POTENTIAL THREATS AND RECOMMENDATIONS

There are a multitude of activities in the French Creek watershed that can potentially threaten water quality, aquatic biota, and ultimately, quality of life for watershed residents. Most of the activities that potentially threaten the health of the French Creek watershed are important to the economic viability of the region and the well being of residents. Because of this, it is important to find ways that these activities can exist and thrive while maintaining the ecological integrity of the watershed. Humans are inextricably linked to the environment in which we live. Acknowledging and fostering this link by both utilizing and protecting natural resources with the goal of sustainability is the true essence of conservation.

It is undeniable that human activities such as agriculture, logging, mineral extraction, development, and even some forms of recreation can potentially threaten the health of the French Creek watershed. The goal of this Plan is to provide information on ways to minimize those threats through education, research, and cooperative community based approaches. Most of the potential threats and recommendations have been voiced by watershed stakeholders through the French Creek Project's Visioning Process, through public stakeholder meetings for the conservation planning process, and by the technical steering committee. Potential threats are described as types of pollutants, forms of habitat degradation, or other activities and land uses that may have a negative impact on the health of the watershed. Human activities that have the potential to produce these threats are described. The recommendations that are offered to address these potential threats are grouped according to the type of action required: education, collection of additional information, or cooperative actions. The list of potential threats to the watershed and the priority of those threats will change as recommendations from this Plan are implemented. The goal of these recommendations is the restoration, maintenance, enhancement, and overall protection of the resources of the French Creek watershed.

Pollutants

"A pollutant is a … by-product of human activities which enters or becomes concentrated in the environment, where it may cause injury to humans or desirable species" (Kline, n.d.). Pollutants are generally described as heat, nutrients and organic wastes, toxins/hazardous substances, and invasive exotic species.

Heat

Heat is considered a type of pollution that can impact aquatic organisms if water temperatures are elevated beyond tolerable limits. Elevated water temperatures decrease dissolved oxygen levels and magnify stresses associated with some chemical pollutants. Thermal pollution is common when point discharges are releasing water into a receiving stream at higher than ambient temperatures; however due to the relatively low number of major point discharges throughout the French Creek watershed and existing regulations, elevated temperatures associated with point source discharges probably produce a negligible effect on surface water temperatures. The loss of riparian buffers along streams also contributes to heat pollution as trees and shrubs in an intact riparian buffer shade the water and help lower water temperatures.

Nutrients and Organic Wastes

PA Department of Environmental Protection biologists have noted nutrients as the leading cause of stream impaiment in the French Creek watershed. The primary nutrients affecting aquatic ecosystems are nitrogen and phosphorous. Although important for plant growth and primary production in ecosystems, excess nitrogen and phosphorous can promote the eutrophication of streams and lakes (See *Eutrophication* under *Water Resources*). These nutrients cycle naturally through the environment and are initially introduced to aquatic and terrestrial ecosystems through the weathering of soil and rock and from the atmosphere. Anthropogenic impacts to the landscape have dramatically increased the amount of these nutrients entering aquatic systems. The U. S. Geological Survey's National Water Quality Assessment Program reported very high levels of dissolved nitrates in groundwater in the New York headwaters of French Creek and somewhat elevated dissolved ammonia levels at various sites in Crawford and Erie County portions of the watershed. The NAWQA program also reported elevated dissolved nitrogen and ammonia levels in groundwater at a site in the Venango County portion of the watershed in 1998.

Nitrogen and phosphorous cycle through the environment in similar continuous cycles, including via the growth, death and decay of plants and animals. Natural levels of these nutrients are augmented through fertilizer use, combustion, sewage, and organic waste breakdown. The U.S. Environmental Protection Agency estimated in 1987 that the yield for nitrogen in the French Creek watershed was 8.74 lbs. per acre per year. The sources for nitrogen were broken down as follows:

- atmospheric deposition at 3.15 lbs./acre/year
- livestock produced 1.93 lbs./acre/year
- fertilizers produced 1.39 lbs./acre/year
- non-agricultural sources produced 1.81 lbs./acre/year
- point sources produced 0.46 lbs./acre/year

Additionally, the EPA assessed the risk of groundwater contamination by nitrates in the French Creek watershed between 1970 and 1995. Although the findings indicated that aquifer vulnerability was low throughout the watershed, nitrogen inputs were considered high throughout approximately 88% of the watershed.

Much of the atmospheric nitrogen is comprised of naturally occurring elemental (N_2) nitrogen. However, nitrogen reacts with hydrogen to form ammonia and with oxygen to form nitrites (NO_2) and nitrates (NO_3). Plants most readily utilize nitrogen in the form of nitrates. Human land-use practices tend to augment the naturally occurring supply of nitrogen resulting in increased rates of eutrophication of surface waters.

The French Creek watershed is well situated to receive air born pollutants from industrial areas to the west due to continental wind patterns. These pollutants can fall as wet deposition (rain or snow), or dry deposition attached to dust particles. Pennsylvania receives rainfall with an average pH of approximately 4.1 (Novak and Woodwell, eds. n.d.). The average acid

precipitation in the French Creek watershed in 1999 varied between 4.33 and 4.39. Acidic precipitation is the result of chemical reactions in the atmosphere between naturally occurring elements, like oxygen and nitrogen, and the byproducts of the combustion of fossil fuels from industry, agriculture, and vehicles. Along with acidification of surface waters, acid precipitation carries various chemical pollutants, including nitrogen and phosphorous that impact streams, lakes, rivers, and ultimately groundwater. Because fossil fuel combustion is a widespread issue and Pennsylvania receives much of its air born pollutants from other states, it is difficult to implement strategies to combat this threat without federal and state cooperation and goal setting to limit air emissions. It has been noted that there is a lack of air quality monitoring stations within the French Creek watershed.

Agricultural practices throughout the watershed have the potential to contribute high levels of nutrients to surface waters and groundwater. In fact, statewide, agriculture has replaced acid mine drainage as the leading cause of non-point source pollution. Representatives from DEP believe that poor farming practices are a major threat to the French Creek watershed (Holden, 1997). Both crop production and livestock are major sources of nutrients. Fertilizers, applied to fields and stored on farms, are the major sources of nutrients in run-off reaching streams and lakes, and contributing to groundwater. These impacts are exacerbated when riparian buffers are removed and agricultural Best Management Practices are not utilized. Livestock are also direct contributors of nutrients, particularly nitrogen, to surface waters. In some areas of the watershed, particularly the New York headwaters, it is estimated there are twice as many dairy cattle as there are humans. Livestock often have direct access to streams in pasture areas and eliminate wastes directly into water. These impacts are worsened by associated erosion produced when livestock trample stream banks and destroy vegetation.

Nutrients can also be contributed to surface and groundwater supplies by other activities throughout the watershed. Increased run-off and erosion from poor timbering practices and mining operations can mobilize large amounts of nutrients trapped in the soil and transport them to streams and lakes. These effects can be minimized when BMPs are utilized to minimize soil disturbance.

Additionally, as impervious surface area increases through development and urbanization, runoff from parking lots, roadways, rooftops, and other areas carry high levels of nutrients to receiving bodies of water. These problems are compounded when development practices fail to limit or mitigate the effect of impervious surfaces through the use of alternative materials, use of greenspace, and sensitive and sufficient stormwater management design.

Nutrients and organic waste are often contributed by point sources (i.e. a pipe from a sewage treatment plant or industrial discharge, on-lot septic systems). Organic wastes are discharged from food processing plants and other industries. Organic wastes breakdown into nitrogen and phosphorous constituents and further contribute to profuse plant growth and low dissolved oxygen levels. Permitting and monitoring by DEP for point source discharges has helped to curb problems associated with these discharges; however in the case of sewage treatment plants, nutrients are still discharged even in treated effluents. Bypasses of raw sewage due to overloads do occur and result in even higher nutrient levels discharged.

Field surveys by DEP in 1991 noted, "fouled substrate conditions, profuse plant growth and low dissolved oxygen levels" below the city of Meadville (Hasse, 1992). At the time, sewage treatment plants for West Mead Township and Meadville were severely overloaded and discharging untreated sewage into French Creek during periods of overload. Since that time, West Mead Township has combined with Meadville and Meadville has constructed a larger sewage treatment plant that incorporates ultraviolet treatment of wastewater instead of traditional chlorination techniques. Other sewage treatment plants in the watershed continue to operate overcapacity and overloads contribute untreated sewage to streams and lakes in the watershed.

A potential major threat to water quality in French Creek are nutrients released from on-lot septic systems associated with older homes and seasonal cottages along streams and lakes in the watershed. Because of the age of some of these structures, they escape regulation by DEP and can severely impact water quality. Although discussed here as a point source of pollution because they can be traced to a discharge pipe, once discharged, sewage and organic wastes can infiltrate groundwater and spread through sub-surface pathways reaching streams at a myriad of locations.

Impacts from areas of high seasonal cottage densities are evident during summer low flows when excessive weed growth and algae blooms clog waterways and impede canoes downstream of these areas. The porous nature of gravelly soils found in flood plains along French Creek may provide little protection even for properly functioning systems. Gravelly soils often contain less clay and other fine particles that more readily trap nutrients like phosphorous.

Toxins and Hazardous Materials

The following is a discussion on toxic wastes from Kline, n.d., *Background working document for a French Creek conservation plan:*

There are natural sources of some toxic substances such as heavy metals. However, many industrial, agricultural, and household processes produce [these and unnatural] toxic materials. Toxic wastes produced by human activities contain substances that rarely occur in nature, or if so are not [found in] high concentrations. Toxic wastes are not readily biodegradable. Examples are: heavy metals, hydrocarbons of petroleum origin, pesticides, and organic poisons, like PCBs, and inorganic poisons, like chlorine and ammonia.

Toxins have the ability to severely impact water quality and can cause rapid mortality for large numbers of aquatic organisms. In other cases, toxins may not kill aquatic organisms outright, but may build up in their body tissue and affect physiological functions when certain levels are reached. Decreased reproductive success is a possible physiological affect of increased toxin levels in body tissue. Reproductive compromise has received national and international attention through studies of a family of pesticides (halogenated hydrocarbons) of which DDT is the most well known. Raptors such as the bald eagle were particularly affected as pesticide residues accumulated in food chains and the bird's bodies. As a result of bald eagles feeding on fish that had built up high levels of these toxins, egg shell thickness decreased to the point that egg laying and incubation were no longer possible. Build-up of toxins can also be harmful to humans and lead to health recommendations in the form of fish consumption advisories. Certain lakes in the

watershed have been found to contain high levels of mercury in benthic sediments, which also leads to fish consumption advisories.

Every three to five years fish tissue is analyzed via the PA Department of Environmental Protection's (DEP) water quality network. Tissues are sampled for priority pollutants to determine suitability for human consumption. Priority pollutants are cadmium, chromium, copper, lead, mercury, PCBs, and pesticides. DEP has no comprehensive assessment or baseline data of toxics for the watershed. The USGS NAWQA project sampled for the presence of pesticides in the lower reaches of French Creek and found persistent pesticides below EPA action levels (Kline, n.d.).

As mentioned previously, chlorine is commonly used for wastewater treatment by municipal, industrial, and private treatment facilities. Chlorine is extremely toxic to freshwater mussel glochidia (young) and other aquatic organisms. PA Department of Environmental Protection water quality standards for chlorine allow for a mixing zone that extends 15 minutes downstream from the sewage treatment plant where discharged. This limit set does not satisfy the concerns of the U.S. Fish & Wildlife Service regarding the protection of aquatic life (Kline, n.d.). Chlorine has been eliminated at the Meadville Sewage Treatment facility but is still utilized by other sewage treatment plants in the watershed. In addition, toxins like formaldehyde and fungicides are discharged by the PA Fish & Boat Commission hatcheries in Corry and Union City, Erie County (Wellington, 1994).

Brine and petroleum products can be released from abandoned oil and gas wells. These substances can be extremely toxic to receiving waters. Brine often has a higher salt content than seawater and is found in deep aquifers. Deeply drilled oil and gas wells often pass through these aquifers and have the potential to release brine to the surface or shallower groundwater aquifers where drinking water contamination can occur. Brine commonly has many other toxins associated with it such as heavy metals.

Roads and railways are often built along stream and river floodplains where topography is flat. These transportation corridors can negatively impact aquatic habitats by contributing pollutants in runoff. Common pollutants associated with runoff include road salt, heavy metals, and petroleum products. These pollutants can degrade riparian vegetation and severely alter aquatic habitats. Whenever these transportation corridors occur in close proximity to waterways, there exists the potential for catastrophic spills of toxic materials. Any such spills could wipe out large portions of the aquatic ecosystem and render the habitat unsuitable for aquatic organisms for an extended period.

Invasive Exotic Species

Exotic species are introduced, non-native species. They are considered invasive if able to out-compete native species for resources. Considered a form of biological pollution, exotic species have the potential to negatively impact the native flora and fauna of the French Creek watershed. When species are introduced to an ecosystem that did not evolve with them as part of the natural community, they have the tendency to aggressively out compete native species for available

resources and are able to drive the native species out. With no natural predators or sufficient competitors, exotic species can quickly become invasive and reduce the community diversity becoming the overwhelmingly dominant species. In some cases, these species have the potential to drastically alter the ecosystem itself with severe consequences to native species. Many of the lakes and reservoirs in the watershed are infiltrated with Eurasian water-milfoil, an aquatic plant that has the potential to out compete native water milfoils and other aquatic species. Considered nuisance weeds by recreational boaters, aquatic plants, and especially thick growing Eurasian water-milfoil, are targeted with mechanical harvesters and herbicides. Such indiscriminate harvesting can have potentially harmful effects on the ecosystem and other non-target species.

Invasive plants in the French Creek watershed include common reed, purple loosestrife, and hybrid cattails. These species all invade wetlands, especially those that have recently been disturbed either by natural processes (e.g. severe flooding) or human activity. Plant species of special concern, due to their needs for specialized habitats and low-competition environments, are perhaps more susceptible to the threats posed by aggressive exotic species.

Other invasive plant species known to exist in the French Creek watershed include multiflora rose (*Rosa multiflora*), Tartarian honeysuckle (*Lonicera tatarica*), Japanese knotweed (*Polygonum cuspidatum*), and giant hogweed (*Heracleum mantegazzianum*). Experts believe these to be some of the most serious threats to our native ecosystems and many have been designated "Noxious Weeds" by the Pennsylvania Department of Agriculture and are also a major concern to our agricultural community. Other invasive plants in the French Creek watershed that deserve our vigilance are common privet (*Ligustrum vulgare*) and reed canary grass (*Phalaris arundinacea*).

Recently a new exotic species was found in the French Creek watershed. The zebra mussel, a small black and white striped bivalve mollusk, was discovered in Edinboro Lake in 2000. Believed to be in the lake for several years prior to discovery, the zebra mussel population had increased until individuals were discovered attached to boat hulls and large numbers in the shallow lake margins around Edinboro Lake. Since its discovery in Edinboro Lake, the zebra mussel has also been documented in Sandy Lake and Canadohta Lake, two glacial lakes just outside of the French Creek watershed.

The zebra mussel first invaded the Great Lakes in the mid-1980's when it was transported from Europe in the ballast water of oceangoing ships. Once established, the zebra mussel quickly colonizes all available hard substrate on lake bottoms. In a little over 10 years since its presence was confirmed, it has had a dramatic effect on the Lake Erie ecosystem, filtering large quantities of water and depleting the aquatic environment of microscopic algae and zooplankton. Additionally, these organisms have clogged water intake pipes for drinking water and industries, and fouled boat hulls.

Now that the zebra mussel has jumped the watershed divide from Lake Erie into the French Creek watershed, only time will tell the impact to Edinboro Lake and French Creek. Believed to have been introduced to Edinboro Lake through recreational boating, the existence of the zebra mussel in Edinboro Lake poses a serious threat to other lakes in the watershed. In the winter of 2000-2001 and again in 2001-2002, DEP and Edinboro Borough undertook a five-foot draw

down of the lake level to expose a large percentage of the zebra mussels to freezing temperatures in an attempt to kill the majority of the population. Viewed as a possible means of keeping the population under control, the results of the experimental drawdowns are currently being reviewed by researchers from Edinboro University of Pennsylvania. The first drawdown coincided with heavy snow cover, which may have acted to insulate the zebra mussels against freezing temperatures. Temperatures during the second drawdown were unusually mild and again may not have achieved the desired effects on the zebra mussel population.

Prevention through education is probably the best means of avoiding zebra mussel introductions. Once established, it is impossible to completely eradicate the zebra mussel with current levels of understanding about the organism. The threat that the zebra mussel poses to native freshwater mussels in French Creek is a debated topic. Research has shown that zebra mussel veligers (young) cannot survive turbulent waters. This is believed to be the reason the zebra mussel has not been successful at colonizing outlet streams of other lakes where it is found. Adult zebra mussels have been found in Conneauttee Creek, the outlet for Edinboro Lake, but only a short distance below the lake. Research by the USACE at Michael J. Kirwan Reservoir on the West Branch of the Mahoning River in nearby northeast Ohio has shown adult zebra mussels only colonize the outlet stream for a short distance (approximately a half mile) below the reservoir. It is thought that this colonization is a result of adults that get detached from the reservoir and wash downstream before reattaching instead of from veligers (U. S. Army Corps of Engineers, 2000). French Creek does have deep, slow moving pools that may resemble lake situations enough to allow the zebra mussel to colonize. For this reason, efforts are being made to educate the boating public on ways to minimize the risk of transporting zebra mussels to other area lakes.

Many other exotic species threaten the native biota of French Creek. Common carp (*Cyprinus carpio*) have been introduced to French Creek and several other carp species have the potential to be introduced from other PA waterways. Carp are primarily benthic feeders that can severely impact benthic communities, including freshwater mussels. They also aggressively compete with native benthic feeders for food resources.

As previously mentioned, the Asian clam has been documented from the French Creek drainage. Other potential exotics not documented to date are gobies, black carp, and triploid carp (supposed sterile hybrids) among others.

Brown trout and rainbow trout, the two most commonly stocked species in the French Creek watershed, are also exotic species that compete with native game fish. This increased competition may have negative effects on native forage fish and benthic communities.

Table 10 - A.
Educational Recommendations to Address Pollutants in the French Creek Watershed

Recommendation	Recommended Approach	Potential Partners	Priority
Increase Public Education about Non-Agricultural NPS Pollution	More education about non-agricultural non-point sources of pollution needed for the general public. Potential sources include faulty septic systems, improper lawn care, urban runoff, and combined sewage overflows. Education should emphasize things all citizens can do voluntarily to decrease non-point source pollution.	Conservation Organizations, DEP, Conservation Districts, School Districts, Universities	High
Identify and Utilize Educational Outlets	Widespread outlets for public education on issues should be identified and utilized. An example may be the newsletter developed and circulated to watershed homeowners by Rural Electric.	Conservation Organizations, DEP Conservation Districts	Medium
Increase Public Education on Lawn Fertilizer Use	Consumers should be educated on proper fertilizer use for lawn care at point of sale through cooperative programs between retailers and conservation organizations. Incentives and recognition should be given to cooperating retailers.	Conservation Organizations, DEP, Conservation Districts, Retailers	High
Increase Public Education on Toxins	Increase public education about toxins and potential effects on aquatic communities and humans. Education should include alternatives to toxins, proper handling, and disposal. This could be accomplished through workshops and printed material.	Conservation Organizations, DEP, Conservation Districts	High
Promote Recycling	Increase public education about benefits of recycling and proper disposal of potential toxins (batteries, pesticides, etc.). Provide incentives for schools and civic organizations to get involved.	Conservation Organizations, DEP, Municipalities	High
Increase Public Education on Use of Household Chemicals	Increase public education on proper use and disposal of common household chemicals (cleaning agents, degreasers, pesticides, etc.) through media and printed material.	Conservation Organizations, Businesses, DEP	High
Increase Education for Emergency Responders on Stream Issues	County and state emergency responders should be educated on issues dealing with stream protection in addition to public health.	County and State Emergency Repsonse Teams, Conservation Organizations	Low

Increase Public Education on Invasive Species Identification	Education to landowners, sportsmen, and outdoor enthusiasts on invasive species identification is important for monitoring and control. A printed photo guide to invasive species in the French Creek watershed would be valuable.	Conservation Organizations, DEP, DCNR, PFBC, Sea Grant, Conservation Districts	High
Increase Public Education on Invasive Ornamental Species	Education for landowners and retail nurseries about the threats posed by certain species, even those considered sterile hybrids. Include information on alternative native species to be planted.	Conservation Organizations, Retailers	Medium
Increase Public Education on Invasive Species Transport	Prevention through education is necessary. Voluntary monitoring of boats, fishing gear, SCUBA gear, planting, and soil transport is best way to avoid transporting invasive exotic species. Bait shops would be a good location to target education programs on aquatic species.	Conservation Organizations, DEP, DCNR, PFBC, Sea Grant, Retailers, Sportsmen	Medium
Educate Fishermen on Native Baitfish	Prevent spread of non-native forage fish species used as bait by educating fishermen on native species. Provide list of acceptable species for use in French Creek.	Conservation Organizations, PFBC, Retailers	Low
Increase Public Education and Support for Landfill Clean-Ups	Provide incentives and education to landowners for dump clean up. Recognize those efforts, which positively impact water quality.	Conservation Organizations, DEP	Medium

Table 10 - B.
Recommended Research to Address Pollutants in the French Creek Watershed

Recommendation	Recommended Approach	Potential Partners	Priority
Assess Nutrient Levels	Phosphorous and nitrogen levels should be assessed in the watershed through a sub-basin approach. This would allow for the identification of areas of significant contribution. Efforts to implement Best Management Practices and Nutrient Management Plans could be prioritized based on sub-basin contribution.	Conservation Organizations, NRCS, DEP, Conservation Districts, Academics	High
Develop Nutrient Budget	Phosphorous and nitrogen data should be used to develop a nutrient budget that shows where most severe nutrient inputs are coming from to account for total nutrients in French Creek. This can be done initially by sub-basin but should be broken down further to identify farmers in need of cooperative assistance with BMP implementation.	Conservation Organizations, NRCS, DEP, Conservation Districts, Academics	High
Increase Air Quality Monitoring	Air quality monitoring stations should be increased throughout the French Creek watershed to determine impacts to watershed from atmospheric deposition.	Conservation Organizations, DEP, Academics	Medium
Sample and Monitor for Toxins Identified	Toxins impacting French Creek need to be identified along with sources. Comprehensive watershed sampling and monitoring programs should be implemented.	Conservation Organizations, DEP, Academics	High
Monitor Minor Discharges	Minor discharges (<100,000 gal/day) should be identified and monitored. This could be done through conservation organization volunteers and students cooperatively with discharge owners. This would allow a better estimation of cumulative amounts of toxins throughout the watershed. Cooperating owners should be recognized with incentive program.	Conservation Organizations, DEP Academics	Medium
Calculate Total Watershed Toxins Loading	Total loadings of toxins for the watershed from all discharges should be calculated to determine possible cumulative effects on aquatic communities.	Conservation Organizations, DEP, Academics	Medium
Compare Fish Tissue/Sediment	Perform analysis of fish tissue/sediment toxin levels to determine if accumulation is occurring beyond levels detected by discharge	Conservation Organizations, DEP,	Low

Toxin Levels with Discharge Levels	monitoring.	PFBC, Academics	
Research Impacts of Abandoned Oil and Gas Wells	Determine impacts of abandoned oil and gas wells on groundwater and surface water supplies in the immediate vicinity. This will allow prioritization of well capping.	Conservation Organizations, DEP	High
Monitor Fish Hatchery Effluents	Determine impacts to the watershed from releases of toxins (and nutrients) from fish hatcheries in the watershed. Hatchery owners should be recognized for cooperation in minimizing releases.	Conservation Organizations, DEP, PFBC, Academics	Low
Monitor Road Inputs to Adjacent Waterways	Monitoring of road run off at critical times of the year should be done to determine if salt and brine application should be modified.	Conservation Organizations, DEP, PennDOT	Medium
Increase Monitoring and Research of Invasive Species	Identify initial invasions and address immediately. Research ways to control existing populations and ways to prevent potential invasions.	Conservation Organizations, Academics, Sea Grant, PFBC, DCNR	High
Inventory Invasive Species in Watershed	Periodic inventories involving volunteers and watershed residents should be initiated to increase monitoring efforts and evaluate control programs.	Conservation Organizations	High
Research Invasive Species' Impacts	Prioritize threats by species, sites, and impacts to the watershed. This will allow more efficient control programs.	Conservation Organizations, Academics, DEP	Medium

Table 10 - C.
Recommended Cooperative Actions to Address Pollutants in the French Creek Watershed

Recommendation	Recommended Approach	Potential Partners	Priority
Increase BMP Implementation	BMPs should be encouraged for agriculture, logging, urban stormwater management, mining, and development. Projects should be implemented through cooperative, incentive-based programs and partners should be recognized for their efforts. Projects should be monitored where possible to determine effectiveness.	Conservation Organizations, Conservation Districts, NRCS, Planners	High
Increase Awareness and Use of NMPs for Agriculture	Development of Nutrient Management Plans for farmers should be encouraged. This may require education about benefits and resources available.	Conservation Organizations, Conservation Districts, NRCS	High
Provide Assistance to Homeowners to Evaluate Septic Systems	A program should be established to assist homeowners in septic system evaluation. Assistance may come from PennVest, HomeAssist, Conservation Districts, or other similar programs. Incentives and recognition should be offered.	Conservation Organizations, Conservation Districts, DEP	Medium
Promote Septic System Maintenance Agreements	Septic system maintenance agreements between homeowners and municipalities should be considered. Franklin Township's program in Erie County could be modeled.	Municipalities, DEP	Medium
Promote Soil Testing	Soil testing should be encouraged before fertilizer application for both lawns and agriculture. Public may need to be made aware of programs.	Conservation Districts, DEP, Penn State Cooperatives	Medium
Promote Safe Storage of Toxins	Stored toxins/hazardous materials/chemicals should be adequately buffered against spills.	All users of hazardous materials	Low
Remove Hazardous Materials from Floodplain	Hazardous materials should not be stored on the floodplain or areas that do not provide adequate buffering against the material entering a waterway.	All users of hazardous materials	Medium
Cap Abandoned Oil and Gas Wells	Collect information on unknown well locations and well owners, and increase efforts on abandoned well capping for those wells that are	Conservation Organizations, DEP	Medium

	impacting waterways.		
Provide Alternatives to Salt/Brine Application on Roadways	Better enforcement is needed for current application guidelines. Less impactive methods of dust suppression should be used when economically feasible.	Municipalities, DEP, PennDOT	Medium
Address Stream Protection in Emergency Response	Make sure emergency response is adequate for stream protection (need knowledge of train/truck cargo in watershed)	County and State Emergency Response Teams	Medium
Support Landowners in Invasive Species Control	Provide financial and educational support to landowners for removal or control of invasive species. Recognize those landowners who voluntarily work to control invasive species.	Conservation Organizations, Conservation Districts, DEP, DCNR	Medium
Expand Current Invasive Species Control Programs	Expand current identification and control programs (i.e. PA Dept. of Ag, hogweed program). Invasive species should be viewed as a serious threat to future biodiversity.	Conservation Organizations, Conservation Districts, Appropriate Agencies	Medium
Organize Volunteers for Invasive Species Removal	Volunteers from conservation organizations and schools can be a valuable resource regarding invasive species removal when educated and supported.	Conservation Organizations, Conservation Districts, Appropriate Agencies	High
Review Baitfish Regulations	Work with PFBC to review regulations on baitfish sales to determine if protection against invasive species introduction is adequate.	Conservation Organizations, PFBC, Retailers	Low
Locate and Address Abandoned Landfills	Need to address small, old, individual, or abandoned municipal dumps. Monitor sites for impacts to water quality and promote voluntary clean-up efforts.	Conservation Organizations, DEP, Municipalities	Medium

Habitat Degradation

Habitat degradation is another major threat to aquatic organisms. In stream or river systems, habitats ranging from uplands to riparian forest areas to stream bottom substrate must be considered when determining habitat quality. Aquatic organisms rely on healthy riparian buffers for many reasons and the stream health cannot be considered separately from the adjacent land areas. French Creek faces many forms of habitat degradation. All of these stem from human activities and various land use practices throughout the watershed.

Erosion and Sedimentation

French Creek, and all streams, have naturally occurring amounts of suspended sediments that are the result of weathering of rocks and soils in the watershed. These natural levels of suspended sediments rarely are high enough to muddy the water, impede sunlight penetration, or smother benthic aquatic organisms or fish eggs. Human activities on the landscape have a tremendous tendency to increase sediment loads of streams and lakes. Increases in erosion and sedimentation lead to higher than normal levels of suspended sediments in surface water and build up of silt on stream bottoms that can smother aquatic organisms. The human activities that most commonly contribute sediments to surface waters are improper agricultural practices, deforestation, construction of buildings and roadways, urbanization, and mining. Also, it may be possible that dams, like the Union City Dam, which holds French Creek at bank-full flows for longer than normal periods, greatly increases downstream scour and erosion.

Increased amounts of suspended solids and sedimentation can lead to increased turbidity, which blocks sunlight penetration and decreases dissolved oxygen levels. Increased scour and erosive forces occur when sediment levels are increased because sediment particles act like sandpaper abrading the streambed. Sediments can also cover clean sand and gravel stream bottoms needed by many aquatic organisms for feeding, living, and laying eggs. If silt input is severe, freshwater mussel beds can be covered and the mussels smothered.

Agricultural land use has been shown to occur over almost half (40%) of the French Creek watershed. Threats from increased sedimentation occur primarily from row cropping or livestock pasturing along waterways. Improper planting of row crops, and the often-associated loss of riparian buffer, can greatly increase sediment loads in run-off and lead to severe erosion of stream banks. This is evident at many locations throughout the French Creek watershed where crops are planted adjacent to stream banks.

Livestock that have access to streams when pastured also increase erosion of stream banks through consumption and trampling of vegetation. There are several BMPs designed to decrease erosion and many of these provide additional benefits to the farmer. Simply fencing livestock out of streams and providing separate watering areas or reinforced stream crossings can greatly reduce the erosion of stream banks and increase the health of the livestock.

Improper timbering practices also have the potential to greatly increase erosion and sedimentation. The French Creek watershed, along with most of Pennsylvania, has gone through several cycles of large-scale timbering. With approximately half of the watershed reverted to

forest, French Creek is facing threats from improper logging practices in areas where mature woodlots exist. Logging, when done unsustainably, removes a large portion of the vegetation from the landscape resulting in increased runoff, which mobilizes large amounts of soil. In areas where the forests being timbered are along ridge tops, the effects may not be as detrimental to French Creek, but in other areas, steep, highly erodable slopes and mature riparian forests are being targeted by loggers. Logging riparian areas poses a significant threat to the aquatic habitats in the French Creek watershed. These riparian forests play key roles in buffering French Creek against activities on the landscape as well as providing shade and scenic value to the stream. Erosion from logging operations is increased by the use of heavy machinery for log skidding and through the construction of temporary logging roads without the use of BMPs.

Road and building construction is a concern in terms of erosion and sedimentation in the French Creek watershed as rural development occurs, often near streams and lakes. If these projects are near a waterway and could potentially impact that waterway they are required to obtain permits from DEP and to follow erosion and sedimentation plans to ensure sediments are prevented from running off site. Unfortunately, these permits are issued by the County Conservation District, an agency that does not have authority to enforce the regulations or the personnel to adequately monitor all sites. Often the construction projects are sub-contracted out to businesses that are not aware of the regulations and sediment releases occur due to lack of enforcement.

Dirt and gravel roads are common throughout the rural French Creek watershed. These roadways have the potential to contribute large amounts of sediment to nearby waterways. The sediments often carry oils, heavy metals, and salts, which further impact stream ecosystems. Hillside dirt and gravel roads are especially prone to erosion during heavy rainfall and spring snow melt events.

Sand and gravel mining occurs throughout the French Creek watershed. All mining operations are required to obtain permits from DEP. The PA Department of Environmental Protection Bureau of Mining's Knox District Office in Knox, PA is responsible for regulation of mining operations in the French Creek watershed. There are currently 110 permitted sand and gravel mining sites in the French Creek watershed. In addition, there is one sand stone mine located near Cooperstown, Venango County. The Sugar Creek sub-watershed does have the largest concentration of sand and gravel mining sites of any major tributary in the southern portion of the French Creek watershed and is also a popular area for oil and gas drilling. When surveyed for freshwater mussels, Sugar Creek was found to be practically devoid of viable populations (Western Pennsylvania Conservancy, 1994). More comprehensive assessments should be done in Sugar Creek to determine if the causes for the decreased mussel viability are related to impacts from mining or oil and gas wells.

Because mining operations are closely monitored by DEP, and sediments must be contained on-site, the amount of sediments reaching streams in the watershed may be low. Mining is however, a serious potential threat to water quality and aquatic organisms in French Creek and sites should be more thoroughly evaluated to determine actual threats. Barriers to prevent sediments from leaving mining sites do fail and can, in some cases, release catastrophic amounts of sediments to receiving streams.

Alterations of Hydrology

Hydrology is simply the study of the movement of water through various stages on the earth's surface. Water is stored (i.e. groundwater, surface water, ice caps) and transported (i.e. evaporation, transpiration, precipitation) in a continuous cycle. Aquatic habitats evolve certain characteristics based on the hydrology of water. Human impacts to the landscape have altered the hydrology of the French Creek watershed in several ways. Dams, like the Union City Dam, Woodcock Creek Dam, Tamarack Lake dams, and others, have altered natural flow regimes. In addition, water withdrawals from streams, lakes, and groundwater alter the watershed's hydrological patterns.

Numerous watershed stakeholders and citizens have raised concerns over the Union City Dam's negative effects on French Creek. Many of them describe changes they have seen in distribution and abundance of aquatic organisms as well as increases in erosion that have occurred at various sites downstream since construction of the dam. As with many of the threats discussed, it is difficult to determine the impacts that the dam has had to French Creek. Certainly, the natural flooding regime that is responsible for distributing nutrients on the floodplain has been altered. Natural flow regimes no longer rise and fall to the extremes that they did prior to the construction of the dam.

Alterations to natural flow regimes may disrupt nutrient flow in an aquatic ecosystem. Streams and rivers depend on nutrient input from the watershed to provide much of the energy to the flowing aquatic system. These nutrients are passed through aquatic food webs and flow from headwater tributaries to higher order streams, lower in the watershed, to provide energy for all aquatic organisms. Annual flooding not only brings nutrients into a stream but helps disperse nutrients back to the floodplain where they can be utilized by plants to once again enter the aquatic system as autumn leaf fall or woody debris. The impacts to this cycle, by dams in the watershed, need to be better understood. In addition to alterations in nutrient flow, dams may exacerbate erosion problems downstream by altering natural flow levels. This potentially leads to increased scour in some areas, increased erosion, substrate instability, and increased sediment deposition. These are all problems that lead to habitat degradation for aquatic organisms.

Studies by the USACE have documented good diversity and abundance of aquatic organisms at the dam's outfall. However, what effects does the dam have on aquatic communities further downstream? By holding French Creek at higher flow levels for longer periods of time, scouring and erosion is no doubt increased in areas downstream. This increases sediment loads carried by French Creek and deposited further downstream. These alterations to the natural hydrology of French Creek need to be examined to determine the effects on the watershed's aquatic communities.

Diversion of surface water and extractions of groundwater occur throughout the French Creek watershed. Farmers irrigate fields from nearby streams during the warmest, driest months of the year when aquatic organisms are already stressed by higher water temperatures and low dissolved oxygen levels. These withdrawals are often not regulated, and impacts to aquatic organisms are not adequately researched. Effects of these withdrawals have been documented by the PFBC on streams like Beaver Run in Erie County. This Exceptional Value stream contains a

naturally reproducing brown trout population, which has decreased in numbers in recent years because of decreased precipitation and increased irrigation by area farmers.

The majority of private residences in the watershed depend upon groundwater withdrawals for their water needs. The city of Meadville supplies its residents with drinking water from large wells. Other smaller towns utilize wells and springs or, in the case of Cambridge Springs Borough, obtain water directly from French Creek. Industries are another user of groundwater. Because groundwater recharges streams and lakes, alterations to groundwater levels can impact aquatic, wetland, and riparian habitats. A hydrologic budget that incorporates historic and current flows, groundwater and surface water, and inputs and withdrawals is needed to fully understand the impacts of hydrologic alterations to the French Creek watershed.

Mining has been discussed as a potential source of sedimentation and pollutants, however, it also has the potential to alter watershed hydrology. Removing large amounts of sand and gravel potentially alters flow regimes of groundwater in the mined area. Subtle increases or decreases in groundwater levels can negatively impact stream, lakes, and wetlands and alter the habitats for many organisms. Additionally, opening groundwater recharge areas to the atmosphere decreases filtration due to the remaining material being overburdened.

Only a very small percentage of the French Creek watershed is considered urban. However, research has shown that only a 10% increase in impermeable surfaces in a watershed can have a dramatic effect on aquatic habitats (Center for Watershed Protection). Increases in impermeable surfaces increase runoff and erosion and decrease infiltration to groundwater supplies. The resulting excessive flooding severely impacts streambeds and banks. Stormwater management plans should be considered in municipalities where population centers represent potential growth areas or where sprawl is occurring and impermeable surfaces are on the increase.

Because wetlands act as natural retention areas, loss of wetlands can increase the amount of water running overland and entering streams and lakes. This alteration to natural hydrology leads to increased erosion of streambeds and banks, increased flooding and flashiness, and loss of habitat for aquatic and riparian species.

Channel/Streambank Modification

Modifications to natural stream channels and streambanks are frequent occurrences. Often these modifications occur without adequate thought to the impacts to aquatic organisms or areas downstream of the modification. It is important to note that alterations to the natural stream channel or streambank design are usually not without negative consequence. Modifications at one point on a stream often cause problems such as increased erosion, flooding, or lowered water levels further downstream.

Channel modifications occur for a variety of reasons. Manipulation of stream channels for agricultural uses and flood control are both prominent in the French Creek watershed. Historically, unregulated by government, stream channelization has occurred to facilitate livestock watering and crop irrigation, as well as to reduce flooding by straightening and

deepening stream channels. "Physical alteration of the channel bed has a number of negative impacts on aquatic species including the effects associated with siltation and alteration of nutrient loads, flow, and flushing flows. Physical alteration of the creek channel destroys habitat for some species while creating habitat for others; the newly created habitat may be of poorer quality than the original or may be occupied by species other than the targeted species." (McAlpine, 1993). The community can engage in successful stream restoration projects and BMPs can be implemented to benefit farmer, livestock, and natural communities.

Stream channels are also modified for roadway and bridge replacement projects. These projects can severely disrupt benthic and riparian habitats. Although strictly monitored by DEP, PFBC, and USFWS, these projects can impact native freshwater mussel beds and fish spawning habitat. Relocations of freshwater mussels have been used as a tool to protect these organisms and allow bridge and roadway projects to occur.

A bridge was recently replaced over French Creek at Utica Borough, Venango County. Biologists from USGS translocated mussels from this site and are monitoring the results of translocation on survival rates. Preliminary reports suggest translocated individuals do experience higher mortality than individuals found at the translocated sites and in control sites (Villella, 2001). Because of the aging bridges found throughout the French Creek watershed, several bridges are scheduled to be replaced by PA Department of Transportation and local municipalities in the near future.

Streambanks are often modified by the removal of native vegetation and trees for the purpose of agriculture, livestock grazing, or development. Banks denuded of vegetation are prone to erosion, which increase the sedimentation in the streambed. This alters benthic habitat for aquatic insects, freshwater mussels, and fish spawning areas. Vegetation also helps shade stream channels, keeping water temperatures lower. Elevated water temperatures lower dissolved oxygen levels and magnify the effects of other stresses, such as pollutants. In addition, riparian vegetation is a major source of energy and nutrients for aquatic systems. This energy is added annually through autumn leaf fall and in the form of woody debris.

Many agencies and organizations are working to restore riparian habitat. It has been said that a functioning, intact riparian habitat is the most important tool in combating the effects of non-point source pollution and streambank erosion. Characterization of the riparian habitats throughout the French Creek watershed will be essential in enabling agencies and organizations to more effectively work on restoration in the most critical areas.

In some areas of the watershed, roadways are very close to waterways and result in accelerated erosion of streambanks due to increased run-off and destabilization of the stream banks. This is also true with railways along some portions of French Creek where it has been necessary to shore up rail beds with cement and rock riprap, which further destroys aquatic habitats and potentially displaces erosive forces further downstream.

Recreation

The French Creek watershed has many recreational opportunities that focus on the natural resources of the watershed. The activities are often associated with the lakes and waterways or riparian corridors along the waterways. It is estimated that recreational demands in the watershed will increase as populations increase. Aquatic habitats are at risk by humans trampling and disturbing them as they seek to enjoy the natural resources found there. In addition, many forms of recreation, such as ATV riding and power boating, may be highly incompatible with some areas. This leads to natural resource degradation and loss of aquatic habitat for many species. Any future recreational developments should be very carefully planned to ensure natural resources are protected. This will benefit all by ensuring outdoor enthusiasts will continue to be attracted to the French Creek watershed and by providing a boost to the local economy.

Table 11 - A.
Educational Recommendations to Address Habitat Degradation and in the French Creek Watershed

Recommendation	Recommended Approach	Potential Partners	Priority
Increase Public Education on Sustainable Forestry	Offer educational opportunities for loggers and woodlot owners on sustainable practices. Recognize loggers who utilize Best Management Practices.	Conservation Organizations, Conservation Districts, Penn State Cooperatives, DCNR	High
Establish a Clearinghouse of Information on Loggers	Develop and maintain a clearinghouse of information on loggers in the watershed that can be shared with landowners interested in having timbering done.	Conservation Organizations, Conservation Districts, Penn State Cooperatives, DCNR	Medium
Increase Education on Construction and Urban BMPs	Provide education and incentives for planners and developers for the implementation of construction and urban BMPs. This would include alternative greener methods of development.	Conservation Organizations, Municipalities, Planners	High
Increase Public Education about Benefits of Riparian Protection	Educate landowners about benefits to both the landowner and the environment gained through streambank and riparian protection.	Conservation Organizations, Conservation Districts, DEP, NRCS	High
Increase Public Education about Assistance Available for Riparian Restoration	Educate landowners on resources/agencies available to help with riparian restoration and protection. This includes funding and technical assistance for streambank fencing, erosion control, revegetation, etc.	Conservation Organizations, Conservation Districts, All Appropriate Agencies	High

Increase Public Education about Natural Stream Conditions	Educate landowners that modification of natural stream bed/banks is not desirable. Education should include "big picture" of how a watershed works. Stress the need to address sources of problems and not just the symptoms.	Conservation Organizations, Conservation Districts, DEP, NRCS	Medium
Increase Public Education about the Benefits of Forested Streambanks	Educate landowners and loggers about the negative impacts of cutting trees off streambanks. Stress the need for an intact riparian zone.	Conservation Organizations, Conservation Districts, Penn State Cooperatives, DEP, NRCS	Medium
Increase Public Education about Negative Impacts from Power Boating	Increase education about the links between impacts of power boating and environmental degradation. Link water quality to quality of life in educational programs.	Conservation Organizations, PFBC, DEP	Medium
Increase Public Education about Responsible ATV Use	Increase educational requirements for ATV riders including linking irresponsible riding to environmental degradation.	Conservation Organizations, DCNR	Medium
Increase Public Education about Urban Streams as Community Assets	Focus on urban streams as community assets (park land, etc.) and raise public support through volunteer efforts for clean ups, community activity days, etc. Develop community parks on appropriate streamside locations.	Conservation Organizations, Municipalities, DCNR	Low

Table 11 - B.
Recommended Research to Address Habitat Degradation in the French Creek Watershed

Recommendation	Recommended Approach	Potential Partners	Priority
Conduct Assessments by Sub-Basins on Suspended Sediments	Sources and deposition patterns of suspended sediments need to be determined and contributions should be addressed at the sub-basin level. This information will allow BMP	Conservation Organizations, Conservation Districts, DEP, NRCS, Academics	High

	implementation to be prioritized based on highest contributions of sediments.		
Characterize Streambed Conditions	Baseline information on streambed conditions needs to be collected. Specifically, degree of siltation, embeddedness, degree of streambank erosion, and streambed scour.	Conservation Organizations, Conservation Districts, DEP, Academics	High
Research Macroinvertebrate Communities	Macroinvertebrate communities should be monitored in non-riffle areas and other areas throughout the watershed to compliment DEP data. This information should be compared to physical assessments.	Conservation Organizations, DEP, Academics	High
Research Fluvial Geomorphology	Perform research to increase understanding of the fluvial geomorphology of French Creek especially as related to excessive flooding. A better understanding of flow patterns will aid restoration efforts.	Conservation Organizations, Academics, USGS, Hydrologists	High
Research Dam Impacts	Research impacts of dams on French Creek aquatic communities and consider alternative management options for Union City Dam if warranted.	Conservation Organizations, Academics, DEP, USACOE	Medium
Develop Water Budget/Hydrologic Model	Develop a watershed budget/hydrologic model, which takes stormwater run off into account. Start with theoretical model and build onto by monitoring and collecting information.	Conservation Organizations, Academics, USGS	High
Explore Current Technologies for Stream Evaluation	Research new GIS data being developed for the purpose of stream reach evaluation. Map areas of excessive bank erosion and streambed instability due to flooding.	Conservation Organizations, Conservation Districts, Academics, Appropriate Agencies	High
Early Warning Monitoring of Water Quantity	Monitoring should be designed to provide early warning of stress to aquatic organisms in the watershed during critical low flow periods.	Conservation Organizations, Academics, DEP	High
Include Community Withdrawals in Hydrologic Model	Tie community withdrawals into overall hydrologic model.	Conservation Organizations, Municipalities, DEP	Medium
Increase Research on Mining Impacts	Hydrogeologic experts should be utilized to determine impacts of mining on waterways. Specific major mining	Conservation Organizations, Academics,	High

	operations or areas should be targeted, especially as related to important biological, or recharge areas in the watershed.	Hydrologic Consultants, DEP, USGS	
Research Appropriate Stream Access Locations for Increased Recreational Opportunities	Access areas should be located in appropriate areas based on ecological research. This will minimize impacts to ecologically sensitive areas.	Conservation Organizations, Academics, USFWS, DEP, PFBC	High

Table 11 - C.
Recommended Cooperative Actions to Address Habitat Degradation in the French Creek Watershed

Recommendation	Recommended Approach	Potential Partners	Priority
Promote Stormwater Management Planning	Promote stormwater management planning to address erosion/run off from urban areas. Encourage counties to develop strormwater management plans and municipalities to adopt stormwater development ordinances.	Conservation Organizations, Municipalities, Planners, DEP	High
Promote No-Till Farming and Organic Methods	Promote no-till farming and organic methods in appropriate areas. Most appropriate areas can be determined through research of nutrient and sediment inputs. Incentive programs should be established.	Conservation Organizations, Conservation Districts, NRCS, Penn State Cooperatives	Low
Promote the Use of BMPs in Logging	Promote BMPs for logging operations throughout the watershed including road construction and log skidding. Incentive programs should be established.	Conservation Organizations, Penn State Cooperatives	High
Promote Conservation Easements	Conservation easements should be promoted as a voluntary tool landowners can use to ensure logging, agriculture, development, mining, and recreation occur in a sustainable manner. They are useful tools to conserve open space and protect important habitat.	Conservation Organizations	High
Promote Forest Owner Cooperatives	Promote the development of watershed-wide forest owner cooperatives to provide a support network for small woodlot owners.	Conservation Organizations, Penn State Cooperatives, DCNR	Medium
Encourage Sustainable Forestry Initiatives	Promote programs that lead to increased sustainable forestry initiatives throughout the watershed. Promote selective cutting, BMPs, or other sustainable forestry practices where appropriate.	Conservation Organizations, Penn State Cooperatives, DCNR	High
Provide Guidance and Incentives for Reforestation	Promote reforestation through consideration of appropriate locations, economics, tax forgiveness for forested areas, and modification of the tax code for forest owners.	Conservation Organizations, Legislators, Penn State Cooperatives, DCNR	Medium
Promote BMPs in New Construction	Promote the use of BMPs for various construction projects and the use of	Conservation Organizations,	Medium

	urban BMPs. Incentive programs should be developed.	Municipalities, Builder's Associations	
Promote Dirt & Gravel Road Program	Promote dirt & gravel road program in the watershed to reduce silt-laden run off from dirt and gravel roads. Consider this program as alternative to brine application for dust control.	Conservation Organizations, Conservation Districts, Municipalities, PennDOT	High
Prioritize Dirt & Gravel Road Program	Prioritize municipalities for the dirt & gravel road program according to impacts to the watershed.	Conservation Organizations, Conservation Districts, Municipalities, PennDOT	Medium
Promote the Establishment of Natural Vegetative Buffers Around Mine Areas	Provide incentives and recognition for miners who maintain natural vegetative buffer strips around mining operations.	Conservation Organizations, DEP	Medium
Reclaim Disturbed Areas with Native Species	Provide incentives and seed sources for native species to miners, road construction crews, and developers to use for reseeding.	Conservation Organizations, Nurseries	Medium
Avoid Dam Construction	Refrain from building any new dams in the French Creek watershed.	Any agency or organization	High
Consider Dam Removal	Consider cost/benefits of removal of small dams in the watershed.	Conservation Organizations, Municipalities, Dam Owners	High
Consider Controlled Flooding	Agencies should consider controlled flooding, where appropriate, to mimic natural flooding regimes. This would require research and public education.	Conservation Organizations, USACOE, DEP, NRCS	Low
Better Management of Dam Releases	Agencies should research how releases impact aquatic communities and aquatic habitat. This information should be used to develop management plans for releases that will better accommodate aquatic communities.	Conservation Organizations, USACOE, DEP, NRCS	Low
Address Agricultural Drainage Tiles Where Appropriate	Locate and assess the impacts from agricultural drainage tiles throughout the watershed. Remove those that are no longer needed and restore wetlands.	Conservation Organizations, Conservation Districts, DEP, NRCS	Low
Promote Urban	Promote BMPs for urban development	Conservation	Medium

BMPs	and retrofit BMPs in established urban areas. Center for Watershed Protection program can be modeled. BMPs include catchment basins, grass swales for run off infiltration, green islands in large parking lots, etc.	Organizations, Municipalities, Planners, Developers, DEP	
Promote Urban Reforestation	Promote reforestation in any open urban areas for shade, wildlife, and aesthetics. Volunteers can be used to foster community pride.	Conservation Organizations, Municipalities	Low
Coordinate and Prioritize Water Withdrawals	Conduct meetings of major water users to voluntarily coordinate withdrawals during low flow periods. Establish incentive programs.	Conservation Organizations	Medium
Promote Agricultural Reservoirs for Irrigation	Encourage agricultural operations to make surface reservoirs for withdrawals where feasible. Do not dam streams in reservoir construction. Identify funding to help farmers develop reservoirs. Encourage practices that limit need for irrigation.	Conservation Organizations, Conservation Districts, NRCS, DEP	Medium
Promote Riparian Protection and Restoration	Promote incentive based voluntary programs for streambank fencing and riparian buffer/streambank protection and restoration. Identify funding to assist landowners.	Conservation Organizations, Conservation Districts, NRCS, DEP, Academics	High
Promote Natural Stream Channel Design	Re-establish natural stream channel morphology at bridges (through engineering) and other areas where development or agriculture has altered natural stream channel fluvial geomorphology. Establish incentive programs for landowners and provide assistance.	Conservation Organizations, Conservation Districts, NRCS, PennDOT, DEP	Medium
Encourage Streambank Fencing	Promote voluntary incentive based programs for landowners to fence livestock out of streams. Crossings and watering areas should be designated and reinforced. Provide assistance to landowners and link them to agencies with available funding.	Conservation Organizations, Conservation Districts, All agencies with fencing programs	High
Work at Sub-Basin Level	Citizen groups should be developed in each sub-watershed to take ownership of local projects. An established network would work for the whole of French Creek by focusing on smaller areas.	Conservation Organizations, Conservation Districts	High

	These groups could seek out funding for local landowners.		
Promote Agricultural BMPs and NMPS	Promote agricultural Best Management Practices and Nutrient Management Plans and supply funding and assistance to encourage farmers to implement projects. Projects should include barnyard stabilization and manure management.	Conservation Organizations, Conservation Districts, NRCS	High
Promote Wetland Protection During Logging	Wetland and vernal pool protection should be promoted with loggers. Encourage BMPs and provide incentive and recognition program.	Conservation Organizations, Conservation Districts, Penn State Cooperatives, DEP	High
Promote Better Enforcement of Erosion and Sedimentation Control Plans	Stricter enforcement of E&S Plans is needed.	Conservation Districts, DEP	Medium
Promote Green Space in Development	Development plans should maximize green space. Building lot clustering, establishing development zones, and shared greenspace within developments are examples of ways to maximize green space.	Conservation Organizations, Municipalities, Planners, Developers	High
Urban Stream Revitalization	Restore bank and riparian habitats in urban areas.	Conservation Organizations, Municipalities	Medium
Encourage Municipalities and State Agencies to Focus Infrastructure Dollars	Target growth areas with state funds to allow development while maintaining open space.	Planners, Municipalities	High
Encourage Long Range Planning	Conduct long range planning at the municipal and county level.	Planners, Municipalities	High
Evaluate Land Use and Planning Options	Promote assistance to municipalities for zoning, sub-division, and comprehensive planning issues. Encourage multi-municipal planning.	Conservation Organizations, Municipalities, Planners	High
Address Improper ATV Usage	Support the implementation of DCNR's new program for ATV registration. Promote designated trails in less sensitive areas. Increase educational requirements for ATV riders.	Conservation Organizations, Recreational Groups, DCNR, PennDOT, PGC	Medium
Encourage	Designate and develop appropriate trails	Conservation	High

Cooperative Approach to Trail Development	and railtrails along stream corridors. Riparian corridors and natural resource protection should be a priority. Private landowners rights should be respected and trail should be developed through voluntary cooperative programs.	Organizations, Municipalities, Planners, Railways, Trail Groups	
Promote Catch and Release	Promote catch and release of native species. Waters with introduced species for put-and-take fisheries should be managed as such.	Conservation Organizations, Sportsmen, PFBC, Trout Unlimited	Low
Customize Baitfish Regulations	Regulations for taking baitfish should be customized to protect French Creek's rare, threatened, and endangered fish species especially during breeding periods.	PFBC	Low
Establish Riparian Development Guidelines	Develop guidelines for riparian development for cabins or trails that would maximize protection for riparian areas. Municipalities should be encouraged to adopt conservation programs that protect streams and lakes.	Conservation Organizations, Municipalities	Medium