D: NOTES ON NITRATE MASS BALANCE CALCULATIONS AND AOI MAPS

Attachment D: Notes on Nitrate Mass Balance Calculations

The "Guidelines for Title 5 Aggregation of Flows and Nitrogen Loading, 310 CMR 15.216", revised 2/22/16 (Guidelines) prescribes assumptions and inputs:

- The mass balance analysis described in the Guidelines is applicable for certain circumstances, including estimating nitrate concentrations at sensitive receptors. "Sensitive receptors are public water supply wells, private wells, drinking water reservoirs and tributaries to drinking water reservoirs" (Guidelines, p. 6).
- The Guidelines assume that total mixing of the effluent plume and groundwater recharge due to precipitation occurs (Guidelines, p. 10).
- For a conventional septic system, wastewater effluent has a nitrate concentration of 35 milligrams per liter (mg/L), which is equivalent to 132 mg of nitrate per gallon (Guidelines, p. 12).
- With enhanced nitrate removal technologies, lower concentrations of nitrate are allowed in the calculations (Guidelines, p. 12). For example, both the Applicant and Nobis have used 19 mg/L for effluent to be discharged to proposed SDAs 1, 2, and 3 (see Figure 3 and Figures D1, D2, and D3 in this Attachment). The septic system for the existing home on the site falls within the AOI for SDA 2 (Figure D2), but Nobis understands that there is no enhanced nitrate removal technology applied to this septic system, so a nitrate level of 35 mg/L is assumed for effluent from this system.
- Wastewater volume is assumed to be 110 gallons per day (gpd) per bedroom (Guidelines, p. 5). This is the same rate used by the Applicant in their 2016 design (Attachment B) and used by Nobis in odd-numbered scenarios presented in this report (see below). Nobis also performed a series of calculations (even-numbered scenarios) using the Town's rate of 165 gpd per bedroom (see below).
- On average, 1000 square feet of lawn receives 933 mg of nitrate per day in fertilizer (Guidelines, p. 12). For the present calculations, Nobis has measured the area of potential lawn in each AOI. The areas were estimated by scanning a figure entitled "Residential Site Plan, Landscape Plan, 1 of 2" by Gardner and Gerrish, LLC in BREM_197 03.31.2015 and using Geographical Information Systems (GIS) software to determine the amount of planned lawn area in each AOI. The above-referenced plan was for the 2015 design, and Nobis has not received a revised plan for the 2016 proposed 40B development. Nobis estimated the areas that would be subject to fertilization based on the 2015 Landscape Plan. Also, the number of days in which fertilizer would be applied each year is unknown. For the sake of conservatism, Nobis assumed that fertilizer would be applied on only one day per year. Informal sensitivity analyses indicate that for any reasonable number of days, the great majority of the nitrate load comes from the septic systems and not from fertilizer.
- Recharge to groundwater from precipitation is assumed to be 18 inches per year (5,062 liters per day (Guidelines, p. 12). (Nobis notes that both the Applicant and Nobis used a more site-specific recharge rate of 8.2 inches per year for mass balance calculations in the Northeast Geoscience Inc. (NGI) March 25 report and the Nobis Phase 2 report, respectively. If a site specific calculation were performed, a recharge rate of 8.2 inches per year is more likely to produce a realistic result for this site, as explained in the NGI report and in Nobis' Phase 2 Report.) The present report (and Nobis 2015 Addendum dated May 20, 2015) used the Guidelines' value of 18 inches (1.5 feet) per year.
- The Guidelines prescribe a 5 step process for the mass balance and nitrate loading analysis (Guidelines, p. 11 – 12).

- Step 1 describes the procedure for delineating Areas of Impact (AOIs). The delineation depends on groundwater flow directions and an assessment as to whether groundwater mounding is "significant." The flow directions and determination of whether mounding is "significant" represent the aspects of the analysis where the most discretion and hydrogeologic interpretation is involved. See below for a discussion of the particular AOIs delineated by Nobis (Figure 3 and Figures D1, D2, and D3 in this Attachment) for the calculations presented in this report.
- Step 2 determines the nitrogen load by combining estimates due to wastewater discharge and fertilizer based on the assumptions described above. Background nitrate concentrations that may be present in groundwater and in rainwater are not considered.
- Step 3 determines the volume of recharge available by combining wastewater that is discharged with water that is recharged to groundwater from precipitation (18 inches per year as a statewide average). Other potential water inputs or outputs are not included. For the present calculations, the wastewater input is the design discharge for proposed SDAs 1, 2, and 3 (1,980 gpd each (Applicant) or 2970 gpd each (Town)). For the existing septic system that serves the existing 4-bedroom house, the design discharge is 440 gpd (Applicant) or 660 gpd (Town).
- Step 4 provides a formula for calculating the resulting nitrate concentration for an AOI: $Cn = (Lww + Lfert)/(Vww + Vr)$, where Cn is the concentration of nitrate; Lww is the wastewater nitrate load; Lfert is the nitrate load from fertilizer; Vww is the wastewater volume; and Vr is the volume of recharge.
- Step 5 calls for a comparison of the result to 10 mg/L, which is the regulatory threshold for nitrate in groundwater at a sensitive receptor (Guidelines, p. 6). If the proposed SDAs are within Wellhead Protection Area Zone II for the proposed PWS, the Guidelines (p. 6) may require a "DEP Nitrogen Loading Assessment" and apply a 5.0 mg/L standard for the Public Well(s).

Nobis also notes that the Town of Carlisle has a regulatory threshold criterion of 5 mg/L of nitrate at a property boundary. The mass balance calculations presented in this report are for AOIs delineated to sensitive receptors in some scenarios, hydraulic receptors in other scenarios, and property boundaries in other scenarios. Nobis notes further that the mass balance calculations presented here represent simplified average nitrate concentrations modeled over an AOI and are not predictions of nitrate concentrations in overburden groundwater at any particular point location. See report Section 7.3 for a discussion of the significance and interpretation of the results.

Septic Disposal Area #1

AOI-1A

AOI-1 Alt 2

AOI-1 Alt 1

#200

#90

#68

Garnet Rock Lane

Long Ridge Road

100' BUFFER FROM BORDERING VEGETATED WETLAND

22' X 16' LAND... BOULDER WITH LANDSCAPE SURROUND (SEE EXHIBIT H)

SEPTIC SYS... (UNITS 1-...)

BIO-RETENTION

FOREBAY

EXIST. CB

SLOPED GRANITE CURB FROM LONG RIDGE ROAD TO STATION 1+00

N/F 1-6 MICHAEL HANAUER 200 LONG RIDGE ROAD CARLISLE, MA

N/F 1-73-26K RINGHEISER, BARBARA 68 GARNET ROCK LANE CARLISLE, MA

N/F LOT 2 GARNET HOMES, LLC BOW, NH

Legend

Surface Type

- Impervious
- Pervious Fertilized
- Pervious Unfertilized
- Existing Water Supply Well

AOI Areas - Septic #1 (sqft)		
1-A	Impervious	4,580
	Pervious Fertilized	4,143
	Pervious Non-Fertilized	6,637
	Total	15,360
1-Alt 1	Impervious	6,962
	Pervious Fertilized	385
	Pervious Non-Fertilized	20,805
	Total	28,152
1-Alt 2	Impervious	5,953
	Pervious Fertilized	0
	Pervious Non-Fertilized	24,960
	Total	30,913

Notes:

1. Source: 'Plan P - Public Water Supply' by Meisner Brem Corp., February 2, 2016.

2. Proposed Septic Disposal Area #1 is included in all area calculations.

3. It is assumed that all pervious areas outside the Site boundary are non-fertilized.

4. Assessor's parcels are from the Town of Carlisle. Aerial photography from MassGIS map service, 2013.

5. Locations of site features depicted hereon are approximate and given for illustrative purposes only.

0 20 40 80

Feet

1 inch = 40 feet

N

DRAFT

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FIGURE D1

SURFACE CHARACTERISTICS
PROPOSED SEPTIC #1 AOI
100 LONG RIDGE ROAD
CARLISLE, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: JV
PROJECT NO. 89220.00	DATE: SEPTEMBER 2016

Path: J:\89220.00 - Carlisle Hydrogeo Evaluation 2015\GIS\Figures\Figure D1 Carlisle AOI-1.mxd Date Printed: 9/12/2016

#132

#100

AOI-2C

AOI-2B

AOI-2A

Septic Disposal Area #2

Existing Septic System

100' BUFFER FROM BORDERING VEGETATED WETLAND

DRAFT

Legend

Surface Type

- Impervious
- Pervious Fertilized
- Pervious Unfertilized
- 100 foot Well Buffer (Zone I)
- Existing Water Supply Well

AOI Areas - Septic #2 (sqft)		
2-A	Impervious	4,327
	Pervious Fertilized	2,981
	Pervious Unfertilized	4,548
	Total	11,856
2-B	Impervious	8,497
	Pervious Fertilized	7,627
	Pervious Unfertilized	10,191
	Total	26,315
2-C	Impervious	8,497
	Pervious Fertilized	7,627
	Pervious Unfertilized	26,022
	Total	42,146

Notes:

1. Source: 'Plan P - Public Water Supply' by Meisner Brem Corp., February 2, 2016.

2. Proposed Septic Disposal Area #2 is included in all area calculations.

3. It is assumed that all pervious areas outside the Site boundary are non-fertilized.

4. Assessor's parcels are from the Town of Carlisle. Aerial photography from MassGIS map service, 2013.

5. Locations of site features depicted hereon are approximate and given for illustrative purposes only.

0 20 40 80

Feet

1 inch = 40 feet

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FIGURE D2

SURFACE CHARACTERISTICS
PROPOSED SEPTIC #2 AOI
100 LONG RIDGE ROAD
CARLISLE, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: JV
PROJECT NO. 89220.00	DATE: SEPTEMBER 2016

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Septic Disposal Area #3

PUBLIC WATER SUPPLY DETAIL
SCALE: 1" = 40'

AOI-3A

AOI-3B

#55

#132

#100

Surfolk Lane Extens

Legend

Surface Type

- Impervious
- Pervious Fertilized
- Pervious Unfertilized
- Existing Water Supply Well

AOI Areas - Septic #3 (sqft)		
3-A	Impervious	23,159
	Pervious Fertilized	35,526
	Pervious Unfertilized	6,518
	Total	65,203
3-B	Impervious	23,159
	Pervious Fertilized	35,526
	Pervious Unfertilized	64,003
	Total	122,688

DRAFT

Notes:

1. Source: 'Plan P - Public Water Supply' by Meisner Brem Corp., February 2, 2016.

2. Proposed Septic Disposal Area #3 is included in all area calculations.

3. It is assumed that all pervious areas outside the Site boundary are non-fertilized.

4. Assessor's parcels are from the Town of Carlisle. Aerial photography from MassGIS map service, 2013.

5. Locations of site features depicted hereon are approximate and given for illustrative purposes only.

0 30 60 120

Feet

1 inch = 60 feet

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FIGURE D3

SURFACE CHARACTERISTICS
PROPOSED SEPTIC #3 AOI
100 LONG RIDGE ROAD
CARLISLE, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: JV
PROJECT NO. 89220.00	DATE: SEPTEMBER 2016

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