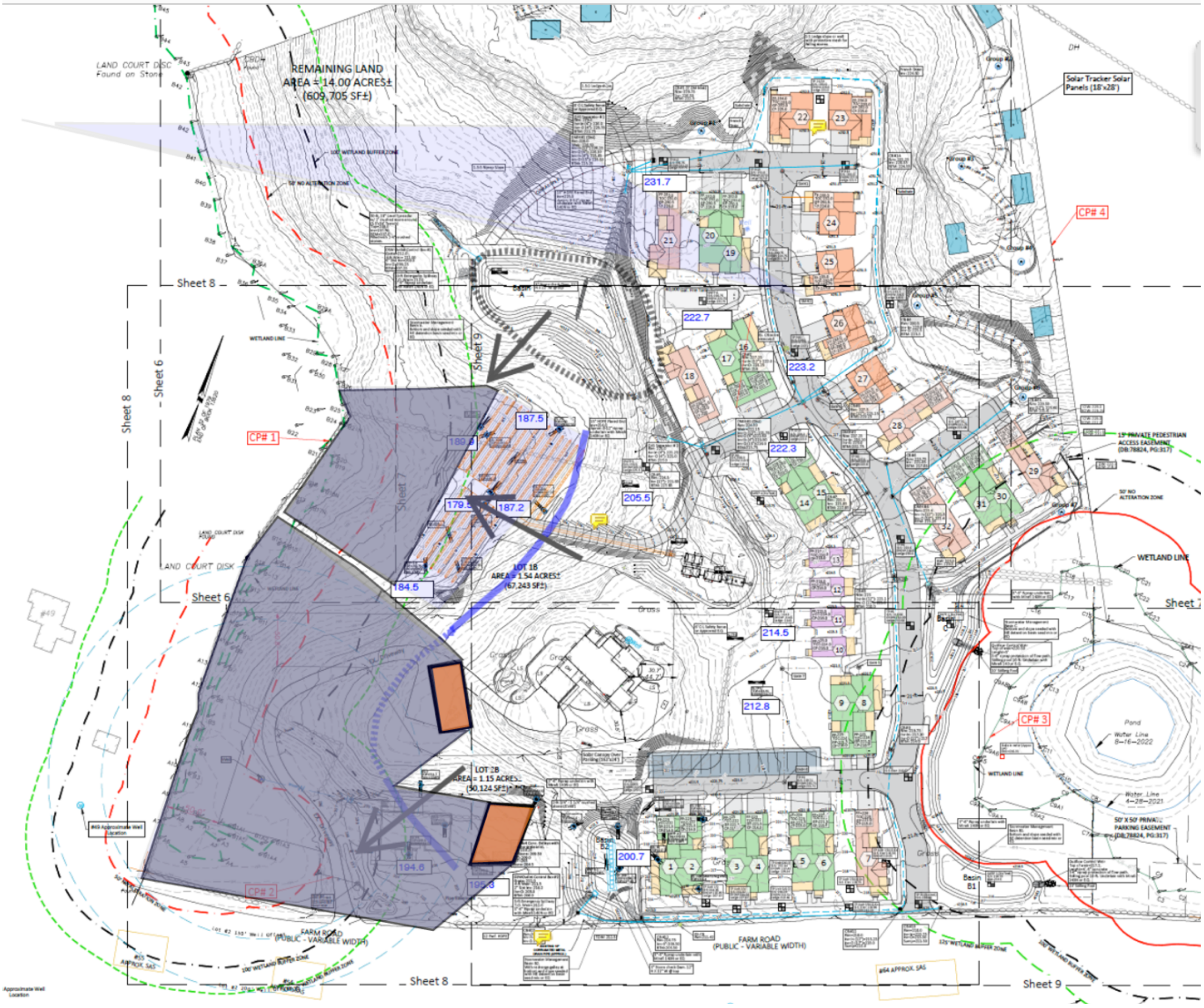

Figure 4 – Areas of Impact

I then calculated the resulting nitrogen concentrations at the downgradient property boundary adjacent to your parcel (see Table 1). I applied an average wastewater concentration of 35 mg/liter for Title 5 systems on the two adjacent lots and a concentration of 19 mg/liter for a potential innovative and alternative (I&A) septic system at the 40B project site.

This analysis indicates that the proposed wastewater discharges will result in nitrate-nitrogen concentrations in excess of state and federal drinking water standard of 10 mg/liter for nitrate-nitrogen at the property boundary of your land. There is an additional drinking water well on the adjacent lots within the Area of Impact that will also be degraded by the wastewater discharges.

Table 1 – Summary of Nitrogen Loading Analysis

	Adjacent Lots	40B	40B
Wastewater design flow (gals/day)	880	8360	8360
Source Concentration (mg N/liter)	35	35	19
Concentration at Property Boundary (mg N/liter)	15.8	26.9	14.6

This analysis is provided as a preliminary/conceptual assessment. A more detailed analysis of these impacts is required by the Sherborn Board of Health Regulations and should be provided by the applicant. This assessment should be updated and revised to include the cumulative groundwater mounding impacts associated with the proposed stormwater and wastewater disposal systems. This will redirect the wastewater plume associated with the 40B septic system further south. A more detailed analysis of the cumulative impacts is required.

Sincerely,

Scott Horsley
Water Resources Consultant