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

Beaver Brook in Derry and Londonderry, NH

Photo Credit: New Hampshire Department of Transportation

April 18, 2008

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

NHDES-R-WD-07-46

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

Beaver Brook in Derry and Londonderry, NH

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1. Introduction

Section 303(d) of the Clean Water Act (CWA) and the 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.

The purpose of this study is to develop a TMDL for chloride in the Beaver Brook watershed located in Derry, Londonderry, Chester, and Auburn, N.H. The goal is 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 Beaver Brook watershed.

2. Problem Statement

a. Waterbody Description

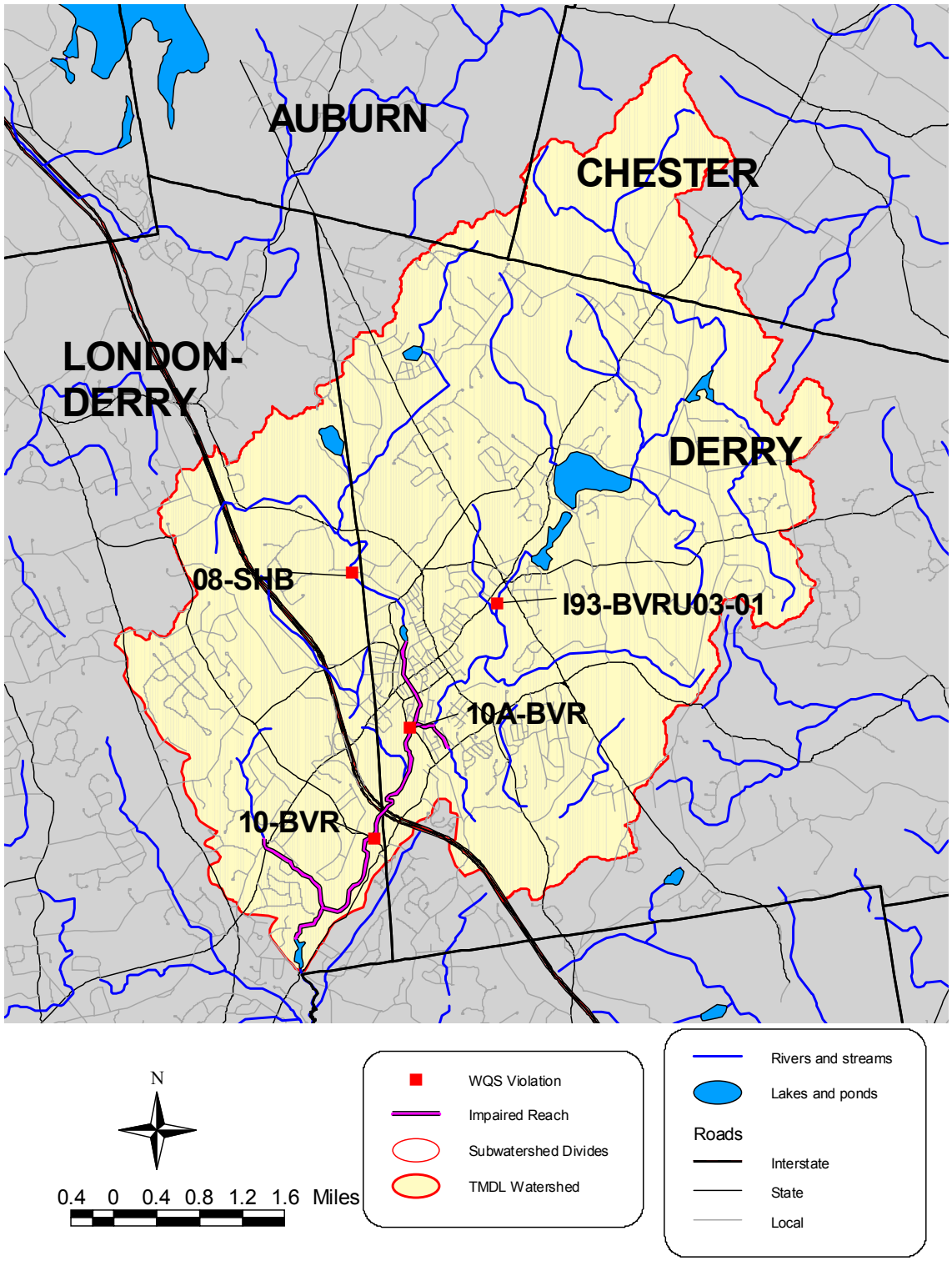
The assessment unit for this TMDL is Beaver Brook (NHRIV700061203-16). It is a stream segment of 4.86 miles located in Derry and Londonderry, N.H. The watershed for this assessment unit is 30.33 square miles (Figure 1) with the upper reaches of the watershed stretching into Chester and Auburn. Land use characteristics of the watershed are listed in Table 1.

Table 1: Land use in the Beaver Brook watershed

Land Use and Demographics	Beaver Brook Watershed	Units
Agriculture	5.91	% of area
Cleared	22.27	% of area
Developed	6.87	% of area
Forested	48.1	% of area
Transportation	11.23	% of area
Wetland	5.62	% of area
Drainage Area	30.33	Square miles
Population	29,895	People
Housing Units	11,525	Number
Population Density	986	People/sq.mi.
"Urbanized Area" Classification	66.0%	% of area

Data Source: DES (2007b)

Figure 1: Impaired Assessment Units and Water Quality Violations in the Beaver Brook Watershed



b. Applicable Water Quality Standards and Water Quality Numeric Targets

Water Quality Standards determine the baseline water quality that all surface waters of the State must meet in order to protect their intended (designated) uses. They are the "yardstick" for identifying where water quality violations exist and for determining the effectiveness of regulatory pollution control and prevention programs. The standards are composed of three parts: designated uses; criteria; and antidegradation regulations.

In New Hampshire, all state surface waters are classified as either Class A or Class B, with the majority of waters being Class B. A general description of designated uses for each classification may be found in state statute, RSA 485-A. According to New Hampshire's Consolidated Assessment and Listing Methodology (CALM; DES, 2005), designated uses for New Hampshire surface waters include those shown in Table 2.

The second major component of water quality standards is the "criteria." These are numeric or narrative criteria which define the water quality requirements for Class A or Class B waters. Criteria assigned to each classification are designed to protect the designated uses for each classification. A waterbody that meets the criteria for its assigned classification is considered to meet its intended use. Water quality criteria for each classification may be found in RSA 485-A:8, I-V [www.gencourt.state.nh.us/rsa/html/L/485-A/485-A-8.htm] and in the State of New Hampshire Surface Water Quality Regulations (Env-Ws 1700) [www.des.nh.gov/rules/env-ws1700.pdf]. The CALM (DES, 2005) describes the methodologies for comparing water quality data with the criteria to assess designated use support.

The third component of water quality standards consists of antidegradation provisions which are designed to preserve and protect the existing beneficial uses of the State's surface waters and to limit the degradation allowed in receiving waters. Antidegradation regulations are included in Part Env-Ws 1708 of the New Hampshire Surface Water Quality Regulations. Antidegradation is not a consideration for this TMDL study.

Beaver Brook is a Class B waterbody. According to Env-Ws 1703.21, the water quality criteria for chloride in nontidal Class B waterbodies to protect aquatic life is that concentrations should not exceed 860 mg/L for acute exposures or 230 mg/L for chronic exposures. Acute aquatic life criteria are based on an average concentration over a one-hour period and chronic criteria are based on an average concentration over a period of four days (EPA, 1991) The frequency of violations for either acute or chronic criteria should not be more than once every three years, on average (EPA, 1991).

Table 2: Designated Uses for New Hampshire Surface Waters

Designated Use	DES Definition	Applicability
Aquatic Life	Waters that provide suitable chemical and physical conditions for supporting a balanced, integrated and adaptive community of aquatic organisms.	All surface waters
Fish Consumption	Waters that support fish free from contamination at levels that pose a human health risk to consumers.	All surface waters
Shellfish Consumption	Waters that support a population of shellfish free from toxicants and pathogens that could pose a human health risk to consumers.	All tidal surface waters
Drinking Water Supply	Waters that with adequate treatment will be suitable for human intake and meet state/federal drinking water regulations.	All surface waters
Primary Contact Recreation (i.e. swimming)	Waters suitable for recreational uses that require or are likely to result in full body contact and/or incidental ingestion of water.	All surface waters
Secondary Contact Recreation	Waters that support recreational uses that involve minor contact with the water.	All surface waters
Wildlife	Waters that provide suitable physical and chemical conditions in the water and the riparian corridor to support wildlife as well as aquatic life.	All surface waters

3. Beaver Brook Receiving Water Quality Characterization

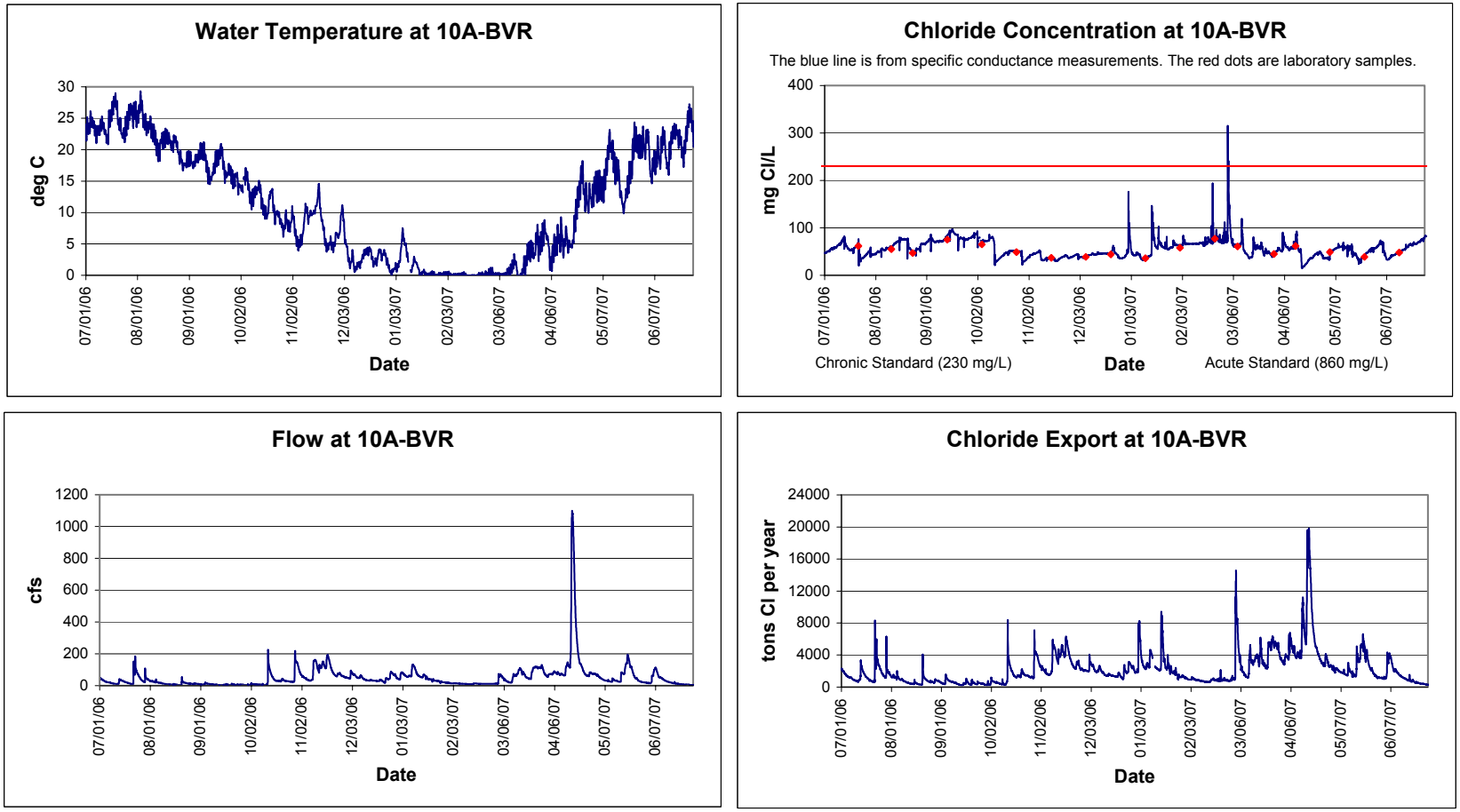
In the winters ending in 2003, 2004, 2005 and 2006, the New Hampshire Department of Environmental Services (DES), the US Environmental Protection Agency (EPA), and the New Hampshire Department of Transportation (DOT) monitored chloride in watersheds in the vicinity of I-93 in southern New Hampshire. Chloride concentrations were primarily measured in winter with near continuous specific conductance readings by data loggers[1]. DES placed the assessment unit NHRIV700061203-16 on New Hampshire's 2006 Section 303(d) list because measurements of chloride concentrations through 2005 demonstrated exceedences of State surface water quality standards. This assessment unit, along with all rivers and lakes in the state, is also listed as impaired for the fish consumption designated use due to the state-wide fish consumption advisory for mercury. Water quality impairments for iron and pH also have been documented in this assessment unit.

The assessment unit was placed on the 2006 Section 303(d) list for chloride because of violations of the chronic water quality standard for chloride in 2004 and 2005. For the period between February 3 and February 9, 2004, water quality violations were detected at stations 10-BVR and 10A-BVR. The durations of the violations were 5.5 to 5.9 days, respectively (approximately 1.5 percent of the year) (DES, 2007b). Another violation of the chronic standard was detected at station 10A-BVR between January 20 and January 25, 2005. The period of violation was 4.6 days (1.2 percent of the year) (DES, 2007b).

For this TMDL study, DES, EPA and DOT developed a monitoring program to collect a comprehensive and standardized dataset for chloride, stream flow, and chloride imports to and exports from the watershed (DES, 2006). The monitoring plan was implemented between July 1, 2006 and June 30, 2007. The data from this monitoring program have been summarized in a Data Quality Audit (DES 2007a) and a Data Report (DES 2007b). The difference between the TMDL monitoring and the previous efforts is that data were collected at the same time at all stations to allow comparison between stations under similar conditions. Stream flow data were collected so that chloride flow duration curves and export calculations could be made. Figure 2 shows the near continuous measurements of temperature, chloride, stream flow, and chloride export (product of chloride concentration and stream flow) at station 10A-BVR between July 1, 2006, and June 30, 2007. The average values for these parameters over the year were 11.33 ^{o}C, 55.86 mg Cl/L, 51.07 cfs, and 2,181.99 tons Cl/yr, respectively. For perspective, typical concentrations of chloride in New Hampshire rivers in 1920, before salt was used as a deicer, were 1.3 mg Cl/L (Hall, 1975).

[1] Data loggers are devices which can be programmed to read and store values from sensors deployed in the field at a set frequency. For this study, data loggers were used to record measurements of water temperature and specific conductance in various streams every 15 minutes.

Figure 2: Time Series of Temperature, Chloride, Stream Flow and Chloride Export at Station 10A-BVR

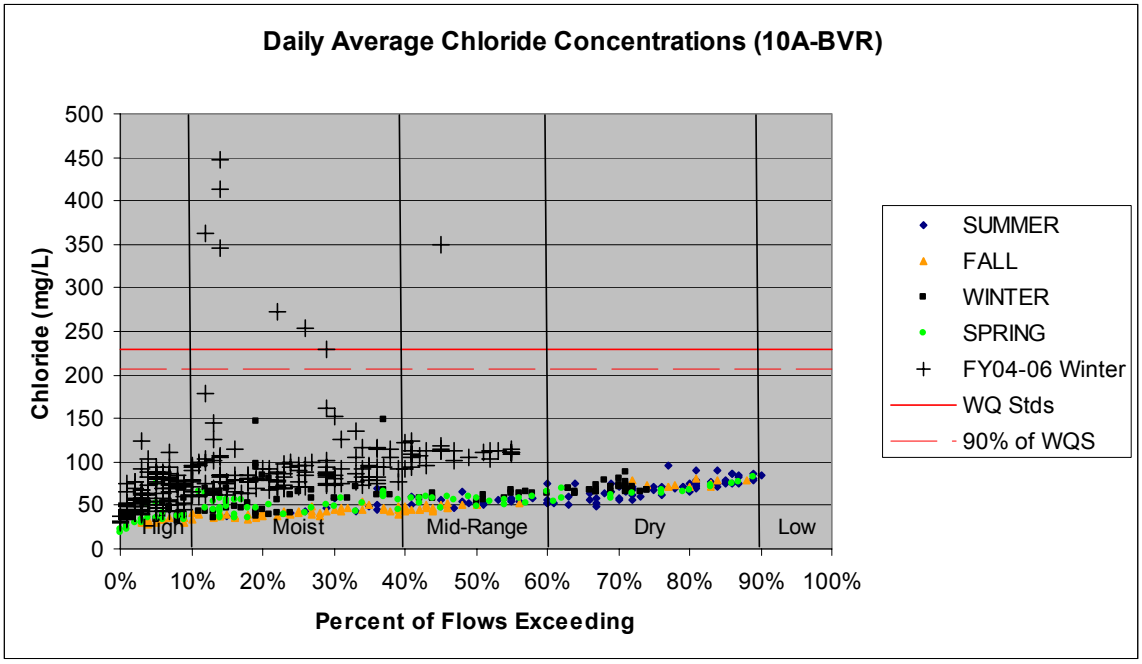


Data Source: DES (2007b)

The monitoring for the TMDL study detected violations of the acute water quality standard at two stations in the Beaver Brook watershed. At station 08-SHB, the chloride concentration spiked to an average concentration of 1,191 mg/L between 12:00 and 15:30 on March 2, 2007. Likewise, at station I93-BVRU03-01, between 06:30 and 07:45 on January 1, 2007, the chloride concentration reached a maximum value of 1,130 mg/L. No violations of the chronic standard were detected at any stations in FY06 or FY07. All of the locations in the watershed at which violations of water quality standards have been detected are shown in Figure 1. The violations on this figure are from a compilation of all relevant data from 2002-2007 (DES, 2007b). The number of violations and the exact dates when these violations occurred are summarized in a data report (DES, 2007b).

Concentration-flow duration curves were used to document how the chloride concentration changed with stream flow (DES, 2007b). For these plots, the measured stream flow on a date was converted to the percent of the time when that flow level is exceeded. The methods for the historical flow duration calculations are provided in a data report (DES, 2007b). The concentration-flow duration plot for station 10A-BVR is shown in Figure 3. Both the full year of data from FY07 and the winter data collected in FY04-FY06 are shown on this plot. Stream flow at 10A-BVR in FY04-FY06 were estimated from the USGS Beaver Brook gage and a watershed area transposition technique. This figure indicates that, in general, chloride concentrations increase as stream flow decreases. However, the violations that were observed in FY04-FY06 occurred during apparent runoff or melt events in the winter season. Summer data for these years were not collected.

Figure 3: Concentration-Flow Duration Plot for Station 10A-BVR



Data Source: DES (2007b)

In addition to the near-continuous monitoring conducted by DES, EPA and DOT, the Town of Derry has collected 63 chloride samples with concentrations ranging from 39 to 150 mg/L from stations located between 10A-BVR and 10-BVR. The samples were collected between June 1995 and April 2007 (2 samples per year at 3 stations). The concentrations in the grab samples were all less than the chronic and acute water quality standards (230 and 860 mg/L, respectively).

4. Source Characterization

Chloride in the form of salt is imported to the study watersheds from several major sources: Roadway deicing, food waste (e.g., sewage), water softeners, atmospheric deposition, and roadway salt pile runoff. DES estimated the mass of salt imported from each source. Details on how these estimates were made are provided in a data report (DES, 2007b). For the TMDL, groundwater was considered a pathway for chlorides, not an independent source.

All of the chloride imported to the watershed is eventually delivered to the impaired reach through stormwater runoff and groundwater flow. Stormwater flow through municipal storm sewer systems (MS4) covered by the Phase II stormwater program regulations will be considered a point source for this TMDL (EPA, 2002). The balance of the stormwater runoff will be considered a non-point source. Sixty-six percent of the watershed is covered by the MS4 Phase II program (Table 1); therefore, 66% of the chloride load will be considered a point source.

The salt imports for FY04, FY05, FY06 and FY07 (FY is July 1 to June 30) are listed by source in Table 3. The values for FY07 were determined using the methods in DES (2007b). For FY04, FY05, and FY06, DES used salt application rates provided by DOT and municipalities plus the following assumptions:

- Imports from atmospheric deposition, food waste, water softeners, and salt piles in FY04-FY06 were the same as for FY07.
- Roadway lane miles and parking lot areas were the same for all years.
- The salt application rate for private roads was the average of the municipal rates.
- The salt application rate for parking lots in FY04, FY05, and FY06 was the value for FY07 (6.4 tons/ac/yr) multiplied by the ratio of the overall average roadway application rate for the year and the overall average for FY07.

The values for roadway and parking lot application rates that were used in the calculations are shown in Table 4.

Salt imports into the watershed varied; the highest value was in FY05 and the lowest value was in FY07. A total of 12,641 tons of salt were imported to the watershed in FY05 at an average rate of 417 tons of salt per square mile of drainage area. In FY07, 6,380 tons of salt were imported, which is equivalent to 210 tons of salt per square mile of drainage area. The contribution of each source to the total load in FY05 is shown in Figure 4. Deicing of roadways and parking lots accounted for 96 percent of the imports, with parking lots being the single largest source (44 percent). Salt piles, water softeners, food waste, and atmospheric deposition were minor components.

The year to year variation in salt imports is primarily due to differences in the severity of the winters. The winter severity index is a climate indicator used by DOT, which is based on daily average temperature and precipitation between November 1 and March 31 for each winter. The index values for FY04 through FY07 are shown at the bottom of

Table 4. The highest salt import rate occurred in FY05 when the winter severity index was the lowest. Conversely, the salt import rate was low in FY07 when the index was high. The winter severity index and salt imports were similar in FY04 and FY06.

Table 3: Sources of Salt to the Beaver Brook Watershed

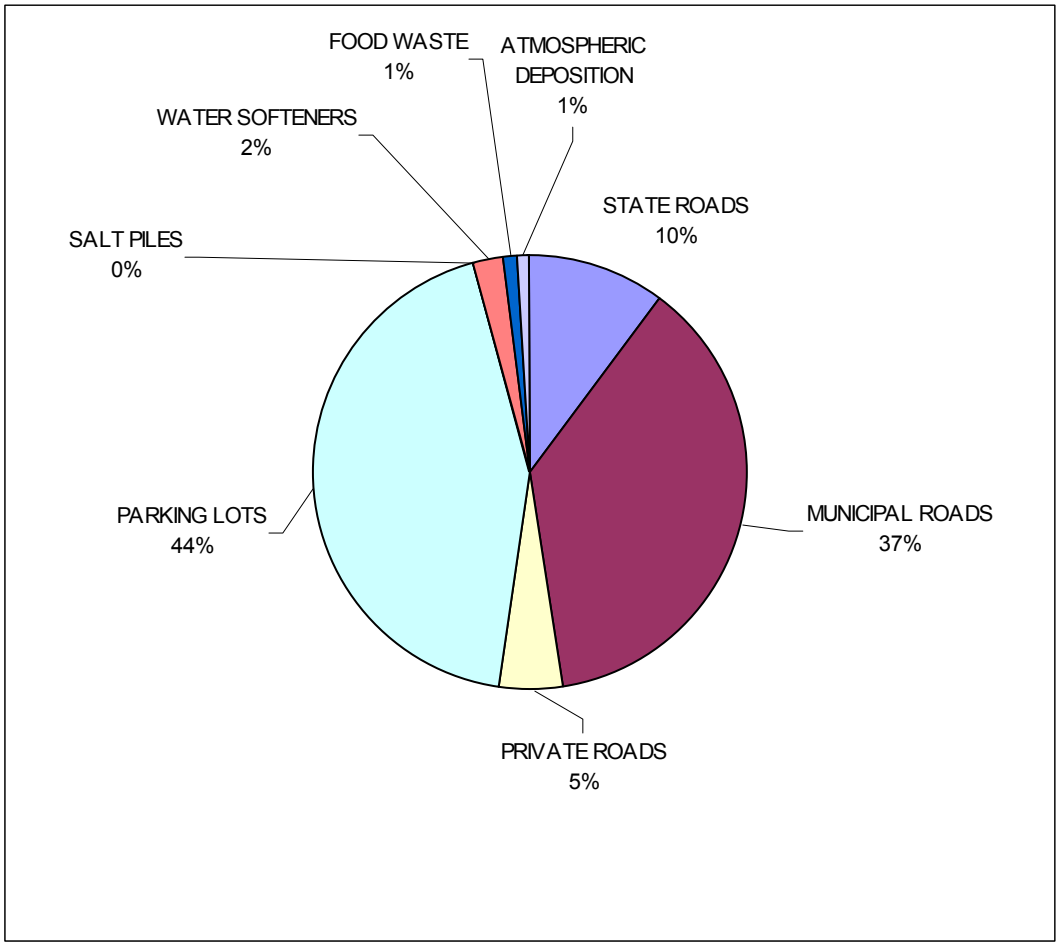
Source	Agency/Town	Salt Imports (tons salt/yr)			
		FY04	FY05	FY06	FY07
State Roads	NHDOT PS 508	53.2	87.2	58.7	57.8
	NHDOT PS 512	137.9	250.9	132.1	150.9
	NHDOT PS 513	66.7	107.8	65.1	58.5
	NHDOT PS 514	110.6	222.2	119.3	97.9
	NHDOT PS 528	466.2	622.0	371.1	303.6
Municipal Roads	Auburn	12.0	12.0	12.0	12.0
	Chester	67.6	67.6	67.6	67.6
	Derry	2,479.4	3,158.7	3,649.1	1,451.3
	Londonderry	1,564.0	1,464.9	858.5	370.2
Private Roads	Chester	25.7	28.6	26.0	15.4
	Derry	375.3	418.4	380.2	225.6
	Londonderry	158.0	176.2	160.1	95.0
Parking Lots	Derry	2,585.9	3,516.6	2,563.7	1,888.0
	Londonderry	1,462.8	1,989.3	1,450.3	1,068.0
Salt Piles	Derry	0.3	0.3	0.3	0.3
	Londonderry	1.3	1.3	1.3	1.3
Water Softeners	NA	272.3	272.3	272.3	272.3
Food Waste	NA	149.5	149.5	149.5	149.5
Atm. Deposition	NA	95.1	95.1	95.1	95.1
Total		10,083.8	12,640.8	10,432.2	6,380.3

Table 4: Salt Application Rates for Roadways and Parking Lots in the Beaver Brook Watershed in FY04, FY05, FY06, and FY07

Town or State PS	Salt Application Rates (tons salt/lane-mile/year)			
	FY04	FY05	FY06	FY07
Auburn	12.00	12.00	12.00	12.00
Chester	12.36	12.36	12.36	12.36
Derry	11.68	14.88	17.19	6.84
Londonderry	20.35	19.06	11.17	4.82
Salem	21.55	31.55	29.24	12.30
Windham	9.29	7.43	6.43	4.11
State PS 508	14.03	22.97	15.47	15.24
State PS 512	8.37	15.23	8.02	9.16
State PS 513	17.91	28.94	17.47	15.71
State PS 514	14.72	29.58	15.88	13.03
State PS 528	21.48	28.66	17.10	13.99
Average of Municipal Rates	14.54	16.21	14.73	8.74*
Average of State Rates	15.30	25.08	14.79	13.43
Overall Average	14.89	20.24	14.76	10.87
Ratio of Overall Average to Overall Average in FY07	1.37	1.86	1.36	1.00
Estimated Parking Lot Application Rate (tons salt/acre/year)	8.8	11.9	8.7	6.4
Winter Severity Index	-16.61	-26.10	-17.67	-11.11

* The average municipal rate for FY07 (8.74 tons salt/lane-mile/year) is slightly higher than the value used in DES (2007b) (8.28 tons salt/lane-mile/year). DES (2007b) calculated the average value with a pivot table which weighted the value based on the number of watersheds associated with each source. The value in this report is an unweighted average.

Figure 4: Relative Contribution of Each Source to the Total Salt Imports to the Watershed in FY05



5. TMDL and Allocations

a. Definition of a TMDL

According to the applicable federal regulations, 40 CFR Part 130.2, the total maximum daily load (TMDL) for a waterbody is equal to the sum of the individual loads from point sources (i.e., waste load allocations or WLAs), and load allocations (LAs) from nonpoint sources (including natural background conditions). Section 303(d) of the CWA also states that the TMDL must be established at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety (MOS), which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality. In equation form, a TMDL may be expressed as follows:

$$TMDL = WLA + LA + MOS$$

where:
WLA = Waste Load Allocation (i.e., loadings from point sources)
LA = Load Allocation (i.e., loadings from nonpoint sources including natural background)
MOS = Margin of Safety

TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measure (40 CFR, Part 130.2 (i)). The Beaver Brook TMDL will be expressed as a load duration curve following guidance from EPA (EPA, 2007). The MOS can be either explicit or implicit. If an explicit MOS is used, a portion of the total allowable loading is actually allocated to the MOS. If the MOS is implicit, a specific value is not assigned to the MOS. Use of an implicit MOS is appropriate when assumptions used to develop the TMDL are believed to be so conservative that they are sufficient to account for the MOS.

b. Determination of TMDL

i. Seasonal Considerations/Critical Conditions

Section 303(d) of the CWA states that the TMDL must be established at a level necessary to attain the applicable water quality standards with seasonal variations. In Table 5, the factors which can influence chloride concentrations have been listed, along with how those factors will be manipulated to ensure that the TMDL will result in attainment of water quality standards during critical conditions.

Table 5: Factors for Determining Critical Conditions

Factor	Effect on Chloride Concentration	Selection of Critical Condition
Season	Figure 3 shows that most violations occurred during the winter season during periods of "moist" stream flow. However, summer season data were not collected in FY04-FY06.	The TMDL will be expressed as a load duration curve to set limits for "moist" flow periods during the winter season.
Stream Flow	Figure 3 shows that chloride concentrations increase as stream flows decrease.	The TMDL will be expressed as a load duration curve to accurately describe the acceptable load at each stream flow.
Location	The proximity of salt sources can affect the chloride concentration in the waterbody.	Data from the year round station with the highest chloride yield (tons Cl/mi2/yr), 09-BVR, will be the basis for the TMDL.
Water Quality Standard	Either the acute or chronic water quality standard must be chosen to set the target for the TMDL.	The chronic standard will be the basis for the TMDL target because most of the violations in the watershed were of the chronic standard. The chronic standard is also lower than the acute standard.

ii. Margin of Safety

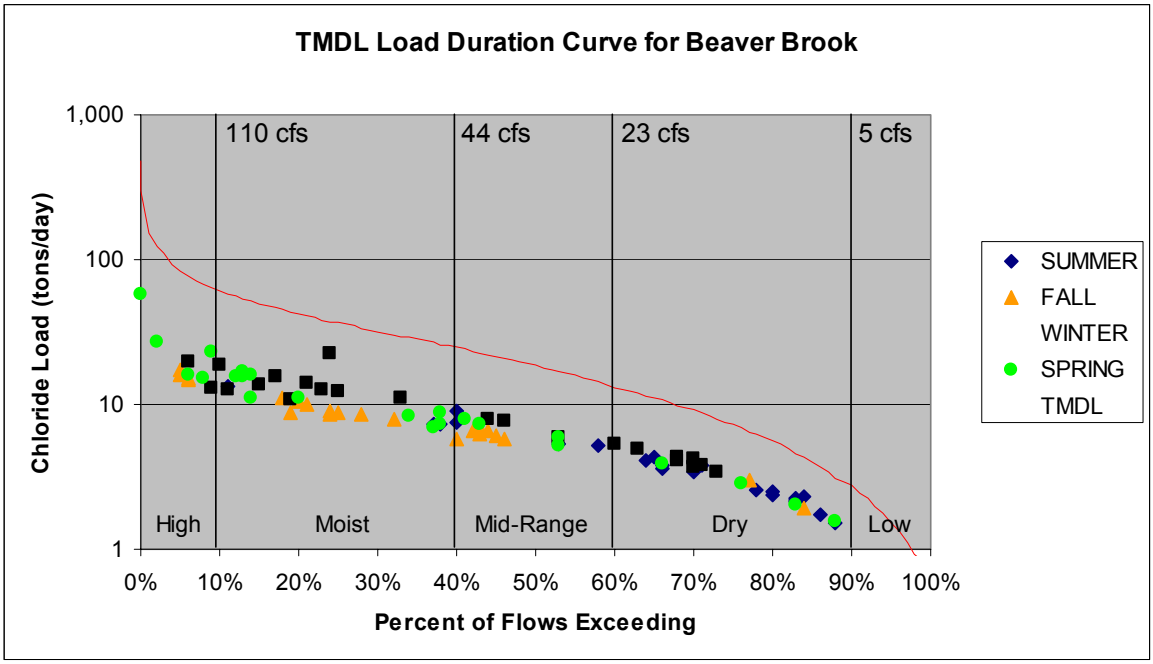
An explicit Margin of Safety (MOS) will be used in the TMDL calculation. The TMDL will be set at 90 percent of the chronic water quality standard (90%*230 mg C/L = 207 mg Cl/L). This assumption is equivalent to holding 10 percent of the loading in reserve to account for scientific uncertainty.

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, 09-BVR, because this station had the highest chloride yield in FY07. Figure 5 shows the TMDL load duration curve and the existing loads measured at 09-BVR between July 1, 2006 and June 30, 2007 (equivalent data were not collected in FY04-FY06). 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 66 percent of the TMDL and the load allocation for non-point sources is 34 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 Beaver Brook watershed.

Figure 5: TMDL Load Duration Curve at Station 09-BVR



The TMDL can be alternatively expressed as a percent reduction goal (PRG) to guide implementation. The salt imports in FY04-FY05 (when chronic water quality violations occurred) can be compared to salt imports in FY06-FY07 (when chronic violations did not occur) to identify the salt import value at which water quality violates the chloride standard. In FY04-FY05, the salt imports ranged from 10,084 to 12,641 tons of salt per year. In FY06-FY07, the salt imports ranged from 6,380 to 10,432 tons of salt per year. Therefore, the apparent threshold for chronic water quality violations must be where these two ranges overlap: 10,084 to 10,432 tons of salt per year. The lowest value in this range (10,084) was from FY04, a year with average annual stream flow and during which violations of the chronic chloride standard occurred. The TMDL must be set at a level for which violations will not occur. Therefore, the TMDL will be the salt loading rate from FY04 reduced by 10% (9,069 tons of salt per year). An additional margin of safety will be applied in the load allocations to ensure that water quality standards are met under all conditions. In FY05, when chronic water quality violations occurred, the salt imports to the watershed, 12,641 tons per year, needed to be 28% lower in order to reach the goal. In FY07, when chronic violations did not occur, salt imports to the watershed were already below the goal.

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 and all other chloride TMDL studies in the I-93 corridor until these studies are completed, and 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, the 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 6 based on the following assumptions:

- 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 all 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.
- 10% of the total allocation will be reserved as a margin of safety.

Table 6: Existing Salt Imports and Load Allocations

Source	Agency/Town	FY05 Salt Imports (tons/salt/yr)	FY07 Salt Imports (tons salt/yr)	Allocation of Loads (tons salt/yr)
State Roads	NHDOT PS 508	87.2	57.8	70.4
	NHDOT PS 512	250.9	150.9	183.6
	NHDOT PS 513	107.8	58.5	71.2
	NHDOT PS 514	222.2	97.9	119.1
	NHDOT PS 528	622.0	303.6	369.4
Municipal Roads	Auburn	12.0	12.0	18.7
	Chester	67.6	67.6	105.5
	Derry	3,158.7	1,451.3	2,264.4
	Londonderry	1,464.9	370.2	577.6
Private Roads	Chester	28.6	15.4	18.1
	Derry	418.4	225.6	263.9
	Londonderry	176.2	95.0	111.1
Parking Lots	Derry	3,516.6	1,888.0	2,217.8
	Londonderry	1,989.3	1,068.0	1,254.6
Salt Piles	Derry	0.3	0.3	0.0
	Londonderry	1.3	1.3	0.0
Water Softeners	NA	272.3	272.3	272.3
Food Waste	NA	149.5	149.5	149.5
Atm. Deposition	NA	95.1	95.1	95.1
Margin of Safety	NA			906.9
Total		12,640.8	6,380.3	9,069.2

6. Implementation Plan

a. Statutory/Regulatory Requirements

Section 303(d)(1)(C) of the CWA provides that TMDLs must be established at a level necessary to implement the applicable water quality standard. The following is a description of activities that are planned to abate water quality concerns in the Beaver Brook watershed.

b. Description of Activities to Achieve the TMDL

i. Implementation Plan

To implement this TMDL, salt imports to the watershed for deicing must be limited to the allocated loads in Table 6. State law (RSA 485-A:12.II) provides that "If, after adoption of a classification of any stream, lake, pond, or tidal water, or section of such water, including those classified by RSA 485-A:11, it is found that there is a source or sources of pollution which lower the quality of the waters in question below the minimum requirements of the classification so established, the person or persons responsible for the discharging of such pollution shall be required to abate such pollution within a time to be fixed by the department."

The details of an implementation plan will be developed by the Salt Reduction Workgroup in 2008 (see section 5(b)(iv) for information on the workgroup). The plan will require that owners of property on which salt is applied track and report the amount applied. This will be compared with allocations on an annual basis to determine compliance with RSA 485-A:12 and the load allocations of Table 6. It should be noted that the load allocations in the TMDL do not include an allowance for future growth, so any future construction of additional roads or parking lots in the Beaver Brook watershed would necessitate additional load reductions elsewhere in the watershed beyond the allocations in Table 6.

The draft implementation plan will be made available for public comment after it is developed by the workgroup.

ii. Monitoring

Pending the availability of resources, specific conductance will be monitored at 15-minute intervals with data loggers at the outlet station for the watershed, 09-BVR, and station 10A-BVR from July 1, 2007 to June 30, 2016. Stream flow at these stations will be estimated from the USGS Beaver Brook stream gage. The data will be analyzed by DES for violations of the acute and chronic water quality standards following the procedures used in DES (2007b). The number of violations and the salt imports to the watershed will be tracked for each year. DES will evaluate changes in these values using multivariate linear or logistic regression with climate variables (e.g., the DOT Winter Severity Index, flow) as covariates. A trend will be considered significant if the

coefficient of the year term in the equation is significant at the $p<0.05$ level. A minimum of five years of data (and most likely 10 years) will be needed before trend analysis can be performed. Biomonitoring should be completed after water quality standards for chloride have been met at stations 09-BVR and 10A-BVR to verify that there are no additional impacts to aquatic life from chlorides or other contaminants.

7. 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 Beaver Brook TMDL was released for public comment on January 2, 2008. The comment period lasted until February 8, 2008. The report was posted on the DES (www.des.nh.gov/wmb/tmdl) and the Rebuilding I93 (www.rebuildingi93.com) websites. A letter announcing the release was distributed to 132 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. DES also issued a press release which generated stories in several local papers.

b. Public Comment and DES Response

DES received comments from five organizations or individuals by the deadline:

- New Hampshire Department of Transportation
- New Hampshire Fish and Game Department
- Appalachian Mountain Club, Conservation Law Foundation, Environment New Hampshire, New Hampshire Audubon, and the New Hampshire Rivers Council
- Sierra Club
- Town of Derry

DES paraphrased the comments from each letter and provided responses in the following sections.

Comments from the New Hampshire Department of Transportation

1.1 The applicable water quality standard for the TMDL should be 250 mg Cl/L, not 230 mg Cl/L.

Category: No change

Response: The assessment unit for this TMDL is impaired for the aquatic life use support designated use. The EPA and DES standard for the protection of aquatic life is 230 mg Cl/L. DES conducted a review of the toxicological literature related to road salt (DES, 2007c). The report concluded that 230 mg Cl/L was the appropriate standard for the TMDL to be protective of humans, wildlife, aquatic organisms, and most vegetation. Therefore, by setting the TMDL at the level necessary to achieve the 230 mg Cl/L

standard, the TMDL addresses impacts associated with chlorides on the instream, benthic, and riparian communities. The secondary drinking water standard for chloride is 250 mg Cl/L. This standard is based on taste and odor issues, not human health. It is not appropriate for the TMDL because it is not the lowest applicable water quality standard and is not related to the impaired designated use.

1.2 The ten percent margin of safety is arbitrary and excessive.
Category: No change
Response: A margin of safety is required for the TMDL to account for any lack of knowledge concerning the relationship between pollutant loads and water quality (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)). DES selected ten percent as the margin of safety for the TMDL in the Quality Assurance Project Plan (DES, 2006), which was reviewed and approved by DOT, USGS, and EPA. There is not compelling evidence that the uncertainty in the relationship is greater than or less than ten percent. Furthermore, given the divergent comments on this topic (see comment 2.1 from AMC et al.), there is not consensus that a larger or smaller margin of safety should be adopted for policy reasons. The margin of safety of 906.9 tons per year listed on Table 6 is for an alternative expression of the TMDL. The official TMDL is the load duration curve shown in Figure 5. The load duration curve for Beaver Brook was generated in the same manner as the load duration curves for Policy-Porcupine Brook, Dinsmore Brook, and the North Tributary to Canobie Lake.

2.1 The error in the salt imports for parking lots is larger than the required salt reductions.
Category: No change
Response: While there may be sizeable error in the salt import estimates for private parking lots, the estimates were made based on the best available science anywhere in the country. In fact, the import estimates used for the TMDL were based on locally derived data. Plymouth State University spent one year researching this issue through painstaking local data collection and nation-wide research (Sassan and Kahl, 2007). Better estimates for salt application by this sector do not exist. An accurate salt accounting system will be needed to reduce the error in the salt import estimates as we move forward with implementation.

2.2 The salt application rate for parking lots in FY04-FY06 should not be assumed to be correlated with salt application rates on roadways. The maintenance decision matrix for parking lots is very different than for roadways and to assume the salt application rate may vary in the same way as public roads needs further investigation.
Category: No change
Response: DES acknowledges that the salt application rate to parking lots was assumed to be correlated with the salt application rate on municipal roadways. No empirical data are available to test this assumption. However, DES has demonstrated that road salt application to roadways varies based on the severity of the winter (see Attachment 3 to the DES-DOT Memorandum of Agreement regarding chloride TMDLs). It stands to reason that more salt will also be applied to parking lots in more severe winters.

Therefore, salt application rates on roadways and parking lots will be positively correlated in some way even if exact form of the correlation is not known. In the absence of data, DES assumed that the relative changes year-over-year in salt application to roadways were the same as for parking lots. DOT and other deicing organizations could conduct additional research over the next several years to provide data to prove or refine this relationship. The TMDL could be modified in the future if this research resulted in significantly different allocations of loads. In the meantime, DES feels that the assumptions made in the TMDL were justified and appropriate.

3.1 The assumption that FY04 and FY05 are representative of years with salt loads that produce water quality violations appears to be a stretch. The water quality violations appear to be event driven not annual load driven … The violations also appear to be flow independent with the events occurring in the moist and mid-range categories, indicating that salt enriched base flow from groundwater is having less of an effect in this watershed than others…As suggested by EPA's TMDL guidance, the extreme data should not be considered when formulating the TMDL. The Department suggests that the two severe winter weather events are anomalies and should not form the basis for the TMDL.

Category: No change

Response: Violations of the chloride standard have occurred in Beaver Brook in three of the past five years which indicates a persistent problem that cannot be explained by extreme events. Two violations of the water quality standard occurred in FY04 and FY05. A third violation of the standard occurred in FY08 in late November-early December 2008. The exact duration of this violation is uncertain because of datasonde failure.

The TMDL for Beaver Brook, though not perfect, fulfills the requirements of the Clean Water Act and provides a logical basis for the responsible parties to proceed with source reductions necessary to eliminate the water quality violations. The official TMDL for Beaver Brook is the load duration curve shown in Figure 5. The basis of this curve is a 20-year flow record and the water quality standard, both of which are known with low uncertainty.

The Federal Highway Administration has allocated funds to assist with salt source reductions to implement the chloride TMDL studies in the Interstate 93 corridor. If the Beaver Brook TMDL were to be delayed several years by more research, these funds would no longer be available for compliance and implementation.

<u>Comments from the New Hampshire Fish and Game Department</u>

1. New Hampshire Fish and Game Department has reviewed both documents and found them to be thorough and well done. As human activities increase on the land, the impacts to aquatic resources become ever more visible, and the people of New Hampshire lose a valuable and integral part of their community and natural heritage. These studies and the reduction of chlorides in aquatic ecosystems are essential to the protection and conservation of our aquatic resources.

Category: No change

Response: No change requested

Comments from the Appalachian Mountain Club, Conservation Law Foundation, Environment New Hampshire, New Hampshire Audubon, and the New Hampshire Rivers Council

1.1 The TMDL does not address impacts that can be associated with chlorides including instream, benthic, and riparian communities.

Category: No change

Response: The assessment unit for this TMDL is impaired for the aquatic life use support designated use. The EPA and DES standard for the protection of aquatic life is 230 mg Cl/L. DES conducted a review of the toxicological literature related to road salt (DES, 2007c). The report concluded that 230 mg Cl/L was the appropriate standard for the TMDL to be protective of humans, wildlife, aquatic organisms, and most vegetation. Therefore, by setting the TMDL at the level necessary to achieve the 230 mg Cl/L standard, the TMDL addresses impacts associated with chlorides on the instream, benthic, and riparian communities. See also the response to comment 4.2 from AMC et al.

1.2 Beaver Brook has been identified as having water quality impairments for pH and iron. Because chlorides pollution can adversely affect pH and can mobilize metals, DES must assess the relationship between chlorides pollution and these impairments and ensure a TMDL for chlorides that will ensure attainment of these water quality standards.

Category: No change

Response: The iron impairment in the Beaver Brook assessment unit (NHRIV700061203-16) is most likely due to contaminated groundwater discharge from the former Derry landfill and the pH impairment is most likely due to groundwater discharge from the landfill as well as atmospheric deposition of acids (i.e., acid rain).

1.3 The TMDL does not ensure that water quality standards will be met in all locations in the watershed.

Category: No change

Response: For the study design, DES established continuous monitoring stations at the outlets of each of the four watersheds. Two of the watersheds were small (Dinsmore Brook and North Tributary to Canobie Lake) and the outlet stations were considered to be representative of the whole watershed. For the Policy-Porcupine and Beaver Brook watersheds, DES chose additional locations in the watersheds to represent worst-case conditions based on monitoring data from 2002-2006. Water quality at these worst-case stations was monitored continuously during the TMDL study. In both watersheds, the water quality was worse at the outlet station than at the "worst-case" station. In Policy-Porcupine Brook, the chronic water quality standard was violated for a total of 87.7 days at the outlet station (I93-POL-01V) compared to 66.0 days at the "worst case" station (I93-POL-04X) (DES, 2007b, Table 13). In Beaver Brook, water quality violations did not occur at either station; however, the average chloride concentration at the outlet

station (09-BVR) was 67.58 mg/L compared to 55.86 mg/L at the "worst case" station (10A-BVR) (DES, 2007b, Table 10). Therefore, DES believes that attainment of the standards at the outlet stations should result in attainment of standards throughout the watershed.

1.4 The TMDL does not state when water quality standards will be met.
Category: Carry forward to implementation plan
Response: This comment is relevant to the implementation plan, which has not yet been drafted. The comment will be carried forward to the Salt Reduction Workgroup to consider when developing the implementation plan.

2.1 The ten percent margin of safety is inadequate. A more protective margin of safety is needed.
Category: No change
Response: The margin of safety is to take into account any lack of knowledge, or scientific uncertainty, concerning the relationship between the loading targets and water quality standards. Here, the official TMDL for this study is the load duration curve shown in Figure 5. The basis of this curve is a 20-year flow record and the water quality standard. Therefore we believe that the targets are reasonably accurate and there is no need for a margin of safety greater than ten percent. While AMC et al.'s comments identify a number of scientific uncertainties related to chloride loadings, those uncertainties are relevant to determining how the TMDL will effectively be implemented, not to the TMDL itself.

2.2 Relying on the data from FY04 and FY05, the study assumes that 332 tons of salt per square mile is the low range at which water quality violations will occur. This assumption, however, fails to account for the time delay that can occur as a result of chlorides migrating through groundwater.
Category: No change
Response: DES agrees that all of the chloride applied to the land surface in one year is not necessarily discharged from the watershed during the same year. However, the mass balance calculations in DES (2007b, p. 16) indicate that most (>80%) of the salt imports are exported in the same year. This assertion is further supported by the fact that there were no water quality violations in FY06, which followed the year with the highest salt imports. Furthermore, to account for uncertainty regarding the assumption that 332 tons of salt per square mile is the low range at which violations occur, DES reduced this value by ten percent to 299 tons of salt per square mile before calculating the alternative expression of the TMDL.

2.3 The TMDL calculation relies on a per-square-mile averaging of salt imports that the watershed can assimilate. This approach ignores key factors, such as the varying proximity and amounts of impervious surface relative to individual segments of the water resource, including the potential for hotspots to occur at locations within the watershed.
Category: No change

Response: See response to AMC et al. comment 1.3. The data collected for this study does not support the argument that chloride concentrations are necessarily worse in stream segments in areas with dense road networks.

2.4 The study does not address the impacts of future development in the watershed.
Category: No change
Response: The TMDL for the watersheds was set at the total amount of road salt that the watershed can assimilate. Aside from a margin of safety, all of the TMDL was allocated to existing sources. However, in Section 6(b)(i) of the TMDL, it states that "any future construction of additional roads or parking lots in the TMDL watersheds would necessitate additional load reductions elsewhere in the watershed beyond the allocations in Table 5." Therefore, the provision for future growth in the watershed is a trading system between current and new sources.

2.5 The final allocations of loads by sector should be made available for public review and comment.
Category: Accept
Response: The allocations of loads will be developed by the Salt Reduction Workgroup, which is a public process. In response to other comments (see AMC et al. comment 5.1), additional members will be added to this group. DES will add an opportunity to comment on draft allocations developed by this group. If necessary, DES will amend the TMDL to incorporate more specific wasteload allocations following public comment.

2.6 The allocations of loads should be split into more categories (e.g., by sector and by town or DOT patrol shed).
Category: Accept
Response: The Tables 3 and 6 in the TMDL will be revised to stratify both the salt import estimates for FY07 and the allocations of loads by town and patrol shed.

2.7 The TMDL should ensure that violations of the acute water quality standard for chlorides do not occur.
Category: No change
Response: The TMDL was based on the chronic standard for chlorides because this standard was violated far more frequently than the acute standard. The chronic standard is also lower than the acute standard (230 and 860 mg/L, respectively). Therefore, if the chronic standard is met, acute violations are unlikely. Of all of the stations monitored for the TMDL, there were only two where acute violations occurred but chronic violations did not (08-SHB and I93-BVRU03-01). These violations occurred for a total of 5 hours out of the 84,960 hourly average measurements made at all of the sites. Therefore, the 10 percent margin of safety for the TMDL should be sufficient to protect against the likelihood of this occurrence (0.006%).

2.8 The TMDL should be established with daily load allocations, not yearly.
Category: No change
Response: For this study, the TMDL, wasteload allocation, and load allocation are shown on the load duration curve shown in Figure 5. The units for this curve are tons of

chloride per day, which meets the requirements of expressing the load allocations as daily loads.

3.1 The final implementation plan should be made available for public review and comment.
Category: Accept
Response: The final implementation plan will be developed by the Salt Reduction Workgroup, which is a public process. In response to other comments (see AMC et al comment 5.1), additional members will be added to this group. DES will add an opportunity to comment on implementation plan developed by this group.

4.1 Monitoring in the watersheds should continue year-round to capture violations in the summer.
Category: No change
Response: The sampling design for the long-term monitoring program is for year-round monitoring at stations 09-BVR and 10A-BVR in the Beaver Brook watershed.

4.2 The implementation monitoring plan should include biomonitoring to detect direct impacts to aquatic life.
Category: Accept
Response: Until the water quality standards for chloride have been achieved in the TMDL watersheds, biomonitoring is not necessary because impacts to aquatic resources have already been demonstrated through water quality monitoring. However, DES agrees that biomonitoring should be completed after water quality standards for chloride have been met to verify that there are no additional impacts to aquatic life from chlorides or other contaminants. Aquatic life may be affected by sources other than road salt in these watersheds.

4.3 The implementation monitoring plan should include stations throughout the watershed to detect "hot spots" of chloride concentrations.
Category: No change
Response: See response to AMC et al. comment 1.3.

4.4 Implementation monitoring must not be "pending resources". A fully-funded monitoring program is critical.
Category: No change
Response: DES agrees that a fully-funded program is necessary. However, State and federal funding for water quality monitoring in the future cannot be guaranteed. Therefore, all programs must be considered to be "pending the availability of resources".

5.1 The Salt Reduction Workgroup should have members from pertinent watershed associations and state-wide environmental organizations.
Category: Accept
Response: DES agrees that representatives from pertinent watershed associations and state-wide environmental organizations should be invited to join the workgroup.

Comments from the Sierra Club

1.1 The boundaries of the stream segment should be justified based on monitoring data.

Category: No change

Response: In 2002, DES created assessment units for all stream segments in the state. The segments were developed using a standardized process described in the memorandum dated March 29, 2002. Monitoring in a variety of locations near the I-93 roadway in 2002-2006, detected chloride violations in one of the assessment units for Beaver Brook. The reported water quality violation triggered the need for a TMDL study of this assessment unit. For the TMDL study, DES delineated a watershed which contributed to the impaired assessment unit. The outlet of the watershed was set at the furthest downstream location in the impaired assessment unit where a temporary stream gage could be installed (station 09-BVR). All of the contributing assessment units upstream of that station were included as the TMDL study area. Therefore, monitoring data were used to select the assessment unit for the TMDL study and hydrology was used to define the watershed boundaries of the study area.

2.1 The TMDL should inventory NPDES permits for chloride discharges.

Category: No change

Response: DES obtained information on NPDES-permitted discharges in the study watersheds. None of the discharges had numeric limits for chlorides and none of the permittees were required to provide monitoring data on chloride loads. No municipal wastewater treatment facilities discharge in the study watersheds. Therefore, an inventory of NPDES permittees will provide no additional information about chloride loads to the watersheds.

3.1 The TMDL does not explain the significance of the arbitrary comparison between FY04-FY05 and FY06-FY07.

Category: No change

Response: For the alternative expression of the TMDL, DES compared the salt application rates in FY04 and FY05 and to the salt application rates in FY06 and FY07. The reason why these years were compared was because in FY04 and FY05 there were water quality violations for chloride in Beaver Brook, while in FY06 and FY07 there were not. This rationale was clearly set forth on Section 5(b)(iii) of the report. A longer record of salt application rates was not included because winter-long chloride measurements were only available for FY04 through FY07.

3.2 It is unclear why the crude calculation of the aggregate salt tonnage divided by the square miles of watershed area means anything. Salt pollution in the Beaver Brook watershed is largely caused, according to the TMDL, by roads and parking lots…The area (in square miles) of the watershed has nothing whatsoever to do with the sources of chloride pollution, nor does the area of the watershed have a direct connection to the level of contamination or actual drainage.

Category: Accept

Response: Dividing the salt imports by watershed area is a common normalization method which allows watersheds of different sizes to be compared. For the Beaver Brook TMDL, only one watershed is considered. Therefore, this normalization method is not necessary. To reduce confusion, the total salt imports to the watershed will be substituted for the normalized salt import values in Section 5(b)(iii). The resulting allocations will not change except for slight deviations due to rounding.

3.3 The Quality Assurance Project Plan for the study does not provide any support for the load allocation baseline calculation set forth in the TMDL.

Category: No change

Response: The official TMDL for Beaver Brook is the load duration curve shown on Figure 5. This load duration curve was created following the procedures set forth in the QAPP. DES was not able to follow the QAPP for the alternative expression of the TMDL because there were no violations of the water quality standard in FY07. Therefore, DES developed another method to provide similar information. The purpose of the alternative expression of the TMDL is to guide implementation. It is not the official TMDL for the waterbody.

3.4 The GIS data as to specific roadways and parking lots described in the QAPP is missing from the TMDL. Such data would provide a far more accurate methodology to calculate the load application limits for each chloride source than, as the TMDL provides, the use of the total area in the watershed and the reported gross salt tonnage.

Category: No change

Response: GIS data on specific roadways and parking lots was used to calculate the total salt imports to the Beaver Brook watershed. Therefore, these data were included in the TMDL. For the allocations of loads in Table 6, DES has agreed to expand the categories to provide more detailed information. See comment 2.6 from AMC et al.

3.5 The QAPP notes that specific conductance should be monitored at "worst case" locations. The Beaver Brook TMDL makes no reference to the "worst case" locations. The TMDL does not suggest that station 10A-BVR is the "worst case" location in the watershed.

Category: No change

Response: Page 11 of the QAPP states that "Specific conductance will be monitored at the outlet of each watershed and at a second, 'worst-case' location in each of the Beaver Brook and Policy Brook watersheds." In Table 8 of the QAPP, there are two stations listed for the Beaver Brook watershed. Station 09-BVR is listed as the outlet station. Therefore, 10A-BVR is implicitly the "worst-case" station as defined by the QAPP.

3.6 The TMDL cannot answer the critical questions posed on page 9 of the QAPP: (1) How much chloride loading should be allocated to each major source category in the watershed in order to meet water quality standards? (2) What actions are needed by state, municipal and private entities to reduce chloride loadings to the TMDL? (3) After the recommended actions are implemented, how will we know whether chloride concentrations are decreasing in the impaired assessment units?

Category: No change
Response: The official TMDL for the waterbody and the allocations between point sources and non-point sources are provided in Figure 5. Table 6 of the TMDL provides an alternative expression of the TMDL which contains allocations for each major source category in the watershed. The actions required by state, municipal, and private entities to achieve water quality standards will be determined in the implementation plan. The plan for monitoring compliance with water quality standards is clearly shown in Section 6(b)(ii) of the TMDL.

4.1 The allocations of loads in the TMDL are only draft. There should be opportunity to comment on the final allocations.
Category: Accept
Response: See response to AMC et al. comment 2.5.

4.2 The TMDL should be established with daily load allocations, not yearly.
Category: No change
Response: See response to AMC et al. comment 2.8.

4.3 The TMDL does not have an implementation plan.
Category: Accept
Response: See response to AMC et al. comment 3.1.

4.4 The TMDLs do not provide for the expected growth from the I-93 expansion.
Category: No change
Response: See response to AMC et al. comment 2.4.

4.5 The TMDL does not include an enforcement plan for private chloride discharges.
Category: Carry forward to implementation plan
Response: This comment is relevant to the implementation plan, which has not yet been drafted. The comment will be carried forward to the Salt Reduction Workgroup to consider when developing the implementation plan.

<u>Comments from the Town of Derry</u>

1. It is unrealistic to place an annual limit on salt usage because the need for salt to maintain safe roadways varies with the severity of the winter.
Category: Carry forward to implementation plan
Response: This comment is relevant to the implementation plan, which has not yet been drafted. The comment will be carried forward to the Salt Reduction Workgroup to consider when developing the implementation plan. For clarification, the official TMDL for Beaver Brook is the load duration curve shown in Figure 5. The annual allocations of salt shown in Table 6 are not the official TMDL, but rather an alternative expression of the TMDL to help guide implementation.

2. The Town of Derry does not have staff resources necessary to monitor salt application to private roadways and parking lots.

Category: Carry forward to implementation plan
Response: This comment is relevant to the implementation plan, which has not yet been drafted. The comment will be carried forward to the Salt Reduction Workgroup to consider when developing the implementation plan.

3. Why was Beaver Brook selected for this study? There must be more urbanized watersheds in New England.

Category: No change
Response: EPA placed Beaver Brook and four other stream segments on the New Hampshire Section 303(d) list in 2006 due to water quality monitoring which showed violations of the chloride standard. When DOT applied for wetlands permits to expand Interstate 93, DES added a requirement that DOT participate in and comply with TMDL studies for these chloride impairments. In a Memorandum of Agreement, DES and DOT agreed to a schedule for completing the TMDLs and to allocate some of the federal funds provided for I-93 water quality studies for the chloride TMDLs.

Violations of the chloride standard are difficult to detect with grab samples because of the extreme variability in concentrations due to stream flow. The violations can only be reliably detected using near-continuous readings of specific conductance by data loggers. This monitoring method is expensive and relatively infrequent, which explains why few chloride impairments have been detected in the region. DES is working with EPA Region I to develop a regional approach to identifying watersheds at risk of chloride impairments and directing datalogger monitoring equipment to these watersheds.

4. Variable roadway treatment due to local salt use limits would be unsafe for motorists.

Category: Carry forward to implementation plan
Response: This comment is relevant to the implementation plan, which has not yet been drafted. The comment will be carried forward to the Salt Reduction Workgroup to consider when developing the implementation plan.

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