NGI

NORTHEAST GEOSCIENCE INC

Water Supply and Environmental Consulting

August 8, 2016

Jeffrey Brem, PE
Meisner Brem Corporation
142 Littleton Road, Suite 16
Westford, MA 01886

Re: Wastewater and Water Supply Design Modification Impacts
Lifetime Green Homes
100 Long Ridge Road
Carlisle, Massachusetts

Dear Mr. Brem:

Northeast Geoscience, Inc. (NGI) has prepared the following analysis to describe the proposed wastewater and water supply design changes to the above referenced project. The analysis includes an updated Nitrate dispersion analysis, based on the model presented by Nobis Engineering, Inc. (April 20, 2015) and a description of the proposed water system. Specific changes to the project design addressed in this correspondence include replacing the private water supply wells with a Community Public Water Supply and moving the location of septic disposal area 2 (see attached Meisner Brem Corporation site plan "Plan P – Public Water Supply").

WATER SUPPLY

The Title 5 flow rate for the existing home and the proposed development is approximately 6,380 gallons per day (gpd), which for water supply purposes equals the daily water supply demand or a continuous flow rate of 4.43 gallons per minute (gpm). A public water supply serving the proposed project must have sufficient yield to meet this demand.

The proposed public water supply consists of a cluster of seven bedrock wells arranged with a 50-foot spacing located along the northeastern edge of the site with each containing overlapping 100 foot Zone I wellhead protection areas. An approximate yield of 0.63 gallons per minute (gpm) per well will be required to meet the water supply demands for the proposed development (0.63 gal/min x 1440 min/day x 7 wells = ~6,380 gal/day). The bedrock wells will be constructed in accordance with MassDEP Guidelines and Policies for Public Water Systems, will be six-inch diameter and will include a sanitary well seal. A 5-day pumping test will be conducted with all seven wells pumping simultaneously at 133% of the required pumping rate. This test will be used to determine the safe yield and water quality of the wells and to identify potential impacts to nearby private wells. The wells will be installed, tested and approved by MassDEP prior to construction of the development. The approved wells will be outfitted with submersible pumps and pitless adapters and the transmission mains will be manifolded together to fill an atmospheric water storage tank, sized to provide a minimum of two days of water storage. System pressure and peak flows will be provided by a booster pumping system. The water system will also be equipped with a back-up power supply and will be managed by a certified water system operator.

NITROGEN MODELING

Changes to the septic system design include minor size and location adjustments of septic disposal area 1 and area 3 and the repositioning of septic disposal area 2 from the northwest corner of the site to a location between septic disposal area 1 and septic disposal area 3. Assuming Title 5 design criteria, the updated disposal area 1 is approximately 45 feet by 45 feet, disposal area 2 is approximately 46 feet by 49 feet, and disposal area 3 is approximately 53 feet by 38 feet.

NGI modeled the potential effects of the reconfigured wastewater disposal areas using the same nitrate dispersion analysis presented by Nobis Engineering, Inc. as part of their original review of the project. The analysis included the development of an analytical advection/dispersion model based on the method described by Domenico (1987). NGI modeled the reconfigured waterwater disposal areas to project nitrate concentrations in the overburden at several points of interest including nearby private wells, property lines, surface water and the proposed public water supply wells. A map showing the estimated streamlines from the septic disposal areas to the individual points of interest is enclosed as Figure 2. The stream lines were either based on previous stream lines drawn by Nobis (lines 1,3,4,5,6,7,11 and 12) or were drawn as flowlines from the receptors back to the disposal areas based on the groundwater contour map created by Nobis for the site (lines 13,14,15,16 and 17).

The model assumptions and limitations are summarized by Nobis (2015). The model was configured to recreate the results of the original Nobis model and then was modified to reflect the proposed disposal system changes. The results are presented on Table 1.

When configuring the model to re-create the original Nobis results it was discovered that a few of the model parameters Nobis used differed from the defined values, which we assumed were a result of unit conversions or rounding. For example, for flow lines 1 through 6 the hydraulic conductivity value defined was 19.1 ft/day (2,124 m/yr) but the value used was 205 ft/day (22,830 m/yr). The model results are presented on Table 1. As can be seen, the results of the original Nobis model (Table 1A) and adjusted Nobis model (Table 1B) were similar, with the largest discrepancy being the predicted Nitrate concentration at line 12 (south property line) being underrepresented by 0.22mg/l. The NGI updated nitrate dispersion model for the reconfigured wastewater disposal areas (Table 1C) for the Nobis modeled flow lines (1,3,4,5,6,7,11 and 12) showed similar predicted nitrate concentration in the overburden groundwater at each of the locations of interest with differences ranging from 0 mg/l (property line east of disposal area #3) to -0.61 mg/l (Higgins #55 Well). Flow lines 13, 14 and 15 for the proposed public water supply wells closest to the proposed septic disposal areas (PWS #1, PWS #2 and PWS #3) showed predicted nitrate concentrations in the overburden groundwater of less than 1 mg/l. In addition, predicted nitrate concentrations at stream locations downgradient of proposed septic disposal area 2 and disposal area 3 were less than 2 mg/l. Based on this analysis, the potential impacts to abutting private wells, on-site wetlands and proposed public water supply wells meet the target of 5 mg/l. It is important to note that the model does not consider the fact that groundwater flow across the site is radial, which would act to further reduce nitrate concentrations at increasing distances from the wastewater disposal areas. Therefore, the predicted nitrate concentrations in the overburden groundwater at the site should be considered conservative estimates.

Of the nitrate concentrations predicted in the model, line 7 (property line east of septic disposal area #3) and line 12 (property line south of septic disposal area 3) require further description, since they exceed the local by-law limit of 5 mg/l at a property line. For discussion purposes it is important to clarify that a property line is not a sensitive receptor but a stated point of compliance and exceeding the 5 mg/l nitrate concentration in the overburden at a property line does not mean that the concentration will be exceeded at an abutting private well. Such an assumption would necessarily require that the abutting well be downgradient of the proposed disposal area and located less than MassDEP imposed private well setbacks, which in this example is not the case.

In order to further clarify the implications of the 5 mg/l nitrate concentration limit at the property line, NGI configured the nitrate dispersion model used above to estimate the setback required for a typical homeowner with a Title 5 septic system to achieve 5 mg/l at the property line (assuming: 35 mg/l nitrate concentration; 50 ft source width; 10 ft/day hydraulic conductivity; 0.02 hydraulic gradient; 0.35 porosity; 1.59 g/cm3; and 0.02 organic carbon content) and the results are shown on Figure 3. The results of the model show that a setback of over 225 feet would be required for a homeowner to meet this limit, which seems excessive and unnecessary to meet the stated goals. In fact, based on the above analysis it would appear that the 5 mg/l limit would be regularly exceeded throughout Carlisle by typical Title 5 septic systems and that applying this criterion to the proposed wastewater disposal areas would seem nonsensical.

In order to fully understand potential nitrate loading impacts, it is also important to consider other modeling approaches applied to this project (i.e. mass-balance/dilution models). As part of our initial discussion of nitrate loading impacts (NGI, March 2015) we developed a mass-balance nitrogen loading model to estimate the existing and proposed nitrate contributing land uses at the site. The purpose of this analysis was to compile the relative nitrate contributions in order to determine if the proposed land use would result in an increase or decrease in nitrogen load. The purpose of the mass-balance model was not to estimate nitrate concentrations at specific locations. In fact, the mass-balance approach (as described by Frimpter et al, 1988) is not applicable for such a determination. According to Frimpter et al (1988), the mass-balance approach is used for "… *evaluating the cumulative effects of nitrogen contributing land uses on water quality*…" and assumes "…*steady-state conditions… where all of the water is mixed*..." and that such modeling "… *is not appropriate for determining contaminant concentrations at other points or determining the concentrations in any smaller (private domestic supply) wells*…" While MassDEP has developed a modified mass-balance method to utilize credit land in cases where proposed developments do not meet the 440 gpd/acre wastewater standard, this approach is extremely conservative and is used to define a "bright-line" for compliance with the specific credit-land approach (which is not being proposed here). The MassDEP credit-land approach is not intended to predict concentrations at specific locations and such an application is invalid, according to Frimpter et al (1988). In other words, MassDEP is free to create a method to assess the suitability of credit land to meet the 440 gpd/acre limit, but the results of the analysis should not be considered "predicted nitrate concentrations."

GROUNDWATER MOUNDING

The modified wastewater disposal configuration will also effect the groundwater mounding estimates for the site, by reducing the groundwater elevations in the northwest portion of the site (at Disposal Area 3) and increasing the groundwater elevations in the central portion of the site (at the re-configured Disposal Area 2). As has been shown previously, the groundwater mounding estimates for the site are reasonable and are within disposal system design parameters. While reasonable, the groundwater mounding estimates do not meet the local by-law for 0% mounding at the property line and probably could not meet the revised 2% mounding limit. Considering that the mathematical methods typically used to estimate groundwater mounding never result in zero feet of mounding at any distance and that Title 5 septic systems are allowed within 10 feet of a property line, this limit seems unlikely to be achieved by even a typical homeowner, is generally unreasonable, and appears to be an arbitrary requirement with undefined justification.

Please do not hesitate to call if you have any questions regarding this matter.

Sincerely;
NORTHEAST GEOSCIENCE, INC.

Joel Frisch, P.G.
Hydrogeologist

REFERENCES:

Domenico, P.A., 1987. An analytical model for multidimensional transport of decaying contaminant species. Journal of Hydrology, 91: 49-58.

M.H. Frimpter, J.J. Donohue, M.V. Rapacz, and H.G. Beye, 1988. A Mass-balance nitrate model for predicting the effects of land use on ground-water quality in municipal wellhead-protection areas. U.S. Geological Survey Open-File Report 88-493. 59p.

Northeast Geoscience, Inc. 2015. Groundwater Impact Analysis, Brem Property, 100 Long Ridge Road, Carlisle, MA, March 25, 2015.

Nobis Engineering, Inc., April 20, 2015, Memorandum: Nitrate dispersion analysis, 100 Long Ridge Road, Carlisle, MA. J. Lambert, File 89220.

FIGURES

NORTHEAST GEOSCIENCE INC
Water Supply & Environmental Consulting

PLAN P – PUBLIC WATER SUPPLY

"The Birches"

100 LONG RIDGE ROAD
CARLISLE, MASSACHUSETTS

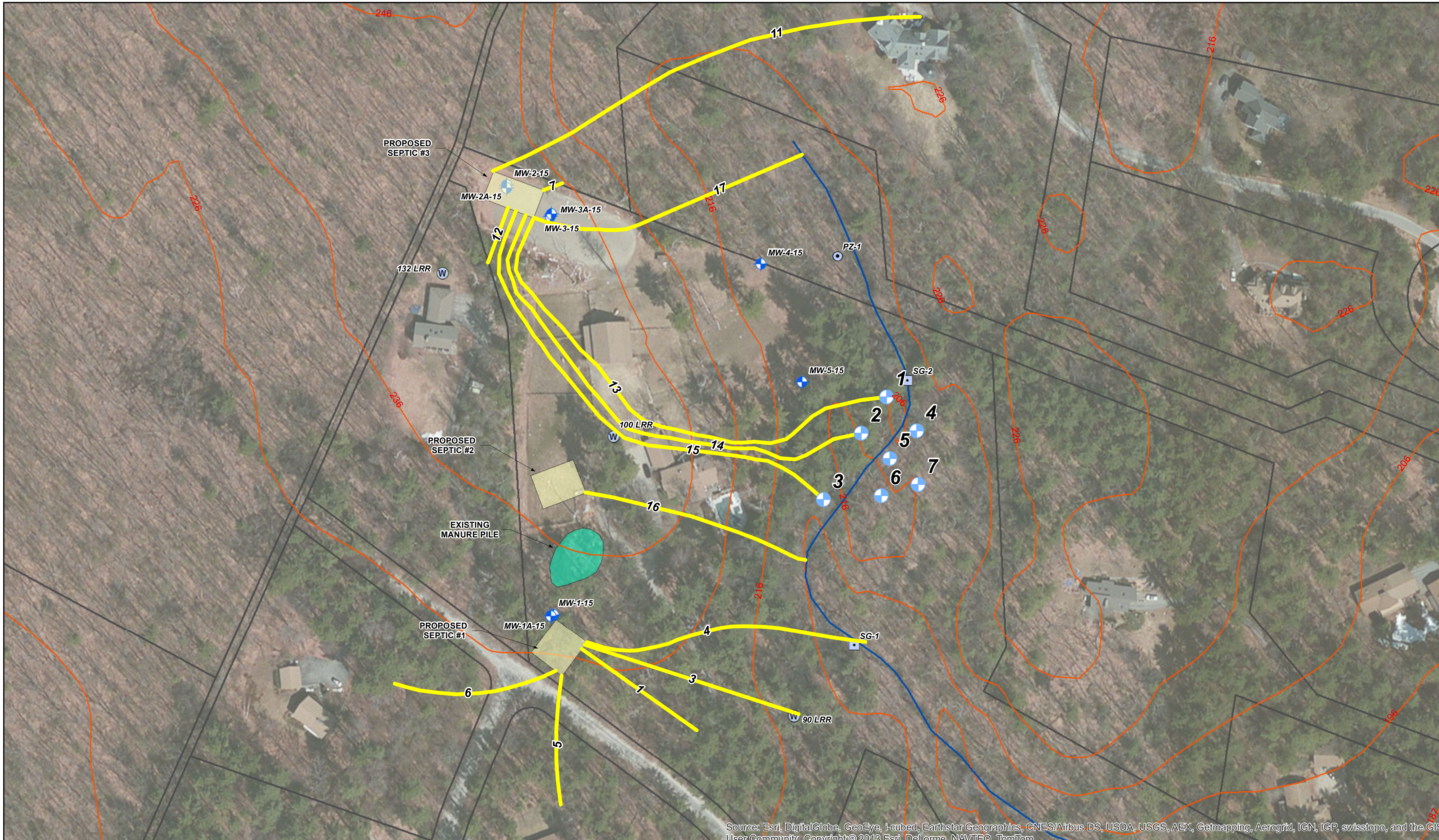
PREPARED FOR:
LIFETIME GREEN HOMES, LLC
142 LITTLETON ROAD
WESTFORD, MA 01886

FEBRUARY 2, 2016 SCALE: 1"= 40'

MEISNER BREM CORPORATION
142 LITTLETON ROAD, STE. 16, WESTFORD, MA 01886 · (978) 692-1313
202 MAIN STREET, SALEM, NH 03079 · (603) 893-3301

JOB NUMBER: 2066

ACAD FILE: 2066m-publicwellsNewlayout.dwg



NGI
NORTHEAST GEOSCIENCE INC
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DRAFT

- Monitoring Well
- Private Domestic Well
- Approximate Stream Location
- Assessors Parcels
- SAS
- Proposed Public Water Supply
- Solute Model Flow Line
- Topographic Contours (feet)

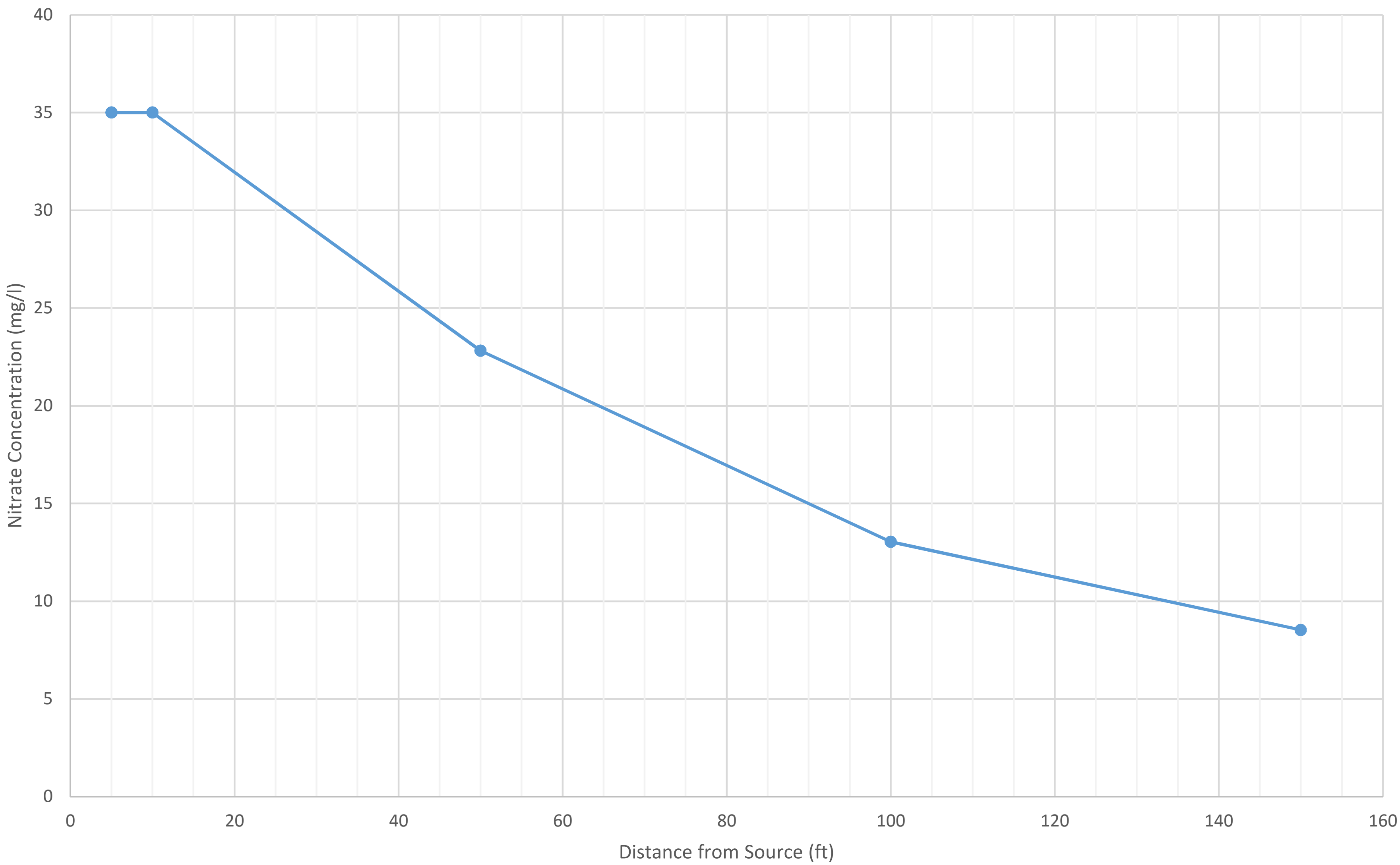
N W E S
0 25 50 100
Feet

SOLUTE MODEL FLOW LINES
LIFETIME GREEN HOMES
100 LONG RIDGE ROAD
CARLISLE, MASSACHUSETTS

NGI REF: Fig2SitePlan
Drafted By: JAF | Date: 08/06/2016
Source: Meisner Brem, MassGIS, ArcGIS.com

FIGURE 2

Figure 3
Nitrate Dispersion Model
Generic Title 5 Septic System



NGI NORTHEAST GEOSCIENCE, INC.

8/8/2016

TABLES

Northeast Geoscience Inc
Water Supply & Environmental Consulting

TABLE 1A, 1B & 1C - NITRATE DISPERSION MODEL
LIFETIME GREEN HOMES, LLC - THE BIRCHES
CARLISLE, MASSACHUSETTS

TABLE 1A - ORIGINAL NOBIS MODEL

Line No.	Source Description	End Point Description	Source Concentration *mg/L*	Source Width *ft*	Source Depth *ft*	Hydraulic Conductivity *ft/day*	Gradient *fraction*	Porosity *fraction*	Bulk Density	Organic Carbon Content *fraction*	Koc	1st Order Decay Coeff* *1/yr*	Time *days*	Horizontal Dispersivity *ft*	Vertical Dispersivity *ft*	Transverse Dispersivity *ft*	POC Coords X *ft*	POC Coords Y *ft*	POC Coords Z *ft*	Predicted Concentration at the POC *mg/L*	Nobis Table 5 *mg/L*	*Difference* *mg/L*
1	Septic 1	Property line southeast of A11	19.0	52.16	5.9	205.2	0.02	0.35	1.59	0.02	0.00	0.00	10,950	10.32	1.03	1.03	178.9	0.00	0.00	3.78	3.78	0.0
2	Septic 1	A11	19.0	52.16	5.9	205.2	0.03	0.35	1.59	0.02	0.00	0.00	10,950	9.16	0.92	0.92	147.5	0.00	0.00	4.73	4.73	0.0
3	Septic 1	90 Long Ridge Road well	19.0	52.16	5.9	205.2	0.03	0.35	1.59	0.02	0.00	0.00	10,950	13.87	1.39	1.39	301.3	0.00	0.00	1.94	1.95	0.0
4	Septic 1	SG-1	19.0	52.16	5.9	205.2	0.04	0.35	1.59	0.02	0.00	0.00	10,950	15.81	1.58	1.58	387.4	0.00	0.00	1.38	1.38	0.0
5	Septic 1	Ringheiser #68 well	19.0	56.10	5.9	205.2	0.01	0.35	1.59	0.02	0.00	0.00	10,950	11.10	1.11	1.11	202.3	0.00	0.00	3.39	3.39	0.0
6	Septic 1	Hanauer #200 well	19.0	56.10	5.9	205.2	0.02	0.35	1.59	0.02	0.00	0.00	10,950	12.95	1.29	1.29	265.3	0.00	0.00	2.42	2.42	0.0
7	Septic 2/3	Property line to east	19.0	109.90	5.9	110.8	0.14	0.35	1.59	0.02	0.00	0.00	10,950	2.03	0.20	0.20	25.2	0.00	0.00	17.77	17.77	0.0
8	Septic 2/3	Well A4	19.0	50.52	5.9	93.1	0.09	0.35	1.59	0.02	0.00	0.00	10,950	12.00	1.20	1.20	231.5	0.00	0.00	2.69	2.69	0.0
9	Septic 2/3	Well A5	19.0	50.52	5.9	93.1	0.07	0.35	1.59	0.02	0.00	0.00	10,950	14.34	1.43	1.43	320.8	0.00	0.00	1.74	1.74	0.0
10	Septic 2/3	SG-2	19.0	50.52	5.9	101.7	0.04	0.35	1.59	0.02	0.00	0.00	10,950	19.19	1.92	1.92	577.0	0.00	0.00	0.77	0.78	0.0
11	Septic 2/3	Higgins #55 well	19.0	109.90	5.9	110.8	0.04	0.35	1.59	0.02	0.00	0.00	10,950	19.56	1.96	1.96	601.2	0.00	0.00	1.37	1.37	0.0
12	Septic 2/3	south property line	19.0	50.52	5.9	110.8	0.04	0.35	1.59	0.02	0.00	0.00	10,950	6.09	0.61	0.61	81.6	0.00	0.00	8.38	8.38	0.0

Note: POC = Point OF Compliance

TABLE 1B - NGI EDITED NOBIS MODEL WITH CORRECTED PARAMETERS

Line No.	Source Description	End Point Description	Source Concentration *mg/L*	Source Width *ft*	Source Depth *ft*	Hydraulic Conductivity *ft/day*	Gradient *fraction*	Porosity *fraction*	Bulk Density	Organic Carbon Content *fraction*	Koc	1st Order Decay Coeff* *1/yr*	Time *days*	Horizontal Dispersivity *ft*	Vertical Dispersivity *ft*	Transverse Dispersivity *ft*	POC Coords *ft*	POC Coords *ft*	POC Coords *ft*	Predicted Concentration at the POC *mg/L*	Nobis Table 5 *mg/L*	*Difference* *mg/L*
1	Septic 1	Property line southeast of A11	19.0	***52.15***	***6.0***	***19.1***	0.02	0.35	1.59	0.02	0.00	0.00	10,950	10.32	1.03	1.03	178.9	0.00	0.00	3.84	3.78	0.06
2	Septic 1	A11	19.0	***52.15***	***6.0***	***19.1***	0.03	0.35	1.59	0.02	0.00	0.00	10,950	9.16	0.92	0.92	147.5	0.00	0.00	4.80	4.73	0.07
3	Septic 1	90 Long Ridge Road well	19.0	***52.15***	***6.0***	***19.1***	0.03	0.35	1.59	0.02	0.00	0.00	10,950	13.87	1.39	1.39	301.3	0.00	0.00	1.98	1.95	0.03
4	Septic 1	SG-1	19.0	***52.15***	***6.0***	***19.1***	0.04	0.35	1.59	0.02	0.00	0.00	10,950	15.81	1.58	1.58	387.4	0.00	0.00	1.41	1.38	0.02
5	Septic 1	Ringheiser #68 well	19.0	***55.95***	***6.0***	***19.1***	0.01	0.35	1.59	0.02	0.00	0.00	10,950	11.10	1.11	1.11	202.3	0.00	0.00	3.44	3.39	0.05
6	Septic 1	Hanauer #200 well	19.0	***55.95***	***6.0***	***19.1***	0.02	0.35	1.59	0.02	0.00	0.00	10,950	12.95	1.29	1.29	265.3	0.00	0.00	2.46	2.42	0.03
7	Septic 2/3	Property line to east	19.0	***110.00***	***6.0***	***10.3***	0.14	0.35	1.59	0.02	0.00	0.00	10,950	2.03	0.20	0.20	25.2	0.00	0.00	17.85	17.77	0.08
8	Septic 2/3	Well A4	19.0	***50.60***	***6.0***	***8.7***	0.09	0.35	1.59	0.02	0.00	0.00	10,950	12.00	1.20	1.20	231.5	0.00	0.00	2.74	2.69	0.05
9	Septic 2/3	Well A5	19.0	***50.60***	***6.0***	***8.7***	0.07	0.35	1.59	0.02	0.00	0.00	10,950	14.34	1.43	1.43	320.8	0.00	0.00	1.77	1.74	0.03
10	Septic 2/3	SG-2	19.0	***50.60***	***6.0***	***9.5***	0.04	0.35	1.59	0.02	0.00	0.00	10,950	19.19	1.92	1.92	577.0	0.00	0.00	0.79	0.78	0.01
11	Septic 2/3	Higgins #55 well	19.0	***110.00***	***6.0***	***10.3***	0.04	0.35	1.59	0.02	0.00	0.00	10,950	19.56	1.96	1.96	601.2	0.00	0.00	1.39	1.37	0.02
12	Septic 2/3	south property line	19.0	***110.00***	***6.0***	***10.3***	0.04	0.35	1.59	0.02	0.00	0.00	10,950	6.09	0.61	0.61	81.6	0.00	0.00	8.60	8.38	0.22

Note: Highlighted values adjusted from original Nobis model. ← Adjusted Values →

TABLE 1C - NGI UPDATED MODEL - SEPTIC MODIFICATIONS AND NEW PWS WELLS

Line No.	Source Description	End Point Description	Source Concentration *mg/L*	Source Width *ft*	Source Depth *ft*	Hydraulic Conductivity *ft/day*	Gradient *fraction*	Porosity *fraction*	Bulk Density *g/cm3*	Organic Carbon Content *fraction*	Koc *fraction*	1st Order Decay Coeff* *1/yr*	Time *days*	Horizontal Dispersivity *ft*	Vertical Dispersivity *ft*	Transverse Dispersivity *ft*	POC Coords *ft*	POC Coords *ft*	POC Coords *ft*	NGI Predicted Concentration at the POC *mg/L*	Nobis Predicted Concentration at the POC *mg/L*	Difference *mg/L*
1	Septic 1	Property Line East of Disposal Area 1	19.0	***45.00***	6.0	19.1	0.02	0.35	1.59	0.02	0	0	10,950	10.53	1.05	1.05	***185.0***	0	0	3.38	3.84	-0.46
3	Septic 1	90 Long Ridge Road well	19.0	***45.00***	6.0	19.1	0.03	0.35	1.59	0.02	0	0	10,950	13.87	1.39	1.39	301.3	0	0	1.76	1.98	-0.22
4	Septic 1	SG-1	19.0	***45.00***	6.0	19.1	0.04	0.35	1.59	0.02	0	0	10,950	15.81	1.58	1.58	387.4	0	0	1.24	1.41	-0.17
5	Septic 1	Ringheiser #68 well	19.0	***45.00***	6.0	19.1	0.01	0.35	1.59	0.02	0	0	10,950	11.10	1.11	1.11	202.3	0	0	3.01	3.44	-0.43
6	Septic 1	Hanauer #200 well	19.0	***45.00***	6.0	19.1	0.02	0.35	1.59	0.02	0	0	10,950	12.95	1.29	1.29	265.3	0	0	2.10	2.46	-0.36
7	Septic 3	Property Line East of Disposal Area 3	19.0	***53.00***	6.0	10.3	0.14	0.35	1.59	0.02	0	0	10,950	2.03	0.20	0.20	25.2	0	0	17.85	17.85	0.00
11	Septic 3	Higgins #55 well	19.0	***53.00***	6.0	10.3	0.04	0.35	1.59	0.02	0	0	10,950	19.56	1.96	1.96	601.2	0	0	0.78	1.39	-0.61
12	Septic 3	south property line	19.0	***53.00***	6.0	10.3	0.04	0.35	1.59	0.02	0	0	10,950	6.09	0.61	0.61	81.6	0	0	8.53	8.60	-0.07
13	Septic 3	PWS #1	19.0	***53.00***	6.0	8.23	0.03	0.35	1.59	0.02	0	0	10,950	21.03	2.10	2.10	705.3	0	0	0.62	-	-
14	Septic 3	PWS #2	19.0	***53.00***	6.0	8.23	0.04	0.35	1.59	0.02	0	0	10,950	20.72	2.07	2.07	682.1	0	0	0.65	-	-
15	Septic 3	PWS #3	19.0	***53.00***	6.0	8.23	0.04	0.35	1.59	0.02	0	0	10,950	21.05	2.10	2.10	706.1	0	0	0.62	-	-
16	Septic 2	Stream	19.0	***46.00***	6.0	8.23	0.07	0.35	1.59	0.02	0	0	10,950	13.96	1.40	1.40	304.8	0	0	1.76	-	-
17	Septic 3	Stream	19.0	***53.00***	6.0	8.23	0.04	0.35	1.59	0.02	0	0	10,950	15.56	1.56	1.56	375.5	0	0	1.49	-	-

Note: Highlighted values changed to reflect system design changes.