WATER RESOURCES

Major Tributaries

The French Creek watershed has ten major tributaries whose sub-basins cover at least 50 square miles (Figure 3). In addition, those major sub-basins can be broken down further into the Pennsylvania State Water Plan designated small watersheds (Figure 13). The PA portion of the main stem of French Creek is classified as a warm water fishery (WWF) by the PA Department of Environmental Protection's Water Quality Standards (PA Title 25, Chapter 93).

West Branch of French Creek

The West Branch of French Creek originates in Chautauqua County, New York and flows southwest into Erie County, Pennsylvania before turning south. It joins French Creek from the right side (facing downstream), near Wattsburg, at river mile 84.42 and drains 77.7 square miles. It drains portions of Northeast, Greenfield, and Venango townships and Wattsburg Borough in Pennsylvania. The low gradient West Branch and all of its tributaries are classified as WWF.

The West Branch sub-basin contains the most extensive wetlands, including rare fens, of any Pennsylvania headwater area. Although this sub-basin still contains blocks of contiguous forest and undeveloped riparian areas, it is beginning to see development pressure from the city of Erie and North East.

Work by Dr. J. Stauffer, *et al*, Penn State University, and other historic records have documented 26 species of fish from the West Branch sub-basin (Western Pennsylvania Conservancy, 1992). These include the PA threatened mountain brook lamprey (*Ichthyomyzon greeleyi*), and Ohio lamprey (*Ichthyomyzon bdellium*). According to surveys by WPC biologists, this stream also supports 13 freshwater mussel species, including a "viable population of the [former] federal candidate *Epioblasma triqueta* (snuffbox)" (Western Pennsylvania Conservancy, 1994).

South Branch of French Creek

The South Branch of French Creek originates in Concord Township, Erie County and flows generally westward to its confluence with French Creek just west of Union City. It joins the main stem from the left at river mile 73.38 and drains 80.3 square miles. It drains portions of Concord, Wayne, Amity, Union, and LeBoeuf townships, the City of Corry, and Elgin and Union City boroughs in Erie County, as well as small portions of Sparta and Bloomfield townships in Crawford County. The South Branch basin is classified as a Cold Water Fishery (CWF) with the exception of one tributary, Beaver Run, one of two Exceptional Value (EV) streams in the French Creek watershed. Beaver Run contains a naturally reproducing wild brown trout (*Salmo trutta*), population (Lee, 2000) and is classified by the PA Natural Diversity Inventory as a high-gradient clearwater creek.

The South Branch sub-basin contains the largest bottomland forest area in the Pennsylvania headwater area. There are also extensive wetlands associated with the section of the South Branch sub-basin between Corry and Union City. Tributaries in this section have rare fens and

calcareous seep wetlands associated with them. Much of the riparian areas of the South Branch are intact but the basin supports a high degree of agriculture that could potentially threaten these areas.

Thirty-one fish species are recorded from the South Branch sub-basin (Western Pennsylvania Conservancy, 1992). The mountain brook lamprey and the gilt darter (*Percina evides*), are the only fish species of special concern. The South Branch sub-basin contains eight mussel species with the cylindrical papershell (*Anodontoides ferussacianus*) and spike (*Elliptio dilatata*), being the only two species recorded from the headwater areas near Corry (Western Pennsylvania Conservancy, 1994).

LeBoeuf Creek

LeBoeuf Creek forms from two major branches. The East Branch originates in Venango and Greene townships just north of Lake Pleasant in Erie County. The main branch originates in Summit Township, Erie County. The two branches flow southward to their confluence in Waterford Township, Erie County and LeBoeuf Creek continues southward to Lake LeBoeuf in Waterford. From Lake LeBoeuf, LeBoeuf Creek flows south to its confluence with French Creek in LeBeouf Township. It joins French Creek from the right at river mile 67 and drains 63.3 square miles. LeBoeuf Creek is classified as a Trout Stocked Fishery (TSF). According to the PA Fish & Boat Commission, however, LeBoeuf Creek was last stocked with trout in 1988 due to posting of private property (Lee, 2000). Trout Run, a tributary to LeBoeuf Creek, is classified as a EV stream and a Class A trout stream because of a naturally reproducing wild brown trout population.

The LeBoeuf Creek sub-basin contains extensive wetlands upstream from Lake LeBoeuf and Waterford, which include fen and calcareous marsh areas. Better draining headwater areas as well as parts of the sub-basin downstream are extensively farmed.

Thirty fish species are recorded from the LeBoeuf Creek sub-basin, including the PA endangered Iowa darter (*Etheostoma exile*) and warmouth (*Lepomis gulosus*), and PA threatened Ohio lamprey (Western Pennsylvania Conservancy, 1992). Lower LeBoeuf Creek, below Lake LeBoeuf, contains a diverse mussel community with at least 13 species, including the federally endangered clubshell mussel (*Pleurobema clava*). Upper LeBoeuf Creek has no documented mussel species, however the cylindrical papershell has been recorded from the East Branch of LeBoeuf Creek.

Muddy Creek

Muddy Creek also forms from two major branches. The East Branch originates in Athens Township, Crawford County where it meets the main branch. The main branch originates in Steuben and Richmond townships, Crawford County and drains Townville before entering Athens Township. The main stem of Muddy Creek flows northwest through Athens, Bloomfield, Richmond, and Rockdale townships in Crawford County. In addition, Muddy Creek flows through the northern Seneca division of the Erie National Wildlife Refuge. Muddy Creek joins French Creek from the left at river mile 55.58 and drains 83.6 square miles. The separate

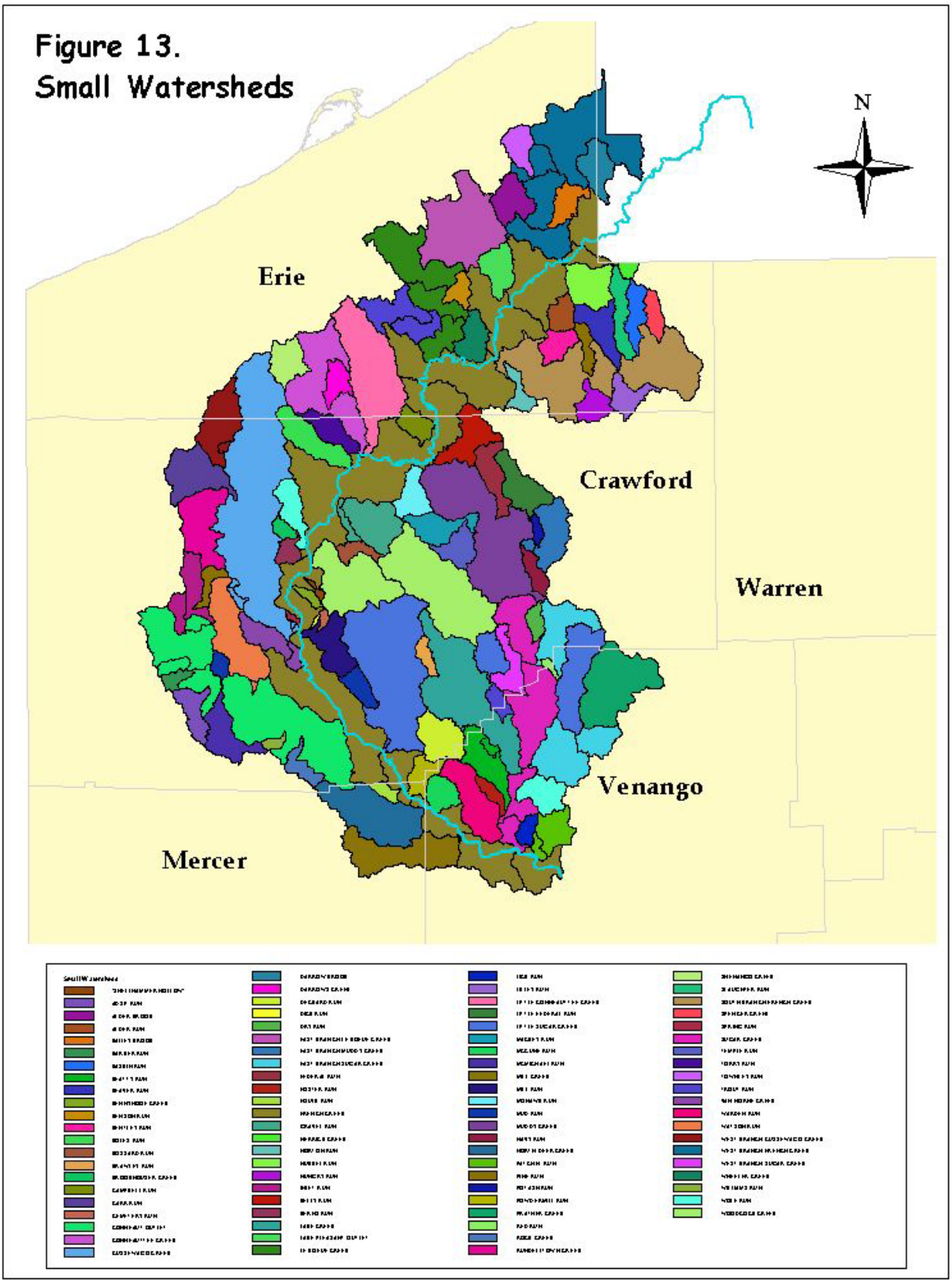


Figure 13.
Small Watersheds
N
Erie
Crawford
Warren
Venango
Mercer

branches of Muddy Creek and its tributaries are classified as High Quality Cold Water Fisheries (HQ-CWF). The main stem of Muddy Creek is a High Quality Trout Stocked Fishery (HQ-TSF).

Much of the headwater areas of the Muddy Creek sub-basin are extensively farmed. In contrast, the Erie National Wildlife Refuge and State Game Lands #83 protect extensive wetlands along the downstream sections of Muddy Creek. Western Pennsylvania Conservancy and the French Creek Project have targeted the Muddy Creek sub-basin for outreach to landowners and implementation of agricultural Best Management Practices.

The Muddy Creek sub-basin holds 25 fish species, including the PA threatened Ohio and mountain brook lampreys (Western Pennsylvania Conservancy, 1992). Muddy Creek also harbors the federally endangered clubshell mussel, along with several other freshwater mussel species. The federally endangered northern rifflesheIl (*Epioblasma torulosa rangiana*) has been documented in French Creek near the mouth of Muddy Creek and may exist in Muddy Creek proper.

Conneauttee Creek

Conneauttee Creek and its tributaries originate in Washington and Franklin townships, Erie County and flow into Edinboro Lake. Upon leaving Edinboro Lake, Conneauttee Creek flows generally south-southeast, draining Edinboro and portions of Washington Township before entering Crawford County where it forms the border between Venango and Cambridge townships. Nearly half of the Conneauttee Creek basin is attributed to its major tributary, Little Conneauttee Creek.

Little Conneauttee Creek drains portions of McKean, Waterford, Washington, and LeBoeuf townships in Erie County and Cambridge Township, Crawford County. Little Conneauttee Creek drains 25.9 square miles before its confluence with Conneauttee Creek just above the mouth of Conneauttee Creek.

Conneauttee Creek joins French Creek from the right at river mile 48.02, northwest of Cambridge Springs, Crawford County, and drains a total of 60.8 square miles. Conneauttee Creek is classified as a WWF with the exception of the segment between Edinboro Lake and the Erie-Crawford County border, which is a TSF. Little Conneauttee Creek and its tributaries are classified as a CWF.

The Conneauttee Creek sub-basin is extensively farmed and offers plenty of restoration opportunities for degraded riparian areas. This sub-basin has been targeted by the FCP for agricultural BMP implementation. The Conneauttee Creek sub-basin has some wetlands including a calcareous fen associated with Edinboro Lake.

There were no records of fish surveys done in the Conneauttee sub-basin by Stauffer *et al*. The PFBC have documented 16 species of fish in Conneauttee Creek. The PFBC also report several instances of sediment pollution to Little Conneauttee Creek from oil and gas well drilling (Lee and Obert, 1984). No mussels have been documented in Little Conneauttee Creek; however,

Conneauttee Creek harbors the federally endangered clubshell mussel, as well as the white heelsplitter (*Lasmigona complanata*).

Woodcock Creek

Woodcock Creek drains portions of Randolph, Richmond, Woodcock, East Mead, and West Mead townships and the boroughs of Blooming Valley and Saegertown, all in Crawford County. Flowing generally westward, Woodcock Creek joins French Creek from the left at river mile 37.84, just south of Saegertown, and drains 50.5 square miles. Woodcock Creek was dammed in 1973 by the U. S. Army Corps of Engineers, creating Woodcock Creek Lake. The dam was designed as a triple use dam: recreation, flood control, and low water augmentation. Woodcock Creek, from its headwaters to the reservoir dam, is classified as a HQ-CWF. From the reservoir dam to its mouth, Woodcock Creek is a CWF.

There are 18 fish species recorded from the Woodcock Creek sub-basin, including the PA threatened Ohio and mountain brook lampreys (Western Pennsylvania Conservancy, 1992). Three mussel species have been recorded from the extreme upstream areas of Woodcock Creek within the Erie National Wildlife Refuge. These species include: cylindrical papershell, creek heelsplitter (*Lasmigona compressa*), and paper pondshell (*Utterbackia imbecillis*). No mussel species have been recorded, and it is doubtful that any exist, downstream near Woodcock Creek Lake (Western Pennsylvania Conservancy, 1994).

Cussewago Creek

Cussewago Creek is a south-flowing tributary that forms from two major branches. The West Branch originates in Elk Creek Township, Erie County and drains portions of Spring and Cussewago townships in Crawford County before its confluence with the main branch. The main branch drains portions of Franklin, Elk Creek, and Washington townships in Erie County before its confluence with the West Branch in Cussewago Township, Crawford County. Cussewago Creek and its tributaries also drain portions of Summerhill, Hayfield, and Vernon townships in Crawford County. Cussewago Creek joins French Creek from the right at river mile 31.38, at the city of Meadville, and drains 96.9 square miles. The entire basin is classified as a WWF.

Cussewago Creek has extensive wetlands and bottomland forest areas associated with it. The entire stream corridor has been designated by Audubon as an Important Bird Area (IBA) and provides habitat for nesting bald eagles (*Haliaeetus leucocephalus*). The sub-basin does have extensive farming in some areas with opportunities for riparian restoration.

Thirty-five fish species are recorded from the Cussewago Creek sub-basin, including the PA endangered redfin shiner (*Lythrurus umbratilis*). No mussel records have been found from Cussewago Creek.

Conneaut Outlet

Conneaut Outlet begins at the outflow of Conneaut Lake in Conneaut Lake Borough. It flows southeast draining portions of Sadsbury, East Fallowfield, Hayfield, Vernon, Summit, Greenwood, Union, and Fairfield townships in Crawford County. Conneaut Outlet joins French Creek from the right at river mile 22.22 and drains 101 square miles. Conneaut Lake itself and several tributaries are considered the source basin for Conneaut Outlet and are classified as a High Quality Warm Water Fishery (HQ-WWF). Conneaut Outlet, from the lake to its mouth, is classified as a WWF.

Conneaut Outlet is the remnant of an ancient streambed that was filled with glacial drift. Today, the Outlet meanders through a large, complex system of wetlands as a result of its glacial history. This robust emergent marsh is the largest marsh complex in the state. The marsh has been designated an IBA by Audubon and lies within SGL #213. The marsh is home to many birds including the state endangered American bittern (*Botaurus lentiginosus*), least bittern (*Ixobrychus exilis*), and black tern (*Chlidonias niger*), as well as bald eagles.

No fish records from Stauffer *et al*. or the PFBC were found for Conneaut Outlet. There is a historic record of longnose gar (*Lepisosteus osseus*) from 1938 (Western Pennsylvania Conservancy, 1992). Several mussel species are recorded from Conneaut Outlet, including the snuffbox, long-solid (*Fusconaia subrotunda*), white heelsplitter, eastern pondmussel (*Ligumia nasuta*), lilliput (*Toxolasma parvus*), and the federally endangered clubshell mussel.

Little Sugar Creek

Little Sugar Creek drains southward through portions of West Mead, East Mead, Randolph, East Fairfield, and Wayne townships, Crawford County, before entering French Creek at Cochranton. Converging with French Creek from the left at river mile 18.96, Little Sugar Creek drains 53 square miles. The entire Little Sugar Creek sub-basin is classified as a CWF.

Mud Run, a tributary of Little Sugar Creek, is one of two streams that were dammed by the U.S. Department of Agriculture (USDA) to form Tamarack Lake.

Surveys by the PFBC have recorded 15 fish species from Little Sugar Creek. No records were found from Stauffer *et al*. Included were reports of lampreys but species were not identified. Mussel surveys in Little Sugar Creek have documented six species, with the PA endangered creek heelsplitter being the most rare. Researchers have recommended further surveys near the mouth of Little Sugar Creek where habitat suggests more species may be found (Western Pennsylvania Conservancy, 1994).

Sugar Creek

Sugar Creek, the largest tributary sub-basin in the French Creek watershed, drains portions of Steuben, Troy, Oil Creek, Randolph, and Wayne townships in Crawford County, as well as Cherrytree, Plum, Oakland, Jackson, and Canal townships and Sugarcreek and Cooperstown boroughs in Venango County. Sugar Creek converges with French Creek from the left at river

mile 4.2 and drains 167 square miles. Sugar Creek has East and West Branches, which converge at Cooperstown. The main stem is joined by another major tributary, Lake Creek, just downstream in Cooperstown. Lake Creek drains the southern Sugar Lake Division of the Erie National Wildlife Refuge. It also feeds and drains Sugar Lake. The entire Sugar Creek sub-basin is classified as a CWF.

The Sugar Creek sub-basin has been extensively mined for sand and gravel, limestone, and oil and gas. The watershed is also extensively farmed and has been targeted by the FCP for agricultural BMP implementation.

Twenty-four fish species are recorded from Sugar Creek (Western Pennsylvania Conservancy, 1992). No threatened or endangered species were recorded. Only a single mussel species was recorded from Sugar Creek and researchers speculate whether the suppressed population is attributable to mining or oil and gas activities.

The major sub-basins within the French Creek watershed provide organizations and agencies the opportunity to break the large French Creek watershed into smaller, more manageable units. Each sub-basin has unique resources and threats to those resources. By taking a sub-basin approach, streams receiving conservation and restoration programs can be prioritized depending upon measurable negative contributions by each sub-basin to the overall water quality of French Creek. In addition, high quality sub-basins that contribute positively to the overall water quality of French Creek can be recognized and protected.

Wetlands

Definition and Types

Wetlands exist in a variety of different forms and are thus, sometimes difficult to define. Generally, wetland definitions are comprised of descriptions of three general characteristics: 1) the presence of water for a significant period of time during the year, 2) unique soils that differ from uplands, and 3) vegetation that is adapted to wet conditions (hydrophytes), and an absence of flooding-intolerant vegetation (Mitsch and Gosselink, 1986). Because the study of wetlands is growing in importance and the acceptance of the fundamental need to protect these ecosystems for their benefits to water quality and quantity, humans, and wildlife is increasing, it becomes necessary to adequately define wetland areas. The most widely accepted definition by wetland scientists and managers was adopted by the U. S. Fish & Wildlife Service in 1979 and is described in a report entitled *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin *et al*., 1979):

> *Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water…Wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes, (2) the substrate is predominantly undrained hydric soil, and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.*

In Pennsylvania, wetland encroachment and alteration is regulated by both DEP and the USACE. Regulation of wetland dredging and filling requires a stricter wetland definition and is described in Section 404 of the 1977 Clean Water Act Amendments:

> *The term "wetlands" means those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support , and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.*

The Pennsylvania Code, Title 25, Chapter 105, describes wetland classification and regulations pertaining to permitting for encroachment or alteration.

Its glacial history has left the French Creek watershed rich with wetland resources (Figure 14). The New York headwater portions of the watershed contain two major wetland systems, Alder Bottom and Beaver Meadow Swamps. The Alder Bottom Swamp is the largest wetland in the NY portion of the watershed and is characterized by a rare plant community, a rich hemlock-hardwood peat swamp (The Nature Conservancy, 1999).

The Pennsylvania portion of the French Creek watershed contains a wide variety of wetland types. The largest wetland systems are on glacial deposits that filled deep stream valleys, while many smaller wetlands formed in the irregular, hummocky topography of the end and ground moraines (Kline, 1993). Vast marsh and swamp wetlands are associated with many glacial lakes and tributaries. In particular, Lake Pleasant Outlet in Erie County and Conneaut Lake Outlet in Crawford County support extensive marshes. Many streams within the watershed, like LeBoeuf Creek and Muddy Creek, have extensive floodplain and forested wetlands. Of particular importance are the rare glacial bog and alkaline fen wetlands in the watershed. Erie County is home to the Wattsburg Fen Natural Area, a National Natural Landmark. Other small fen and bog wetlands occur in Erie County and elsewhere in the watershed.

Benefits

Wetlands are integral parts of the watershed ecosystem. They function in a variety of ways to benefit humans as well as wildlife. Wetlands improve water quality in lakes and streams by stabilizing and filtering sediments and toxins. Wetland plants also remove or transform excessive nutrients and prevent them from entering waterways.

Wetlands augment and help control water quantity in a watershed. They retain waters during high flow periods to lessen flooding. Loss of wetlands can cause a dramatic increase in flash flooding incidents. Wetlands also provide important recharge areas for groundwater. This is especially important for low flow augmentation for streams and rivers.

Additionally, wetlands are important habitats for many species of plants and animals that depend upon these habitats and no others. Wetlands serve as a link between terrestrial and aquatic environments and dramatically increase plant and animal diversity for both environments.

Lastly, wetlands are important for the recreational and aesthetic values they provide to humans. Boating, fishing, hunting, and birding are just a few of the activities provided by wetlands.

Floodplain

Many of French Creek's floodplains lie in broad, low relief valleys (Figure 15). Historically, the floodplains in the watershed would have been forested with silver maple (*Acer saccharinum*), eastern sycamore (*Platanus occidentalis*), black willow (*Salix nigra*), and several other species dominating. These forested valleys and the streamside buffers that they furnished have been lost in many areas to agriculture, transportation routes and development. In better draining soils of the stream valleys, potatoes, corn, and other grains are grown in the fertile floodplains. Many population centers within the watershed are located in and around floodplains. This pattern of development was further increased by the construction of a flood control dam on French Creek near Union City and a triple use dam (flood control, water supply, and recreation) on Woodcock Creek.

As a relatively young stream, French Creek meanders through gravel filled streambeds with wide floodplains. The coarse, gravelly soils laid down by glacial events tend to be highly erodable. Many areas along French Creek have experienced high levels of erosion due in part to the stream's natural tendency to meander as it cuts its way through the gravelly outwash plains of the former glacial advances. Settlement and development has led to the loss of riparian buffers, the draining and filling of wetlands, and the increase in impervious surfaces in the watershed. These changes have increased the erosive forces of French Creek. This is especially true along French Creek near Wattsburg where severe erosion has occurred. Areas in the NY headwater portions of this stream have seen the loss of significant expanses of wetlands, which historically helped regulate stream flow levels (Peck, 2001). Coupled with the increase in impervious surfaces due to roadway construction, these alterations to the watershed hydrology have significantly changed the stream channel and floodplain characteristics further downstream.

While many sections of French Creek's natural floodplain have been lost to development, transportation routes, agriculture, and erosion, other areas remain intact. Some sections of French Creek and its tributary sub-basins have large sections of intact floodplain forests and wetlands. These areas should be protected as other areas of degraded floodplains and riparian areas are restored.

Lakes and Ponds

The French Creek watershed has a number of natural lakes and ponds, as well as a large number of man-made impoundments and beaver ponds. Five of northwestern Pennsylvania's seven large (> 50 acres) inland glacially formed lakes are located within the watershed (Figure 16). Such lakes are critically imperiled in Pennsylvania due to their unique characteristics, rarity and vulnerability. These water bodies are generally characterized by alkaline water chemistry, associated wetland systems, and habitat for many plant and animal species of concern in the state. In addition, there are several man-made reservoirs, which serve flood-control, water supply, low-flow augmentation, and recreational purposes. These man-made reservoirs typically

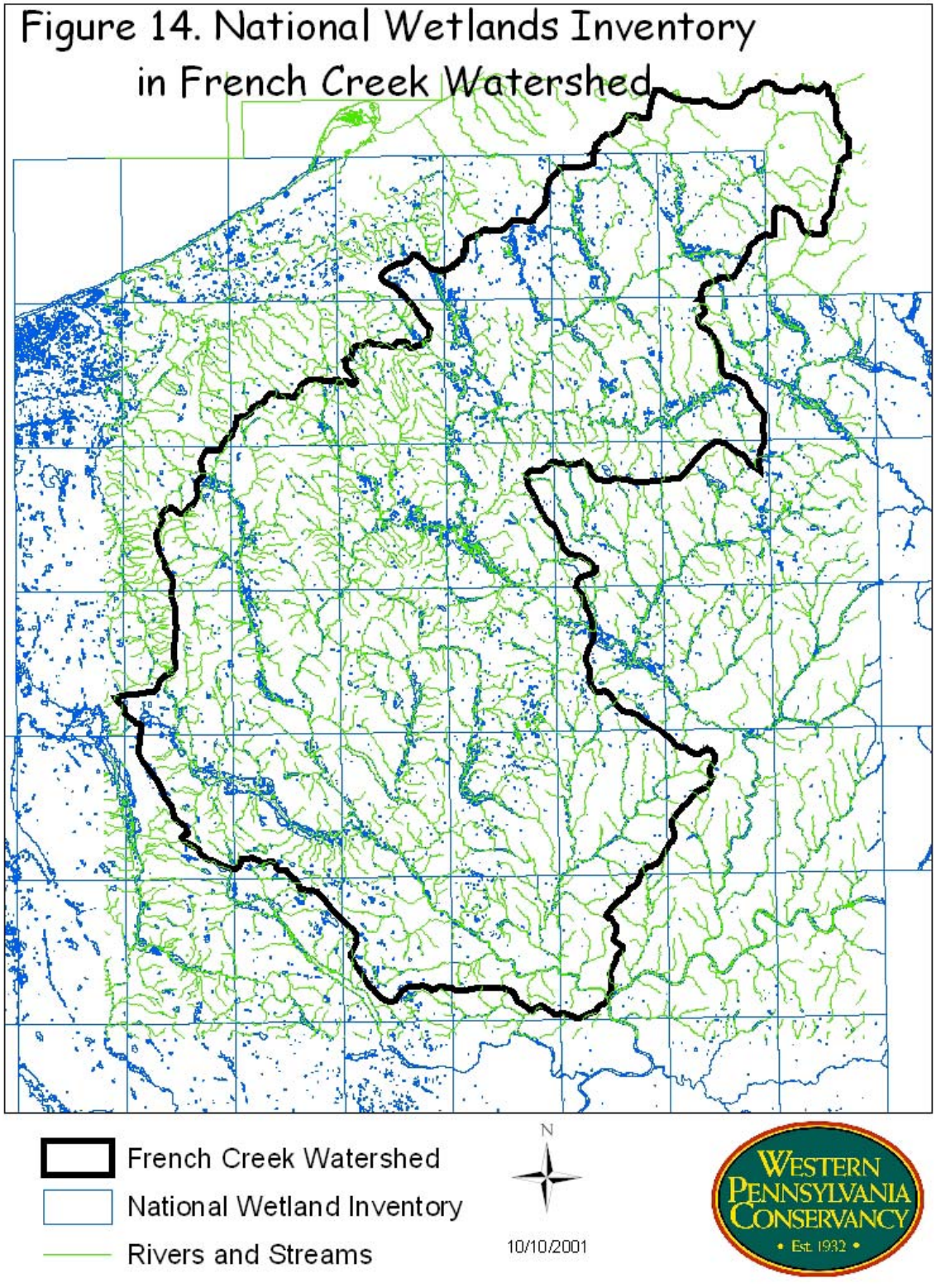


Figure 14. National Wetlands Inventory
in French Creek Watershed
French Creek Watershed
National Wetland Inventory
Rivers and Streams
N
10/10/2001
WESTERN
PENNSYLVANIA
CONSERVANCY
• Est. 1932 •

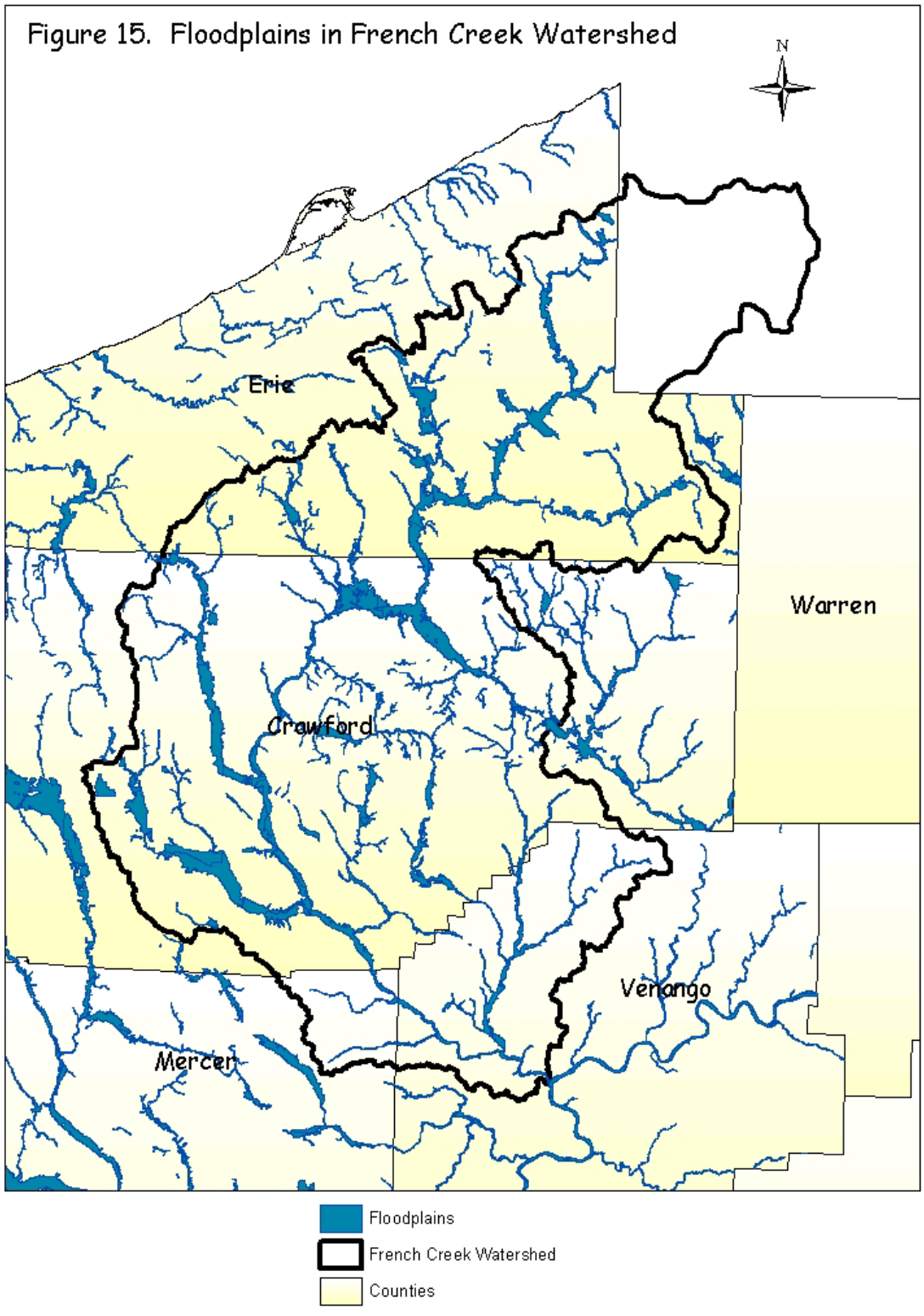
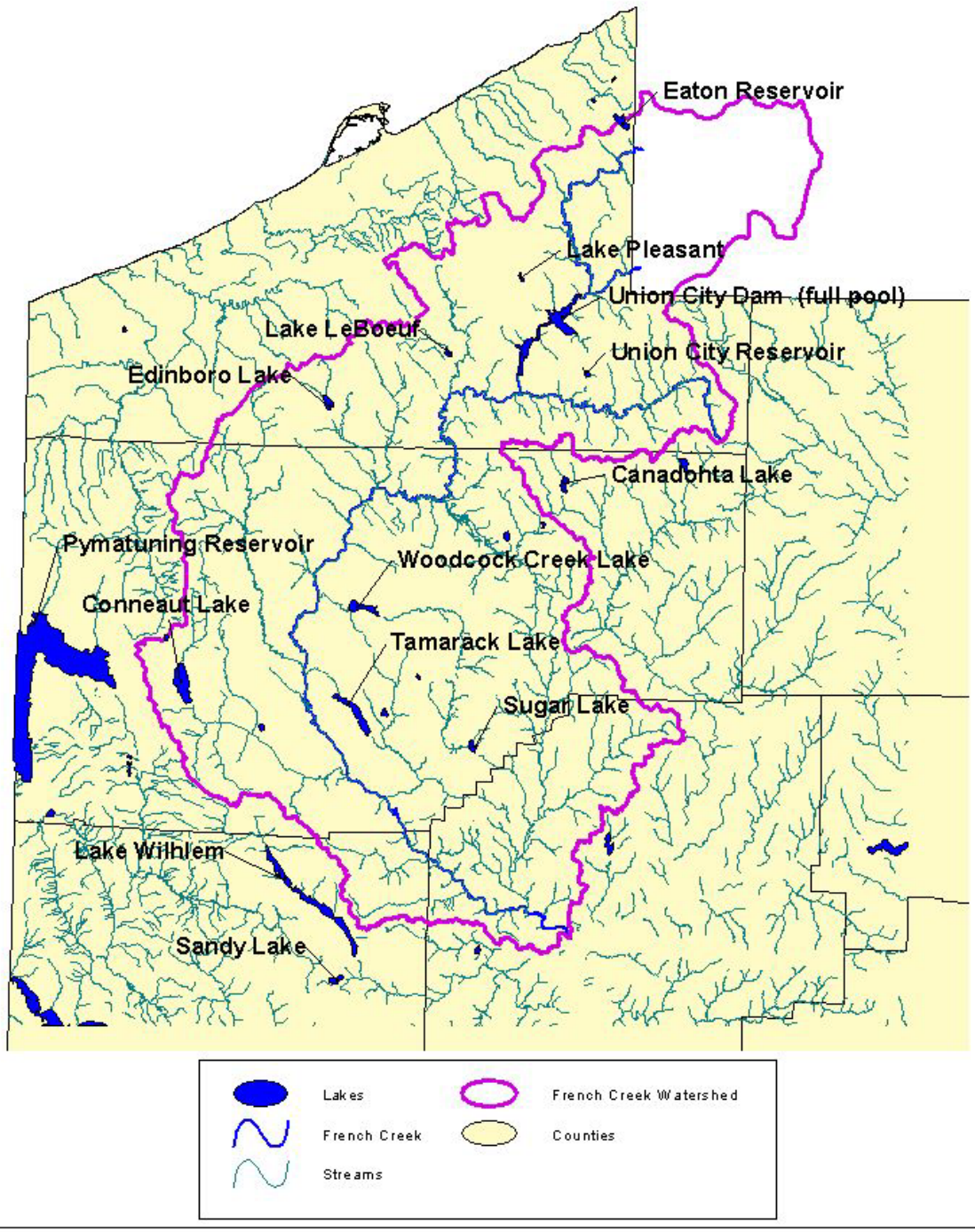


Figure 15. Floodplains in French Creek Watershed
N
Erie
Warren
Crawford
Venango
Mercer
Floodplains
French Creek Watershed
Counties

Figure 16. Lakes in French Creek Watershed



do not have the same characteristics or qualities of natural lakes, such as water quality, species of special concern, or unique natural communities.

Lake Pleasant

Lake Pleasant is an approximately 64-acre oval shaped natural glacial lake (~ 1120' x 2560') located at the head of a glacially carved valley in southwest Venango Township, Erie County, and is drained by Lake Pleasant Outlet, a tributary of French Creek. The lake has a surface elevation of approximately 1300 feet with the surrounding hillsides rising another 250 feet above the lake surface. The lake is 40-45 feet deep with a gravelly bottom covered with silt. Widely accepted as the best example of an intact glacial lake ecosystem in northwest Pennsylvania, this lake has been targeted for protection by WPC. Lake Pleasant has good water quality with neutral to slightly basic pH values and relatively high alkalinity. Minimal surface flow into the lake, and no motors allowed for boats on the lake, have helped protect the good water quality. Most of the water recharge to Lake Pleasant arrives via subsurface flow channels.

The exclusion of boat motors has also helped keep Lake Pleasant free from invasive aquatic plants and animals. Pieces of invasive plants, like Eurasian watermilfoil (*Myriophyllum spicatum*), which is found in nearby impoundments often travel on hulls, trailers, and motors. The exotic zebra mussel (*Dreissena polymorpha*), which invaded the Great Lakes in the 1980's and was recently discovered in nearby Edinboro, Sandy and Canadohta Lakes, is also spread in this manner. There have been introductions of invasive exotic wetland plants like common reed (*Phragmites australis*), purple loosestrife (*Lythrum salicaria*), and hybrid cattail (*Typha X glauca*) to some wetland areas within the watershed.

The lake is bordered to the north, west, and south with extensive wetlands. The lake and associated wetlands provide habitat for at least 24 plant species of special concern in Pennsylvania and two fish species that are endangered in the state. Of particular importance is a basin graminoid-forb fen community to the south of the lake, which receives mineral-rich ground water and supports seven of the 22 plant species of special concern associated with Lake Pleasant.

Lake Pleasant faces many threats within its roughly 2.7-square mile watershed. Mineral extraction in the form of sand and gravel mining pose threats to ground water levels and chemistry. The lake is fairly nutrient-rich and faces the threat of over-eutrophication by the influx of nutrients, primarily nitrogen and phosphorous, from runoff associated with agriculture and forestry practices. In addition, septic systems associated with homes and cottages around the lake pose a potential threat of nutrient seepage into the lake. State Route 1001, locally known as Lake Pleasant Road, borders the eastern lakeshore and poses the threat of toxins and nutrients entering the lake via surface runoff. Specifically, petroleum products, nutrient-laden silt, heavy metals, and brine are common constituents of runoff from roadways. The vegetative buffer along the eastern lakeshore has been degraded through overuse by automobile traffic and provides no protection against runoff. With the presence of an asphalt plant at the northern edge of the watershed and the associated truck traffic, the potential for a catastrophic spill that could severely impact the lake's ecosystem exists. Despite these and other threats, the Lake Pleasant

community has avoided over-development of the lake's shoreline and loss of buffering wetlands keeping the lake relatively healthy.

Currently, Lake Pleasant is stocked with non-native trout by the PFBC and receives the most attention as a put-and-take fishery. The impact of these trout on native species of forage fish and other native predators is not well understood. The lake also supports a good largemouth bass (*Micropterus salmoides*), fishery. Lake Pleasant is classified as a HQ-CWF. Public access is maintained by the PFBC on WPC owned land through a lease agreement.

Through a grant from DEP's Growing Greener program, WPC is conducting a scientific assessment of the geology, hydrology, and ecology of the Lake Pleasant watershed. This assessment began March 2001 and will continue for two years. The object of this assessment is to gain a better understanding of the processes that occur in the watershed and ultimately affect the water quality and quantity of the lake ecosystem. Through this understanding, a management plan will be developed and conservation projects implemented. Western Pennsylvania Conservancy is also beginning floral inventories on native and invasive aquatic and wetland species associated with Lake Pleasant as part of a multi-year inventory project on all northwest glacial lakes.

Lake LeBoeuf

Lake LeBoeuf is an approximately 70-acre glacially formed lake in Waterford Borough and Waterford Township, Erie County. The lake has a surface elevation of 1166 feet and a maximum depth of 31 feet. The watershed covers 64.2 square miles. The major tributaries to Lake LeBoeuf are Trout Run and LeBoeuf Creek. The outlet stream is LeBoeuf Creek, a tributary of French Creek. An interesting feature of Lake LeBoeuf is an island in the middle of the lake that was formed during the glacial processes that formed the lake itself. The bottom of the lake is described as being composed of rock and silt.

Lake LeBoeuf still has a large area of associated wetlands composed of emergent marsh areas, shrub swamp, and tree savanna swamps. Lake LeBoeuf and its associated wetlands contain four plant species of special concern in Pennsylvania and one fish species. Lake LeBoeuf has fair water quality with relatively high alkalinity. Warm water temperatures and low summer dissolved oxygen levels make this a warm water fishery unable to sustain trout even as a put-and-take fishery. The lake does support good populations of black crappie (*Pomoxis nigromaculatus*), white crappie (*Pomoxis annularis*), walleye (*Stizostedion vitreum*), and northern pike (*Esox lucius*), as well as a fair population of largemouth bass (PA Fish & boat Commission, 2000). Lake LeBoeuf is a brood lake for muskellunge (*Esox masquinongy*), and is also stocked with walleye fingerlings.

The Commonwealth of Pennsylvania owns Lake LeBoeuf and the PFBC operates a public access area. There is a 10 h.p. restriction on boat motors on the lake making fishing the primary recreational use. Although trout have been stocked in tributaries to the lake, Lake LeBoeuf is classified as a WWF.

Nutrient levels are fairly high in Lake LeBoeuf and algal blooms are common. The watershed is characterized by a mixture of forest and agricultural lands. There are several dairy operations within the watershed. Stormwater runoff from Waterford Borough and nutrients from septic systems around the lake are potential sources of nutrients. Interestingly, a 1897 report from the Pennsylvania Commission on Fisheries characterizes the lake as "very clear…absolutely pure…"

Edinboro Lake

Edinboro Lake is another calcareous glacially-formed lake located in Edinboro Borough and Washington Township, Erie County. The lake is approximately 240 acres in size with a surface elevation of 1197 feet and a maximum depth of 34 feet. The lake watershed covers 16.2 square miles and incorporates four main tributaries: Conneauttee Creek, Shenango Creek, Whipple Creek (local name), and Lakeside Run (local name). The outlet stream is Conneauttee Creek, a major tributary to French Creek.

Edinboro Lake continues to have some areas of intact wetlands, including a rare fen; however much of the lake's shoreline has been developed and extensive dredging has occurred in some wetlands to form channels at the lake's northern end. The lake and associated wetlands harbor 23 plant species of special concern in Pennsylvania. Edinboro Lake was originally dammed around 1900 with subsequent enlargements of the dam to its present size, which raises the water level in the lake approximately 11 feet. Historic reports state that Edinboro Lake was as deep as 50 feet (anecdotal); however, large silt deposits have left the lake shallower than previously reported.

In 2000, WPC completed a two-year assessment of the health of Edinboro Lake. It was determined that Edinboro Lake is in the advanced state of eutrophication with water quality rated as poor to fair (Western Pennsylvania Conservancy, 2000). The lake shows strong stratification for temperature and dissolved oxygen levels. Nutrient levels are very high and lead to excessive algal and plant growth. Land uses in the drainage basin that may be contributing nutrients and sediments via surface runoff include agriculture, a golf course, and development. Other nutrient sources include septic systems near the lake and Washington Township's sewage treatment plant discharge. There is also a high population of Canada geese, *Branta canadensis*, associated with the lake that contribute some additional nutrients. Nutrients build up in the sediments on the lake bottom and are released during turnover events also contributing to the eutrophication problem.

Other problems affecting the health of Edinboro Lake stem from excessive erosion and sedimentation within the basin, loss of wetland and shoreline to development, and no limitations on outboard motor size for boats on the lake.

Recently, a new threat to the health of Edinboro Lake was discovered. The zebra mussel has built up a substantial population in Edinboro Lake. The effect of this invasive exotic mussel to the lake ecosystem remains to be seen. Of equal importance is the threat that the zebra mussel poses to French Creek, now with a direct linkage via Conneauttee Creek. Researchers from DEP and Edinboro University are monitoring the zebra mussel. During the 2000-2001 winter and again during the 2001-2002, the lake was drawn down to expose many of the zebra mussels to freezing temperatures in the hopes of killing many of the adult mussels. Eradication of the zebra

mussel may be impossible but it is hoped that periodic drawdowns may help keep the population under control. The effects of the drawdowns on other aquatic and wetland species is not fully understood; however periodic drawdowns have occurred in the past for dam maintenance. Currently, the Edinboro Lake Preservation and Restoration Foundation is forming to address the protection of Edinboro Lake.

Edinboro Lake is a WWF supporting populations of largemouth and smallmouth bass (*Micropterus dolomieu*), bluegill (*Lepomis macrochirus*), and black crappie among others. It is utilized as a brood lake by the PFBC for muskellunge and is also stocked yearly with walleye fingerlings. Aside from fishing, the lake is utilized by a large number of powerboats and jet skis for skiing, tubing, and other recreational activities. A public access area is operated by Washington Township on the west side of the lake.

Conneaut Lake

Conneaut Lake, the largest natural lake in the Commonwealth, is found in Summit and Sadsbury townships, Crawford County and borders the borough of Conneaut Lake. The lake surface covers 929 acres and lies at an elevation of 1073 feet. Conneaut Lake's maximum depth is approximately 65 feet. The watershed covers 27.9 square miles and includes the drainage of the major tributary Inlet Run. Conneaut Outlet, a major tributary of French Creek that has associated with it a large marsh complex, drains the lake. Most of the lake's surrounding wetlands have been lost, although one large area still remains on the west side of the lake.

The lake and associated wetlands, including those immediately downstream around the outlet, contain 16 plant and 6 animal species of special concern in Pennsylvania. Conneaut Lake has no identifiable dam although some rubble does exist near the outlet that may have been an early dam. The PA Game Commission does own a dam on the outlet near Geneva, which helps control water levels in Conneaut Marsh, downstream of the lake.

Conneaut Lake's watershed has a high degree of agriculture, some forested areas, and intensive development near the lake. These factors, coupled with the loss of wetlands surrounding the lake, have led to increased nutrient levels and greatly increased aquatic vegetation growth. Because Conneaut Lake is a major recreational area with high numbers of power boaters and jet skiers during the summer months, the Conneaut Lake Aquatic Management Association was formed to address the overgrowth of aquatic vegetation. This organization has attempted to control aquatic plants, including the invasive Eurasian watermilfoil through weed harvesting, dredging, and herbicide application. Public access to the lake is possible at the north end via a PFBC access and the south end via a Conneaut Lake Borough access.

Conneaut Lake is classified as a HQ-WWF. The PFBC stocks the lake with walleye fry, muskellunge, white bass fingerlings (*Morone chrysops*), and yellow perch fry (*Perca flavescens*). There is a healthy northern pike population as well as many other warm and cool water species. The state record muskellunge and white bass were caught in Conneaut Lake. Gizzard shad (*Dorosoma cepedianum*), and quillback carpsucker (*Carpiodes cyprinus*), were introduced to the lake and pose a potential threat to panfish through competition for food (PA Fish & Boat Commission, 1999).

Sugar Lake

Sugar Lake is a glacially formed lake in Wayne Township, Crawford County. The surface area of the lake is 90 acres with a surface elevation of 1288 feet and a maximum depth of 15 feet. The watershed covers 23.3 square miles with the major tributary being Lake Creek, which flows through the Erie National Wildlife Refuge's southern Sugar Lake Division. Lake Creek also drains the lake and joins with Sugar Creek at the borough of Cooperstown in Venango County. The property surrounding the lake is largely in private ownership and large tracts of wetlands still occur. Some riparian areas have been developed as home sites. The wetland areas adjacent to the lake are home to nesting bald eagles the only species of special concern, both state and federal, documented to date at Sugar Lake.

Although privately owned, Sugar Lake has a PFBC public access and is managed under Conservation Regulations, which govern fish harvest. There is a maximum 6 horsepower restriction, or electric motor only, limitation for boats on the lake. There are populations of both warm water and cool water fish species in the lake, with largemouth bass being the primary warm water predator, and the muskellunge the primary cool water predator (PA Fish & Boat Commission, 1996). Sugar Lake is used as a brood lake for muskellunge by the PFBC.

Woodcock Creek Lake

Woodcock Creek Lake was formed by a USACE dam project on Woodcock Creek, completed in 1974. It was one of three flood control reservoirs authorized for the French Creek basin by the Omnibus Rivers and Flood Control Act of 1962. The three-reservoir system consisted of Union City Reservoir, Woodcock Creek Lake, and Muddy Creek Reservoir. The Union City Reservoir was completed in 1971, but the Muddy Creek Reservoir has not been approved for construction. Woodcock Creek Lake serves three main purposes: recreation, the reduction of flood stages in the French Creek and Allegheny River Valleys, and low-flow augmentation and water quality control at Meadville (U. S. Army Corps of Engineers, 1980).

Woodcock Creek Lake lies in Woodcock Township, Crawford County. The full pool of Woodcock Creek Lake covers 775 acres with a surface elevation of 1209 feet. The average summer pool covers 333 acres with a surface elevation of 1181 feet. The lake has a maximum depth of 72 feet at full pool. The drainage basin for the lake covers 45.7 square miles. Much of the drainage basin has historically been in agriculture, resulting in a great deal of sedimentation in the lake. The lake is under USACE ownership with a public recreational area leased and operated by Crawford County.

Woodcock Creek Lake supports fair populations of smallmouth and largemouth bass. The PFBC stocks walleye, muskellunge, and channel catfish (*Ictalurus punctatus*). Panfish populations are low in the lake because the lake experiences annual winter drawdowns, which reduces shoreline habitat needed for breeding and congregates fish making them more susceptible to predation. The PFBC also stocks Woodcock Creek Lake with trout as a put-and-take fishery. The reservoir is designated as a HQ-CWF.

Union City Dam Reservoir

Considered a dry dam due to its singular purpose of flood control, the Union City Dam was completed in 1971. Dry dams allow normal flows to pass through unhindered, but during periods of heavy rainfall or snow melt, higher flows are retained by the dam. During these periods of heavy flow, the reservoir behind the dam will fill up and the dam releases the water at a controlled rate. Situated on French Creek in Waterford Township, Erie County, the Union City Dam, under normal flow conditions, creates no impoundment. During high flow periods, the surface area of the impoundment can cover 2,290 acres. The surface elevation of the full pool is 1278 feet.

The effects of this dam on the ecological health of French Creek are debated. While the USACE points out that the dam has saved millions of dollars in flood damages (personal communication), the potential damage to the French Creek system is difficult to quantify. One potential problem is the alteration of natural flooding regimes. Flooding serves to inundate the floodplain with nutrients and may recharge groundwater in some areas. The Union City dam has stopped the natural flooding process. Also, holding French Creek at bank-full conditions for longer periods via retention and release from the dam may increase erosive forces to areas downstream.

The USACE has completed a feasibility study on making the Union City Dam into a permanent pool. This legislation has been brought forth several times in the past and has been voted down by the county.

Union City Reservoir

Not to be confused with the USACE Union City Dam Reservoir, the Union City Reservoir is a small (25 acre) manmade impoundment that serves as a water supply for Union City Borough. Located in Union Township, Erie County, the reservoir has a surface elevation of 1394 feet and a maximum depth of approximately 23 feet. Bentley Run, a tributary to the South Branch of French Creek, drains Union City Reservoir. Union City Borough owns the impoundment and public access area. The reservoir provides good fishing for largemouth bass and other panfish and is utilized by the PFBC as a brood lake for muskellunge. There is a no motor restriction for boats on the reservoir.

Tamarack Lake

Tamarack Lake, a man-made impoundment a few miles southeast of Meadville, Crawford County, is unique in that it was formed across a watershed divide by the damming of two neighboring streams. Tamarack Lake was constructed in 1963 by the USDA Soil Conservation Service by damming Mill Run, a tributary of French Creek, and Mud Run, a tributary of Little Sugar Creek. The lake covers 562 acres and has a normal pool elevation of 1216 feet. Because the lake is situated on a saddle between two drainages, it is relatively shallow with a mean depth of 4.3 feet and a maximum depth of 13 feet. This has led to excessive aquatic vegetation that must be controlled by annual winter drawdowns.

Tamarack Lake is owned by the PFBC and has six public access points. The lake is stocked with walleye and muskellunge fingerling. There is an electric motors only restriction for boats on the lake. Studies indicated that the excessive vegetation in the lake may contribute to slower than normal growth rates for bass and panfish (PA Fish & Boat Commission, 1995).

Eaton Reservoir

Eaton Reservoir is a man-made impoundment on a tributary to the West Branch of French Creek in northeastern Erie County constructed in 1941. It is owned by the borough of North East and serves as a water supply impoundment. The reservoir has a surface area of 244 acres and a surface elevation of 1422 feet. Its maximum depth is 15 feet.

Eaton Reservoir is open for public fishing with a no motor regulation for boats. The reservoir has healthy populations of walleye, smallmouth and largemouth bass, and panfish. The PFBC has historically stocked channel catfish, northern pike, and various species of forage fish. Recently it was determined that the northern pike population was stunted due to several possible factors, including warm temperatures and a large recruitment of small individuals. Attempts were made to transplant all northern pike from Eaton Reservoir to Presque Isle Bay in Lake Erie. The PFBC determined these efforts were futile in attempting to eradicate all northern pike from Eaton Reservoir (PA Fish & Boat Commission, 1998).

The use of water by North East and the resulting drainage of this water into Lake Erie via pipes represents an inter-basin transfer between French Creek and Lake Erie. Water draw during summer months for orchard and vineyard irrigation places significant strain on the water levels in nearby West Branch of French Creek, where water is pumped from to replenish the reservoir. Currently, North East is finishing facilities that will enable them to get their drinking water supplied directly from Lake Erie. Eaton Reservoir will only be used for drinking water in emergencies or during periods of high use.

Findley Lake, N.Y.

Findley Lake was formed in 1810 by a private landowner who dammed the West Branch of French Creek in Chautauqua County, New York. The lake surface elevation is 1420 feet and covers 230 acres. Land use in the drainage basin is a mix of forest and agriculture. The lake is a major tourist attraction and has seen the development of the town of Findley Lake at the north end of the lake as well as numerous homes and cottages along the western and eastern lakeshores.

Watershed Hydrology

The hydrologic cycle, or water cycle, describes the flow of water through the aquatic, terrestrial and atmospheric environments. This cycle includes water storage and transportation. Water can be stored as groundwater, surface water, snow and ice, and atmospheric moisture. Water is transported through evaporation and transpiration from the Earth's surface to the atmosphere. Condensation and precipitation bring the moisture back to the earth. Runoff brings the water

back to storage areas and the cycle continues. This entire process is driven by energy from the sun.

A water budget/hydrologic model is an important piece of information lacking for the French Creek drainage. Through a better understanding of how water cycles through this watershed, better informed decisions can be made regarding changes to groundwater and surface flows. Much of the information for developing a water budget exists in the form of United States Geologic Survey (USGS) gage station data sets and meteorological data. Comprehensive groundwater data does not exist for the watershed. This information must be pulled together with the help of a computerized Geographic Information System (GIS), and analyzed to fully develop a working model for the French Creek water budget. Such a model would allow situations to be tested and predictions to be made regarding land use changes, pollutants, mixing zones, and nutrient loading to name a few.

Surface Flow

There are currently five gauging stations monitored by USGS within the French Creek basin. These stations provide daily stream flow levels at their respective locations. Historically, there were a total of 18 USGS gauging stations in the French Creek watershed (Table 3).

Table 3. List of USGS Gauging Stations in the French Creek Watershed, Current and Historic

Station #	Station Name	County	Dates of Operation
03021350	French Creek, Wattsburg	Erie	1974-present
03021410	W. Br. French Creek, Lowville	Erie	1975-1993
03021500	French Creek, Carters Corners	Erie	1910-1971
03021520	French Creek, Union City	Erie	1972-1991
03021700	Little Conneauttee Creek, McKean	Erie	1960-1978
03022000	French Creek, Venango	Crawford	1938-1946 (partial)
03022500	French Creek, Saegertown	Crawford	1921-1939
03022540	Woodcock Creek, Blooming Valley	Crawford	1974-1995 (partial)
03022554	Woodcock Creek, Woodcock Creek Dam	Crawford	1974-1991
03023000	Cussewago Creek, Meadville	Crawford	1910-1938
03023100	French Creek, Meadville	Crawford	1988-present
03023300	Van Horne Creek, Kerrtown	Crawford	not available
03023500	French Creek, Carlton	Mercer	1908-1925
03024000	French Creek, Utica	Venango	1932-present
03024500	Sugar Creek, Wyattville	Venango	1910-1916
03025000	Sugar Creek, Sugarcreek	Venango	1932-1979
03025200	Patchel Run, Franklin	Venango	1967-1978
03025500	Allegheny River, Franklin	Venango	1914-present
Source: USGS Water Resources Data			

Analysis of stream gauge data sets are important to determine how French Creek's flow regime has changed in response to land use changes, population growth, and dam construction.

Comparison of the current data with pre-1970 data shows that the construction of the Union City Dam and the Woodcock Creek Dam have significantly reduced the yearly peak flows in French Creek. A more thorough analysis is needed to determine the effects of these projects on the overall flow regime in French Creek. It is possible that organisms adapted to natural flow regimes would be seriously impacted by alterations to these flows as a result of dam construction. Alterations to flow regimes may also impact the fluvial geomorphology of streams and cause increased erosion in areas of the French Creek watershed.

Groundwater

Groundwater is an extremely important component of the water cycle and its quality, quantity and distribution need to be better understood to effectively protect the water and biological resources of the French Creek watershed. Groundwater serves as a major source of drinking water and contributes nearly all of the flow to streams during warm, summer months. Groundwater is key to the existence and health of rare fens and other wetlands, glacial lakes, and plant and animal communities that rely on the flow of high quality groundwater. Nutrients, such as nitrogen and phosphorous, and other pollutants such as herbicides and pesticides, can infiltrate groundwater sources and threaten the water quality and health of aquatic ecosystems. Pollutants can also impact drinking water sources for people utilizing both private and public wells.

An aquifer is a body of rock material that is permeable to water flow and is underlain by impermeable material. It is capable of storing significant quantities of water fed by groundwater passing through the material. Southern portions of the French Creek watershed are underlain by Pennsylvanian Aquifers, which cover approximately 118 square miles. These are sandstone aquifers in the unglaciated portions of the watershed in Venango County and portions of southeastern Crawford County. Central portions of the watershed are underlain by Mississippian Aquifers covering approximately 326 square miles. These are sandstone and carbonate-rock aquifers in southern glaciated sections of the watershed. Approximately 780 square miles of the northern sections of the watershed have no principle aquifers (U. S. Geological Survey, 1998).

In general, groundwater is more readily available (i.e. well yields are higher) in the unconsolidated glacial material of the outwash plains as opposed to the bedrock aquifers or upland glacial till materials (Richards *et al*., 1987). Groundwater in the French Creek watershed is, on average, hard to very hard. This is due to minerals that the groundwater dissolves while percolating through the glacial material, mainly constituents of calcium and magnesium. Chloride is also a constituent of groundwater and can cause water to be saline, similar to ocean water, if concentrations become too high. Higher salinities are generally found at greater depths where aquifers hold ancient groundwater that does not flush and has time to dissolve chloride from surrounding bedrock. Salinity levels in the French Creek watershed are generally low even in deeper wells; this may be due to the increased rate of flow of groundwater through unconsolidated deposits and the subsequent flushing of even the deeper aquifers.

Groundwater supplies are recharged by precipitation entering the ground through recharge areas. These areas may be wetlands, lakes and streams, or other areas where soils are permeable to water flow. Identification and protection of recharge areas are important to insure quality and quantity of water for aquatic systems and drinking water supplies. Excess runoff resulting from

an increase in impervious surfaces, draining of wetlands, and alterations to hydrology of a watershed decreases groundwater recharge. These factors lead to decreased base flows of streams, decreased water quality, decreases in drinking water quality and quantity, and increased stress on aquatic and wetland organisms.

Water Quality

Natural Water Chemistry

Overall, the water quality in the French Creek watershed is relatively good; however there are sections that are degraded by various pollutants. Water quality has remained good partially due to the glacial history of the watershed. Material deposited across the French Creek landscape by the glaciation process is high in carbonate, which acts as a natural buffer against acidification by atmospheric deposition and industrial discharges. The glacial material in the French Creek watershed is high in calcium carbonate ($CaCO_3$), as well as dolomite, another carbonate-rich material. This leads to the alkaline nature of water in the French Creek watershed.

Alkalinity allows water to withstand certain levels of acidic input without affecting pH levels. Acids are high in hydrogen ions (H+). The more hydrogen ions there are, the higher the acidity. Carbonate (CO_3) binds to the hydrogen ions, neutralizing the acidic conditions. The more CO_3 that is available, the more acidity can be neutralized. The associated calcium in $CaCO_3$ is beneficial to aquatic organisms in a variety of ways; it helps ameliorate the effects of some dissolved compounds on aquatic organisms and it is important for shell and exoskeleton formation as well as many other physiological functions.

Another factor leading to good water quality in French Creek is the highly rural nature of the watershed. With relatively little development and low percentages of impervious material, precipitation and runoff in the watershed is able to seep into the ground and carries fewer pollutants to waterways. There are, however, threats to French Creek's naturally occurring good water quality. In areas where development has occurred at higher levels, especially around lakes, water quality has been degraded. In addition, point discharges from urban areas, including industrial discharges and sewage treatment plants have degraded sections of French Creek and certain lakes within the watershed. While the rural nature of the watershed has protected it from degradation due to urban runoff, the threat of degradation due to improper agricultural and forestry practices is substantial. Improper agriculture and forestry practices can impact water quality by increasing sediment loads, introducing nutrients and pesticides, and eliminating or reducing riparian buffers.

The French Creek watershed has a certain capacity for assimilating pollutants before water quality is degraded. Components of the watershed including wetlands, riparian buffers, alkaline soils, and intact forests all help to boost the capacity of the watershed to buffer water quality against degradation from pollutants. In areas where land use practices excessively disrupt these watershed components, water quality degradation occurs and can spread a significant distance downstream until water inputs dilute the negative impacts sufficiently to restore water quality. For these reasons, we see good water quality in some sections of the French Creek watershed and degraded water quality in other areas of the watershed.

Lewis (1906) describes the water quality at several points along French Creek. At that time, water clarity and alkalinity were described as very good. However, major towns along French Creek like Corry, Union City, Cambridge Springs, and Meadville were discharging sewage into French Creek. There was also widespread agriculture in the watershed that contributed pollutants to French Creek. Deaths due to typhoid fever, probably caused by drinking water fouled by sewage, were noted in these areas. During the late 1800's and early 1900's, many of these towns that were getting drinking water directly from French Creek began to look at alternative water sources because sewage discharges and farming runoff were polluting French Creek. By 1906, Corry and Union City were getting most of their water supply from reservoirs. Cambridge Springs had been utilizing groundwater, which became fouled by high mineral content and forced the town to revert back to drawing water directly from French Creek. Meadville introduced a groundwater public supply in 1901 because of upstream sewage discharges and farming runoff.

Nutrients and Energy Flow

Vitally important to the protection of a waterway's resources is an understanding of how nutrients and energy cycle through the system. This includes how nutrients and energy sources enter the stream and move through the aquatic food web. In many aquatic environments, primary producers or autotrophs (plants and other photosynthesizing organisms) function as the primary energy source and their contribution is dependent upon the width and flow rate of the stream or river. Smaller or swifter moving waterways rely less on autotrophs (i.e. periphyton, macrophytes, and phytoplankton) for primary energy production than do larger, slower moving rivers (Allan, 1995). Lakes within the watershed, which are lentic (standing water) environments, rely much more heavily on primary production by autotrophs. In these instances, the limiting nutrients for primary production are usually nitrogen and phosphorous.

Generally, lotic (moving water) systems receive the bulk of their energy inputs in the form of non-living organic matter. This may come from dead aquatic macrophytes, terrestrial plant material that falls into the stream, dead aquatic organisms or terrestrial organisms that fall into the waterway, or organic soil matter. Non-living organic matter generally comes in three forms, based on particle size, coarse particulate organic matter (CPOM), fine particulate organic matter (FPOM), and dissolved organic matter (DOM).

The contribution to the stream of dead plant material from aquatic macrophytes, autumn leaf fall, or woody debris as well as dead organisms are referred to as CPOM. These materials are first softened by bacterial breakdown, and then macroinvertebrate shredders and detritivores further breakdown the material and utilize the energy. As small pieces are broken off and flow downstream, it becomes FPOM. Further breakdown, including feces from macro-organisms, causes DOM to enter the aquatic food web. The nutrients flow through the aquatic food web as microorganisms and macroinvertebrates are preyed upon by other macroinvertebrates and fish.

Eutrophication

Eutrophication is the process of nutrient enrichment in aquatic ecosystems. This usually occurs with rising nitrogen and phosphorous levels, two of the most important nutrients in an aquatic system. This process occurs naturally over time and is especially evident in lakes. Oligotrophic lakes are nutrient-poor and are generally characterized as having clear water with low productivity, lower nutrient levels, and high levels of dissolved oxygen. These lakes are generally considered geologically young with little exposure to sediments from the weathering of surrounding rock and soil.

As lakes age, they collect sediments through run off. These sediments carry nutrients that provide for the growth of primary producers like photosynthetic aquatic plants and algae. As nutrient levels rise, lakes become mesotrophic, or midway through the eutrophication process. At some point, nutrients are so plentiful that they no longer become the limiting factor for plant growth in an aquatic system. These aquatic systems are said to be eutrophic and may continue to the point of being hypereutrophic. When this occurs, plant production becomes so high that the water is depleted of oxygen during plant respiration and decaying plant matter further depletes oxygen levels. This leads to the death of aquatic organisms, which can further deplete oxygen levels as the organic tissue decays. The lakes in the French Creek watershed are all fairly productive and in various stages between mesotrophic and eutrophic, possibly even hypereutrophic during the summer months.

Nutrient enrichment is occurring in French Creek and many of its tributaries. This is evident by summer algal blooms and excessive aquatic weed growth. Eutrophication may not be as pronounced in the moving stream environment where oxygen levels are constantly replenished by flowing water, but excessive nutrients can still have a negative effect on aquatic organisms as nutrient levels build up and oxygen levels are sometimes critically depleted during warmer summer months when flows are reduced. This is especially problematic for French Creek's freshwater mussel species, which depend on oxygenated water and cannot move to find more suitable conditions. Excessive aquatic weed growth also reduces aesthetic and recreational opportunities in French Creek.

Point Sources

Portions of French Creek have been historically degraded by sewage discharges from Meadville, West Mead Township, and Cambridge Springs' sewage treatment plants. A portion of French Creek downstream of Meadville was listed as impaired in 1996 on the PA 303(d) list of impaired waterways. The source of impairment was listed as Municipal Point Source, and the cause of impairment was nutrients.

Surveys performed by DEP have documented fouled substrate conditions, profuse plant growth, low dissolved oxygen, and elevated concentrations of suspended and dissolved solids, nutrients, metals, and fecal coliforms below the discharges for these sewage treatment plants (Hasse, 1992, 1994). It was documented that sewage bypasses in 1991 to French Creek from Meadville's sewage treatment plant resulted in 1,837 hours of actual bypassing time and bypasses from West Mead's sewage treatment plant resulted in 14.7 million gallons of untreated sewage entering French Creek.

In total, there are 13 public sewage treatment facilities in the French Creek watershed, which return approximately 3.4 million gallons of treated wastewater to streams in the watershed per day (U. S. Geological Survey, 1990). Recently, the West Mead and Meadville sewage treatment plants were upgraded to prevent future sewage bypasses. The West Mead sewage treatment plant is now linked to a new upgraded Meadville sewage treatment plant. The Cambridge Springs sewage treatment plant, which released over two million gallons of untreated sewage into French Creek in 1993, has not been upgraded. It is unknown how many gallons of untreated sewage are still entering French Creek during overflow periods.

All industrial, commercial, and municipal discharges are permitted by DEP under the National Pollutant Discharge Elimination System (NPDES) (Figure 17). Permitted discharges in the French Creek watershed are listed in Appendix E.

Non-Point Sources

Non-point source (NPS) pollution is the major cause of surface water degradation in the state. Because NPS pollution cannot be traced to a pipe or ditch, it is extremely difficult to control. Non-point source pollution can travel via surface runoff or it can enter the groundwater and flow to streams and lakes via sub-surface channels.

Pennsylvania Department of Environmental Protection's 2000 305(b) Water Quality Assessment Report lists agriculture as the major source of impairment to the Commonwealth's streams and lakes. The associated causes for the impairments are nutrients, organic enrichment/low dissolved oxygen, and siltation.

In 1999 and 2000, the Northwest Regional Office of DEP finished assessing the French Creek watershed (Sub-basins 16A and16D, State Watershed Plan). A total of 255 sites were assessed using aquatic macroinvertebrates as indicators of water quality as well as field measurements of pH, dissolved oxygen, conductivity, and temperature, and a visual assessment of the riparian and in-stream conditions, such as sedimentation of the stream bottom, at each site. Biological impairment or habitat degradation causes the stream segment to be placed on the PA 303(d) report, which lists impaired streams, the source and cause of impairment based on the field biologists' conclusions, and whether Total Maximum Daily Load (TMDL) restrictions will be placed on the stream in an attempt to improve water quality.

The 2000 303(d) Report lists portions of Conneauttee Creek (downstream of Edinboro Lake), Gravel Run and its tributaries, Bentley Run, Boles Run, LeBoeuf Creek, Darrows Creek, Torry Run, an unnamed tributary to Muddy Creek, Little Conneauttee, and ten unnamed tributaries to the South Branch of French Creek as impaired out of all streams sampled in the northern portion of the French Creek watershed (126 sites, 29 impaired) (Figure 18). These streams represent approximately nine percent of the total stream miles surveyed in the northern portion of the watershed (Sub-basin 16A, State Watershed Plan). The source of impairment at 26 of 29 sites was crop related or grazing related agriculture and the cause of impairment was excessive nutrients. At the three remaining impaired sites, road runoff was the source of impairment with siltation as the cause. None of these impairments are scheduled to have TMDLs implemented by 2002.

The remaining southern portions of the French Creek watershed (Sub-basin 16D, State Watershed Plan) were assessed in 2000 (128 sites, 1 impaired). Less than one percent of stream miles assessed in the southern portions of the watershed were considered impaired. Lick Run was the only impaired site.

Lakes within the watershed are also assessed for impairments. Only Conneaut Lake is listed as impaired within the French Creek watershed. It has been listed on the PA 303(d) list since 1998. The sources of impairment in Conneaut Lake are listed as Urban Runoff/Storm Sewers and other sources contributing nutrients and suspended solids to the lake. Conneaut Lake is to have TMDLs in place by 2002. In response to the problems associated with runoff from urban areas, the Conneaut Lake and Conneaut Outlet basin municipalities are the only municipalities within Crawford County to have implemented a comprehensive stormwater management plan.

Other potential sources of NPS pollution include gravel mine drainage, urban runoff/storm sewers, residential runoff, atmospheric deposition, golf courses, development and construction projects, leachate from landfills, and silviculture projects.

Monitoring

An ongoing, watershed-wide, comprehensive monitoring program is lacking in the French Creek drainage. There are several agencies, organizations, and individual researchers that have conducted water quality monitoring at various points throughout the watershed or in certain sub-watersheds. It is not easy to compare results between any of these monitoring programs due to differences in sampling techniques and protocols.

In addition to its stream assessment program, DEP has 10 stations in its Surface Water Quality Monitoring Network (WQN) within the French Creek basin (Table 4). These locations are sampled on a regular basis for macroinvertebrates and water chemistry. Some of these stations have been monitored since 1962.

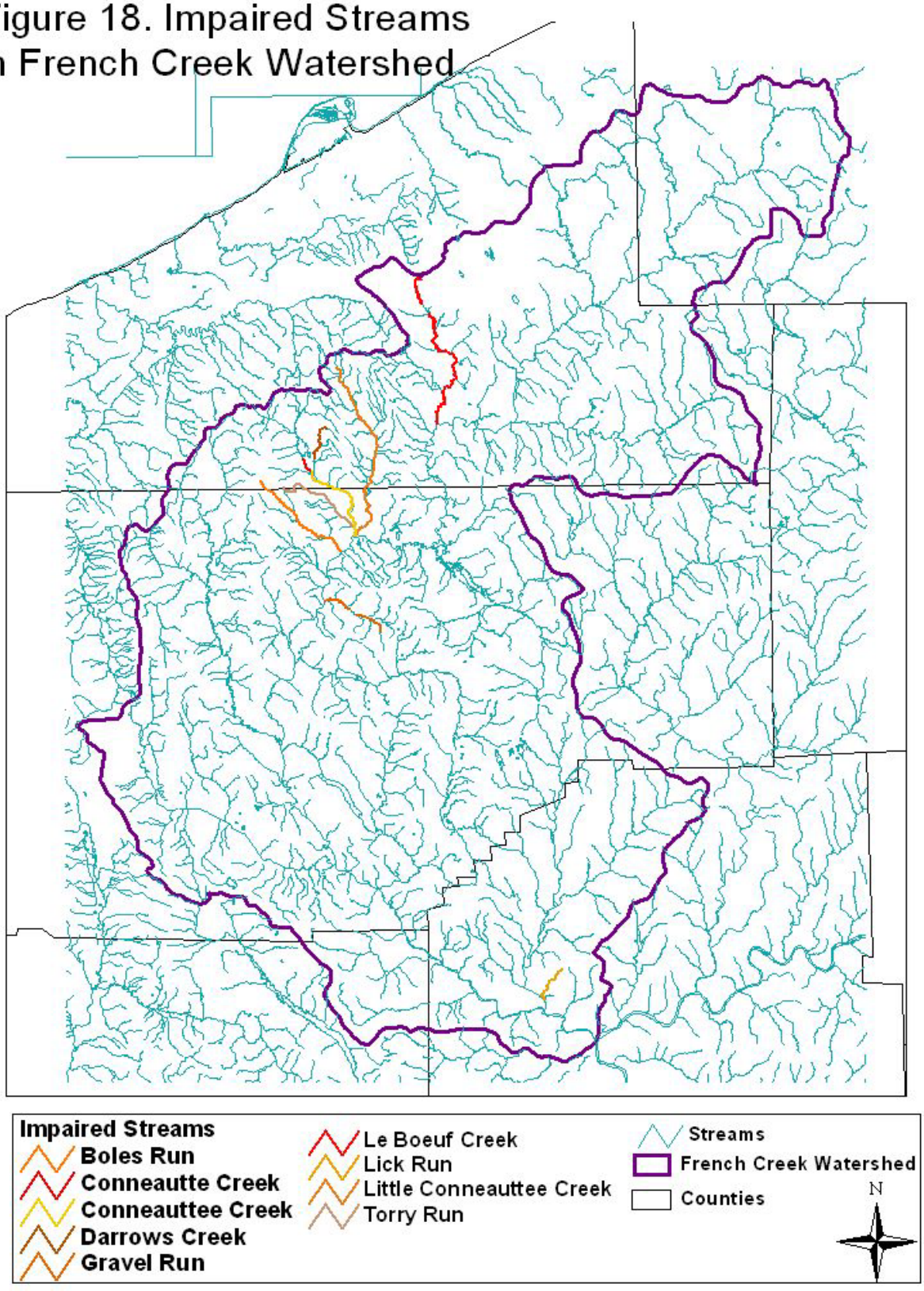
Table 4. DEP Water Quality Network Monitoring Stations in the French Creek Watershed

Station #	Waterway	Location
827	French Creek	Amity Township, Erie Co.
869	French Creek	Venango Borough, Crawford Co.
849	Woodcock Creek	Woodcock Township, Crawford Co.
850	Conneauttee Creek	South of Edinboro, Erie Co.
851	Muddy Creek	Steuben Township, Crawford Co.
805	Lake Pleasant	**Rotates between Erie Co. lakes**
826	French Creek	Utica Borough, Venango Co.
845	French Creek	Franklin, Venango Co.
846	French Creek	Wilson Chutes Launch, Crawford Co.
847	French Creek	South of Saegertown, Crawford Co.
Source: U.S. EPA STORET Database		

Figure 17. NPDES Permitted Discharges in the French Creek Watershed

Data not yet available

Figure 18. Impaired Streams in French Creek Watershed



PA Department of Environmental Protection conducts fish tissue sampling in area lakes and streams to monitor bioaccumulation of toxins and heavy metals. Of particular interest are high levels of mercury in fish sampled from Lake Pleasant, Lake LeBoeuf, and to a lesser extent, Edinboro Lake, as noted by the Erie County Health Department. Mercury is a component of various industrial emissions. It is contributed to waterways through dry and wet atmospheric deposition. Once in a lake ecosystem, the mercury settles to the bottom and can accumulate in the substrate. It is also taken up by aquatic organisms and accumulates in the tissue of fish.

PA Department of Environmental Protection also conducts "cause and effect" studies to document pollution occurrences and follow-up monitoring to assess the impacts of these occurrences.

U.S. Geological Survey conducts a variety of water quality and quantity monitoring programs for both surface and groundwater. There have been 17 USGS stations throughout the French Creek watershed and one on the Allegheny River at the mouth of French Creek that monitored daily streamflow levels during certain periods, some beginning as early as 1908 (Table 3). Currently, only four stations record daily flow levels with two other stations operated as partial-record stations.

As part of its National Water Quality Assessment Program (NAWQA), USGS had several stations within its network that also collected various water chemistry parameters. The NAWQA program focused on the Allegheny and Monongahela River basins in New York, Pennsylvania, Maryland, and West Virginia. The French Creek station at Utica was utilized as a NAWQA water quality monitoring station for various periods from 1956 until the NAWQA program in the Allegheny and Monongahela rivers basins was discontinued in 1998. Water quality parameters monitored included pH, temperature, specific conductance, dissolved oxygen, hardness, alkalinity, nitrogen, phosphorous, solids, and many major anions and cations. As part of the NAWQA monitoring program, algae, aquatic macroinvertebrates, and fish were also sampled at the French Creek, Utica station.

Water quality information reported from French Creek at Utica for the water year October 1997 to September 1998 includes:

- mean pH of 7.67 (7.3-8.1)
- mean specific conductance of 236 µS/CM (112-341)
- mean water temperature of 11 deg C (1.0-24.0)
- mean dissolved oxygen of 10.5 mg/L (7.4-14.5)
- mean dissolved calcium concentration of 27 mg/L (11-40)
- mean total alkalinity of 68 mg/L $CaCO_3$ (22-112)
- mean total nitrogen of 0.583 mg/L (0.325-0.968)

- mean total phosphorous of 0.041 mg/L (0.010-0.138)
- mean suspended sediments of 24 mg/L (3-113)

U. S. Geological Survey NAWQA data suggests that French Creek at Utica has a stable circumneutral (approximately 7.0-7.5) pH with good alkaline buffering capabilities against acidification. Increased nutrient levels (nitrogen and phosphorous) as well as increased sediment loads coincided with increased flows January through April.

In addition, the NAWQA program reported 48 fish species collected at Utica between 1997 and 1999, 69 macroinvertebrate families collected in 1996, and 61 macroinvertebrate families in 1997. Aquatic macroinvertebrates are often used as indicators of water quality. A high number of families, including pollution intolerant forms such as those found at Utica, suggest good biodiversity and relatively good water quality.

Groundwater wells throughout Pennsylvania are also monitored by USGS for groundwater levels. Only one well, in Erie County, is within the French Creek watershed. This well, near McKean, has been monitored daily since July 1966. The highest water level recorded was 10.00 feet below land-surface on March 17, 1973 and the lowest level was 24.66 feet below land-surface on September 30, 1998 (U. S. Geological Survey, 1998).

U. S. Army Corps of Engineers has monitored the water quality at several points around Woodcock Creek Lake monthly since the reservoir was formed in 1974. There is also water level monitoring done at both Woodcock Creek Lake and the Union City Reservoir Dam.

Other significant water quality monitoring groups in the French Creek watershed include Creek Connections and the Environmental Alliance for Senior Involvement (EASI) through the French Creek Project. Creek Connections is a project operated from Allegheny College in Meadville that works with French Creek elementary, middle, and high school classes to monitor stream sites near their respective schools. Within the French Creek watershed, there are 46 sites that are regularly monitored by students and the data is obtainable online at http://creekconnections.allegheny.edu/. This program has been working with students on water quality monitoring in French Creek since 1995 and recently expanded to work with schools in the Pittsburgh area. The students routinely perform field analyses for temperature, pH, total dissolved solids, dissolved oxygen, nitrogen, phosphorous, alkalinity, turbidity, sulfates, and iron as well as doing visual assessments of the stream conditions.

The EASI group utilizes senior citizen volunteer water quality monitors. The FCP in Meadville directs the Crawford and Venango County EASI volunteers in doing water quality monitoring in French Creek. This group routinely samples 12 sites along French Creek and performs field analyses for water chemistry as well as visual inspections of stream and riparian conditions. The EASI group maintains an online database of water quality information from their monitoring program at http://www.environmentaleducation.org/.

County Conservation Districts perform some water quality monitoring in sub-basins where their efforts are focused on implementing BMPs for agriculture or other projects to address stream impairments. The PFBC also conducts water quality monitoring throughout the watershed. They utilize water chemistry field analysis, macroinvertebrate sampling, and fish sampling to monitor the health of waterways. This sampling is done periodically on stream segments that are routinely stocked by the PFBC.

There are also numerous researchers associated with local universities who have performed monitoring projects throughout the watershed. These studies are generally short-term and sporadically located throughout the watershed.

Monitoring in the French Creek watershed has not adequately addressed some of the most basic questions regarding water quality and aquatic organisms. In a highly rural, largely agricultural watershed, it is not known where the most significant sources of nutrients are. Data gaps exist with regards to groundwater quality, quantity, and identification of important recharge areas. Biological monitoring has only been done to any degree in easily accessible riffle areas. Macroinvertebrate information as an indication of water quality is lacking for non-riffle and other areas. Aquatic organisms have not been adequately monitored to determine the health of aquatic communities as a whole or populations of certain species, including species of special concern.

Water Supply

Public/Private

Approximately 67 percent of watershed residents receive drinking water from a community or public water supply. Approximately 17 percent of those residents get their water from a public surface water supply and the other 83 percent are utilizing public groundwater supplies. Approximately 4.87 million gallons of water per day are withdrawn from public groundwater supplies for drinking water. Another 1.01 million gallons of water per day are withdrawn from public surface water supplies. The remainder of the watershed population gets their drinking water from private wells. Approximately 3.09 million gallons of groundwater are used daily for drinking water from private wells (U. S. Geological Survey, 1990).

Cambridge Springs Borough is the only municipality in the French Creek watershed that has its public water supplied directly by a surface water intake from French Creek. Other public surface water supplies include 2600 acres of reservoirs in the watershed with the remainder of public water supply sources being wells and springs. Figure 19 shows types and locations of public water supply intakes in the French Creek watershed.

Well Head Protection Areas

States are required to establish wellhead protection programs by the Safe Drinking Water Act. Pennsylvania's wellhead protection program is administered by DEP and is intended to protect groundwater supplies from contamination. Major sources of groundwater contamination as listed by DEP include: pesticides, leaking storage tanks, surface impoundments, landfills,

hazardous waste sites, industrial facilities, spills, mining and mine drainage, pipelines, and sewer lines.

The wellhead is the location of the well and the area in the immediate vicinity that makes up the well's recharge zone. The wellhead protection program works by establishing buffer areas around public drinking water wells. Typically, the buffer areas are laid out in three zones. Zone one is generally a 100-400 foot radius around the wellhead. Zone two is up to a half mile radius from the wellhead and zone three is any area outside of one half mile that contributes to the well. Protection to the drinking water supply is afforded through assessments and monitoring, plugging of abandoned wells (water, oil or gas) in the vicinity, education of local water users, and assistance by DEP to the local municipality with establishing zoning regulations.

As of 1998, 160 municipalities were in the process of developing or implementing wellhead protection programs throughout Pennsylvania (DEP 2000 305(b) report). There are five public water supplies with wellhead protection plans being worked upon in the French Creek watershed:

- Cochranton Borough Water Department
- Guys Mills Mutual Water Association
- Meadville Area Water Authority
- Mitchell Lake Mobile Home Park
- Washington Township Water Authority

At the present time, none of these five programs have met DEP's criteria for approval. However, DEP continues to work with these groups to improve their wellhead protection programs.

Dams and Impoundments

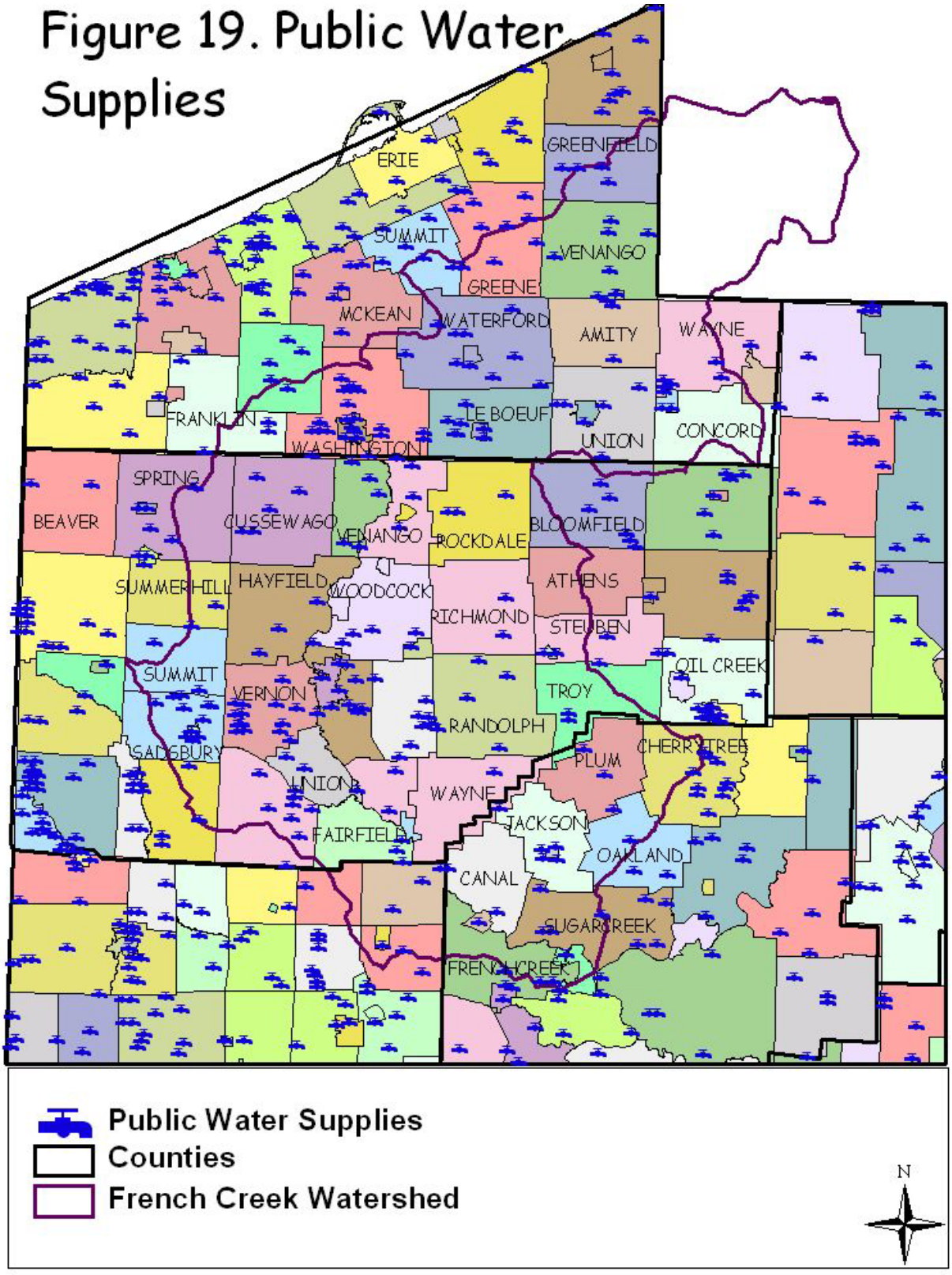
In colonial times, French Creek was reported to have many small dams associated with mills throughout the watershed. Most of these structures have long since vanished but some dams built in the 1800's still remain. The dam that created Findley Lake in the New York headwaters of the West Branch of French Creek was built in 1810. There are also the remains of 1800's dams built at Saegertown and Venango, Crawford County.

The only major dam on the main stem of French Creek is the Union City Dam in Erie County. Built in 1971, this dam is a flood control dam that has reportedly saved millions of dollars in flood damages since its installation (U. S. Army Corps of Engineers, 2000). The only other USACE dam in the French Creek watershed is the Woodcock Creek Dam on Woodcock Creek in Crawford County. Built in 1974, this dam is a multi-use dam (flood control, recreation, and water supply control).

Tamarack Lake was formed by the construction of two dams on neighboring streams. Mill Run and Mud Run, in Crawford County, were dammed by the USDA to form Tamarack Lake.

The PGC has constructed dams in two SGL areas within the French Creek watershed. Conneaut (Geneva) Marsh has a dam built on Conneaut Outlet to provide approximately 1,400 acres of

Figure 19. Public Water Supplies



habitat for waterfowl in SGL #213. Siegel Marsh Dam was built on a tributary of LeBoeuf Creek to form a 150-acre impoundment in SGL #218 for waterfowl habitat.

Edinboro Lake, a naturally formed lake, was originally dammed around 1900 for a mill and later raised to deepen the lake for boating. Howard Eaton Reservoir was formed in 1941, when the borough of North East built a dam on a tributary of the West Branch of French Creek for the creation of a public water supply.

There is a current movement in the United States to reevaluate the need for many of the dams that no longer serve the purpose for which they were originally built. Often the maintenance costs far exceed the cost of removal and generally the aquatic system benefits from the removal. Dam removal needs to be considered on a case-by-case basis with the environmental impacts with the dam in place compared to the potential losses due to dam removal.

Water Withdrawal

Water withdrawal is an important issue in fully understanding the hydrology of the French Creek watershed. Concerns over water withdrawals have been voiced by the public at meetings for the conservation planning process as well as by the PFBC in personal communications. Water withdrawals typically occur for irrigation and livestock purposes during the warmer, drier summer months. This coincides with the timing of the most stress on aquatic organisms due to water temperatures and low dissolved oxygen levels. Water withdrawals can compound the effects of already low dissolved oxygen levels and elevated water temperatures.

Withdrawals of both groundwater and surface water within the French Creek basin were estimated by USGS in 1990. These figures do not include withdrawal for public drinking water, which was already discussed.

- Commercial withdrawals of both groundwater and surface water amount to approximately 170,000 gallons of water daily.
- Industrial withdrawals amount to approximately 5.1 million gallons of water daily.
- Mining operations in the watershed withdrawal approximately 1.17 million gallons of groundwater and surface water daily.
- Livestock use in the watershed accounts for 1.41 million gallons of water daily.
- Irrigation withdrawals from both groundwater and surface water amount to approximately 550,000 gallons of water daily.

Effects of water withdrawals have been documented by the PFBC in survey reports compiled on Beaver Run in Erie County. Beaver Run supports a wild, naturally reproducing brown trout population and is one of only two EV streams in the French Creek watershed. According to PFBC biologists, water withdrawals by area farmers for irrigation during periods of naturally reduced flows in Beaver Run have led to a decrease in the reproduction of the wild brown trout population (personal communication).

Inter-Basin Transfers

An inter-basin transfer occurs when water is pumped, diverted, or drained out of one watershed and into another. This has potentially negative consequences on water quality and quantity, and it increases the chances of spreading invasive exotic species from one watershed to another. The only inter-basin transfer affecting French Creek occurs when the Borough of North East in Erie County uses Eaton Reservoir (French Creek watershed) for their drinking water supply and the water is transported to the Lake Erie basin via pipes, resulting in a net loss of water for French Creek. Currently, North East is in the process of installing an intake pipe from Lake Erie to their water filtration plant to supply drinking water. This will significantly decrease the need for the borough to utilize Eaton Reservoir for their drinking water supply.