Chapter 6
Water Quality Stressors

6.1 Stressor and Source Identification

6.1.1 Introduction – Stressors

Water quality stressors are identified when impacts have been noted to biological (fish and benthic) communities or water quality standards have been violated. Stressors apply to one or more use support categories and may be identified for Impaired as well as Supporting waters with noted impacts. Identifying stressors is challenging because direct measurements of the stressor may be difficult or prohibitively expensive. DWQ staff use field observations from sample sites, special studies and data from ambient monitoring stations as well as information from other agencies and the public to identify potential water quality stressors. It is important to identify stressors and potential sources of stressors so that water quality programs can target limited resources to address water quality problems.

Most stressors to the biological community are complex groupings of many different stressors that individually may not degrade water quality or aquatic habitat, but together can severely impact aquatic life. Sources of stressors are most often associated with land use in a watershed, as well as the quality and quantity of any treated wastewater that may be entering a stream. During naturally severe conditions such as droughts or floods, any individual stressor or group of stressors may have more severe impacts to aquatic life than during normal climatic conditions. The most common source of stressors is from altered watershed hydrology.

> ***Cumulative Effects***
>
> While any one activity may not have a dramatic effect on water quality, the cumulative effect of land use activities in a watershed can have a severe and long-lasting impact.

Stressors to recreational uses include pathogenic indicators such as fecal coliform bacteria, escheria coli and enterrococci. Stressors to fish consumption are mercury and any other substance that causes the issuance of a fish consumption advisory by the NC Division of Health and Human Services (NCDHHS).

6.1.2 Overview of Stressors Identified in the Little Tennessee River Basin

The stressors noted below are summarized for all waters and for all use support categories. Figure 11 identifies stressors noted for streams in the Little Tennessee River Basin during the most recent assessment period. The stressors noted in the figure may not be the sole reason for the impairment. For specific discussion of stressors to impairments or noted impacts, refer to the subbasin chapters (Chapters 1 – 4). Stressor definitions and potential impacts are discussed in the remainder of this chapter.

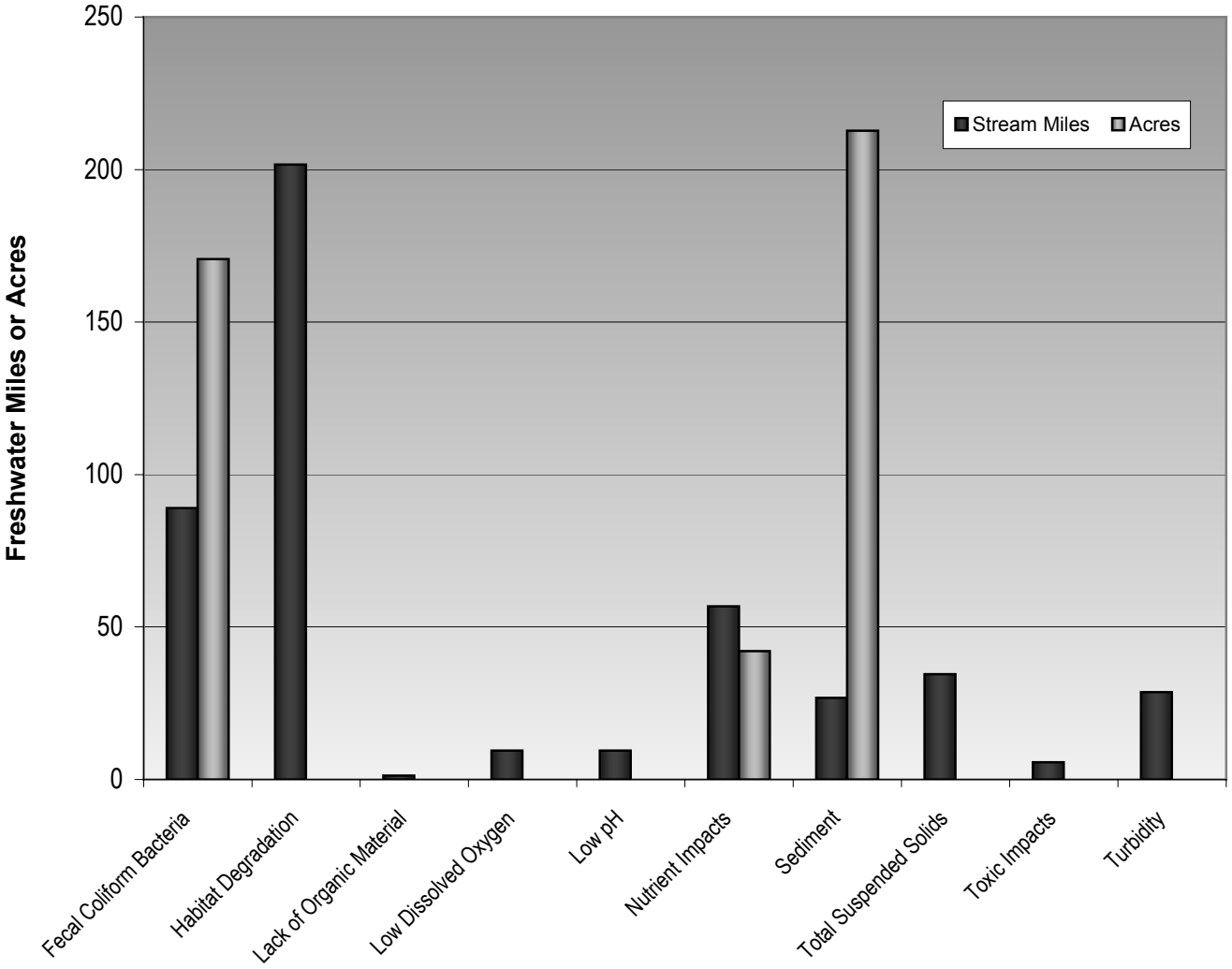


Figure 11 Stressors Identified for Streams in the Little Tennessee River Basin

6.1.3 Introduction – Sources of Stressors

Pollutants that enter waters fall into two general categories: *point sources* and *nonpoint sources*. Point sources are typically piped discharges and are controlled through regulatory programs administered by the state. All regulated point source discharges in North Carolina must apply for and obtain a National Pollutant Discharge Elimination System (NPDES) permit from the state.

Point Sources

Piped discharges from:

- Municipal wastewater treatment plants
- Industrial facilities
- Small package treatment plants
- Large urban and industrial stormwater systems

Nonpoint sources are from a broad range of land use activities. Nonpoint source pollutants are typically carried to waters by rainfall, runoff, and snowmelt. Sediment and nutrients are most often associated with nonpoint source pollution. Other pollutants associated with nonpoint source pollution include fecal coliform bacteria, heavy metals, oil and grease, and any other substance that may be washed off the ground or deposited from the atmosphere into surface waters. Unlike point source pollution, nonpoint pollution sources are diffuse in nature and occur intermittently, depending on rainfall events and land disturbance. Given these characteristics, it is difficult and resource intensive to quantify nonpoint contributions to water quality degradation in a given watershed.

Nonpoint Sources

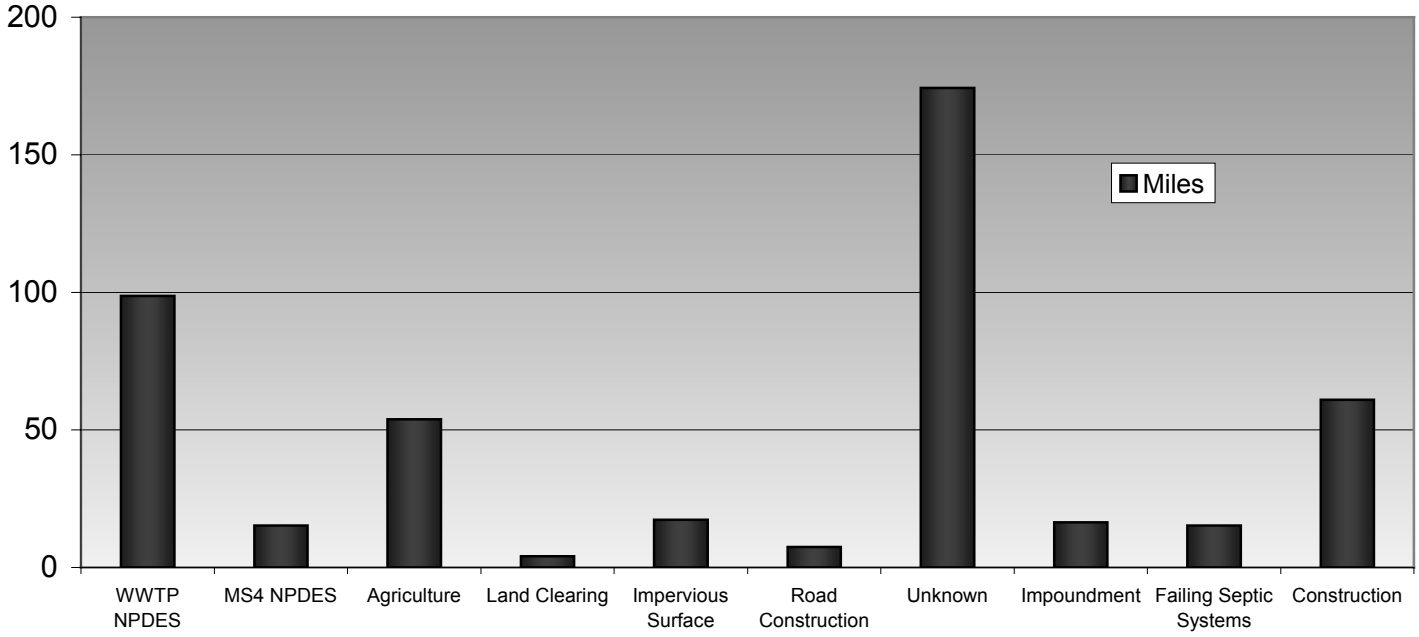
- Construction activities
- Roads, parking lots and rooftops
- Agriculture
- Failing septic systems and straight pipes
- Timber harvesting
- Hydrologic modifications

DWQ identifies the source of a stressor, point or nonpoint, as specifically as possible depending on the amount of information available in a watershed. Most often the source is based on the predominant land use in a watershed. Sources of stressors identified in the Little Tennessee River basin during the most recent assessment period include urban or impervious surface runoff, land clearing, and road building. Point source discharges are also considered a water quality stressor source. In addition to these sources, many impacts originate from unknown sources.

6.1.4 Overview of Stressor Sources Identified in the Little Tennessee River Basin

The sources noted below are summarized for all waters and for all use support categories. Figure 12 identifies sources of stressors noted for waters in the Little Tennessee River Basin during the most recent assessment period. Refer to the subbasin chapters (Chapters 1 – 4) for a complete listing and discussion of sources by stream.

Figure 12 Sources of Stressors Identified in the Little Tennessee River Basin



WWTP NPDES (wastewater treatment plants) were noted as a potential source to several stream miles in the Little Tennessee River basin. WWTPs are just one of many sources that can contribute excess nutrients that may increase the potential for algal blooms and cause exceedances in the chlorophyll *a* standard. WWTPs were noted as a potential source of water quality problems in 98.6 stream miles. Better treatment technology and upgrades to facilities in the Little Tennessee River basin are likely to decrease the number of stream miles impacted by WWTPs. MS4 NPDESs were noted as a potential source of water quality problems in 15.3 stream miles.

Field observations indicate that agricultural activities may be impacting water quality in several watersheds of the Little Tennessee River basin. In several areas where pasture was noted as the predominant land use, cattle had direct, easy access to the stream. Agriculture was noted as a potential stressor source for 53.8 stream miles. For more information related to agricultural water quality initiatives, refer to Chapter 9.

Impervious surface as a stressor source accounted for noted impacts to 17.4 stream miles and road construction activities accounted for noted impacts to 7.4 stream miles. Impervious surface cover and road construction activities are often associated with increased development. Refer to Chapter 7 for more information related to population growth and land cover changes and their potential impacts on water quality.

Stressor sources could not be identified for 599.7 stream miles in the Little Tennessee River basin. These stream segments may be in areas where sources could not be identified during field observations, but the streams had noted impacts (i.e., habitat degradation). DWQ and the local agencies will work to identify potential sources for these stream segments during the next basinwide cycle.

6.2 Aquatic Life Stressors – Habitat Degradation

6.2.1 Introduction and Overview

Instream habitat degradation is identified as a notable reduction in habitat diversity or a negative change in habitat. This term includes sedimentation, streambank erosion, channelization, lack of riparian vegetation, loss of pools and/or riffles, loss of organic (woody and leaf) habitat, and streambed scour. These stressors to aquatic insect and fish communities can be caused by many different land use activities and less often by discharges of treated wastewater. In the Little Tennessee River basin, 9.2 stream miles are Impaired where at least one form of habitat degradation has been identified as the stressor. There are an additional 201.6 stream miles that are not Impaired but where habitat degradation is a noted impact to water quality. Many of the stressors discussed below are either directly caused by or are a symptom of altered watershed hydrology. Altered hydrology increases both sources of stressors and delivery of the stressors to the receiving waters. Refer to the subbasin chapters (Chapters 1 – 4) for more information on the types of habitat degradation noted in a particular stream segment.

Good instream habitat is necessary for aquatic life to survive and reproduce. Streams that typically show signs of habitat degradation are in watersheds that have a large amount of land-disturbing activities (i.e., construction, mining, timber harvest, agricultural activities) or a large percentage of impervious surfaces. A watershed in which most of the riparian vegetation has been removed from streams or channelization (straightening) has occurred also exhibits instream habitat degradation. Streams that receive a discharge quantity that is much greater than the natural flow in the stream often have degraded habitat as well.

Some Best Management Practices to Improve Habitat Degradation

Agriculture

- No till or conservation tillage practices
- Strip cropping and contour farming
- Leaving natural buffer areas around small streams and rivers

Construction

- Using phased grading/seeding plans
- Limiting time of exposure
- Planting temporary ground cover
- Using sediment basins and traps

Forestry

- Controlling runoff from logging roads
- Replanting vegetation on disturbed areas
- Leaving natural buffer areas around small streams and rivers

Quantifying the amount of habitat degradation is very difficult in most cases. To assess instream habitat degradation in most streams would require extensive technical and monetary resources and then even more resources to restore them. Although DWQ and other agencies (i.e., SWCD, NRCS, town and county governments) are starting to address this issue, local efforts are needed to prevent further instream habitat degradation and to restore streams that have been Impaired by activities that cause habitat degradation. As point source dischargers become less common sources of water quality impairment, nonpoint sources that pollute water and cause habitat degradation must be addressed to further improve water quality in North Carolina's streams and rivers.

6.2.2 Sedimentation

Sedimentation is a natural process that is important to the maintenance of diverse aquatic habitats. It is the process by which soil particles that washed off the landscape and stream banks are deposited within the stream. Streams naturally tend toward a state of equilibrium between erosion and deposition of sediments. As streams meander through their floodplains, the outside of the stream cuts into the bank eroding it away, while the inside of the stream deposits sediments to create sand bars further downstream. The natural process of erosion and deposition can be disrupted by human activities such as dams, dredging, agriculture, development, or logging. Construction projects or logging in the upper reaches of a watershed may worsen erosion or sediment deposition on someone else's property further downstream. If people straighten, narrow, or move stream channels without taking into consideration their natural energy, erosion and sediment deposition rates can increase, resulting in the loss of valuable agricultural land, damage to roads or structures, destruction of productive wetlands, and addition of sediments and nutrients to waterways that can degrade surface water quality and biodiversity.

Overloading of sediment in the form of sand, silt and clay particles fills pools and covers or embeds riffles that are vital aquatic insect and fish habitats. Suspended sediment can decrease primary productivity (i.e., photosynthesis) by shading sunlight from aquatic plants, thereby affecting the overall productivity of a stream system. Suspended sediment also has several effects on various fish species including avoidance and redistribution, reduced feeding efficiency which leads to reduced growth by some species, respiratory impairment, reduced tolerance to diseases and toxicants, and increased physiological stress (Roell, 1999). Sediment filling rivers

and streams decreases their storage volume and increases the frequency of floods (NCDENR-DLR, 1998). Suspended sediment also increases the cost of treating municipal drinking water.

Streambank erosion and land-disturbing activities are sources of sedimentation. Streambank erosion is often caused by high stormwater flows immediately following rainfall events or snowmelts. Watersheds with large amounts of impervious surface transport water to streams more rapidly and at higher volumes than in watersheds with more vegetative cover. In many urban areas, stormwater is delivered directly to the stream by a stormwater sewer system. This high volume and concentrated flow of water after rain events undercuts streambanks often causing streambanks to collapse. This leads to large amounts of sediment being deposited into the stream. Many urban streams are adversely impacted by sediment overloading from the watershed as well as from the streambanks. Minimizing impervious surface area and reducing the amount of stormwater outlets releasing stormwater directly to the stream can often prevent substantial amounts of erosion.

Land-disturbing activities such as the construction of roads and buildings, crop production, livestock grazing, and timber harvesting can accelerate erosion rates by causing more soil than usual to be detached and moved by water. In most land-disturbing activities, sedimentation can be controlled through the use of appropriate best management practices (BMPs). BMPs that minimize the amount of acreage and length of time that the soil is exposed during land-disturbing activities can greatly reduce the amount of soil erosion. For more information on sedimentation as it relates to changes in land use, refer to Chapter 7.

Livestock grazing with unlimited access to the stream channel and banks can also cause severe streambank erosion resulting in sedimentation and degraded water quality. Although they often make up a small percentage of grazing areas by surface area, riparian zones (vegetated stream corridors) are particularly attractive to cattle that prefer the cooler environment and lush vegetation found beside rivers and streams. This concentration of livestock can result in increased sedimentation of streams due to "hoof shear", trampling of bank vegetation, and entrenchment by the destabilized stream. Despite livestock's preference for frequent water access, farm veterinarians have reported that cows are healthier when stream access is limited (EPA, 1999). For more information on the livestock exclusion, refer to Chapter 5.

6.2.3 Loss of Riparian Vegetation

During the 2002 basinwide sampling, DWQ biologists reported degradation of aquatic communities at several sites throughout the Little Tennessee River basin in association with narrow or nonexistent zones of native riparian vegetation. Riparian vegetation loss was common in rural and residential areas as well as in urban areas (NCDENR-DWQ, 2003). The loss of riparian vegetation and subsequent reduction of organic aquatic habitats (Section 5.2.4) is most commonly associated with land clearing for development, agriculture, pastureland, and forestry. Instream organic habitat loss has also been caused by stream channelization or debris removal activities.

Removing trees, shrubs and other vegetation to plant grass or place rock (also known as riprap) along the bank of a river or stream degrades water quality. Removing riparian vegetation eliminates habitat for aquatic macroinvertebrates that are food for trout and other fish. Rocks lining a streambank absorb the sun's heat and warm the water. Some fish require cooler water temperatures as well as the higher levels of dissolved oxygen cooler water provides. Trees,

shrubs and other native vegetation cool the water by shading it. Straightening a stream, clearing streambank vegetation, and lining the streambanks with grass or rock severely impact the habitat that aquatic insects and fish need to survive.

Establishing, conserving and managing streamside vegetation (riparian buffer) is one of the most economical and efficient BMPs. Forested buffers in particular provide a variety of benefits including filtering runoff and taking up nutrients, moderating water temperature, preventing erosion and loss of land, providing flood control and helping to moderate streamflow, and providing food and habitat for both aquatic and terrestrial wildlife (NCDENR-DWQ, 2004). To obtain a free copy of DWQ's *Buffers for Clean Water* brochure, call (919) 733-5083, ext. 558.

6.2.4 Loss of Instream Organic Microhabitats

Organic microhabitat (i.e., leafpacks, sticks and large wood) and edge habitat (i.e., root banks and undercut banks) play very important roles in a stream ecosystem. Organic matter in the form of leaves, sticks and other materials serve as the base of the food web for small streams. Additionally, these microhabitats serve as special niches for different species of aquatic insects, providing food and/or habitat. For example, many stoneflies are found almost exclusively in leafpacks and on small sticks. Some beetle species prefer edge habitat, such as undercut banks. If these microhabitat types are not present, there is no place for these specialized macroinvertebrates to live and feed. The absence of these microhabitats in some streams in the Little Tennessee River basin is directly related to the absence of riparian vegetation. Organic microhabitats are critical to headwater streams, the health of which is linked to the health of the entire downstream watershed. For more information related to headwater streams, refer to Chapter 7.

6.2.5 Channelization

Channelization refers to the physical alteration of naturally occurring stream and riverbeds. Typical modifications are described in the text box. Although increased flooding, streambank erosion and channel instability often occur in downstream areas after channelization has occurred, flood control, reduced erosion, increased usable land area, greater navigability and more efficient drainage are frequently cited as the objectives of channelization projects (McGarvey, 1996). Direct or immediate biological effects of channelization include injury and mortality of aquatic insects, fish, shellfish/mussels and other wildlife populations, as well as habitat loss. Indirect biological effects include changes in the aquatic insect, fish and wildlife community structures, favoring species that are more tolerant of or better adapted to the altered habitat (McGarvey, 1996).

Restoration or recovery of channelized streams may occur through processes, both naturally and artificially induced. In general, streams that have not been excessively stressed by the channelization process can be expected to return to their original forms. However, streams that have been extensively altered may establish a new, artificial equilibrium (especially when the channelized streambed has been hardened). In such cases, the stream may enter a vicious cycle of erosion and continuous entrenchment. Once the benefits of a channelization project become outweighed by the costs, both in money and environmental integrity, channel restoration efforts are likely to be taken (McGarvey, 1996).

Channelization of streams within the continental United States is extensive and promises to become even more so as urban development continues. Overall estimates of lost or altered riparian habitats within US streams are as high as 70 percent. Unfortunately, the dynamic nature of stream ecosystems makes it difficult (if not impossible) to quantitatively predict the effects of channelization (McGarvey, 1996). Channelization has occurred historically in parts of the Little Tennessee River basin and continues to occur in some watersheds, especially in small headwater streams.

Typical Channel Modifications

- Removal of any obstructions, natural or artificial, that inhibit a stream's capacity to convey water (clearing and snagging).
- Widening, deepening or straightening of the channel to maximize conveyance of water.
- Lining the bed or banks with rock or other resistant materials.

6.2.6 Recommendations for Reducing Habitat Degradation

In March 2002, Environmental Management Commission (EMC) sent a letter to the Sedimentation Control Commission (SCC) expressing seven recommendations for improving erosion and sedimentation control, based on a comprehensive performance review of the turbidity standard conducted in 2001 by DWQ staff. Specifically, the recommendations are that the EMC and SCC:

(1) Evaluate, in consultation with the Attorney General's Office, whether statutory authority is adequate to mandate temporary ground cover over a percentage of the uncovered area at a construction site within a specific time after the initial disturbance of the area. If it is found that statutory authority does not exist, then the EMC and SCC should prepare resolutions for the General Assembly supporting new legislation to this effect.

(2) Prepare resolutions supporting new legislation to increase the maximum penalty allowed in the Sedimentation Pollution Control Act from $5,000 to $25,000 for the initial response to a noncompliant site.

(3) Jointly support a review of the existing Erosion and Sediment Control Planning and Design Manual by the NC Division of Land Resources (DLR). This review should include, but not be limited to, a redesign of the minimum specifications for sedimentation basins.

(4) Evaluate, in consultation with the Attorney General's Office, whether the statutory authority is adequate for effective use of the "Stop Work Order" tool and, if found not to be adequate, to prepare resolutions for the General Assembly supporting new legislation that will enable staff to more effectively use the "Stop Work Order" tool.

(5) Support increased research into and experimentation with the use of polyacrylamides (PAMs) and other innovative soil stabilization and turbidity reduction techniques.

(6) Jointly support and encourage the awarding of significant monetary penalties for all activities found to be in violation of their Stormwater Construction General Permit, their Erosion and Sediment Control Plan, or the turbidity standard.

(7) Hold those individuals who cause serious degradation of the environment through excessive turbidity and sedimentation ultimately responsible for restoration of the area.

DWQ will continue to work cooperatively with DLR and local programs that administer sediment control in order to maximize the effectiveness of the programs and to take appropriate enforcement action when necessary to protect or restore water quality. However, more voluntary implementation of BMPs is needed for activities that are not subject to these rules in order to substantially reduce the amount of widespread sedimentation present in the Little Tennessee River basin. Additionally, more public education is needed basinwide to educate landowners about the value of riparian vegetation along small tributaries and the impacts of sedimentation to aquatic life.

Funding is available through numerous federal and state programs for landowners to restore and/or protect riparian buffer zones along fields or pastures, develop alternative watering sources for livestock, and fence animals out of streams (refer to Chapters 9 and 13). EPA's *Catalog of Federal Funding Sources for Watershed Protection* (Document 841-B-99-003) outlines some of these and other programs aimed at protecting water quality. A copy may be obtained by calling the National Center for Environmental Publications and Information at (800) 490-9198 or by visiting the website at http://www.epa.gov/OWOW/watershed/wacademy/fund.html. Local contacts for various state and local agencies are listed in Appendix VII.

6.2.7 Small Dams, Impoundments, and Water Features

The consensus among river ecologists is that dams are the single greatest cause of the decline of river ecosystems (World Commission on Dams, 2000). This report was focused on large dams, but by design, all dams, including small impoundments, alter the natural flow regime, and with it virtually every aspect of a river ecosystem, including water quality, sediment transport and deposition, fish migrations and reproduction, and riparian and floodplain habitat and the organisms that rely on this habitat (Raphals, 2001). Dams also require ongoing maintenance. For example, reservoirs in sediment-laden streams lose storage capacity as silt accumulates in the reservoir.

Dams cause significant adverse impacts to the ecology of rivers and streams by blocking migration of fish to upriver spawning habitat; warming water temperatures in impoundments well above downstream conditions and accumulating sediment, which degrades water quality and often buries high quality fisheries habitat.

The damming and/or diverting of streams can lead to the loss of habitat resulting from the inundation of wetlands, riparian areas, and farmland in upstream areas of the impounded waterway, or erosion of these resources in downstream areas. As dams trap sediment and other pollutants, changes in water quality especially in tailwaters and downstream areas occur. They include: reduced sediment transport, decreased dissolved oxygen, altered temperature regimes, and increased levels of some pollutants, such as hydrogen sulfide, nutrients, and manganese.

Once streams are impounded, water demand dictates the artificial regulation and control of streamflow. The new flow rates and volume often do not reproduce natural conditions preceding the impoundment. Releases of impounded water with decreased levels of dissolved oxygen, high turbidity, or altered temperature can reduce downstream populations of fish and other organisms. Not only can reservoir water temperatures and oxygen content differ significantly from expected

seasonal temperatures in the formerly free-flowing stream or river, but critical minimum flows needed for riparian areas are often not maintained as well. (EPA, 1995).

These effects are seen in both large and small impoundments. In 2003, the Tennessee Department of Environment and Conservation, Division of Water Pollution Control was awarded a grant to perform a probabilistic monitoring study of 75 streams below small impoundments. Many of these are similar to those found in western North Carolina. The study measured effects of the impoundments on aquatic life, nutrients, dissolved oxygen, pH, iron, manganese, habitat, flow and periphyton density in the downstream stream reaches.

Macroinvertebrate communities were adversely affected in most of the streams sampled. Of the 75 sites below impoundments, only four passed biological criteria guidelines or were comparable to unimpounded streams in both seasons sampled. A shift in the type of dominant organisms toward more tolerant taxa was also observed.

Lack of adequate flow was one of the biggest problems downstream of impoundments. Approximately one third of the perennial streams that were randomly selected for reconnaissance were dry. Of those with flow during the summer reconnaissance, one fourth had dry channels by the fall sampling period. Thirty-nine percent of the dams with year-round discharge provided insufficient flow to supply adequate habitat for aquatic life during at least one season.

Disruption of habitat was a major concern below most of the impoundments. Sediment deposition was the most significant habitat problem in impounded streams with 80% failing to meet regional expectations. High levels of sediment deposition are symptoms of an unstable and continually changing environment that becomes unsuitable for many aquatic organisms. Other frequently documented habitat problems included embedded substrate, instability of banks, loss of stream sinuosity and disruption of bank vegetation.

The most frequently encountered chemical water quality problems below impoundments were elevated iron, manganese and nutrients as well as low dissolved oxygen concentrations. Elevated manganese was the number one problem. Ammonia was the most frequently elevated nutrient.

Dissolved oxygen in lakes and streams is critical to support fish and aquatic life. Low levels of dissolved oxygen may be caused by decay of organic material, respiration of algae, inflow of substantial amounts of ground water, or reduced stream flow. Dissolved oxygen was below criteria in at least one season at 21 of the impounded test sites. Many sites that passed dissolved oxygen criteria during daylight hours did not maintain saturation comparable to reference levels. Streams with dissolved oxygen saturation below this level may not be providing adequate oxygen to support benthic communities appropriate for the ecoregion.

Water temperature is an important component of the aquatic environment. Almost all facets of life history and distribution of aquatic macroinvertebrates are influenced by temperature. Eight of the impounded streams violated the temperature criterion at the time of sampling. Most of the test sites fell outside the temperature ranges found in regional reference streams.

Approximately half of the impounded test sites had elevated suspended solids (TSS) compared to regional reference streams. Total suspended solids (TSS) can include a wide variety of material, such as silt and decaying organic matter. High TSS can block light from reaching submerged vegetation. Particles can clog gills, reduce growth rates, decrease resistance to disease and

prevent egg and larval development of benthic fauna. Suspended particles absorb heat from sunlight, which can result in higher water temperatures. Pollutants such as bacteria, nutrients, pesticides and metals may attach to sediment particles and be transported to the water where they are released or carried further downstream. (Arnwine, 2006)

These results clearly demonstrate the negative impact small dams and impoundments can have on stream habitat and water quality. DWQ strongly encourages developers and homeowners to carefully consider these impacts before choosing to install a water feature. In many cases, the harm caused will outweigh the benefits. Additionally, many existing small dams and impoundments may have outlived their usefulness. These old dams negatively influence biological communities and may have become maintenance problems. Removal options should be explored for these dams.

6.3 Aquatic Life Stressors – Water Quality Standards

6.3.1 Introduction and Overview

In addition to the habitat stressors discussed in the previous section, the stressors discussed below are identified by water quality standards. These are usually direct measures of water quality parameters from ambient water quality monitoring stations. The water quality standards are designed to protect aquatic life. As with habitat degradation, altered watershed hydrology greatly increases the sources of these stressors as well as delivery of the stressors to the receiving waters. The following are water quality standards that were identified for waters with noted impacts. Refer to the subbasin chapters (Chapter 1 – 4) for more information on the affected waters.

6.3.2 pH

The pH water quality standard for Class C waters is between 6.0 and 9.0. In the Little Tennessee River basin during the most recent assessment period, pH was identified as a potential stressor for 9.5 stream miles for waters with noted impacts.

6.3.3 Toxic Impacts

Toxic impacts are noted as a stressor during biological monitoring. Waters are not impaired due to toxic impacts, but toxic impacts can be noted as a potential stressor on the system. In the Little Tennessee River basin during the most recent assessment period, toxic impacts were noted on 5.7 stream miles. Refer to Chapter 1 for more information.

6.3.4 Fish Consumption Advisories and Advice Related to Mercury

The presence and accumulation of mercury in North Carolina's aquatic environment are similar to contamination observed throughout the country. Mercury has a complex life in the environment, moving from the atmosphere to soil, to surface water, and eventually, to biological organisms. Mercury circulates in the environment as a result of natural and human (anthropogenic) activities. A dominant pathway for mercury in the environment is through the atmosphere. Mercury emitted from industrial and municipal stacks into the ambient air can circulate around the globe. At any point, mercury may then be deposited onto land and water. Once in the water, mercury can accumulate in fish tissue and humans. Mercury is also

commonly found in wastewater; however, mercury in wastewater is typically not at levels that could be solely responsible for elevated fish levels

Fish is part of a healthy diet and an excellent source of protein and other essential nutrients. However, nearly all fish and shellfish contain trace levels of mercury. The risks from mercury in fish depend on the amount of fish eaten and the levels of mercury in the fish. In March 2003, the Food and Drug Administration (FDA) and the Environmental Protection Agency (EPA) issued a joint consumer advisory for mercury in fish and shellfish. The advice is for women who might become pregnant, women who are pregnant, nursing mothers, and young children. Aside from being issued jointly by two federal agencies, this advisory is important because it emphasizes positive benefits of eating fish and gives examples of commonly eaten fish that are low in mercury. In the past, the FDA issued an advisory on consumption of commercially caught fish, while the EPA issued advice on recreationally caught fish.

By following these three recommendations for selecting and eating fish, women and young children will receive the benefits of eating fish and shellfish and be confident that they have reduced their exposure to the harmful effects of mercury. These recommendations are:

- **Do not eat shark, swordfish, king mackerel, or tilefish**. They contain high levels of mercury.

- Eat up to 12 ounces (two average meals) a week of a variety of fish and shellfish that are lower in mercury. Five of the most commonly eaten fish that are low in mercury are shrimp, canned light tuna, salmon, pollock, and catfish. Another commonly eaten fish, albacore ("white") tuna, has more mercury than canned light tuna. So, when choosing your two meals of fish, you may eat up to 6 ounces (one average meal) of albacore per week.

- Check local advisories about the safety of fish caught by family and friends in your local lakes, rivers, and coastal areas. If no advice is available, eat up to 6 ounces (one average meal) per week of fish you catch from local waters. Don't consume any other fish during that week.

For more detailed information, visit EPA's website at http://www.epa.gov/waterscience/fish/ or visit the FDA at http://www.cfsan.fda.gov/seafood1.html. The FDA's food information toll-free phone number is 1-888-SAFEFOOD.

The NC Department of Health and Human Services (NCDHHS) also issues fish consumption advisories and advice for those fish species and areas at risk for contaminants. NCDHHS notifies people to either limit consumption or avoid eating certain kinds of fish. While most freshwater fish in North Carolina contain very low levels of mercury and are safe to eat, several species have been found to have higher levels. More information regarding use support assessment methodology related to fish consumption advisories and advice can be found in Appendix VIII.

Due to high levels of mercury in seventeen saltwater and five freshwater fish species, the NCDHHS offers the following health advice (updated March 31, 2006).

> Women of childbearing age (15 to 44 years), pregnant women, nursing women, and children under 15:

- **Do not eat** the following ocean fish: almaco jack, banded rudderfish, canned white tuna (albacore tuna), cobia, crevalle jack, greater amberjack, south Atlantic grouper (gag, scamp, red, and snowy), king mackerel, ladyfish, little tunny, marlin, orange roughy, shark, Spanish mackerel, swordfish, tilefish, or tuna (fresh or frozen).
- **Do not eat** the following freshwater fish: bowfin (blackfish), catfish (caught wild), chain pickerel (jack fish), or warmouth caught in North Carolina waters south and east of Interstate 85.
- **Do not eat** largemouth bass caught in North Carolina waters (statewide).
- Eat up to two meals per week of other fish. A meal is 6 ounces of cooked fish for adults or 2 ounces of cooked fish for children under 15.

All other people:

- Eat no more than one meal (6 ounces) per week of ocean and/or freshwater fish listed above. These fish are often high in mercury.
- Eat up to four meals per week of other fish. A meal is 6 ounces of cooked fish for adults or 2 ounces of cooked fish for children under 15.

For more information and detailed listing of site-specific advisories, visit the NCDHHS website at http://www.schs.state.nc.us/epi/fish/current.html or call (919) 733-3816.

6.4 Recreation Stressor – Fecal Coliform Bacteria

Water quality standards for fecal coliform bacteria are intended to ensure safe use of waters for recreation and shellfish harvesting (refer to Administrative Code Section 15A NCAC 2B .0200). The North Carolina fecal coliform standard for freshwater is 200 colonies/100ml based on the geometric mean of at least five consecutive samples taken during a 30-day period and not to exceed 400 colonies/100ml in more than 20 percent of the samples during the same period. Current methodology requires additional bacteriological sampling for streams with a geometric mean greater than 200 colonies/100ml or when concentrations exceed 400 colonies/100ml in more than 20 percent of the samples. These additional assessments are prioritized such that, as monitoring resources become available, the highest priority is given to those streams where the likelihood of full-body contact recreation is the greatest. Several streams in the Little Tennessee River basin are Impaired for fecal coliform bacteria. Those include Scotts Creek, Savannah Creek, and segments of the Tuckasegee River (See Chapter 2).

Fecal coliform bacteria live in the digestive tract of warm-blooded animals (humans as well as other mammals) and are excreted in their waste. Fecal coliform bacteria do not actually pose a direct danger to people or animals. However, where fecal coliform are present, disease-causing bacteria may also be present and water that is polluted by human or animal waste can harbor other pathogens that may threaten human health. Pathogens associated with fecal coliform bacteria can cause diarrhea, dysentery, cholera and typhoid fever in humans. Some pathogens can also cause infection in open wounds.

The presence of disease-causing bacteria tends to affect humans more than aquatic creatures. High levels of fecal coliform bacteria can indicate high levels of sewage or animal wastes that could make water unsafe for human contact (swimming). Fecal coliform bacteria and other

potential pathogens associated with waste from warm-blooded animals are not harmful to fish and aquatic insects. However, high levels of fecal coliform bacteria may indicate contamination that increases the risk of contact with harmful pathogens in surface waters.

Sources of Fecal Coliform in Surface Waters

- Urban stormwater
- Wild animals and domestic pets
- Improperly designed or managed animal waste facilities
- Livestock with direct access to streams
- Improperly treated discharges of domestic wastewater, including leaking or failing septic systems and straight pipes

Under favorable conditions, fecal coliform bacteria can survive in bottom sediments for an extended period of time (Howell et al., 1996; Sherer et al., 1992; Schillinger and Gannon, 1985). Therefore, concentrations of bacteria measured in the water column can reflect both recent inputs as well as the resuspension of older inputs.

Reducing fecal coliform bacteria in wastewater requires a disinfection process, which typically involves the use of chlorine and other disinfectants. Although these materials may kill the fecal coliform bacteria and other pathogenic disease-causing bacteria, they also kill bacteria essential to the proper balance of the aquatic environment, and thereby, endanger the survival of species dependent on those bacteria.

There are a number of factors beyond the control of any state regulatory agency that contribute to elevated levels of disease-causing bacteria. Therefore, the state does not encourage swimming in surface waters. To assure that waters are safe for swimming indicates a need to test waters for pathogenic bacteria. Although fecal coliform standards have been used to indicate the microbiological quality of surface waters for swimming and shellfish harvesting for more than 50 years, the value of this indicator is often questioned. Evidence collected during the past several decades suggests that the coliform group may not adequately indicate the presence of pathogenic viruses or parasites in water.

The detection and identification of specific pathogenic bacteria, viruses and parasites such as *Giardia*, *Cryptosporidium* and *Shigella* are expensive, and results are generally difficult to reproduce quantitatively. Also, to ensure the water is safe for swimming would require a whole suite of tests for many organisms, as the presence/absence of one organism would not document the presence/absence of another. This type of testing program is not possible due to resource constraints.