

VERMONT
LAKE WATER QUALITY ASSESSMENT
1996

Agency of Natural Resources
Department of Environmental Conservation
Water Quality Division
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VERMONT LAKES AND PONDS PROGRAM

The primary objective of Vermont's Lakes and Ponds Program is to assure that the maximum sensible recreational potential of every Vermont lake is achieved and maintained. The program has four major elements: (1) monitoring and surveillance, (2) special studies, (3) management and restoration, and (4) protection. Each of these elements is discussed in more detail in the following sections.

(1) Monitoring and Surveillance

During 1994-1995, there were seven basic monitoring programs in Vermont that together provided information on lake nutrient enrichment, algal and macrophyte productivity, water clarity, general in-lake and watershed conditions, Eurasian watermilfoil populations, and the effects of acid precipitation on acid-sensitive lakes.

The Spring Phosphorus Program collects total phosphorus data from up to 75 lakes each spring shortly after ice-out. Spring-time phosphorus concentrations are related to summertime lake productivity, and this program provides the majority of the data used to determine the trophic status of Vermont's lakes. Potential problem lakes with elevated or increasing nutrient levels are also identified. Sampling once a year in the spring is an efficient way to monitor the water quality of a large number of lakes. Since the start of the program in 1977, the Department has collected spring phosphorus data on 228 lakes. A total of 174 lakes have been sampled four or more years. A core of 36 lakes have ten or more years of data.

The Acid Precipitation Program collects chemical and biological data on lakes located in low alkalinity regions (those sensitive to acidification based on the bedrock buffering capacity) to determine the effects of acid deposition on Vermont's lakes. Nearly 200 lakes statewide were surveyed during the winters of 1980 through 1982 to identify the acid-sensitive areas of the state. Eleven lakes in these areas were included in the Acid Precipitation Long-Term Lake Monitoring Program during 1994-1995, and were sampled at least eight times every year for chemical parameters related to acidification. Biological sampling is occasionally conducted on some of the lakes. These activities are conducted in cooperation with the US EPA and USDA-FS. In addition, a network of eight statewide volunteer monitors collect and analyze precipitation samples for pH on an event basis. Both program elements have been in operation since 1980. Federal funding for the Acid Precipitation Program was significantly reduced during the 1994-1995 period. Nevertheless, the Water Quality Division continues to view this as a necessary program. Continued federal funding at a baseline level is considered critical to maintaining an accurate and up-to-date assessment of acidification on Vermont lakes.

The Lay Monitoring Program equips and trains local lake users to measure the nutrient enrichment of lakes by collecting lake water quality data following a rigorously documented and quality assured methodology. The program is designed such that all Lake Champlain stations and many inland lakes are sampled for chlorophyll-a, total phosphorus, and Secchi disk transparency. In addition, a selection of inland lakes on which only limited information is needed are sampled for Secchi disk transparency. All sampling occurs on a weekly basis during the summer. The tremendous success of the Lay Monitoring Program is largely due to the enthusiasm and dedication of the approximately 120 volunteers who monitor the lakes each year. These volunteers perform a valuable service in helping to protect Vermont lake water quality. Annual reports, prepared by the Vermont Department of Environmental Conservation in an educational format, are made available to all Lay Monitors and to the interested public. Since its inception in 1979, the Lay Monitoring Program has generated valuable

data on more than 70 lakes, and 36 Lake Champlain stations. Fifty-eight lakes and twenty-seven Lake Champlain stations have five or more years of full season data.

The Lake Assessment Program is funded primarily through a grant from the U.S. Environmental Protection Agency under Section 314 of the Clean Water Act. The main purpose of this program is to assess the water quality of lakes for which little data presently exists, and to detect water quality problems and threats. Under the program a lake is visited once during the summer and the following information is collected: depth survey, aquatic macrophyte survey; selected water quality parameters including Secchi disk transparency, total phosphorus, alkalinity, temperature and dissolved oxygen; potential and actual problems in the lake; specific information regarding the lake's natural and scenic features; and information regarding land use and development on the lakeshore and in the watershed and its potential for affecting the lake environment and its uses. Since the Program's initiation in 1989, a total of 230 lakes have been assessed. In 1994, the emphasis of the Lake Assessment Program was changed to (1) involve citizens in lake and watershed assessments through the use of the Lake and Watershed Survey form developed for citizens and through an expanded Lay Monitoring Program; and (2) collect lake assessment data on the larger, more heavily used lakes where recent data collection has been limited to the standard Lay Monitoring Program parameters. The lake assessment program continually seeks to improve the Department's existing lake assessment information, and to this end, a total of 38 lakes were visited during the 1994-1995 biennium. During 1994, the lake assessment information gathered since 1989 were used to complete the computerized Vermont Lake Protection Classification System, the purpose of which is to efficiently direct limited staff and financial resources toward lakes which have the highest priority for protection needs

Under the Aquatic Plant Survey Program, detailed qualitative aquatic macrophyte surveys are conducted on selected lakes and areas of Lake Champlain from mid-June to early September each year. All of the species present are identified and mapped with an indication of density and extent of cover. Due to the fact that Lake Champlain has 380 miles of shoreline in Vermont, plant surveys on Lake Champlain have generally been restricted to mapping and describing the location of only nuisance levels of macrophyte growth. Selected high use areas of the lake have been surveyed more thoroughly, however. Detailed aquatic plant surveys have been completed on 231 lakes and 28 major areas of Lake Champlain since 1982. These surveys will be useful in documenting future changes in both the extent and the species composition of aquatic plant communities in Vermont's lakes.

The Aquatic Plant Survey Program has given special emphasis to Eurasian watermilfoil (*Myriophyllum spicatum*) in recent years. Lakes with known milfoil infestations have been surveyed periodically to document the spread of this non-indigenous species, and uninfested lakes in the vicinity of known infestations have been searched for milfoil plants. In addition, a statewide Milfoil Watchers Program has been established under the auspices of Vermont's Eurasian Watermilfoil Control Program. Through the Milfoil Watchers Program, volunteers are trained in milfoil identification and search techniques and pledge to watch for milfoil on a presently uninfested lake. There are presently 55 lakes and approximately 150 milfoil watchers involved in the program. This program, combined with the searches conducted by state personnel, has resulted in the discovery of new milfoil infestations early enough to make control realistic in several lakes.

The Lake Champlain Long-term Water Quality and Biological Monitoring Program was designed to continue and expand upon the data collection activities started in 1990 under the Lake Champlain Diagnostic-Feasibility Study. The project began in 1992 as a 2-4 year intensive characterization of water quality, phytoplankton, zooplankton and zoobenthos at 12 stations on Lake Champlain and at 18

tributaries in the Lake Champlain Basin. The sampling program was intended to support research projects in lake hydrodynamics, internal phosphorus cycling, and food web interactions. In 1995, the design of the sampling program was shifted to a long-term environmental trend monitoring emphasis, based on statistical considerations for optimal sampling design for detecting water quality changes in the lake. The project is being conducted jointly with the New York State Department of Environmental Conservation and the State University of New York Biological Survey. Funding for the project is provided by the Lake Champlain Basin Program, using EPA funds appropriated under the Lake Champlain Special Designation Act of 1990. Data are maintained in computerized databases at the Vermont DEC and the New York State DEC. Progress reports are submitted to the Lake Champlain Basin Program annually.

The Lake Champlain Zebra Mussel Monitoring Project, initiated in 1994, tracks the spread of the nuisance zebra mussel (*Dreissena polymorpha*) throughout Lake Champlain using standardized methods adopted from the Great Lakes. The project focuses on larval (veligers) and juvenile (post-veligers) life stages, because zebra mussels are most easily spread during these developmental stages. Monitoring begins in early spring and extends into the late fall. Adult zebra mussel densities are evaluated semi-quantitatively during the fall. This project emphasizes early detection and trend detection, and monitoring results are quickly forwarded to water districts and treatment plants around the lake.

It is anticipated that the seven basic monitoring and surveillance programs described above will be continued during the next two years unless a change in funding or priorities dictates a change in program emphasis.

(2) Special Studies

Special studies are conducted as part of Vermont's Lakes and Ponds Program for a wide variety of reasons, but they can be generally categorized into three classes - diagnostic studies, lake modelling studies, and planning and management studies.

Diagnostic studies are initiated on selected lakes to diagnose a cause when water quality problems have been experienced or a change in water quality has been detected. Federally-funded Clean Lakes Program Phase I diagnostic studies have been completed on four lakes in Vermont - Lake Morey in Fairlee, Harvey's Lake in Barnet, Lake Iroquois in Hinesburg, and Lake Champlain. State-funded diagnostic studies of more limited scope have been completed on Lower Orange Reservoir in Orange, Inman Pond in Fair Haven, Lake Pinneo in Hartford, and Silver Lake in Barnard. In every case, causes have been determined and recommendations for management or restorative action have resulted from the studies. In response to a need for state-funded full scope diagnostic studies, a comprehensive study was conducted on Fairfield Pond in Fairfield, Vermont, using local volunteer samplers. Using the experience gained from this study, low cost state-funded diagnostic studies of varying scopes with volunteer samplers may be attempted on other qualified lakes in the future. Presently, special assistance can be given to no more than one to two lakes at a time over a two to three year period. This situation is expected to continue unless additional funding becomes available for supplemental full-time staff.

Field data collection for a limited-scope diagnostic assessment has just recently been completed on Lake Carmi, in Franklin, VT. This diagnostic assessment was undertaken in conjunction with the Lake

Carmi Campers Association, in order to ascertain whether excessive phosphorus loadings to that lake are external or internal in nature. A modeling analysis of the 1994 data indicated that external phosphorus loadings were sufficient to account for the annual summer phosphorus concentration in Lake Carmi of 30 parts-per-billion. Follow-up sampling was conducted during the openwater season of 1995 to confirm these findings.

Where point source nutrient discharges presently exist or may be anticipated in the future, special lake modelling studies are undertaken to assess the water quality impact of the discharge(s). Modelling studies have been conducted on several Lake Champlain embayments including St. Albans Bay, both before and after the expansion and upgrade of a municipal discharge; Burlington Bay, where combined sewer overflows and nearby municipal discharges were being separated and upgraded; Hawkins Bay, where a fish hatchery discharge was anticipated; and Shelburne Bay, where three municipal discharges were scheduled for expansion and upgrading. Lake Memphremagog was also studied prior to the upgrade of the Newport City wastewater treatment facility, as was Arrowhead Mountain Lake before and after the construction of a whey processing plant discharge. The purpose of most of these modelling studies is to assure that Vermont Water Quality Standards are not being and will not be violated by the discharges, and that undue adverse impacts will not occur. In the case of St. Albans Bay, the second modelling study, conducted after the upgrade of the municipal discharge, was to investigate the reason for continued high phosphorus levels in the Bay.

Special planning and management studies are initiated in Vermont when additional data is required to make informed management decisions. In response to concerns regarding possibly dangerous levels of toxic substances in Lake Champlain fish, a special Fish Contaminant Monitoring Program was initiated in 1986 to assess the existence and/or extent of toxic contamination in fish tissue in Lake Champlain and other Vermont lakes. This program was formalized in 1988 with the formation of an Interagency Fish Contaminant Monitoring Committee composed of representatives from the Vermont Departments of Fish and Wildlife, Health, and Environmental Conservation. Fish sampling conducted on Lake Champlain resulted in changes in the Vermont Department of Health's lake trout consumption advisory and the addition of a walleye consumption advisory. The lake trout advisory, issued in April of 1989, states that adults should limit consumption of lake trout larger than 25 inches to one meal per month. Women of childbearing age and children under age 15 should not eat any lake trout larger than 25 inches in size. The walleye advisory, issued in May of 1990, states that adults should limit their consumption of Lake Champlain walleye to one meal per month. Women of childbearing age and children under age 15 should not eat any walleye.

With the possible exception of atmospheric mercury deposition, which has been found to be a potential problem elsewhere in the country, toxic pollutants were not previously anticipated to be a significant problem in other Vermont lakes. However, before 1994, the Fish Contaminant Monitoring Program generated a small yet very compelling dataset to indicate the contrary. As a result, in July of 1995, the Vermont Department of Health issued interim fish consumption advisories for lake trout and walleye from *all* Vermont waters containing these species. Correspondingly, collection of fish tissue for mercury and PCB analysis was significantly augmented during 1994 and 1995. The data generated in conjunction with this monitoring effort will be used to re-evaluate the interim consumption advisory. It is anticipated that with new data, the interim advisory could be refined to reflect specific lake by species combinations, or to reflect regions in Vermont.

Management decisions for Lake Champlain and Lake Memphremagog have been particularly difficult due to the size and complexity of the lakes and the lack of recent lakewide nutrient budget information.

The Lake Champlain Diagnostic/Feasibility Study was initiated in 1989 as a joint project between the states of Vermont and New York, funded in Vermont by the U.S. Environmental Protection Agency under sections 205(j) and 314 of the Clean Water Act, with cooperative assistance supplied by the U.S. Geological Survey. The study focused on the issue of phosphorus and eutrophication, with most of the project effort being devoted to the measurement of phosphorus loadings to Lake Champlain and a modeling analysis of the lake's water quality response to phosphorus loadings. The data collected during the study was used to establish a phosphorus budget for Lake Champlain which identified and ranked all the major phosphorus sources to the lake. A whole-lake phosphorus mass balance model was then developed to analyze the lake's eutrophication response to its phosphorus loadings. The model was applied in a phosphorus load allocation procedure to establish target point and nonpoint source phosphorus loads in order to attain in-lake phosphorus water quality criteria endorsed by New York, Quebec, and Vermont in the 1993 Lake Champlain Water Quality Agreement. The results of this study form a major basis for the section of the Lake Champlain Management Conference's *Comprehensive Pollution Prevention, Control, and Restoration Plan* which addresses phosphorus and eutrophication. The final diagnostic/feasibility study report was completed in 1994. Currently, the States of Vermont and New York are negotiating a phosphorus load allocation strategy which balances reductions from point and non-point sources in an economically and politically acceptable manner.

The Lake Memphremagog Quebec/Vermont Working Group, established by the governments of Quebec and Vermont in 1989, completed their Final Report on *Managing Lake Memphremagog and its Environment* in 1993. Nearly 50 recommendations regarding the management of point sources of pollution, nonpoint sources, water levels, and other resource considerations were made, and a Vermont Memphremagog Steering Committee was formed in the spring of 1995 to work with its Quebec counterpart. Currently joint working groups have been formed to address agricultural issues and lake water quality monitoring and objectives.

The Lakes and Ponds Section recently developed a Citizen Lake and Watershed Survey for use by lake and watershed residents to identify lake problems and potential pollution sources in lake watersheds. Since 1993, the first year of this survey program, citizen initiated surveys have been conducted in the watersheds of Harvey's Lake, Lake Parker, and Lake Carmi. It is anticipated that local lake protection projects will be initiated in the watersheds of these lakes based on the results of the surveys. An additional four or five lake associations are currently in the process of initiating watershed surveys on their respective lakes.

The protection of existing and potential lake uses has received a considerable amount of emphasis, both federally and in Vermont, in recent years. However, until recently, very little information was available in the literature relating lake uses with lake water quality. Thus, management decisions regarding the protection of lake uses such as swimming, boating and aesthetic value were made without a scientific basis. A lake user perception survey was conducted in Vermont in 1987-1988 to determine how the recreational users of Vermont's lakes perceive various lake water quality conditions. The water quality data and simultaneous user opinions collected in 1987-1988 were analyzed to develop a relationship between lake water quality and Vermont user satisfaction. The results of this study are described in detail in "Analysis and Application of Lake User Survey Data," a paper presented by Smeltzer and Heiskary at the North American Lake Management Society's 9th International Symposium in November 1989. The relationship found between lake water quality and user satisfaction has since been used in Vermont to provide a more scientific basis for specific numeric lake water quality standards in Lake Champlain and Lake Memphremagog. In addition, this relationship was used in the 1996 Lake Water Quality Assessment to assess the impairment of uses in Lake Champlain. Additional data relating user

perceptions and water quality was collected annually from 1988-1991 as part of Vermont's ongoing Lay Monitoring Program. This information has been helpful in determining compliance with Vermont's narrative eutrophication standards and can link lake protection efforts with lake uses.

The rapid spread of Eurasian watermilfoil in Vermont and the associated severe impairment of recreational uses in heavily infested lakes has made the development of satisfactory milfoil management techniques a top priority of the Lakes and Ponds Program in recent years. Under the auspices of Vermont's Eurasian Watermilfoil Control Program, special demonstration projects have been, and are currently being conducted within the state to assess the effectiveness of various milfoil management techniques. Several types of **bottom barriers** have been studied in Vermont, including Dartek, Texel and Bottom Line. Periodic Eurasian Watermilfoil Control Program reports detail the results of these studies. A very **large scale mechanical harvesting** project was initiated on Lake Bomoseen in 1988 after more limited mechanical harvesting had been shown to be unsuccessful. Unfortunately, a survey conducted at the end of the summer indicated that the majority of the lake association members felt that the expanded 1988 harvesting program still was not effective in keeping the water surface free of weeds and that they would not be satisfied with a continued large scale harvesting program. It appears that regardless of the level of effort, lake residents are not satisfied with weed harvesting as a control method in heavily milfoil-infested lakes. **Hydroraking** has been used in Vermont with some short-term success. **Lake water level drawdown** has been attempted on three Vermont lakes. In the case of the largest lake, Lake Bomoseen, an extensive study was conducted before and after the fall 1988 drawdown to determine the impact of the drawdown on aquatic plants in the lake proper and in the large wetland bordering the lake (Eurasian watermilfoil as well as native aquatic plants), and the impacts on wildlife, fisheries and macroinvertebrates. A user opinion survey was also conducted. The results of these studies were included in a report prepared for the Vermont Legislature in January 1990 entitled "The Lake Bomoseen Drawdown: An Evaluation of its Effects on Aquatic Plants, Wildlife, Fish, Invertebrates and Recreational Use." In general, the study concluded that the negative impacts on native plants, fish, invertebrates and wildlife outweighed the short-term positive impact of Eurasian watermilfoil control in the exposed 0-4 foot depth zone of the lake. This is an ongoing controversy on Lake Bomoseen, as some lakeshore residents would like additional drawdowns regardless of the negative impacts on non-target flora and fauna.

In November 1992, the Commissioner of the Department of Environmental Conservation (VTDEC) established a **Milfoil Study Committee** to evaluate the potential use of chemical pesticides to control Eurasian watermilfoil. The Study Committee, composed of representatives from State agencies, lake associations, the Vermont Legislature and the Vermont Public Interest Research Group (VPIRG), studied available data on chemical pesticide controls for milfoil and considered the effectiveness of non-chemical control alternatives. The findings and recommendations of the Study Committee were released in a March 1993 report. The Study Committee that the possibility to use Garlon 3A experimentally in two Vermont lakes be investigated. The town of Fairlee, Vermont, received a permit to use Garlon 3A in Lake Morey in 1993. This permit was overturned on appeal in April, 1994.

In April 1995, the Vermont Legislature directed VTDEC to investigate the uses of chemicals for the control of milfoil, and to prepare chemical treatment plans in three Vermont lakes (Burr Pond, Lake Horntonia, and Lake Bomoseen). The results of the VTDEC investigation are anticipated to be released in April of 1996. In conjunction with the VTDEC investigation, the Burr Pond Association has submitted an application for a permit to use Garlon 3A in Burr Pond in 1996, and that application is currently being reviewed.

The most promising prospect for long-term control of Eurasian watermilfoil in Vermont may be a natural biological control agent or agents. In late 1989, it was discovered that a previously thriving Eurasian watermilfoil population in Brownington Pond, in Brownington, Vermont, had nearly disappeared. Native plants had begun to repopulate the lake. Upon closer examination, a large variety of herbivorous insects were found in the sole remaining milfoil bed, with two aquatic caterpillars and an aquatic weevil appearing to be the most significant species. A researcher from Middlebury College, under contract with the DEC, subsequently determined that these species also exist in small numbers in other Vermont lakes, including Lake Bomoseen. The Lakes and Ponds Program received funding under the **Clean Lakes Demonstration Program** in 1990 to study the situation at Brownington Pond, determine the reason for the decline in milfoil there and, if herbivorous insects are the control agent and success appears feasible, rear and introduce the critical insects into Lake Bomoseen in an attempt to achieve biological control of the milfoil population in Lake Bomoseen. Results of this work have been very promising, particularly focusing on the weevil *Euhrychiopsis lecontei*. During the summer of 1993, 10,000 weevil eggs, larvae or adults were introduced into Lake Bomoseen and Norton Brook Reservoir, a remote reservoir that has a significant Eurasian watermilfoil population but no previous weevil population. Additional weevils were introduced in 1994, and monitoring was conducted to evaluate any impacts the weevils may be having on milfoil populations in these two lakes. During 1995, the project sought to implement volunteer-based rearing of weevils, in an attempt to expand the distribution of weevils into milfoil-infested lakes statewide, in a cost-effective manner. Federal funding for the weevil demonstration project terminated late in 1995. Although this demonstration project has the most far-reaching implications for Eurasian watermilfoil control, all of the special milfoil demonstration projects described above help guide overall lake management recommendations for Eurasian watermilfoil control in Vermont.

Zebra mussels are the most recent non-indigenous aquatic nuisance to invade Vermont's waters. In 1993, prior to the discovery of zebra mussels in Lake Champlain, the Vermont Legislature directed the Agency of Natural Resources to study the present and potential impact of zebra mussels on wastewater and water supply facilities throughout the state, and on the streams and waterbodies of the state. The Agency convened a Zebra Mussel Study Committee, composed of representatives from the Agency, the Lake Champlain Coalition of Water Suppliers, the Lake Champlain Basin Program, Vermont lake associations, the Vermont Division for Historic Preservation and the Lake Champlain Maritime Museum. The Committee reviewed the available literature on zebra mussel impacts and control methods, and presented their findings and recommendations in a January 1994 report to the Vermont Legislature. Many of the recommendations contained in the report were implemented in 1994 as part of a statewide zebra mussel control strategy. Specifically, comprehensive monitoring programs were initiated to assess zebra mussel spread through Lake Champlain, as well as to document the effects of dreissenid colonization of rocky littoral habitat and native unionids. In addition, a full time staff member, funded under the Lake Champlain Special Designation Act (1990) was added to implement an education and outreach program designed to heighten awareness of the zebra mussel, as well as slow its spread to inland lakes.

The special studies described above were ongoing, recently completed, or were planned as of February, 1996. This element of the Lakes and Ponds Program is very dynamic with most studies having a fairly short life span and new studies being continually developed as the need arises and funding becomes available.

(3) Management and Restoration

There are two possible courses of action once the cause of a lake's water quality problem has been identified through monitoring and surveillance or special studies. Either a feasibility study is initiated to gather information and determine what management or restoration measures would be appropriate, or management or restoration activities may immediately be recommended if a study is not warranted. In Vermont, a distinction is made between aquatic nuisance management activities and lake restoration activities. Management activities are those control measures that manage a nuisance but do nothing to eliminate the source of the nuisance. Restoration activities are aimed at eliminating the source of a problem in order to achieve long-term benefits.

Aquatic nuisance management activities in Vermont are almost exclusively used to control excessive rooted macrophyte growth. When several alternative plant control methods are possible in a lake, a feasibility evaluation is made by state personnel to determine the best alternative(s). In the past, financial assistance was then available to municipalities through the Aquatic Nuisance Control Program for the implementation of recommended lake management activities. Fourteen municipalities received assistance under the program before funding was discontinued in 1990 due to state budget cutbacks. Several ongoing aquatic plant harvesting programs continued with local funding despite the loss of state funds. State funding for aquatic nuisance management activities became available again in 1994 due to an increase in motorboat registration fees. In addition, from 1982 to 1990, the U.S. Army Corps of Engineers and the State of Vermont cooperated in funding the Lake Champlain Aquatic Nuisance Control Program to manage water chestnut and Eurasian watermilfoil growth in portions of Lake Champlain. In 1991, insufficient state funds were available to match the Corps funds. However, the Lake Champlain Management Conference (LCMC) provided financial assistance and water chestnut was harvested in southern Lake Champlain in 1991. In 1992-1993, the state of New York administered the water chestnut harvesting program on Lake Champlain using LCMC funding. Vermont had no funds to match the program and did not participate administratively. Vermont regained management of the harvesting program again in 1994, using a combination of state, Corps of Engineers and LCMC funding.

Management techniques such as copper sulfate treatments for the control of excessive algae growth are rarely used in Vermont. Rather, it is generally recommended that the cause of nuisance algal growth be controlled before any management measures are implemented.

Lake restoration activities have been undertaken on several Vermont lakes, and recommendations for lake restoration have been developed for several others. Funding for lake restoration activities may include federal, state or local sources, or a combination of these. Lake Morey, in Fairlee, Vermont, underwent an alum treatment in May of 1986 as part of a federal, state, and locally funded Clean Lakes Program Phase II restoration project. Significant and continuing water quality improvements have been documented since 1986, despite possible short-term aluminum toxicity to fish which may have resulted from the treatment. Indeed, annual average secchi transparency has improved by nearly 100% from 1986 to 1995 (Figure 1).

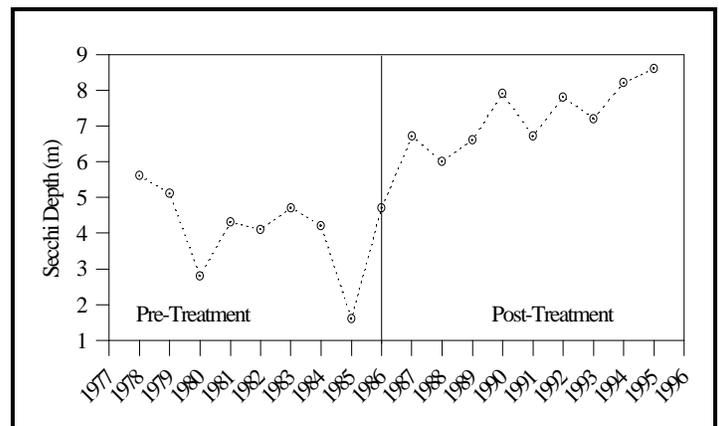


Figure 1. Annual mean summer Secchi transparency of Lake Morey before and after the 1986 alum treatment.

The implementation of lake restoration activities requires a strong local commitment in addition to federal and state financial and technical assistance. Lake restoration recommendations were developed in the 1980's for Harvey's Lake in Barnet and Lake Iroquois in Hinesburg, only to be shelved due to a lack of local initiative to complete the projects. Fortunately, these projects were only delayed, not terminated. On Harvey's Lake, local residents subsequently implemented some of the recommendations without additional state involvement. On Lake Iroquois, with the support of the four towns located in the watershed of the lake, the state applied for and received federal funds through the Nonpoint Source Program to implement the recommendations, six years after the original recommendations were made. The resulting Lake Iroquois Watershed Demonstration Project (1992-1993) was very successful due to a considerable amount of local participation and support for the watershed-wide erosion control project. The importance of local involvement and commitment cannot be overstated. Due to past experiences, lake diagnostic and feasibility studies will only be initiated in the future on lakes where there is a high likelihood that recommended actions will be implemented in a timely manner.

The Natural Resources Conservation Service (NRCS) and local farmers have been instrumental in lake restoration activities in Vermont through the implementation of best management practices on agricultural land in lake watersheds. Lake Parker, Lake Carmi, Lake Iroquois, Lake Memphremagog and Lake Champlain have all benefitted from NRCS programs in recent years. In addition, the St. Johnsbury NRCS office has recently become actively involved in the implementation of the Harveys Lake restoration activities, as well as in beginning the process of developing a watershed plan for Ticklenaked Pond. Finally, the staff of the George D. Aiken Resource Conservation and Development Area assisted the Town of Barnard and the Silver Lake Association in developing an erosion control plan for the Silver Lake watershed in Barnard, Vermont. Implementation of the plan is the responsibility of the Town and the Lake Association.

State-managed restoration projects are now being conducted on two lakes where early infestations of Eurasian watermilfoil have been discovered since 1987. An immediately implemented project involving handpulling and/or bottom barriers, combined with continued annual surveillance, has been used to control Eurasian watermilfoil in Black Pond in Hubbardton, Lake Dunmore in Leicester and Salisbury, Cedar Lake in Monkton and Sunset Lake in Benson and Orwell. Dedicated lake associations took over the projects on Lake Dunmore and Cedar Lake in 1992-1993. Similar projects attempted on Sunrise Lake in Benson and Echo Lake in Hubbardton were unsuccessful and milfoil subsequently spread beyond the ability for handpulling and bottom barriers to control it in those lakes.

Recently, the number of newly infested lakes needing control projects to limit the spread of milfoil has exceeded the ability of the Lakes and Ponds Section to personally manage using existing staff and resources. Handpulling efforts must be conducted annually to keep up with spreading milfoil plants. Reducing or eliminating efforts for even one season can result in a milfoil population that is too large to be controlled by small scale, relatively inexpensive methods. The Lakes and Ponds Section now places emphasis on technical assistance to lakeshore residents to help local residents design and implement lake-specific milfoil spread prevention programs on newly infested lakes. Locally sponsored milfoil spread prevention projects using handpulling, bottom barriers and/or suction harvesting are currently taking place or are planned for seven lakes (Lake Dunmore and Cedar Lake, mentioned above, as well as Beebe Pond in Hubbardton, Burr Pond in Sudbury, Fairfield Pond in Fairfield, Halls Lake in Newbury, and Lake Morey in Fairlee). If a new milfoil infestation is found and there is insufficient local interest to develop a milfoil spread control program, the Lakes and Ponds Section may decide to initiate state-managed spread prevention activities if the situation warrants and sufficient state

resources are available. The most recently infested lake is Kent Pond, in Sherburne, Vermont. Handpulling activities will likely be initiated there in 1996.

Lake management and restoration activities are often complex and very expensive. A continued partnership of federal, state and local resources for both technical and financial assistance is imperative for the successful implementation of these activities.

(4) Protection

Vermont is fortunate to have only a limited number of lakes with impaired uses in need of extensive lake management or lake restoration work. In many "impaired" lakes, only a small portion of the lake is considered impaired, or impairments exist to only one use, and most lake visitors would not observe serious problems. However, the 1996 lake assessment data indicates that the water quality of 67 percent of those Vermont lakes that currently fully support their uses is threatened. If the present unimpaired water quality of Vermont's lakes is to be maintained, effective broad-based lake protection measures must be implemented soon to generally reduce common threats, and lake-specific protection measures must be developed for priority lake watersheds. Lake protection is of prime importance in Vermont.

Lake protection is addressed on a general scale in Vermont, using a three pronged approach of monitoring and surveillance, education, and regulation. The monitoring and surveillance programs described earlier in this report are an important part of lake protection. The early detection of a water quality problem often leads to a simpler, less expensive and more effective solution. By the time a problem becomes visible to lake users, corrective measures are often expensive and may not even be feasible. Although Vermont's monitoring programs are fairly extensive for a small state, the 1996 lake assessment data showed that only 58 percent of Vermont's assessed lakes were actually monitored from 1991-1995. However, these lakes do reflect 98 percent of the total acreage of Vermont's lakes, indicating the emphasis placed on monitoring larger lakes when funding is limited. However, the smallest Vermont lakes are an important resource worthy of protection, and monitoring and surveillance programs should include these lakes as resources permit.

Education plays a critical role in lake protection. Public awareness and cooperation can result in the widespread implementation of lake protection measures that are difficult or impossible to achieve through any other means. Several lake protection, Eurasian watermilfoil and zebra mussel slide shows/films/videos are available to the public; numerous brochures are available on topics ranging from shoreland property maintenance to local planning; a semiannual newsletter, "Out of the Blue," is produced by the Vermont Water Quality Division's Lakes and Ponds Section; newspaper articles and radio and television spots appear statewide every summer; metal signs have been placed at all lake access areas warning boaters to control the spread of nuisance aquatic plants and zebra mussels; and the Department of Environmental Conservation staff prepares exhibits and talks for many public meetings each year. Recently completed lake-related publications include "Reestablishing a Lakeshore Buffer Strip" and "Native Vegetation for Lakeshores, Streambanks and Wetland Buffers," and "Vermont Better Backroads Manual," as well as numerous zebra mussel-related materials. The listings of Water Quality Educational Tools and zebra mussel information included in Appendix B-1 demonstrate the extensive educational material currently available to the public from the Water Quality Division. However, despite such efforts, a large number of citizens continue to make uninformed decisions that threaten the water quality of Vermont's lakes. Educational programs must be continued and expanded to reach more people involved with lake management in Vermont. To promote the

incorporation of aquatic education into primary and secondary school curricula, the Water Quality Division became a sponsor for a national environmental education program, Project WET (Water Education for Teachers), in 1995.

The Vermont Lake and Watershed Protection Program was implemented in 1989 in response to the urgent need for specific education and technical assistance pertaining to shoreland and watershed lake protection measures at the state, regional, local and individual level. A major focus of the Lake and Watershed Protection Program continues to be the encouragement of planning and action at the local level for the protection of lake water quality, since Vermont has no statewide shoreland zoning laws. This encouragement is being achieved through the distribution of planning manuals for municipal and regional planners, through general information sent to local planners that provides an overview of lake and watershed issues relevant to water quality, and through individual contact and technical assistance where possible. Vermont's Citizen Lake and Watershed Survey process enables lake and watershed residents to identify lake problems and determine potential pollution sources in lake watersheds. A shift in emphasis for the Lake Assessment Program from basic data collection to assisting the public with conducting lake and watershed surveys occurred during 1994-1995. Public participation is an essential part of a successful Lake and Watershed Protection Program. With guidance and technical assistance from the Lakes and Ponds Section, it is hoped that the survey process will educate citizens regarding lake protection and will result in specific actions being taken at the local level to promote lake protection. It is essential that lake protection become an integral part of town planning and the daily life of lakeshore and watershed residents.

Lakes found to be a high priority for protection through Vermont's new Lake Protection Classification System are a current focus area for the Lake and Watershed Protection Program. Specific demonstration projects regarding shoreland and watershed protection measures to maintain lake water quality are in the planning phase. The 1992-1993 Lake Iroquois Watershed Demonstration Project, described earlier as a lake restoration project, also had several lake protection demonstration elements. This project involved the correction of numerous small erosion sites scattered throughout the lake watershed, as well as the correction of shoreline erosion problems, including two using bioengineering techniques. The project was well documented and advertised, and field trips were offered to lake residents around Vermont to give them an example of the type of project that can be undertaken by local organizations.

Erosion from backroads in Vermont is considered a significant pollution source to rivers and lakes. In 1994, the Water Quality Division initiated a two year project to educate municipal and private road officials regarding best management practices for backroad construction and maintenance in order to minimize erosion and protect water quality. The Vermont Backroads Project will involve the development of educational materials, numerous workshops, and a "Road of the Year" demonstration contest.

Vermont has several regulatory programs that provide protection to lakes on a statewide level. The underlying basis to most of these programs is the Vermont Water Quality Standards, which generally prohibit activities that will result in an undue adverse impact on the quality of the State's waters. Revisions to the state's Water Quality Standards in 1991 provided additional protection to many lakes and ponds by requiring that there be no significant increase in total phosphorus in these lakes over

background conditions. Specific numeric total phosphorus criteria were also established for Lake Champlain and Lake Memphremagog, two lakes not covered by the "no significant increase" criterion.

Permits are required under 10 V.S.A. Chapter 47 to discharge waste either directly or indirectly into Vermont's lakes. The Vermont legislature enacted a phosphorus reduction statute (10 V.S.A. §1266a) in 1992 which establishes basin-wide phosphorus effluent limits for wastewater treatment facilities in the Lake Champlain and Lake Memphremagog drainage basins. A phosphorus concentration effluent limit of 0.8 mg/l P applies to all discharges greater than 200,000 gal/day in these basins, with facilities using aerated lagoon treatment processes exempt from this requirement. Compliance with this section is required only to the extent that 100% state funding is provided to municipalities for the construction cost of phosphorus removal facilities. Most of the Vermont treatment facilities in the Lake Champlain and Lake Memphremagog basins that are not subject to the requirements of 10 V.S.A. §1266a are exempt from specific phosphorus effluent limits under current policy. However, Vermont Water Quality Standards require that there be "no significant increase over currently permitted phosphorus loadings" to Lake Champlain and Lake Memphremagog, and wastewater treatment facilities undergoing flow expansion have been required to maintain their current loadings under this standard.

Permits are required under 29 V.S.A. Chapter 11, for encroachments into public lakes. The introduction of chemicals to waters of the state to control nuisance aquatic conditions also requires a permit under 10 V.S.A. Chapter 47, as does the control of nuisance aquatic plant growth by powered mechanical devices or bottom barrier materials. State law also prohibits the known transport of Eurasian watermilfoil and/or zebra mussels to or from Vermont lakes. Other statewide regulatory measures that protect lakes either directly or indirectly include Vermont's Land Use and Development Law (Act 250); the Department of Environmental Conservation's Environmental Protection Regulations, Indirect Discharge Regulations, Groundwater Protection Regulations and Wetland Regulations; and a ban on the sale of detergents containing phosphorus in Vermont. The Water Resources Board also has jurisdiction over lake water levels and surface water use under 10 V.S.A. Chapters 37 and 49.

In addition to the general statewide approach described above, lake-specific are now also a focus of the Lake and Watershed Protection Program. It is anticipated that protection measures may be initiated on some lakes designated as a high priority for protection by the Lake Protection Classification System without further data collection. On other lakes, however, additional lake assessment information may be needed to focus future protection activities. Technical assistance will be needed to assist local citizens in conducting lake and watershed assessments and developing comprehensive watershed protection programs for threatened lakes. This process is demonstrated well by the on-going efforts of the Lake Carmi Campers Association, which is using the results of the Lake Carmi Diagnostic Assessment, along with their watershed survey efforts, to formulate a watershed plan for controlling nutrient loadings to that lake. The Vermont Lake and Watershed Protection Program will continue to provide this assistance and may also initiate lake protection measures on certain priority lakes as time and funding allows.

Due to its large size and tremendous recreational value, Lake Champlain has already been identified as a high priority for lake protection measures. The states of New York and Vermont and the province of Quebec signed a Cooperative Lake Agreement in 1988 that provides guidance for future management and protection programs on Lake Champlain. The federal Lake Champlain Special Designation Act of 1990 further established the Lake Champlain Management Conference, which is charged with developing a comprehensive pollution prevention, control and restoration plan for Lake Champlain. It

is hoped that federal and interstate cooperation and a renewed emphasis on the issues affecting the water quality of Lake Champlain will soon result in a comprehensive watershed management plan for Vermont's largest lake.

LAKE IDENTIFICATION AND CLASSIFICATION SURVEY - 1996

The Vermont Lakes and Ponds Program provides the structural framework for the sound management of the state's lakes and ponds. Program priorities are reviewed on a periodic basis and alterations are made when needed to address new or changing issues. The prioritization of lakes within the four major programs elements, however, has only been occasionally reviewed on a statewide basis.

The first Vermont Lake Classification Survey, completed in December 1980, summarized lake water quality and watershed land use data for the majority of the state's lakes larger than fifteen acres in size. A ranking system was created to prioritize the lakes for restoration purposes, and sixteen lakes were designated as high priority for lake restoration projects. Lake restoration efforts in Vermont from 1980-1987 were largely guided by the findings and recommendations of the Lake Classification Survey.

In June of 1987, the Department of Environmental Conservation determined that accelerating development and pollution pressures and the rapid spread of Eurasian watermilfoil in Vermont had made the 1980 Lake Classification Survey too obsolete to merely be updated to comply with the expanded lake assessment requirements included in the reauthorized Clean Water Act. A major new lake assessment effort was undertaken in order to prepare the 1988 Lake Water Quality Assessment Report.

Since the 1988 Lake Water Quality Assessment Report, additional information has been obtained on many lakes and ponds through ongoing monitoring and surveillance programs and the Lake Assessment Program, initiated in 1989 with partial funding from the U.S. Environmental Protection Agency. In 1988, 29 lakes were sampled under the ongoing Spring Phosphorus Program. The number of lakes sampled has substantially increased since then, now averaging nearly 70 lakes per year, despite recent decreases in staffing to the Lake Assessment Program. A total of 174 lakes have now been sampled for four or more years, resulting in sufficient data to estimate the precision of their mean spring phosphorus values. This estimate is important to consider when the mean spring phosphorus data is used to make management decisions on these lakes. There are a total 228 lakes on which spring phosphorus data is available. Twenty lakes have been added to this list since the 1994 Lake Water Quality Assessment.

In 1988, 38 lakes and 21 stations on Lake Champlain were sampled under the Lay Monitoring Program. In 1995, 45 lakes and 23 stations on Lake Champlain were sampled for at least a portion of the summer. There is significant continuing public interest in the Lay Monitoring Program, and the number of lakes sampled under the program is limited only by the availability of funding and staff to oversee the program. The number of lakes sampled under the program has not grown in the past two years. The program has reached the maximum size possible with existing staff and funds.

Through the Aquatic Plant Survey Program and Lake Assessment Program, detailed aquatic plant surveys have been completed on 5 lakes since the 1994 Lake Water Quality Assessment. Eurasian watermilfoil surveys have been conducted on 14 milfoil-infested lakes. In addition, approximately 150 watchers representing 55 lakes have now joined the Milfoil Watchers Program.

The majority of the lake assessment data collected since the 1994 Lake Water Quality Assessment was obtained through the Lake Assessment Program. A total of 41 lakes were visited, sampled and

assessed under this program in 1994 and 1995. The lakes were chosen due to a lack of previous data or due to the presence of threats or special concerns, and a subset of these were visited to corroborate impairments based upon anecdotal information contained in the database. A total of 237 lakes have been assessed through the Lake Assessment Project since 1989. Data collected during these assessments has been entered into the Vermont Lakes and Ponds Inventory computer database.

The following 1994 lake water quality assessment is based on information obtained since the inception of the Lake Assessment Program in 1987. No attempt will be made in this report to present specific water quality data and assessment information for each significant lake in Vermont. This information is available upon request from the Lakes and Ponds Inventory computerized database. A list of the data and information included in this database is shown in Appendix B-2. The Lakes and Ponds Inventory is continually being updated as new data and assessment information becomes available.

There are 809 significant lakes and ponds in Vermont, totaling approximately 228,969 acres. Each of these lakes, with its official name and location and the latitude and longitude of the outlet, is listed in the Lakes and Ponds Inventory. The outlet was chosen as the identifying location since this site could be more accurately determined than the approximate center of the lake which was requested in the Environmental Protection Agency's guidance document.

A lake is considered significant in Vermont if it is included in the Vermont Lakes and Ponds Inventory. The criteria for inclusion is all lakes and ponds greater than or equal to five acres in size, and all lakes and ponds smaller than five acres that are specifically named on the most recent U.S. Geological Survey topographic maps. There are 601 lakes known to be at least five acres in size in Vermont, and 285 lakes twenty acres or larger (Figure 2). There are 81 lakes known to be less than five acres in size included on the Inventory. The acreage of 127 significant lakes and ponds included in the Inventory is presently unknown. These lakes have not been assessed and do not appear in the total lake acreage figures included in this report. It is anticipated that together they comprise less than 1,000 acres.

The public or private status of lakes in Vermont is not clearly defined. The definition of "private ponds" in Vermont statutes relates to fishing and has resulted in some confusion. The public/private status of many Vermont lakes is presently unknown. It is anticipated that the ultimate clarification of this situation will be made by either the legislature or the courts. However, private waters, and public waters with little public use, are still considered significant in Vermont for several reasons. First, the State has regulatory jurisdiction over these waters in many areas such as the application of chemicals for the control of aquatic nuisances. In addition, land ownership and public use patterns are changing rapidly in the state. As lakefront property continues to rise in value, private waters may become public with the sale of shoreland property, and lakes that are rarely used now may become much more popular. It is imperative that all of these lakes be assessed and included in Vermont's management and protection programs to insure that their water quality will meet the needs of future generations. The inclusion of

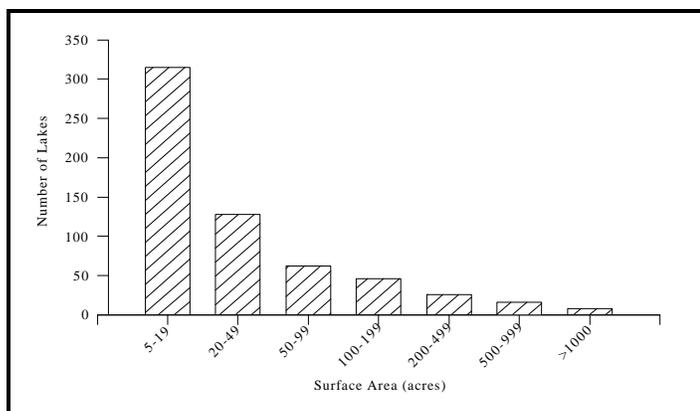


Figure 2. Surface area distribution for 601 Vermont lakes.

these lakes also allows the acquisition of lake assessment information which can be used to establish priorities for public land acquisition on lakes that are currently private waters. Improved public access to lakes is one of the goals of the 1988 Vermont Recreation Plan.

The Department of Environmental Conservation collected information regarding the level of public use of the state's significant lakes and ponds under the Lake Assessment Program. Use information is one factor considered when lakes are prioritized for lake restoration and protection activities in Vermont.

When known, a lake's trophic condition is listed in the Lakes and Ponds Inventory. Trophic state has been determined on 201 lakes using water quality data collected since 1983, according to the following criteria:

<u>Trophic State</u>	<u>Avg. Summer Secchi disk transparency</u>	<u>Avg. Summer Chlorophyll-a Concentration</u>	<u>Avg. Spring Total Phosphorus Concentration</u>	<u>Color (platinum cobalt units)</u>
Eutrophic	0-3.0 meters	\$7.0 ug/l	>15 ug/l	--
Mesotrophic	3.0 - 5.5	>3.5 - 7.0	>7.0 - 15	--
Oligotrophic	\$5.5	0 - 3.5	#7.0	--
Dystrophic	---	---	---	\$50
Hypertrophic	---	---	>100 ug/l	--

When monitoring data gives conflicting information, spring total phosphorus concentrations are weighted more heavily for the inland lakes, then chlorophyll-a, then Secchi disk transparency. For Lake Champlain, chlorophyll-a is weighted most heavily due to the lower chlorophyll yield per unit of phosphorus in Lake Champlain. It is felt that chlorophyll-a concentrations most appropriately characterize the trophic states of the various lake segments. There are 33 inland lakes in Vermont classified as oligotrophic according to this method. A total of 119 lakes have been classified as mesotrophic, 31 are eutrophic, 16 are dystrophic, and two are considered hypertrophic. Seven segments of Lake Champlain are mesotrophic and four segments are eutrophic.

Spring total phosphorus levels have been monitored on 228 Vermont lakes larger than 15 acres since 1977 under the Spring Phosphorus Program (Figure 3). There are 38 Vermont lakes with an average spring total phosphorus concentration of 7 ug/l or less, a level which generally indicates oligotrophic conditions. There are 44 lakes with an average spring total phosphorus concentration greater than 15 ug/l, indicating probable eutrophic conditions. The majority of the lakes sampled have intermediate phosphorus levels that indicate they are generally mesotrophic in character.

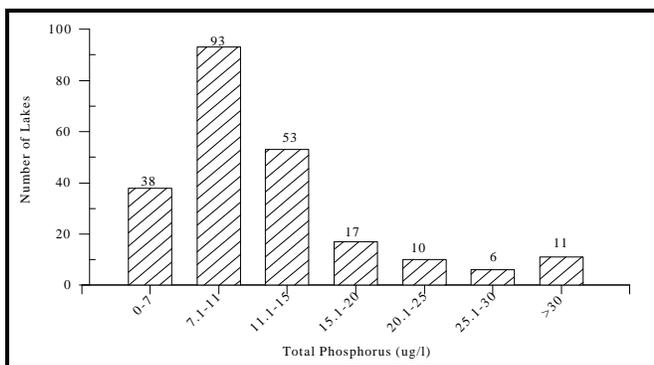


Figure 3. Average spring total phosphorus distribution for 228 Vermont lakes (1977-1995).

Information relating to the water quality status/use impairment of each significant lake or pond, when known, is included in the Lakes and Ponds Inventory. Appendix B-3 describes the methods used to determine use impairments and threats for the 1996 lake water quality assessment. Specific

information regarding the causes and sources of identified use impairments or threats on each lake is also included in the Inventory. Lake assessments conducted during 1994 and 1995, though fewer in number, were primarily conducted on larger lakes, resulting in more precise use impairment information on over 7,700 lake acres.

A more significant change in designated use support acreages across inland Vermont lakes has resulted from the issuance, in July, 1995, of a fish consumption advisory for both walleye and lake trout on **all** Vermont waters due to mercury (walleye) and PCB (lake trout) contamination. This advisory was issued based upon incomplete yet compelling fish tissue monitoring data from a small sampling of Vermont surface waters conducted during 1994, and should be considered both interim and conservative in nature. Accounting for the interim advisory, fully 63 percent (33,853 acres) of Vermonts' inland lake acreage does not fully support all designated uses. However, the interim nature of the advisory necessitates caution in evaluating use impairment based upon fish consumption uses. Accordingly, use impairment, cause, and source assessment for inland Vermont lakes are presented to reflect both the existing interim fish consumption advisory, as well as acreages were the advisory *not* in place. Ignoring the interim fish consumption advisory, designated uses are presently impaired on 39 percent of the inland lake acreage in Vermont (20,821 acres). Discussions involving use support in the Lake Water Quality Trends portion of this document will not account for the effect if the interim advisory.

A more comprehensive database of fish flesh contamination exists for Lake Champlain. Accordingly, following EPA definitions for use impairments, toxic pollutants are considered to partially impair fish consumption uses as a result of ongoing fish consumption advisories resulting from high PCB and mercury levels in certain fish species. There has been no change in the fish advisories for Lake Champlain in the past two years. Without accounting for the interim Fish Consumption advisory, there are a total 134 inland lakes with impaired uses in at least some portion of the water body. Certain designated uses are considered to be impaired in all of Lake Champlain (174,175 acres).

The major causes of the use impairments in Vermont lakes are summarized in Table I. Nutrients are the largest single cause of use impairments in Vermont, being a major factor in both Lake Champlain and the inland lakes. Total phosphorus concentrations in the entire Vermont portion of Lake Champlain, except Malletts Bay, exceed 14 ug/l summer mean total phosphorus, the concentration threshold where more than half of the lake users found their enjoyment of the lake slightly or substantially impaired no more than 1% of the time during the summer. (See Appendix B-3 for more information on how this determination was made). In 1994, under then new EPA use support definitions, Lake Champlain was judged by actual use impairments, as determined by user surveys. No change in overall use impairment on Lake Champlain has been noted in the past two years. Nutrients impair more inland lakes than any other cause, impairing a total of 94 lakes. Algae, a result of excess nutrients, is another major cause of lake impairments in Vermont.

The native plants and exotic species categories highlight the differing impact of native versus non-native plants. Native plants impair 63 inland lakes, but only 417 acres have a high impact, and a total of 1,555 inland lake acres are impaired. In contrast, exotic species impair only 24 inland lakes, but 1,708 acres have a high impact, and a total of 2,109 inland lake acres are impaired. Exotic species have a severe impact in the lakes they infest.

Siltation and/or turbidity impairs a considerable number of lake acres, mostly in Lake Champlain, but relatively little of the impact is high. Major examples of this impact are turbid waters in southern Lake

Champlain, Missisquoi Bay and run-of-the-river reservoirs, and deposits of sediment in deltas off the mouths of inlet streams on numerous lakes.

Most (79 percent) of the lake acres affected by organic enrichment, specifically, low dissolved oxygen concentrations, are in Malletts Bay in Lake Champlain. The state fisheries biologist for Malletts Bay indicates that the bay's coldwater fisheries are partially impaired due to low dissolved oxygen concentrations in the cool hypolimnetic waters during the summer. Thirteen inland lakes are affected by organic enrichment/low dissolved oxygen concentrations.

TABLE I
Causes for Lake Acres Not Fully Supporting Uses
(Acres)

Cause	High Impact		Moderate/Slight Impact		Total Acres ⁺ Impacted
	Inland Lakes*	Lake Champlain	Inland Lakes*	Lake Champlain	
Metals [†]			4,391	84,577	88,968
Priority Organics				84,577	84,577
Other Inorganics	6				6
Nutrients	5,660	74,069	1,644	100,106	181,479
pH	466		3,634		4,059
Siltation/Turbidity	1,885	3,029	2,672	13,506	21,092
Organic Enrichment/D.O.	1,957		960	10,734	13,651
Thermal Modification	7				7
Flow Alteration	7,288		4,959		12,247
Other Habitat Alterations	7				7
Pathogens	54	700	10	100	851
Taste & Odor			18	10,497	10,515
Suspended Solids			215	300	515
Noxious Aquatic Plants					
Algae	2,572	11,697	2,524	840	17,633
Native Plants	417	530	1,138	2,696	4,781
Exotic Species	1,708	20,774 [‡]	401	29,022 [‡]	51,905
Filling/Draining	27		46		73
Total Toxics [†]	973		2,110		

* All lakes except Lake Champlain.

⁺ The sum of these acreages exceeds the total acres not fully supporting uses since the same acres may be impacted by more than one cause.

[†] These values reflect the causes for the interim fish consumption advisory.

[‡] These values reflect the combined Lake Champlain acreage of Eurasian watermilfoil, water chestnut, and zebra mussels.

Flow alteration, specifically the fluctuation of water levels for power generation, impacts the fisheries of numerous Vermont lakes and reservoirs. The littoral communities of other lakes are affected by periodic drawdowns requested by lakeshore residents. Although many acres are affected, only 35 waterbodies are involved. VTDEC is working with power suppliers and lakeshore residents to reduce the number of lakes affected and the magnitude of the impact of water level fluctuations.

Most of the lake acres impaired by pathogens are in Lake Champlain, where point source discharges and combined sewer overflows are responsible for periodic discharges of untreated or inadequately treated sewage. This problem has existed for many years, but received increased visibility in recent years when several beaches on Lake Champlain in the Burlington, Vermont, area were repeatedly closed due to the high bacteria counts that followed heavy rainstorms and the subsequent discharge of untreated sewage into the lake. Progress is being made to correct this situation throughout Vermont. Vermont's Water Pollution Control Program has added combined sewer overflow (CSO) correction projects to the priority list as eligible projects. The highest priority has been given to correcting existing overflows in lake watersheds, with the cities of Burlington, on Lake Champlain, and Newport, on Lake Memphremagog, given first priority. Grants are now available for up to 25 percent of the cost of a CSO project. The Vermont Legislature has also established a loan program through which municipalities may obtain no interest loans to fund up to 50 percent of projects to separate and treat combined sewer overflows. A project to separate and treat CSOs in Burlington was recently completed. Unfortunately, a rupture of the final diffuser section of the new treatment facility's outflow required emergency repairs during 1995. For this reason, no changes were made to impairment acreages for uses affected by bacterial contamination in Burlington Bay in this assessment.

Low pH is currently the major impairment on 466 lake acres in Vermont. New data on two large reservoirs in which low pH is not considered the major impairment, has resulted in an additional 3,608 moderately impaired lake acres.

Other causes of use impairments in Vermont lakes include suspended solids, inorganics, habitat alterations other than flow, thermal modifications, and metals and toxics. For the latter two causes, acreages are reported in Table 1 and Table 2 only for those lake on which actual fish tissue data was collected for analysis of mercury or PCB's. This was done in order to emphasize the fact that the advisory for inland lakes is interim at this time. Results of the on-going monitoring activities will be evaluated during early 1996, at which time more accurate acreage estimates for these causes will be presented.

Of the lakes in Vermont that presently fully support their uses (ignoring the effect of the interim Fish Consumption Advisory), 55 percent (199 lakes) have at least a portion of their waters threatened, primarily by poor development practices in the vicinity of the lake, excessive nutrient levels within the lake, nearby Eurasian watermilfoil or zebra mussel populations, or continued acid precipitation. This represents a 17 percent reduction in the percent of lakes considered threatened as reported in the 1994 assessment. This change is attributable to a change in the methodology used to assess threats to individual lakes. A 1985 analysis conducted by the Vermont Law School had identified 37 Vermont

towns as "Rapid Growth Towns." If any part of a lakes watershed was located within (or contained) a "Rapid Growth Town," the lake was considered threatened for a variety of uses in previous 305(b) assessments. This was considered an acceptably robust first assessment of threats to Vermont lakes. For the current assessment, however, it was decided that adequate actual lake assessment data was available to remove threats attributed solely to the Rapid Growth Town status. Table II lists the causes of threats to Vermont lakes. Specific threats are discussed at length in the next section, "Lake Water Quality Trends."

TABLE II
Causes for Lake Acres With Threatened Uses
(Acres)

Cause	Inland Lakes*	Lake Champlain	Total Acres ⁺ Threatened
Priority Organics		81,600	81,600
Metals	25	89,598	89,623
Nutrients	6,101		6,101
pH	6,942		6,942
Siltation/Turbidity	4,908	25,222	30,130
Organic Enrichment/DO	2,261		2,261
Flow Alteration	1,495		1,495
Other Habitat Alterations	94		94
Pathogens	80	188	268
Oil & Grease	6		6
Algae	2,159		2,159
Native Plants	2,365		2,365
Exotic Species	4,279		4,279
Filling/Draining	29		29

* All lakes except Lake Champlain.

⁺ The sum of these acreages exceeds the total threatened acres since the same acres may be threatened by more than one cause.

Specific data and information for each impaired and threatened lake in Vermont is available upon request from the Vermont Lakes and Ponds Inventory computerized database. Chemical and biological data collected through the Lakes and Ponds Program is also available in detail from the DEC's Water Quality Division files. Portions of this data are summarized on the Lakes and Ponds Inventory. The Inventory also identifies the uses currently impaired or threatened on each lake and the reasons. The general characteristics of each lake such as maximum depth, mean depth, surface area, etc., are included where known. Watershed area and land uses have been entered into the Inventory for most lakes larger than fifteen acres. The topography and major soil types of these watersheds are available from file maps or from U.S. Soil Conservation Service data. Very few lakes in Vermont receive discharges from major point sources. Where point sources do exist, the state's regulatory programs control the pollution through the issuance of NPDES permits.

Specific information on the causes and sources of use impairments on Vermont's lakes is also included in the Lakes and Ponds Inventory. Since very few Vermont lakes receive point source discharges, nonpoint pollution sources are responsible for nearly all of the use impairments. It is important to note that the nonpoint sources listed for each lake have been identified almost entirely from evaluated information, and the reliability of this information is unknown. Past experience has shown that reliable information regarding the significant sources of nonpoint pollution on specific lakes can only be obtained through watershed surveys and monitoring programs, unless gross nonpoint sources are present. Diagnostic studies conducted on three lakes in Vermont all concluded that the major source of nonpoint pollution to the lake was something other than what professionals had believed it to be from personal evaluations made prior to the monitoring programs. There is therefore a definite need for further lake assessment work and diagnostic studies to better identify the major nonpoint pollution sources on specific lakes in Vermont.

Vermont's 1988 Nonpoint Source Assessment report identifies the major sources of nonpoint pollution in Vermont. It is expected that the relative importance of these sources on a statewide basis is consistent with their importance to lakes in Vermont. The State nonpoint programs currently in place to control these sources are of a general nature and, while lakes do receive some benefit, the programs do not deal specifically with lakes. However, the protection and improvement of lake water quality is a high priority of the Natural Resource Conservation Service in Vermont, and major projects have been completed in the watersheds of Lake Champlain, Lake Memphremagog, Lake Parker, and Lake Carmi. Unfortunately, the Natural Resource Conservation Service work is limited by national program priorities and funding allocations. There is a need for more emphasis in Vermont on a State nonpoint source control program that can address nonpoint problems on a lake watershed basis and provide technical and financial assistance to local and regional officials to implement recommended control procedures in priority lake watersheds.

LAKE WATER QUALITY TRENDS

Considerable effort has been made in Vermont to develop a methodology for detecting trends in lake water quality. However, after conducting more than ten years of extensive water quality monitoring programs that were designed to detect water quality trends, it has been concluded that it is unrealistic to expect lake monitoring programs to detect the small water quality changes that are typical of gradually increasing cultural eutrophication. This highlights the need to develop a status and trends detection framework which incorporates indicators which are more sensitive to these small downward shifts in water quality. Presently, the Lake Assessment Program is in the process of developing a biological assessment framework for Vermont lakes. A properly designed bioassessment of Vermont lakes should enable the detection of small shifts in water quality using measures of the biological community of lakes. Early detection of emerging water quality threats is critical to effective management of Vermont lakes in that mitigative efforts can be made before full-scale lake restoration projects become necessary.

Larger changes in water quality that can be detected by Vermonts' existing monitoring programs are generally observed by the public as well. Such large changes are very rare in Vermont. No lake-specific information is therefore presented in this report regarding lake water quality trends. Instead, trends in the factors that threaten lakes are discussed, since these trends are the harbinger of lake water quality trends in Vermont.

If the effect of the interim fish consumption advisory is overlooked (as discussed on page 16), there are 379 lakes in Vermont that presently fully support all designated assessed uses. Many other Vermont lakes fully support designated uses in a portion of their waters. Overall, there are presently 32,555 inland lake acres which fully support their designated uses in Vermont, which represents 61 percent of the inland lake acreage in the state. This represents a 5 percent decrease in use support which is attributable to the more precise use impairment estimates afforded by the lake assessments which were conducted on primarily large lakes during 1994 - 1995. It is alarming, however, that over one third of these acres (43%) are threatened by imminent pollution sources. As was the case in 1994, no Lake Champlain acreage is considered to fully support its designated uses, primarily due to reduced aesthetic value resulting from nutrients and turbidity, fish consumption advisories for lake trout and walleye resulting from PCB and mercury contamination, and colonization of the littoral zone by zebra mussels.

While 39% of lake acres are assessed as not fully supporting uses, many of these lake acres are on lakes where only a small portion of the lake is considered impaired, or impairments exist to only one use, and most lake visitors may not observe serious problems. For instance, while 4,557 lake acres are assessed as impaired by siltation, there are only 19 lakes (1,616 acres) on which siltation is considered to impair the entire lake bottom. Vermont lakes for the most part have good to excellent water quality. Protection, rather than restoration, of lake water quality is of prime importance in Vermont. This is reflected in the work of the Lake and Watershed Protection Program and in the recent shift in emphasis of the Lake Assessment Program from baseline data collection to assisting lake associations in lake and watershed surveys in order to encourage protection efforts, and to developing biological indicators capable of detecting subtle lake water quality changes.

Land development is a major threat to Vermont's lakes. Vermont's lakes and ponds are fragile ecosystems that are particularly sensitive to phosphorus inputs. They deserve strict protection from unwise land use and substandard waste disposal practices in their watersheds. Vermont's 1996 Water Quality Standards include a narrative phosphorus standard of "no significant increase over background

conditions in total phosphorus" for lakes with drainage basin areas of less than 40 square miles and drainage area to surface area ratios of less than 500, and the tributaries to such lakes. Ensuring this standard is met will require controlling many varied nonpoint sources of pollution.

Less sensitive lakes that do not meet the criteria for the strict phosphorus standard described above should also be protected from the cumulative impacts of point and nonpoint source discharges. The Agency's Phosphorus Reduction Plan discusses such protection through the establishment of in-lake eutrophication standards and watershed management programs. Lake Champlain and Lake Memphremagog, which ultimately receive point and nonpoint source discharges from half of the state's land area, are the highest priority for the implementation of numeric standards and a watershed management program. The Vermont Water Resources Board has adopted specific numeric total phosphorus criteria for 12 segments of Lake Champlain and 2 segments of Lake Memphremagog. The water quality standards require all discharges in the watersheds of these lakes to comply with plans designed to achieve the in-lake criteria by 1998. The Lake Champlain Diagnostic-Feasibility Study provided the next step in the planning process by developing segment-specific total phosphorus load reduction targets, along with associated cost estimates. Vermont and New York are currently negotiating a phosphorus load allocation strategy which balances reductions from point and non-point sources to achieve in-lake phosphorus criteria. This strategy will be incorporated into the Comprehensive Pollution Prevention, Control, and Restoration Plan prepared by the Lake Champlain Management Conference.

The Lake Memphremagog Quebec/Vermont Working Group, established by the governments of Quebec and Vermont in 1989, completed their Final Report on *Managing Lake Memphremagog and its Environment* in 1993. Various recommendations were made regarding reducing point and nonpoint sources of pollution, and a Vermont Memphremagog Steering Committee was formed in the spring of 1995 to work with its Quebec counterpart to implement priority recommendations as the next step in the planning process. Joint working groups have recently been formed to address agricultural issues and lake water quality monitoring and objectives.

Although progress is being made, the control of nonpoint sources continues to be elusive. At the present time, large scale development in Vermont is regulated by Vermont's Land Use and Development Law (Act 250). Smaller land subdivisions and development on existing lots receive only limited review under the Department's Environmental Protection Regulations (with jurisdiction over on-site sewage systems only). Local municipal zoning ordinances are variable when they exist, but in most cases do not provide comprehensive water resource protection. The review of new development under any of these authorities very rarely takes into consideration existing development in a lake watershed and the overall cumulative impact of all nonpoint sources of pollution to the lake. Regional and local planners need to understand the issues involved and receive the necessary technical assistance to develop comprehensive watershed protection programs for lakes threatened by development pressure.

Lakeshore property statewide has continued to increase in value, resulting in increased shoreland development. This is continuing to some degree despite the recent recession. Vermont has no statewide shoreland zoning laws, and much of the shoreland development currently taking place receives little or no state review. Water quality protection is dependent on municipalities enacting and enforcing good resource protection measures. On-going education and technical assistance is urgently needed to encourage the development and implementation of effective shoreland protection measures at the state, regional, local and individual level.

The Vermont Lake and Watershed Protection Program, initiated in 1989, was developed in response to the recognized urgent need for technical assistance for planning for watershed and shoreland protection. Since the start of the program, four statewide mailings have been sent to town planning commissions, conservation commissions, and lake associations describing the value of water quality protection and offering state assistance. Many requests for additional information have been answered, 30 meetings have been held with specific planning groups, and more than 16 town plans or shoreland zoning ordinances have been reviewed. Regional plans were reviewed and commented on for water quality protection effectiveness. A comprehensive manual, *Planning for Lake Water Quality Protection*, was prepared to assist local and regional planners in protecting lake water quality. In addition, several other publications have been prepared including *Shoreland Zoning Options for Towns*, *Buying Lakeshore Property in Vermont*, *Native Vegetation for Lakeshores, Streamsides and Wetland Buffers*, *Reestablishing Lakeshore Buffer Strips*, *The Vermont Better Backroads Manual*, and *For Your Lake's Sake*, (a pamphlet for shoreland owners originally published in Maine).

In 1993, the Lake and Watershed Survey was introduced as a means of assisting towns or lake associations in assessing potential pollution problems and inventorying land uses. As of 1995, five lake associations have begun work on a watershed survey, with the process expected to take several years. Several other associations have expressed interest in the survey process. The VTDEC has been actively involved in a comprehensive watershed survey and in-lake sampling at Lake Carmi to estimate sources of phosphorus to the lake and develop a phosphorus reduction strategy for the lake. The project involves close coordination and the participation of the Lake Carmi Campers Association, the Franklin/Grand Isle Regional Commission, and the Franklin County Natural Resource Conservation District.

Continued support for the Lake and Watershed Protection Program is crucial to overall lake health in Vermont as this program provides a critical educational and technical support function to Vermont citizens and municipalities. Lakes identified by Vermont's now-completed Lake Protection Classification System as being a high priority for lake protection efforts are currently being targeted by the Lake and Watershed Protection Program for the development of watershed protection plans to address the threats caused by land development.

Eurasian watermilfoil poses a significant threat to the recreational use of Vermont's lakes. Fourteen percent of Vermont's lakes 20 acres or greater in size (39 lakes) are currently infested with this non-indigenous aquatic plant, including the state's three largest lakes: Lake Champlain; Lake Memphremagog; and Lake Bomoseen. Another 43 percent of these lakes (105 lakes) are situated within 10 miles of a lake that is already infested, making them particularly vulnerable to the introduction of Eurasian watermilfoil by boaters or wildlife. There are also uncounted numerous smaller lakes less than 20 acres in size in close proximity to infested lakes.

The Vermont Eurasian Watermilfoil Control Program has made preventing further milfoil spread within a lake and more importantly, between lakes, a top priority. Although it is hoped that biological methods to control Eurasian watermilfoil will be available in the future, spread prevention is still the most effective means of control. The Milfoil Watchers Program and statewide educational efforts under the Eurasian Watermilfoil Control Program must be continued if significant progress is to be made in this area. New milfoil growth must be detected as early as possible; immediate management action and adequate funding are critical to prevent lake-wide spread. Diver-operated suction harvesting and committed annual handpulling and education efforts have successfully managed a pioneer milfoil infestation in Halls Lake in Newbury. Several other lakes with new milfoil infestations (Lake Fairlee,

Fairfield Pond, and Kent Pond, among others) need immediate attention to prevent milfoil's establishment and lake-wide spread. Unfortunately, a lack of adequate funding could significantly limit the use of any early intervention control methods unless both state and local sources of funding are available.

During the summer of 1993, the nonindigenous species, zebra mussel (*Dreissena polymorpha*), was found for the first time in Lake Champlain. By the end of 1995, the prolific mussel had spread throughout most of the lake with the exception of the northeast arm which includes Malletts Bay, St. Albans Bay, the Inland Sea, and Missisquoi Bay. Results from the lake-wide zebra mussel monitoring program (discussed in the monitoring and surveillance section) revealed that adult zebra mussel population densities increased substantially and reproduction increased exponentially during the 1995 summer season.

While many people discovered zebra mussels on their boats and other submerged equipment in 1994, the first reports of actual problems caused by the zebra mussel were received in 1995. The engines of several moored boats, left unused for most of the summer, were so heavily encrusted with zebra mussels that they could not be started. Numerous boat hulls were found heavily encrusted as well. Lakeshore residents who draw water directly from Lake Champlain discovered zebra mussels attached to their intake structures and many have spent between \$300.00 - \$3,000.00 on specially designed filtration systems. Adult zebra mussels were discovered in the wet wells of the state fish hatchery in Grand Isle and the Vergennes/Panton water supply facility. Fortunately major problems have so far been averted at each of the many water treatment facilities along the lake, but more than \$1.5 million has already been spent on zebra mussel monitoring and controls at those facilities. Historic shipwrecks, particularly those in water depths of 40 feet or less, are beginning to be encrusted by zebra mussels and it is feared that many will become completely obscured within a few years. Zebra mussels have also begun to heavily encrust and kill Lake Champlain's native mussels. Seven of Vermont's native mussel species exist primarily within Lake Champlain or its immediate drainage basin and therefore are at threat of extirpation from the entire state. The zebra mussel is expected to continue to expand its populations in Lake Champlain in the next couple of years and, consequently, all of the aforementioned impacts are expected to increase.

The zebra mussel has not yet been discovered in any of Vermont's inland lakes or ponds, however a preliminary vulnerability assessment conducted in December of 1995 for 236 Vermont lakes and ponds determined that 33 are highly vulnerable to infestation. The study took into account key water quality parameters, recreational use, and accessibility, as well as current infestation levels in Lake Champlain. Once the vulnerability assessment is finalized, use support on these 33 lakes will be listed as threatened for appropriate designated uses.

Since there currently is no environmentally sound way to reduce or eliminate zebra mussels from a waterbody in which they are established, statewide efforts continue to focus on education and spread prevention. Preventing, or at least delaying, the movement of zebra mussels to other waterbodies will allow more time for the development of control technologies as well as to learn how to minimize the mussel's impacts. Spread prevention efforts will be directed toward those lakes and ponds deemed most vulnerable. Continuation of the Zebra Mussel Education and Outreach Program and the Lake Champlain Zebra Mussel Monitoring Program will depend on the availability of state and federal funds.

There are 17 lakes in Vermont with average spring total phosphorus concentrations of 15.1-20 ug/l. Most of these lakes are not presently experiencing nuisance algae blooms. However, phosphorus concentrations in the 15-20 ug/l range approach the threshold concentration when periodic nuisance blooms can be expected to occur. It is imperative that the nutrient sources to these lakes be identified and controlled and watershed protection plans be implemented through the Lake and Watershed Protection Program before algae problems arise and lake uses are impaired.

There are 119 lakes in Vermont with alkalinities less than 10.0 mg/l as CaCO₃ that are considered to be threatened or impaired by acid precipitation. One lake, Lake-of-the-Clouds in Cambridge, frequently exhibits a pH of less than 4.5. Vermont has no program or plans to mitigate the effects of high acidity in these lakes or to control the toxics mobilized by this acidity. The recommended course of action on these lakes, as it is for all lakes requiring management, restoration, or protection in Vermont, is to first control the source of the problem or threat, then treat any resulting in-lake problems if necessary.

A study conducted for the Vermont Department of Environmental Conservation's Air Pollution Control Division concluded that 99.9 percent of the pollutants responsible for wet sulfate deposition in Vermont originates from out-of-state sources. Vermont therefore encourages the implementation of federal emission standards to reduce the discharge of pollutants responsible for acid precipitation and intends to pursue all available legal and political avenues to reach this end. The state's Acid Precipitation Program continues to provide lake and precipitation data from Vermont to support these efforts, despite drastic reductions in federal funding during the biennium.

While prior fish tissue sampling had raised some concern that PCBs and mercury threaten aspects of Lake Champlain's fishery, toxic contamination was not previously thought to be a widespread problem in Vermont's inland lakes. Unfortunately, compelling new fish tissue monitoring data has indicated that mercury and PCB contamination may be ubiquitous in the fillets of walleye and lake trout (respectively) throughout Vermont and northern New England. To assess the extent of fish tissue contamination more fully, Vermont's Fish Contaminant Monitoring Program was expanded considerably during 1995, and is continuing to monitor many Vermont waters. While yet unproven, it is suspected that certain species not currently included in Vermont's new interim Fish Consumption Advisory may also harbor mercury levels above that which is considered to pose a reasonable level of consumption risk by the Vermont Department of Health. It is due to the paucity of documented fish tissue monitoring data in 1995, that fish contamination is not treated as the threat that it may represent in this current 305(b) reporting cycle. By the time the current 1996-1997 305(b) reporting period has elapsed, the extent of fish tissue contamination, as well as the risk that contamination poses to those who consume the fish, will be well documented. At that point, a reasonable estimation of use impairment for Fish Consumption and Overall uses due to mercury and PCB contamination will be achievable. Given the current lack of data, the State of Vermont feels that it is unreasonable to make blanket statements regarding fish consumption uses on Vermont lakes.

The six basic threats outlined above-poor development practices, Eurasian watermilfoil, zebra mussels, threshold in-lake nutrient levels, acid precipitation, and the potential toxic contamination throughout Vermont - represent the major threats to Vermont's lakes that exist today. The Vermont Lakes and Ponds Program provides a sound framework for dealing with these threats and managing and restoring lakes that already have impaired uses. However, if the Vermont program is to continue to be successful and hold the line on eutrophication in the state, consistent federal Clean Lakes Program funding is needed. Periodic, unpredictable funding does not allow for the development of long-range program plans. Funding is specifically needed for continued lake assessment activities in order to set

priorities and provide the background data for diagnostic, restoration and protection projects. In addition, ongoing basic program grants are needed under the Clean Lakes Program and the Nonpoint Source Management Program to enable Vermont to develop an experienced staff that can implement critical statewide Lake and Watershed Protection Programs and provide technical assistance to lake watershed protection programs at the local level. With more than a third of Vermont's unimpaired lake acreage threatened, lake protection on a statewide and watershed-specific basis must be a top priority. A strong partnership of federal, state and local resources will be needed to ensure that Vermont's lakes continue to fully support their designated uses in future years.

Appendix B-1

Lake Water Quality Assessment Methods

Sources of Information

The water quality assessment of lakes was based on information derived from a wide variety of sources. Site specific water quality data was used whenever available. In addition, public opinion regarding the condition of each lake was solicited in 1987 and the assessment of some small lakes is based on such information. Public opinion was not specifically sought during 1991-1995 to update the assessment, but most unsolicited opinions received since 1987 were taken into consideration. The various sources of information are detailed below.

Much lake information was obtained from Department of Environmental Conservation Lakes and Ponds Section sampling programs and files. Basic water quality data was available from the Lay Monitoring Program, the Spring Phosphorus Program, the Lake Assessment Program, the Aquatic Plant Survey Program, the Eurasian Watermilfoil Control Program, and the Acid Precipitation Monitoring Program's Long-Term Lake Monitoring. In addition, several other in-depth lake studies yielded more comprehensive information on certain lakes. Yearly weed and algal complaint files and information from correspondence files aided in the assessment of public opinion regarding specific lakes.

Regional employees of the Agency of Natural Resources were contacted in 1987 regarding the conditions of lakes in their respective districts. Fish and Wildlife wardens were sent questionnaires about the lakes located in their towns. District Fisheries Managers were sent a different questionnaire about each lake in their district. Lake questionnaires were also sent to Vermont Town Clerks in 1987. This information was used to help assess the public perception of the water quality condition of specific lakes and to gather knowledge regarding sources of existing water quality impairments. Similar questionnaires were sent to the 100 lake associations in Vermont known to the Department of Environmental Conservation. All of the comments received from these questionnaires have been entered into the Lakes and Ponds Inventory computer database, evaluated, and used in the determination of current lake use impairments.

Additionally, any information relevant to lakes encountered by other Water Quality Division staff members while contacting professionals and individuals around the state for the Nonpoint Source Assessment was included in the Lakes Assessment.

For the 1996 Lake Water Quality Assessment, use support definitions were based on the criteria recommended by the State/EPA 305(b) Consistency Workgroup for the 1996 Guidelines. Where EPA did not define use support standards, Vermont Water Quality Standards were applied. The following list compares the new EPA use support definitions with their corresponding Vermont Water Quality Standard.

EPA Definition

No standard
Aquatic life
Drinking water supply
Fish/shellfish consumption
Secondary contact
Swimming
No standard

VT Water Quality Standard

Aesthetics
Biota
Filtered water supply
No standard
Non-contact recreation
Contact recreation
Unfiltered water supply

No EPA definitions or state standards are given for industrial or agricultural water supply uses. For these two uses, the effects of nuisance macrophyte beds and exotic species (e.g., zebra mussels) were assessed to determine use support.

For each major use, definitions were developed that helped describe when a use was fully supported, partially supported, or not supported in a lake setting, as follows:

Aesthetics

Fully Supported: Clear water and no floating algae scums. Aquatic macrophytes not present in surface mats or covered with periphyton. Few to no public complaints.

Partially Supported: Algae bloom every few years. Generally elevated algae levels (more than likely under natural conditions). Floating algae scums at low levels. Minor amounts of periphyton and/or surface mats of aquatic macrophytes. Some public complaints.

Not Supported: Regular and serious algae blooms. Persistent floating algae scums. Surface mats of nuisance aquatic macrophytes. Clumps of macrophytes washed up on shore.

In addition, for Lake Champlain, total phosphorus concentrations were considered when determining use support for aesthetics, as described below under "Additional Considerations for Lake Champlain."

Aquatic Life

Biological Assessment

Fully Supported: Reliable data indicates that the biological community (e.g., fish, macroinvertebrates or algae) has not been modified beyond the natural range of the reference condition.

Partially Supported: At least one of the assemblages (e.g., fish, macroinvertebrates or algae) indicates less than full support with slight to moderate modification of the biological community noted. Other assemblages indicate full support.

Not Supported: At least one assemblage indicates non-support. Data clearly indicates severe modification of the biological community.

Conventional (DO, pH, alkalinity)

Fully Supported: For any one pollutant or stressor, criteria exceeded in ≤ 10 percent of the measurements.

Partially Supported: For any one pollutant, criteria exceeded in 11 to 25 percent of the measurements.

Not Supported: For any one pollutant, criteria exceeded in ≥ 25 percent of the measurements.

Additional Parameters

In addition, the following parameters were used to determine support of aquatic life uses: turbidity, lake bottom siltation, exotic species, and nutrient levels exceeding state standards.

Drinking Water Supply

Fully Supported: No drinking water supply closures or advisories in effect during reporting period; no treatment necessary beyond "reasonable levels."

Partially Supported: One drinking water supply advisory lasting 30 days or less per year; or problems not requiring closures or advisories but adversely affecting treatment costs and the quality of polished water, such as taste and odor problems, color, excessive turbidity, high dissolved solids, pollutants requiring activated charcoal filters, etc.

Not Supported: One or more drinking water supply advisories lasting more than 30 days per year, or one or more drinking water supply closures per year.

Fish/Shellfish Consumption

Fully Supported: No fish/shellfish advisories or bans are in effect.

Partially Supported: "Restricted consumption" fish advisory or ban in effect for general population or a subpopulation that could be at potentially greater risk (e.g., pregnant women, children). Restricted consumption is defined as limits on the number of meals or size of meals consumed per unit time for one or more fish/shellfish species.

Not Supported: "No consumption" fish/shellfish advisory or ban in effect for general population or a subpopulation that could be at potentially greater risk, for one or more fish species; commercial fishing/shellfishing ban in effect.

Secondary Contact

Fully Supported: No dense surfacing nuisance macrophyte beds. Aquatic plants present at natural levels.

Partially Supported: Some dense surfacing macrophyte beds, not affecting the entire shoreline.

Not Supported: Dense surface macrophyte beds covering most of the shoreline. Frequent public complaints.

In addition, the following parameters were considered in determining support of secondary contact uses: frequency/extent of algal blooms, surface scums and mats, or periphyton growth; phosphorus concentration; turbidity (reduction of water quality due to suspended solids); lake bottom siltation; and aesthetics.

Swimming

Fully Supported: No bathing area closures or restrictions in effect during the reporting period.

Partially Supported: On average, one bathing area closure per year of less than one week's duration.

Not Supported: On average, one bathing area closure of greater than one week's duration, or more than one bathing area closure per year.

In addition, for Lake Champlain, total phosphorus concentrations were considered when determining use support for swimming, as described below under "Additional Considerations for Lake Champlain."

Unfiltered Water Supply

Fully Supported: Fecal coliform bacterial concentration rarely or never exceeds 200/100 ml.

Partially Supported: More than one repeat bacteria sample exceeding 200/100 ml during a summer over the past five years.

Not Supported: Regular fecal coliform bacteria concentrations exceeding 200/100 ml.

Industrial Water Supply

No specific standards apply. The effects of nuisance macrophyte and exotic species (e.g. zebra mussels) were used to determine industrial water supply use support.

Additional Considerations for Lake Champlain

The assessment of Lake Champlain with respect to aesthetic and swimming uses was based on the results of the Vermont Lake User Survey, as suggested by the EPA Guidelines. From 1987-1991, citizen monitors sampling Lake Champlain under the VT Lay Monitoring Program completed a survey form each time they sampled. The survey asked the monitors to assess the physical condition of the water and their own impression of the extent of nuisance conditions on the day they sampled. Survey results were correlated with the phosphorus sampling results, and threshold phosphorus levels were calculated for various degrees of recreational impairment. For the purposes of this assessment, the following definitions were used:

Fully Supported: < 14 ug/l summer mean total phosphorus. Corresponds to lake conditions where more than half of the lake users found their enjoyment of the lake slightly or substantially impaired no more than 1% of the time during the summer.

Partially Supported: 14 - 35 ug/l summer mean total phosphorus.

Not Supported: > 35 ug/l summer mean total phosphorus. Corresponds to lake conditions where more than half of the lake users found their enjoyment of the lake slightly or substantially impaired more than 90% of the time during the summer.

Whenever possible, the likely natural condition of a lake was taken into account in addition to the above definitions when assessing use support. For instance, a naturally shallow, weedy pond cannot be expected to be used for secondary contact, so no use impairment was noted. In many cases, however, no site visit has been made to a lake so the extent of use impairment is an estimate based on information from the public and contacted professionals. During 1994-1995, a total of 25 small ponds

in the "evaluated" category, were visited and/or sampled by a qualified biologist in order to verify reported use impairment or support.

Threats to use support were identified through two major avenues. First, information received from Fish and Wildlife wardens, District Fisheries Managers, Town Clerks, lake associations and members of the public often indicated a use impairment in a particular lake and the source of that impairment. When the various information sources did not agree about an impairment or its causes and sources, the lake was listed as threatened rather than not supported or partially supported. These situations all need further assessment and verification. Second, four major statewide threats to lakes were identified by the Department of Environmental Conservation. Each lake was evaluated as to its vulnerability to these four threats, according to the following criteria:

Eurasian Watermilfoil

Lakes within a ten mile radius of a lake already containing a Eurasian watermilfoil population were considered highly vulnerable to an infestation and were evaluated as threatened. In addition, lakes with pioneer milfoil populations were evaluated as threatened. Generally, 20% of the lake's acreage was considered threatened to correspond to the approximate acreage of the littoral zone. The cause was listed as # 26 (exotic species) and the source was # 87 (recreational activities). Milfoil threats and pioneer infestations were listed as threats to aesthetic, aquatic life, secondary contact, and swimming uses.

Zebra Mussels

Zebra mussels have now occupied a majority of the shoreline acreage in most segments of Lake Champlain. The ONLY exceptions to this are the 3 Lake Champlain segments known as Malletts Bay, the Inland Sea, and Missisquoi Bay. In those areas where infestations have achieved nuisance levels, and direct effects were noted on aquatic biota (eg. native unionids) affected uses were considered not supported. In those areas where populations are still developing, uses were partially supported. Data to support these use impairment assessments was generated through the Lake Champlain Zebra Mussel Monitoring Program, and other related programs (section 1 of this report). Zebra mussels impair all uses except fish/shellfish consumption.

Development Within a Lake's Watershed

Previously, lakes located in "Rapid Growth Towns" were considered threatened by the cumulative impacts associated with land development and the subsequent runoff from urban and cleared areas. Rapid Growth Towns were defined by the Growth Areas Research Project (Vt. Law School's Environmental Law Center, 1985). However, as more actual assessment information was incorporated into the lakes and ponds database, it became apparent that "Rapid Growth" status, in many situations, had little to no bearing on actual watershed-level threats. For the 1996 assessment, the threats to lakes from watershed development were evaluated in the context of the Lake Protection Classification System. The relative extent of development within individual lake watersheds was summarily evaluated for all of the lakes assessed in conjunction with the Lake Assessment Program. All of these lakes were then evaluated under the Lake Protection Classification System. While actual detailed pollutant source assessments have not been made in these watersheds, the Lake Protection Classification System provides a framework by which relative watershed-level threats to lakes are scored and ranked. The Lake Protection Classification System incorporates the following threat types and lake qualities which relate to development:

- (1) Accelerated Eutrophication.
- (2) Zoning regulations in the town(s) surrounding the evaluated lake.
- (3) Wilderness or Wilderness-like status

Using information gathered in conjunction with the Lake Assessment Program, or other Department monitoring programs, all lakes in the state of 20 acres in size or more have been evaluated in conjunction with the Lake Protection Classification System. While these lakes represent only 54 percent of the total number of assessed lakes, they represent fully 99 percent of the states total assessed lake acreage. Accordingly, the threats presented in the 1996 assessment can be considered accurate.

Acid Precipitation

Lakes with low alkalinities (less than 10 mg/l as CaCO₃) are considered potentially susceptible to the impacts of acid precipitation. These lakes warrant further study so that any changes in their water quality or biota that may occur can be documented. The entire acreage of these lakes was considered threatened, because a significant decrease in pH could affect the biota lakewide. The cause was listed as pH and the sources were both atmospheric deposition and natural, since the extent to which the low alkalinities occur naturally is unknown. Aquatic life use was listed as threatened by acid precipitation.

Information regarding fishable/swimmable goals, and outdated fecal coliform bacteria data, have been omitted from the lake assessment tables in the Lakes and Ponds Inventory computer database and were not used during this reporting period.

! **GROUND WATER - Out of Site Not Out of Danger:** A 23 minute slide show with tape produced by the New England Interstate Water Pollution Control Commission. This presentation addresses ground water protection, emphasizing why it's necessary to protect our ground water resources. Appropriate for grade levels 7-12 and beyond. **Contact:** Dennis Nealon, Water Supply Division, (802) 241-3400.

! **LAKE EUTROPHICATION - An Abundance of Life:** A 28 minute, 16mm film which explores eutrophication (the natural aging of a lake) accelerated by cultural impacts in Vermont lakes. Designed for grade levels 7-12 and beyond. Available on loan. **Contact:** Your local library.

! **LAKE PROTECTION - Everyone Contributes:** A 12 minute video produced in Minnesota discussing ways in which shoreland residents can prevent pollution from their properties. Available on loan.

! **LAY MONITORING PROGRAM SLIDE SHOW:** A 20 minute slide show . This slide show gives a perspective on the range of water quality in Vermont lakes, and explains that much of the data used to assess Vermont lake water quality is collected by lay water quality monitors. Appropriate for grade levels 7-12 and above.

! **VERMONT LAKES - Neglected or Protected?:** A 25 minute slide show including tape or script which explores lake ecology and water quality issues. Focus is on the watershed of a lake and those activities which can degrade water quality. Appropriate for grade levels 7-12 and above. Available on loan.

! **WETLAND CONSERVATION:** A 20 minute slide show with tape that discusses the values of Vermont's wetlands and steps that must be taken to preserve them. Designed for middle grade school children and older. Available on loan. **Contact:** Wetlands Program, (802) 241-3770.

! **VERMONT WETLANDS "A NATURAL RESOURCE", 1995:** A 25 minute video on Vermont wetlands. Appropriate for middle grade school children and older. Available on loan. **Contact:** Wetlands Program, (802) 241-3770.

! **THE INVASION OF THE ZEBRA MUSSELS: JUST A MATTER OF TIME?:** 10-minute video. Narrated by actor Mason Adams, the video provides an overview of the zebra mussel invasion and its impacts, and illustrates spread/introduction prevention precautions that boaters and anglers can take to minimize their role in the range expansion of the zebra mussel (and nuisance aquatic plants). Appropriate for grade levels 7 and up. Available on loan.

! **ZEBRA MUSSELS:** 30-minute Video. An excellent overall introduction to zebra mussel biology, impacts, spread prevention, and controls. Appropriate for grade levels 7 and up. Produced by New York Sea Grant Institute. Available on loan.

! **ZEBRA MUSSELS AND THE LAKE CHAMPLAIN BASIN:** Slide Show and Script. Over 70 slides are used to present a general overview of the zebra mussel issue and how it relates to Vermont and the Lake Champlain Basin of New York. Topics covered include: zebra mussel distribution, habitat requirements, biology/life cycle,

impacts, modes of spread, spread prevention, controls, and the monitoring and education and outreach efforts of the Vermont Department of Environmental Conservation\Lake Champlain Basin Program. Appropriate for grade levels 7 and up. Soon available on loan.

! **ZEBRA MUSSELS, THE SILENT INVADER:** 16-minute Video. The video focuses primarily on zebra mussel impacts to large power generating facilities on the Great Lakes, but it gives an excellent summary of zebra mussel biology and dramatically illustrates the magnitude of the zebra mussel threat. Appropriate for grade levels 7 and up. Produced by the Electric Power Research Institute of Palo Alto, California. Available on loan.

AVAILABLE LITERATURE

! **PROJECT WET (WATER EDUCATION FOR TEACHERS)** (See Other Educational Tools, Page 7).

! **ACID RAIN STUDY GUIDE:** A Wisconsin Department of Natural Resources publication designed to provide hands-on activities in acid rain education to grade levels 1-12. A curriculum of five classroom activities are included in the guide. **Contact:** Jim Kellogg, R. A. LaRosa Environmental Laboratory, Acid Deposition Program, (802) 244-4520.

! **ACID PRECIPITATION PUBLICATIONS** are available from the Water Quality Division. **Contact:** Jim Kellogg, R. A. LaRosa Environmental Laboratory, Acid Deposition Program, (802) 244-4520.

! **BIOLOGICAL AND CHEMICAL INFORMATION** is available on many streams and rivers in Vermont. **Contact:** Steve Fiske, R.A. LaRosa Environmental Laboratory, (802) 244-4520.

! **EROSION AND SEDIMENT CONTROL PAMPHLETS AND PUBLICATIONS** are available from the Water Quality Division. **Contact:** Jerry McArdle, Planning Section, (802) 241-3770

! **EURASIAN WATERMILFOIL EDUCATIONAL PACKET** includes information on milfoil identification, lake search methods and spread prevention activities.

! **EURASIAN WATERMILFOIL IDENTIFICATION POSTERS** are available on heavy cardboard or durable waterproof paper.

! **EURASIAN WATERMILFOIL PAMPHLETS AND ANNUAL REPORTS** are available from the Water Quality Division.

! **A REPORT FROM THE MILFOIL STUDY COMMITTEE ON THE USE OF AQUATIC HERBICIDES TO CONTROL EURASIAN WATERMILFOIL IN VERMONT.**

! **FIELD MANUAL FOR WATER QUALITY MONITORING - An Environmental Education Program for Schools:** A 165 page guide on how schools can start and develop a chemical approach to water quality

monitoring. Contains instructions on how to test for water quality indicators such as turbidity, dissolved oxygen, acidity, etc. Also included is an explanation of macroinvertebrate life cycles. Available for a fee of \$9. **Contact:** William B. Stapp, 2050 Delaware, Ann Arbor, MI 48130.

! **GUIDES FOR EVALUATING THE OUTSTANDING RIVERS AND STREAMS OF VERMONT:**

A publication for those interested in protecting, preserving and restoring Vermont's unusual river and stream resources. **Contact:** Mike Kline, Rivers Program, (802) 241-3770.

! **GUIDE TO NURSERIES THAT SUPPLY NATIVE PLANTS FOR WETLANDS AND PONDS:**

A listing of some Vermont and regional nurseries that carry native wet-tolerant or wetland plant species. **Contact:** Cathy Kashanski, Water Quality Division, (802) 241-3770.

! **GUIDE TO MACROINVERTEBRATE SAMPLING:**

A "how to" guide for monitoring river aquatic insects. This publication presents an introduction to a community of insects that are indicators of overall water quality and the methods used to assess them. Available for a fee of \$5.00. **Contact:** River Watch Network, Montpelier, VT, (802) 223-3840.

! **GUIDES FOR RIVER PLANNING :**

Informational sheets to help citizens inventory river uses and values, define river management goals and recommend actions to achieve goals or resolve issues. **Contact:** Mike Kline, Rivers Program, (802) 241-3770.

! **GROUND WATER RESOURCES, MANAGEMENT AND PROTECTION PUBLICATIONS**

are available from the Water Supply Division. **Contact:** Dennis Nealon, Water Supply Division, (802) 241-3400.

! **HYDROPOWER IN VERMONT - An Assessment of Environmental Problems and Opportunities:**

If you are interested in knowing more about the information available in this publication - **Contact:** Stacy Gibson, Water Quality Division, (802) 241-3770.

! **KEY TO THE FRESHWATER MACROINVERTEBRATE FAUNA OF NEW ENGLAND:**

This key was prepared to accompany the River Watch Network training program, a program that monitors the water quality of rivers through biological communities, and incorporates the most common taxa occurring in the major rivers of New England. Available for a fee of \$5.00. **Contact:** River Watch Network, Montpelier, VT, (802) 223-3840.

! **KEY TO COMMON VERMONT AQUATIC PLANT SPECIES:**

A dichotomous key to 30 common aquatic plants.

! **LAKE AND PONDS PAMPHLETS AND PUBLICATIONS**

on pollution prevention and protection measures.

! **LAKE AND POND PLANTS - A Guide to Vermont's Common Aquatic Plants and their Natural Values in Lakes.** A 28 page booklet.

! **LAY MONITORING ANNUAL REPORTS** present water quality data from over 40 lakes and 36 stations on Lake Champlain and are available from the Water Quality Division.

! **NATIVE VEGETATION FOR LAKESHORES, STREAMSIDES AND WETLAND BUFFERS:** What you need to know to re-establish or enhance a buffer strip along water and wetlands in Vermont. Information on native plant species as well as on planning and planting a buffer strip. **Contact:** Cathy Kashanski, Water Quality Division, (802) 241-3770.

! **"OUT OF THE BLUE"** is a semiannual newsletter of the Water Quality Division's Lakes and Ponds Section. This newsletter shares information on the lake environment, water quality and state activities through articles on lake ecology and section programs.

! **PLANNING FOR LAKE WATER QUALITY PROTECTION:** A manual for towns interested in addressing lake issues through their town plan, by-laws or town programs. Also available is other information on lake protection and management. **Contact:** Cathy Kashanski, Water Quality Division, (802) 241-3770.

! **RIVER PUBLICATIONS AND BASIN MANAGEMENT PLANS** are available from the Water Quality Division. **Contact:** Mike Kline, Rivers Program, (802) 241-3770.

! **VERMONT RIVERS STUDY:** A compilation of river-related natural, physical and cultural resources on the 17 river basins of Vermont. **Contact:** Mike Kline, Rivers Program, (802) 241-3770.

! **VERMONT STREAMBANK CONSERVATION MANUAL:** A 60 page manual on the value of streambanks and their protection. Included is a lay person guide to outstanding stream water quality problems and potential solutions. **Contact:** Water Quality Division, (802) 241-3770.

! **VERMONT'S WHITEWATER RIVERS - Their Geology, Biology and Recreational Use:** An atlas of Vermont whitewater streams, available Summer 1994. **Contact:** Mike Kline, Rivers Program, (802) 241-3770.

! **WATER QUALITY EVALUATION AND PLANNING, AND WATER POLLUTION PUBLICATIONS** are available from the Water Quality Division. **Contact:** Water Quality Division (802) 241-3770.

! **WATER QUALITY DATA AND INFORMATION** is available on many lakes in the state.

! **AN ACTIVITY GUIDE TO WETLAND EDUCATION:** A 57 page booklet which includes wetland related activities and an extensive resource bibliography to introduce children and young adults to Vermont's wetlands. **Contact:** Wetlands Program, (802) 241-3770.

! **VERMONT WETLANDS: A LANDOWNER'S GUIDE TO PROTECTION.** *Contact:* Wetlands Office, (802) 241-3770.

! **WATER CHESTNUT: A problem nonnative aquatic plant in Vermont.** A 7 page booklet.

! **WETLAND FACT SHEETS:** A series of 2-4 page fact sheets on topics such as Act 250 and Pre-Act 250 Review, Utility Line Crossings, Wetland Rules, Conditional Use Determinations, Wetland Functions and Values, Buffer Zones, Agricultural Activities in Wetlands Policy on Enforcement of Wetlands Rules, Wetland Mitigation and Stormwater and Wetlands. *Contact:* Wetlands Office, (802) 241-3770.

! **ZEBRA MUSSEL RESOURCE LIST,** a list of reference materials available from the VTDEC.

! **BE AWARE OF ZEBRA MUSSELS,** *An Introduction To Zebra Mussel Impacts And Spread Prevention:* Pamphlet. Produced by the Vermont Department of Environmental Conservation (VTDEC) and the Lake Champlain Basin Program (LCBP).

! **CONTROL OF ZEBRA MUSSELS IN RESIDENTIAL WATER SYSTEMS:** Charles R. O'Neill, Jr., 1993: 12-page booklet. A comprehensive guide to protecting private residential water supply systems from zebra mussel infestations. Produced by New York Sea Grant.

! **BOATERS TAKE NOTE:** 4"x9" rack card. Summarizes measures boaters should take before transporting boats between waterbodies to avoid spreading zebra mussels. Produced by VTDEC and LCBP.

! **DIVERS TAKE NOTE:** 4"x9" rack card. Summarizes techniques which divers should use to prevent transporting zebra mussels in dive equipment between waterbodies. Produced by VTDEC and LCBP.

! **REPORT OF THE VERMONT ZEBRA MUSSEL STUDY COMMITTEE:** January 1994: 41-page booklet. Prepared by the Vermont Agency of Natural Resources in response to a legislative directive to study the potential impact of the zebra mussel in Vermont. Sections include: Biology and Spread, Impacts and Control Methods, Monitoring, Permitting Issues, Recommendations, and References.

! **SLOW THE SPREAD OF ZEBRA MUSSELS AND PROTECT YOUR BOAT AND MOTOR, TOO:** David O. Kelch, 1994: Fact Sheet. An explanation of simple techniques for ridding boats and equipment of zebra mussels after their use and a summary of different antifoulant paints used to discourage zebra mussel attachment. Produced by Ohio Sea Grant.

! **TIPS FOR LAKESHORE RESIDENTS:** *Protecting Residential Water Supply Systems From The Threat Of Zebra Mussels:* Pamphlet. An introduction to both on and off-shore control devices for protecting private residential water supply systems from zebra mussel infestations. Contains Vermont and New York permitting contacts. Produced by the VTDEC and the LCBP.

! **ZEBRA MUSSEL CITIZEN ACTION PROGRAM (ZMCAP):** Information Packet. Description of program and ten ways citizens can help slow the spread of zebra mussels and protect noninfested waterbodies from zebra mussel infestation.

! **ZEBRA MUSSEL, LAKE CHAMPLAIN BASIN PROGRAM FACT SHEET SERIES, NUMBER 1:** A 4 page booklet. General information on zebra mussel biology/life cycle, habitat, identification, spread prevention, and control measures. Produced by the LCBP.

! **ZEBRA MUSSEL WATCH:** Wallet-size card. Includes a zebra mussel photograph and description to help with zebra mussel identification, and telephone numbers for reporting sightings. Produced by the University of Wisconsin Sea Grant Institute and the LCBP.

! **ZEBRA MUSSEL WATCHERS:** Instructions and Log Sheets. Simple, step by step instructions for monitoring the presence/absence of adult zebra mussels in a waterbody.

MAPS

! **REGIONS SENSITIVE TO ACIDIC DEPOSITION IN VERMONT:** (Revised February 1987)
Contact: R. A. LaRosa Environmental Laboratory, Acid Deposition Program, (802) 244-4520.

! **VERMONT LAKES INFESTED WITH EURASIAN WATERMILFOIL:** Updated annually.

! **LAKE CHAMPLAIN DRAINAGE BASIN MAP:** A 24" X 32" map that highlights town, county, state and international boundaries within the drainage basin. The principal surface waters, and the boundaries of major river basins which lie within the Lake Champlain basin are also illustrated. Available for a fee of \$3.00. **Contact:** Lake Champlain Basin Program, 1-800-468-5227.

! **DEPTH CHARTS OF VERMONT LAKES AND PONDS:** Over 80 depth charts of many Vermont lakes are available to the public at a fee of \$1.00 each. Contact the Department for a listing of available lake charts.

! **VERMONT RIVER BASIN MAPS:** Available for all 17 basins in two scales: 1 inch = 5208 feet and 1 inch = 1 mile. **Contact:** Mike Kline, Rivers Program, (802) 241-3770.

OTHER EDUCATIONAL TOOLS

! **PROJECT WET (WATER EDUCATION FOR TEACHERS):** The Water Quality Division is sponsoring this interdisciplinary water education program intended to supplement a school's existing curriculum. Project WET offers the educator: activity guides and modules designed for K-12, computer simulations, water history

publications, ground water from models, a series of children's story and action books and a water resources information network. All materials are available by attending a workshop. For more information **Contact:** Deb Parrella or Amy Picotte, Water Quality Division, (802) 241-3777.

! **GROUND WATER FLOW MODEL:** A plexiglass tank distributed with various sand lenses that illustrates how groundwater, and contaminants, migrate through porous materials. Appropriate for grade levels 4-12 and beyond. Available on loan. **Contact:** Dennis Nealon, Water Supply Division, (802) 241-3400.

! **EURASIAN WATERMILFOIL PRESSED DRIED SPECIMENS** are available mounted on heavy paper and encased with a waterproof covering.

! **EURASIAN WATERMILFOIL EDUCATIONAL EXHIBIT - Decline of an Underwater Exotic:** A tabletop display about the Lake Bomoseen Demonstration Program, a research project that is investigating the potential to control Eurasian watermilfoil with a native aquatic weevil. Through text, photographs and drawings, the display illustrates the problems Eurasian watermilfoil causes in lakes, describes a naturally occurring milfoil decline in Vermont, and explains the research that is currently underway to determine if the weevil can be used to reduce milfoil to a manageable level. Appropriate for the high school level and beyond. Exhibit has lights and needs an 8 x 3 foot table for set-up. Available on loan.

! **LAKE PROTECTION EDUCATIONAL EXHIBIT - For the Lake's Sake:** A tabletop display for use at meetings, fairs and conferences. Photographs and drawings illustrate the causes and sources of lake water quality problems, and provide ideas for locally-based protective projects. Appropriate for grade levels 7-12 and beyond. Exhibit has lights and needs an 8 x 3 foot table for set-up. Accompanying handouts also available. Available on loan.

! **ZEBRA MUSSELS AND THE LAKE CHAMPLAIN BASIN:** Presentation. (See above for description).

! **ZEBRA MUSSEL CITIZEN ACTION PROGRAM:** Workshop. Designed for groups interested in taking an active role in slowing the spread of zebra mussels and in protecting noninfested waterbodies from zebra mussel infestation.

! **OTHER ZEBRA MUSSEL PRESENTATIONS** can be designed to meet the needs of specific group ages and/or interests.

VOLUNTEER PROGRAMS

! **ACID PRECIPITATION MONITORING NETWORK** represents a long-term effort to document trends in Vermont's precipitation (rain and snow). Seven volunteers throughout the state currently collect and measure the amount of precipitation, and test the ph with meters and equipment on loan from the Department of

Environmental Conservation on an event basis. **Contact:** Jim Kellogg, Acid Deposition Program, R. A. LaRosa Environmental Laboratory, (802) 244-4520.

! **LAY MONITORING PROGRAM** is a citizen participation program in which volunteers are trained and equipped to conduct periodic water quality sampling on lakes. The program measures water quality parameters that relate to increased nutrient enrichment.

! **MILFOIL WATCHERS PROGRAM** utilizes a statewide network of volunteers to conduct annual lake searches for Eurasian watermilfoil in an effort to prevent the further spread of this nuisance aquatic plant. An informational packet on how to distinguish milfoil from beneficial native aquatic plants and search your lake for milfoil.

! **RIVER WATCH NETWORK** is an organization which works with schools and citizen groups on water quality monitoring activities on over a dozen rivers in Vermont. Study designs and water quality study reports are available for many of their programs. **Contact:** River Watch Network, (802) 223-3840.

! **ZEBRA MUSSEL WATCH PROGRAM**, like the Milfoil Watchers Program, is dependent on a statewide network of volunteers to search lakes regularly for new infestations of zebra mussels. An informational package is available containing log sheets, lake maps, ID cards instruction son how to become a volunteer zebra mussel monitor and search your lake.

The Vermont Department of Environmental Conservation is an equal opportunity agency and offers all persons the benefits of participating in each of its programs and competing in all areas of employment regardless of race, color, religion, sex, national origin, age, disability, or other non-merit factors.

This document is available upon request in large print, braille or audio cassette.

VT Relay Service for the Hearing Impaired
1-800-253-0191 TDD>Voice - 1-800-253-0195 Voice>TDD

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