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25 October 2021

Ms. Sarah Mellish, Chair
Town of Manchester-by-the-Sea
Zoning Board of Appeals
10 Central Street
Manchester-by-the-Sea, MA 01944-1399

Dear Ms. Mellish and Board Members:

RE: The Sanctuary, School Street, Manchester-by-the-Sea, MA

I have been retained by the Manchester-Essex Conservation Trust to review hydrologic and water quality impacts associated with the proposed project, The Sanctuary, School Street, Manchester-by-the-Sea, MA. I have reviewed the site plans prepared by Allen & Major Associates dated September 21, 2020 and July 16, 2021, the Drainage Report prepared by Allen & Major dated July 16, 2021, as well as other relevant data including Massachusetts GIS, NRCS Soil Surveys, USGS surficial geologic maps, USGS StreamStats, and USEPA water quality criteria.

Qualifications: I have over 30 years of professional experience in the field of water resources management and on a broad range of water contamination and restoration projects. I have been retained as a consultant to federal, state, and local government agencies, non-governmental organizations (NGOs), and private industry throughout the United States, Central America, the Caribbean, the Pacific Islands, Bulgaria, and China. I have served as an instructor for a nationwide series of U.S. Environmental Protection Agency (USEPA) workshops on drinking water protection and watershed management. I have also served on numerous advisory boards to the USEPA, the National Academy of Public Administration, Massachusetts Department of Environmental Protection (DEP), Massachusetts Executive Office of Energy and Environmental Affairs (EEA), and the National Groundwater Association. I have received national (USEPA) and local awards for my work in the water resources management fields. I serve as Adjunct Faculty at Harvard University Extension School and Tufts University, where I teach courses in water resources policy, wetlands management, green infrastructure, and low impact development (LID). These courses focus on the critical role of local governments who have the primary responsibility and authority of regulating land uses in critical water resource protection areas. I assisted in the preparation of the Water Resources Protection Plan for the town of Manchester (Horsley Witten Hegemann, 1990).

General Comments: The proposed project includes a 92,560 square foot multi-family residential building, large areas of impervious surfaces and significant grading. A proposed on-site wastewater treatment and disposal facility will discharge an estimated 25,520 gallons/day to the groundwater underlying the site that will subsequently discharge to the surrounding wetlands, streams, and ultimately to the town's drinking water supply. Stormwater drainage from rooftops, parking lots, and roadways is proposed to be infiltrated into the underlying groundwater and subsequently will discharge and overflow to the surrounding wetlands, streams, and ultimately the town's drinking water supply.

The project site is surrounded by wetlands (including Cedar Swamp and two potential vernal pools), streams (including Sawmill Brook), and is within the contributing area to the towns' drinking water supply at the Lincoln Street well. The project site has numerous on-site wetlands, is comprised of low permeability soils, and is constrained by shallow depths to groundwater and bedrock. Although no information regarding on-site hydrology is provided by the Applicant, regional information available suggests that the proposed wastewater and stormwater will discharge to Sawmill Brook and ultimately to the town's drinking water supply at the Lincoln Street well.

The project site is comprised of thin glacial till underlain by shallow bedrock. Steep slopes indicate surface drainage to flow radially to the north, east, south, and west from the site. Groundwater levels are anticipated to be shallow with discharge to the surrounding wetlands, streams, and the town's drinking water supply.

Sawmill Brook is a coldwater fishery and is a source of drinking water to the Lincoln Street public water supply wellfield. Cedar Swamp is a sensitive wetland system that has provided a public water supply to the City of Gloucester and remains a backup water supply for the City. The entire development site lies within the town's Water Resource Protection District and within the Zone 3 protection area of the Lincoln Street well.

Historically, surface water and groundwater supplies have been managed and regulated separately. However, as we now know, they are inexorably linked and are more effectively managed and regulated together. Groundwater provides baseflow to streams, lakes and wetlands. Similarly, surface waters can provide sources of water to groundwater supplies (as in the case of the Lincoln Street well). This is particularly true of public drinking water supplies that draw some water from adjacent streams (such as Cedar Swamp and Lincoln Street well).

My specific comments are as follows.

1. The project site plans are incomplete, locations of test pits have been deleted, and do not provide subsurface test pit data. The "existing conditions" sheet contained in the preliminary site plans dated September 29, 2020 show the locations of 19 test pits (see Figure 1 below) However, no test pit data were provided at that time.

The revised site plans dated July 16, 2021 also include an "existing conditions" plan. However, inexplicably the test pit locations have been deleted from the plan. Again, no test pit data has been provided with the plans.

Test pit data provides critical information regarding subsurface conditions including soil types, groundwater levels, and depths to bedrock. These data are required to evaluate the feasibility of the proposed project. An explanation regarding why their locations were deleted from the current site plan is warranted, and the data should be provided as soon as possible to enable the Board and the public to evaluate the wastewater and stormwater management systems.

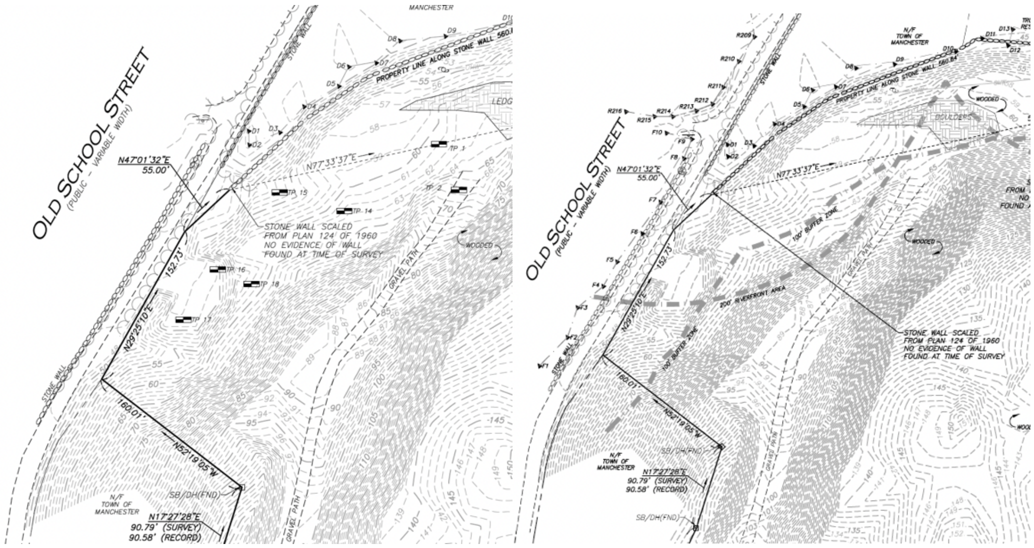

Figure 1 - Existing Conditions Plans - 9/21/20 (left) and 7/16/21 (right)

2. The proposed project does not comply with the test pit requirements in the MADEP Stormwater Handbook. The MADEP Stormwater Handbook requires a minimum of at least two test pits for each stormwater infiltration facility. The site plans include three stormwater infiltration facilities but no test pits at those locations. MADEP Stormwater Handbook, Volume 2, Chapter 2, page 97, provides clear criteria for planning for infiltration basins. It states: *"A minimum of 2 soil borings should be taken for each infiltration trench. Infiltration trenches over 100 ft. in length should include at least one additional boring location for each 50 ft. increment. Borings should be taken at the actual location of the proposed infiltration trench so that any localized soil conditions are detected"*.

3. The project proposal does not comply with MADEP Stormwater Standard 3 and may result in hydraulic failures with the infiltration systems, surface breakouts on slopes, downstream flooding, and hydrologic impacts to wetlands. MADEP Stormwater Standard 3 is designed to maintain the hydrologic balance in underlying groundwater and adjacent wetlands. It requires that post-development recharge[1] is maintained at existing pre-development recharge rates. MADEP Stormwater Handbook, Volume 2, Chapter 1 provides guidance and clarification regarding this requirement to maintain natural hydrology. Page 6 of this document states, *"Standard 3 of the Stormwater Management Standards requires that proponents <u>preserve infiltration at predevelopment levels</u> in order to <u>maintain</u> <u>base flow and groundwater recharge</u>"*.

[1] Recharge is the process of infiltrating water entering the underlying groundwater. Under natural conditions precipitation is the primary source of recharge and results in ambient groundwater levels (water table). If recharge rates increase (due to infiltration of wastewater or stormwater) groundwater levels rise.

Recharge provides baseflow to wetlands and contributes to their hydroperiod (the natural cycle of water levels through the seasons). Changes to this hydrologic balance of recharge areas to a wetland constitute "alterations" to the wetland. This project will result in significant alterations to these recharge rates and to the hydrologic regime of the wetland.

The Drainage Report provides the proposed recharge calculations for Standard 3 - see excerpt from page 224 reproduced below as Figure 2. It indicates that the existing recharge volume (or "*required volume*" to maintain and preserve existing water levels) is **1225 cubic feet** and that the "*provided volume*" is **67,076 cubic feet** (see attached Table from applicant's Drainage Report). This means that the stormwater infiltration system is exceeding current conditions **by more than a factor of fifty-five (55).** This will cause significant increases in groundwater levels on the site (including long term rises and short-term mounding) and will likely cause surcharges and hydrologic alterations to the adjacent wetlands (see Figure 2). The increased groundwater levels may also result in breakouts in steeply sloped areas and interference with the wastewater infiltration system. A groundwater model (such as MODFLOW) is required to evaluate these impacts.

Computation Sheet

Title	***MA DEP Standard Calculations***	By	DMR/SJL
Project	*School Street, Manchester-by-the-Sea, MA*	Chk'd	CMQ
Date	July 16, 2021	Apprv'd	CMQ
Revised			

Rv = F * Impervious Area
Rv *= Required Recharge Volume, expressed in ft^3, cubic yards or acre-feet*
F *= Target Depth Factor associated with each Hydraulic Soil Group*
Impervious Area *= pavement & rooftop area on site*
V_{WQ} *= Required Water Quality Treatment Volume (ft^3)*
D_{WQ} *= Water Quality Depth (in)*
A_{IMP} *= Impervious Area (excluding non-metal roofs)*

			IMPERVIOUS AREA (S.F.) BY HSG		*Recharge Required*			*Water Quality Volume Required*	
W'SHED	Area (Sq. Ft)	Landscaped		HSG D (F=.1)	*F Avg. (Inches)*	*Impervious Area (Sq. Ft)*	*Rv (ft^3)*	D_{WQ} *(Inch)*	V_{WQ}
P-1	17,171	17,171		0	0.100	0	0	1.0	0
P-2	9,691	9,691		0	0.100	0	0	1.0	0
P-3	27,985	27,985		0	0.100	0	0	1.0	0
P-4	117,759	117,126		633	0.100	633	5	1.0	53
P-5	14,879	3,134		11,745	0.100	11,745	98	1.0	979
P-6	18,477	17,512		965	0.100	965	8	1.0	80
P-7	24,884	24,096		788	0.100	788	0	1.0	66
P-8	22,451	5,972		16,479	0.100	16,479	137	1.0	1,373
P-9	15,326	10,268		5,058	0.100	5,058	42	1.0	422
P-10	30,342	0		30,342	0.100	30,342	253	1.0	2,529
P-11	20,180	0		20,180	0.100	20,180	168	1.0	1,682
P-12	27,254	0		27,254	0.100	27,254	227	1.0	2,271
P-13	17,700	4,236		13,464	0.100	13,464	112	1.0	1,122
P-14	19,605	13,079		6,526	0.100	6,526	54	1.0	544
P-15	18,455	18,455		0	0.100	0	0	1.0	0
P-16	20,820	11,633		9,187	0.100	9,187	77	1.0	766
P-17	11,737	11,737		0	0.100	0	0	1.0	0
P-18	5,160	0		5,160	0.100	5,160	43	1.0	430
Total	**439,876**	292,095		147,781		13,343	**1,225**		**12,315**

STORMWATER RECHARGE SUMMARY CALCULATIONS

Rv = F * Impervious Area
Rv *= Required Recharge Volume, expressed in ft^3, cubic yards or acre-feet*
F *= Target Depth Factor associated with each Hydraulic Soil Group*

	Required (cf)	*Provided (cf)*	
Rv =	*475*	*42,647*	***96" CMP Underground Infiltration System - 1 (P-10, P-11, P-14)***
Rv =	*179*	*4,321*	***36" CMP Underground Infiltration System - 3 (P-8 & P-9)***
Rv =	*339*	*15,235*	***36" CMP Underground Infiltration System - 2 (P-12 & P-13)***
Rv =	*106*	*0*	***36" CMP Underground Detention System - 4 (P-5, P-6, P-7)***
Rv =	*77*	*1,939*	***Surface Detention Pond - 1 (P-15, P-16, P-17)***
Rv =	*0*	*1,419*	***Rain Garden - 1 (Flows from UDS-4)***
Rv =	*43*	*1,515*	***Rain Garden - 2 (P-18)***
Rv =	*5*	*0*	***Deminimus Unmitigated Area (P-1, P-2, P-3, P-4)***
Rv =	*1,225*	*67,076*	Page 1 of 4

Figure 1 - Recharge Calculations (Allen & Major Associates)

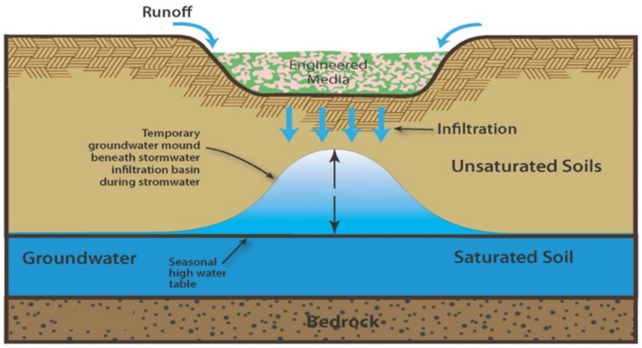

Figure 3 - Groundwater Mounding (USGS)

4. The project plans for wastewater management are incomplete. The project plans identify a treatment plant location and two wastewater infiltration areas. However, no details are provided regarding elevations, hydraulic loading rates, wastewater treatment technology, which infiltration area will be used, discharge rates, or effluent water quality. This information must be provided to fully evaluate the impacts of the project on underlying groundwater, surrounding wetlands, streams, and the downgradient drinking water well at Lincoln Street.

The proposed discharge of this volume of wastewater into these glacial till soils with shallow groundwater levels and shallow bedrock raises serious questions about hydraulic impacts including groundwater mounding. A groundwater mounding analysis is required to evaluate these impacts. This analysis should be coordinated and integrated with the groundwater mounding impacts associated with the proposed stormwater infiltration facilities. Both long term (steady state) and short term (precipitation event based) impacts should be evaluated. Maximum high water table elevations should be used as the basis of this analysis.

5. The wastewater discharge will exceed water quality criteria (phosphorus). The proposed wastewater system will infiltrate to groundwater and will discharge to Sawmill Brook and ultimately the town's drinking water supply at Lincoln Street.

The Massachusetts Surface Water Quality Standards state that nutrients "shall not exceed the site-specific limits necessary to control accelerated or cultural eutrophication" (314 CMR 4.05(5)(c)). The Massachusetts Surface Water Quality Regulations stipulate that the 7Q10 flows be used as the basis to determine water quality impacts (314 CMR 4.03(3)).

According to the USGS StreamStats model Sawmill Brook has a 7Q10 flow of 12,180 gallons/day adjacent to the project site. The proposed wastewater discharge is approximately 25,520 gallons/day. This suggests a ratio of approximately 2 parts wastewater – 1 part stream within Sawmill Brook.

EPA has produced several reference documents which contain total phosphorus criteria for receiving waters. The 1986 Quality Criteria of Water ("*the Gold Book*") recommended maximum in-stream phosphorus concentrations of 0.05 mg/liter.

In December 2000, EPA released an updated report "Ecoregional Nutrient Criteria," that provided more current and region-specific data to reduce problems associated with excess nutrients in water bodies located within specific areas of the country (USEPA 2000). The published criteria represent conditions in waters within each specific ecoregion which cause eutrophication. Manchester is within Ecoregion XIV, Eastern Coastal Plains (level III ecoregion 59). The recommended total phosphorus criteria for Ecoregion XIV is 0.024 mg/liter and can be found in the USEPA publication, "*Ambient Water Quality Criteria Recommendations, Information Supporting the Development of State and Tribal Nutrient Criteria, Rivers and Streams in Ecoregion XIV"*.

Mitchell, Liebman, Ramseyer, and Card (2004), under contract with USEPA, developed potential nutrient criteria for rivers and streams in New England. Using several river examples representative of typical conditions for New England streams and rivers, they investigated several approaches for the development of river and stream nutrient criteria that would be dually protective of designated uses in both upstream reaches and downstream impoundments. Based on this investigation an instream total phosphorus concentration of 0.020 - 0.022 mg/liter was identified as protective of designated uses for New England rivers and streams. The development of this New England-wide total phosphorus concentration was based on more recent data than the National Ecoregional nutrient criteria and have been subject to quality assurance measures. Additionally, the development of the New England-wide concentration included reference conditions for waters presumed to be protective of designated uses.

Wastewater contains phosphorus concentrations in the range of 6-12 mg/liter (MADEP, 2018). According to USEPA the best available technology in treatment plants can potentially reduce phosphorus levels in effluent to 0.2 mg/liter. This concentration of 0.2 mg/liter is ten times higher than the maximum stream threshold of 0.02 mg/liter.

Based upon the proposed wastewater flow (25,520 gallons/day) and an assumed (best case) phosphorus concentration of 0.2 mg/liter relative to the base flows in Sawmill Brook (12,180 gallons/day) the project will result in a phosphorus concentration of 0.14 mg/liter in the stream. This would exceed the USEPA criteria of 0.02 mg/liter by a factor of seven (7) times. This calculation also assumes that the existing phosphorus concentration in the stream is zero and there are no other phosphorus sources in the watershed.

6. Thermal Impacts: As indicated earlier the project site is surrounded on three sides by Sawmill Brook. Sawmill Brook is classified as a coldwater fishery by the Commonwealth of Massachusetts (see attached figure 4).

According to a fish survey conducted by the state Department of Fish and Wildlife in August, 2019, there is a confirmed population of native (i.e., not stocked) brook trout in Sawmill Brook. The stream may include anadromous species that spend a portion of their lifecycle at sea, or so-called "sea run brook trout." This finding is extremely rare; according to the Sea Run Brook Trout Coalition based in Newburyport, this is the only known population of native brook trout north of Boston or in Southern New Hampshire, and the stream may eventually serve as a resource for the reintroduction of native brook trout to North Shore streams where populations have been extirpated due to drought events.

According to a 2015 Fact Sheet published by the Department of Fish and Wildlife:

> *The eastern populations [of Brook Trout] have declined, and today only a few geographically isolated populations remain. Likewise, salter Brook Trout that were historically found in one or two tributaries to Massachusetts Bay have been extirpated. The remnant Brook Trout populations in eastern Massachusetts are indicators of the location of relatively undisturbed environments. Their continued presence serves as a barometer for measuring the condition of the environment for the trout and other organisms that require cold clean water.*
>
> *Any activities which decrease water quality, increase temperature or cause siltation of spawning habitat are detrimental to this sensitive species.*

See, Brook Trout, *Salvelinus fontinalis*, Fact Sheet 2015, attached as Exhibit A.

Water quality testing has confirmed that the stream, if preserved, will continue to support this fragile resource. According to the Massachusetts Surface Water Quality Regulations (314 CMR 4.00), coldwater fisheries must be protected from thermal impacts and temperature changes of more than 3 degrees F. The Regulations state, "the rise in temperature due to a discharge shall not exceed 3°F (1.7°0C) in rivers and streams designated as coldwater fisheries (314 CMR 4.05 (3)(b)).

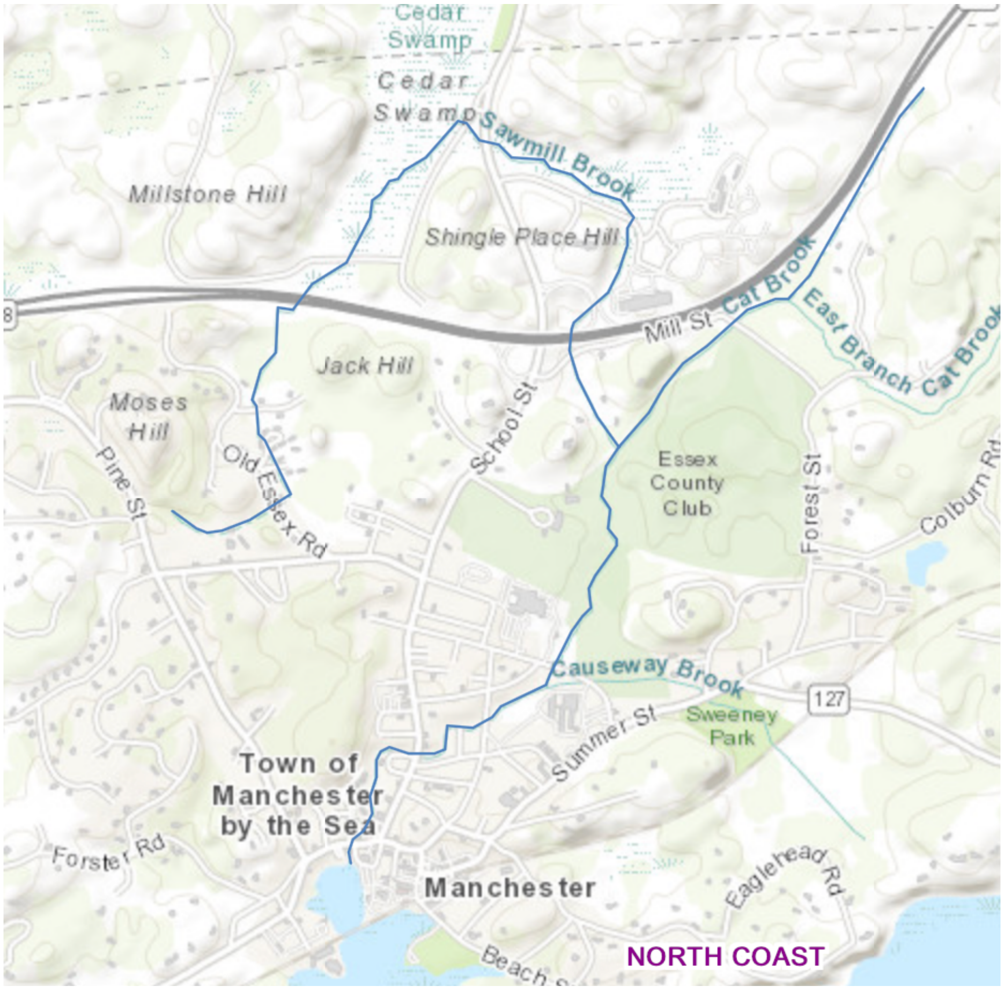

Figure 4 - Coldwater Fishery (MA Division of Fisheries and Wildlife)

The proposed project will discharge approximately 25,520 gallons/day of wastewater at elevated temperatures. This effluent will flow downgradient in the subsurface groundwater environment as a concentrated plume insulated from surface temperatures and with little mixing with surrounding groundwater. It will likely discharge into the Sawmill Brook which has an estimate 7Q10 flow of 12,182 gallons/day.

The USGS studied the thermal impacts of a wastewater treatment plant on Cape Cod (Leblanc, 1984). This study indicated that the thermal area of contamination (referred to as a plume) in groundwater associated with the wastewater discharge was detectable 2600 feet from the discharge location. The temperature of groundwater in the center of the plume was measured at 14 degrees C compared to ambient groundwater was 9.5 - 11.0 degrees C. This indicated an increase of 3.0 - 4.5 degrees C (or 5 – 8 degrees F).

Considering the proposed wastewater discharge of 25,520 gallons/day and a baseflow of 12,180 gallons/day (a ratio of approximately 2 parts wastewater – 1 part stream) within Sawmill Brook, the Massachusetts regulatory standard limiting increases to 3 degrees F in coldwater fishery streams and the potential for a 5 – 8 degree F increase in temperatures a thermal impact analysis is warranted.

7. The proposed wastewater treatment plant will discharge contaminants of emerging concern (CECs) including PFAS. Recent studies being conducted by MADEP and others are showing that concentrated wastewater discharges contain an increasing list of contaminants of emerging concern (CECs). These include pharmaceuticals (that pass through the human body), flame retardants (washed from clothing and other fabrics), and most recently PFAS compounds (found in non-stick cookware and other household sources).

Considering this information in context with the proposed wastewater flow volumes relative to the 7Q10 flows in Sawmill Brook and its contribution to the town's drinking water well at Lincoln Street, there is clearly the need for an in depth water quality impact assessment that includes CECs.

Summary and Recommendations:

1. Test pit data for all test pits on the project site should be provided. This should include an explanation as to why this information was deleted from current "existing conditions" site plan.

2. Additional test pits are required within the footprints of the proposed stormwater and wastewater infiltration facilities.

3. A conservative assessment of maximum groundwater levels is required. It should be based upon multiple methods including soil logging (redox features), monthly measured water levels throughout the fall, winter, and spring seasons in observation wells, and comparison with long-term data from USGS index wells.

4. A water table map should be prepared showing groundwater flow directions and discharge areas. This should be based upon the above monthly measured water levels in observation wells.

5. Permeability tests should be conducted for saturated hydraulic conductivity. This is required for groundwater modeling.

6. Groundwater modeling using the USGS code MOFLOW should be conducted for both long-term (steady state) changes in water levels associated with increased annual recharge rates AND event-based groundwater mounding associated with 10, 25, and 100-year storm events. This modeling should evaluate the interactive impacts between the proposed wastewater and stormwater infiltration facilities.

7. Water quality impact assessments should be conducted for nutrients (nitrogen and phosphorus), pathogens (bacteria and viruses), temperature (thermal), and contaminants of emerging concern (CECs).

8. Input variables used in the above-described modeling and assessments should be based upon on-site data to extent possible and conservative assumptions (using the precautionary principle) should be made. Sensitivity analyses that show ranges of model outcomes using various inputs/assumptions should be provided.

Thank you for the opportunity to provide these comments. Please contact me directly with any questions that you might have.

Sincerely and respectfully,

Scott W. Horsley
Water Resources Consultant