CHAPTER 2 – METHODOLOGY AND COORDINATION

2.1 Geology

2.1.1 Regulatory Framework

There are no federal regulatory standards related to geology. Within Vermont, Criterion 9(D) of Vermont Act 250 requires that applicants for an Act 250 permit demonstrate that their proposed project will not significantly interfere with the future extraction of earth resources, if the project is located on “lands with a high potential for extraction of mineral or earth resources” (10 V.S.A. § 6086).

2.1.2 Data Collection and Methodology

Information regarding bedrock and surficial geology within the project area was obtained from published maps made available through the Vermont Geological Survey and the Vermont Center of Geographic Information (VCGI). Descriptions of underlying bedrock material were obtained from the Centennial Geologic Map of Vermont (Doll 1961, reclassified 1981).

2.2 Soils

2.2.1 Regulatory Framework

Sediment in runoff from large construction sites is regulated by the Clean Water Act Section 402, which in Vermont is administered by the Vermont Agency of Natural Resources Department of Environmental Conservation (VANR DEC) (30 U.S.C. § 1342). Construction activity that disturbs five or more acres requires a Phase I National Pollutant Discharge Elimination System (NPDES) permit (40 C.F.R. § 122.26 and VANR DEC, 2003). On September 13, 2006, VANR DEC adopted a new general permit for construction projects (Construction General Permit 3-9020) that lowers the permit threshold from five acres to one acre of disturbance, among other changes (VANR DEC, 2006). Construction General Permit 3-9020 also contains a rating system to categorize projects as either low-risk construction activities, moderate-risk construction activities or construction activities requiring an individual permit (VANR DEC, 2006) as follows:

- **Low-risk construction activities** require the use of the erosion prevention and sediment control practices in the *Vermont Small Sites Construction Handbook*.

- **Moderate-risk construction activities** require an Erosion Prevention and Sediment Control Plan. Guidance on the creation of an Erosion Prevention and Sediment Control Plan is provided by the *Vermont Standards and Specifications for Erosion Prevention and Sediment Control*.

- **Construction activities requiring an individual permit** cannot be covered by a Construction General Permit. The individual permit process requires an Erosion Prevention and Sediment Control Plan and has additional oversight and protective measures tailored to the specific project. Individual permits also have a public comment period and provide an opportunity for appeals.

Soil erosion in Vermont is also regulated by Criterion 4 of Act 250. Criterion 4 requires that Act 250 permit applicants demonstrate that their proposed project will not cause unreasonable soil erosion or reduce the capacity of the land to hold water so that a dangerous or unhealthy condition may result (10 V.S.A. § 6086).

Federal Highway Administration (FHWA) has adopted regulations to prevent and control erosion from construction projects that receive funding under Title 23 USC (23 C.F.R. § 650B). Projects are required to take all reasonable steps to control erosion in the design of projects as well as during construction. FHWA has adopted the American Association of State Highway and Transportation Officials (AASHTO) Highway Drainage Guidelines, Volume III, *Erosion and Sediment Control in Highway Construction* (AASHTO, 1992). However, if state level requirements are more stringent than the AASHTO guidelines, the state requirements will apply (23 C.F.R. § 650B).

Primary agricultural soils and farmland are discussed in the Land Use Technical Report.

2.2.2 Data Collection and Methodology

Soils

The Soil Survey Geographic (SSURGO) database for Chittenden County, Vermont was obtained for the Natural Resource Conservation Service's Soil Data Mart (NRCS, 2006).

Soils are classified into four Hydrologic Soil Group (HSG) categories according to their infiltration rates (NRCS, 2003). Infiltration rates are inversely related to runoff potential; soils with high infiltration rates have low runoff potential.

- **HSG A** soils have high infiltration rates and low runoff potential.
- **HSG B** soils have moderate infiltration rates.
- **HSG C** soils have slow infiltration rates.
- **HSG D** soils have very slow infiltration rates and high runoff potential.

In addition to HSG classifications, soils are also classified according to their potential erodibility. Class 1 soils are highly erodible, class 2 soils are potentially highly erodible and class 3 soils are not highly erodible (NRCS, 1992).

Build Alternative encroachment on soils was calculated based on roadway slope line limits. In addition to calculating the total encroachment on NRCS-designated highly erodible soils, soil erosion risks were also assessed based on slope and soil erodibility (K factor), according to the Vermont Standards and Specifications for Erosion Prevention and Sediment Control, as shown in Table 2-1. Slope was calculated from a Digital Elevation Model (DEM) based on Chittenden County Metropolitan Planning Organization (CCMPO) Light Detection and Ranging (LIDAR) data. Surface horizon soil K factors were obtained from the NRCS SSURGO database. The results of the analysis divided the total area of soil disturbance under each Build Alternative into "low", "medium" and "high" erosion risk areas.

Table 2-1
Erosion Risk Based on Slope and Soil Erodibility

Erodibility	Slope		
	Low (< 5%)	Medium (5-15%)	High (> 15%)
Low (K < 0.18)	Low	Low	Medium
Medium (0.17 < K < 0.38)	Low	Medium	High
High (K > 0.37)	Medium	High	High

Source: Vermont Standards and Specifications for Erosion Prevention and Sediment Control (VANR DEC, 2006).

2.3 Groundwater

2.3.1 Regulatory Framework

Groundwater resources that provide public drinking water are protected by the Federal Safe Drinking Water Act as amended (42 U.S.C. §221 et seq), which is implemented by VANR DEC in Vermont (VANR DEC, 2005). The regulation of groundwater wells depends on the number and type of people served by the well.

- **Public water supply wells** are defined by having 15 or more connections or serving 25 or more people. All other wells are designated **non-public**.
- The category of public supply wells is divided into two groups, community wells and non-community wells. **Public community wells** serve residential customers year round, while **public non-community wells** serve non-residential groups such as restaurants and schools.
- The category of public non-community wells is subdivided into transient or non-transient. **Public non-transient non-community wells** usually serve the same users over time, while **public transient non-community wells** serve different users over time. Schools and offices are examples of public non-transient non-community water systems. Restaurants and motels are examples of public transient non-community water systems.

The Vermont Water Supply Rule requires public community water systems and public non-transient non-community water systems to create Source Protection Plans and the delineate Source Protection Areas (SPAs). Source protection areas for groundwater are defined as the surface and subsurface area where contaminants would be likely to reach the well source (42 USC § 300h-7). SPAs are delineated into three zones (VANR DEC, 2005):

- **Zone 1** is a source isolation zone with a radius of 200 feet surrounding the water supply system. Contaminant impact in this zone are likely to be certain and immediate.
- **Zone 2** is the area outside of Zone 1, within a radius defined by the results of test pumping. Impacts from unmitigated sources of contamination would be probable in this zone.
- **Zone 3** consists of the remaining recharge area to the water supply system, not delineated as Zone 1 or Zone 2. Impacts may be possible from unmitigated sources of contamination in Zone 3.

Groundwater resources in Vermont are further protected by the standards established in the Groundwater Protection Rule and Strategy (GPRS) (VANR DEC, 2005). The GPRS creates a detailed system of enforcement standards and indicators for groundwater pollutants. The GPRS also requires the delineation of groundwater resources into four classes based on their current use and future potential for use as a public drinking water source. Each class of groundwater has specific management requirements associated with it to maintain water quality, including activities that are prohibited within each zone because of their likelihood of causing substantial harm (unacceptable activities). The characteristics of each groundwater class and the unacceptable activities within each class are summarized below (VANR DEC, 2005).

- **Class I groundwater** is suitable for use as a public water supply and is not exposed to activities that could reduce its potential future use as a public water supply. All human activities in Class I areas are unacceptable, except for recreation and low density agriculture and forestry.

- **Class II groundwater** is suitable for use as a public water supply, but is exposed to activities that put its current and future potential for use as a public water supply at risk. In addition to the discharge of hazardous waste, new stockpiles of highway deicing salt or salted sand piles are unacceptable activities in Class II areas.

- **Class III groundwater** is suitable for individual domestic water supply, agricultural, or industrial uses. The discharge of hazardous waste is an unacceptable activity in Class III areas.

- **Class IV groundwater** is not potable, but may be suitable for some agricultural or industrial uses. Class IV areas do not have specific unacceptable activities defined, but must be managed to maintain Class III standards at the border of the Class IV area and to improve water quality.

Class III is the default class for areas that have not yet been classified by VANR DEC. Some areas in Vermont have been designated Class IV, but no areas have been designated Class I or II. Investigations into groundwater resources necessary to make further classifications are ongoing (VANR DEC, 2004).

Criterion 1 of Act 250 also applies to groundwater resources, and requires that the permit applicant demonstrate that undue water pollution will not result from their proposed project (10 V.S.A. § 6086).

2.3.2 Data Collection and Methodology

Groundwater data from the Vermont Source Protection Area data collection was obtained from VANR DEC. The data identify the type of water source (private well or public water system) for residential, commercial, and industrial structures and any associated underground water pipes. Water supply data was also obtained from the Champlain Water District (CWD). A groundwater potential map was obtained from the Vermont Geological Survey (Stewart, 1973). Chloride concentrations in public water supply wells were obtained from VANR DEC.

2.4 Surface Water

2.4.1 Regulatory Framework

The purpose of the Clean Water Act (CWA) is to restore and maintain the chemical, physical and biological integrity of the Nation's waters (33 U.S.C. § 1251). In cooperation with other federal agencies and state water pollution control agencies, EPA is required to develop programs for preventing, reducing or eliminating the pollution of navigable waters and ground waters and improving the sanitary condition of surface and underground waters (33 U.S.C. § 1252). VANR DEC implements the CWA through the Vermont Water Quality Standards and the NPDES permitting program in Vermont.

In addition, Vermont's stormwater management law, 10 V.S.A. § 1264, implemented by DEC, establishes a program for the post-construction management of regulated stormwater. Two separate rules for stormwater management exist; one for stormwater impaired waterbodies and one for unimpaired waterbodies. Finally, for projects subject to Act 250 jurisdiction, compliance with DEC stormwater regulations will satisfy the requirements for Criterion 1.

Clean Water Act

Section 303 (d) of the CWA requires states to identify and publish every two years a list (303 (d) list) of surface waters that are water quality impaired by one or more pollutants. Water quality impairment occurs when a water body fails to meet the applicable water quality standards (33 U.S.C. § 1313).

Section 303 (d) of the CWA also requires development of a pollutant loading and reduction plan, called a Total Maximum Daily Load (TMDL), for each waterway on the 303(d) list (33 U.S.C. § 1313). The purpose of the TMDL is to identify necessary limits to existing and new discharges into the impaired water body to correct the impaired status.

Section 305 (b) of the CWA requires submittal of a report that describes the quality of the State's surface waters, including an analysis of their suitability for fish, wildlife and recreational uses (33 U.S.C. § 1315). The biennial Vermont Water Quality Assessment Report is commonly known as the "305b Report."

Section 402 of the CWA establishes the NPDES permitting system, described in Section 2.2.1 in the context of sediment runoff from construction sites. The NPDES also requires permitting for small municipal separate storm sewer systems (MS4s), which are described in more detail below.

Section 404 of the CWA requires that the discharge of dredged or fill material into navigable waters be regulated by permits from the U.S. Army Corps of Engineers (USACE) (33 U.S.C. § 1344). The USACE also has authority over discharges into and construction within navigable waters under Section 10 of the Rivers and Harbors Act (33 U.S.C. § 403).

Vermont MS4 NPDES Permit Program

VANR DEC implements the NPDES Phase II rule through general permit 3-9014. An MS4 is defined by the EPA NPDES Phase II rule as "a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains)" owned or operated by a state or local government body for the purpose of collecting or conveying stormwater (40 C.F.R. §122.26(b)). Not all MS4s are regulated by the Phase II rule. MS4s are automatically regulated in urban areas (as designated by the U.S. Census) and additional MS4s can be regulated through a special designation process. The municipalities of Burlington, Colchester, Essex, Essex Junction, Milton, Shelburne, South Burlington, Williston, and Winooski fall within designated urbanized areas and are required to comply with the Phase II rules. In addition to these municipalities, the University of Vermont, Burlington International Airport and VTrans facilities are designated as MS4s. State highways and VTrans facilities are regulated when they are within urbanized areas, or within a stormwater impaired watershed that is at least partially within an urbanized area (VTrans, 2003).

The requirements for regulated MS4s include the development of a stormwater management program. Stormwater management programs are required to contain "six minimum control elements" to reduce pollutant discharges to the maximum extent practicable. The six minimum control elements are Public Education and Outreach, Public Participation/Involvement, Illicit Discharge Detection and Elimination, Construction Site Runoff Control, Post-Construction Runoff Control and, Pollution Prevention/Good Housekeeping (EPA, 2005). Regulated MS4s are also required to describe measurable goals for each of six minimum control elements.

Vermont Water Quality Standards

The Vermont Water Resources Panel of the Natural Resources Board establishes the Vermont Water Quality Standards (VWQS) for the water classifications in Vermont. Water classifications are used to define the water uses that a water body should be managed to support, such as drinking water supply or recreation. The actual quality of the water body may be better or worse than its classification. The classification establishes the level of water quality that needs to be obtained (if the actual quality is lower than the classification) or maintained (if the actual water quality is better than or equal to the classification). The VWQS include narrative and numerical standards which implement the general water classifications through specific measurable and descriptive hydrologic, biologic, aesthetic, public water supply, irrigation and recreational water quality criteria.

All waters in Vermont are classified as Class A or Class B. All waters above an elevation of 2,500 feet are classified as Class A (1) waters. Waters that supply public drinking water are classified as Class A (2) waters. All other waters are classified as Class B waters (10 VSA § 1253). Within Class B waters, subcategories of designated uses and criteria have been created by water management types designated B1, B2 and B3 (Vermont Natural Resources Board, Water Resources Panel, 2006). No water management types have been established for waters in the project area.

Vermont Stormwater Permitting

Vermont's Stormwater Management Rule of July 2005 implements the state permit program for post-construction management of stormwater runoff to waters that are not stormwater-impaired waters. The Rule serves to assure compliance with the VWQS through the use of technically sound and cost-effective stormwater management methods as required by 10 V.S.A. Chapter 47, § 1263 and §1264(b). The Rule establishes permitting thresholds for discharges of regulated stormwater runoff that require a stormwater discharge permit; sets forth treatment standards designed to minimize the adverse impacts of regulated stormwater runoff; provides for the issuance of individual and general permits; specifies application requirements, including the contents of permit applications and public notification requirements; and amends the Vermont Stormwater Management Manual. The rule requires Best Management Practice (BMP)-based stormwater treatment practices rather than individual load allocations (VANR DEC, 2005).

A related rule, the Stormwater Management Rule for Impaired Waters (January 2006), establishes an interim and long-term permit program while VANR DEC develops a long-term TMDL plan or Water Quality Remediation Plan (WQRP) for each stormwater-impaired waterbody, pursuant to 10 V.S.A. Chapter 47 § 1264 and § 1264a. The rule applies to discharges of regulated stormwater runoff to stormwater-impaired waters from new development, redevelopment and the expansion of impervious surfaces (VANR DEC, 2006).

Fundamentally, both of the Vermont stormwater rules rely on the 2002 Vermont Stormwater Management Manual (VSWMM) as the basis for stormwater treatment practices required for new, expanded, and redeveloped impervious surfaces. However, additional interim permitting requirements apply within stormwater impaired watersheds to ensure that jurisdictional projects do not increase the sediment load or hydrologic impact to these waterbodies in advance of the development of TMDLs and implementation of watershed general permits for these watersheds.

The Allen Brook watershed is currently designated as stormwater-impaired under the VWQS, subjecting it to the Stormwater Management Rule for Stormwater-Impaired Waters. There is no EPA approved TMDL for this waterbody. During this interim period prior to the implementation of a TMDL, VANR DEC requires that new discharges or the expanded portion of existing discharges to stormwater-impaired water bodies not increase the sediment load or hydrologic impact to the receiving water. If the on-site stormwater management does not meet the no increase requirement, the applicant can meet this standard by mitigating any uncontrolled sediment load or hydrologic impact by implementing an offset or paying a stormwater impact fee.

In addition to the Stormwater Management Rule for Stormwater-Impaired Waters, there is also precedent from the Water Resources Board that requires, for impaired waters, that new development not contribute to or increase loads of the constituent for which the stream is impaired. There is a no net increase in pollutant loadings requirement for these waterbodies, as well (e.g., nutrient loadings to Muddy Brook, which is impaired for nutrients).

Vermont Act 250

Criterion 1 of Act 250 requires that the permit applicant demonstrate that undue water pollution will not result from their proposed project. Criterion 1(E) specifically requires that development adjacent to a stream maintain the natural condition of the stream whenever feasible and not endanger public safety (10 V.S.A. § 6086). For projects subject to Act 250, compliance with DEC stormwater regulations will satisfy the requirements of Criterion 1.

2.4.2 Data Collection and Methodology

Hydrology

The watersheds of streams that intersect the VT 2A or Circ A/B corridors were delineated based on USGS topographic maps. The area of each watershed upstream of the intersection with each corridor was also calculated for flow modeling purposes. Storm event flows for the Winooski River were determined based on the 1981 FEMA Flood Insurance Study for the Town of Essex, Vermont. All other storm event flows were modeled using the TR-20 computer program based on factors such as the size of the drainage area, channel form geometry, land use, impervious surface area, and rainfall depth (NRCS, 1992). Winooski River streamflow statistics were calculated based on the historical record at the USGS gauging station near Essex Junction (1928 - 2005). For all other streams crossed by a project corridor, the following streamflow statistics were estimated based on the size of the drainage area and the Vermont average values for following components:

- Annual Mean Flow: This value represents the average of daily flows over a calendar year. The Vermont average value for annual mean flow is 2.0 cubic feet per second per square mile of drainage area (csm).

- February Median Flow (FMF): The Vermont average value for FMF is 0.8 csm. These values were calculated because winter stream flows are typically the lowest in February. Fish eggs and macroinvertebrates need a minimum stream flow to prevent them from freezing in the winter. Maintenance of FMFs is not a regulatory requirement for highway projects, but it is a requirement of snowmaking operations at ski resorts in Vermont (Shanley and Wemple, 2002).

- August Median Flow (AMF): The August median flow is the minimum summer flow value which represents the most severe naturally occurring condition that a stream community would experience. The Vermont average value for AMF is 0.5 csm.

- 7Q10: This value is the lowest stream flow for seven consecutive days that would be expected to occur once in ten years. This stream flow value is used by many states and the Federal government in setting discharge limits in National Pollutant Discharge Elimination System (NPDES) water quality permits. A permit will only be granted if the proposed amount of pollutant discharged into a river would not impair its designated uses (i.e. swimming, drinking) when the stream flow falls to the 7Q10 level. The Vermont average value for 7Q10 is 0.1 csm.

Water Quality and Aquatic Biota

Impaired water designations were obtained from the 2006 Vermont 303(d) List of Impaired Waters (VANR DEC 2006). The water quality and aquatic biota data sources used are described below.

- Water quality and aquatic biota data for the Winooski River was analyzed based on sampling data provided by VANR DEC (VANR DEC, 2006).

- Water quality and aquatic biota data for Allen Brook was summarized from the *Draft Biologic and Aquatic Life Use Support Attainment Assessment of Allen Brook* (VANR DEC, 2006).

- Water quality and aquatic biota data for Muddy Brook was analyzed based on sampling data provided by VANR DEC (VANR DEC, 2007).

- Water quality and aquatic biota data for the Unnamed Tributary of Muddy Brook was summarized from the *Draft Biological and Aquatic Life Use Attainment Assessment of Tributary 4 to Muddy Brook* (VANR DEC, 2005).

The methodology used by VANR DEC in assessing the status of aquatic life is described in *Methods for Determining Aquatic Life Use Status in Selected Wadeable Streams Pursuant to Applicable Water Quality Management Objectives and Criteria for Aquatic Biota Found in Vermont Water Quality Standards Chapter 3 Section 3-01, as Well as Those Specified in 3-02(Al and B3), 3-03(A1 and B3), and 3-04(A1 and B4:a-d)* (VANR DEC, 2003). Macroinvertebrate and fish communities are assessed by comparing measured characteristics to a "reference condition." Reference conditions are established based on the streams in Vermont that are least impacted by human activities. The end result of the aquatic biota assessment process is a separate rating of excellent, very good, good, fair, or poor for macroinvertebrate and fish communities at a particular sampling location. Ratings of fair or poor indicate that the waterbody is impaired for aquatic life support at the sampling site.

Fish communities are assessed by VANR DEC using the Mixed Water Index of Biological Integrity (MWIBI).

Stormwater Modeling

Two separate methodologies were used to evaluate the potential effect of roadway stormwater runoff on surface water quality, the "Simple Method" (Schueler, 1987) for sediment, nutrients and metals, and the "Toler analysis" (USGS, 1973) for chloride from deicing salt. Impacts of the Build Alternatives were analyzed in comparison to existing water quality conditions.

Simple Method Methodology

Sediment, nutrient and metal loadings to surface waterbodies were estimated using the "Simple Method" of Schueler, 1987. The Simple Method has been accepted by the Water Resources Board as an appropriate approach to estimate pollutant loadings from stormwater runoff (See *In re CCCH Stormwater Discharge Permits* Docket Nos. WQ-02-11 and WQ-03-05, -06, and -07 Findings of Fact, Conclusions of Law, and Order (Oct. 4, 2004) at thirty-four; Also see *In re Hannaford Bros. Co.,* Docket No. WQ-01-01, Findings of Fact, Conclusions of Law, and Order (Jan. 18, 2002) at 8-9). The method provides a straightforward approach for the comparison of alternative land uses, combined with treatment and management options. The pollutants analyzed include sediment (TSS), nutrients (total phosphorus (TP) and total nitrate (NO_3)), and metals (copper (Cu), and zinc (Zn)).

For the area within the Circ A/B and VT 2A corridors, pollutant loads were calculated using a detailed analysis based on actual impervious area, specific land use type, and treatment considerations. In existing conditions, the Circ A/B corridor is predominantly forest and open while the VT 2A corridor is classified as transportation. Depending on the alternative, in proposed future conditions, both corridors are classified as transportation land uses. The future percent imperviousness within each corridor was calculated using data developed for the analysis of stormwater runoff as part of the preliminary design of each alternative. Based on these preliminary design analyses, the stormwater treatment practices to be utilized for this project would include stormwater ponds, grass lined swales and infiltration basins. The pollutant removal efficiencies of these treatment practices have been determined from pooled data sources and represent the anticipated effectiveness of those incorporated in this project. Existing treatment within the VT 2A corridor is minimal and removal efficiencies for TSS, nutrients, and metals have been estimated as 30 percent, 10 percent, and 10 percent, respectively.

For the remaining watershed area that is located outside of the project corridors, an alternative evaluation was applied to determine the existing pollutant load contribution. Land use classifications for the remaining watershed area were acquired from Vermont Land Class Land Use (LCLU) data produced by the Vermont Spatial Analysis lab at the University of Vermont. The original data set was generated by classifying a mosaic of several 2002 Landsat – 7 ETM+ scenes into a grid (30m x 30m) layer consisting of 16 LCLU classes. This data set was simplified to nine land use classifications used in this analysis: water, open/meadow, residential, commercial, industrial, transportation, forest, cropland, and pasture. Percent imperviousness was estimated by comparing mapped impervious areas in the City of South Burlington with the LCLU data to determine the average percent impervious for eight of the nine land use types. The simple method treats water as 100% impervious. No treatment was assigned to the pollutant loads contributed by the remaining watershed area.

The Simple Method requires as an input the drainage area of the evaluation site in addition to the drainage area of the entire associated waterbody. The drainage areas of the Circ A/B corridor were acquired from the Application for Stormwater Discharge Permit, prepared by Dubois & King (D & K), July 19, 2002. The drainage areas for the VT 2A corridor were defined by analysis of existing drainage pathways as part of the preliminary design and updated to reflect recent drainage infrastructure changes. Watershed drainage areas were delineated using VT Digital Elevation Model (DEM) point data from the Vermont Mapping Program, detailed site investigation and stormwater impaired watershed mapping. For purposes of analysis, "Winooski Direct" includes all drainage area associated with the project which falls outside of Muddy Brook, Allen Brook, Redmond Creek, and Winooski Tributary 1 watershed areas. The drainage areas used as model inputs are provided in Table 2-3.

Table 2-2
Drainage Area Inputs used in the Simple Method

		Areas affected by Project Alternatives	
Watershed (Description)	**Total Watershed Area (Square Miles)**	**VT 2A Drainage Area (Acres)**	**Circ A/B Drainage Area (Acres)**
Muddy Brook Headwaters to confluence with Winooski River	20.9	15.5	0.00
Allen Brook Headwaters to confluence with Winooski River	10.6	7.9	65.8
Redmond Creek Headwaters to confluence with Winooski River	0.46	0.0	5.9
Winooski Tributary 1 to confluence with Winooski River	0.80	0.0	39.7
Winooski Direct to mouth at Lake Champlain (Excluding the above Tributaries.)	1045	10.5	74.8

Impervious areas within the corridors under the existing conditions were digitized using 2004 orthophotos acquired by the Chittenden County Regional Planning Commission (CCRPC). Impervious area within the corridors for the build alternatives were calculated from preliminary design plans of the alternatives. Certain areas that would be vegetated after construction were not counted as impervious surface, including the “hole” in the center of roundabouts and landscaped medians.

Toler Analysis Methodology
The potential effect of deicing salt on surface water resources was evaluated using the Toler analysis (USGS, 1973) and New York State Department of Transportation (NYS DOT) guidance on the use of the Toler analysis (NYS DOT, 1995). The Toler analysis estimates in-stream chloride concentrations based on the amount of deicing salt applied and the amount of water available to dilute the deicing salt. Inputs include the average annual salt application rate per lane-mile, the number of lane-miles of the roadway segment being studied, drainage areas and precipitation data from which runoff rates are calculated. The output stream concentration is the additive effect of the roadway being studied to average annual chloride concentrations in the stream. Other roadways and chloride sources upstream of the roadway are not included in this concentration. If a measured background chloride concentration is available, the estimated contribution of the roadway calculated using the Toler analysis can be added to the background concentration to obtain an estimate of the total chloride concentration in the receiving water downstream of the roadway. The Toler analysis conservatively anticipates that all of the deicing salt applied to roadways would reach surface waters.

The Toler equation is:

$$[(T \times M)/(I \times A)] \times K = C + B = \text{Total average annual chloride concentration, mg/l}$$

- T: Annual average deicing salt application rate of in tons per lane-mile
- M: Number of lane-miles
- I: Average annual inches of runoff (annual inches of rain X 0. 4)
- A: Drainage area (square miles)
- K: 8.37
- C: Average annual chloride concentration, mg/l (contribution from roadway only)

- B: Background average chloride concentration in stream

Deicing Salt Application Rate

The VTrans District 5 1981-2005 average annual deicing salt application rate of 14.7 tons per lane mile was used in the Toler Analysis. Actual application rates vary following a specific event based on the temperature, relative humidity and snow and ice conditions each winter (USGS, 2005).

Lane-Miles

Lane-miles were calculated using preliminary engineering plans based on the area of travel lanes, including turning lanes at intersections and the flared approach at roundabouts, but not including shoulders landscaped medians, splitter islands, or the “hole” in the center of roundabouts. For alternatives involving improvements to existing roadways, only the area of pavement expansion beyond the existing travel lane pavement area was included in the calculations (the effect of the deicing salt application to existing pavement was accounted for through the use of background chloride concentrations, discussed below).

The calculated travel lane area was then converted to an equivalent amount of lane-miles for use in the Toler equation. Anticipating an average lane width of 12 feet, one lane mile is equivalent to 63,360 square feet (12 feet x 5,280 feet in one mile) or 1.454545 acres.

Runoff

Average annual rainfall for the central Chittenden County area from 1960 to 1990 was obtained from the Parameter-elevation Regressions on Independent Slopes Model (PRISM) map of Vermont (PRISM Group, Oregon State University). PRISM maps estimate precipitation at a grid cell level based on measured precipitation and a digital elevation model (DEM). In accordance with guidance on the application of the Toler analysis, average annual precipitation multiplied by 0.4 was used as an estimate of average annual runoff (NYS DOT Environmental Analysis Bureau, 1995).

Background Chloride Concentrations and Drainage Areas

In order to assess the total effect of the project alternatives on stream chloride concentrations, the effect of the proposed new roadways or existing roadway expansions was added to the measured or modeled “background” chloride concentrations in the affected streams. Mean chloride concentrations based VANR DEC monitoring was used when available. The availability of measured chloride concentrations downstream on the Vermont 2A and A/B corridors was also used to choose the point at which to analyze the effect of the project alternatives. For example, because of the availability of measured chloride concentrations at River Mile (RM) 0.2 on the Unnamed Tributary of Muddy Brook, RM 0.2 was used as the analysis point for the Toler analysis. For waterbodies with measured chloride concentrations, the drainage area input in the Toler equation used the upstream drainage area reported in VANR DEC water quality monitoring data and reports. For streams with measured chloride concentrations, the background concentration and upstream drainage areas used in the Toler analysis are summarized in Table 2-3, below.

RM locations are shown on figure 3-19.

Table 2-3
Drainage Areas and Background Chloride Concentrations for Waterbodies with Measured Chloride Concentrations

Waterbody	Location of Analysis Point	Upstream Drainage Area (square miles)	Background Chloride Concentration (mg/l)	Source of background Chloride Concentration
Unnamed Tributary of Muddy Brook	RM 0.2 (near Brownell Road crossing)	2.0	369.1	Mean of 18 samples from 2005 to 2006.
Muddy Brook	RM 1.2	20.9	135.8	2 samples 2003-2004
Allen Brook	RM 2.4 (near Industrial Avenue crossing)	13.6	96.9	Mean of three samples from 2003 to 2005.
Winooski River (direct and cumulative total)	RM 16.3 (Between VT 2A and confluence with Muddy brook)	1040.2	17.6	One sample in 2005.

A background concentration based on actual water quality monitoring was not available for Tributary to the Winooski (1) or Redmond Creek. For these waterbodies a background chloride concentration was estimated based on the lane-miles of other existing roadways in each watershed, using the same deicing salt application rate and precipitation inputs as described above. Lane-miles were calculated based on the 2005 road centerline file from VCGI (TransRoad_RDS). It is important to note that this modeled background concentration does not include other potential chloride other than roads, such as parking lots, driveways and septic systems.

The Tributary to the Winooski (1) and Redmond Creek watersheds were analyzed at their confluence with the Winooski River. Tributary to the Winooski (1) and Redmond Creek are intermittent streams where they cross the Circ A/B corridor. However, comments from VANR DEC indicated that these streams may support macroinvertebrates and/or fish in their lower reaches. Therefore, analyzing the effect of the project alternatives on these streams at the point where they enter the Winooski River is appropriate for estimating potential effects on aquatic life due to chloride.

Table 2-4 summarizes the number of lane-miles, upstream drainage areas and calculated background chloride concentrations for the Tributary to the Winooski (1) and Redmond Creek.

Table 2-4
Drainage Areas, Lane-Miles and Background Chloride Concentrations for Waterbodies without Measured Chloride Concentrations

Waterbody	Analysis Point	Upstream Drainage Area (square miles)	Existing Roadway Lane-Miles	Modeled Background Chloride Concentration (mg/l)
Tributary to the Winooski (1)	Confluence with the Winooski River	0.8	6.4	64.4
Redmond Creek	Confluence with the Winooski River	0.5	0.9	17.4

2.5 Floodplains

2.5.1 Regulatory Framework

The Federal Emergency Management Agency (FEMA) oversees Flood Insurance Rate Mapping (FIRM) maps which depict 100-year and 500-year floodplains and base flow elevations in some areas. Their purpose is to encourage building outside of flood prone areas.

Federal Executive Order 11988, *Floodplain Management*, directs federal agencies to "take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains…." The FHWA has established regulations to implement the requirements of Executive Order 11988 (23 C.F.R. § 650A). The purpose of the FHWA regulations is to prevent hazardous development on floodplains, to avoid construction on floodplains when practicable, to minimize the impacts of FHWA actions on floodplains, and to protect and restore beneficial floodplain functions.

FHWA requires an "Only Practicable Alternative Finding" when the preferred alternative identified in the Final EIS would result in a "significant encroachment" on a floodplain. The findings statement must justify why the proposed action must occur in a floodplain and why alternatives to avoid the floodplain were not practicable (23 C.F.R. § 650A).

Supplementing federal regulations, Criterion 1(D) of Vermont Act 250 requires activities within a floodway not to restrict or divert the flow of flood waters, significantly increase downstream peak discharge, or endanger public safety (10 V.S.A. § 6086). VANR DEC defines floodways as the area subject to both flood inundation and fluvial erosion hazard. This definition is more restrictive than the FEMA definition. The VANR maps floodways using the *Technical Guidance for Determining Floodway Limits Pursuant to Act 250 Criterion 1(D*) (VANR DEC, 2003).

The Vermont Stormwater Management Manual contains stormwater treatment design criteria that would be utilized as part of the proposed project to provide flood protection and extreme flood control (VANR DEC, 2002).

2.5.2 Data Collection and Methodology

Floodplain data were collected directly from FEMA. Floodway limits for Allen Brook were obtained from VANR DEC.

The area of encroachment on the FEMA 100-year floodplain and the VANR DEC Allen Brook floodway for each of the Build Alternatives was calculated using the proposed roadway slope limits. This method provides a basis for comparing the relative potential floodplain involvement of the Build Alternatives including the potential for effects on beneficial floodplan functions such as flood storage and riparian habitat. A floodplain findings statement for the preferred alternative will be provided in the FEIS in accordance with Executive Order 11988 and FHWA regulations. As appropriate, the effect of the preferred alternative on flood elevations will also be calculated in the FEIS.

Stream Geomorphology

Stream geomorphic assessment summary sheets were provided by the VANR DEC River Management Division (VANR DEC, 2006). A specific stream geomorphic assessment (SGA) for a 5.1-mile reach of Allen Brook was provided by the University of Vermont. This was conducted in the summer of 2005 using *The Rapid Stream Assessment Field Protocols of the Vermont Stream Geomorphic Assessment Phase 2 Handbook* (VANR DEC, 2005). Allen Brook was divided into five segments based on changes in valley width, changes in channel planform, channel slope and grade controls. At each segment the SGA examined channel characteristics to determine stream type, channel condition and channel sensitivity. The SGA compares the stream being studied to a stable reference condition. The theoretical basis of the SGA is the five stage channel evolution model that describes the channel adjustment process.

- Stage 1 is the stable reference condition in which sediment loads are transported without changing the channel planform or geometry.
- In Stage 2 is the channel downcutting (incising) that occurs as a result of a physical change to the watershed (such as an increase in impervious surfaces).
- In Stage 3 the channel begins to widen when the channel banks become unstable and begin to erode.
- In Stage 4 channel banks stop eroding and revegetate once the channel widens sufficiently for the velocity of the stream to decrease. The lower stream velocity results in an increase in sediment deposition in the channel.
- In Stage 5 channel stabilization is complete and the stream is once again considered to be in the reference condition.

Key SGA terms are defined in Table 2-5, below (VANR DEC, 2006).

Bridge and Culvert Assessment

Stream crossing structures were assessed using the methods described in Appendix G: Bridge and Culvert Assessment and Survey Protocols, of the *Vermont Stream Geomorphic Assessment Handbook* (VANR DEC, 2006). Stream crossing structures were assessed to identify potential problems associated with streambank and channel instability, sediment transport processes, and barriers to fish and wildlife movement. Stream crossing structures are assigned a state structure number by the VTrans Local Bridge and Culvert Inventory Program. Stream crossing structures that have not been assigned a state structure number by VTrans were given a letter designation.

Table 2-5
Stream Geomorphic Assessment Terminology

Term	Definition
Bankfull stage	The point at which the stream flow begins to enter the active floodplain.
Bankfull width	The width of the stream channel when it is carrying the bankfull stage.
Channel Aggradation	The process by which sediment deposition raises the level of the streambed.
Channel planform	The shapes a stream can take, such as straight, meandering or braided.
Channel sensitivity	Reflects the likelihood that a stream will respond to watershed changes or local disturbances. Channel sensitivity ratings range from extreme to very low and are determined by the geomorphic rating of stream condition and by stream type. An extremely sensitive stream is likely to change as a result of disturbance, while a very low sensitivity stream is unlikely to change.
Entrenchment ratio	Floodprone width/bankfull width. Measures the stream's access to its floodplain during high flow events: less than 1.4 indicates floodplain is not accessible, 1.4-2.2 indicates floodplain is accessible, greater than 2.2 indicates the stream has little or no entrenchment and has access to its floodplain during the bankfull discharge.
Flood chutes	The shortened path a stream may take during a flood, flowing straight across instead of around a meander for example.
Floodprone width	The width of the river at flood flows greater than the annual flood, measured at an elevation of twice the maximum bankfull depth.
Geomorphic rating of stream condition	Numerical designation of stream condition based on the measurements taken during the SGA. Reference condition= 0.85-1.0 Good condition= 0.65-0.84 Fair condition=0.35-0.64 Poor condition=0.00-0.34
Incision ratio	Low bank height/maximum bankfull depth. Measures channel bed degradation or downcutting processes: 1.0 ratio indicates no degradation; greater than 1.0 indicates bed degradation has occurred in the recent past.
Low bank height	The height of the lower of the two banks beyond the bankfull channel. The height is measured from the thalweg of the channel.
Maximum bankfull depth	The depth from the bankfull elevation to the deepest point of the channel (thalweg).
Mean bankfull depth	The mean depth of the channel from the bankfull elevation to the channel bed at 10 evenly spaced intervals.
Reference reach	The reference reach is an undisturbed reach of the same stream type as the stream being analyzed. It serves as the benchmark for assessing degradation.
Stream Type	A stream classification system that primarily consists of a capital letter determined by the entrenchment ratio, width-depth ratio, and sinuosity; and a number that is determined by the dominant stream bed sediment type.
Width/depth ratio	Bankfull width/mean bankfull depth. Describes shape of the stream: high indicates a wide and shallow stream, low indicates a narrow and deep stream.

2.6 Agency Consultation and Coordination

As discussed in Sections 2.1 through 2.5 above, relevant data was obtained from agencies as part of the evaluation of Geology, Soils and Water Resources. Since inception of the technical studies, regularly scheduled Interagency meetings have been held approximately monthly with various Federal and State agencies, including the Corps, EPA, USFWS, FHWA, VANR and VTrans. The purpose of these meetings is to coordinate and discuss ongoing environmental studies with the agencies, including issues related to geology, soils and water resources.