NHDES-R-WD-07-43

AMENDMENT

Total Maximum Daily Load (TMDL) Study For Waterbodies in the Vicinity of the I-93 Corridor from Massachusetts to Manchester, NH:

North Tributary to Canobie Lake in Windham, NH

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1. Introduction

Section 303(d) of the Clean Water Act (CWA) and Environmental Protection Agency's Water Quality Planning Regulations (40 CFR Part 130) require states to develop total maximum daily loads (TMDLs) for water quality limited segments that are not meeting designated uses under technology-based controls for pollution. The TMDL process establishes the allowable loadings of pollutants for a waterbody based on the relationship between pollutant sources and instream water quality conditions, so that states can establish water quality based controls to reduce pollution from both point and non-point sources and restore and maintain the quality of their water resources.

In 2008, the New Hampshire Department of Environmental Services (DES) prepared a TMDL for chloride for the North Tributary to Canobie Lake watershed located in Windham, N.H. This TMDL was subsequently approved by the Environmental Protection Agency. The official TMDL was expressed as a load duration curve in order to be applicable to the full range of stream flows in the watershed. In addition, an alternative expression of the TMDL was calculated to guide implementation. The alternative expression of the TMDL used a percent reduction goal to estimate the tons of salt that could be imported to the watershed in a typical year and still attain water quality standards.

The North Tributary to Canobie Lake watershed is unique among the I-93 watersheds because there was a large source of salt besides deicing activities. Up until 2005, a municipal well in the watershed had operated a water softener and injected the waste salt brine back into the groundwater. Approximately 55 tons of salt per year were added to the watershed from this well. When monitoring for the TMDL was done in 2007, this source was not active but it had created a high background concentration of chloride in the watershed. As a result, the percent reduction goal for the alternative expression of the TMDL was large (39.6%) relative to the amount of deicing in the watershed.

The goal of this amendment to the TMDL is to recalculate the alternative expression of the TMDL with updated information on the remaining effects on the brine discharge after five years. Salt loading allocations for the different deicing sectors will also be updated. The official TMDL for the watershed, expressed as a load duration curve, will *not* be changed because this calculation was not influenced by the brine discharge. This amendment contains replacement text for Sections 5(b)(iii) and 5(b)(iv) of the 2008 TMDL report as well as explanations of the methods used for the update.

The goal of the amended TMDL for the North Tributary to Canobie Lake remains to reduce chloride loads so that water quality standards for all the designated uses affected by chloride pollution are met in all areas of the North Tributary to Canobie Lake watershed.

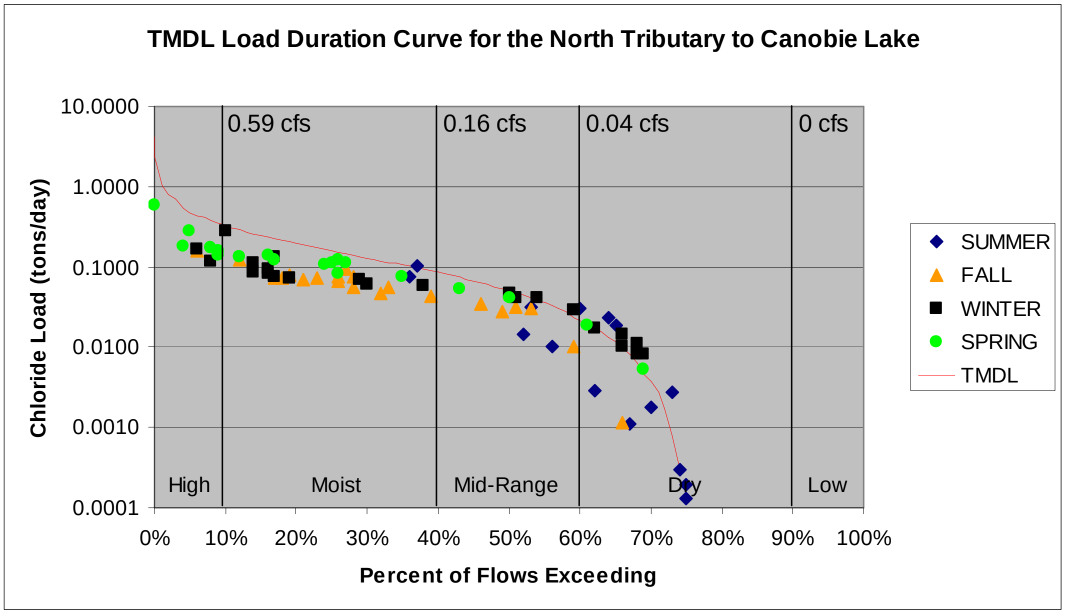
2. Replacement Text for Section 5 of the 2008 TMDL Report

Added text shown in ***bold italics***.
Deleted text shown in ~~strikethrough~~.

b(iii) TMDL Calculation

The TMDL will be expressed as a load duration curve following guidance from EPA (EPA, 2007) and in compliance with the approved Quality Assurance Project Plan (DES, 2006). The TMDL will be 90 percent of the chronic water quality standard (207 mg Cl/L) multiplied by each stream flow in the four-day average flow duration curve. The four-day average flow duration curve was used because the chronic water quality standard applies to four-day average concentrations. The TMDL will be set for the outlet station of the watershed, I93-NTC-01, because this is the only station in the watershed at which violations of the water quality standard have been detected. Figure 5 shows the TMDL load duration curve and the existing loads measured at I93-NTC-01 between July 1, 2006 and June 30, 2007. The units for the TMDL are tons of chloride per day. At each point on the TMDL curve, the waste load allocation for MS4 permittees is 100 percent of the TMDL and the load allocation for non-point sources is 0 percent of the TMDL (not shown on figure). The margin of safety is explicit. The TMDL load duration curve is not expected to change; therefore, this TMDL is relevant to all existing and future impairments due to chloride in the North Tributary to Canobie Lake watershed. It should be noted that the TMDL load duration curve goes to zero near 70 percent flow exceedence because there is no flow and only stagnant water in the stream approximately 30 percent of the time.

Figure 5: TMDL Load Duration Curve at Station I93-NTC-01



The TMDL can be alternatively expressed ~~as a percent reduction goal (PRG)~~ ***in units of tons per year*** to guide implementation. The method for calculating ***the alternative expression of the TMDL follows the approach published by Trowbridge et al. (2010).*** ~~the PRG was described in the approved Quality Assurance Project Plan (DES, 2006). In summary, each individual chloride export value was compared to the TMDL.~~ ***This report demonstrated that, if the annual average chloride concentration in a New Hampshire watershed was less than 102 mg/L, violations of the chronic water quality standard typically did not occur. Furthermore, the annual average chloride concentrations could be predicted from the annual salt imports and the annual average runoff in the watershed. The North Tributary watershed will have a drainage area of 125 acres after highway construction is complete. The average annual runoff for this drainage area is 0.35 cfs, based on data from 2001-2012 at the Beaver Brook stream gage transposed to the size of the North Tributary to Canobie Lake watershed. The model indicates that the salt load to this watershed should be no greater than 58.2 tons per year in order to attain water quality standards during a typical year. To account for uncertainty in the model, this amount should be reduced by 10% to 52.4 tons per year to add a margin of safety.*** ~~If the value was higher than the TMDL, the percent by which this value would need to be reduced to reach the TMDL was calculated. All of the individual PRGs calculated for the "dry" hydrologic condition were grouped and the 90th percentile value calculated (DES, 2007b). The four-day averaging period was used for this calculation to be consistent with the chronic water quality standard and the TMDL load duration curve. For the North Tributary to Canobie Lake watershed, the PRG was determined to be 39.6 percent for the July 1, 2006 to June 30, 2007 period. The total salt imports to the watershed during this period were 46.5 tons of salt per year. Therefore, salt imports to the watershed should be less than 28.1 tons of salt per year in order to attain water quality standards.~~

b(iv) Allocation of Loads

In 2006, DOT and DES established an interagency Salt Reduction Workgroup. The purpose of the workgroup is to advise DES and DOT on this TMDL study and all other chloride TMDL studies in the I-93 corridor until these studies are completed, and then to advise and assist with implementation of required salt load reductions. The workgroup includes representatives from the following: DES; DOT; EPA; the Federal Highway Administration (FHWA); the selectmen's office of each town with area in a TMDL watershed; the public works department of each town with area in a TMDL watershed; the University of New Hampshire Technology Transfer (T2) Center; private winter road and parking lot maintenance companies; motorist associations; the State Police; the Southern New Hampshire Regional Planning Commission; the Nashua Regional Planning Commission; and the Rockingham Planning Commission. Representatives from pertinent watershed organizations and state-wide environmental organizations will be invited to join the workgroup in 2008.

~~**In 2008,**~~ ***T*****he Salt Reduction Workgroup will determine the final load allocations by sector in the implementation plan. There will be an opportunity for public comment on the implementation plan. However, as a starting point, draft allocations are**

presented in Table 5 based on the following assumptions:

- ~~Ninety-eight~~ ***Ninety-six*** percent of the salt imports to the watershed were for deicing activities. Therefore, essentially all of the salt import reductions will need to come from reduced deicing loads. The percent reduction in salt imports will be the same for state, municipal, and private roads and parking lots.
- The allocation for salt pile runoff will be zero because there were no salt piles in the watershed and any new salt and salt-sand piles should be covered.
- The existing loads from water softeners, food waste, and atmospheric deposition will be used as the allocation for these sources.

Table 5: Existing Salt Imports and Load Allocations

Source	**Agency/Town**	**~~FY07~~ *FY08-FY12* Salt Imports (tons salt/yr)**	**Allocation of Loads (tons salt/yr)**
State Roads	NHDOT PS 514	~~7.2~~ ***10.3***	~~4.3~~ ***16.5***
	NHDOT PS 528	~~31.6~~ ***18.2***	~~18.7~~ ***29.0***
Municipal Roads	Windham	~~4.2~~ ***0.6***	~~2.5~~ ***1.0***
Private Roads	Windham	0.0	0.0
Parking Lots	Windham	~~2.3~~ ***3.0***	~~1.4~~ ***4.8***
Salt Piles	Windham	0.0	0.0
Water Softeners***, not including brine discharge***	NA	0.4	0.4
Food Waste	NA	0.2	0.2
Atmospheric Deposition	NA	0.6	0.6
Margin of Safety		***0***	***5.8***
Total		~~46.5~~ ***33.3***	~~28.1~~ ***58.2***

3. Explanation

Calculation of Salt Loads from Brine Discharge

There was a large discharge of salt brine in the North Tributary to Canobie Lake watershed from the W&E municipal water supply well. The brine discharge was estimated to contribute 55 tons of salt per year until it ceased 2005. When the TMDL report was written in 2007, it was assumed that the effects of the brine discharge on surface waters would still be evident for several years but no details were known for certain.

DES has used a model of chloride fate and transport in watersheds and monitoring data from 2007 and 2009 show that the effect of the brine on surface water quality declined rapidly after 2005. Trowbridge et al. (2010) demonstrated that the annual average chloride concentration in New Hampshire watersheds can be estimated by dividing the salt imports by the annual average stream flow. This approach was used to estimate the expected average chloride concentration in the North Tributary to Canobie Lake from deicing activities in 2007 and 2009. The measured average chloride concentrations in these years were higher than the predicted values. The difference between the modeled and measured concentrations was assumed to be the remaining effects of the brine discharge on the surface water quality (Table 1). Figure 1 shows that the load of salt from the brine discharge declined linearly from 55 tons per year in 2005 to an expected value of zero in 2011. Therefore, for 2012 onwards, the effects of the former brine discharge are negligible.

For this assessment of the brine discharge, DES used updated watershed boundaries, roadway lane-miles, and parking lot areas provided by the Department of Transportation based on field surveys of the watershed. The watershed boundary is more accurate than the one used in the 2008 TMDL report because it reflects the stormwater drainage network. The watershed boundary used in the 2008 TMDL report was based on topography but did not account for stormwater control structures. Overall, the watershed draining to the North Tributary to Canobie Lake covers 87.33 acres currently. The planned highway construction will add new stormwater control structures and drainage areas, which will increase the size of the watershed to 125.8 acres. Figure 2 shows the boundaries of the watershed.

Table 1: Calculation of residual salt inputs from brine discharge in 2007 and 2009

	2007	2009
1. Stream Flow at Beaver Brook Gage (yearly average, in cfs)	97.2	111.5
2. Estimated Stream Flow in NTC watershed (yearly average, in cfs)	0.28	0.32
3. Salt input from deicing (tons/yr)	25.5	38.1
4. Chloride input from deicing (mg/s)	446.2	665.4
5. Expected chloride concentration from deicing (yearly average, mg/L)	56.8	73.8
6. Actual chloride concentration (yearly average, mg/L)	152	112
7. Predicted salt input from brine (tons/yr)*	42.8	19.7

* The predicted salt input from brine (in tons per year) was calculated using the following equation:
Brine input (Line 7) = (Line 6 – Line 5) x Line 2 x CF x (1 mg NaCl/0.6066 mg Cl)
where CF is a conversion factor equal to 0.9824 L ton s ft^{-3} mg^{-1} yr^{-1}

Figure 1: Measured and modeled salt inputs from brine discharge

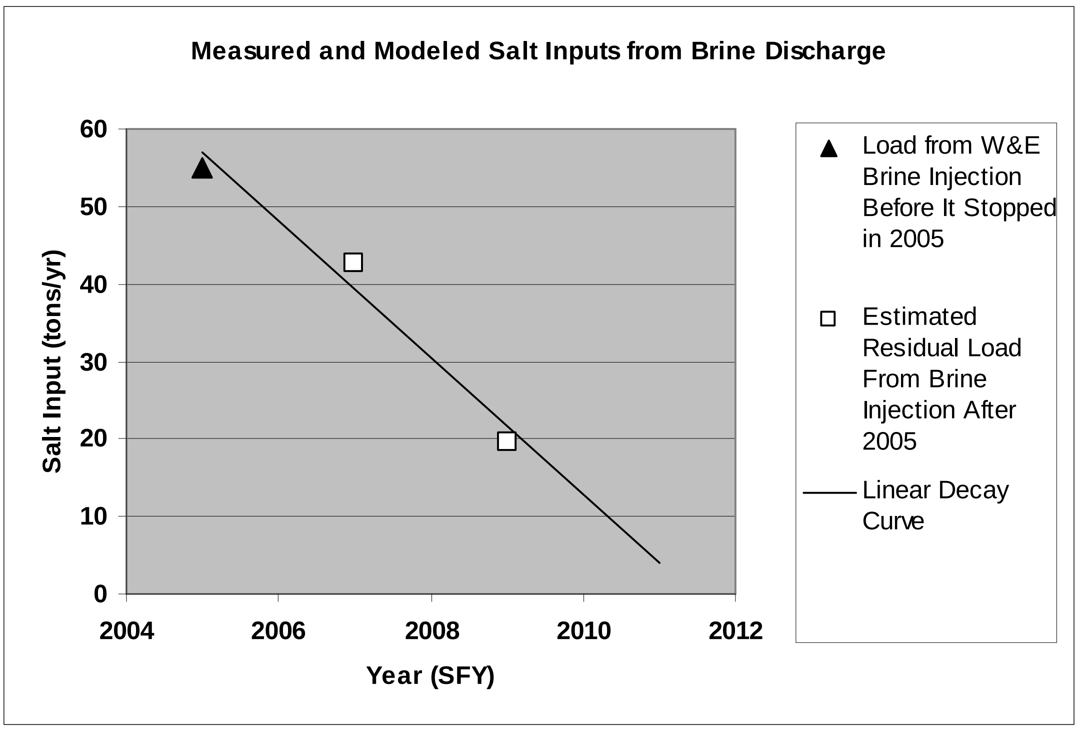
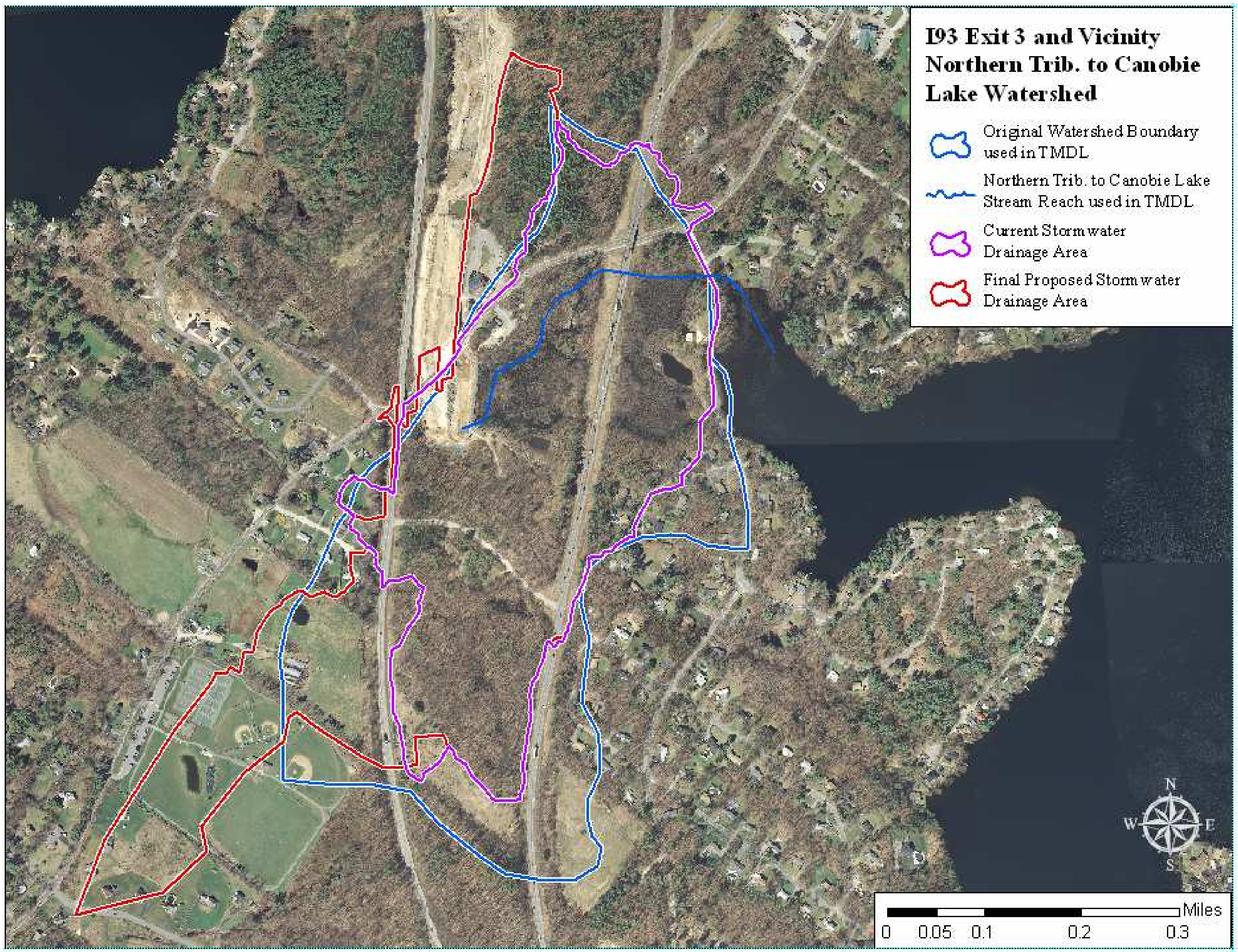


Figure 2: Watershed boundaries for the North Tributary to Canobie Lake



Calculation of Alternative Expression of the TMDL

The alternative expression of the TMDL in the 2008 TMDL report used paired measurements of chloride concentrations and stream flow to calculate a percent reduction goal for critical conditions. This approach cannot be updated because new data on daily stream flow for this watershed are not available. Instead, DES used a model from Trowbridge et al. (2010) to recalculate the alternative expression of the TMDL.

Trowbridge et al. (2010) demonstrated that, if the annual average chloride concentration in a New Hampshire watershed was less than 102 mg/L, violations of the chronic water quality standard typically did not occur. Furthermore, the annual average chloride concentrations could be predicted from the annual salt imports and the annual average runoff in the watershed. The North Tributary watershed will have a drainage area of 125.8 acres after highway construction is complete. The average annual runoff for this drainage area is 0.35 cfs, based on data from 2001-2012 at the Beaver Brook stream gage transposed to the size of the North Tributary to Canobie Lake watershed. The model indicates that the salt load to this watershed should be 58.2 tons per year in order to attain water quality standards during a typical year. To account for uncertainty in the model, this amount should be reduced by 10% to 52.4 tons per year to add a margin of safety.

Sector Loading Allocations

Preliminary load allocations of salt for the different deicing sectors were calculated using the same approach as the 2008 TMDL report. The load allocation for sources other than deicing was set equal to the existing load for these sources (1.2 tons/year). The remaining 51.2 tons per year was allocated to deicing. The deicing allocation was further divided up by sector using the percentage of the salt load from deicing in FY08-FY12 contributed by each sector.

4. Public Participation

a. Description of the Public Participation Process

EPA regulations (40 CFR 130.7 (c) (ii)) require that calculations to establish TMDLs be subject to public review. The North Tributary to Canobie Lake TMDL amendment was released for public comment on January 28, 2013. The comment period lasted until February 28, 2013. The report was posted on the DES (www.des.nh.gov/wmb/tmdl) website. A letter announcing the release was distributed to members of a stakeholder group, consisting of the Water Quality Standards Advisory Committee, the Lakes Management and Advisory Committee, the Rivers Management Advisory Committee, the Local River Management Advisory Committees, the New Hampshire Water Council, local and regional conservation organizations, and the Salt Reduction Workgroup.

b. Public Comment and DES Response

DES received one comment on the draft amendment during the public comment period. The comment and the DES response are listed below.

Comment from the Environmental Protection Agency

> *"I read with interest your Draft Amendment to the Total Maximum Daily Load Study for Chlorides in the North Tributary to Canobie Lake (NTCL) in Windham, NH. Generally, it has an excellent analysis of the deicing salt inputs to the tributary's watershed. However, there is no mention of the effects on future chloride concentrations due to adjacent municipal well pumping, which I believe can be significant when considering the watershed's overall salt budget.*
>
> *For example, PEU/W&E wells 3 and 4 are bedrock wells that reportedly pumped 1,740,809,000 gallons in 2012 (according to pumping statistics for EPA ID#2542030 in the Drinking Water database). Both wells are located in the NTCL watershed, and are about 400 and 450 feet, respectively, from the NTCL culvert under Shore Road. In October 2012, chloride in Well 3 was measured at 220 mg/l. Assuming this level to be representative of the 12 month period (and making all of the metric to English unit conversions), this works out to be approximately 3,189,403 pounds or 1,595 tons of chloride pumped out of the wells' contributing area last year, and which includes the smaller NTCL watershed within the wells' source water protection areas (4,000-foot radius circles).*
>
> *My comment is that any future analysis of chloride levels for the watershed should be based on a refined [such as MODFLOW] numerical model that factors both chloride inputs from paved surfaces and septic systems and outputs from municipal well pumping. The model would also include the influence of Canobie Lake as both a potential source of induced well water to PEU/W&E and as a receptor of ground water flow containing residual amounts of chloride from past brine discharges and from I-93 deicing activities in its watershed. So my key comment is that looking at only chloride inputs to the NTCL watershed is only half the picture. Given the area's hydrogeologic complexity, I think that detailed mathematical modeling is necessary before any viable predictive conclusions can be reached."*

DES Response:

The goal of a TMDL is to attain and maintain the applicable narrative and numerical water quality standards for impaired surface waters. (40 CFR 130.7(c)(1)) Pollutant loads to and from groundwater are relevant to a TMDL in so far as they affect conditions in the impaired surface water.

The chloride extracted from groundwater by municipal drinking water wells is not necessarily a net removal of chloride from the system. As the wells are pumped, locally elevated concentrations may be reduced, but eventually the groundwater chloride concentrations in the pumping area will equal the regional concentration. Continued pumping will not reduce chloride concentrations any more because the pumping will draw in more groundwater with the same regional concentration. At steady state, the amount of chloride pumped out of the well will equal the amount drawn into the pumping area. Moreover, the municipal wells in the NTCL watershed mostly supply water to homes inside the wellhead protection area, and most of these homes use septic systems for wastewater disposal. Therefore, most of the chloride removed from the groundwater by the wells is not a net loss because it is later returned to the groundwater in the same area.

The monitoring and calculations for the TMDL considered the effects of groundwater concentrations on surface waters in the NTCL watershed. The one complication was the locally elevated chloride concentrations near the wells due to a former brine injection practice that ceased in 2005. The amendment to the TMDL showed that these locally elevated groundwater concentrations have been mostly dissipated. With this complication eliminated, detailed groundwater modeling is not needed to improve the accuracy of the TMDL.

Surface water quality monitoring in the NTCL watershed will be continued to ensure that the surface water quality standards are attained. Monitoring will track the combined effects of chloride loads from de-icing, groundwater, and other sources.

5. References

Trowbridge, P.R., J.S. Kahl, D.A. Sassan, D.L, Heath, and E.M. Walsh. 2010. Relating road salt to exceedences of the water quality standard for chloride in New Hampshire streams. *Environ. Sci. Technol.* 44: 4903–4909.