TOTAL MAXIMUM DAILY LOAD
for
TOTAL PHOSPHORUS

BLACK RIVER
at LUDLOW, VT

Waterbody ID: 10-14

February, 2001

Prepared by:

State of Vermont
Department of Environmental Conservation
Water Quality Division
103 South Main Street
Building 10 North
Waterbury, VT 05671-0408

Submitted to:

U.S. Environmental Protection Agency-Region 1
One Congress Street
Suite 1100 (CVT)
Boston, MA 02114-2023

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Introduction

Waterbody Location

The impaired water for which this TMDL is developed is identified on the 2000 Vermont 303(d) List as the "Black River, below Ludlow WWTF (wastewater treatment facility) for approximately 0.5 miles"and is located by the Waterbody ID VT10-14 as defined by the State of Vermont River Basins map. The impaired reach is located approximately 25 river miles upstream from the mouth of the Black River at its confluence with the Connecticut River in Springfield, Vermont. The stream is classified as Class B in the Vermont Water Quality Standards effective July 2, 2000. This TMDL aims to restore the impaired segment of the waterbody to at least the minimum level described in those standards.

Priority Ranking

According to the 2000 Vermont 303(d) List, TMDL development for the Black River at Ludlow was scheduled for 2001, which represents a high priority scheduling for TMDL development. Waters listed on the 2000 303(d) List were prioritized over a period of 13 years, through 2013.

Pollutant of Concern

The Black River at Ludlow TMDL was developed for total phosphorus in an effort to control organic enrichment in the river and prevent impairment of biological communities.

Format

This Black River at Ludlow TMDL has been prepared in accordance with EPA Region 1 TMDL submittal guidance.

Problem Assessment and Investigations

Problem Assessment

The identification of impairment of the Black River was initially determined from macroinvertebrate assessments conducted above and below the Town of Ludlow wastewater treatment facility (WWTF) in the years 1987 and 1991 (Appendix A). Based on a matrix of several criteria developed by the VT DEC to determine the condition of the macroinvertebrate community, one indicator, the Biotic Index exceeded the levels established for Class B waters at the downstream sample site. The Biotic Index value is a measure of an organism's tolerance to organic enrichment. The results of the 1987 and 1991 biomonitoring are given below in Table 1. It was concluded that the WWTF effluent was having an unacceptable enrichment effect on the aquatic community and phosphorus loading was determined to be the specific problem. Based on the two years biomonitoring data showing similar and consistent results, the portion of the Black River below the Ludlow WWTF was initially listed on the EPA approved 1998 303(d) List of Impaired waters.

Table 1. Biotic Index results for above and below Ludlow WWTF.

Year	Site	Biotic Index (Biocriteria < 5.00)
1987	Upstream	4.90
	Downstream	5.46
1991	Upstream	4.28
	Downstream	5.34

In early 1999, the Town of Ludlow expressed a desire to VT-DEC to possibly expand the permitted flow of its WWTF, and thereby increasing its phosphorus load to the Black River. Because of the identified impairment of nutrient enrichment, it was determined that further investigation as to the source and extent of the problem would be needed in considering the WWTF expansion. Since the age of the biomonitoring data was between eight and twelve years old at the time and there was no nutrient chemical monitoring data, a monitoring plan was developed for the summer of 1999 to better characterize the conditions of the Black River and the effluent of the WWTF.

Data Collection and Results

The assessment study during 1999 included three distinct areas of investigation. First, chemical sampling of the WWTF effluent and the Black River upstream of the WWTF was conducted. Several parameters were measured focusing primarily on nutrients. Second, biomonitoring above and below the WWTF was conducted including both fish and macroinvertebrate communities. Third, a mixing study was conducted to determine the point at which effluent from the WWTF was completely mixed in the river. This was to help better locate the stations used for the downstream biomonitoring sites.

Since the primary source of impairment was identified as the effluent phosphorus load from the WWTF, the most critical period for sampling was during dry weather low flows. All chemical data was collected during dry weather as was the mixing and biomonitoring data. The results of the chemical monitoring data are given in Appendix B and are further discussed in the loading capacity analysis below.

The mixing study was conducted to ensure that the locations selected for downstream biomonitoring would be in a portion of the river where the WWTF effluent was thoroughly mixed during low stream flows. Also, the mixing study would help identify where the biomonitoring sites from the previous years were with regard to a fully mixed effluent. A single mixing study was conducted on July 27, 1999 during low stream flow conditions (approx 14 cfs). Rhodamine WT dye was introduced into the WWTF effluent and tracked at several downstream transects across the river to determine where complete mixing occurred. The results of the mixing study are given in Appendix B and identified that at a distance of 2500 feet downstream the effluent was completely mixed.

Based on this information, the downstream biomonitoring sites were located at the first appropriate site where complete mixing occurred. The downstream macroinvertebrate sampling site from 1987 and 1991 was located approximately 700 feet downstream of the outfall in an area that may not have been completely mixed. However, actual mixing conditions at the time of previous sampling can only be inferred because river flows were not determined at the time of sampling. In order to determine any differences in results from either downstream location, the previous years' site was sampled in addition to the completely mixed location.

Results of the 1999 biomonitoring for both the macroinvertebrate and fish communities are given in a memo in Appendix A. In short, results from the 1999 biomonitoring revealed that at the downstream sampling site the structure and function of the macroinvertebrate community was not altered to below Class B criteria. Similarly, the fish assemblages of both upstream and downstream sections passed the biological criteria for the Class B water quality criteria. Even though the most recent sampling showed biological communities meeting Class B criteria while previous years' sampling revealed impairment, substantial weight was given to the 1999 data because it was collected under ideal conditions to magnify the effects of the WWTF.

While the 1999 biomonitoring data did not identify any impairments due to enrichment as identified on the 1998 303(d) List of Impaired Waters, it was not de-listed on the 2000 303(d) List. Several years data meeting the biological criteria are necessary to show consistent improvement before de-listing can occur. However, the results of the 1999 data collection identified that the current level of phosphorus loading from the WWTF was not likely to cause an enrichment impairment and was at or below the phosphorus loading capacity for this portion of the Black River.

Applicable Water Quality Standards and Numeric Water Quality Target

State Water Quality Standard

The Black River at Ludlow is designated as a Class B water. As a Class B water, the Vermont Water Quality Standards (Effective July, 2000) state in §3-01(B)(2) that:

> In all waters, total phosphorus loadings shall be limited so that they will not contribute to the acceleration of eutrophication or the stimulation of the growth of aquatic biota in a manner that prevents the full support of uses.

The designated uses are identified in the Vermont Water Quality Standards in §3-04(A) where it is stated that:

> Class B waters shall be managed to achieve and maintain a level of quality that fully supports the following designated uses:

including:

1. Aquatic biota, wildlife, and aquatic habitat - aquatic biota and wildlife sustained by high quality aquatic habitat with additional protection in those waters where these uses are sustainable at a higher level based on Water management Type.

2. Aesthetics - water character, flows, water level, bed and channel characteristics, exhibiting good aesthetic value and, where attainable, excellent aesthetic value based on Water Management Type designation.

6. Boating, fishing, and other recreational uses - Suitable for these uses with additional protection in those waters where these uses are sustainable at a higher level based on Water Management Type.

Numeric Water Quality Target

There is no specific target phosphorus loading or target concentration identified in the Water Quality Standards. However, the standards do provide for the use of biological criteria as a surrogate to determine use support or impairments to the system. For this TMDL, the measure of the aquatic biota provides the most direct measure for the health of the system and directs the corresponding required pollutant loads to achieve and maintain the uses provided by the standards. An advantage of using biological indicators, especially in cases of nutrient enrichment, is that they are not as subject to time variability of pollutant loads and tend to give an integrated representation of overall community health. The macroinvertebrate biocriteria for this stream type (Medium Mountain Stream) are given below in Table 2 and act as the numeric target for this TMDL.

Table 2. VT DEC macroinvertebrate biocriteria for Medium Mountain Streams.

Biometric	Description	Class B Criterion (WQ Targets)
Density	Relative abundance of organisms in a sample	> 300
Species Richness	Number of different taxa in a sample unit	> 20
EPT	Number of water quality sensitive taxa from the insect orders Ephemeroptera, Plecoptera and Trichoptera.	> 18
EPT/Richness	Ratio of water quality sensitive EPT taxa to all taxa found in Community	> 0.45
Biotic Index	**The community tolerance to organic/nutrient loading, based on the tolerances of the species found in the community**	**< 5.00**
EPT/EPT & Chironomid	Ratio of density of EPT taxa to EPT and tolerant Chironomidae	> 0.45
% Dominant Genera	Percent of dominant genera in the community	> 40%

The biometric of primary importance for this TMDL is the Biotic Index because it measures an organism's (and collectively a community's) tolerance to organic enrichment.

Antidegradation Policy

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

> Existing uses of waters and the level of water quality necessary to protect those existing uses shall be maintained and protected regardless of the water's classification. Determinations of what constitute existing uses of particular waters shall be made either during the basin planning process or on a case-by-case basis during consideration of an application. The use of waters to receive or transport discharges of waste shall not constitute an existing use for purposes of these rules. In making a determination of the existing uses to be protected and maintained under this section and all other sections of these rules, the Secretary shall consider at least the following factors:
>
> a. Aquatic biota and wildlife that utilize or are present in the waters;

b. Habitat that supports existing aquatic biota, wildlife, or plant life;
c. The use of the waters for recreation or fishing;
d. The use of the water for water supply, or commercial activity that depends directly on the preservation of an existing high level of water quality; and
e. With regard to the factors considered under paragraphs (a) and (b) above, evidence of the use's ecological significance in the functioning of the ecosystem or evidence of the use's rarity.

Pollutant Sources

Point Sources

There is a single NPDES permitted point discharge to the impaired stream segment addressed by this TMDL, the Town of Ludlow WWTF. A monitoring program was developed and conducted during the summer of 1999 to better characterize the effluent from this facility. Grab samples were collected at nine occasions throughout the summer and correspond to the collection of dry weather upstream river samples collected to identify background river concentrations. The total phosphorus results are given below in Table 3.

Table 3. 1999 Ludlow WWTF effluent sampling data.

Date	Total Phosphorus (mg P/L)	Flow (MGD)		Date	Total Phosphorus (mg P/L)	Flow (MGD)
5/06/99	1.8	0.459		7/08/99	2.3	0.301
6/01/99	1.0	0.411		8/05/99	3.8	0.270
6/04/99	1.1	0.352		8/12/99	4.2	0.285
6/18/99	1.7	0.299		9/03/99	3.4	0.395
7/02/99	2.3	0.394				
Mean Total Phosphorus: 2.4 mg P/L						
Mean Flow: 0.352 MGD						

Nonpoint and Background Sources

No differentiation was made between source categories of pollutants comprising background phosphorus from areas upstream of the listed impaired segment. The biomonitoring data suggested the primary cause of impairment was the WWTF, so upstream sources were all categorized as background. The historical biomonitoring data did suggest that the upstream sample point indicates enrichment impacts above reference conditions, but the significant nutrient loading from the WWTF was considered the primary contributing factor of historical impairment below the facility. Dry weather

phosphorus data was collected throughout the summer immediately upstream of the WWTF outfall and is presented below in Table 4. Dry weather flows were defined as those preceded by 72 hours without precipitation.

Table 4. 1999 upstream total phosphorus sampling data for the Black River.

Date	Total Phosphorus (mg P/L)		Date	Total Phosphorus (mg P/L)
5/06/99	0.010		7/08/99	0.016
6/01/99	0.0025*		8/05/99	0.0025*
6/04/99	0.054		8/12/99	0.0025*
6/18/99	0.007		9/03/99	0.009
7/02/99	0.011			
Mean Total Phosphorus 0.013 mg P/L				

* data points represent values less than the detection limit, ½ of detection limit values were used for calculation of mean concentration.

The data suggests that there are no significant sources of total phosphorus discharging to the Black River above the WWTF during dry weather. The average total phosphorus concentration suggests low background loading. The background condition of the river was not characterized during wet weather runoff because the biological indicators identified the WWTF as the primary cause of impairment when the greatest impacts would occur during dry weather, low flows. Also, the intermittent phosphorus loading from wet weather runoff was considered less critical than the impact from the consistent daily loading of biologically available phosphorus from the WWTF.

Linkage Analysis

The linkage analysis is a necessary TMDL element that establishes the cause-and-effect relationship between measurable water quality targets and identified sources. This may be accomplished through a variety 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 or observations that associate waterbody responses to specific loading conditions.

The method chosen to determine the appropriate level of phosphorus loading to the impaired segment of the Black River includes a determination of the current phosphorus loading to the river and correlates it to the condition of the aquatic biota present. There are no applicable numeric standards for phosphorus loadings to rivers in the Water Quality Standards, but as identified earlier, biological criteria

act as a surrogate or indicator for this TMDL. This linkage method is most appropriate in this instance because it relies on site-specific data for both the biological indicators and phosphorus loading.

The phosphorus source identified with the greatest potential to cause the nutrient impairment was the Ludlow WWTF. This is based on the three years of biological monitoring above and below the WWTF in 1987, 1991 and 1999. Since the sampling location located above the WWTF did not show impairment in the 3 years of biomonitoring, it is assumed that the phosphorus loading from upstream alone was not sufficient to cause impairment. Two of the three years (1987 and 1991) identified the downstream site as being impaired due to nutrient enrichment. The 1999 data suggests an improved condition below the WWTF, but indications of nutrient enrichment were still noted.

Critical conditions are an important consideration in determining the linkage between pollutant sources and their ultimate pollutant allocation. A frequently utilized method when working with point source loadings to rivers is to limit the loading of pollutants during low flows, such as 7Q10, to a specified loading limit. This is normally the case when considering pollutants that cause a severe and immediate impact such as oxygen depletion or acute toxic effects that can destroy a biological community. However, in this instance of low level nutrient impairment, a different approach is necessary.

Since there are no specific target concentrations for phosphorus in the Water Quality Standards, the use of a specific flow, such as 7Q10, to limit loading is of less importance. The nature of nutrient enrichment in rivers is more a cumulative effect over the course of the summer and is less controlled by intermittent spikes than it is by consistently high nutrient concentrations. The use of biological monitoring is a very useful tool in determining the necessary loading because it acts to integrate the cumulative effects over the course of the season. Therefore, the critical conditions for which this TMDL was developed were observed low flow summer conditions during which the lowest dilution of phosphorus from the WWTF would occur.

Loading Capacity

Based on the 1999 data, it was determined that the current phosphorus loading from the Ludlow WWTF was not impacting the river biota to a degree to cause impairment, but sampling indicates a slight increase in the Biotic Index, approaching the impairment cut-off . In light of this fact, it was determined that a substantial and consistent increase in phosphorus loading would indeed result in an impaired condition in the immediate downstream segment from the WWTF. Therefore, the loading capacity of this section of the Black River was set equal to the 1999 measured phosphorus loading from the combination of the Ludlow WWTF and the background upstream sources during low flow conditions.

To calculate the phosphorus loading to this portion of the Black River during low flow, reliable estimates of both flow and phosphorus concentrations are necessary. Useful flow data for the Black River in 1999 is unavailable, but a USGS gaging station is located on the adjacent Williams River

watershed near Rockingham, Vermont (USGS gage #01153550). By incorporating the unitized flows (flow per unit of drainage area) from the adjacent basin into the Black River, 1999 summer flows were estimated. Data from that gage indicates that the months of July and August averaged very low flows reported as 0.14 and 0.15 cfs/sq. mi. respectively (Appendix B). This correlates to an estimated average flow of 10.9 cfs for the months of July and August in the Black River. For comparative purposes, the estimated 7Q10 flow for the Black River at Ludlow is 0.11 cfs/sq. mi, or 8.5 cfs. Considering the documented low flow conditions, 1999 summer flows presented ideal conditions to assess the maximum impacts of the WWTF on the biologic communities.

The collected 1999 phosphorus data (Tables 3 and 4) was used to quantify the phosphorus loads from the primary sources. From the Ludlow WWTF, average total phosphorus was measured to be 2.4 mg P/L accompanied with and average effluent discharge of 0.35 MGD. These data were collected between May 9th and September 3rd, 1999 and are believed to be typical values for flow and total phosphorus concentrations from the WWTF during the summer season. An average daily load of total phosphorus from the WWTF was determined to be 7.0 pounds/day.

Current P loading from WWTF = 2.4 mg P/L * 8.33 * 0.35MGD = 7.0 lbs/day

The combined loading associated with background sources above the WWTF during low flows was determined from the estimated average river flows and the 1999 chemical monitoring data collected. Average flow for July and August was estimated to be 10.9 cfs and upstream average phosphorus concentrations were 0.013 mg P/L. Loading was estimated to be 0.8 pounds/day.

Background P loading = 0.013 mg P/L * 10.9 cfs * 5.38 = 0.8 lbs P/day

The sum of these two sources was determined to be a conservative loading capacity of the downstream reach from the WWTF during summer low flows. A summary is given below in Table 5.

Table 5. Average phosphorus loading during summer 1999 low flow conditions.

Phosphorus Sources		Flow	Avg TP (mg/L)	Average TP Load
Background				
	Black River upstream of Ludlow WWTF	10.9 cfs *	0.013	0.8 pounds/day
Identified Point Sources				
	Ludlow WWTF	0.35 MGD	2.4	7.0 pounds/day
Average total phosphorus loading				**7.8 pounds/day**

* *Estimated average flow during July and August based on Williams River USGS gaging station 01153550.*

These loading estimates for both the WWTF and upstream sources also supports the linkage that the WWTF is the primary contributor to the impairment. The WWTF contributes 90% of the total phosphorus loading to the river reach immediately below the WWTF during low flow conditions. For this reason, TMDL development was centered around the Ludlow WWTF and other phosphorus sources were considered to be minor and categorized as background.

Strengths of the approach used for determining the appropriate loading capacity are several. First, site specific data was collected during a year that provided critical instream conditions. This provided a clearer understanding of the linkage between the level of phosphorus loading and the resulting condition of the aquatic biota. Second, the use of biological targets provides a more protective indicator because they measure the overall health of the affected resource and don't rely on an estimated linkage between loading and community response. These are very useful indicators when dealing with nutrient impairments because they measure the long term conditions and are resistant to short term variability. Lastly, the selection of a loading capacity value that is below the level when observed impairment occurs is most protective.

TMDL Allocations

The TMDL allocation is composed of the sum of individual waste load allocations for point sources, load allocations for nonpoint sources, and natural background levels. In addition, the TMDL must provide a margin of safety that accounts for any uncertainty in the allocation being able to attain water quality standards. This TMDL has made no distinction between point/nonpoint sources upstream from the WWTF and has considered them collectively as background sources. All indications from the investigations identify the WWTF as the primary source of phosphorus and thus the impairment.

The allocations for this TMDL have been developed for the summer growing season only. It is during the summer months that algal productivity is the greatest and has the greatest potential to negatively

impact the biologic communities. Also, summer months normally result in the lowest instream flows that act to magnify the impact from the largest phosphorus source, the Ludlow WWTF. Therefore, phosphorus allocations have not been prepared outside of the context of the summer growing season, May through October, because other external environmental conditions (light, temperature, etc.) significantly limit the possibility for excessive algal production and community impairment.

Wasteload Allocation

The total phosphorus wasteload allocation for this segment of the Black River is set equal to the calculated summer 1999 point source load, and is given below.

	Total Phosphorus Allocation (summer)
Point Sources	**7.0 pounds/day**

This allocation may also be expressed in future applications in equivalent units over longer time periods. For example, the allocation may be expressed in pounds/day as a monthly average in a NPDES permit, provided that the average daily total phosphorus load does not exceed 7.0 pounds/day. This allocation procedure is appropriate in this case because the expected response time of the algal community is less dependant on short term (daily) total phosphorus fluctuations than it is on longer time scales (weeks or months). This total phosphorus allocation is established for the period between May 1 and October 31 to correspond with the summer growing season.

Load Allocation

The load allocation for all background and nonpoint sources of phosphorus have been combined into a single allocation for low flow summer conditions. This load was set equal to the measured summer 1999 background loads and is given below.

	Total Phosphorus Allocation (summer)
Combined Nonpoint Source / Background	**0.8 pounds/day**

Margin of Safety

A basic conservative assumption was incorporated into the determination of the loading capacity that results in an implicit margin of safety. Biomonitoring data suggest that current (1999) phosphorus loading, set as the TMDL value, is actually somewhat below the loading capacity for this segment of the Black River. Since biomonitoring results indicated the downstream portion of the river was meeting the biocriteria standards during critical conditions, this implies that there remains an additional capacity for the biological communities to withstand additional phosphorus loading. Therefore, if the loading is held constant at 1999 levels when no impairment was detected, there remains an additional unallocated phosphorus load that acts as an intrinsic margin of safety.

Seasonal Variation

The allocations incorporated in this TMDL are protective for the most critical period of potential impairment, the summer growing season accompanied by low instream flows. A conservative loading capacity, and subsequent allocations, were determined from site specific data collected during critical flow periods and are designed to be protective with an appropriate margin of safety.

Monitoring Plan

EPA guidance recommends the preparation of a monitoring plan only when a TMDL is developed under the phased approach. The TMDL developed for this segment of the Black River is not a phased TMDL and therefore no detailed monitoring plan has been prepared. However, periodic and routine effluent monitoring of phosphorus and other parameters will occur at the NPDES permitted discharge according to permit limits set according to this TMDL. It is also anticipated that periodic biomonitoring will occur in this portion of the Black River to track attainment of the Vermont Water Quality Standards as part of ongoing water quality assessment programs.

Public Participation

A final draft version of this TMDL was made available to the public in order to receive comment. A thirty day public comment period was advertised in two regional newspapers, the Rutland Herald in Rutland, Vermont and the Eagle Times in Claremont, New Hampshire, on February 7, 2001. The period of public comment was from February 7 through March 8, 2001. The notice is given in Appendix C. Also, the same notice was posted on the Vermont DEC Water Quality Division Web Page during the public comment period. At the time of the public notice, a copy of the TMDL document was sent to the Town of Ludlow for review. Several requests for the draft document were made but no written comments were received.

APPENDIX A

1999 Biological Assessment Summary of the
Black River at Ludlow, VT

Agency of Natural Resources
Department of Environmental Conservation

Water Quality Division
Building 10 North
802-241-3777

MEMORANDUM

To: Tim Clear TMDL Coordinator DEC/WQD

From: Steve Fiske and Rich Langdon Aquatic Biologists DEC/WQD

Date: November 1, 1999

Subject: Biological Assessment of Black River in Ludlow, VT

An assessment of the biological integrity of the macroinvertebrate and fish communities of the Black River above and below the Ludlow Waste Water Treatment Facility (WWTF) was done in early September 1999. The biological assessment of the river was needed to determine if the biological integrity of the stream community is meeting the Class B biological criteria as presently applied by the VTDEC. The results of this assessment are presented in this memo and show that the Black River below the Ludlow WWTF presently meets the minimum biocriteria for Class B waters.

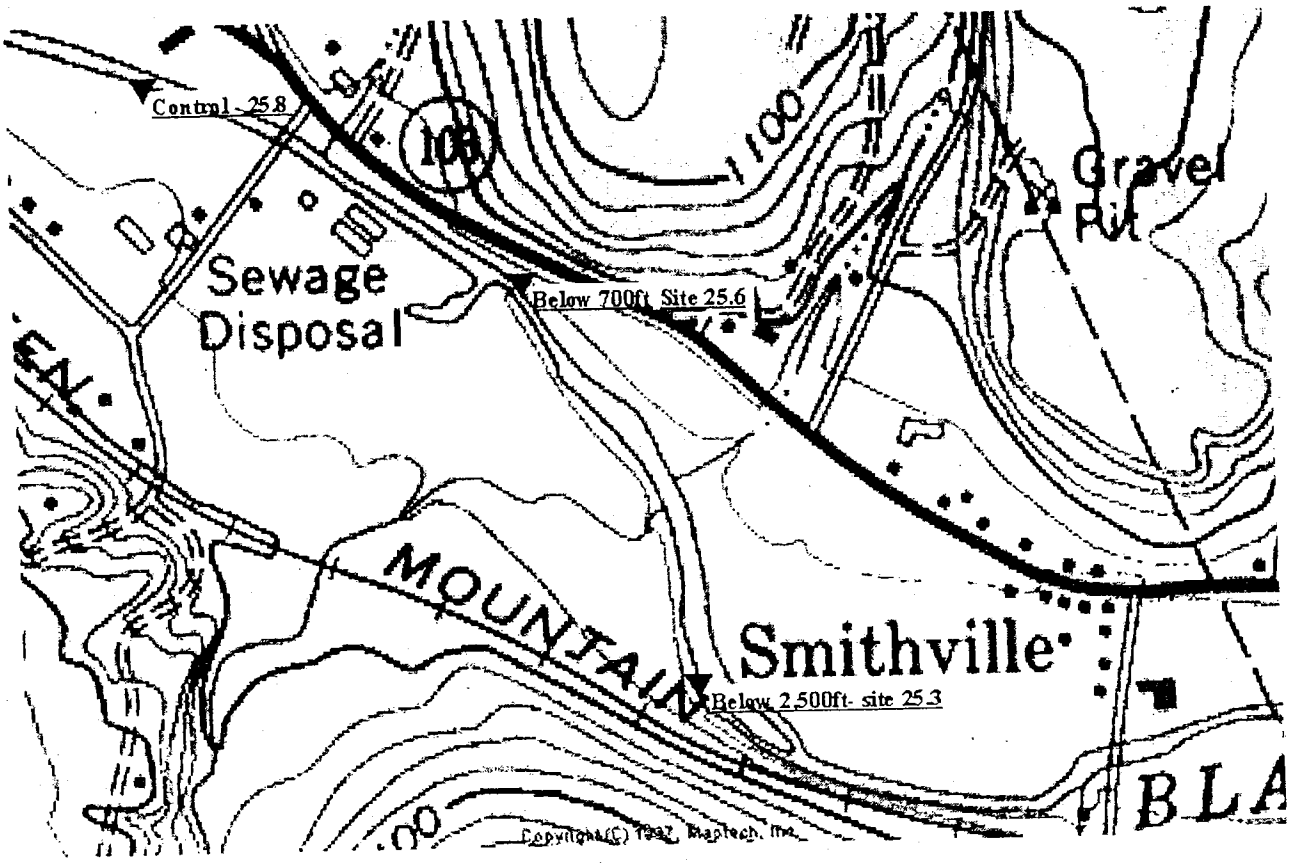
Macroinvertebrate Community Assessment

Previous assessments in 1987 and 1991 showed the macroinvertebrate community to be moderately enriched below the Ludlow WWTF due to an elevated old (0-5) Bio Index value (2.79 and 2.88) respectively. This was just above the Class B criteria (<2.75) used by the Department at the time. The Department now is using an improved new (0-10) Bio Index value which was modified by Hilsenhoff in 1987. The new Bio Index also indicates that the stream was enriched in 1987 and 1991 (5.46 and 5.33) respectively. Additionally the Department has developed a large enough database that it now has revised the Class B biocriteria to better reflect a true departure from wadeable streams of similar biological potential based on stream gradient (substrate composition), size, elevation, alkalinity and canopy cover. The Black River in Ludlow is a high gradient (cobble bottom), medium sized stream (D.A. 147km^2), at an elevation of 1065 ft, with a moderate alkalinity (32.6mg/l), and about 50 per cent canopy. These characteristics indicate that it should be evaluated as a Medium Sized High Gradient stream (**MMeHg**) (see attachment A).

The macroinvertebrate community was sampled and evaluated in three locations in 1999 (see attached map). The control and first below site were sampled in 1987 and 1991. The control site (mi 25.8) was located upstream of the WWTF adjacent to the recreation fields. Two assessment sites were located below the WWTF. Site 25.6 was located about 700 ft below the WWTF in the first riffle. Macroinvertebrates were sampled from both sides of the river (North

and South), and samples were kept separate in order to better define the extent of impairment if needed at this point in the river. This was done because earlier evaluations of effluent plume dynamics in the river had determined that the WWTF effluent was only about 50 percent mixed at this point (700 ft below) in the river. Site 25.3 was located 2500 feet below the WWTF, below an old coffer dam. It was determined that the WWTF effluent was completely mixed at this point in the river. (See letter to Mr Loren Geenslet from Aquaterra 7/30/99).

Figure 1: Site locations of macroinvertebrate and fish assessments above and below the Ludlow Waste Water Treatment Facility, Ludlow VT.



Four macroinvertebrate samples were collected from each site, using a standard kick net (KN) method, from riffle habitat in each location. Samples were preserved in the field with 75 percent Ethyl Alcohol, and processed in the VTDEC laboratory using standard sub-sampling techniques. Three samples were processed and four held in reserve, to be processed only if needed due to high variability. All animals were identified to the lowest practical taxon as indicated in the VTDEC macroinvertebrate taxa file.

Table 1 presents the biometrics for the three sites in the Black River, the biocriteria presently used by the Department to determine Class B standards for **MMeHG** streams in Vt, and the mean metric value for **MMeHg** streams from the VTDEC reference database. The biometrics

indicate the river is slightly enriched above the WWTF when compared to the reference stream data and increases in productivity below the WWTF. The increase in productivity due to the WWTF however does not impair the community to below Class B biocriteria values. No discernable difference was detected in the macroinvertebrate community metrics between sites 2 and 3 located below the WWTF.

Some nutrient enrichment from the WWTF to the macroinvertebrate community is indicated by the following movement in the metric values from above to below the WWTF; the density of the community increased by over 100 percent below the WWTF; the overall taxa richness increased below, but the number of sensitive EPT taxa remained unchanged, resulting in a decrease in the EPT/Richness ratio below the WWTF (this indicates that the increase in taxa richness was due to an increase in more pollution tolerant taxa below the WWTF); the Bio Index value, a measure of the overall tolerance of the community to organic enrichment, increased slightly below the WWTF; and the ratio of the abundance of EPT/EPT&c decreased.

In summary, the above shifts in the metrics indicate that the productivity (abundance) of most species in the macroinvertebrate community below the WWTF has significantly increased, and there is an increased number of more pollution tolerant species. The pollution tolerant species however, have only become slightly more dominant and therefore, although showing the signs of increased enrichment, the structure and function of the macroinvertebrate community has not been altered to below the Class B criteria by the WWTF.

Table 1: The macroinvertebrate biometrics from 3 sites on the Black River in Ludlow, VT. Site numbers represent the river mi from the mouth. The Class B criteria for Medium High Gradient streams, and the reference mean are listed in last columns. Class B criteria is always equal to, and > or < value as indicated.

	25.8 Above	**25.6 Below(700')**	**25.3 Below(2500')**	**Class B**	**Reference mean**
Density	1856	5041	5148	>500	1919
Richness	51.6	61.7	61.3	>30	47.6
EPT	24.7	25.0	24	>18	26.8
EPT/R	0.48	0.40	0.39	>0.38	0.57
PMA- O	79	76	76	>45	81
Old Bio Index (0-5)	2.39	2.60	2.61	<2.75	1.76
New Bio Index (0-10)	4.48	4.73	4.68	<5.00	3.10
EPT/EPT&c	0.77	0.63	0.63	>0.45	0.86
% Oligocheata	<1	0	<1	<15	<1
PPCS-F	0.51	0.51	0.55	>0.40	0.64

Fish Assemblage Assessment

Two reach-representative sections of the Black River in the town of Ludlow were sampled for fish on September 1 and 2, 1999. One section (site 25.3) was located approx 2,500ft below the Ludlow Wastewater Treatment Plant, below an old coffer dam. The fish assemblage of his section was assumed to be within the influence of the outfall of the Ludlow WWTF. The "control" section (site 25.8) was located approx 650ft upstream of the WWTF, adjacent to the recreation fields . This section was used as a comparative standard to the downstream section.

The fish assemblages of both sections passed the biological criteria for the Class B Water Quality criteria. The downstream section scored a 31 (good) on the Mixed Water Index of Biotic Integrity for Fish (MWIBI). The upstream site MWIBI score was 33 (good). Attached is the MWIBI description for your information. The difference in MWIBI scores is considered a result of physical habitat differences unrelated to the Ludlow WWTF.

The downstream site supported a moderately altered fish assemblage (**Tables 2 and 3**). MWIBI metrics which were de-scored the most (lost 4 points each) were "per cent generalist feeders" and "per cent top carnivores". Just over 50 per cent of the assemblage was comprised of generalist feeders (primarily white suckers and creek chubs). Both of these species are tolerant of a wide range of disturbance and usually dominate in degraded locations. The top carnivore metric value was also low. A site containing a greater density of the intolerant brown trout would have been scored more favorably.

The downstream site score fell into a range (29-31) which is between meeting and not meeting the Class B criteria. The final assessment of a site which scores in that range is determined by "Best Professional Judgement". The scoring of the nine metrics as well as other biological and physical characteristics are considered in making the final determination. In this case, the assessment of *compliance* with the criteria was made with relative confidence. Fifty-six Atlantic salmon juveniles were captured in the section. Although, since it is stocked, this species was not entered into the computation of the MWIBI, it is considered as intolerant to disturbance with many of the larger salmon having been resident in this section for two years. Their presence is consequently taken as a strong positive indication, thereby influencing the final assessment towards a compliance determination.

The upstream site MWIBI was similar to the downstream site, but several metric scores differed. . The reason for this is that the physical habitat differed somewhat between the two stations. Site species composition (and to some extent density) is influenced by the ratio of pools to riffles. Some species prefer faster water, such as longnose and blacknose dace, while others are found more often in the quit areas of pools (eg. creek chub, white sucker and common shiner). The downstream site was comprised of 50 per cent pool and 31 per cent riffle, while the upstream site contained 24 % pool and 58 per cent riffle. Increases in the daces at the upstream station accounted for much of the metric scoring differences between the two sites. A closer match between the sites in pool to riffle ratios would have probably resulted in closer scoring of the individual metrics. Under the conditions, however these sections represented the closest two habitats available for sampling in that reach of the Black River

Table 2: Species collected from two sections on Black River during September 1-2, 1999. Per cent composition is given.

	Downstream (Station 25.3)	Upstream (Station 25.8)
Blacknose dace	25	41
Longnose dace	16	31
Common shiner	21	16
White sucker	20	6
Creek chub	8	1
Atlantic salmon	4	4
Brown trout	4	1
Tessellated darter	0.5	.01
Rockbass	0.3	0
Fallfish	0.2	0
Fathead minnow	0.2	0

Table 3: Fish Mixed Water Index of Biotic Integrity (MWIBI) metric scoring comparison between sections fished on the Black River, September, 1999.

MWIBI Metrics	Above Ludlow WWTF		Below Ludlow WWTF	
	Raw Metric Value *	Score	Raw Metric Value*	Score
Richness	6	3	7	5-[1]
# of Intol Spp	1	3	1	3
# of Benth. Insectivores	1	3+[1]	2	5
% Creek chub and White Suckers	7.0	5	29	3
% Generalist Feeders	23.9	3	51.0	1
%Insectivores	75.3	5	44.6	3
% Top Carnivores	0.8	1	4.3	1
% DELT Anomalies	0	5	0	5
1 Run Density (#s/100m^2)	69.5	5	44.9	5
MWIBI		**33** (Passes Class B Criterion)		**31** (Passes Class B Criterion)

* Raw values for both Index scores were computed under the following conditions:

1. Atlantic salmon were not included in the calculations of any metric value since they have been stocked. They were however, considered when applying BPJ to the final assessment.

2. Rock bass were not included in any metric calculations since they are considered non-residents of this section.

3. Fathead minnow and brown trout were not considered for the computation of the species richness metric (1) since they are non-native species to this section.

4. Brown trout were used as a an intolerant species and as a top carnivore since they are naturally populating in that section of river

[1]. When metric raw value falls close to a scoring cut off a + or - is affixed to the metric score indicating its nearness to the next metric score. Two +'s or -'s add two points to the final MWIBI

APPENDIX B

Chemical Monitoring Results, Mixing Investigation Results,
and USGS Williams River Flow Data

Black River and Ludlow WWTF Sampling Data - 1999

Black River upstream of WWTF - grab samples collected by WWTF staff

Date	TP	TDP	Nitrate	pH	Temp
	mg P/L	mg P/L	mg N/L	s.u.	°C
05/06/99	0.01	0.008	0.1	6.9	12.6
06/01/99	**0.0025**	**0.0025**	0.2		
06/04/99	0.054	0.047	0.2		
06/18/99	0.007	0.006	0.2	7.13	15.6
07/02/99	0.011	0.005	0.3		
07/08/99	0.016	0.009	0.3	7.16	19.8
08/05/99	**0.0025**	**0.0025**	0.2	7.16	18.9
08/12/99	**0.0025**	**0.0025**	0.2	7.2	19.8
09/03/99	0.009	0.008	0.2	7.05	18.7
mean	0.013	0.010	0.2	7.1	17.6
min	0.0025	0.0025	0.1	6.9	12.6
max	0.054	0.047	0.3	7.2	19.8

(bold values represent values less than DL, 1/2 of detection limit used for calculations)

Ludlow WWTF effluent - grab samples collected by WWTF staff

Date	TP	TDP	Nitrate	TKN	NH_3	pH	Temp	Flow
	mg P/L	mg P/L	mg N/L	mg N/L	mg N/L	s.u.	°C	mgd
05/06/99	1.8	1.7	1.8	1.7	0.8	6.6	11.3	0.459
06/01/99	1.0	0.9	4.4	1.1	0.6	6.1	18	0.411
06/04/99	1.1	1.0	9.2	0.7	**0.25**	6.3	15	0.352
06/18/99	1.7	1.5	13	0.7	**0.25**	6.6	17	0.299
07/02/99	2.3	2.2	11	0.7	**0.25**	6.2	19	0.394
07/08/99	2.3	2.2	14.4	1.0	**0.25**	6.4	20	0.301
08/05/99	3.8	3.3	18	1.0	**0.25**	6.1	21	0.270
08/12/99	4.2	3.6	20	1.7	**0.25**	6.2	20	0.285
09/03/99	3.4	2.9	16	2.0	**0.25**	6.0	21	0.395
mean	2.4	2.1	12.0	1.2	0.35	6.3	18.0	0.352
min	1.0	0.9	1.8	0.7	0.25	6.0	11.3	0.270
max	4.2	3.6	20	2	0.8	6.6	21	0.459

(bold values represent values less than DL, 1/2 of detection limit used for calculations)

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Aquaterra
60 Highland Terrace
South Burlington, Vermont 05403
Tel/fax: (802) 860-5016

30 July 1999

Mr. Loran Greenslet
Municipal Office
P.O. Box B
Ludlow, VT 05149-0250

Re: Mixing study in Black River downstream of Ludlow's WWTF outfall on 27 July 1999

Dear Mr. Greenslet

Aquaterra conducted a mixing study on the Black River downstream of Ludlow's Wastewater Treatment Facility (WWTF) outfall on 27 July 1999. This study was conducted to determine the point of complete mixing in support of pending biomonitoring studies associated with a proposed WWTF expansion. The following is a summary report of this study, along with a summary table and map showing the point of complete mixing.

A chemical metering pump continuously discharged Rhodamine WT dye solution (known concentration of 2450 milligrams per liter, or mg/l) into the outfall of the WWTF chlorine contact tank. This discharge was measured using a graduated cylinder and stopwatch; measurements found the discharge rate to be constant (10.3 milliliters per minute). Dye injection commenced at 1830 on 26 July 1999 and stopped at 1130 on 27 July 1999.

Surface grab samples of river water at measured distances downstream of the outfall (using a cloth tape) and across the river (using a measuring stick) were collected on the morning of 27 July (0630 to 1100). The depth at each sample location was also measured. Samples were individually placed in a glass test tube (sample rinsed) and sample fluorescence was measured in a Turner Designs Model 10 fluorometer, which responds linearly to dye concentration in the concentrations employed in this study. Fluorometer readings were noted, and additional locations further downstream were sampled until 15% or less variability in fluorometer readings were observed for samples across the river. This location was found at 2500 feet downstream from the WWTF outfall, about 200 feet downstream of an abandoned dam/bridge foundation which acts to funnel river water together for effective mixing.

Samples of ambient river water upstream of the WWTF outfall (just downstream of the Pleasant Street bridge) were collected on the evening of 26 July and used to create standards with known dye concentrations (1 and 2 micrograms per liter, or ug/l). These standards were also analyzed in the fluorometer on 27 July and used to convert fluorometer

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readings to dye concentrations. The attached summary table contains, for each measurement point downstream of the outfall, the stream width, distance across the stream (from the south, or outfall, shore), water depth, and dye concentration. This summary table also contains: relevant dye injection data; an estimate of river discharge based on the dye solution concentration, injection rate, and the average dye concentration measured at the two furthest downstream measuring locations; WWTF discharge; and locations of features along the river (e.g. riffles, power line, bridges, etc.).

As we discussed, I am planning on performing the second dye study at a higher river discharge once you notify me that such conditions have been reached. Please contact me if you have any questions concerning the information in this report or the pending second dye study.

Sincerely

Roland Luxenberg, P.E.

cc: Mr. Jeff Wennberg, Municipal Manager (Ludlow, VT)
Mr. Ron Jaeger, Dufresne & Henry (North Springfield, VT)
Mr. Tim Clear, ANR DEC Water Quality Division (Waterbury, VT)

Summary of Mixing Study in Black River Downstream of Ludlow's Wastewater Treatment Facility; 27 July 1999.

500 feet downstream*						stream width = 53 feet				
Distance, ft. *	0	5.8	11.5	17.3	23	29	35	40	46	52
Depth, ft.	<0.5	0.7	1.2	2.1	2.2	2.4	2.2	1.6	1.0	0.8
Dye conc., ug/l	2.0	2.4	2.1	2.0	1.75	1.2	0.60	0.31	0.22	0.39

770 feet downstream*						stream width = 36 feet		
Distance, ft. *	0	5	10	15	20	25	30	35
Depth, ft.	<0.5	0.4	0.7	1.2	0.9	1.0	1.0	<0.5
Dye conc., ug/l	1.62	2.1	2.0	1.71	1.07	0.73	0.65	0.60

1000 feet downstream*						stream width = 44 feet			
Distance, ft. *	0	5	10	15	20	25	30	35	40
Depth, ft.	<0.5	0.4	0.6	0.5	0.7	0.5	0.6	0.4	0.4
Dye conc., ug/l	1.67	1.88	1.71	1.45	1.24	1.07	0.90	0.73	0.65

1500 feet downstream*						stream width = 47 feet				
Distance, ft. *	0	5	10	15	20	25	30	35	40	45
Depth, ft.	<0.5	0.8	0.7	1.0	1.0	1.7	1.6	2.0	1.7	<0.5
Dye conc., ug/l	1.37	1.41	1.45	1.37	1.28	1.20	1.07	0.86	0.77	0.73

2300 feet downstream*						stream width = 45 feet				
Distance, ft. *	0	5	10	15	20	25	30	35	40	45
Depth, ft.	<0.5	1.3	1.4	1.5	0.7	0.7	0.7	0.5	0.4	<0.4
Dye conc., ug/l	0.94	1.03	0.94	0.90	0.90	0.88	0.86	0.86	0.82	0.75

2500 feet downstream*						stream width = 41 feet				
Distance, ft. *	0	5	10	15	20	25	30	35	40	
Depth, ft.	<0.5	2.3	3.3	2.7	1.4	0.9	0.4	0.4	<0.4	
Dye conc., ug/l	0.99	0.99	0.99	0.99	0.94	0.94	0.90	0.90	0.90	

Notes:

* Distance from south shore or distance downstream from wastewater outfall

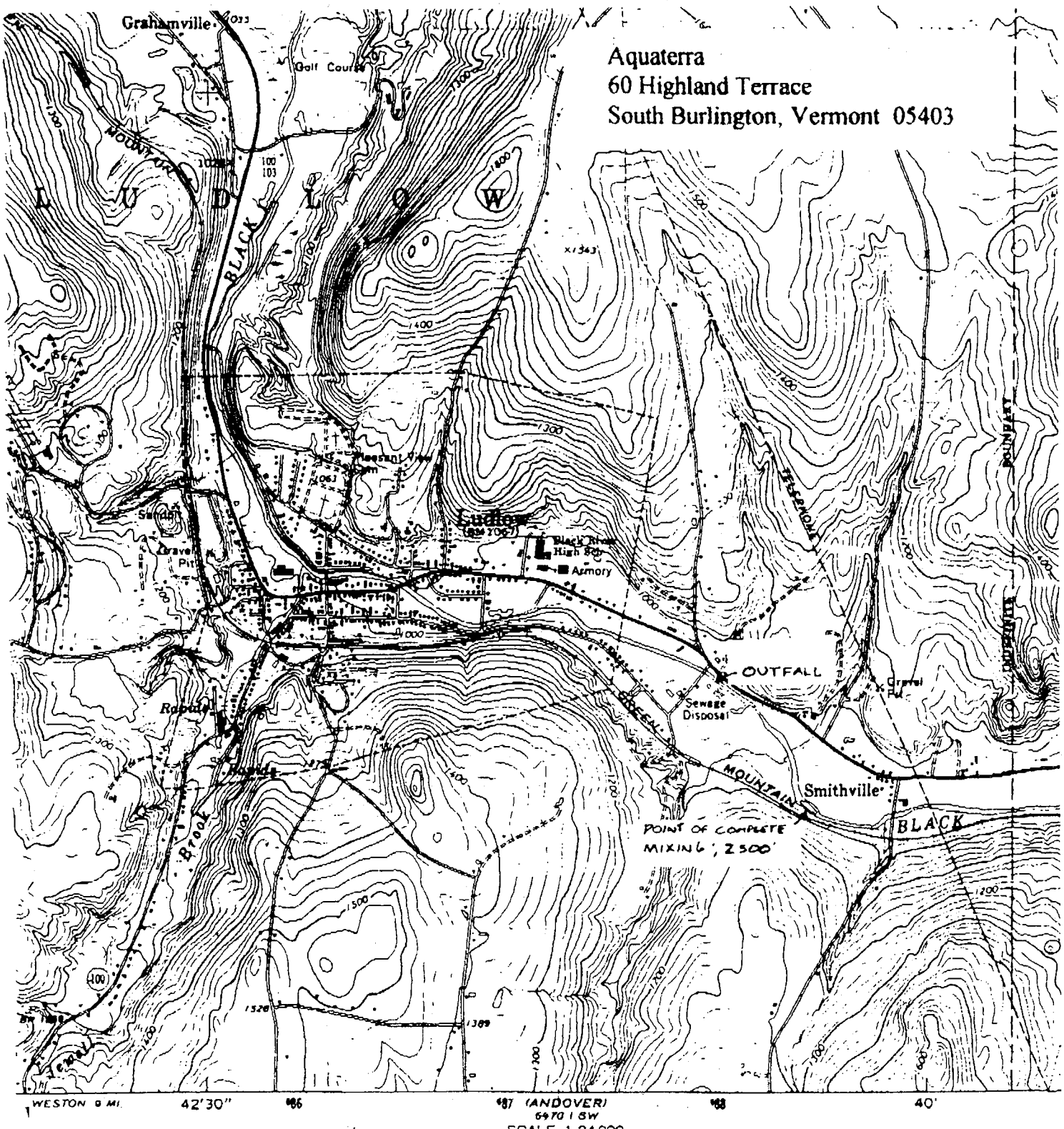
Dye injection solution concentration = 2450 mg/l; dye injection rate (average) of 10.3 mls/min.

Dye injection data (mls/min.): 10.3 @1830, 26 July; 10.1 @0630 and 10.3 @1130. 27 July.

Estimated river discharge = 14 cfs, using above values and 1.03 ug/l for river dye conc.

Wastewater discharge ranged from 0.22 (0100-0600) to 0.52 (0900-1000) cfs during study.

River observations	Distance, feet*	River observations	Distance, feet
End of first riffle	770	Power line	1825
End of second riffle	950	End of sixth riffle	1900
Start/end of third riffle	1000/ 1050	Cold water on south shore	2000
End of fourth riffle	1200	Start/end of seventh riffle	2150/ 2300
Fallen tree in river	1265	Dam / bridge (= 8th riffle)	2400
End of fifth riffle	1500	Start of ninth riffle	2500
Start of sixth riffle, island	1700	Smithville Bridge	3900



Mixing Study in Black River
downstream of Ludlow's Wastewater
Treatment Facility outfall; 27 July 1999.

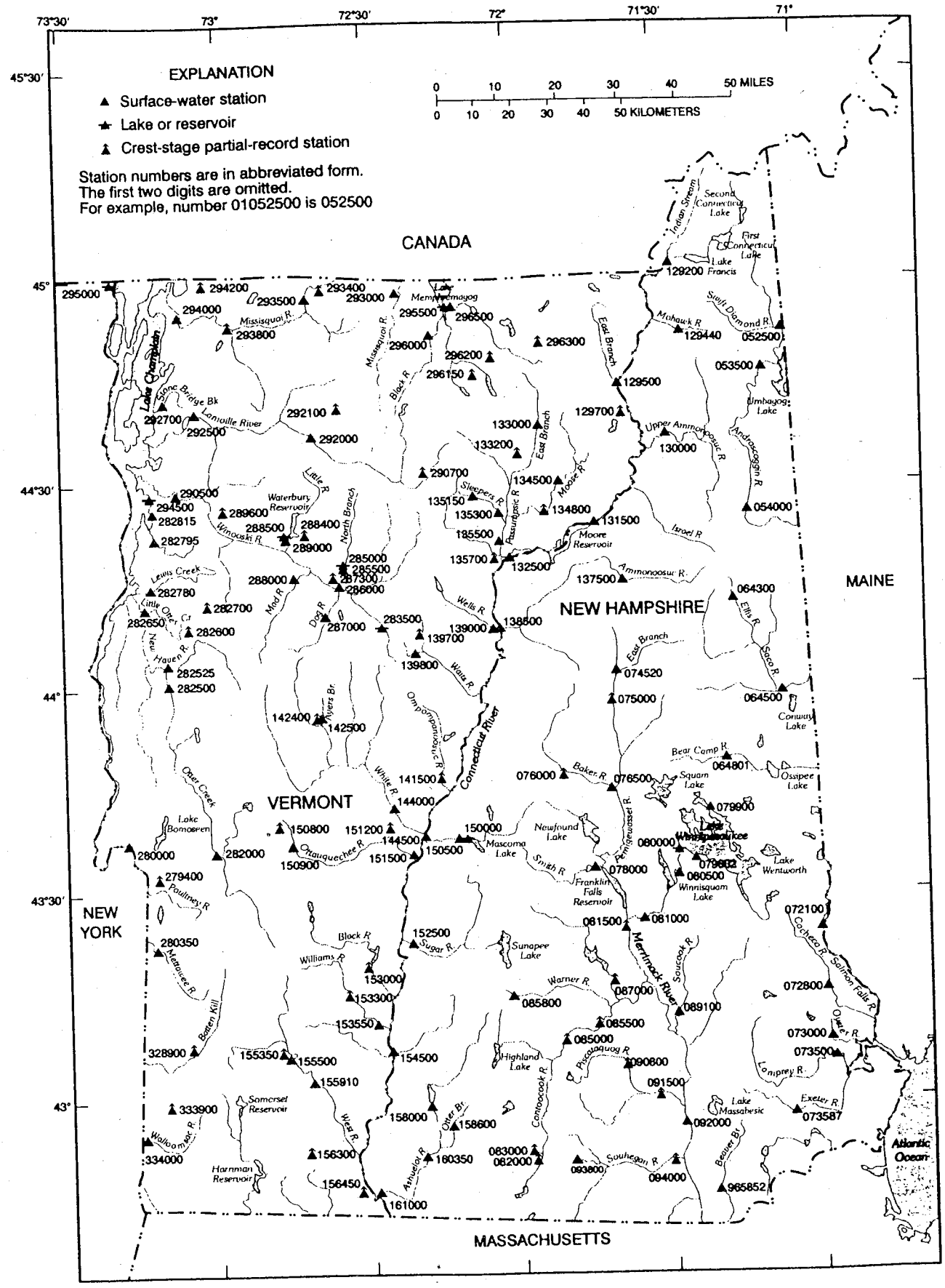


Figure 1. Location of surface-water data-collection sites.

from Water Resources Data for New Hampshire and Vermont, Water Year 1999; USGS 2000.

01153550 WILLIAMS RIVER NEAR ROCKINGHAM, VT

LOCATION.--Lat 43°11'30", long 72°29'08", Windham County, Hydrologic Unit 01080107, on left bank, 50 ft downstream from highway bridge on Parker Hill Road, 0.2 mi downstream from Divoll Brook, 0.35 mi northeast of Rockingham, 2.2 mi upstream from mouth, and 4.5 mi northwest of Bellows Falls.
DRAINAGE AREA.--112 mi^2.
PERIOD OF RECORD.--Discharge records: October 1986 to current year.
GAGE.--Water-stage recorder and crest-stage gage. Elevation of gage is 300 ft above sea level, from topographic map.
REMARKS.--Records good except those for estimated daily discharges which are poor. Low flow regulated by powerplant upstream October 1986 to September 1992.
EXTREMES OUTSIDE PERIOD OF RECORD.--Flood in September 1938 had greatest discharge since at least 1753.
EXTREMES FOR CURRENT YEAR.--Peak discharges greater than base discharge of 2,600 ft^3/s and maximum (*):

Date	Time	Discharge (ft^3/s)	Gage height (ft)	Date	Time	Discharge (ft^3/s)	Gage height (ft)
Mar. 22	1445	7,100	9.07	Sept. 17	0115	* 7,570	* 9.27

Minimum discharge, 7.0 ft^3/s, August 4,6-8.

DISCHARGE, CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1998 TO SEPTEMBER 1999
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	20	28	73	e78	e145	e120	1610	110	103	23	11	12
2	22	27	70	e78	e160	e150	1620	103	97	22	8.5	11
3	19	27	63	e79	e240	e130	1240	97	94	26	7.7	9.7
4	18	26	60	e79	e190	e250	1120	99	85	27	7.4	8.9
5	17	27	55	e78	e160	e260	837	152	72	29	7.5	8.4
6	17	26	52	e76	e150	e205	772	170	64	24	7.3	18
7	16	26	50	e74	e140	e185	915	139	58	29	7.4	35
8	20	25	49	e70	e135	e170	813	136	51	20	10	21
9	30	25	56	e69	e130	e160	685	343	47	17	14	19
10	41	25	52	e72	e125	e150	505	197	51	17	11	35
11	139	49	50	e73	e127	e140	410	153	44	15	8.8	54
12	63	59	46	e72	e130	e135	365	131	38	14	8.7	27
13	43	42	47	e70	e180	e130	322	117	34	13	8.2	19
14	66	37	51	e79	e155	e120	289	106	33	13	8.9	16
15	136	38	78	e71	e150	e125	268	97	51	12	59	15
16	71	38	60	e76	e140	e120	258	89	41	11	45	901
17	52	41	48	e76	e130	e140	310	81	33	11	21	2400
18	44	44	45	e77	e125	e195	306	75	33	9.6	15	354
19	40	40	45	e185	e125	e220	253	402	30	12	13	181
20	36	45	50	e145	e110	e180	233	1020	28	18	11	129
21	33	79	46	e115	e90	e170	220	328	26	14	12	131
22	31	63	234	e105	e86	2980	199	224	25	12	19	200
23	30	51	137	e100	e87	1350	197	180	23	10	16	201
24	28	46	96	e325	e89	770	179	410	21	9.4	13	131
25	27	44	155	e450	e89	623	160	498	20	9.2	12	101
26	27	159	166	e250	e90	563	151	310	19	15	11	85
27	25	331	155	e200	e92	596	142	251	18	31	11	77
28	26	133	e130	e180	e94	649	132	199	18	16	42	72
29	30	96	e110	e150	---	1090	125	166	27	13	29	68
30	30	80	e90	e140	---	1160	117	140	29	12	17	248
31	28	---	e79	e130	---	1240	---	119	---	11	13	---
TOTAL	1225	1777	2498	3822	3664	14476	14753	6642	1313	515.2	485.4	5588.0
MEAN	39.5	59.2	80.6	123	131	467	492	214	43.8	16.6	15.7	186
MAX	139	331	234	450	240	2980	1620	1020	103	31	59	2400
MIN	16	25	45	69	86	120	117	75	18	9.2	7.3	8.4
CFSM	.35	.53	.72	1.10	1.17	4.17	4.39	1.91	.39	.15	.14	1.66
IN.	.41	.59	.83	1.27	1.22	4.81	4.90	2.21	.44	.17	.16	1.86

STATISTICS OF MONTHLY MEAN DATA FOR WATER YEARS 1987 - 1999, BY WATER YEAR (WY)

MEAN	130	198	180	173	150	410	643	293	139	64.4	45.0	65.8
MAX	461	382	443	441	306	850	1199	544	440	227	123	282
(WY)	1988	1996	1997	1996	1997	1990	1994	1996	1998	1996	1990	1987
MIN	29.4	59.2	78.2	58.7	51.0	184	156	90.4	34.9	16.6	15.7	13.4
(WY)	1994	1999	1990	1989	1993	1994	1995	1995	1995	1999	1999	1995

SUMMARY STATISTICS	FOR 1998 CALENDAR YEAR		FOR 1999 WATER YEAR		WATER YEARS 1987 - 1999	
ANNUAL TOTAL	76398		56758.6			
ANNUAL MEAN	209		156		207	
HIGHEST ANNUAL MEAN					283	1996
LOWEST ANNUAL MEAN					111	1995
HIGHEST DAILY MEAN	3340	Jun 14	2980	Mar 22	6670	Mar 31 1987
LOWEST DAILY MEAN	16	Sep 30	7.3	Aug 6	6.9	Sep 7 1995
ANNUAL SEVEN-DAY MINIMUM	18	Sep 24	8.0	Aug 2	7.5	Sep 2 1995
INSTANTANEOUS PEAK FLOW			a 7570	Sep 17	a 11500	Mar 31 1987
INSTANTANEOUS PEAK STAGE			9.27	Sep 17	10.59	Mar 31 1987
INSTANTANEOUS LOW FLOW			b 7.0	Aug 4	b 7.0	Aug 4 1999
ANNUAL RUNOFF (CFSM)	1.87		1.39		1.85	
ANNUAL RUNOFF (INCHES)	25.38		18.85		25.16	
10 PERCENT EXCEEDS	377		310		455	
50 PERCENT EXCEEDS	97		72		100	
90 PERCENT EXCEEDS	22		13		23	

a From rating curve extended above 3,800 ft^3/s.
b Also occurred on August 6-8.
e Estimated.

from: Water Resources Data for New Hampshire and Vermont, Water Year 1999; USGS 2000.

APPENDIX C

Public Notice Announcement for Comment Period

Agency of Natural Resources
Department of Environmental Conservation

Water Quality Division
Building 10 North
802-241-3770
Fax #:802-241-3287

NOTICE: Public comments invited on the Total Maximum Daily Load document for the Black River at Ludlow

POLLUTANT OF CONCERN: Total Phosphorus

PUBLIC COMMENT PERIOD: February 7, 2001 - March 8, 2001

DESCRIPTION: The Black River in Ludlow (Waterbody ID VT10-14) is listed on the Vermont 2000 Part A list of Impaired Surface Waters due to nutrient enrichment impacting the biologic community. Section 303(d) of the Federal Clean Water Act requires that for impaired waters, states determine the pollutant loading capacity or necessary pollutant reduction needed for the waterbody to achieve compliance with the applicable water quality standards. These loading capacity determinations are compiled in a Total Maximum Daily Load (TMDL) document that demonstrates how water quality standards can be achieved.

FURTHER INFORMATION: Copies of the TMDL document may be inspected at the Vermont Agency of Natural Resources Waterbury Office. Copies of the TMDL may be obtained by calling (802) 241-3770. Office hours are 8:00 AM to 4:30 PM, Monday through Friday.

PUBLIC COMMENT: Public comments should be submitted in writing to the address below.

Department of Environmental Conservation
Water Quality Division
TMDL Comments
103 South Main Street
Waterbury, VT 05671-0408

The comment period will close at the end of the business day (4:30PM)