April 30, 2014

Westford Planning Commission
Attn: Melissa Manka, Planning Coordinator
Westford Town Office
1713 VT Route 128
Westford, Vermont 05494

STONE ENVIRONMENTAL INC

535 Stone Cutters Way
Montpelier, Vermont
05602 USA

Phone / 802.229.4541
Fax / 802.229.5417
Web Site / www.stone-env.com

Stone Project No. 13-224

Re: Site Specific Community Wastewater Capacity Soil Study /
Tests in the Town Common Area

Dear Melissa:

We are pleased to provide the results of field and desktop analysis of the potential onsite wastewater treatment capacity of three properties located near Westford's Town Common: the United Church of Westford property; the portion of the Town Common located between Brookside Road and White Church Lane; and the Brick Meeting House. This work was completed to support the Westford Planning Commission's continued exploration of ways to build capacity to accommodate focused and appropriate development in the Town Center, and is part of the ongoing Municipal Planning Grant-funded *Town Center Revitalization Project and Visual Preference Survey*, currently being conducted with the assistance of PlaceSense of Port Henry, New York. While the soils underlying the Brick Meeting House property and the Town-owned land were generally not suitable for the construction of new onsite wastewater treatment systems, a small area of suitable soils was located on the United Church of Westford property. This area may support a new onsite wastewater system with a capacity of at least 1,220 gallons per day, if further testing confirms the results of the preliminary field investigation.

Sources of information consulted to complete the analyses included:

- Site Plan Sheet C-1, Brick Meeting House Wastewater Disposal System, prepared by Champlain Consulting Engineers Inc. and dated December 15, 1997.
- Letter and supporting data from Civil Engineering Associates, Inc. to Ira Allen of the Westford Selectboard regarding the Spiller Property Wastewater Investigation, dated October 16, 2012.
- *Study of Community Wastewater Disposal Alternatives for the Town Center, Westford, Vermont*, final report prepared by Stone Environmental, Inc., Green Mountain Engineering, Inc., and Yellow Wood Associates, Inc., dated March 21, 2008.
- LiDAR data for the 1,200-foot buffer surrounding the Browns River, dated August 2007; acquired by Stone in April 2014. Metadata available at http://maps.vcgi.org/gisdata/metadata/ElevationOther_LiDAR_Chittenden_Floodplain_2007.htm.
- ANR Natural Resources Atlas and Well Locator mapping database, http://anrmaps.vermont.gov/websites/anra/, as accessed on April 30, 2014.

- Pre-marked soil testing locations, chosen during a site meeting attended by Amy Macrellis of Stone Environmental, Inc., Melissa Manka of the Town of Westford, and several members of the Westford Planning Commission on March 19, 2014.
- Hand-completed soil auger test holes completed by Amy Macrellis of Stone Environmental, Inc. on April 29, 2014.
- GPS locations of soil auger test holes and bedrock outcrops, completed by Amy Macrellis of Stone Environmental, Inc. on April 29, 2014.

Site Descriptions and Field Soil Characterization Results

United Church of Westford

The property, located at 21 Brookside Road, is approximately 2.0 acres in size with an existing church and a small gravel parking area. The eastern portion of the site is underlain by shallow bedrock, and a ridge of bedrock outcrops on a north-south line behind the church building. West of the bedrock ridge, the site slopes gently for 75-100 feet before dropping more steeply to the west towards along the western edge of the terrace down to an unnamed tributary to the Browns River. The undeveloped, western portion of the site contains scattered evergreen and deciduous trees. According to the Soil Survey of Chittenden County, Vermont (USDA-SCS, 1969), well-drained Stetson gravelly fine sandy loams underlie much of the sloping terrace west of the bedrock ridge. However, the eastern portion of the property is mapped as Lyman-Marlow rocky loams (poorly drained and underlain by shallow bedrock), and the westernmost, steeply sloping area of the property is underlain by silty to clayey terrace escarpments. There is an existing holding tank east of the parking lot currently serving the church. The property's water comes from a drilled well located near the southeast corner of the church building.

Four locations on this site (AH-1 through AH-4) were pre-marked during the March 19, 2014 Planning Commission meeting. Ten soil auger tests, AH-1 through AH-10, were advanced by hand in the central, gently sloping portion of the property, where the soil survey indicated suitable soils were potentially located. The soil tests were 7-96 inches (0.6- 8.0 feet) deep. The soil test logs are attached, and test locations are shown on the site plan (Figure 1).

The soil auger tests revealed a great deal of variability in the soils on this property. Of the four pre-marked locations, only the southern location (AH-1) was underlain by well-drained fine sandy loam to loamy sand to bedrock at a depth of 67 inches (5.6 feet), consistent with the mapped Stetson series soils (attached soil logs and Figure 1). The other three pre-marked test locations on the terrace to the north of AH-1 consisted of silty clay loam to clay loam, with no discernable forest duff layer and indications of seasonal high groundwater high in the soil profile (4-7 inches below ground surface). A visual observation of the presence or absence of the forest duff layer in the area between AH-1 and AH-2 was used to initially constrain the area of well-drained soils (Figure 1). Six additional soil tests (AH-5 through AH-10) were then advanced in the vicinity of AH-1 to better characterize the extent of the well-drained soils. A small area of loamy sand to very fine sandy loam soils was defined in the area of AH-1, AH-5, AH-6, AH-7, and AH-9. Limiting conditions encountered in these test holes included indications of seasonal high groundwater at depths ranging from 36 inches (3.0 feet) at AH-9 to 64 inches (5.3 feet) at AH-1, and refusal (likely bedrock) at depths ranging from 36 inches (3.0 feet) at AH-5 to greater than 96 inches (8.0 feet) at AH-7.

The best possible option for wastewater disposal on this property is in the areas of test pits AH-1, AH-5, AH-6, AH-7, and AH-9, parallel to the bedrock ridge running from north to south across the property. After accounting for a 25-foot separation from areas of unsuitable soils, an oblong area approximately 50 feet wide by 120 feet long (6,180 ft^2) is potentially available for wastewater disposal. This area is additionally limited by the presence of bedrock at its eastern edge, but may be increased somewhat if additional testing to the south proves that the area of suitable soils continues past the existing tests and/or the south property boundary. The presence of nearby private water supplies, especially on the abutting property to the south, may also substantially constrain the land area that is available for wastewater disposal.

Town Common

This undeveloped, Town-owned property, located east of the United Church of Westford between White Church Lane and Brookside Road, is approximately 1.2 acres in size. According to the Soil Survey of Chittenden County, Vermont (USDA-SCS, 1969), the western portion of the property is mapped as Lyman-Marlow rocky loams (poorly drained and underlain by shallow bedrock), and the eastern area of the property is underlain by Munson and Raynham silt loam (poorly drained, but not underlain by shallow bedrock). While there is no existing development on the property, there is an existing private spring water supply located on the northern end of the parcel.

Two locations on this site were pre-marked during the March 19, 2014 Planning Commission meeting. Two soil auger tests, AH-11 and AH-12, were advanced by hand in the southern portion of the property to confirm the soil survey data. The soil tests were 9 inches (0.75 feet) deep. The soil test logs are attached, and test locations are shown on the site plan (Figure 1).

The soil auger tests revealed that conditions on this site are consistent with the soil survey. At both locations, the soils consisted of clay loam, with indications of seasonal high groundwater high in the soil profile (4 inches below ground surface). These conditions are not suitable for onsite wastewater treatment.

Brick Meeting House

The property, located at 1685 Vermont Route 128, is approximately 0.6 acres in size with an existing meeting hall, an outbuilding, and a small parking area. Most of the property is flat, with the eastern portion of the site dropping more steeply to the east, down to the Browns River. According to the Soil Survey of Chittenden County, Vermont (USDA-SCS, 1969), the western two-thirds of the site are underlain by Munson and Raynham silt loam (poorly drained, but not underlain by shallow bedrock). The eastern portion of the property is mapped as Munson and Belgrade silt loams, 12 to 25 percent slopes (poorly drained and steeply sloping, but underlain by shallow bedrock). There is an existing wastewater treatment system located off the northeast corner of the meeting house. A permit (DEC Wastewater System and Potable Water Supply permit number WW-4-1173) was granted in 1997 for construction of a replacement wastewater system, but as the existing system has not failed, the replacement has not been constructed. The property's water comes from a drilled well located on the parcel to the north of the Brick Meeting House.

Four locations on this site were pre-marked during the March 19, 2014 Planning Commission meeting. Four soil auger tests, AH-13 through AH-16, were advanced by hand to confirm the soil survey data. The soil tests were 9-22 inches (0.75-1.8 feet) deep. The soil test logs are attached, and test locations are shown on the site plan (Figure 1).

The soil auger tests revealed that conditions on this site are generally consistent with the soil survey. At AH-13, 14, and 15, the soils consisted of compact silt to clay loam, with indications of seasonal high groundwater high in the soil profile (4 inches below ground surface). These conditions are not suitable for onsite wastewater treatment. The final soil test at AH-16 revealed very stony sandy loam to fine sandy loam soils with no indications of seasonal high groundwater to a depth of 22 inches below ground surface, where the soil auger was refused on a large stone.

If further testing is completed with larger equipment that indicates these conditions continue deeper into the soil profile, the area near AH-16 may prove suitable for constructing a system with capacity similar to the already-permitted replacement system for the Brick Meeting House. However, such construction would necessitate the destruction of the existing outbuilding, and the system constructed would, at maximum, only supply capacity for the continued use of the Brick Meeting House (currently permitted at 480 gallons per day).

Capacity Analysis for the United Church of Westford Site

The best possible option for wastewater disposal on this property is in the areas of test holes AH-1, AH-5, AH-6, AH-7, and AH-9, parallel to the bedrock ridge running from north to south across the property. After accounting for a 25-foot separation from areas of unsuitable soils, an oblong area approximately 50 feet wide by 120 feet long (6,180 ft^2) is potentially available for wastewater disposal on the parcel. This area is additionally limited by the presence of bedrock at its eastern edge, but may be increased somewhat if additional testing to the south proves that the area of suitable soils continues past the existing tests and/or the south property boundary.

In order to estimate the hydraulic capacity of the potential wastewater dispersal site on the United Church of Westford property, we used a conservative method called Darcy's Law. This formula is represented as Q = KiA where

> Q = design flow (gallons/day)(gpd)
> K = hydraulic conductivity (ft./day)
> i = hydraulic gradient (slope of water table)
> A = transmitting soil cross-sectional area (square feet) = D x L where
>> D = transmitting soil thickness (depth to impeding layer or water table, minus the required separation depth, minus the system depth) (feet), and
>> L = length of the disposal system in the estimated direction of groundwater flow (feet)

We used this formula to develop a hydraulic capacity estimate, given the assumptions described below. The full calculations are included in Table 1.

1. Hydraulic conductivity (K) = 25 feet per day. Vermont DEC guidance regarding K values for the loamy sand to very fine sandy loam soil textures encountered gives a range of 25-50 feet/day.
2. Hydraulic gradient (i) = 13.0%, estimated as similar to ground surface slope from 2007 LiDAR data (12-14% in the area of suitable soils). Groundwater mounding beneath the disposal field will also slightly increase the hydraulic gradient, but we did not include an allowance for this increased slope in the capacity analysis.
3. The most limiting depths to an impeding layer (3.0 feet to bedrock at AH-5) or seasonal high water table (3.0 feet at AH-9) are assumed to be continuous across the potential disposal area.
4. Given these limiting conditions, the most feasible design that maximizes capacity will be for a filtrate mound system with the bottom of the trench, at minimum, at the ground surface. For purposes of this analysis, the system bottom is assumed to be 1.0 foot above the ground surface, and so system depth = 0.0 feet.
5. For a filtrate system, the required separation distance to seasonal high groundwater = 2.0 feet, with 1.5 feet between the induced groundwater mound and the bottom of the filtrate trench.
6. System length (L) across slope (perpendicular to contours) = 25 feet.

Based on our calculations, the available capacity for wastewater disposal in this area is on the order of 1,220 gallons per day. The site's capacity could increase somewhat if additional testing to the south proves that the area of suitable soils continues past the existing tests and/or the south property boundary. The presence of nearby private water supplies, especially on the abutting property to the south, may also severely constrain the land area that is available for wastewater disposal.

United Church of Westford Property Treatment and Disposal System

The results of the preliminary investigation identified the best possible location on this property for wastewater disposal to be behind the church, near the southern property boundary (Figure 1). An area approximately 50 feet wide by 120 feet long (6,180 ft^2) was determined to be available for wastewater disposal as shown on Figure 1. To estimate the hydraulic capacity of this area, the preliminary layout assumed the disposal area was designed as a filtrate mound using absorption trenches. Once setbacks from property lines and un-suitable soils are accounted for, a trench length of 75 feet can be located parallel to the ground contours. If the estimated capacity of 1,220 gallons per day is dosed over a 75-foot-long by 4-foot-wide trench, the resulting linear loading rate for the system is 16.26 gallons per linear foot per day. This linear loading rate is higher than 4.5 gallons per day, and so the state's small scale wastewater rules (Section 1-916(a)(3)(E) require that a hydrogeologic analysis be completed to demonstrate:

- The distance between the bottom of the leachfield and the seasonal high water table or induced groundwater mounding is maintained (this distance may include both naturally occurring soil and approved fill material); and
- The induced groundwater mounding is at least one foot below grade at the downhill toe of the filtrate effluent disposal system.

Mounding Analysis for the Proposed Filtrate Disposal System

The response of the water table to artificial recharge, commonly called a mounding analysis, was assessed using a two-dimensional computer simulation program based on the Hantush equation that was developed at Colorado State University (CSU) (Molden and Sunata, 1988). The purpose of the modeling exercise was to determine whether the groundwater mound induced by recharge from the proposed system will maintain the required unsaturated soil thickness between the proposed leachfield bottom and the seasonal high water table (18 inches / 1.5 feet for filtrate system effluent). A summary of inputs and assumptions relative to this application of the model are shown in Table 2, and supporting calculations are included as Table 3. A schematic diagram illustrates how the CSU model is typically set up, assuming a horizontal water table (Figure 2). This model is generally conservative due to the horizontal water table assumption; therefore, actual mounding at the site will likely be lower than the predicted one.

The wastewater dispersal system as proposed is a filtrate absorption trench measuring 4 feet wide by 75 feet long (see Table 2 and Figure 1). The field is modeled as a single infiltrative surface with flows uniformly distributed over the leachfield area.

The model requires a determination of the depth of the saturated zone which will function as the transmitting layer above any impermeable boundary. The minimum depth to the seasonal high water table observed at the site was 36 inches (3.0 feet), and the proposed filtrate mound system will provide an additional 1.0 foot of mound sand beneath the trench bottom elevation, for a total unsaturated thickness of 4.0 feet between the most limiting seasonal high water condition and the system bottom. The trench will be 12 inches deep, and covered by 4 inches of topsoil (16 inches or 1.5 feet of material). Thus, for modeling purposes, the total unsaturated thickness above the most limiting seasonal high water condition at the center of the proposed mound system is 5.5 feet, and the system is installed at a depth of 1.5 feet. Refusal that can reasonably be interpreted to represent bedrock was encountered in three soil tests: AH-1 at a depth of 5.6 feet, AH-5 at a depth of 3.0 feet, and AH-6 at a depth of 5.0 feet. Bedrock was not encountered in AH-7 (to 5.3 feet) or AH-9 (to 8.0 feet). Additionally, overburden thicknesses in wells on abutting properties immediately to the south of the United Church of Westford, as recorded in the online Vermont Natural Resources Atlas, range from 11-32 feet below ground surface (Figure 1). The geometric mean of the observed bedrock depth estimates at or near the site of 7.4 feet below the existing ground surface was assumed, as it resulted in a more conservative estimate than the arithmetic mean 9.98 feet). Thus, a saturated thickness of 4.4 feet is potentially available to transmit groundwater away from the mound site at the worst-case seasonal high groundwater condition. The mathematical solution of the CSU computer model is not valid if the estimated mound for any individual model run exceeds half of the saturated thickness.

In order to calculate a loading rate for the proposed wastewater treatment system, a volume of effluent equivalent to the proposed system's design flow was assumed to enter the system each day for the duration of the model run (Table 2). Dividing the daily loading rate by the distribution system area yields a loading rate of 0.54 feet/day for the proposed system.

Table 2: Summary of Inputs and Assumptions for Groundwater Mounding Model

Parameter	**Value**	**Comments**
Recharge Rate (ft/day)	0.54	Recharge rate was derived assuming that the proposed system was consistently loaded at its design flow (1,220 gpd).
Transmissivity (ft^2/day)	110	Transmissivity is derived from hydraulic conductivity and estimated saturated thickness. The hydraulic conductivity prescribed for use by VTDEC desktop hydrogeologic assessment guidance for the loamy sand to fine sandy loam soils encountered at the site (25 ft/day) and a saturated thickness of 4.4 ft were used in this calculation.
Specific Yield	0.2	Estimated for loamy sand to fine sandy loam soils from field investigations
Final Time (days)	3650, 7300	The final time was used to understand how the artificial recharge may affect the surrounding groundwater flow regime over long time periods (10-20 years).
Depth to Water (feet)	5.5	The most conservative depth to seasonal high water observed during field investigations (3.0 feet at AH-9) was used in this analysis. The 1 foot of mound sand beneath the trench, and 1.5 feet of cover including and above trench, were added to this number to illustrate the total unsaturated thickness above limiting condition after construction of the system.
Final Distance (feet)	150	Horizontal extent over which the mound profile is calculated.
Basin Width (feet)	4	Scaled from Figure 1
Basin Length (feet)	75	Scaled from Figure 1

The final time step of 10-20 years was chosen in order to observe the effect of long-term artificial recharge on the groundwater beneath the system. In reality, such sustained loading at the system's capacity is unlikely to occur and the groundwater mound profile and peak height will be lower than predicted.

The model scenario completed using the assumptions and inputs described above predicts the east-west and north-south mound profiles for the proposed system. For the east-west mound profile, the nearby bedrock outcrop is represented as an impermeable barrier located 25 feet to the east of the proposed infiltrative surface. The north-south mound profile was also predicted for the proposed system using the same inputs as for the east-west profile, but with the mound predicted at an angle of 90 degrees from the first scenario. The proposed system was loaded at design flow, and the resulting mound profiles are illustrated on the graphs accompanying Tables 4 and 5.

- At the final time steps of the simulation, the maximum mound height beneath the proposed system in both the east-west and north-south profiles was 2.03-2.19 feet (Tables 4 and 5, and accompanying graphs of results). Since this is less than half of the aquifer saturated thickness (full saturated thickness is 4.4 feet, so half of the saturated thickness is 2.2 feet), the model solutions are valid.
- The bottom of the filtrate trench for the east-west profile of the proposed system will be a maximum of 1.5 feet below the final ground surface (Table 4). Therefore, at least 1.81 feet of unsaturated material remains between the field bottom and the mound peak under this loading scenario.
- The 1.81 feet of unsaturated material remaining between the field bottom and the mound peak in the east-west profile is greater than the 18 inches / 1.5 feet of unsaturated material required for filtrate effluent dispersal.
- The model-predicted mound never rises to a level higher than the pre-construction ground surface.
    - Along the east-west profile with a final time step of 20 years, the model predicts a mound height of 1.88 feet at a distance 25 feet west of the mound (see graph accompanying Table 4). Given an observed depth to seasonal high groundwater of at least 3.0 feet downgradient of the system, a minimum depth of 1.12 feet (13.5 inches) of unsaturated soil will exist. Thus, at least six inches of freeboard are available at the toe of the mound and 25 feet downslope.
    - Similarly, along the north-south profile with a final time step of 20 years, the model predicts a mound height of 1.79 feet at a distance 25 feet north and south of the mound (see graph accompanying Table 5). Given an observed depth to seasonal high

groundwater of at least 3.0 feet downgradient of the system, minimum depth of 1.21 feet (14.5 inches) of unsaturated soil will exist. Thus, at least six inches of freeboard are available at the toe of the mound and 25 feet downslope.

- Although this model never completely converges to equilibrium, the very small incremental increase in maximum mound heights between the 10 and 20 year final time steps in the two model runs (0.16 feet over 10 years) indicates that the mound has essentially reached equilibrium.

Conclusions and Next Steps

In summary, our field and desktop analyses indicate that a new filtrate mound wastewater disposal system (with pre-treatment and an adsorption-trench mound dispersal field) to accommodate existing or new development with design flows of 1,220 gpd may be feasible at the United Church of Westford site. The dispersal field is predicted to have adequate capacity to accommodate this design flow while maintaining the required 18"/1.5 feet of unsaturated soil between the induced mound and the bottom of the absorption trench mound system, and to maintain adequate thicknesses of unsaturated soil at the toes and side-slopes of the mound to a distance of at least 25 feet downslope of the mound toe. This design flow would be adequate to serve the current needs of the United Church of Westford (at 150 sanctuary seats, roughly 190 gallons/day), the Westford Town Offices and Library (permitted design basis of 7 employees, 90 gallons/day), and the Brick Meeting House (permitted design basis of 66 persons, 480 gallons/day), with 460 gallons/day of capacity remaining to serve other current or future needs.

The soils at the Town Common and Brick Meeting House sites are generally not suitable for the construction and successful operation of new onsite wastewater treatment systems. A limited amount of capacity, at maximum enough to serve the current design flow of the Brick Meeting House, may exist behind the meeting house building, though this location is within the Town's Water Resource Overlay zoning district.

There are several steps to be taken in finalizing the capacity of the United Church of Westford site, keeping in mind that additional testing may increase or decrease the preliminary hydrogeologic capacity developed during this study.

1. We recommend that backhoe soils testing be conducted to verify and potentially expand the extent of suitable soils for wastewater disposal. These tests will also help determine whether there are any further limiting conditions that need to be considered in the system layout and depth.

2. Conduct percolation tests and a topographic survey of the site. Surveying the bedrock outcrop extend, and the bank slope to the west, are both important in determining final system location and the extent of bedrock removal that may be needed to connect to the leachfield location.

3. As part of the topographic survey of the site, locate and determine the current status of potable water supplies serving nearby properties. The drilled well serving the United Church of Westford is on the opposite side of the topographic divide formed by the bedrock ridge between the Church and the potential leachfield site, and thus is likely at little risk from the proposed system. However, the position of the drilled well serving the property to the south of the Church, as well as the current status of the spring located at the toe of the slope near the northwest corner of the Church property, should be verified before progressing with a final design. The horizontal isolation distances required to adequately protect these water supplies could significantly constrain the location and capacity of any wastewater disposal system on the Church property.

4. Use the site-specific topographic survey data and a preliminary disposal field design layout to refine the preliminary capacity analysis presented in this letter. The absorption trench layout presented here is conceptual only, and accounts for the amount of sand fill and cover needed only to determine hydraulic capacity. It may be difficult to successfully engineer a mound system that meets minimum grading requirements, especially for setbacks between the toe of the mound and areas of soils not suitable for onsite wastewater treatment, in the small area of suitable soils defined during this investigation.

An additional consideration for potentially increased wastewater flows is to have discussions with the adjacent property owner to the south of the United Church of Westford property. There is potential for limited additional capacity on the Church site if the 25-foot setback to the side property line could be waived with an easement, or if the abutting owner was interested in conducting soils testing on their property to determine whether there are additional suitable soils along the terrace extending south from the area defined in this study.

Sincerely yours,

Amy Macrellis

Amy Macrellis
Project Water Quality Specialist

Direct Phone / 802.229.1884
E-Mail / amacrellis@stone-env.com

Encl.

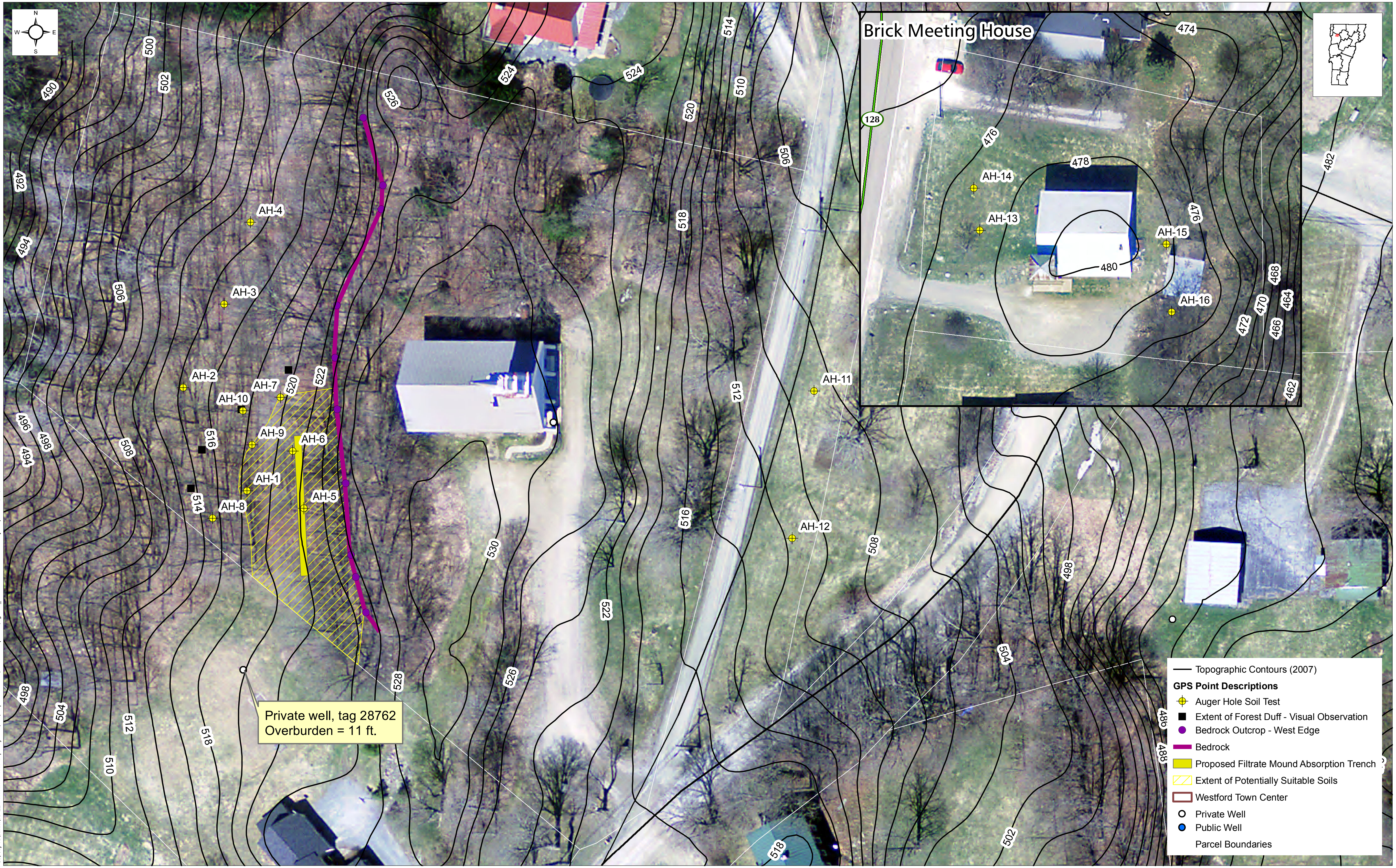

FIGURE 1: SITE MAP

Site Specific Community Wastewater Capacity Soil Study / Tests in the Town Common Area
Westford, Vermont

0 25 50 100 150 200 Feet

Sources: Hydrography, VCGI, 2008; Roads, VCGI, 2008; Digital Elevation Model, FEMA and VGCI, 2007; Parcel Boundaries, IVS, 2002; Private Well Locations; Stone Environmental, 2008 and Vermont ANR Natural Resource Atlas, 2014.

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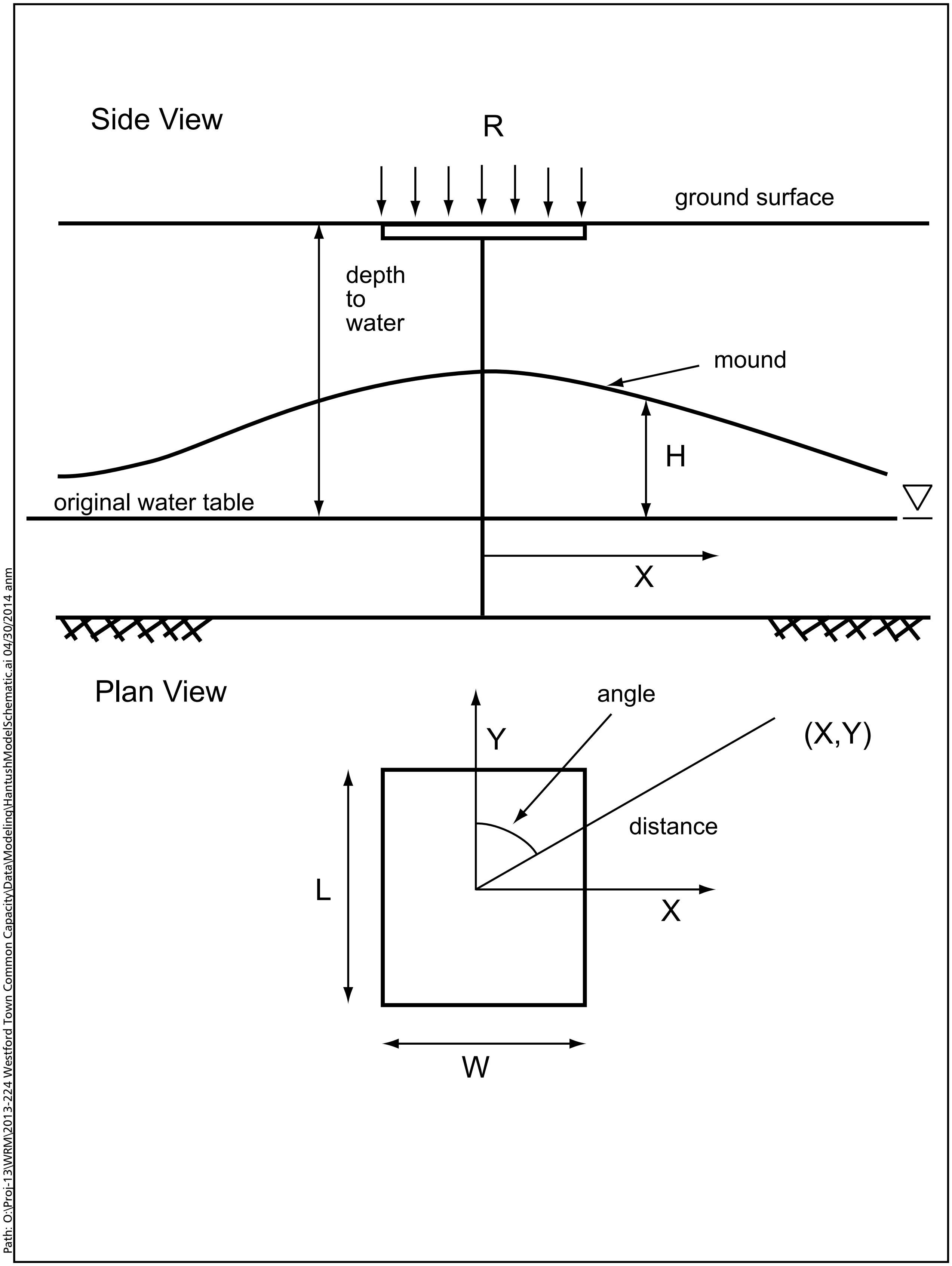

Figure 2: Schematic of Single Bed Mounding Analysis
Site Specific Community Wastewater Capacity Soil Study / Tests in the Town Common Area
Westford, Vermont

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Community Wastewater Capacity Soil Tests and Analysis in the Westford Town Common Area – Auger Hole Test Logs

Soils investigation conducted by Amy Macrellis of Stone Environmental, Inc. on April 29, 2014.

United Church of Westford site

Auger Hole AH-1

0" – 2"	Very dark brown fine sandy loam, granular structure, loose consistence, moist. Forest duff.
2" – 9"	Dark brown loamy fine sand, granular structure, loose consistence, moist. Common tree roots.
9" – 14"	Yellowish brown loamy fine sand, granular structure, loose consistence, moist.
14" – 18"	Brown loamy fine sand, granular structure, friable consistence, moist.
18" – 24"	Light olive brown loamy sand, granular structure, friable consistence, moist.
24" – 62"	Grayish brown loamy sand, granular structure, friable consistence, moist.
62" – 67"	Grayish brown loamy very fine sand, subangular blocky structure, friable consistence, moist. Few fine faint mottles along bedding planes at 64-66".

Refusal at 67" – likely bedrock. Seasonal high groundwater indicators at 64".

Auger Hole AH-2

0" – 4"	Brown silty clay loam, granular structure, loose consistence, wet. No duff or A horizon.
4" – 12"	Grayish brown clay loam, subangular blocky structure, very firm consistence, moist. Many medium prominent mottles at 6" and below.

Seasonal high groundwater indicators at 6".

Auger Hole AH-3

0" – 7"	Brown silty clay loam, granular structure, friable consistence, wet. No duff or A horizon.
7" – 16"	Grayish brown clay loam, subangular blocky structure, very firm consistence, moist. Many medium prominent mottles at 7" and below.

Seasonal high groundwater indicators at 7".

Auger Hole AH-4

0" – 7"	Grayish brown clay loam, subangular blocky structure, very firm consistence, wet. Many medium prominent mottles at 4" and below. Saturated at 6".

Seasonal high groundwater indicators at 4".

Auger Hole AH-5

0" – 3"	Dark brown very fine sandy loam, granular structure, loose consistence, moist. Forest duff.
3" – 12"	Reddish brown very fine sandy loam, granular structure, loose consistence, moist.
12" – 18"	Yellowish red very fine sandy loam, few gravel clasts, granular structure, loose consistence, moist.
18" – 28"	Brown very fine sandy loam, subangular blocky structure, friable consistence, moist.
28" – 36"	Dark yellowish brown very fine sandy loam, subangular blocky structure, friable consistence, moist. Fine roots throughout; wet at 34-36".

Refusal at 36" – likely bedrock. No seasonal high groundwater indicators.

Auger Hole AH-6

0" – 2"	Very dark brown very fine sandy loam, granular structure, loose consistence, moist. Forest duff.
2" – 8"	Brown very fine sandy loam, granular structure, loose consistence, moist. Common roots.
8" – 20"	Dark red very fine sandy loam, subangular blocky structure, friable consistence, moist. Spodic horizon at 14-18".
20" – 30"	Reddish yellow loamy very fine sand, subangular blocky structure, friable consistence, moist.
30" – 48"	Light olive brown loamy sand, subangular blocky structure, friable consistence, moist. Few interbeds of firm very fine sand at 42" with few fine faint mottles on bedding planes.
48" – 60"	Light olive brown loamy very fine sand, subangular blocky structure, friable consistence, moist. Few interbeds of firm very fine sand at 48" with few fine faint mottles on bedding planes.

Refusal at 60" – likely bedrock. Seasonal high groundwater indicators at 42".

Auger Hole AH-7

0" – 2"	Very dark brown very fine sandy loam, granular structure, loose consistence, moist. Forest duff.
2" – 12"	Strong brown very fine sandy loam, granular structure, loose consistence, moist. Common roots.
12" – 18"	Yellowish red very fine sandy loam, subangular blocky structure, loose consistence, moist. Spodic horizon.
18" – 26"	Yellowish brown loamy very fine sandy loam, subangular blocky structure, loose consistence, moist. Texture grades to silt loam at 22-26".
26" – 31"	Light olive brown silt loam, subangular blocky structure, loose consistence, moist. Texture grades to very fine sandy loam at 28".
31" – 60"	Light olive brown loamy very fine sand, subangular blocky structure, friable consistence, moist. Few interbeds of firm very fine sand at 42" with few fine faint mottles on bedding planes.
60" – 96"	Light olive brown sand, granular structure, loose consistence, moist. Texture grades to very fine sand by 78".

No refusal to 96". Seasonal high groundwater indicators at 42".

Auger Hole AH-8

0" – 2"	Dark brown very fine sandy loam, granular structure, loose consistence, moist. Forest duff.
2" – 10"	Brown very fine sandy loam, grading to silt loam, subangular blocky structure, loose consistence, moist.
10" – 18"	Light olive brown clay loam, subangular blocky structure, very firm consistence, moist. Few medium distinct mottles at 10" and below.

Seasonal high groundwater indicators at 10".

Auger Hole AH-9

0" – 2"	Very dark brown very fine sandy loam, granular structure, loose consistence, moist. Forest duff.
2" – 12"	Brown very fine sandy loam, granular structure, loose consistence, moist.
12" – 21"	Brown very fine sandy loam, subangular blocky structure, friable consistence, moist. Spodic horizon.
21" – 36"	Brown loamy very fine sand, subangular blocky structure, loose consistence, moist.
36" – 42"	Brown silt loam, subangular blocky structure, firm consistence, moist. Many medium prominent mottles throughout. Few bands of very fine sandy loam.
42" – 64"	Light olive brown loamy fine sand, subangular blocky structure, loose consistence,

No refusal to 64". Seasonal high groundwater indicators at 36".

<u>Auger Hole AH-10</u>

0" – 11"	Strong brown silt loam, granular structure, loose consistence, moist.
11" – 16"	Light olive brown clay loam, subangular blocky structure, very firm consistence, moist. Many medium prominent mottles at 11" and below.

Seasonal high groundwater indicators at 11".

Town Common site

<u>Auger Holes AH-11 and AH-12</u>

0" – 4"	Very dark grayish brown clay loam, granular structure, firm consistence, wet.
4" – 9"	Very dark grayish brown clay loam, subangular blocky structure, very firm consistence, saturated. Many fine distinct mottles at 4" and below.

Seasonal high groundwater indicators at 4".

Brick Meeting House site

<u>Auger Holes AH-13 and AH-14</u>

0" – 4"	Very dark grayish brown clay loam, granular structure, firm consistence, wet.
4" – 9"	Very dark grayish brown clay loam, subangular blocky structure, very firm consistence, wet. Many fine distinct mottles at 4" and below.

Seasonal high groundwater indicators at 4".

<u>Auger Hole AH-15</u>

0" – 4"	Very dark grayish brown stony clay loam, granular structure, loose consistence, moist. No grass.
4" – 10"	Very dark grayish brown clay loam, subangular blocky structure, very firm consistence, wet. Many fine distinct mottles at 4" and below.

Seasonal high groundwater indicators at 4".

<u>Auger Hole AH-16</u>

0" – 4"	Dark brown very fine sandy loam, granular structure, loose consistence, moist. No grass.
4" – 16"	Brown very fine sandy loam, granular structure, loose consistence, moist.
16" – 22"	Brown fine sandy loam, granular structure, loose consistence, moist. Many stones, hard to auger. Refused on large stone (not ledge) at 22".

No seasonal high groundwater indicators to 22".

Table 1: Darcy's Law Capacity Analysis, United Church of Westford Site

Project Title: Community Wastewater Capacity Soil Tests and Analysis in the Westford Town Common Area
Stone Project No.: 13-224
Date: April 30, 2014
Prepared by: Amy Macrellis

Darcy's Law Calculations: Q = KiA
Q = design flow (gallons / day)
K = Hydraulic conductivity (feet / day)
i = Hydraulic gradient (slope of water table, unitless)
A = transmitting soil cross-sectional area (D) times length of disposal system (L) in square feet, where
D = depth to impeding layer or water table, minus required vertical separation, minus system depth

Assumptions:

1. Hydraulic conductivity (K) = 25 feet/day (range 25-50 ft./day for soils encountered)
2. Water table slope (i) is similar to ground surface slope, estimated from 2007 LiDAR data (13%)
3. Depth to impeding layer or water table (3.0 ft. to bedrock at AH-5) is continuous across site
4. Design is for a filtrate mound system with the bottom of trench one foot above ground surface. For purposes of this analysis,the system bottom is assumed to be 1.0 foot above the ground surface, so system depth = 0.0 feet.
5. Required separation distance to seasonal high groundwater = 2.0 feet
6. System length (L) across slope (perpendicular to contours) = 25 feet

Calculations:

K = 25 ft./day
i = 13%
L = 25 ft.
D = (4.0 ft. - 2.0 ft. - 0.0 ft.) = 2.0 ft.

Q = 25 ft./day x 0.13 x (25 ft x 2.0 ft) x 7.48 gal/ft^3
Q = 1,220 gallons / day

A mound system utilizing a single four-foot-wide trench, maximizing the available length along contour (75 ft.) with this capacity would have a linear loading rate of 1,220 gal/day / 75 ft. = 16.27 gal/day/linear foot. A desktop mounding analysis is required to demonstrate that separation distances between system bottom and seasonal high water table are maintained.

Table 3
Supporting Calculations for Hydrogeological Analysis

Proposed Expansion of Existing Wastewater Disposal System

Recharge Rate:	1,220 gpd/7.48 gpcf = 163 cfpd Design loading rate = 4.07 gpd/sf Required Area for full design flow: 1,220 gpd / (4.07 gpd/sf) = 300 sf Area provided in design: 75 ft x 4 ft = 300 sf 163 cfpd/300 sf = 0.54 fpd recharge rate
Transmissivity:	T = kb k = 25 fpd, b = 4.4 ft. T = 25(4.4) = 110 sfpd
Time of Travel:	$\frac{n\,L}{K\,i}$ Assume Porosity (n) = 0.2 Distance to Sensitive Receptor (L) = 300 ft. (from AH-5 west to stream) k = 25 fpd Water Table Gradient (i) = 13.0% 0.2(300 ft.)/25 fpd(0.13) = 60/3.25 = 18 days (0.05 years)

List of Terms
shgwt = seasonal high groundwater table
gpcf = gallons per day per cubic foot
cfpd = cubic feet per day
gpd = gallons per day
fpd = feet per day
sfpd = square feet per day

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Date: 04/30/2014 anm

TABLE 4

Hydrogeological Analysis for Proposed Disposal System - East-West Profile

United Church of Westford Capacity Assessment, Westford, Vermont

Based on the Colorado State University Pit and Well (CSUPAWE)
Computer Model to Glover's Analytical Solution to the Hantush Equation
Proposed Wastewater Disposal System at Darcy-Estimated Design Flow

Input Data			
Recharge Rate		0.54	fpd
Transmissivity		110	sfpd
Specific Yield		0.2	
Initial Time	3650 & 7300		days
Final Time	3650 & 7300		days
Time Increment	3650 & 7300		days
Time Of Cut Off	3650 & 7300		days
Initial Distance		0	feet
Final Distance		150	feet
Distance Increment		30	feet
Depth to water		5.50	feet
System Depth		0	feet
Distance to Barrier		25	feet
Width		4	feet
Length		75	feet
Angle		0	degrees
Stream Distance	n/a		feet
Mound Profile	Yes		
Stream Discharge	No		

Results		
Coordinates	East-West Mound Height (ft) at 3650 days	East-West Mound Height (ft) at 7300 days
(-25,0)	1.97	2.13
(0,0)	2.03	2.19
(30,0)	1.72	1.88
(60,0)	1.51	1.67
(90,0)	1.37	1.53
(120,0)	1.26	1.43
(150,0)	1.17	1.33

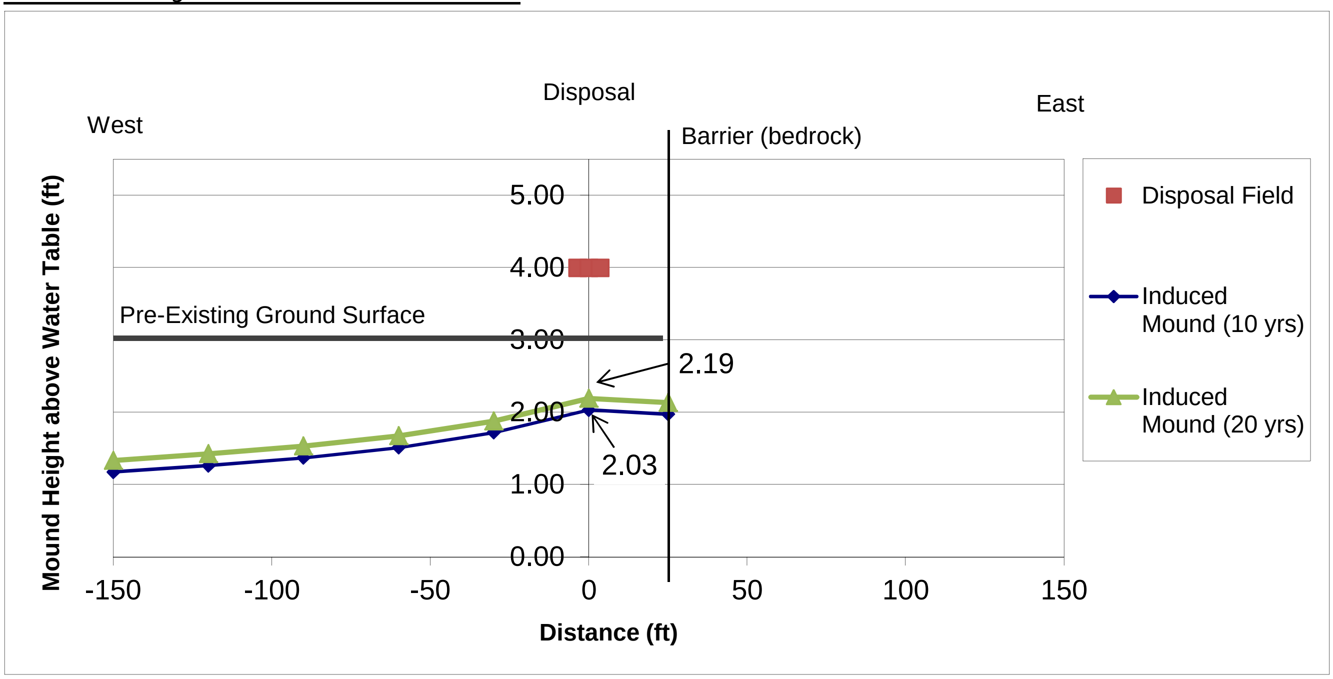

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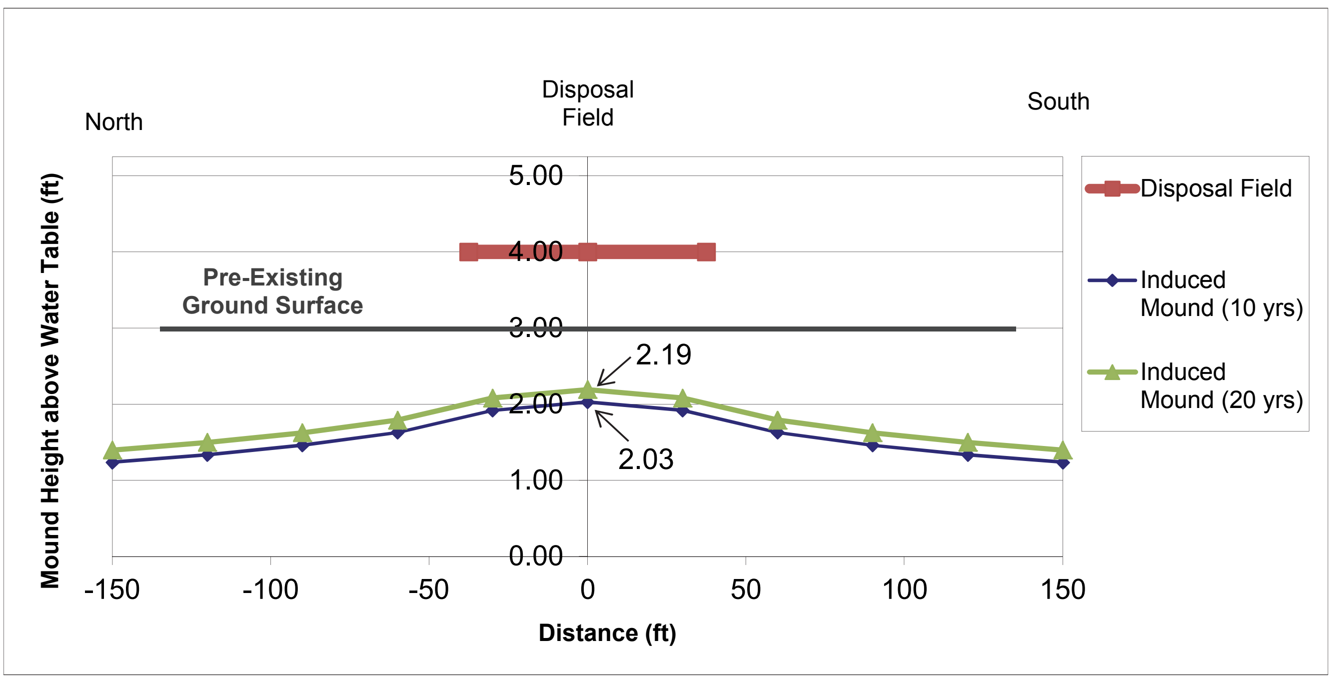
TABLE 5
Hydrogeological Analysis for Proposed Disposal System - North-South Profile
United Church of Westford Capacity Assessment, Westford, Vermont

Based on the Colorado State University Pit and Well (CSUPAWE)
Computer Model to Glover's Analytical Solution to the Hantush Equation
Proposed Wastewater Disposal System at Darcy-Estimated Design Flow

Input Data			
Recharge Rate		0.54	fpd
Transmissivity		110	sfpd
Specific Yield		0.2	
Initial Time		0	days
Final Time		3650 & 7300	days
		(10 & 20	years)
Initial Distance		0	feet
Final Distance		150	feet
Distance Increment		30	feet
Depth to water		5.50	feet
System Depth		0	feet
Distance to Barrier		25	feet
Width		4	feet
Length		75	feet
Angle		90	degrees
Stream Distance	n/a		feet
Mound Profile	Yes		
Stream Discharge	No		

Results		
Coordinates	North-South Mound Height (ft) at 3650 days	North-South Mound Height (ft) at 7300 days
(0,0)	2.03	2.19
(-30,0)	1.92	2.08
(30,0)	1.92	2.08
(-60,0)	1.63	1.79
(60,0)	1.63	1.79
(-90,0)	1.46	1.62
(90,0)	1.46	1.62
(-120,0)	1.34	1.50
(120,0)	1.34	1.50
(-150,0)	1.24	1.40
(150,0)	1.24	1.40



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Date: 04/30/2014 anm