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Civil & Traffic Engineers • Surveyors • Planners • Landscape Architects

F. A. Hesketh
& Associates, Inc.

August 29, 2016

Jennifer Kaufman
Inland Wetland Agent
Town of Mansfield
4 South Eagleville Road
Mansfield, CT 06268

Re: The Lodges-- IWA Application W1564
Response to August 12, 2016 Memo

Dear Ms. Kaufman:

Below, we have provided responses to the four (4) comments/questions raised in the memo addressed to you from Mary Harper, a member of the Conservation Commission, dated August 12, 2016. Our responses are numbered following the order presented in the memo.

Comment No. 1:

The memo raises a number of questions regarding the soil types found on the property and how they have been depicted on the application plan set. Reference is made to Sheet IW-1, the NRCS soils map and a 2007 soils report prepared by John P. Ianni, a certified soil scientist, who previously provided consulting services for the project. Regarding Sheet IW-1, in accordance with the required application items listed in the town wetland regulations, the upland soil types were included on this plan based on an interpretation of the NRCS map and the limits of wetland soils were shown taken from the defined limits included on the recently approved official wetlands map for the property. In order to clear up any confusion on this issue, we have revised Sheet IW-1 to more clearly define the soil type boundaries and have also added the wetland soil types to the soil classification table listed on the plan (see attached Sheet IW-1, revised 8/30/16).

It is widely understood that the USDA-NRCS Soil Survey maps are a coarse-scale representation of soil mapping units in the landscape, with an emphasis on agricultural uses. NRCS soil scientists would map hundreds of acres per day. While the soil survey maps are valuable for planning purposes, they are not accurate enough for final site design. That is why the project team's soil scientist accurately delineated the limits of poorly and very poorly drained soils on the property, which were then surveyed and plotted on the plans. This is also the reason why project team members, including the soil scientist of record, Mr. George Logan, inspected the upland soils within the development envelope, and found them to be generally consistent with the types of soils identified in the NRCS soil survey, even though the limits of the soil series may differ considerably in the field as compared to those seen on the less accurate NRCS soil survey map.

It must be noted that the limits of the different types of soils are a matter of some interpretation since it is not possible to directly translate the limits depicted on the NRCS map, or other similar reference source mapping, to the plan set due to a lack of common mapping scale, loss of accuracy because of previous reproduction/reprographics inconsistences and recognition of obvious topographical features found on a specific property that affect the drawing of the limits on the plan. Site planners often refer to the NRCS map and other available soil reference materials as tools during the undertaking of an initial general analysis of soil characteristics in concert with the start of the preliminary planning phase for a given site and generally do not do any type of detailed calculations or final site design based heavily on this data. The only soil types on the property that have been defined precisely are the limits of wetland soils shown which were flagged in the field by the soil scientist and located by the project land surveyors.

Responding to another question raised, the point at which the referenced cross culvert under Hunting Lodge Road enters the northeast corner of the property is shown on the plan set and is discussed in the various reports presented with the application. The discharge from this culvert does continue to the west in a poorly defined channel which intersects with the significant north-south wetland and intermittent watercourse corridor which exits the site in the southeasterly corner of the property. No development is proposed that would have any effect on this existing condition.

A question is raised as to the likelihood that infiltrated stormwater runoff could possibly break out further downstream after traveling through the soil profile for some distance particularly during high water table seasons. The purpose of installing the infiltrator systems is to replenish the groundwater flow that will be lost with the introduction of upstream impervious cover. Therefore, any breakout that could occur even under the most severe seasonal conditions would only be replicating existing conditions.

<u>Comments No. 2 & 3:</u>

Our responses to Comments No. 2 and 3 have been combined since we believe both comments raise essentially the same concerns and questions regarding the suitability of the on-site soils to allow infiltration to successfully occur from the proposed stormwater infiltrator systems and the bio-retention basins. First, no one is disputing that the underlying soil types do present a challenge to the designers to successfully introduce the concept of infiltration into the overall stormwater management system for the project. This is a design goal for the design of the stormwater management plan for the project to address the issues of water quality treatment and replenishment of current groundwater recharge lost by the installation of impervious surfaces throughout the project site.

It should be noted that the macro stormwater hydrologic analysis completed for the project including all the computer modeling does not include any effects realized by the inclusion of infiltrator units or bio-retention basins in the system. The infiltrators are treated in the calculations as detention devices similar to above ground detention basins or watertight underground chambers or solid pipe systems. Therefore, achieving the design goal for post-development conditions of reducing peak flow rates leaving the developed site to downstream watersheds for all design storm events is not dependent on reducing runoff from the site by retaining and infiltrating the runoff on site. This results in a very conservative design, especially once the positive effects of the infiltrators are factored in.

It is our opinion that the design of the infiltrator systems and the use of the bio-retention basins will prove to be very successful in accomplishing our design goals. Each component of the proposed infiltrator systems has been carefully placed throughout the development based on detailed field inspections and soil testing that included deep hole tests and the conduct of permeability testing for each system location. The proper location for each of the bio-retention basins was determined in the field by our soil scientist George Logan, based on his field observations. As noted in our response to Comment No. 1 above, the use of soil type delineations based on the NRCS soil map or other printed reference materials is simply not accurate enough for any level of detailed analysis or design. A detailed summary of the soil testing completed and the design parameters used was presented in our written responses to GEI comments dated June 17, 2016. A copy of the table included in that response is attached.

The specific location and depth at which the bottom of the proposed infiltrator systems and bio-retention basins are set at take into account the detailed soil observations completed in the field at each proposed location. For some of the systems, we will install an underdrain system upstream of the infiltrator field or at the bottom of a bio-retention basin to ensure that the seasonal groundwater elevation is maintained at the assumed design grade. The discharge of flow from these underdrains will be day-lighted to the surface in a conventional manner based on the available topographical conditions. It should be also noted that it is our experience that once the project is completed, the seasonal high groundwater elevation will be permanently dropping in the areas where the systems are located due to the loss of surface infiltration with the installation of upstream impervious surfaces. This will further enhance the performance of the infiltrators in restoring groundwater recharge.

A question was raised in the memo regarding the permeability testing procedure used by SSES, which is the falling head permeability test method. This is an industry standard utilized for this type of soil analysis following standard ASTM protocol. There are basically two types of laboratory tests: falling head and constant head methods. Falling head method is usually used when there will be samples with a wide gradation of fine and coarse soil types as is the case on this site. An interesting article prepared by University of Toledo that presents a rather thorough explanation of the two permeability test methods is attached.

The soil testing completed by George Logan at the location of each of the proposed bio-retention basins was to answer the review question: is the seasonal high groundwater table high enough that an underdrain would be required? For bio-retention basins 1, 2, and 3, the answer was no, since these would be located in well drained soils. For the rest of the basins, to be located in moderately well drained soils, the answer was yes. The distinction between "faint" and "prominent" mottles was the soil scientist's attempt to more carefully record field conditions. Occasionally faint mottles, which typically indicate a high groundwater table for short periods of time during the wettest years, are missed.

Ms. Harper references her experience regarding a proposed 2015 residential subdivision application in Mansfield, Williams Re-subdivision (a.k.a. Williams Heights), to the subject proposal. We believe this reference is not apropos on a number of points, including the fact that the two sites are substantially different. For instance, a substantial portion of the reference re-subdivision site and contributing sub-watersheds had been disturbed in the past, apparently having a significant impact with regards to drainage patterns. The proposed project was for a large lot single family residential subdivision utilizing septic systems with a very basic stormwater management plan proposed. This is not the case at the subject site. The assertion that "many soil engineers and scientists do not consider mottling to be a reliable indicator of high seasonal water tables" is not supported by common design practice nor the design guidelines included in the Public Health Code. Soil mottling in undisturbed soils, such as those identified throughout the subject site, is a reliable indicator of seasonal high groundwater.

Comment No. 4:

At the request of GEI during the comment review period, a small riprap emergency overflow spillway was added to each of the bio-retention basins rather than relying on surface flow overtopping of the vegetated sides of the basins. The flow from the spillway will be directed to overland flow towards the receiving wetlands. We will add a detail for the spillways on the next revised set of plans. This is a minor addition to the plan details.

In summary, it is our professional opinion that there is no technical reason to conduct any additional testing or monitoring of groundwater or soil conditions on the property at this juncture. This opinion is based on our design team's experience over many years with the successful implementation of these types of infiltrator systems on many projects, combined with the exhaustive field observations and data collection already undertaken by the design professionals over the past 10 years. Further, given the flexibility in the design and installation options available for these types of systems, minor adjustments in the field to enhance performance can be completed at the time of installation based on any unanticipated conditions encountered.

Very truly yours,

F. A. Hesketh & Associates, Inc.

David S. Ziaks, P.E.

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The University of Toledo
Soil Mechanics Laboratory

Permeability Testing - [1]Constant and Falling Head Tests

Introduction

In 1856 the French engineer Henri D'arcy demonstrated by experiment that it is possible to relate the discharge rate of water flowing from a soil to the hydraulic or total head gradient in the soil and a property of the soil which we refer to as the coefficient of permeability or the hydraulic conductivity (Equation 1). Darcy's Law, as it is called, is a very useful law because it is not possible to derive a theoretical law for the flow of water in soil. Soils samples are tested in the laboratory using constant head or falling head test procedures in order to obtain the coefficient of permeability. The coefficient of permeability is used to compute the quantity of flow for all types of flow problems in soil where laminar flow conditions exist.

Darcy's Law

$$q = k \cdot i \cdot A \qquad (1)$$

where
q = discharge rate (L^3/T)
k = coefficient of permeability (L/T)
i = hydraulic (total head) gradient = h / L, (L/L)
A = cross-sectional area of the soil sample (L^2)

Apparatus

1. Funnel
2. Pan
3. Balance
4. Permeameter
5. Constant head tank
6. Manometers
7. Overflow flask
8. Graduated flask
9. Timing Device
10. Thermometer

[1] ASTM D 2434 – 1968 (Reapproved 1994)

Procedure

A. Preparation

1) Obtain the mass of the permeameter.
2) Carefully place and compact the dry soil in the permeameter in 3 to 5 layers. Level the top surface of the soil by applying a small pressure to the porous stone.
3) Measure the height of the compacted soil. This is equal to L for the computing the total volume of soil.
4) Measure the distance from the top manometer tube to the top of the bottom porous stone. This is the length L for the falling head test.
5) Measure the mass of the permeameter and the dry soil.

B. Constant Head Permeability Test

1) Assemble the permeameter and attach the manometer tubing to the side of the permeameter. Attach the tubing from the constant head supply to the top of the permeameter. Attach the exit tubing to the bottom of the permeameter and place the other end in the overflow flask.
2) Open the valves to the permeameter and slowly add water to the constant head tank to saturate the soil sample.
3) Open the clamps on the manometer tubes.
4) Adjust the rate of flow and allow the flow to reach a stable head condition, i.e. water levels in the manometer remain constant. Record the water levels in the manometers as h_1 (near the top of the soil) and h_2 (near the bottom of the soil).
5) Measure and record the discharge q and the time t.
6) Repeat the steps 3 and 4 two additional times using different values of h_1 and h_2 (total head difference), which can be achieved by adjusting the overflow level of the discharge.

C. Falling Head Permeability Test

1) Close the clamp on the bottom manometer tube.
2) Place the overflow flask adjacent to the manometer scale so that the water level can be read on the manometer scale. Record this as the reading of the discharge level, R_d.
3) Close the valve on the bottom of the permeameter cell and allow the top manometer tube to fill with water. Close the valve to the top of the permeameter.
4) Obtain the reading on the top manometer scale. Record this reading as R_1.
5) With one person watching the manometer and another person timing, open the valve to the bottom of the permeameter and measure the time for the water to flow from level 1 to level 2. Record these as R_2 and t.
6) Close the valve to the bottom of the permeameter and open the valve to the top of the permeameter in order to add water to the top manometer tube. Repeat the test two additional times (steps 4 and 5) using different water levels (R_1 and R_2) in the manometer tubes.

Calculations
Compute average values of permeability obtained from both the constant and falling head tests using Equations 2 and 3 and Table 1. Compute the void ratio of the soil using Equation 4 and the data in Table 2.

Constant Head Test

$$k = \frac{QL}{hAt} \tag{2}$$

Where

Q = total discharge volume (L^3);

L = length of the soil sample between the manometers (L);

h = total head difference measured on the manometers (L);

A = cross-sectional area of the soil sample (L^2).

Falling Head Test

$$k = \frac{aL}{At} \ln\left(\frac{h_1}{h_2}\right) \tag{3}$$

Where

a = cross-sectional area of the standpipe (L^2);

L = length of soil sample measured from the top manometer to the bottom of the soil;

t = time increment for measuring flow for constant head test or time for water to fall from h_1 to h_2 for falling head test (T);

h_1, h_2 = total head at time t_1 and t_2 (L).

Void Ratio

$$e = \frac{G_s \gamma_w}{\gamma_{dry}} - 1 \tag{4}$$

Results

For the constant head test, compute the discharge velocity (v = Q / A x t) and total head gradient (i = h/L). Plot discharge velocity versus total head gradient for the constant head test using Figure 1. Obtain the slope of the best-fit line.

Conclusions

Is the permeability representative of the type of soil tested in the laboratory?
Compare the average values of permeability from the two tests.
For the constant head test, compare the average permeability and the slope of the best-fit line from the graph of discharge velocity versus total head gradient.
Did laminar flow occur for the test? Explain.

Table 1- Constant and Falling Head Permeability

Permeability Test	**Group** ________	**Date** __________	
Soil Description			
Weight of Dry Soil	(lb.)		
Diameter of Permeameter	3.0 Inch		
Area of Soil Sample	$(\text{Inch})^2$	$(\text{cm})^2$	
Total Length of Soil Sample	(Inch)		
Dry Unit Weight	(lb/ft^3)		
Specific Gravity (Assumed)	2.65	Void Ratio =	
Soil Length for Falling Head Test, L	10.0 (cm)		
Manometer Tube Spacing (= L for CHT)	7.6 (cm)		
Constant Head Test (CHT)	Trial 1	Trial 2	Trial 3
Time, t (sec)			
Discharge, Q (cm^3)			
Water Level in Manometer, h_1(cm)			
Water Level in Manometer, h_2(cm)			
Total Head Difference, $h_1 - h_2$ (cm)			
Coefficient of Permeability, k (cm/sec)			
Average value of k (cm/sec)			
Discharge Velocity, Q/(Ax t) (cm/sec)			
Gradient, i = h/L			
Slope of Best-Fit Line (cm/sec)			
Falling Head Test (FHT)	Trial 1	Trial 2	Trial 3
Area of Inlet Tube, a (cm^2)	0.32	0.32	0.32
Length of Soil Sample, L (cm)			
Elapsed Time, t (sec)			
Reading of discharge level, R_d (mm)			
Reading at start of test, R_1 (mm)			
Reading at end of test, R_2 (mm)			
$h_1 = R_1 - R_d$ (mm)			
$h_2 = R_2 - R_d$ (mm)			
Coefficient of Permeability, k (cm/sec)			
Average value of k (cm/sec)			

Table 2- Data for Computing Void Ratio

Cell Number	1	2	3	4
Weight of Dry Soil (W_s) (lb)	2.46	2.42	2.41	2.47
Total Length of Soil Sample (inch)	4.74	5.57	5.04	5.13

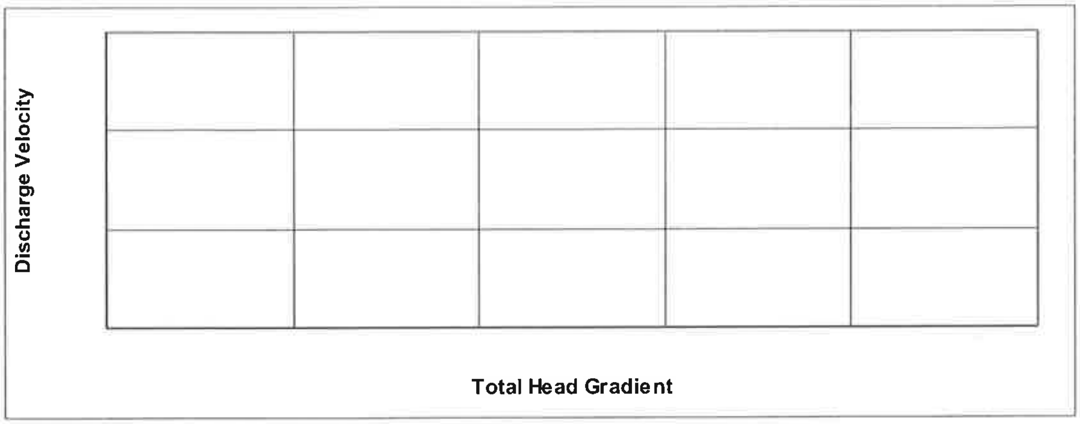
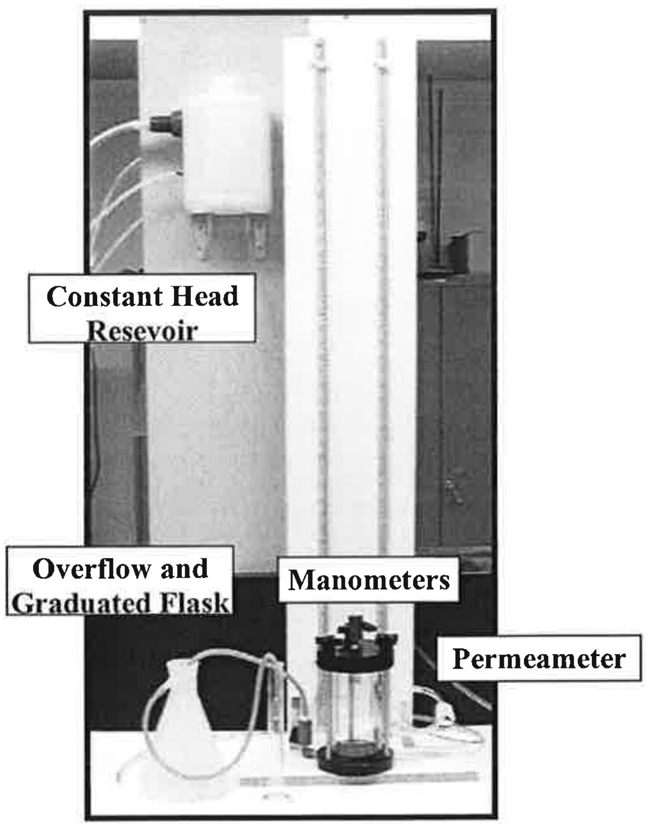


Figure 1 – Discharge Velocity Vs. Total Head Gradient (Constant Head Test)



Picture 1 – Permeability Apparatus

TAKEN FROM JUNE 17 RESPONSES BY FAHA

Attachment A – Response to GEI Comment # 3:

Design Assumptions for Stormwater Infiltrator Systems:

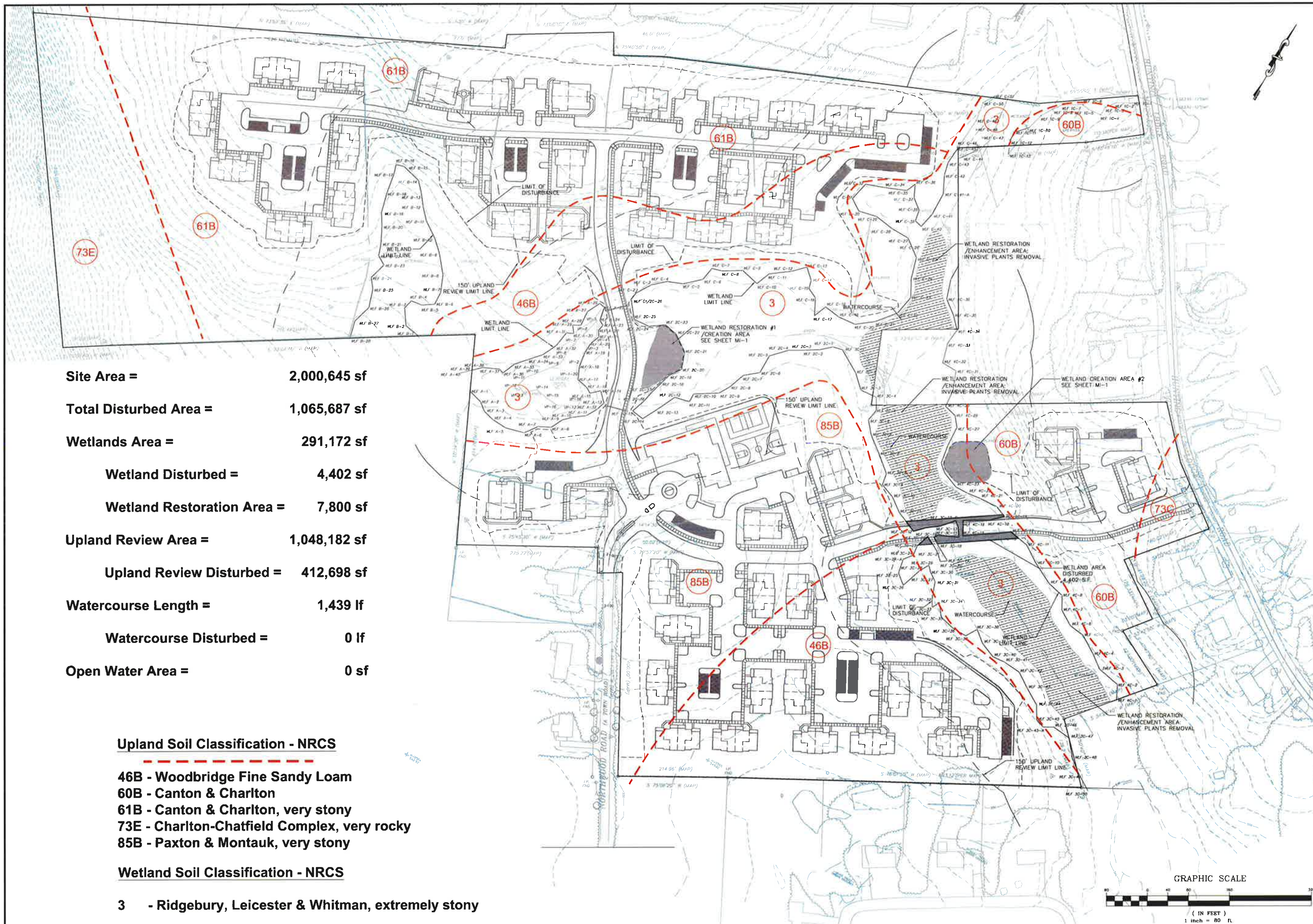
- No credit was taken in the macro model calculations for infiltration or ~~other LID~~ design techniques that are included in the proposed site drainage system design. To be conservative, the drainage model treats all pavement types as impervious. The actual peak rates of runoff generated for all storm events will therefore be actually less than projected in the macro model results.
- The purpose of incorporating infiltrator systems in the site stormwater management design was to provide the opportunity for groundwater recharge to the extent possible. Since the existing soils are mixture of B and C horizons, it appears that this is a prudent design approach. The infiltrator systems combined with the bio-retention basins provide sufficient volume for WQV and GRV as defined by the CTDEEP.
- Based on the field testing recently conducted, it appears that extended period of high groundwater is not a concern where the system units are proposed. In general, permeability rates are more than sufficient throughout the first 3-5 feet of soil and there is no true hardpan cutoff layer of soil but a somewhat compact, complex C horizon comprised of coarse gravelly and sandy loams starting at about 3 feet below existing surface and continuing down to 7-8 feet. Except for one location downstream of Test Pit #1, no ledge was detected in the deep test pits conducted. Given the size of the excavator used for the testing, it was not possible to determine if this was ledge refusal or just a local heavy concentration of compacted very boney material.
- In addition to the infiltration flow from the units to the surrounding soils, the outlets from the systems are regulated by a weir placed in the outlet control structures which is set to allow the units to drain completely between storm events.
- Generally speaking, the GW elevations in developed areas will drop below their historic levels due to cut-off of surface recharge to the underlying groundwater table.
- Below is a summary of the assumed design parameters for placement of the seven (7) infiltrator unit systems.

System #	Average Existing Grade	Assumed GW Elev. (1)	Observed Seepage (1)	Bottom of Units	Avg. Perm Rate (2)
VIII-A	565.0	5.0	8.0	560.0	8.8
II-A	565.5	3.6 (3)	5.0	562.0	6.1
IV-A	553.5	3.0	4.0	552.0	15.6
VI-A	555.0	4.0	n/a	550.0	5.0
VII-A	551.0	4.0	n/a	548.0	9.5
X-A	558.5	3.0	5.5	556.0	6.3
IX-A	553.0	3.0	5.1	551.67	4.5

(1) Based on an interpretation of the data recorded for observed faint to darker mottling, indications of any seepage in the deep hole tests and general field observations.

(2) Feet./Day

(3) Underdrain provided upstream of system to reduce GW below 561.0.



Site Area =	2,000,645 sf
Total Disturbed Area =	1,065,687 sf
Wetlands Area =	291,172 sf
Wetland Disturbed =	4,402 sf
Wetland Restoration Area =	7,800 sf
Upland Review Area =	1,048,182 sf
Upland Review Disturbed =	412,698 sf
Watercourse Length =	1,439 lf
Watercourse Disturbed =	0 lf
Open Water Area =	0 sf

Upland Soil Classification - NRCS

46B - Woodbridge Fine Sandy Loam
60B - Canton & Charlton
61B - Canton & Charlton, very stony
73E - Charlton-Chatfield Complex, very rocky
85B - Paxton & Montauk, very stony

Wetland Soil Classification - NRCS

3 - Ridgebury, Leicester & Whitman, extremely stony

THE LODGES AT STORRS

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Revisions:

No.	Date	Description
1	06-10-2016	Town comments
2	08-30-2016	Add Wetland Soil Types

INLAND WETLANDS PLAN
PREPARED FOR
STORRS LODGES, LLC
HUNTING LODGE ROAD
MANSFIELD, CONNECTICUT

Date: 03-18-16	Drawn by: CAD	Job no: 04161
Scale: 1" = 80'	Checked by: DSZ	Sheet no: 1 OF 1

IW-1