TOTAL MAXIMUM DAILY LOAD
for SEDIMENT

TRIBUTARY #1 to NORTH BRANCH
BALL MOUNTAIN BROOK

Waterbody ID: 11-15

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Introduction and Waterbody Description

The impaired water for which this TMDL was developed is identified on the 1998 Vermont 303(d) List as Tributary #1 to North Branch Ball Mountain Brook and is located by the Waterbody ID VT11-15. This is an unnamed stream but is referred to as "Tributary #1" throughout this document and other supporting documentation.

This stream is located in the upper reaches of the West River Basin in sub-basin 11-15, as defined by the State of Vermont River Basins map. The stream is classified as Class B in the Vermont Water Quality Standards effective July 2, 2000 (Water Resources Board 1999). This TMDL aims to restore the impaired waterbody to at least the minimum level described in these standards.

Tributary #1 and its associated watershed of 0.6 mi^2 lies almost entirely within the holdings of a single property owner. The Stratton Corporation, single owner of a ski resort and associated adjacent properties, developed a multi-year development Master Plan which was submitted for review under Vermont's Act 250 land use and development control law. According to the Act 250 review process, one aspect is to review potential effects development may have on adjacent water resources. Since waters listed on the 1998 303(d) list were identified within the area of impact, including Tributary #1, a requirement of permit approval was the development of a remediation plan to restore impaired waters. Stratton Corporation agreed to develop and implement a water quality remediation plan.

One permit requirement of Act 250 was the Stratton Master Plan-Water Quality Remediation Plan (SWQRP), developed by Pioneer Environmental Associates, LLC (Pioneer 1999) with review, comment and approval provided by the Vermont Department of Environmental Conservation, Division of Water Quality. This plan provides the technical basis for the TMDL and is referred to extensively throughout this document and provides the necessary supporting information.

The SWQRP provides the overall structure from which this TMDL was developed as the goals of both are identical, to restore Tributary #1 to at least the minimum requirements of the Vermont Water Quality Standards. The SWQRP provides the extensive sediment source identification necessary to guide remediation measures to limit sediment loading to the brook. Additionally, the SWQRP provides a thorough monitoring and improvement tracking capability to ensure the remediation efforts are sufficient to meet the goals. It should be noted that the SWQRP addresses other issues outside the scope of this TMDL but which all play a part in the water quality improvement of Tributary #1. This TMDL acts to formalize the connection between the remediation of the impaired Tributary #1 and the requirements of the Clean Water Act with regard to impaired waters.

Since the development of the original SWQRP in 1999, there have been two annual updates reporting on the monitoring and remediation efforts undertaken (Pioneer 2000, 2001). Throughout this two year process some of the water quality targets have been modified from the

original plan but all are still consistent with the goals of the TMDL and the Vermont Water Quality Standards. These changes are discussed in the following relevant sections of the TMDL.

A description of the watershed is given in the SWQRP, Section 2.2, including stream descriptions, existing land uses and other detailed information. A site plan of the watershed is given as an Appendix map in the SWQRP where the Tributary #1 watershed is identified as the sum of the sub-basins labeled "B".

Problem Assessment and Pollutant Sources

Problem Assessment

Macroinvertebrate sampling of Tributary #1 was conducted by the State of Vermont in the fall of 1997. Results of that sampling identified the biologic integrity of the stream to be poor and that it was not meeting the minimum Class B criteria. Indications were that the impairment was based on habitat degradation primarily from excessive sand/silt loading. Habitat evaluation revealed a high substrate embeddedness. From this evaluation, Tributary #1 was placed on the 1998 303(d) List of Impaired Waters. A complete description of the biological assessment is given in Appendix A.

In addition to excessive sediment loading to the stream, significant hydrologic change has occurred in the watershed which has increased peak discharge rates during precipitation and snow melt events. The increase in peak runoff rates is the result of land use changes that have increased impervious area. These changes exacerbate the sediment loading problem and play a role in the stream habitat impairment. Remediation measures need to reduce both the sediment loading amount and the peak discharge runoff rates.

Based on the 1997 evaluation of Tributary #1, growth of filamentous algae and lack of significant portions of the riparian buffer also appeared to be having a negative impact on the macroinvertebrate community as identified in Appendix A. In addition to the observed sedimentation impacts, observations identified a shift in the macroinvertebrate community composition, in part, caused by the lack of leaf litter and by the prolific filamentous algal growth. The shifts resulted in an decrease in the shredder species typical for this stream type.

Priority Ranking

According to the 1998 Vermont 303(d) List, TMDL development for Tributary #1 was scheduled for 2002. This represents a high priority scheduling for TMDL development considering that TMDLs were scheduled over a 15 year period extending through 2013. Watershed planning efforts in the state in conjunction with the Act 250 permitting process allowed this TMDL investigation, and subsequent management plan, to be developed earlier than anticipated.

Pollutant of Concern

The Tributary #1 TMDL was developed for sediment. High degrees of substrate embeddedness, primarily from sand, have degraded macroinvertebrate habitat. However, consideration of the hydrologic conditions that significantly added to the stream's impairment also played a large role in determining the remedial measures necessary under this phased TMDL. While altered hydraulic conditions are not technically considered pollutants by EPA, those conditions play a direct role not only in sediment loading, but also stream habitat alteration.

Also identified as a source of impairment of Tributary #1 was the growth of filamentous algae. The prolific growth of algae in portions of the stream was attributed to increased available light and nutrients. Portions of the riparian buffers have been lost, thus allowing a greater amount of light to enter the stream to fuel algal growth. Also adding to algal growth were nutrients associated with elevated sediment loading.

It is anticipated that the remediation measures set forth in the SWQRP will sufficiently address the ancillary impacts other than the primary impairment of sedimentation. While there is considerable uncertainty in predicting benthic algal growth and nutrient dynamics in small mountain streams, one significant consideration is key to the overall success of the restoration of Tributary #1. Since phosphorus has such a strong affinity to particulate matter, significant and sufficient nutrient reductions are anticipated in association with the sediment loading reductions outlined in this TMDL and the SWQRP. Also addressed in the SWQRP are plans to reestablish riparian buffer sections that when implemented will decrease light and increase leaf litter to the stream. These additional actions in conjunction with the decrease of nutrient inputs from sedimentation are expected to significantly limit instream algal growth.

Pollutant Sources

Field observations of the stream and watershed were used to document specific areas of nonpoint source sediment loading to Tributary #1. The small size of the drainage area and short length of Tributary #1 allowed a thorough investigation of sediment sources and other factors contributing to stream impairment. These sources fall into several categories including road crossings, drainage ditches and parking lots. A description of sediment sources is given in the SWQRP, Section 2.2.3. Specific areas of concern are:

- Road crossings (West Hill Rd., Stratton Mountain Rd., Maple Hill Rd., North Branch Rd., Middle Ridge Rd.)
- Stratton Wastewater Treatment Plant access drive
- Ditch below liftline lodge
- Diversion weir at Stratton Lake
- Existing parking lots #2, #3, and #4
- Vicinity of Stratton Mountain Inn
- Vicinity of Birkenhaus and Stratton Mountain School

While the sediment sources listed above are given for specific areas, they fall into several projects prioritized for management actions. Individual restoration projects were given an

impact ranking (Table 1) based on field observations and measurements which consider the significance of each of the water quality impact factors identified in Section 2 of the SWQRP. These factors include existing land uses, hydrology, erosion and sediment yield, riparian vegetation, channel processes and water quality.

Table 1. Prioritized areas for management activities based on impact ranking.

Impact Ranking	Management areas
1	Existing parking lots
2	Village Center/Commercial Development
3	Golf Course
4	WWTF Drive
5	Stratton Mtn. Road
6	Stream relocation at old spray field
7	On-stream Pond (Snyder)
8	Ski trails/work roads
	Single family housing [1] Roads (private public) Condominium projects [1]

[1] denotes activities believed to have minimal water quality impacts

Most of the prioritized actions above deal primarily with sediment reductions, however, actions proposed for the Golf Course, WWTF Drive, and the On-stream Pond include reestablishment of the riparian buffer. Loss of portions of the riparian buffer were identified as contributing to poor water quality conditions in the impairment of Tributary #1.

In the course of the continued investigations and refinement of the SWQRP, additional sediment loading sources are being identified. These are listed in the SWQRP Annual Updates (Pioneer 2000, 2001) together with recommended remediation measures.

Natural Background

A distinction was not made between natural background loadings of sediment and the total sediment load to Tributary #1. The assumption was made that because of the small size of the watershed, the problem areas could be identified and treated to minimize sediment loading to the stream. These problem areas were observed to be major contributing factors to impairment. Any natural loading that occurred was considered to be minimal and did not contribute significantly to the impairment.

Applicable Water Quality Standards and Numeric Water Quality Target

State Water Quality Standard

There is no applicable numeric standard for the sediment load carried in streams in the Vermont Water Quality Standards, but Tributary #1 is listed as impaired based on narrative criteria. The excessive sedimentation to Tributary #1 (as interpreted through various biometrics) has resulted in a violation of the Vermont Water Quality Standard's § 3-04(B)(4) which states that there shall be:

> No change from the reference condition that would prevent the full support of aquatic biota, wildlife, or aquatic habitat uses. Biological integrity is maintained and all expected functional groups are present in a high quality habitat. All life-cycle functions, including overwintering and reproductive requirements are maintained and protected.

Designated Uses

Since Tributary #1 is a Class B waterbody, the Vermont Water Quality Standards state in §3-04(A) and that:

> Class B waters shall be managed to achieve and maintain a high level of quality, that is compatible with the following beneficial values and uses:

including §3-04(A)(1):

> aquatic biota and wildlife sustained by a high quality aquatic habitat with additional protection in those waters where these uses are sustainable at a higher based on Water Management Type designation.

Since macroinvertebrate biomonitoring data did not meet the criteria for Class B standards, Tributary #1 does not support the designated uses for Class B waters.

Antidegradation Policy

In addition to the above standards, the Vermont Water Quality Standards contain, in part, the following General Antidegradation Policy in §1-03(B):

> All waters shall be managed in accordance with these rules to protect, maintain, and improve water quality.

Numeric Water Quality Target

The Clean Water Act states that TMDLs "shall be expressed at a level necessary to implement the applicable water quality standards..." Without specific numeric targets defining impairment in the Vermont Water Quality Standards, a set of numeric biological community criteria were established to identify when conditions were not fully supporting the standards. The VT DEC uses a variety of biological indicators to identify when conditions exist that are not fully supportive of the expected aquatic community for a particular stream type. As described above, Tributary #1 was determined not to be attaining the Vermont Water Quality Standards based on the failure to fully support the aquatic biota, namely the macroinvertebrate community.

Biological water quality criteria were initially developed in the SWQRP which included the macroinvertebrate indices in use at the time. However, subsequent to the development of the original plan, new Vermont Water Quality Standards were adopted. In response to the new standards, a new set of biological indicators were adopted for several different water quality classifications. Of these updated biocritera values, those of the Class B, water management type 2-3, have been established as the current biocriteria targets for Tributary #1. This change was noted in the SWQRP 1999 Annual Update (Pioneer 2000). These values are given in Table 2.

Table 2. Macroinvertebrate biocritera and TMDL targets for Tributary #1.

Biometric	Description	Class B Criterion (WQ Targets)
Species Richness	The number of species in a sample unit.	>27
EPT	The number of distinct taxa identified in a sample from the environmentally sensitive insect orders Ephemeroptera, Plecoptera and Tricoptera.	>16
PMA-O	A measure of order-level similarity to a model based on the reference streams.	>45
Biotic Index	A measure of the macroinvertebrate assemblage tolerence toward nutrient enrichment.	<4.50
% Oligochaeta	A measure of the percent of the macroinvertebrate community made up of the Order Oligochaeta.	<12
EPT/EPT+Chiro	A measure of the abundance of the intolerant EPT orders to the generally tolerant Diptera family Chironomidae.	>0.45
PPCS-FG	A measure of the functional feeding group similarity to a model based on reference streams.	>0.40

Sediment targets were also developed as restoration goals for Tributary #1 and are given below in Table 3. While the biological criteria given in Table 2 are the ultimate measure for attainment of water quality standards, the sediment targets act as another means of tracking the effectiveness of the phased remediation measures. These targets give a relative estimation of the amount and nature of sediment loading by evaluating instream conditions. A further description of the sediment targets is given in the SWQRP 1999 Annual Assessment (Pioneer 2000).

Table 3. Sediment condition indices and targets for Tributary #1.

Sediment Index	Target Value
% Embeddedness	< 25%
% Fines	< 8%
% Particles <8mm	<20%

Perhaps the best measure for quantification of sediment loading for this TMDL is the measure of percent embeddedness. This index provides both a measure of macroinvertebrate habitat condition and an inference into the level of sediment reductions needed. The pre-remediation percent embeddedness was measured to range from 50% to 75% and a target goal of < 25 % was developed. The target goal of 25% embeddedness was selected because it represents an "excellent" substrate condition for benthic macroinvertebrates (USEPA 1989).

Linkage Analysis

The linkage analysis is a required TMDL element that establishes the cause-and-effect relationship between measurable water quality targets and identified sources. This can be accomplished through a number of methods from qualitative assumptions based on sound scientific judgement to the use of sophisticated predictive models. The method chosen should be supported by monitoring data that associate waterbody responses to specific loading conditions.

The cause of the impairment in Tributary #1 was determined to be excessive sedimentation due to sediment loading as identified by macroinvertebrate community sampling and habitat assessment. This lead to an extensive visual watershed assessment directed at locating specific sediment sources. During the qualitative assessment, sediment sources were quite clear in this small watershed and determined to be the primary cause of impairment. Best professional judgement dictated that effective control of all or most observed sediment sources contributing to the impairment would ultimately return the stream to compliance with Class B water quality standards.

This qualitative method to link the desired water quality targets to the observed sources was deemed appropriate in this watershed primarily because of its small area. A thorough survey identified significant pollutant sources that could be addressed by implementing remediation measures. Under the phased TMDL approach, incremental water quality gains are tracked by

monitoring as implementation measures are undertaken. The required level of sediment loading reductions are realized when biocriteria standards and numeric targets are met.

In addition to the above qualitative linkage, a quantitative assessment of sediment loading was also developed. The simple method employed here allows a gross estimation of instream sediment loads that result based on watershed loading conditions. This estimation represents average overall stream condition based on field observations. By using the instream sedimentation target of 25 % embeddedness as the desired endpoint, the required instream load reductions can be calculated. In other words, the current or pre-remediation condition resulted in an instream embeddedness of 50-75%, so the necessary instream sediment reductions are those that result in an embeddedness rating of 25% or less. Utilizing sediment indices, such as percent embeddedness, to link sediment loading to the water quality targets is identified as a useful techniques in EPA's Protocol for Developing Sediment TMDLs (USEPA 1999). It is expected that over time, with sediment control measures in place, the existing instream sediment will move through the system and a more stable equilibrium between sediment loading and the instream condition will be established. The discussion below describes these calculations.

First, the pre-remediation instream sediment load producing the 50-75% embeddedness needs to be calculated. By knowing the median size of the dominant natural substrate, the depth of what 50-75 % embeddedness represents, the relative area between the dominant particles where the fines settle, and the physical properties of the sediment fines, in this case sand, this value can be obtained. The values used for the sediment loading calculations are given below in Table 4 and are described in the following discussion.

Field observations reveal that the dominant natural substrate particle size is cobble (64 - 128 mm diameter). While there are other natural particles both larger and smaller than cobble present, namely boulders and gravel respectively, the cobble size class dominates. For the sake of simplification, the median cobble diameter in the size class, 96 mm, is used for the calculations of sediment volumes and loadings. By using the median cobble diameter, the depth of sediment fines can be calculated for both pre-remediation and target conditions of embeddedness. The embeddedness of the pre-remediation condition of 50 - 75% represents a sediment depth of 48 - 72 mm. The remediation target of 25% embeddedness is a sediment depth of 24 mm.

Next, by using the observed percentage of sand coverage of stream bottom, the volume of the interstitial spaces between the larger natural particles can be determined for the sediment depths of interest. Sand was observed to cover approximately 20% of the stream bottom in the areas sampled. On a per square meter basis, this represents 0.2 square meters of sand for every square meter of stream bottom. The pre-remediation volume of fine sediment ranges from 0.0096 to 0.0144 cubic meters and the target volume of for 25 % embeddedness equals 0.0048 cubic meters.

When calculating the volume of the sand in the streambed alone, consideration must be given to the porosity of sand. A loose sand mixture has a porosity value of approximately 0.4, that is, approximately 40 % of a given volume is empty space. So in calculating the volume of sand in

the stream for any given condition, as done above, the volume of the interstitial space between cobbles must be multiplied by 0.6. This product gives the actual volume of sand between the cobbles and disregards the empty spaces between the particles.

Finally, in order to convert the fine sediment volume to a mass per unit area in-stream loading, the physical characteristics of the fine sediment must be considered. Sand has a density of approximately 2.65 grams per cubic centimeter. Multiplying the density by the actual volume of sand in the interstitial spaces gives the resulting in-stream loading for any given depth of embeddedness.

Table 4. Data used to calculate pre-remediation and target sediment loading rates.

	Pre-remediation	Target
% Embeddedness	50 - 75 %	25 %
Dominant natural substrate	cobble	cobble
Median diameter of dominant natural substrate	96 mm	96 mm
Depth of fine sediment	48 - 72 mm	24 mm
Interstitial area between natural substrate	0.2 m^2	0.2 m^2
Dominant fine sediment type	sand	sand
Porosity of fine sediment - estimated	0.40	0.40
Density of fine sediment - estimated	2.65 gr/cm^3	2.65 gr/cm^3

The loading ranges for both the pre-remediation and target values for Tributary #1 are given in Table 5. Based on the methodology for determining sediment loading described above, an estimated reduction of solids loading between 50 and 67% will be necessary to meet the instream sediment target of 25% embeddedness.

Table 5. Estimated instream sediment loading condition.

	Fine sediment (sand) loading (kg/m^2)	% reductions necessary to meet instream target
Pre-remediation	15.3 - 22.9	**50 - 67%**
Target	7.6	

The strength of this quantitative approach is that it estimates the actual fine sediment loading to the streambed, which is the primary cause of impairment. This approach is based on observations and eliminates many of the uncertainties and complexities involved with monitoring water column suspended solids and predicting the fate and transport of sediments

originating from the watershed. This method does not attach expected load reductions associated with the various remediation measures, however, as discussed above in the qualitative linkage approach, the size of the watershed allowed extensive visual investigations of sediment sources and utilized professional judgement to prioritize appropriate remediation measures to attain standards.

In addition to the qualitative assessment of sediment sources and the quantitative loading analysis presented above, an analysis of hydrologic alteration due to change in land use was also used to link causes of pollutant loading and the impaired condition of Tributary #1. Comparisons of peak discharge runoff rates between Tributary #1 and an adjacent, largely undeveloped watershed were used to gain a qualitative understanding of the hydrologic impacts that directly affect sedimentation and habitat alteration. By bringing peak runoff flows of Tributary #1 more in line with the reference watershed through remediation measures, there will be an expected reduction in a major contributing factor to sediment loading. A further discussion of the hydrologic implications related to sediment loading and habitat change in Tributary #1 is given in the SWQRP, section 2.2.2.

TMDL Allocations

The TMDL is considered the loading capacity of a waterbody for a particular pollutant and EPA regulations require that a TMDL include a wasteload allocation (point sources), a load allocation (nonpoint sources) and a margin of safety. The margin of safety accounts for any lack of knowledge concerning the relationship between effluent limitations and water quality. Regulations also require that seasonal variations be considered when determining allocations.

As specified in the regulations, TMDLs may be expressed in terms of either "mass per unit time, toxicity, or other appropriate terms." Because of the nature of sediment loading and deposition in small mountain streams and the extremely imprecise methodologies used for its estimation, this TMDL bases its allocations on "other appropriate terms."

Because sediment loading is largely a function of runoff characteristics related to rainfall and snowmelt events, expressing it as daily loading is clearly not appropriate. Annual loading may give a better overall indication of the magnitude of reductions needed, but it is not perfect either, because of the dynamics involved with sediment generation and transport in mountain streams and the role that large infrequent storms have on moving sediment. Annual loadings can fluctuate dramatically.

Since sediment loading calculations from multiple and varied sources are extremely difficult, highly imprecise and full of uncertainty, this approach was not utilized in the Tributary #1 TMDL. Without a reasonable methodology for determining sediment loading estimates from each individual source, it is not practical to allocate loading reductions among them. Instead, the sediment allocation for Tributary #1 is given as the percent reduction in sediment loading necessary to achieve an instream condition believed to provide optimal macroinvertebrate habitat conditions. Percentage reduction targets allocated among sources is identified as a useful

method in dynamic watershed situations (USEPA 1999). As the calculations from the previous section indicate, the reduction in fine sediment loading to reduce embeddedness from the pre-remediation range of 50-75% to 25% is approximately 50-67%.

Sediment is contributed to Tributary #1 from a number of sources, both point sources and nonpoint sources. The point sources found in the Tributary #1 watershed are from a variety of runoff conveyances that may include pipes, ditches and channels that discharge water directly to Tributary #1 and may potentially discharge sediment. Even though the discharge points to the stream may be isolated, the sediment sources tend to be nonpoint in nature. Because of the difficulties in determining loading rates from these sources as discussed above, these and all potential sediment sources have been incorporated into the Load Allocation for nonpoint sources. Under the framework of the SWQRP, if the individual source was considered to contribute significantly to sediment loading to the stream, it was scheduled for remedial measures. No differentiation was made between point source or nonpoint source as to how the sediment was introduced to the stream.

For the same reasons as above, permitted point sources were not allocated to individually and were incorporated into the Load Allocation. Tributary #1 contains a State of Vermont general permit issued for the management of stormwater during construction (NOI 364, issued in 1998). Stormwater discharge permits #1-1362 (3/23/01) and #1-1467 (6/26/01) were also issued for Stratton Commons and Stratton Village projects respectively.

Wasteload Allocations

No Wasteload Allocations were made for sediment sources in the Tributary #1 watershed, therefore, the TMDL recommends a Wasteload Allocation of zero. All identified sources of excessive sediment loading are accounted for in the Load Allocation below.

Percent reductions of fine sediment loading needed from Point Sources	**0 %**

Load Allocations

The total needed reduction in sediment loading to Tributary #1 is accounted for in the Load Allocation.

Percent reductions of fine sediment loading needed from Nonpoint Sources	**50 - 67 %**

Future Growth

All allocations for sediment inputs due to future growth are incorporated into the Load Allocation. It is expected that future development conducted within this watershed will not contribute significant sediment loading to Tributary #1. The framework that provides this protection is the SWQRP that protects against future sediment impacts and whose goal is for overall sediment loading reduction. First, several of the proposed remediation efforts identified

in the Plan are linked to future development projects resulting in a net reduction of sediment loading potential. In Tributary #1, this is accomplished in large part through development and elimination of gravel parking areas. These lots were identified as significant sources of sediment loading to the stream (Table 1). Second, peak flow reduction goals are in place in the watershed to limit the hydrologic impact from future development projects. This doesn't address sediment loading directly, but it is an indirect control measure on future growth impacts that has potential to increase stream channel erosion and sedimentation.

Undoubtedly, some State of Vermont stormwater permits will be required for planned future development in the watershed. However, permit requirements to control runoff hydrology and sediment loading are considered sufficient to protect the stream in the overall scope of sediment loading reductions of the SWQRP.

Margin of Safety

The statute and regulations require that a TMDL include a margin of safety to account for any lack of knowledge concerning the relationship between effluent limitations (or in this case nonpoint source remediation measures) and water quality. This margin of safety can be either implicit in the analysis by using conservative assumptions or explicit as a separate loading allocation. In the case of Tributary #1, an implicit margin of safety was used.

There is an inherent margin of safety established for the Tributary #1 TMDL with the selection of a conservative percent embeddedness target of <25%. A "good" embeddedness rating covers a wide range of values from 25% to 50% and in most instances provides adequate habitat for the expected macroinvertebrate community based on stream type. A percent embeddedness rating of less than 25% is considered "excellent" as interpreted both by the Vermont DEC and EPA's rapid bioassessment protocols and has been selected as the target for this TMDL. With such a conservative target as the goal of the implementation measures, compliance with the Vermont water quality standards should be assured.

Also, since this phased TMDL relies on followup monitoring and adaptive management, an added level of assurance is gained. The adaptive approach being applied in Tributary #1 ensures water quality standards will ultimately be met through continued monitoring and remediation actions. If monitoring indicates that implemented projects are not enough to sufficiently improve water quality, then remediation measures continue. Also, as part of the Act 250 permit process, future development in the impaired watershed outside the scope of the remediation plan is not allowed until the water quality standards are met.

Seasonal Variation

A TMDL is also required to consider seasonal variation in the loading analysis and resulting allocations to ensure water quality standards will be met throughout the year under various environmental conditions. Seasonal variation was inherently incorporated in the consideration of this TMDL for Tributary #1 and will be protective of water quality throughout the year.

The selected numeric water quality endpoints represent water quality conditions that are a result of the cumulative impacts of both dry and wet weather conditions that occur over extended periods. Because of this, the allocations and resulting implementation measures are directed primarily at reducing sediment sources and not at the sediment delivery mechanisms. By utilizing this approach, seasonal variations have little effect on sediment loading if the sources are no longer present. Examples include elimination of gravel parking lots and stabilization of eroding soils.

The SWQRP Implementation Plan also includes measures to treat stormwater runoff to significantly reduce sediment entering the stream. Examples include extended detention and infiltration basins and vegetated drainage areas to reduce sediment loading. The implementation measures selected will be engineered to function under all climatic conditions to sufficiently treat stormwater runoff throughout the year.

Monitoring Plan for TMDL Development Under the Phased Approach

A plan for continued monitoring is essential and required for any phased TMDL. An extensive monitoring plan has been developed and is explained in detail in the SWQRP, Section 5.4. The section below gives the overall monitoring approach and the rationale used for its development. The monitoring of Tributary #1 is only a part of an overall monitoring plan provided in the SWQRP. The described monitoring plan provides a holistic monitoring approach including not only the 303(d) listed waters of Tributary #1, but also adjacent impacted watersheds.

Since the implementation of this TMDL and water quality management plan is to be a phased process, a long-term monitoring plan was developed. The overall approach of the monitoring plan is to develop a reliable baseline documenting existing conditions, and to track future changes in water quality resulting from discrete and incremental remediation measures. A five year data collection program was established beginning in 1999. The Stratton Corporation is primarily responsible for data collection, however, all results are submitted to Vermont Agency of Natural Resources in the form of annual assessments. Annual assessments have been conducted for 1999 and 2000.

Specific to Tributary #1, nine sampling locations have been established for which a variety of parameters are monitored. Although this TMDL is developed for sediment, the SWQRP covers a broad range of parameters including water chemistry, sediment, temperature and macroinvertebrates. Not every sampling location is monitored for all parameters, but each site is monitored for parameters specific for tracking progress of implementation measures.

In-stream measures of sediment load include the Pebble Count Procedure and Percent Embeddedness. Targets for each of these have been developed and annual monitoring results will track the progress of habitat improvement over the course of the implementation plan. Combined with the biomonitoring portion of the plan, compliance status with the Vermont Water Quality Standards will be tracked until conditions exist that can perpetuate continued compliance.

Implementation Plan

Strategies to Remediate Impairments

A number of remediation measures were identified for water quality improvement and many were meant to specifically reduce sedimentation in Tributary #1. All potential measures were ranked according to their overall impact for improving water quality and habitat condition. The ranking is based on field observations and measurements that consider relative benefit potential. A list of all proposed implementation measures is provided in the SWQRP, section 4.0 and 4.2 and includes parking lot runoff treatment and modification, land use conversion and buffer improvement among others.

To aid in identification and ranking of appropriate remediation measures, a hydrologic analysis was conducted for each sub-basin within the Tributary #1 watershed. A breakdown of peak flow rates and total runoff volumes for a two year storm was conducted for existing conditions and following the proposed implementation plan measures. The results from this analysis are given in the Appendix of the SWQRP.

Also as part of the hydologic analysis, target peak flow rates were developed for all sub-basins within the Tributary #1 watershed. These targets are used to guide future planned development in the watershed by limiting the effects of peak flow discharges. State of Vermont stormwater permits are issued to new development projects only if it can be shown that the new project will not exceed the target peak flows determined to be protective of the stream. Control of peak flow discharges will have an indirect but important impact on sediment loading to Tributary #1 both by reducing instream erosion and direct sediment loading. Two stormwater permits have been issued in Tributary #1 in compliance with the SWQRP: #1-1362 for Stratton Commons issued 3/23/01 and #1-1467 for Stratton Village issued 6/26/01.

Implementation Schedule

A complete schedule for implementation of remedial measures is given in the SWQRP, Section 5.0. Remediation measures for Tributary #1 are expected to be completed by 2001 and biocriteria standards for Class B waters are expected to be attained by 2005.

Reasonable Assurances

In waters impaired solely by nonpoint sources, reasonable assurances that implementation measures will be carried out are not required for a TMDL to be approved. However, EPA encourages states to provide reasonable assurances whenever possible that may include regulatory, non-regulatory, and or incentive-based measures. The TMDL for Tributary #1 includes an extensive implementation plan aimed at restoring the stream to the acceptable numeric targets.

Since the SWQRP was developed as a permit requirement of the Vermont Act 250 land use and development control law, there is a strong incentive, and reasonable assurance, that the plan will be implemented. The primary land owner, Stratton Corporation, will be ineligible for future

development permits outside the scope of the remediation plan until the impaired waters, including Tributary #1, attain the Vermont Water Quality Standards. Implementation of remediation measures has begun in coordination with the VT-DEC.

Public Participation

Public participation in the development of this TMDL occurred in two phases. The first phase occurred during the review of the Stratton Corporation's request for approval of a master plan permit covering major proposed developments projects under Vermont's "Act 250" law. As previously discussed, the Stratton Water Quality Remediation Plan which is a condition of Stratton's Act 250 master plan permit is the method by which the TMDL is being implemented. The second phase of public participation was a thirty day public comment period provided for the receipt of written comments on this document.

Public Participation During the "Act 250" Process

Vermont's Act 250 program addresses the broader impacts from large scale development projects that are not covered by discharge permit programs administered by the Vermont Agency of Natural Resouces' Department of Environmental Conservation (DEC). For example, the Act 250 District Environmental Commission found that Stratton must address all the nonpoint source pollution associated with the proposed master plan, whether a DEC permit for a discharge is required or not. The Stratton Water Quality Remediation Plan (SWQRP) was the mechanism adopted by the Commission for addressing nonpoint source pollution at Stratton.

The Act 250 process is quasi-judicial in nature. Public notice of a permit application includes an invitation to become a party to the proceedings. The criteria for gaining party status are broad. As a result of that notice the Stratton Area Citizen Committee (SACC), a local citizen group with long standing interest in water quality, and the Vermont Natural Resources Council (VNRC), a statewide environmental organization with a special interest in water quality were both admitted as parties to the proceedings. Unlike citizens in the typical informational public hearing, parties in Act 250 proceedings may introduce evidence, present expert testimony, cross examine witnesses of other parties, file legal memorandum and proposed findings of fact, and seek administrative and judicial appeals of regulatory rulings.

As a result of water quality concerns raised by the involved parties, the Act 250 district commission requested comments from DEC on how the commission should respond to Stratton's expansion plans in light of the fact that its existing developments were contributing to nonpoint source violations of state water quality standards. DEC's response was to suggest that Stratton be required to prepare and implement a water quality remediation plan with specific water quality improvement targets as a condition of going forward with new development projects.

On April 9, 1999 the district commission issued notice of a public hearing "to review a specific plan for correcting impaired stream segments and achieving compliance with the Vermont Water Quality Standards." The commission also requested that DEC approve the SWQRP and "set

quantifiable benchmarks by which to judge the effectiveness of the remediation strategy." The SWQRP was presented for approval at a public hearing before the Act 250 district commission. The SWQRP was approved by the district commission along with a master plan permit. The SWQRP also requires periodic public meetings to review implementation progress.

In summary, the SWQRP was the result of more than two years of intense public hearings regarding water quality concerns. The hearings included ongoing input from local citizens and statewide environmental interests. Implementation of the SWQRP began in 1999.

Public Comments on This Document

A 30 day public comment period was provided for the final draft of the Tributary 1 TMDL document. The comment period extended from September 12, 2001 through October 12, 2001. Notification of the comment period was provided on the Vermont Department of Environmental Conservation web site, in two newspapers covering the vicinity of the impaired water and through direct mailings to local landowners, concerned citizens and organizations known to have an interest in the remediation of Tributary #1. A response to public comments received is provided in Appendix B.

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Appendix A

Results of Tributary #1 Bioassessment
October 1, 1997

Agency of Natural Resources
Department of Environmental Conservation

Water Quality Division
Biomonitoring and Aquatic Studies Unit
R.A.LaRosa Laboratory
802-244-4520

MEMORANDUM

To: The Record

From: Steve Fiske

Date: November 7,1997

Subject: Biological Assessment of Streams on Golf Course at Stratton Mt Ski Area

Two tributary streams that enter the Stratton Golf course pond were assessed on October 1,1997. The tributary streams were walked with Ralph Rawson from Stratton Mountain Ski Area, Kim Kendall from VNRC, Jessica Rykker from the VtDEC, and myself. Macroinvertebrate samples were collected at one point on each stream as indicated on the attached map. Sampling methods followed the VtDEC kick net method for sampling small wadeable streams. In addition to the biological sampling a stream habitat assessment was done and water samples collected for pH, alkalinity and conductivity analysis. The biometrics from this assessment for the two streams as well as the median value from the VtDEC reference stream database from similar streams is presented in tables 1-3. A summary of the important habitat and chemical variables from each stream site is presented in table 4.

The overall conclusion from the biological assessment and habitat evaluation done on tributary #1 is that the biological integrity is poor, and does not meet the minimum Class B biological criteria presently applied by the VtDEC. The community biometrics indicate that the community is being impaired by both habitat degradation from sand/silt, and nutrient enrichment. The habitat evaluation from the stream indicates that there is a high sediment bedload (both sand and silt), the substrate embeddedness rating is fair (50-75%), and filamentous algae is prolific.

The biological assessment and habitat evaluation for tributary #2 is that the stream community integrity is still good but has been moderately changed from its natural condition. The community present more closely resembles that of a moderately enriched larger sized stream, atypical for its stream type, but of good biological integrity.
The habitat assessment indicates the stream also contains considerable amounts of sediment, but less so then tributary #1, the embeddedness rating is good 25-50%, and the periphyton community has considerably less filamentous algae present.

The following paragraphs detail how the macroinvertebrate community assemblage of each tributary deviates from that of reference quality streams of similar type. Included in each table 1-3 below is a column that shows the median value for each of the macroinvertebrate community attributes from the VtDEC reference database for streams of similar type to the tributary streams assessed. The reference stream type can be described as small, high elevation, high gradient, canopied streams; that are usually relatively low in alkalinity and pH, but not so critically low as to be limiting to the aquatic biota.

Tributary #1 is low in density (299), and EPT richness (11) compared to the reference stream database, which shows that densities typically average about 800+ and EPT richness about 23.5. It appears that both silt and algae tolerant *Diptera* and *Oligocheata* taxa have become the dominant macroinvertebrates in the stream. This dominance of the more pollution tolerant taxa is seen in the ratio between the EPT/richness metric (.27) and in the # of EPT/EPT&c (.20). The median value for these ratios is .58 and .88 respectively for this stream type. The Bio Index value is a measure of the overall nutrient enrichment tolerance of a community based on an average of the tolerance rating for each species and their abundance in the community. The Bio Index value for tributary #1 is very high at 2.76, compared to the reference stream database 1.29. The dominant taxa in the stream *Cricotopus spp* typifies the stream conditions. It is an algae shredder that is also tolerant of silt and sand.

The percent composition of the dominant orders and functional groups also illustrates how tributary #1 has been severely altered from that found in a natural stream of its type. Normally this type of stream is more dominated by *Plecoptera and Trichoptera* species that process leaf litter and are functionally classified as shredders. In tributary #1 we see relatively low percentages of these species and a high percentage of *Diptera* and *Oligocheata* species. The species from these orders represented in tributary #1 function as either generalist collector gatherers or shredders of filamentous algae.

The habitat assessment performed at the time of sampling tends to support the above stream community impacts are due to habitat degradation, and enrichment of the stream water. Habitat problems that need to be corrected are: **1- a high level of sand and silt in the substrate,** which is causing the cobble substrate to be embedded, thus eliminating biologically critical crevice habitat. **2-The lack of stream canopy, and riparian zone** has caused a loss of leaf litter in the stream, resulting in a dramatic decrease in the shredder species typical for this stream type. It has also probably contributed to the increase in algal growth observed due to a decrease in stream shading that often results in an increase in stream temperature, and available nutrients in the water column. This type of non-point stream habitat degradation is usually caused by poor riparian zone and storm water runoff management.

Tributary #2 is not as degraded as tributary # 1; however the composition of the macroinvertebrate community has been substantially changed to look like that of a moderately enriched larger river. The biometrics most effected in this case are density, the Bio Index value, and the EPT/richness ratio. The density of the community is very high (3672) and the Bio Index value is 2.57, indicating that the stream is being moderately enriched. Reference quality streams average about 878 animals per sample unit, and a Bio Index value of 1.29. The EPT/richness ratio is 0.44, just below the present Class B criteria indicating that more tolerant taxa are

beginning to outnumber the intolerant EPT taxa. The EPT/EPT&c ratio is 0.74 showing that the EPT taxa are still numerically dominating the community. Finally the dominant taxa at tributary # 2 makes up a typical 24% of the community composition. The taxa however is *Fossaria sp.* a snail that is classified as an algae scrapper. It is highly unusual to find a snail dominating the community of this type stream.

Once again the percent composition of the dominant macroinvertebrate orders and functional groups can help reveal how the community has been modified from its reference condition. In this case the percentage of *Plecoptera* has been reduced in the community primarily by the unusual high percentage of *Gastropoda*. This has resulted in a functional shift in the community from one with a dominance of leaf shredders to a high percentage of scrappers compared to a reference stream community.

The habitat assessment again points toward a loss of canopy, and an increase in the sand load and embeddedness of tributary # 2, compared to a natural reference stream of this type. The observed amount of filamentous algae however indicates that nutrient enrichment may not be as much of a factor in stream #2. Again to correct the biological impairments identified here both riparian zone, and storm water management should be of high priority in the watershed.

In summary both the tributary streams sampled in this assessment have been impaired from non-point sources of sediment and the lack of riparian zone management. Tributary # 1 is in poor condition and does not meet the present Class B biocriteria as applied to all streams in Vermont. The community is reduced in density, and EPT richness, has an unacceptable high Bio Index value, and ratios between intolerant taxa and tolerant taxa. Tributary # 2 has been moderately enriched to the point where it is barely meeting the present minimum Class B biocriteria. Compared to a reference data set specific to small stream types the community has been highly modified to look like that of an enriched river, with shifts in the functional composition and order level composition of the community. Many of the species now present are more typically found in larger rivers that are moderately enriched.

Table 1: The macroinvertebrate community biometrics for two tributary streams from the Stratton Mt Ski Area Golf course, and the median, and 25-75 percentile values from the Vt DEC ecoregional reference database for similar type streams, and the current Class B biocriteria being applied by the DEC.

Biometric	Tributary #1	Tributary #2	Ref Median Str Type 2 (25-75 %)	Present Class B
Density	299	3672	878 (681-1473)	>500
Richness	41	48	40 (35-44)	>30
EPT	11	21	23.5 (20-24)	>18
EPT/Rich	.27	.44	.58 (.53-.59)	>.45
Bio.Index	2.76	2.57	1.29 (1.08-1.51)	<2.75
EPT/EPT&c	.20	.74	.88 (.82-.93)	>.45
%Hydrop	4.35	16.2	5.7 (2-10)	
%Dom	21 Cricotopus	24 Fossaria	20 (18-25)	<40

Table 2:The percent composition of the major macroinvertebrate Orders for two tributary streams from the Stratton Mt Ski Area Golf course, and the median, and 25-75 percentile values from the Vt DEC ecoregional reference database for similar type streams.

	Trib #1	Trib #2	Ref Median Str Type 2 (25-75 %)
%Coleoptera	1	2	4 (0.8-6.0)
%Diptera	57	24	16 (12-21)
%Ephemeroptera	2	26	20 (14-32)
%Trichoptera	6	21	29 (21-44)
%Plecoptera	3	2	18 (14-29)
%Oligocheata	31	1	<1 (0-0.3)
%Other (Gastropoda)	1	24	<1 (0.1-0.5)

Table 3 :The percent composition of the Functional Groups within the macroinvertebrate community for two tributary streams from the Stratton Mt Ski area Golf course, and the median, and 25-75 percentile values from the Vt DEC ecoregional reference database for similar type streams.

	Trib #1	Trib #2	Ref Median Str Type 2 (25-75 %)
Collector Gatherer	49	35	26 (21-42)
Collector Filterer	8	19	18 (13-26)
Predator	18	11	20 (13-27)
Shrd-Detritus	3	1	14 (10-16)
Shrd-Herb.	22	2	<1 (0-2)
Scraper	1	30	8 (4-15)

Table 4: Selected important habitat and water chemistry variables as observed or measured for two tributary streams from the Stratton Mt Ski area Golf course.

	Trib # 1	Trib # 2
pH units	7.56	7.45
Alkalinity mg/l	44.8	48.7
% Sand	20	10
Embeddedness	>75	50-75
% Canopy	40	10
% Fila. Algae	50	10

cc Doug Burnham VtDEC
Dan Maxon VtDEC
Brian Kooiker VtDEC
Kim Kendall VNRC
Michele Grenier Stratton Resort
Ralph Rawson Stratton Resort

Appendix B

Summary of Public Comments

Comments Received on the TMDL

Two comment letters were received by the VT DEC by the October 12, 2001 deadline. The submissions are listed below with abbreviations to identify the individual comment in the response section.

Submitted by:	Signed by:	Date Submitted	Identification
Stratton Area Citizens Committee 123 Upper Taylor Hill Rd Jamaica, VT 05343	Darlene Palola Chair of SACC	October 11, 2001	SACC
Vermont Natural Resources Council 9 Bailey Ave. Montpelier, VT 05602	Kelly D.H. Lowry, Esq. General Council, VNRC	October 12, 2001	VNRC

Response to Comments

VNRC: Despite such clear and consistent direction on this fundamental point [reference to CWA definitions and USEPA TMDL Guidance documents], the TMDLs for Tributary 1 and Styles Brook do not contain any loading analysis. Instead, the TMDLs use the current embeddedness of the stream as the starting point from which ANR recommends a reduction a 50-67% in order to meet the biological targets. Tributary 1 TMDL at 10; Styles Brook TMDL at 9. It is difficult to understand how a "Total Maximum Daily Load" that includes neither a "daily" component nor a "loading" component can meet the requirements set out in the Clean Water Act and EPA's regulations and Guidance.

> Response: The approach used to define the "loading capacity", which relates the instream sediment condition to the desired substrate embeddedness, is indeed unconventional compared to traditional point source based TMDL's. However, VTDEC believes this approach provides a useful and measurable link between sediment loading and the biological impairment. Traditional sediment loading allocations were perceived to be extremely variable and error prone to be of any use. VTDEC worked directly from specific EPA Region 1 guidance, as well as from national sediment TMDL guidance, in developing this loading capacity.
>
> Moreover, the National Academy of Science noted in its recent report to Congress on the state of TMDL science that there are no accurate models for predicting land use impacts on biocriteria:
>
> **"MODELS FOR BIOTIC RESPONSE: A CRITICAL GAP** The development of models that link stressors (such as chemical pollutants, changes in land use, or hydrologic alterations) to biological responses is a significant challenge to the use of biocriteria and for the TMDL program. There are currently no protocols for identifying stressor reductions necessary to achieve certain biocriteria." (National Academy of Science, *Assessing The TMDL Approach To Water Quality Management,* 2001, page 55)

However, The National Academy of Science did not view the lack of predictive models as an excuse not to do TMDLs rather they encouraged the states to use simpler analyses:

"Highly detailed models are expensive to develop and apply and may be time consuming to execute. Much of the concern over costs of TMDLs appears to be based on the assumption that detailed modeling techniques will be required for most TMDLs. In the quest to efficiently allocate TMDL resources, states should recognize that simpler analyses can often support informed decision-making and that complex modeling studies should be pursued only if warranted by the complexity of the analytical problem. More complex modeling will not necessarily assure that uncertainty is reduced, and in fact can compound problems of uncertain predictions." (National Academy of Science, *Assessing The TMDL Approach To Water Quality Management,* 2001, page 50)

VTDEC believes that the loading analysis conforms to both the spirit and intent of the "other appropriate measure" option for expressing loading as provided in 40 C.F.R. §130.2(i) and is consistent with advice of the National Academy of Science.

VNRC: Both of the proposed TMDLs allocate the entire load reduction of 50-67% to non-point sources, and allege that "[t]here are no sediment point sources" in either watershed. Tributary 1 TMDL at 9; Styles Brook TMDL at 11.

Response: It is clearly stated in both TMDLs that there are point source sediment delivery mechanisms present in both watersheds (Tributary #1 TMDL at 11; Styles Brook TMDL at 9). However, as also explained in the text of both TMDLs, since the origin of the sediment is nonpoint in nature, all allocations were accounted for in the Loading Allocation portion of the TMDL to be consistent with the established remediation activities.

VNRC: It is altogether unclear why ANR would assert in its TMDLs submitted in June 2000 and again in September 2001 that there are no sediment point source discharges in these watersheds when ANR itself has issued stormwater permits authorizing a sediment point source discharge into Styles Brook.

Response: The delivery mechanism from the permitted stormwater discharges may indeed be point source in nature, however, for the purposes of allocating necessary reductions, all sediment sources to the streams were considered in total, and to originate from nonpoint sources. This process is consistent with EPA guidance and is also compatible with the SWQRP through which the control actions are directed.

VNRC: In the "Public Participation" section of the TMDLs, ANR describes the Act 250 permitting process through which the SWQRP came into being, and includes a description of VNRC's role in this process. VNRC is concerned that ANR's description leaves the impression that VNRC is satisfied with the SWQRP. In the TMDL, ANR states that "development of the water quality remediation plan was a collaborative process involving DEC and Stratton and review by VNRC." Tributary 1 TMDL at 15; Styles Brook TMDL at 14. The TMDLs further state that, after the Act 250 District Commission approved the SWQRP and incorporated it into the permit, VNRC appealed the decision but does not challenge the SWQRP benchmarks. Id.

To make the point rather plainly, VNRC is by no means satisfied that the SWQRP will result in

attainment of the biological benchmarks in Tributary 1 and Styles Brook. The SWQRP fails to provide enough specificity to determine what the effects of final build-out will be on the streams. Actually, current scientific understanding of the proportions of impervious surfaces relative to undisturbed land in Vermont watersheds indicates that it is more likely than not that these streams will not meet the biological benchmarks even with the present level of development. VNRC entered into the settlement agreement because it provides for a cessation of development if the remediation plan is not working. This is not the same as VNRC believing that it will actually work.

> Response: VTDEC did not presume to interpret VNRC's position concerning the SWQRP but only attempted to state the facts of how the Act 250 process proceeded. Although, in an attempt to describe the inclusive and public nature of the Act 250 process, the involved parties were noted, including VNRC. However, in order to avoid confusion, references seen as attempting to interpret VNCR's position in the Act 250 process will be removed from the TMDLs.

VNRC: In sum, VNRC believes that the Agency is making a mistake by moving forward with these TMDLs. As we have said, they are not TMDLs by any definition of the phrase. The question is not whether they fit within the "other appropriate measure" allowed by EPA in 40 C.F.R. § 130.2(i), which they may in fact be. The question is whether they comply with the relevant provisions of the Clean Water Act and the regulations implementing it. VNRC strongly believes that they do not.

The Agency should not submit these to EPA for approval. Rather, the Agency should hold them in abeyance in favor of issuing a watershed-wide general permit under the "new" approach outlined by ANR and the Governor in the last couple of weeks. Indeed, this seems most appropriate given the fact that these two streams appear on the list of waters for which ANR is considering these general permits.

> Response: The VTDEC intends to submit these TMDLs to EPA Region 1 for final approval as initially planned.

SACC: SACC recommends that the language under Reasonable Assurances be clarified to correspond with the Environmental Board decision on Stratton Mt. Master Plan #2W0519-10. We suggest that in the second paragraph of this section the sentence beginning "the primary landowner, Stratton Corporation..." be reworded to show clearly that "future development permits", in this context refers specifically to projects being carried out under the Stratton Master Plan.

> Response: Changes will be made to reflect that the "future development" referred to concerns only development under the Master Plan.

SACC: Regarding the "Pollutant Sources" section of the TMDL for Tributary #1, several areas and land uses were identified as potential sediment sources.

> Response: It should be noted that as part of the ongoing SWQRP, and identified in the annual updates, sediment sources are continually being identified and remediation actions planned if necessary. SACC concerns over additional sediment sources have been forwarded to representatives of Stratton corporation.