

Basin 10

Black River and Ottauquechee River Watersheds

Water Quality and Aquatic Habitat

Assessment Report

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General Description of the Basin*

Basin 10 consists of two major watersheds in eastern Vermont - the Ottauquechee River watershed and the Black River watershed. Both rivers flow into the Connecticut River. Most of the Black and Ottauquechee Rivers drainage is located in Windsor County, but the basin also includes lands in Rutland County. Following are brief descriptions of each of these two major rivers and their significant tributaries.

Ottauquechee River watershed

The Ottauquechee River has a mainstem length of 38 miles and drains an area of 223 square miles in east central Vermont. The Ottauquechee River valley is extremely narrow with few large meadows, and the surrounding terrain is rugged and hilly with precipitous slopes. For most of its course, the mainstem is moderately swift with a total fall of 1,485 feet from its source to mouth. Most of its tributaries are flashy mountain streams. Precipitation in the basin averages over forty inches per year, ranging from about forty-five inches in the mountains of Killington to thirty-seven inches at the river mouth in North Hartland.

The Ottauquechee River originates on the eastern slopes of the Green Mountain Range in the town of Killington in Rutland County. From its source, the river flows northeasterly down the mountainside, to the valley floor where its course changes to a near southerly direction. At river mile 32.2, the Ottauquechee flows through the community of South Sherburne and continues its southerly course into the town of Bridgewater. In the community of West Bridgewater, the Ottauquechee is joined by Woodward Brook, which enters from the south.

Reservoir Brook, which is 3 miles long and drains an area of 7 square miles, begins in the town of Plymouth. Immediately below its source, the brook enters Woodward Reservoir, which has a surface area of 106 acres and is one of the largest bodies of water in the Ottauquechee River watershed. From Woodward Reservoir, Reservoir Brook flows rapidly northward into the town of Bridgewater where it enters the Ottauquechee River.

From Reservoir Brook, the Ottauquechee River winds in a generally eastward course to Bridgewater Corners where, at river mile 22.3 it is joined by the North Branch from the north.

The North Branch, which has a length of 8.5 miles, originates on the southern slope of Bull Hill in the town of Bridgewater. It flows southerly to the nearly abandoned hamlet of Chatauguay and then southeasterly and southerly, passing through Bridgewater Center, to its confluence with the Ottauquechee River.

*The description taken largely from the 1976 Black and Ottauquechee River Basins Management Plan.

After being joined by the North Branch, the Ottauquechee continues easterly through Bridgewater Corners. Immediately downstream of that community at river mile 21.8, Broad Brook enters from the south.

Broad Brook has a length of 8 miles and a drainage area of 27 square miles. Broad Brook rises on the southwestern slopes of Long Hill, in the town of Reading, and flows westerly into the town of Plymouth, passing through the hamlet of Five Corners, where its course changes to a generally northerly direction, and then flows into the town of Bridgewater. At a point 1.3 miles from its mouth, Broad Brook is joined by Pinney Hollow Brook from the west.

Pinney Hollow Brook, which is 6 miles long and has a drainage area of 12 square miles, has its source on the northern slopes of Soltudus Mountain in the town of Plymouth. From its source, this brook flows northerly through the community of Plymouth, and then northeasterly and easterly to its confluence with Broad Brook. After being joined by Pinney Hollow Brook, Broad Brook continues northerly to its confluence with the Ottauquechee River.

From Broad Brook, the Ottauquechee River continues its easterly course, passing through the village of Bridgewater and entering the town of Woodstock, where it alters direction to a northeasterly course. It then flows through the village of West Woodstock and enters Woodstock Village, where at river mile 13.5 it is joined by Kedron Brook, which enters from the south.

Kedron Brook is 9 miles long and has a drainage area of 16 square miles. From its source in Reading Gulf in the town of Reading, Kedron Brook flows northeasterly into the town of Woodstock. It winds through the open Kedron Valley and, after passing through South Woodstock, the stream turns northerly for the remainder of its course to the Ottauquechee River.

From its confluence with Kedron Brook, the Ottauquechee continues northeasterly to river mile 12.7, where it is joined by Barnard Brook, which enters from the northwest.

Barnard Brook, which has a length of 8.5 miles and a drainage area of 38 square miles, rises in the hills about one mile east of Silver Lake in the town of Barnard. From its source, this brook tumbles down through hardwood forests or winds through small alder and willow wetlands southeasterly into the town of Pomfret. In a somewhat wider, flatter valley, it passes through the community of South Pomfret and enters the town of Woodstock. At a point 1.3 miles from its mouth, Barnard Brook is joined by Gulf Stream, which enters from the west.

Gulf Stream, which begins in Barnard Gulf in the town of Barnard, is 7.5 miles long and has a drainage area of 18 square miles. From its source, Gulf Stream flows southeasterly through the town of Pomfret into the town of Woodstock, where it enters the community of Prosper. From this community, Gulf Stream flows easterly to its confluence with Barnard Brook. Barnard Brook then continues southerly to its juncture with the Ottauquechee River.

The Ottauquechee River flows easterly from its confluence with Barnard Brook, passing through the community of Taftsville, where the course of the river changes to a northeasterly direction for about 3 miles, skimming the edge of the town of Hartland and entering the town of Hartford. After returning to a southeasterly course, the Ottauquechee River flows through Quechee to the Deweys Mills dam at river mile 5.4.

Passing over this dam, the river flows southeasterly into the North Hartland Flood Control Reservoir, formed by the North Hartland Dam at river mile 1.5. From this dam, the Ottauquechee River flows southeasterly to its confluence with the Connecticut River, at the northern extremities of North Hartland village.

According to a land use/land cover analysis of the Ottauquechee River watershed, 86% or over 124,000 acres of the watershed area is forested -- a high percentage for a single land cover type. Only 5% of the land area (7,139 acres) is in agriculture and another 5% is developed land (7,798 acres), which includes residential, commercial and transportation uses. Surface waters account for only 3% of the watershed (4,100 acres) and wetlands only 1% (1,106 acres).

Black River Watershed

The Black River, which has a mainstem length of 40 miles, is formed at the outlet of Black Pond in the town of Plymouth. With its tributaries, the Black River drains an area of 202 square miles in Rutland and Windsor Counties. The valley of the Black River is generally narrow, as is characteristic of the rivers in eastern Vermont. The surrounding drainage basin is composed of hilly and mountainous terrain.

From its source at the outlet of Black Pond, the Black River flows southeasterly through the town of Plymouth passing into and through Amherst and Echo Lakes to a point 0.1 mile north of the Ludlow town line where it is joined by Patch Brook, which enters from the west. This confluence is 7.1 miles from the source of the Black River at Black Pond.

Patch Brook begins at the outlet of Lake Ninevah in the town of Mt. Holly and is a flashy stream with a length of 3.0 miles and a drainage area of 5.5 square miles. The Black River then continues southerly for a distance of 3.5 miles to its juncture with Branch Brook, about 1.5 miles north of the village of Ludlow. In this stretch, the Black River passes through Rescue Lake and Reservoir Pond, both in the town of Ludlow.

Branch Brook, which enters from the west, is the first major tributary of the Black River. A flashy stream with a length of 8.0 miles and a drainage area of 16.0 square miles, Branch Brook rises in the town of Mt. Holly and passes through the community of Healdville before entering the Black River just downstream from the community of Grahamville.

From Branch Brook, the Black River continues southerly for 1.7 miles into the village of Ludlow where it is joined by Jewell Brook which enters from the south.

Jewell Brook, which is 4.5 miles long and has a drainage area of 9.5 square miles, rises in the southwestern part of the town of Ludlow and flows northerly, quite precipitously, to the village of Ludlow where it enters the Black River.

From its confluence with Jewell Brook, the Black River flows easterly through the communities of Ludlow and Smithville, both in the town of Ludlow, and the communities of Proctorsville and Cavendish, both in the town of Cavendish. One-half mile east of Cavendish, the Black River turns northerly at the Cavendish Gorge. At a point 6.1 miles downstream from its confluence with Jewell Brook, the Black River is joined by Twenty Mile Stream which enters from the northwest.

Twenty Mile Steam, which rises in the town of Reading on the westerly side of The Alps, is 8.5 miles long and has a drainage area of 15.5 square miles. Twenty Mile Stream flows southerly from its source, for about half its length and then southeasterly for the remainder to its juncture with the Black River at the village of Whitesville, in the town of Cavendish.

The Black River then meanders through its steep, narrow valley, flowing generally easterly and passing through Perkinsville in the town of Weathersfield before being joined by the North Branch at a point 8.9 miles downstream from Twenty Mile Stream.

The North Branch, which enters from the north, is the largest single tributary of the Black River, with a length of 11.0 miles and a drainage area of 33.0 square miles. The North Branch rises in the town of Reading on the east side of the Alps and flows southeasterly through the communities of South Reading and Felchville, both in the town of Reading, and the communities of Greenbush and Amsden, both in the town of Weathersfield, before it enters Stoughton Pond, the upper pool of the North Springfield Flood Control Reservoir. After leaving this pool, the North Branch flows southerly a short distance to its confluence with the main stem of the Black River.

From the mouth of the North Branch, the Black River flows southwesterly through the North Springfield Flood Control Reservoir in the towns of Weathersfield and Springfield. Shortly after leaving the reservoir, the Black River enters North Springfield where, at a point 3.2 miles below the North Branch, it is joined by Great Brook from the west.

Great Brook emanates from the hills adjacent to the Duttonsville Gulf in the town of Cavendish. After leaving Cavendish and entering the town of Chester, Great Brook changes its course from a southerly to an easterly direction and enters the town of Springfield, flowing through North Springfield to its confluence with the Black River.

For the remaining 7.6 miles of its length below North Springfield, the Black River flows southeasterly through the village of Springfield and past the hamlet of Goulds Mill, entering the Connecticut River 1/4 mile downstream from the Cheshire Toll Bridge.

The Black River watershed is less forested than the Ottauquechee River watershed but nonetheless, 75% or 161,375 acres are deciduous or coniferous forest in the Black River's drainage area. Twice as much land is in agriculture in the Black River watershed as compared to the Ottauquechee River watershed with 10% or 22,609 acres in some form of agricultural activity. Developed land accounts for 7% or over 15,000 acres, surface water accounts for 4% or 9,512 acres and wetlands cover 3% or 7,395 acres.

There are a total of 19 lakes and ponds 20 acres or larger in the Ottauquechee and Black River Basins totaling approximately 1,610 acres. North Springfield Reservoir, North Hartland Reservoir, Rescue Lake, Lake Ninevah and Woodward Reservoir are the largest bodies of water in Basin 10, each being at least 100 acres in area.

Wetland Communities

A review of the Vermont Significant Wetland Inventory Maps for the Black River and Ottauquechee River watersheds reveals that the predominant wetland type is shrub swamp, a rather common wetland community type. The dominant shrub species in these wetlands are alders and willows. In general, the wetlands in Basin 10 are relatively small in size with few areas that are large wetland complexes. There are many man-made ponds scattered throughout the Ottauquechee watershed, making them perhaps the second most common wetland type.

The largest wetland complex in the basin is found along the Ottauquechee River in the town of Killington. From its headwaters almost to the West Bridgewater town line, the river flows through five and one half miles of shrub swamp and emergent marsh. Even though there has been encroachment in various spots along its length, and invasive exotic plants (purple loosestrife and phragmites) have colonized some areas, the wetland complex is highly important to protect water quality, control erosion, store flood and stormwater, and provide open space, and wildlife and fish habitat. Other isolated large swamp complexes are found in the towns of Cavendish and Weathersfield. Little is known about these swamps, and a field inventory would be needed for more information.

Developed areas of the basin follow the major road ways: routes 100, 131, 106, and 11, which follow the Black River from Plymouth to Springfield. Routes 100 and 4 follow the Ottauquechee from Killington to Hartland. Consequently, most of the wetland projects reviewed by the Vermont Department of Environmental Conservation (DEC) Wetlands Office staff have been concentrated along these corridors. Within the last few years, there has been very little known loss of wetland area or loss of wetland function and values in this basin. Projects have involved mostly buffer encroachment or disturbance to Class Three wetlands. Most of the wetland loss in the Black River watershed has been associated with the Okemo golf course and ski area expansion. However, known functions have been maintained, and critical wetlands along the Black River have been protected as has a vernal pool as part of the Okemo golf course project. The vernal pool was monitored in Spring of 2000 to assess its biological health before the golf course opened. Projects in the Ottauquechee watershed have been primarily pond projects, projects in buffer zones, or minor direct impacts for property access.

Beaver-human conflicts have been numerous in the North Springfield area, both along Route 106 north of the village, and along Route 10 which parallels Great Brook and its alder-dominated swamps. The protocols outlined in the draft best management practices (BMPs) for beaver management have been useful in dealing with some of these situations; other situations have been problematic when dams were removed improperly.

Fisheries of Basin 10

The fishery of the Ottauquechee River and its tributaries

The Vermont Department of Fish and Wildlife (VDFW) has conducted trout population surveys of the Ottauquechee River mainstem since 1982. These surveys are the source of the information below. The very uppermost station surveyed on the Ottauquechee River (at elevation 1260) supports a relatively low density population of brook trout in contrast with other Vermont streams of similar size and elevation. Brown trout and rainbow trout were first observed just below this station at elevation 1180. From this station downstream to elevation 1055 (junction of Routes 4 & 100), the trout population includes brook and brown trout with lower numbers of rainbow trout. Trout populations in this reach are moderate, and reflect the highest levels observed in the Ottauquechee mainstem from the sampling. Trout population sampling conducted below this area, from elevation 1010 to 740, revealed relatively low populations of brown and rainbow trout, although brook trout were also observed. Trout populations and habitat were also investigated in this reach by a private consultant in 1983 for the John Wheelock Titcomb Ottauquechee River Restoration organization. That study concluded that trout abundance in this reach is probably limited by temperature and physical habitat. The river channel is very wide and shallow in this stretch, which promotes solar heating and elevated temperatures and provides poor instream cover for trout.

The size and depth of the river below Woodstock are too great to permit trout population estimates. A series of dams and impoundments, including Taftsville, Simon Pierce, Deweys Mills, North Hartland and White Current, have had an impact on water quality, physical instream habitat and fish movement in varying degrees. In some reaches where the river is not influenced by instream impoundments, physical habitat for trout appears good and there is anecdotal evidence from anglers that “pocket populations” of trout provide good fishing opportunities. This is the case for the following reaches: Woodstock Village to the sewage treatment plant, Taftsville Dam to the Quechee Lakes golf course and the Quechee Gorge.

Vermont Department of Fish and Wildlife survey data confirms trout reproduction on the mainstem as far downstream as the Lincoln Covered Bridge in Woodstock (elevation 735). Surveys below this elevation have been limited due to river size. Trout reproduction in these lower unsurveyed areas should not, however, be ruled out. Trout spawning is also known to occur on Babcock, Barnard, Broad, Curtis Hollow, Falls, Happy Valley, Harlow, Kedron, Kent Pond, North Branch, Roaring, Whitman and Reservoir Brooks based on VDFW survey data.

Black River fishery

The Black River main stem supports populations of Atlantic salmon, brown trout, rainbow trout, and brook trout. The distribution and abundance of individual species in the river is dictated by environmental factors (e.g., water temperature) and fishery management activities (e.g., stocking). Much of the Black River main stem, such as downstream of Cavendish to the Connecticut River, must be classified as largely marginal habitat for wild trout populations and even for sustaining stocked fish through the year. Summer water temperatures in this portion of the river frequently exceed 27°C, the upper limit for even the most temperature tolerant trout species. Consequently, large sections of the lower Black River are unable to support trout on a sustainable basis except in localized areas, such as at ground water seeps or at the mouths of cold water tributaries. Unlike trout, Atlantic salmon are more tolerant of warm water temperatures and appear to thrive in the Black River, especially above North Springfield Reservoir. Despite less than optimal habitat conditions for trout, the Black River every now and again yields trophy size brown trout. The river, particularly downstream of Springfield, is frequented by smallmouth bass and other warmwater fishes.

Above Cavendish, habitat for trout improves somewhat with wild populations of brown and brook being more abundant, although habitat is generally less than optimal for salmonids and thermal conditions are still harsh. The only portion of the Black River main stem supporting a sizable wild rainbow trout population is located above Amherst Lake in Plymouth. Other small populations can be found in some tributaries. Sections of the main stem are stocked annually in the spring with catchable-size brown and rainbow trout to provide additional fishing recreation.

The several large lakes on the upper portion of the main stem have a negative effect on the river downstream. All of these lakes, totalling over 380 acres, have discharges of surface water which elevate river water temperatures during the summer. In addition, the river has six hydroelectric power generation facilities, one flood control project, two old mill dams, and two major population centers on the main stem which have modified the river environment.

At the present time, Atlantic salmon occur in the Black River solely as a result of annual stocking of fry into suitable juvenile nursery habitat. This stocking is being done as part of the multi-state and federal fishery agency program for the restoration of anadromous Atlantic salmon to the Connecticut River basin. Fry stocking in the Black River makes use of abundant juvenile habitat for producing salmon smolts, which will migrate out to sea and contribute to increasing adult salmon returns to the Connecticut River.

The North Branch is the largest tributary of the Black River main stem. It supports wild populations of both brook and brown trout. Brook trout are also stocked in some reaches of the North Branch. Like the main stem, much of the North Branch experiences high summer water temperatures. There are also extensive areas where streambank erosion is occurring and introduces significant quantities of sand to the stream degrading aquatic habitat.

Special Features, Uses and Values of Basin Rivers and Streams

Although many stretches of stream in the Ottauquechee River watershed and Black River watershed are likely to have some special feature or value, those briefly described below are features or special places that were identified in one or more of three state studies: *The Waterfalls, Cascades, and Gorges of Vermont* (1985), *Vermont's Whitewater Rivers* (1989) and *Vermont Swimming Hole Study* (1992).

Cavendish Gorge on the Black River in Cavendish is a large and beautifully sculptured gorge containing a series of small falls or chutes linking pools of various sizes. It is 50 to 100 feet wide at the base with sheer rock walls 50 to 80 feet high. There is a dam at the upper end of the gorge and a powerplant at the lower end.

Below Cavendish Gorge, from Whitesville to Perkinsville, there is a Class II whitewater run that includes a short stretch of Class III water. The run is approximately seven miles long and has a lot of rocks and holes and some interesting ledges and waves. The stretch has been described as a "fine, varied beautiful whitewater run of medium difficulty, widely known to boaters and receiving considerable use."

Buttermilk Falls is on Branch Brook (Black River watershed) in Ludlow and consists of a series of three falls with a large, shallow pool below each. There are a lot of sunny cobble and gravel shores and this stretch of stream is a popular swimming and bathing area.

Quechee Gorge on the Ottauquechee River in Hartford is the state's longest and deepest gorge. The gorge is about a half mile long, 50 to 100 feet wide at the bottom and 200 feet wide at the top. The greatest depth is about 150 feet. It is a popular tourist stop although most visitors stay on the bridge or trails and do not go far into the gorge itself.

North Hartland Falls on the Ottauquechee River in Hartland consists of two 25 foot high cascades on either side of a rocky island below a covered bridge and dam. The area is used for swimming, fishing and as a gathering place.

Special Uses and Values of Basin Lakes and Ponds

The Vermont DEC Lake Protection Classification System is a framework within which lakes can be evaluated for their significance when compared to other lakes statewide. The system identifies unique lakes based on their wilderness status, the occurrence of scenic and natural features, the existence of very high water quality, and the presence of rare, threatened and endangered species. Several of the lakes in Basin 10 are notable in their Lake Protection Classification System ranking, or due to recent improvements in water quality.

Black Pond, Plymouth: This 20 acre private pond constitutes the headwaters of the Black River. Despite being relatively close to VT Route 100, it has a secluded feeling, and the majority of the shoreline is forested. There exists an unusual cluster of boulders on the shoreline which provide for scenery of statewide significance.

Echo Lake, Plymouth: This lake supports two rare species of watermilfoil: *Myriophyllum alterniflorum*, which was last observed in 1985, and *M. farwelli*, which was last seen in 1990.

Kent Pond, Killington: At one time, Kent Pond was characterized by poor water quality, with algae growth identified throughout the pond. However, the water in Kent Pond has improved in recent years. During an assessment performed in 1998, far better water quality conditions were observed than had been noted during prior assessments. Indeed, a sediment delta, which had been forming during the 1980's, appears to have stabilized. These observations of improved water quality are corroborated by a review of available spring phosphorus monitoring data, which show a decrease in recent years.

Woodward Reservoir, Plymouth: This impounded lake has an adjacent palustrine wetland characterized by a floating bog mat. This is a significant feature, and is rare in the Black and Ottauquechee River Basin.

Ninevah Lake, Mount Holly: This 171 acre high elevation (1,755 ft above m.s.l) lake is significant for a variety of reasons. While the lake is developed along approximately one third of its northern shoreline, the remainder is undeveloped forested land. The watershed of the lake is also completely forested. The southern portion of the lake is bordered by a 56 acre wetland. This mixed lacustrine/openwater and emergent palustrine system has significant habitat value for both wildlife and other aquatic biota. Indeed, the lakeward margins of the wetland are documented long-term loon (*Gavia immer*) nesting sites. In 1986, the rare watermilfoil *M. farwelli* and the rare pondweed *Potamogeton obtusifolius* were also observed in Lake Ninevah.

The Pogue, Woodstock: This small pond has become part of the new Marsh-Billings-Rockefeller National Historic Site, and as such is now under the protection and stewardship of the National Park Service.

Deweys Mills Pond, Quechee: This impoundment was originally created by construction of a dam on the Ottauquechee River in the early 1900s. In the 1970s, a dike was built to separate the impoundment from the river. The current 56 acre impoundment is managed specifically to support waterfowl and wildlife uses. The pond is characterized by dense macrophyte cover, with significant shallow areas.

Reading Pond, Reading: This small 22 acre pond is considered a high quality wilderness lake by the Lake Protection Classification System.

Population and Housing Growth in Basin Towns

The five towns that comprise most of the Ottauquechee River watershed experienced huge population growth rates from 1970 to 1980. The growth rates ranged from 11% in Bridgewater to 60% in Killington. The average population growth rate for the towns in the watershed from 1970 to 1980 was approximately 29%. (This is approximate because some of the towns listed are not entirely within the watershed and small portions of other towns are not included in the tables in Appendix C). The next decade, 1980 to 1990, showed a different situation with Killington experiencing a substantial drop in population (-17%), Woodstock showing a stable population, and Plymouth having the highest growth rate at 9%. The average watershed growth rate in this decade was 1%. Despite the more moderate population growth rate in the Ottauquechee watershed from 1980 to 1990, the number of housing units still increased markedly in this decade. Housing units in Woodstock increased 13%, the lowest rate of the five towns, while the housing units in Killington more than doubled with a 122% growth rate. The average growth rate for the watershed was 49% (from 4,044 units to 6,022 units).

The population growth rates in Black River watershed towns were less dramatic than those of the Ottauquechee River watershed although the rate from town to town varied widely. Ludlow's population declined 2% from 1970 to 1980 while Weathersfield and Plymouth's populations grew 24% and 43%, respectively. The average population growth rate for the watershed from 1970 to 1980 was 5%. The population declined in four of the seven watershed towns from 1980 to 1990 resulting in an average watershed population growth rate of 0.3%. Housing units, however, grew substantially in the decade 1980 to 1990. In Ludlow, where the population reportedly declined over the past two decades, the housing units increased 55% from 1980 to 1990. Vacation or second home development appears to account for the majority of this growth. The average housing unit growth for the watershed is 21% from 1980 to 1990.

Permitted Discharges

Six wastewater treatment facilities discharge treated effluent to the Ottauquechee River (Bridgewater, Taftsville, Quechee, Woodstock, Sherburne Fire District #1) or its tributaries (South Woodstock), and three wastewater treatment facilities discharge to the Black River (Springfield, Cavendish, Ludlow). Two industries and another business also have direct discharges to the Black River. There are over thirty-one permitted stormwater permits issued in the basin; some of the permits cover multiple discharges. Fifteen of the stormwater permits are for discharges in the Ottauquechee River watershed and sixteen are for stormwater discharges in the Black River watershed.

Table 1. Municipal Wastewater Treatment Facilities in Basin 10

WWTF	Permitted Flow (gallons/day)	Annual Average Flow (gallons/day)
Bridgewater	43,000	10,300
Taftsville	10,000	2,500
Quechee	300,000	154,600
Woodstock	450,000	214,100
Sherburne FD1	300,000	106,100
South Woodstock	50,000	9,100
Springfield	2,200,000	1,434,800
Cavendish	150,000	71,300
Ludlow	700,000	372,300

Dams of Basin 10

There are eighty-nine (89) dams identified in the Vermont Agency of Natural Resources dam database that are on the rivers and streams of Basin 10. Of the eighty-nine dams identified, forty-two are known to be in service, fifteen are breached, two are not in use, one has been drained, one is “deleted”, and for twenty-eight of them the status is not known. A complete list of the dams, the streams on which they are located, and their status if known, are given in a table in Appendix D.

River Water Quality or Aquatic Habitat Impacts or Threats

The Ottauquechee River is affected by a range of activities and uses from the dams and manifestations of dense human settlements (WWTFs, roads, golf courses) in the lower portion of the river to past channelization, loss of riparian vegetation and ski area water withdrawals as one progresses upstream. Loss of riparian or streamside trees and shrubs is a widespread problem for the river and its tributary streams: yards, roads, pasture, recreational areas all encroach on the riparian vegetation leaving narrow lines of trees and shrubs at the top of the banks or no buffer at all. Road maintenance practices are also a problem for the Ottauquechee tributary streams' health and integrity.

The Black River is a heavily used river with three wastewater treatment plants, many combined sewer overflows, six hydroelectric dams, a flood control dam, a number of hazardous waste sites from earlier industrial activity, and urban runoff all affecting its health. These sources of impact or threat are in addition to the effects of riparian vegetation loss, road maintenance and runoff, and development.

Following is a presentation of the identified causes (pollutants or conditions) and sources (land uses or activities) of problems for the Ottauquechee and Black Rivers water quality and the effects of these causes and sources on various designated uses of the waters.

Designated Use Support Status

There are six designated uses of rivers and streams identified in the Vermont water quality standards (dated June 10, 1999) as well as one use that the U.S. Environmental Protection Agency expects the states will track. The seven uses include aquatic biota and habitat, contact recreation (swimming, wading, tubing), secondary contact recreation (boating, fishing), aesthetics, public water supply, agricultural water supply (crop irrigation and other uses), and fish consumption. As part of the assessment process, the Vermont DEC Water Quality Division determines whether each use is fully supported, fully supported but threatened, partially supported, or not supported. Uses that are not fully supported (i.e. partially or not supported) are impaired.* To the extent possible, the Division also determines the causes and sources of the threatened, partial or non-support status.

Overall, 86% of the river miles in basin 10 fully support the designated uses while 12% of the assessed miles are partially supported and less than 2% are not supported. Roughly one-third of the miles fully supported are threatened by an identified pollutant, condition, or activity.

* In the 305(b) assessment process, partial or non-support of uses is considered an impairment of those uses. The determination of partial or non-support is made using a wide range of information and data from best professional judgement to modelling to rigorous biological monitoring. In the 303(d) listing process, a subset of the 305(b) waters identified as not fully supporting or impaired is called out. The stretches of river and stream that are partially or not supported as determined with sound and recent monitoring data (biological, chemical or physical) are those considered impaired for inclusion on the Vermont 303(d) List of

Impaired Waters. See also the section on 303(d) Listed Waters on page 23.

Aquatic biota and/or habitat is the use impaired over the greatest number of miles in Basin 10. Over twenty-nine (29.4) miles of river and stream do not fully support the aquatic community or its habitat in these two watersheds. Identified threats exist for over ninety-three (93.5) miles.

Secondary contact recreation, which is fishing in this situation, is impaired over the second greatest number of miles with 17.6 miles not fully supporting this use. Another 44 miles are threatened.

Swimming is not fully supported on at least fourteen (14.2) miles. These areas are stretches where it is known that there are numbers of *E. coli* above the standard. There are threats to the use of swimming on another forty-six (46.3) miles at least. Threats to swimming are identified where there are likely sources of pathogens discharging to the river but there are no data showing high *E. coli* levels.

Aesthetics are not fully supported on almost ten (9.8) miles and threatened on another fifty-six (56.2) miles. Stretches with turbid or oily water, algae-dominated channel bottoms, stained rocks, raw streambanks or other characteristics that are not natural or healthy are judged impaired or at least threatened for aesthetics.

Unless there are known toxics in a river or stream, drinking water and agricultural water supply uses are not assessed for use support at this time.

Table 2. Support Status of Basin 10 River and Streams Uses in Miles

Use	Degree of Use Support (miles)				
	Full Support	Threat	Partial Support	Non Support	Not Assessed
Overall	155.5	88.2	33.7	4.6	0
Aquatic biota/habitat	159.1	93.5	27.7	1.7	0
Fish Consumption	282.0	0	0	0	0
Swimming	221.5	46.3	9.9	4.3	0
Secondary Contact Recreation	220.4	44.0	16.1	1.5	0
Aesthetics	216.0	56.2	5.4	4.4	0
Drinking Water	46.0	2.4	0	1.5	232.1
Agricultural Water Supply	0	2.0	0	0	280.0

Causes and Sources of Problems and Threats to Basin 10 Rivers

The major cause of impacts to river and stream aquatic habitat in Basin 10 is flow alteration from snowmaking water withdrawals and the two flood control dams. Sedimentation is the second greatest cause of impairment but it is by far the largest threat to stream and aquatic community health. At least eighty miles of river and stream aquatic habitat are threatened by sedimentation. Bank erosion, land development, road runoff, and removal of riparian vegetation all are sources of increased sedimentation.

The presence of pathogens as indicated by *E. coli* bacteria impair the third greatest number of miles and threaten the fourth greatest number. The use affected by this pollutant is swimming. Municipal point sources and combined sewer overflows with some agricultural land use activities are the sources of the bacteria and pathogens.

Thermal modifications and nutrients are responsible for documented problems on a handful of miles but these two causes also threaten many miles (45-50 miles identified). Loss of riparian vegetation, developed land runoff, and water held behind dams result in thermal modifications.

The wastewater treatment facilities, developed land runoff, and agricultural land runoff result in nutrient inputs to surface waters. Other problems listed below include organic enrichment as well as habitat alterations from channelization work in past years.

Tables 3 and 4 below list the causes and sources of either impairments or threats to the rivers and streams of Basin 10.

Table 3. Causes of Impacts or Threats to Basin 10 Rivers and Streams

Causes of Impacts or Threats	Degree of Impact or Threat (in miles)			
	High	Moderate/Minor	Total	Threat
Flow Alterations	17.3	3.2	20.5	9.5
Sediments	6.2	5.8	12.0	79.8
Pathogens	6.0	5.8	11.8	33.5
Thermal Modifications	0	6.1	6.1	49.1
Nutrients	0	5.8	5.8	46.6
Organic Enrichment/Low D.O.	0	5.0	5.0	21.5
Habitat Alterations	0	1.5	1.5	14.0

Table 4. Sources of Impacts or Threats to Basin 10 Rivers and Streams

Sources of Impact or Threat	Degree of Impact or Threat (in miles)			
	High	Moderate/Minor	Total	Threat
Flow Regulation/Alteration	17.3	4.1	21.4	0
Bank Erosion	0	6.5	6.5	27.2
Land Development	5.2	0	5.2	58.3
Recreation Activities	6.5	0	6.5	5.5
Upstream Impoundment	1.0	4.1	5.1	0
Highway/Road/Bridge Runoff	0	2.8	2.8	59.3
Municipal Point Sources	0	2.8	2.8	22.0
Removal of Riparian Vegetation	0	2.0	2.0	56.7
Channelization	0	1.5	1.5	28.0
Agriculture	0	0	0	25.7
Developed Land Runoff	0	0	0	11.6

Lake Water Quality and Aquatic Habitat Impairments and Threats

There are 49 lakes and ponds in the Black and Ottawaquechee Rivers watersheds, comprising 1807 acres. Of the total 1807 acres, 1,755 of these have been assessed. Of the 1,755 assessed acres, 1,468 acres are monitored, while 287 acres are evaluated.

Only five lakes out of the thirty-nine assessed are identified as having partial or non-support of some uses. The two 'lakes' whose acres are in the non-support category are actually flood control reservoirs.

Designated Use Support

A total of 1,068 lake and pond acres in Basin 10 support all designated uses. There are 505 lake acres (29%) in Basin 10, which do not support one or more uses, and 182 acres (10%) which partially support one or more uses. Table 5 provides an accounting of lake acres which support, threaten or do not fully support designated uses.

Table 5. Support Status of Basin 10 Lake Uses in Acres.

Use	Full Support	Threatened	Partial Support	Non Support	Not Assessed
Overall Uses	908	160	182	505	10
Aesthetics	1002	228	10	505	10
Aquatic Life Use Support	757	301	182	505	10
Agricultural Water Supply	0	0	0	0	1755
Drinking Water Supply	0	0	0	0	10
Fish Consumption	1745	0	0	0	10
Filtered Water Supply	0	0	0	0	1755
Industrial Water Supply	0	0	0	0	1755
Secondary Contact Uses	1003	227	10	505	10
Swimming Uses	998	232	10	505	10

Causes and Sources of Problems and Threats to Basin Lakes

The principal cause of impacts to lakes in Basin 10 is flow alteration, which affects several uses on two flood control facilities as discussed below. Critically low pH of several lakes and ponds impairs 171 lake acres, and threatens an additional 145 lake acres. The presence of exotic species causes impacts to 11 lake acres. Table 6 lists the causes of impacts to lakes in this basin.

Table 6. Causes of Impacts or Threats to Basin 10 Lakes

Cause of Impact	Magnitude of Impact (acres)			Total Acres Not Fully Supporting	Total Acres Threatened
	High	Moderate	Minor		
0500 Metals	365	0	0	365	0
0560 Mercury	365	0	0	365	0
0900 Nutrients	0	0	0	0	123
1000 pH	171	0	0	171	145
1100 Siltation	0	0	0		132
1500 Flow alteration	505	0	0	505	0
2200 Noxious aquatic plants - Native	0	0	0	0	123
2210 Noxious aquatic plants - Algae	0	0	0	0	128
2600 Exotic Species	11	0	0	11	208

The major sources of these impairments are flow regulation/modification, which precludes support of 505 acres, and atmospheric deposition, which impairs 536 acres and threatens 145 acres, respectively. Table 7 summarizes the sources of impacts to designated uses in the Black and Ottawaquechee Rivers Basin.

Table 7. Sources of Impacts or Threats to Basin 10 Lakes

Source of Impact	Magnitude of Impact (acres)			Total Acres Not Fully Supporting	Total Acres Threatened
	High	Moderate	Minor		
3000 CONSTRUCTION	0	0	0	0	132
3100 Highway/Road/Bridge Construction	0	0	0	0	4
3200 Land Development	0	0	0	0	132
7000 HYDROMODIFICATION	505	0	0	505	0
7400 Flow Regulation/Modification	505	0	0	505	0
7600 Removal of Riparian Vegetation	0	0	0	0	19
7900 MARINAS and BOATING	10	0	0	10	208
7910 In-Water releases	10	0	0	10	208
8100 ATMOSPHERIC DEPOSITION	536	0	0	536	145
8300 ROAD MAINTENANCE /RUNOFF	0	0	0	0	123
8600 NATURAL SOURCES	171	0	0	171	145

To provide background information on individual lakes in this basin, a summary of overall use support by individual lake is provided in Table 8. The majority of lakes in the basin are considered monitored, meaning that some new water quality data, in addition to any observational or other information, is available from within the past five years.

Table 8. Overall Use Support by Individual Lake in Basin 10

Lake Name	Lake Area (ac)	Last Assessed (YYYYMM)	Assessment Type	Acres Fully Supporting	Acres Partially Supporting	Acres Not Supporting
AMHERST	81	199904	Monitored	81	0	0
BLACK (PLYMTH)	20	199904	Monitored	20	0	0
CARLTON	4	199904	Evaluated	4	0	0
COLBY	20	199904	Evaluated	20	0	0
COOK	3	199904	Monitored	3	0	0
COX	2	199904	Evaluated	2	0	0
CRYSTAL (HARTLD)	2	199904	Evaluated	2	0	0
DEWEYS MILL	56	199910	Evaluated	56	0	0
ECHO (PLYMTH)	104	199812	Monitored	104	0	0
GRAHAMVILLE;	8	199909	Evaluated	8	0	0
JEWELL BK #1;	14	199904	Evaluated	14	0	0
JEWELL BK #2;	17	199904	Evaluated	17	0	0
JEWELL BK #3;	18	199909	Evaluated	18	0	0
KENT	99	199912	Monitored	89	10	0
KNAPP BROOK #1	25	199909	Monitored	25	0	0
KNAPP BROOK #2	35	199904	Monitored	35	0	0
LAKOTA	20	199904	Monitored	20	0	0
LOWER MOORE	5	199904	Evaluated	5	0	0
MECAWEE	11	199909	Evaluated	11	0	0
NINEVAH	171	199904	Monitored	0	171	0
NORTH HARTLAND	215	199910	Monitored	0	0	215
NORTH SPRINGFIELD	290	199912	Monitored	0	0	290
PICO	12	199904	Evaluated	12	0	0
PINNEO	50	199909	Monitored	50	0	0
READING	22	199904	Monitored	22	0	0
RESCUE	180	199904	Monitored	180	0	0
RESERVOIR	32	199904	Evaluated	32	0	0
SOUTH MECAWEE;	2	199909	Evaluated	2	0	0
SPOONERVILLE;	8	199904	Evaluated	8	0	0
SPRINGFIELD	10	199904	Evaluated	0	0	0
STOUGHTON	56	199912	Monitored	56	0	0
THE POGUE	11	199904	Monitored	11	0	0
TINY	29	199904	Evaluated	29	0	0
UPPER MOORE	3	199904	Evaluated	3	0	0
VIEW	4	199904	Evaluated	4	0	0

Table 8. Overall Use Support by Individual Lake in Basin 10

Lake Name	Lake Area (ac)	Last Assessed (YYYYMM)	Assessment Type	Acres Fully Supporting	Acres Partially Supporting	Acres Not Supporting
VONDELL	10	199904	Evaluated	10	0	0
WOODWARD	106	199912	Monitored	105	1	0

The following paragraphs describe the most important impacts and threats to specific Basin lakes.

Colby Pond, Plymouth: This small 20 acre pond was assessed in the mid-1980's. At that time, its low alkalinity of less than 12.5 mg/l (as CaCO₃) was determined to threaten aquatic life uses on the pond. Further assessment of the present acidification status of this pond is needed.

Echo Lake, Plymouth: This 104 acre recreational lake has experienced significant shoreline development in the past decade. At last count, there were 34 houses within 100 feet of the shoreline, many of which have unbuffered shorelines. While water quality remains good and stable as measured by the spring phosphorus sampling (mean spring total phosphorus is 7 ug/l), the level of development on Echo Lake poses a threat to this high quality. Correspondingly, aesthetic, swimming, boating, and aquatic life uses are considered threatened for the lake's entire acreage. This lake has a coldwater fishery including lake trout.

Kent Pond, Killington: This 99 acre lake has a 10 acre infestation of Eurasian watermilfoil. As the infestation in these acres is very dense, aesthetics, swimming, boating, and aquatic life uses are only partially supported.

Knapp Brook Ponds 1 and 2, Cavendish: These two undeveloped ponds (25 and 35 acres) are characterized by alkalinity values below 12.5 mg/l (as CaCO₃). Correspondingly, due to acid sensitivity, aquatic life uses are considered threatened for the full acreage of each lake.

Ninevah Lake, Mt. Holly: This 171 acre lake is characterized by an alkalinity of less than 12.5 mg/l (as CaCO₃). Aquatic life uses are considered partially supported for the entire lake acreage due to acid sensitivity.

North Hartland Reservoir, Hartland: This 215 acre flood control reservoir is operated by the U.S. Army Corps of Engineers. Due to extreme water level fluctuations which result from the reservoir's operations, aquatic life uses are not supported.

North Springfield Reservoir, Springfield: This 290 acre flood control reservoir is operated by the U.S. Army Corps of Engineers. Due to extreme water level fluctuations which result from the reservoir's operations, aquatic life uses are not supported.

Reading Pond, Reading: This small 22 acre pond was assessed in the mid-1980's. At that time, its low alkalinity of less than 12.5 mg/l (as CaCO₃) was determined to threaten

aquatic life uses on the pond. Further assessment of the present acidification status of this pond is needed.

Rescue Lake, Plymouth: Eurasian watermilfoil was found in this lake in 1998. Presently, the infestation is categorized by the Vermont DEC Water Quality Division as light. Correspondingly, 36 of the lakes 180 acres are considered threatened for aesthetic, aquatic life, boating, and swimming uses. Rescue Lake has a coldwater fishery.

303(d) Listed Waters in Basin 10

There are six separate segments of river and stream and one wetland in five different waterbodies on the EPA-approved 1998 Vermont List of Impaired Surface Waters (the Clean Water Act section 303(d) list). Waters that are included on this list are a subset of the waters described elsewhere in this report as impaired or not fully supporting their uses. The 303(d) listed waters are those determined to be impaired based on data from biological, chemical and/or physical monitoring work. The listed river or stream segments include the East Branch Roaring Brook (10-06), Roaring Brook (10-06), the Black River near the mouth (10-11), the Black River near Ludlow (10-14), Soapstone Brook (10-14) and a tributary to Jewell Brook (10-14). The wetland is located adjacent to an unnamed tributary to the Ottauquechee River in Bridgewater (10-04). All miles of river and stream are impaired for fish consumption due to mercury. For the causes of impairment and status of the problems on these stretches, see the approved 1998 303(d) list available from the Water Quality Division.

There are no lakes from Basin 10 on the 1998 303(d) list.

Specific Projects or Water Quality Protection Efforts in the Basin

Killington/Pico Upland Stream Study

A four year study is being conducted from 1997 through 2000 by a consulting firm for Killington, Ltd. to “quantify biologic and hydrologic impacts to Class A water from upland ski trail and lift construction.” The streams being evaluated include Pico Pond Inlet, Roaring Brook, Kent Brook tributary, North Fork of Madden Brook, Rams Head, Carpenter Brook, Falls Brook and Falls Brook tributary in the Ottauquechee River watershed; Tinker East in the Black River watershed; and Sargent Brook and Pico West in the Otter Creek watershed. The study is evaluating the following parameters and conditions: stream chemistry, water temperature, stream morphology, land use, hydrology and aquatic biota in 11 streams between elevation 2,300 and 2,600 feet. A full report with the data and an evaluation of the data is expected in Spring 2001.

North Hartland Reservoir Phosphorus Study

In August and September 1997, the U.S. Army Corps of Engineers (ACOE) noticed signs of nutrient enrichment in the upper reaches of North Hartland Reservoir: “billowing clouds of the filamentous algae *Oedogonium* were in the water column and covering vegetation.” In fiscal year 1998 (October 1, 1997 - September 30, 1998), the ACOE began collecting

samples upstream of the area it had sampled in the past; however, laboratory errors made all the samples from FY98 and the initial samples from FY99 invalid. Following identification of the laboratory errors, the phosphorus numbers from the samples were high but not unrealistically high as they had been previously reported. The Vermont DEC Water Quality Division plans to work with the ACOE to continue investigating the enrichment problem at North Hartland and find ways to address it.

Barnard Brook Watershed Mapping Project

The Two River/Ottawaquechee Regional Planning Commission has done a land use/land cover analysis and map for the Barnard Brook watershed. Following production of the map, the Commission held a public meeting to solicit comments about the brook's special areas, threats and obvious problems. The Vermont DEC Water Quality Division has and will be following up on issues, comments, and questions raised at the meeting. The Water Quality Division will also use the mapping project's results in its larger Ottawaquechee Basin Planning Process.

Town of Barnard Wetland Protection Work

The Barnard Conservation Commission has been concerned about potential impacts to wetlands within its town. The Commission especially wants to protect those significant wetlands that are not well protected by the State of Vermont (Class Three wetlands) and provide better protection to Class Two wetlands. The Commission has been drafting a section entitled "Wetlands Overlay Area" for addition to their zoning regulations.

Black River Contact Recreation Use Study

In the summer of 1999, the Southern Windsor County Regional Planning Commission (SWCRPC) completed a study of contact recreational use (swimming, wading, bathing) of the Black River between the Ludlow Wastewater Treatment Facility (WWTF) and the Cavendish WWTF. The Regional Planning Commission staff developed an inventory of swimming areas based on interviews and public meetings. Staff then counted swimmers at these areas on three sunny Saturday afternoons. The report found that on the swimming hole just above the Cavendish WWTF was very popular as were several swimming holes on Twentymile Stream.

Southern Windsor County Water Quality Plan

In 1999 and 2000, the SWCRPC updated the map of uses and threats to surface waters in southern Windsor County and produced a report which synthesizes planning and assessment work completed on surface waters in the region to date. Recommendations for future projects on the Black River generated at public meetings include: starting a watershed group on the Black River; developing an ongoing monitoring program to educate people about swimming conditions; and continuing to look at erosion and urban runoff issues. Recommendations for the North Branch of the Black River include completing an erosion study and following up on water quality issues on Stoughton Pond.

Discussion and Recommendations

The dominant threats and impacts to water quality and aquatic habitat in Basin 10 identified during this assessment process are discussed below. Some initial recommendations for state, regional or local agencies, organizations, or programs are also presented - recommendations that will result in some immediate protection or restoration of the surface waters in the two major watersheds of this basin. These are considered initial recommendations, however, because they will be developed further during the basin planning process - a process, which has an important public participation component. Nonetheless, there are actions that state, regional, and local entities can take now based on the assessment findings and these are identified in italics in the paragraphs below.

Instream/Onstream Concerns

The issues and problems in the Ottauquechee River watershed and the Black River watershed are not unlike those in many other watersheds in Vermont. However, in these two watersheds, instream and onstream sources cause the primary impacts on, and threats to, water quality and aquatic habitat. These instream and onstream sources include combined sewer overflows, municipal wastewater treatment facility discharges, flow alterations, and dams for hydroelectric use, recreational impoundments, flood control, and other purposes. Eighty-nine dams are identified in the basin, which is the third highest number of dams per basin out of the seventeen Vermont basins. In addition, the Black River has two substantial population centers located on it, Springfield and Ludlow, with the resulting containment and channelization of the river and its tributaries through these urban areas. Woodstock has an impact on the Ottauquechee River and tributaries in a similar manner.

Ludlow and Springfield are in the process of developing applications to expand their wastewater treatment facilities on the Black River and, as part of each expansion, phosphorus removal capabilities are proposed. The phosphorus removal should reduce the nutrient enrichment problems identified in the stretches below the plants. *The State should continue to provide technical assistance and funding to Springfield and Ludlow as they pursue phosphorus removal at their wastewater treatment facilities.*

Land Runoff Concerns

The same land runoff problems and threats that dominate in other Vermont watersheds are a secondary, but critical issue in these two watersheds. Springfield, Ludlow, and Woodstock are population centers that result in polluted runoff, which comes from a relatively high concentration of impervious surface. Additionally, both watersheds have ski

resorts in their steep, upper reaches and both resorts have expansion plans. In the suburban and rural portions of the watersheds, gravel road runoff, loss of riparian vegetation due to yards, pasture, and recreational activities, and scattered housing development all cause impacts or pose threats to water quality and aquatic habitat.

The Killington Ski Resort is in the Ottauquechee River watershed and Okemo Mountain Resort is in the Black River watershed. The former affects the tributary streams and the Ottauquechee with snowmaking water withdrawals as well as the land clearing and development of trails and residential units. Okemo, which is smaller, affects tributaries to the Black River due to land development. Both ski resorts have developed master plans and, as a part of that process, are implementing water quality studies. The four year study mentioned earlier is being done on upland streams in the area of the Killington ski resort. The results will lead to a more definitive picture of what ski area activities are having an impact on upland stream aquatic habitat and integrity and how to avoid or mitigate those impacts. The Okemo Jackson Gore development proposal also has a water quality monitoring plan. *Results from the various ski area water quality studies should be evaluated and summarized and used to protect these and other streams in appropriate forums and regulatory processes.*

Runoff from roads, sedimentation from road maintenance practices, and loss of riparian vegetation along roads are significant threats to basin rivers and streams and especially those in the Ottauquechee River watershed. The problem is both a state and local issue. *The State should be careful to set a good example with its road and bridge construction and maintenance projects. The State also needs to review its vegetation management practices when the work is within 50 feet of a river or stream.* Municipalities and their road crews need to know the availability of best management practice guidance, technical assistance, training opportunities, and grants for road projects. *The State, regional planning commissions, watershed groups, local commissions or a partnership of groups should take the lead in education efforts for town road crews.*

Both watersheds in the basin experienced substantial development of new housing in the decade 1980 to 1990: the Ottauquechee River watershed housing unit growth rate was 49% (4,044 units to 6,022 units). The Black River watershed growth rate was 21% (8,447 units to 10,185 units) in the same period. Housing unit growth is a good indicator of threats and possible impacts to surface waters because of the soil exposure, change in topography and drainage, and loss of vegetation. The towns in Basin 10 need to have strong, clear town plan goals and zoning regulations that protect surface waters and riparian habitats to prevent further impacts from housing unit additions. Local setback and buffer requirements along rivers, streams, lakes, and ponds is a critical first step for water quality protection. *The State or the regional planning commission should review the effectiveness of current plans and zoning and offer planning and zoning technical assistance to watershed towns.* The priority should be those towns with the fastest housing unit growth.

High temperatures are a problem for the fishery on both the Black and Ottauquechee

Rivers due to the loss of riparian vegetation and alterations to the river channels and flow. *The State along with a local fishing or watershed organization should identify priority areas for buffer re-establishment and habitat enhancement.* An appropriate starting place might be Kedron Brook - a key tributary where buffers are few or lacking.

The Army Corps of Engineers (ACOE), as part of the National Environmental Policy Act (NEPA) process, is currently updating the Environmental Assessments done in the 1970's for their flood control reservoirs. The ACOE will review the operation of North Springfield Reservoir and North Hartland Reservoir as part of this update process.

The focus of the basin water quality and aquatic habitat assessments has been to identify and describe problems and threats. The DEC Water Quality Division is working to include more identification and description of high quality waters so we afford protection to these waters through the appropriate classification.

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Appendix A
Land Use and Land Cover
Basin 10 Watersheds

Table A.1. Land Use/Land Cover of the Ottawaquechee River Watershed (1997)

Land Use¹	Acres	% of Total
Forested	124,093	86
Agriculture	7,139	5
Transportation	5,860	4
Surface Water	4,099	3
Wetlands	1,106	1
Developed Land ²	1,938	1
Total:	144,235	100

Table A.2. Land Use/Land Cover of the Black River Watershed (1997)

Land Use	Acres	% of Total
Forested	161,375	75
Agriculture	22,609	10
Transportation	9,906	5
Surface Water	9,512	4
Wetlands	7,395	3
Developed Land	5,145	2

1 Doesn't include "brush or transitional land" or "barren land"

2 Developed land = residential, commercial, industrial, all but transportation

Total:	215,942	99
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Appendix B
Stream Macroinvertebrate Sample Sites
Results Since 1992

Table B.1. Basin 10 River or Stream Macroinvertebrate Sampling Sites (1992 - 1999)

Id #	Stream or River Name	Town	Mile-point	Date	Assessment
VT10-05	Ottauquechee River	Bridgewater	27.5	10/15/92	excellent
VT10-06	Roaring Brook	Sherburne	1.4	10/15/92	fair
VT10-06	Roaring Brook	Sherburne	1.4	10/02/97	fair
VT10-06	East Trib Roaring Brook	Sherburne	0.5	8/29/95	fair
VT10-07	Kedron Brook	Woodstock	5.2	10/13/94	excellent
VT10-11	Black River	Springfield	2.4	9/17/92	good
VT10-11	Black River	Springfield	2.4	10/03/95	good
VT10-11	Black River	Springfield	2.4	10/08/97	good
VT10-11	Black River	Springfield	2.4	9/13/99	good-
VT10-14	Black River	Ludlow	25.3	9/01/99	good-
VT10-14	Black River	Ludlow	25.6	9/01/99	good
VT10-14	Black River	Ludlow	25.8	9/01/99	good
VT10-15	Black River	Plymouth	36.4	10/15/92	good

Appendix C
Population and Housing Data
for Basin 10 Watersheds Towns

Table C.1. Population Data for Ottauquechee River Watershed Towns*

Town	1970 Population	1980 Population	Change 1970-1980	1990 Population	Change 1980-1990
Woodstock	2,603	3,214	23%	3,212	0%
Pomfret	620	856	38%	874	2%
Bridgewater	783	867	11%	895	3%
Plymouth	283	405	43%	440	9%
Killington	558	891	60%	738	-17%
Total	4,847	6,233	29%	6,159	1%

Table C.2. Housing Data for Ottauquechee River Watershed Towns*

Town	1980 Housing Units	1990 Housing Units	Change 1980-1990
Woodstock	1,548	1,755	13%
Pomfret	404	490	21%
Bridgewater	486	571	17%
Plymouth	495	736	49%
Killington	1,111	2,470	122%
Total	4,044	6,022	49%

*Towns whose land area is completely or substantially within the watershed

Table C.3. Population Data for Black River Watershed Towns*

Town	1970 Population	1980 Population	Change 1970-1980	1990 Population	Change 1980-1990
Springfield	10,063	10,190	1.3%	9,579	-6%
Baltimore	170	181	6%	190	5%
Weathersfield	2,040	2,534	24%	2,674	6%
Cavendish	1,264	1,355	7%	1,323	-2%
Ludlow	2,463	2,414	-2%	2,302	-5%
Plymouth	283	405	43%	440	9%
Reading	564	647	15%	614	-5%
Total	16,820	17,726	5%	17,122	0.3%

Table C.4. Housing Data for Black River Watershed Towns*

Town	1980 Housing Units	1990 Housing Units	Change 1980-1990
Springfield	4,076	4,256	4%
Baltimore	78	88	13%
Weathersfield	1,069	1,249	17%
Cavendish	649	785	21%
Ludlow	1,726	2,677	55%
Plymouth	495	736	49%
Reading	354	394	11%
Total	8,447	10,185	21%

*Towns whose land area is completely or substantially within the watershed

Appendix D
Dams in Basin 10

Table D.1. Dams on Rivers and Streams in Basin 10

Dam Name	Stream	Town	Status	Use*	Built	Re-built	State ID
Rockefeller	Woodward Reservoir	Plymouth	In Service	R	1970		156.07
Mirror Lake	Roaring Brook	Killington	In Service	O	1973	1990	188.06
Snowshed Pond	Roaring Brook TR	Killington	In Service	O	1970	1993	188.07
Gray Camp Pond	Barnard Brook-TR	Barnard	Unknown				11.02
Klose	Barnard Brook - TR	Barnard	In Service	R	1968		11.03
Sonnenberg Ski Area	Barnard Brook-TR	Barnard	Unknown		1969		11.04
The Pogue	Barnard Brook TR	Woodstock	In Service	R	1895	1990	254.08
Billings Pond	Barnard Brook	Woodstock	In Service	R	1890		254.01
Upper Moore Pond	Pinney Hollow Brook	Plymouth	In Service	R	1974	1987 .	156.04
Pinney Hollow Brook	Pinney Hollow Brook	Plymouth	Drained				156.09
Mecawee Pond	Broad Brook- TR	Reading	In Service	R	1920	1978	163.01
Lakota Lake	Richmond Brook	Barnard	In Service	R	1891	1983	11.05
Johnson	Ottauquechee River	Killington	Unknown	R	1965		188.08
Woodward Reservoir	Reservoir Brook	Plymouth	In Service	R	1983		156.01
Cox Reservoir	Ottauquechee River	Woodstock	In Service	S	1930		254.03
Carlton Reservoir	Ottauquechee River	Woodstock	Unknown	S	1948		254.04
Taftsville	Ottauquechee River	Woodstock	In Service	H	1905	1910	254.05
Deweys Pond	Ottauquechee River	Hartford	In Service	RO	1973		94.07

North Hartland	Ottauquechee River	Hartland	In Service	RC	1961		95.01
Dam Name	Stream	Town	Status	Use	Built	Re-built	State Id
White Current	Ottauquechee River	Hartland	In Service	H	1900	1988	95.05
Crystal Pond	Happy Valley Brook	Hartland	Unknown				95.08
Jewel Brook Site No. 1	Jewell Brook	Ludlow	In Service	C	1969		117.07
Jewel Brook Site No. 2	Grant Brook	Ludlow	In Service	C	1969		117.06
Jewell Brook Site No. 3	Jewell Brook-TR	Ludlow	In Service	CR	1970		117.12
Jewel Brook Site No. 3	Parker Brook	Ludlow	In Service	CR	1970		117.04
Jewel Brook Site No 5	Sanders Brook	Ludlow	In Service	C	1972		117.05
Okemo Snow Pond	Black River -OS	Ludlow	In Service	R	1994		117.13
Reservoir Pond	Black River	Ludlow	In Service	R	1920	1978	117.02
Lake Ninevah	Patch Brook	Mount Holly	In Service	R	1920		135.01
Black Pond	Black River	Plymouth	In Service	R	1897	1952	156.02
Amherst Lake	Echo Lake-TR	Plymouth	In Service	R	1950		156.05
Colby Pond	Twenty mile Stream	Plymouth	In Service	R	1959		156.06
Martin	Cloudland Brook -T	Pomfret	In Service	R	1969	1988	157.02
Reading Pond	Reading Pond Brook	Reading	Breached				163.02
Pico Pond	Kent Pond-TR	Killington	Unknown				188.17
Kent Pond	Kent Brook	Killington	In Service	R	1965		188.09
Sunrise village Lagoon	Falls Brook-TR	Killington	Unknown		1983		188.15
Lake Rescue	Black River	Ludlow	In Service	RS	1978		117.01
North Springfield	Black River	Springfield	In Service	CR	1960		194.01
Fellows	Black River	Springfield	Not in Use	H	1900	1936	194.02

Gilman	Black River	Springfield	In Service	H	1913		194.03
Slack (Lower)	Black River	Springfield	In Service	H			194.05
Dam Name	Stream	Town	Status	Use	Built	Re-built	State id
Lovejoy	Black River	Springfield	Unknown	H	1912		194.06
Cavendish	Black River	Cavendish	In Service	H	1907		44.01
Muckcross	Black River-TR	Springfield	In Service	R	1900		194.08
Carey	Black River-TR	Springfield	In Service	R	1968		194.12
Knapp Brook Site No. 1	Knapp Brook	Cavendish	In Service	R	1958		44.04
Knapp Brook Site No 2	Knapp Brook	Cavendish	In Service	R	1961		44.05
Stoughton Pond	North Branch Black	Weathersfield	In Service	R	1960		229.01
Widow Hill	North Branch Black	Cavendish	Unknown				44.06
Line Pond	Barnard Brook - TR	Barnard	Deleted				11.06
Bridgewater Woolen Mill	Ottauquechee River	Bridgewater	Breached	O	1936		28.01
Murdock	Black River	Cavendish	Breached				44.02
Kenwood Mills	Black River	Cavendish	Breached				44.03
Gay Bros.	Black River	Cavendish	Breached				44.08
Parker Bros.	Black River	Cavendish	Breached				44.09
Black Bear Woolen Co.	Black River	Cavendish	Breached				44.10
Quechee Mills	Ottauquechee River	Hartford	In Service	O	1900		94.01
Deweys Mills	Ottauquechee River	Hartford	In Service	H	1900		94.02
Hartland	Ottauquechee River	Hartland	Unknown				95.06
Village	Black River	Ludlow	Breached				117.03
Verd Mont Mills	Black River	Ludlow	Breached				117.08
American Woolen Co.	Black River	Ludlow	Breached				117.09

Smithville	Black River	Ludlow	Unknown				117.11
Grist Mill	North Branch Black	Reading	Unknown				163.07
Dam Name	Stream	Town	Status	Use	Built	Re-built	State Id
Lower Moore Pond	Pinney Hollow Brook	Plymouth	Unknown	R	1974		156.03
Plymouth - 8	Patch Brook - TR	Plymouth	Unknown				156.08
Sherburne - 5	Kent Pond - TR	Killington	Unknown				188.05
Chevalier	Ottauquechee River	Killington	Unknown				188.10
Briggs	Ottauquechee River	Killington	Breached				188.11
Sherburne - 12	Ottauquechee River	Killington	Breached				188.12
Sherburne - 14	Reservoir Brook - TR	Killington	Unknown				188.14
Bear Pond	Falls Brook - TR	Killington	Unknown				188.16
Springfield - 9	Black River - TR	Springfield	Unknown				194.09
Springfield - 10	Black River - TR	Springfield	Unknown				194.10
Springfield - 11	Black River - TR	Springfield	Unknown				194.11
Powerhouse	Black River	Springfield	Breached				194.13
Vermont Snath	Black River	Springfield	Breached				194.14
Slack (Upper)	Black River	Springfield	Unknown				194.15
Springfield Reservoir	Black River - TR	Weathersfield	Not in Use	SO	1903	1970	229.02
Soapstone	Black River	Weathersfield	Unknown				229.03
Perkinsville	Black River	Weathersfield	Unknown				229.04
Amsden	North Branch Black	Weathersfield	Unknown				229.05
Tolles Hill	Black River	Weathersfield	Unknown				229.06
Vondell Reservoir	Vondell Brook	Woodstock	In Service	S	1962		254.02
Woodstock Mills	Ottauquechee River	Woodstock	Unknown				254.06
Bridgewater	Ottauquechee	Woodstock	Unknown				254.07

Woolen Co.	River						
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* H = hydroelectric, R = recreation, C = flood control, S= water supply, O = other