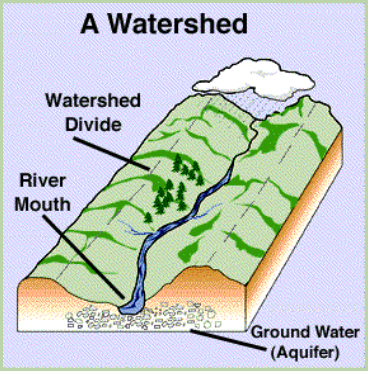
# Green and Tradewater Basins

## Status Report

March 2001




**What is a watershed?**

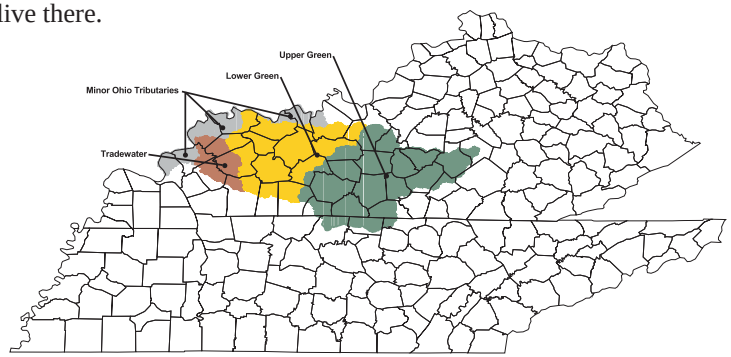
No matter where you live, work, or play, you are in a watershed. A watershed is a geographic area where all water drains to a specific location. This location may be a stream, river, lake, wetland, ocean, or the water may drain underground into the groundwater. A creek drains a small watershed, while a river drains a larger watershed. Every creek, stream, or river that drains into another body of water is considered a tributary to that body of water. The watershed boundaries for a large body of water will include many smaller tributary watersheds. A surface watershed is defined by the surrounding topography. A watershed extends from the end of the drainage area (the lowest point) upgradient to all the highest points that surround the drainage channel.

# Description of the Green and Tradewater basins

To understand the health of the watershed, one must also understand the natural conditions of the watershed. The geology, or physiographic makeup of the basin, the type of terrain, the amount of water, population, land-use activities, etc., all have a bearing on where and how pollutants move in the environment and how we are exposed to them. In the end, these natural conditions affect the health of the watershed and the people who live there.

## Regions of the watershed

For the purpose of this report, the Green River basin is divided into two regions based on hydrologic units, which divide the overall Green River watershed into sub-basins defined by tributaries within the basin. On this basis, the part of the watershed upstream from the Green's junction, or confluence, with the Barren River near Woodbury is considered the **Upper Green River** basin. Similarly, the areas that drain to the Green downstream from this point will be referred to as the **Lower Green River** basin.




This report also deals with all of the Tradewater River drainage basin, plus a few smaller watersheds that are minor tributaries to the Ohio River.

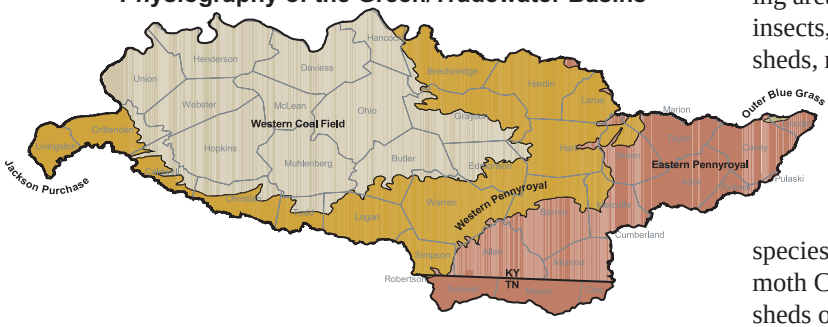
## Physiography

The physiography of a region is influenced by a variety of underlying features. Most important is the type and geometry of bedrock in the area. Surface and groundwater flows are controlled by the nature of these rocks and the associated surface features. There are two main physiographic regions through which the Green and Tradewater Rivers flow. The **headwaters of the Green River** lie in the region known as the Eastern Pennyroyal. Most of this area is characterized by flat-lying limestones, sandstones, and shales that underlie flat to gently rolling terrain. The limestone areas have well-developed karst topography, characterized by vast sinkhole plains that take virtually all surface water that comes to them and channel it through caves and smaller underground passages below the ground surface. Several springs in this region, discharging from major underground passages, are large enough to support municipal water systems. The **Lower Green River** traverses the Western Coalfield. This region consists primarily of thick flat-lying sandstone and shale beds and is generally characterized by flat to gently rolling terrain. Groundwater flow is predominantly through fractures, with wells in valleys typically producing more water than wells on ridges. The upper part of the **Tradewater River** Region flows northward from the Western Pennyroyal. As it approaches its confluence with the Ohio River, it flows over gently rolling terrain underlain mainly by loose sediments such as sand and silt. Groundwater flow there is primarily through the spaces between the grains of sediment. Shallow wells in the area are widely used for domestic water supplies; in addition, deeper wells in confined aquifers provide abundant water for industrial, municipal, and domestic use.

## What's different about these watersheds?

In most landscapes, slopes control the runoff from precipitation and stream drainage, with ridgelines forming the drainage boundaries. Underground water in most watersheds and drainage basins tends to follow the lay of the land. However, in soluble limestone terrain or karst regions, the underground drainage may differ from the boundary of its surface watershed and flow through caves and cracks in the rocks beneath the surface ridges. This is sometimes called "misbehaved" karst drainage. In the Mammoth Cave region, 15%-20% of the underground water is misbehaved.

**Physiography of the Green/Tradewater Basins**




## Is the watershed healthy?

Watershed health is the main question this report explores. In order to determine if the region's streams are impaired or contaminated, we have reviewed water sampling data, assessments of stream and river bank conditions, discharge permits for wastewater treatment plants, and activities like farming, development, logging, and mining. What happens in the river basin – or *watershed* – directly impacts water quality and habitat conditions. According to current records, some tributaries in the Green River basin and the Tradewater River region are contaminated by agriculture (293 miles of streams), resource extraction (242 miles), municipal impacts (186 miles), man-made drainage changes (141 miles), and waste disposal on the land (86 miles**)**. These sources of pollutants contribute bacteria from sewage or livestock; silt from erosion, construction, or logging; algae blooms fed by nutrients from fertilizers or manure; and various pollutants from mining and industrial or urban wastewater plants. Unfortunately only 22% of the basin's streams have been assessed. Most of the streams in the region, however, seem to be free of excessive pollution. Maintaining good water quality in the unpolluted parts of the river and cleaning up contamination in other sections will require a closer look at what is happening in the watershed, how it impacts watershed health, and what can be done to improve conditions.

## Biodiversity

Because of the variety of biological and physiographic regions that occur in the Green River and the Tradewater River region, the natural biodiversity is high compared with many surrounding areas. For example, great diversities of fish, aquatic insects, and freshwater mussels are found in these watersheds, many of which exist only in this part of the nation and should be protected. The Green River in Hart, Barren, and Edmonson counties flows through one of the most significant areas for unique cave species diversity in the United States. These rare and endangered cave-dwelling invertebrate species have not been fully identified; therefore, the Mammoth Cave area, in particular along the edges of the watersheds outside of the National Park, requires further study.

Natural biological systems help humans by filtering and cleansing water and storing and detoxifying pollutants. But the loss of habitat or excessive pollution and/or siltation can threaten biodiversity. The Kentucky Biodiversity Task Force is an excellent source of information on the status of Kentucky's plant and animal biodiversity. Visit its website at *http://www.nr.state.ky.us/nrepc/dnr/ksnpc/biodiv.htm.*

## Floodplain Management

As more and more development occurs, land becomes a premium. Unfortunately, good land for farming and development is often located in the floodplain. When development occurs in the floodplain, several potential problems arise. First and foremost, people and property are at risk during a flood event. Many lives and millions of dollars have been lost to flooding in Kentucky. Ninety-six counties and close to 300 municipalities in Kentucky have established a floodplain management program that tries to protect the floodplain and minimize threats to people and property. Thirteen of the 34 counties in the Green/Tradewater rivers region have yet to adopt a floodplain management program; but, within some of those counties, municipalities have enacted their own floodplain management ordinances for their citizens. Only communities and/or counties that adopt a Flood Damage Prevention Ordinance and submit an application to the Federal Emergency Management Agency (FEMA) are eligible to purchase federal flood insurance. Flood insurance is not available in counties and municipalities that have not joined the National

**Basin or Watershed?**
The basin of a river, stream, or lake is all the land that is drained by the river, stream, or lake. Another word for basin is watershed, which comes from the observation that water is shed from an area of land and flows downhill into a body of water.

**Geography and Stream Health**
How does geography affect the health of streams? The lay of the land, soil types, and vegetation in an area can directly affect water quality -- especially when the land is cleared or tilled. For example, basins with loose soils, steep hills, or little vegetation are often severely eroded by rainstorms, leaving streams and rivers muddy and subject to flooding from rapid runoff. Vegetation can reduce flooding by slowing down runoff from rainstorms and can even filter out silt and other contaminants before they reach streams. Trees, bushes, and tall grass along stream banks also reduce erosion along the channel and create valuable habitat for birds, mammals, and other creatures.

**Biodiversity**
Biodiversity is the number and kind of organisms present, including bacteria, plankton, plants, fungi, and animals. The degree of biodiversity is both affected by;, and impcts upon, the health and function of streams, lakes, and wetlands.

**Mammoth Cave National Park** adds significantly to the natural and recreational resources of the region and attracts a number of out of state tourists. The Mammoth Cave National Park website is: http://www.nps.gov/maca/

**Karst Topography**
Karst topography is defined as that type of terrain and geologic region underlain by bedrock that dissolves easily, such as limestone, and characterized by depressions in the ground (sinkholes), caves, and underground drainage. Because water can enter the subsurface easily through caves and cracks in the soluble limestone bedrock, karst groundwater is highly susceptible to contamination.

Flood Insurance Program. One means for measuring the potential threat to a community is by the amount of property insured against flood damage. More than $224 million worth of property is insured against flood damage in the region. Since 1978, more than $15 million in flood insurance claims have been paid in the region, with more than $9 million of that figure in Christian County alone.

## Natural and Recreational Resources

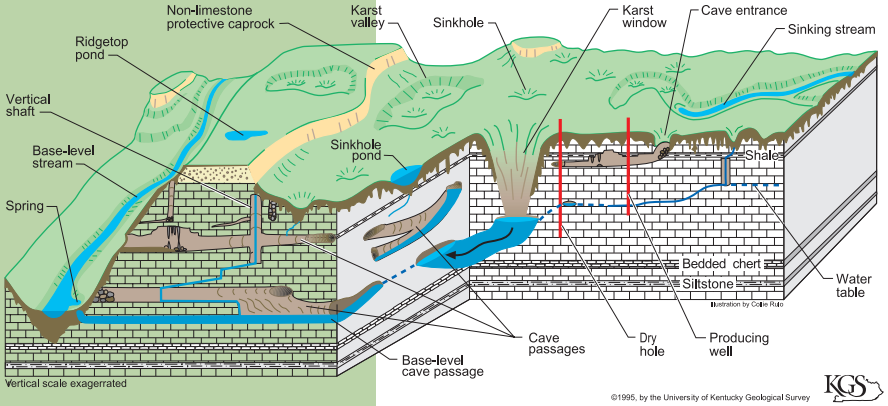
A number of natural and recreational resources exist in the Green River Basin, making it necessary to strike a balance between the economics of the area's tourism and environmental protection.

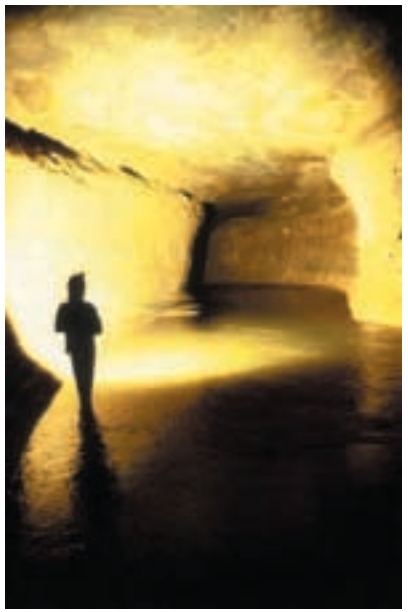
***Mammoth Cave*** The major natural resource of the area is the renowned Mammoth Cave and the region's karst topography; however, there are a number of other special natural resources, including significant fisheries, threatened and endangered mussels, and wildlife management areas.

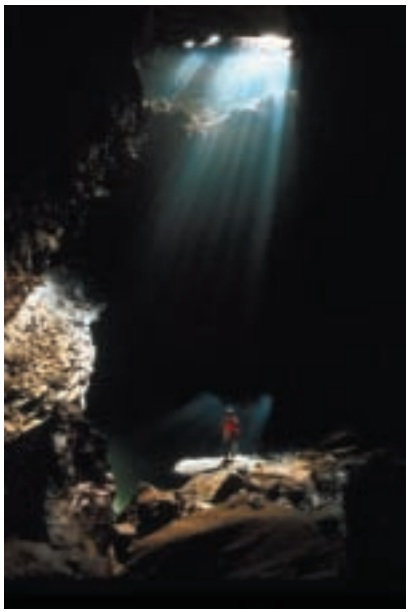
***Reservoirs*** The Army Corps of Engineers (COE) plays a major role in providing for flood protection and recreation in the Green River Basin. Although the four reservoirs, Barren, Green, Nolin and Rough River lakes, were built primarily for flood protection, they have taken on a significant role as important regional recreational resources. The lands leased for state parks, campsites, and outdoor activities, along with areas managed by the COE, add significantly to the recreational benefits of the region. The remaining land and water owned by the COE are managed by the Kentucky Department of Fish and Wildlife Resources (KDFWR) as part of a management agreement between the COE and KDFWR. The lakes provide habitat for a number of species of popular gamefish, including largemouth bass, hybrid striped bass, crappie, channel catfish, sunfishes, and flathead catfish. In addition, there are hunting areas for cottontail rabbits, quail, squirrels, turkey, waterfowl, morning doves, and whitetail deer. These reservoirs contain a number of conservation efforts and recreational opportunities. Visit this Web site for more information:

*http://www.lrl.usace.army.mil/or/or_pages.htm*

**Block diagram of karst features**





Two underground rivers within the Green River Basin: Lost River in Warren County (left) and Hawkins River in Edmonson County (right).

***Green River Bioreserve*** The Nature Conservancy's (TNC) conservation program, Green River Bioreserve, was established as a landscape-scale, community-based conservation effort in recognition of the value of the Green River's biodiversity. Work will begin on the ground level with agencies, conservation groups, communities, and private landowners. TNC and the COE are working cooperatively with a variety of state/federal agencies and academic partners to propose modifications in flow and temperature management of the Green River Lake reservoir to recapture more natural patterns of variation, while still meeting the demands for reservoir recreation, flood storage, and flood control. TNC is also the local sponsor and cost-sharing partner with the COE on a Section 1135 Environmental Restoration project for bank stabilization/bioengineering and riparian restoration on the Green River just below the confluence with Russell Creek.

The Green River Bioreserve, consisting of the Upper Green River, its tributaries, and portions of Mammoth Cave National Park, comprises a watershed of approximately 1,350 square miles. This watershed is among the most significant of aquatic ecosystems in North America. Its characteristic landscape features, including much karst topography, habitat diversity, and geographic location, contribute to form one of North America's foremost centers for unique qualities and biodiversity. The Green River Bioreserve supports nearly 60 species of freshwater mussels, one of the world's most imperiled organism groups. There is one freshwater mussel species that can be found only in Kentucky, and then only here. Of the Green River's 151 fish species, 109 are found within the bioreserve. Seven of these species are found only in Kentucky, and at least 12 fishes are considered globally rare. A number of rare, threatened, or endangered plants and other animals are also native to the Green River Bioreserve. An altered hydrological regime, local land-use practices, bank erosion, agricultural runoff and other nonpoint source pollution, and rural development are primary threats. A study performed in the Upper Green River basin has revealed several priority sites in need of improved conservation practices.

## Water Resources

The Green River and Tradewater watersheds are unrivaled water resources within Kentucky and our nation. Karst topography is a natural feature of these watersheds. Because of the rich supply of streams, other surface waters, and karst topography, water use (including drinking water) relies heavily on both surface water and groundwater sources. The nature of karst topography results in an intermingling of surface water and groundwater. Interactions of karst topography, surface water, and groundwater produce water supplies that are extremely vulnerable to poor land-use practices.

With approximately 27,668 miles of surface streams in these two watersheds, the importance of protecting and enhancing watershed health is obvious. An abundance of water creates many important habitats and supplies many needs. With the confluence of many small streams in the eastern headwaters of the Green River watershed, the rivers become much larger and broader in the western region of Kentucky. The gentle terrain, soil types, and geology of the lower portions of the Tradewater and Green Rivers create river flows that produce wide meanders. As a result of the physical surroundings, the rivers frequently receive much of their stream flow from pockets of wetlands scattered about the western region. Wetlands in this region play a critical role in flood control by slowly releasing water to the rivers after a rain event. During periods of drought, wetlands help maintain base flow levels for fisheries and drinking water supplies in area rivers. Additionally, these wetlands provide critical habitat for wildlife, filter out pollutants, and help to sustain watershed health.

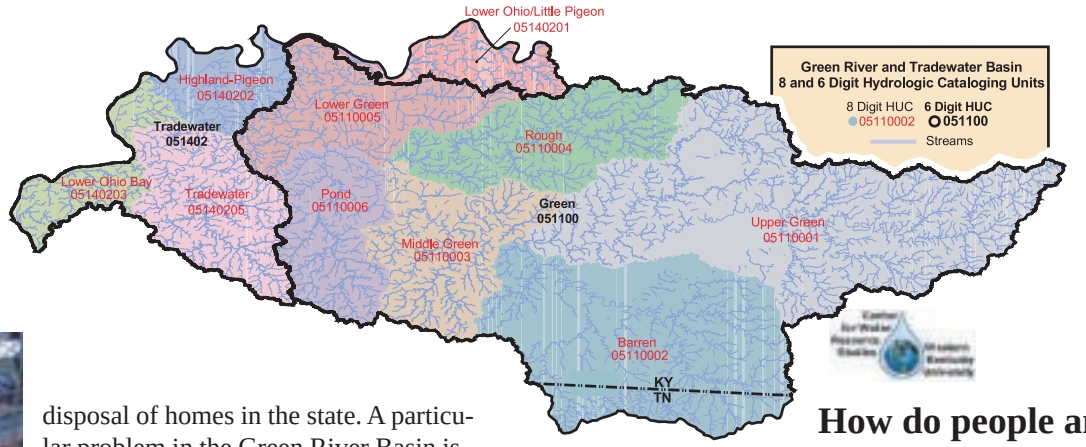
## Wastewater

A large volume of wastewater is discharged in this region from industrial facilities and sewage treatment plants. A sanitary sewage treatment system and any other type of industrial or process wastewater plant must have a Kentucky Pollutant Discharge Elimination System (KPDES) permit and meet specific discharge quality standards. "On-site" wastewater systems, such as septic systems, are used throughout most of the basin and comprise about 40% of the wastewater

**Drinking Water Supplies**
Source water for drinking must be piped from groundwater (wells and springs) or surface water supplies to the users. Public drinking water utilities have to be concerned with the quantity and quality of the supply in order to meet the needs of the public. Both factors can be greatly affected by droughts and upstream activities. While the water is treated prior to distribution, the raw water that comes from the well, lake, or river must be of high enough quality to allow safe treatment. During periods of drought or heavy rainfall, the quality can be adversely affected by discharges of wastewater or pollutants that run off the land, making protecting the drinking water source and its watershed even more important to everyone.

**Consumer Confidence Reports**
The Safe Drinking Water Act requires that all community water systems annually report to water users information about the quality of the water delivered by the system. These public reports are available from each drinking water provider and describe water sources, water distribution, detected contaminants, and water quality violations with associated public health information.

**Connectivity**
The uniqueness of karst watersheds strongly reflects the connectivity of the land to the water and to public health.



disposal of homes in the state. A particular problem in the Green River Basin is that septic systems often do not perform properly within the extensive karst regions because of inadequate filtration and rapid drainage into the groundwater system. Some homes do not have proper wastewater disposal systems; these "straight pipes" release raw sewage to creeks, rivers, or to unconfined underground cavities and pose a significant health threat.

In areas where there are recreational boats, discharge and disposal of wastewater can also be a serious problem. Correction of this problem will involve installation of pump-out and treatment facilities at marinas, along with education of the boating public. Many of the larger recreational lakes in Kentucky have marine waste pump-out stations.

## Waste Disposal

Most solid waste goes to contained landfills, which are designed to capture any leachate (contaminant-laden water) that may be produced. Unfortunately, open dumps are all too common. Illegal dumps in sinkholes in the karst plain of central and south central Kentucky are a particular problem. Sinkhole dumps pose a serious threat to human health and the environment because they drain directly to groundwater where they can contaminate drinking water supplies.

Under a statewide campaign, thousands of dumps have been cleaned up, millions of waste tires have been picked up, and several new programs have been initiated.

Owensboro wastewater treatment plant

## How do people and land use affect a watershed?

All land-use activities, including agriculture, landfills, coal mines, logging, gas and oil production, concentrated animal feeding operations and urban sprawl, affect water quality. The predominant land-use activities within a watershed are good indicators of the potential contaminant sources within that watershed.

*Agricultural land* represents about 54.6% of the region and is used to grow crops or raise farm animals. Farming utilizes chemicals such as fertilizers, herbicides, or insecticides that could be carried off into a stream by stormwater runoff. Other impacts include soil erosion, resulting in sediments entering the streams, and pathogens and nutrients from animal wastes entering the streams.

*Forest land* represents about 39.1% of the region and may be a natural area that is relatively undisturbed or an area where intensive harvesting occurs or something in between. Most of these forests are deciduous; about one-tenth represent evergreen forest types. A forest area that is managed as a natural area may have relatively little or no impact on the waters within the watershed. However, a forest that is harvested for lumber and poorly managed may impact the watershed through soil erosion (primarily from logging roads).

*Residential land* includes small communities and suburban areas of homes. Land disturbance during construction as well as land changes affect the hydrology of streams. Many homes

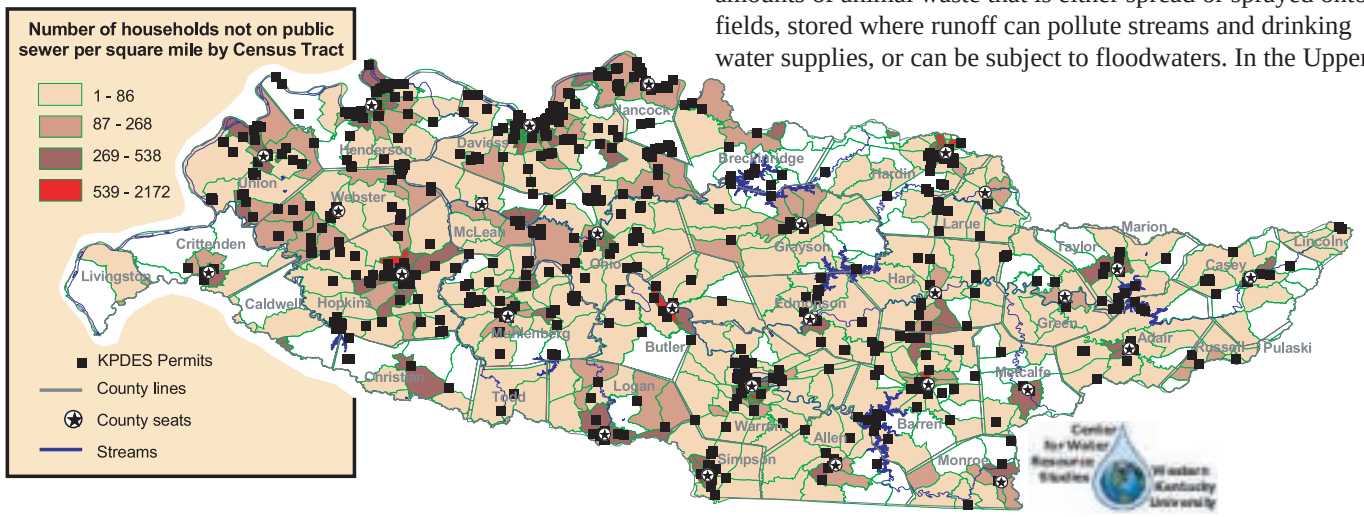
depend on septic tanks, which, if not properly maintained, may be sources of bacteria, pathogens, and nutrients. Chemicals applied to lawns, trees, and shrubs by homeowners, such as fertilizers, insecticides, and herbicides, are carried off by stormwater and may harm the quality of the water in the creeks or harm the animals and plants in the creek. Stormwater runoff from cities contains automotive oils, sediment from land-clearing activities, particulates from cars and other sources, nutrients that feed algae blooms, and other urban contaminants. The loss of greenspace to development of new buildings, roads, and parking lots also causes surges in stream levels due to rapid runoff that erodes stream banks and can cause localized flooding. These changes also reduce groundwater recharge, so stream flows in summer months are lower. Finally, the loss of trees, shrubs, and grasses along stream banks causes further instability and erosion, with resulting increases in siltation and decreases in both in-stream and stream-bank habitat. Channelization, the clearing and straightening of stream channels, aggravates both flooding and sedimentation, despite the common notion that it reduces flooding. This is a very widespread practice in the Lower Green River part of the watershed. Urban, or built-up land, represents about 2.7% of the region.

*Water resources* represent about 2.1% of the total land cover in this region, as estimated by land-use grids. Note that none of the abundant underground water flows in this region are reflected in this value.

*Barren land* (1.1% of the area) uses include transitional areas, strip mines, quarries, and transportation corridors. No land-use data is available for 0.1% of the region.

Because agriculture is the predominant land use, livestock operations become significant in the watershed. A large percentage of Kentucky's livestock operations are located in the Green River Basin: 69% of the state's Concentrated Animal Feeding Operations (CAFOs) and 46% of its Animal Feeding Operations (AFOs). Under the 1974 Clean Water Act, CAFOs are generally defined as livestock operations of 1,000 animal units or more (for example, 1,000 cattle, 2,550 grown or 10,000 immature swine, or 100,000 chickens). An operation smaller than this is termed an AFO, but may also be defined as a CAFO if it is known to be a significant source of water pollution.

Concentrated Animal Feeding Operations that raise poultry and hogs present a particular threat to the Tradewater/ Lower Green watershed, as these CAFOs produce vast amounts of animal waste that is either spread or sprayed onto fields, stored where runoff can pollute streams and drinking water supplies, or can be subject to floodwaters. In the Upper



Riparian buffer

**Riparian area**
Stream banks and the land along them are called a riparian area. With appropriate vegetation, riparian areas provide natural protection from pollutants that drain off the land. Good riparian management can prevent erosions and flooding.

Manure crib

**KPDES Permits**
The State of Kentucky requires all point source discharges of pollutants to the waters of the Commonwealth to be permitted. This includes stormwater runoff discharges from certain types of industries and construction sites exceeding five (5) acres. The permitting program known as the Kentucky Pollution Discharge Elimination System (KPDES) is managed by the Division of Water. Any person or entity proposing a new discharge must submit an application for approval at least 180 days prior to the proposed date that discharge is anticipated.

**What are AFOs and CAFOs?**

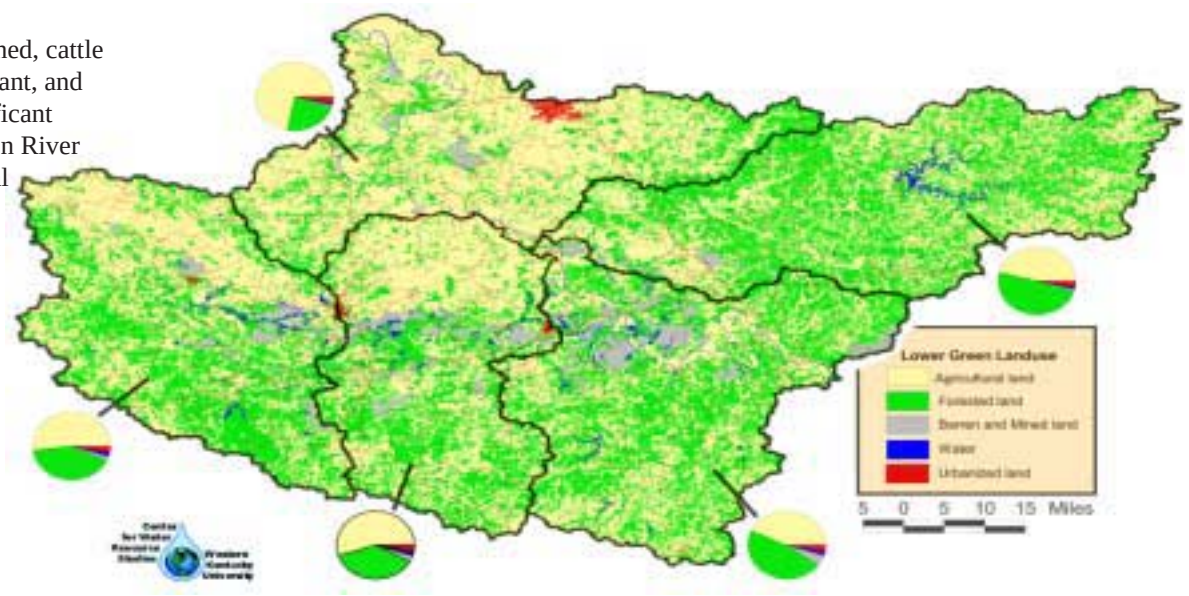
An Agricultural Feeding Operation (AFO) is defined as a lot or facility where animals are confined and maintained for a total of 45 days or more in any 12-month period and are fed by means other than grazing. Concentrated Animal Feeding Operations (CAFOs) must meet the definition of an AFO, and there must be a specified number of animals confined at the operation. A facility is a CAFO if the operation contains more than 300 Animal Units confined and there is a discharge to the waters of the Commonwealth or if there are more than 1000 Animal Units confined. The vast majority of operations in Kentucky qualify as CAFOs because they have more than 1000 Animal Units. What are "Animal Units?" 1000 Animal Units are equal to:

- **Beef** — 1000 head of cattle
- **Dairy** — 700 head of cattle
- **Swine** — 2500 pigs, each weighing more than 55 lbs.
- **Poultry** — 100,000 laying hens or broilers

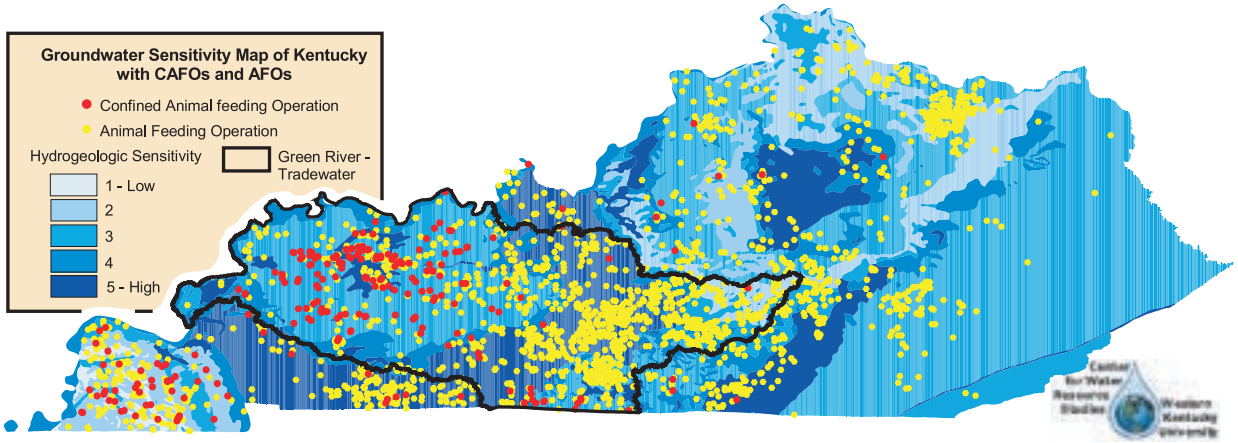
Operations that are defined as CAFOS are required to obtain a Kentucky Pollutant Discharge Elimination System (KPDES) Permit.

Poultry houses

Green River watershed, cattle AFOs are predominant, and they can have significant impacts on the Green River streams and physical damage to stream banks where cattle are unfenced. Fecal contamination can come from chicken and hog manure disposal sites, which are located throughout the basin. Because of the prevalent karst topography in the Upper Green and the abundance of surface water in the Tradewater/Lower Green, this basin can be easily impaired by large concentrations of livestock animals. Excess nutrients (nitrogen and phosphorus) from animal wastes can cause algal growth, which reduces oxygen in the water and can result in fish kills. Animal wastes produced in CAFOs and AFOs also contain pathogens, high amounts of antibiotics, and heavy metals. These can seep into groundwater or wash into rivers and streams.




There is a minimum of 19 million chickens in the Green River basin, according to the Kentucky Division of Water. In McLean County alone, there are almost 250 poultry houses along the Green River. In addition, there were commercial processing plants, at least 36 swine CAFOs, and 130 poultry CAFOs in the Green River/Tradewater basin as of January 2001.



# What is the condition of the Lower Green and Tradewater watersheds?

## Description

This region includes the Tradewater River and Lower Green River basins, plus independent tributaries that drain to the Ohio River. These watersheds drain approximately 5,674 square miles in all or part of 17 counties in western Kentucky. Cities in the region include Hawesville, Madisonville, Morgantown, Henderson, Hopkinsville, Owensboro, Calhoun, Princeton, and Marion. Major impoundments include Rough River Lake, Caneyville Reservoir, Grapevine Lake, Lake Beshear, Lake Washburn, Lake Pewee, Lake Luzurne, Lake Malone, and Moffit Lake.

## Forests

Due to the highly productive soils found in the Tradewater Region, the woodlands of this area are mostly smaller tracts of timber that are remnants of forests that were cleared for agricultural purposes. Both upland and bottomland hardwoods of the oak-hickory forest type dominate the region; cherrybark oak is particularly important, both silviculturally and economically. Bottomland forests, in particular, provide several significant watershed benefits. In addition to filtering water before it reaches the main watercourse, trees help to stabilize these areas by holding soil in place with their root structures. These areas are also particularly rich in wildlife resources because of the valuable habitat that they provide. The conditions that allowed for these forests to develop naturally have been altered by man-made changes, usually in the drainage patterns of the surrounding farmland. Even slight changes in the amount of water in an area can affect what tree species can survive and flourish there.

The forestland of the Lower Green Region consists of upland hardwoods of the oak-hickory forest type with a small percentage of bottomland hardwoods also present. Most of the timberland in this region consists of areas that were not cleared for agricultural purposes, mostly due to topography that was not ideal for farming. The majority of the woodlands found here consist of third- and fourth-generation trees. Regeneration has occurred mainly through the sprouting of stumps from trees that have been harvested. The oaks are probably the most important tree family in the area, both in terms of the number of species present and economic value. White oak is the most dominant of these, along with northern red oak, black oak, and cherrybark oak. Yellow poplar, hickories, maples, ash, and black walnut can also be found consistently throughout the region.

## Water Quality

Water quality in the region is generally good. To date, 1,176 miles of stream (19 %) of a total of 6,192 miles have been monitored and assessed for water quality and biological integrity. The results of these surveys have revealed that approximately 67 percent of the assessed streams are fully meeting water quality standards. Streams not meeting standards are shown on the centerfold map.

## Agriculture

Kentucky agricultural producers, although faced with many challenges, continue to look forward and anticipate opportunities upon entering the 21st Century. The number one cash crop of tobacco has experienced quota reductions, pressing agriculturists to explore new areas of opportunity and development. Kentucky's producers are challenged with analyzing new technology and marketing opportunities as they adapt to diversified operations.

The Lower Green River and direct tributaries to the Ohio River drain most of the Western Kentucky coalfields, and the

**Contaminants and their effects**

**Nutrients** – nitrogen and phosphorus can cause an increase in algal growth; when the algae die, their decomposition removes oxygen from the water, resulting in low dissolved-oxygen concentrations. The breakdown of some nitrogen compounds by bacteria also lowers dissolved oxygen.

**Pesticides** – runoff of pesticides into streams results in harm and/or death to beneficial plants and animals that live in or use the water.

**Pathogens** – a high concentration of pathogens (bacteria, viruses, protozoans) may cause illness in humans and other animals and, in some instances, can cause death.

**Sediments** – the result of soil erosion causes reservoirs to lose capacity as the silt settles out, reduces suitable habitat in streams, and transports attached contaminants (nutrients and metals).

**Metals** – are toxic to fish, humans, and other animals and can cause illness, deformities, and death.

Western Kentucky Farm

Western Kentucky coal mine

Tradewater River drains the far western area. Portions of Webster, Union, and Christian counties drain into the Tradewater basin. In 1999, Webster County ranked eighth in Kentucky for cash receipts from livestock production, Union County ranked fourth for cash receipts from crops, and Christian County ranked first for cash receipts from crops (Kentucky Agricultural Statistics 1999-2000).

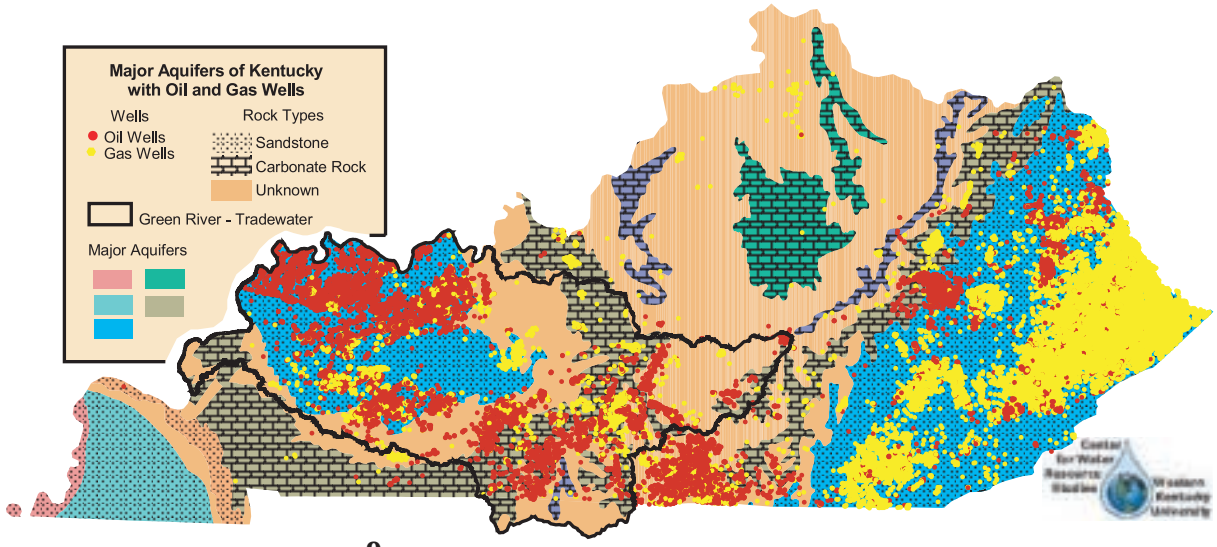
## Oil and Gas Production

Oil reserves tend to float on prehistoric brine water, which has salt concentrations higher than today's oceans. The salt water becomes a by-product of lifting crude oil to the surface. While the current most environmentally acceptable method of disposal is to inject it back into the subsurface, prior to regulation this brine was routinely dumped into creeks and rivers. Streams that have intermittent flow are more vulnerable to brine impacts. Brine spills to soil have the potential of impacting groundwater and surface water for users down gradient.

## Coal Mining

Coal mine sites active after 1972 are regulated by the Department of Surface Mining Reclamation and Enforcement (DSMRE), and sites mined prior to 1972 are considered "pre-law" and are regulated by the department's Division of Abandoned Mine Lands (AML). Areas mined "pre-law" were unprotected; consequently, environmental requirements were minimal or nonexistent. Erosion, loss of vegetation, and acid mine discharge were common on old mine sites, or AMLs. Iron and manganese leached from AML sites and colored the stream bed with a bright red coating. Discharges from older reclamation sites may have vegetative cover and silt control, yet still have redwater discharges from old mine works under the surface mine reclamation work. Current practices are available to fix these areas, but the cost is high. Creeks in the older coalfields of Western Kentucky have wildlife habitat options, wetland options, and grass cover reclamation. Since these creeks have shallower slopes, there are far fewer blackwater complaints compared to the steep slopes encountered in Eastern Kentucky coalfields.

Water quality is impacted in AML sites not only by acid mine runoff, but by siltation and blackwater releases from impounded coal slurry and erosion of coal refuse piles. In the western coalfields, gentle slopes and flat land lead to the formation of wetlands from siltation deposits. These lie in drainage channels of Greasy Creek, Elk Creek, Flat Creek, Drakes Creek, Clear Creek, Buffalo Creek, Richland Creek,



Hurricane Creek, Copper Creek and Copperas Creek, and parts of the Tradewater River, with acid mine runoff causing the greatest impact on water quality. During the last 30 years, AML reclamation sites and KPDES permitting have improved water quality and allowed for the reestablishment of fishable stream segments.

## Special Resources

Many parts of the state have been set aside and given special protection because of their natural qualities and scenic beauty. While these lands are managed for their long-term protection, many are open to the public. In addition to providing a safe haven for rare species and unique ecological systems, these areas provide outstanding scenery and recreational opportunities. Hiking, wildlife viewing, canoeing and kayaking, and other non-motorized sports can be enjoyed over much of these areas. Contact the various agencies listed in the back of this document for more information.

The Lower Green/Tradewater region contains the Pennyrile State Forest and three state parks: John James Audubon, Ben Hawes, and Rough River state parks. Plus, there are four state wildlife management areas in the region: Henderson/Sloughs, Higginson-Henry, Peabody, Rough River Lake, and Jones-Keeney state wildlife management areas. The Kentucky Department of Fish and Wildlife Resources administers state wildlife management areas.

## Proposed National Wildlife Refuge

Establishment of a Green River National Wildlife Refuge (NWR) in Henderson County has been proposed for the purpose of restoring and managing a valuable wetland complex for the benefit of migratory birds. Land surrounding the confluence of the Green River and Ohio River is within the proposed refuge boundary. Historically, this area was part of a large bottomland hardwood forest, which had extensive oak, hickory, and native pecan trees. Currently, the area consists of ridge and swale farmland, river-scar oxbows, several sloughs, wet depressional areas, and a small amount of bottomland hardwoods.

Waterfowl are plentiful; on one occasion, more than 10,000 ducks and 8,000 geese were observed feeding and resting in the flooded bottoms. Waterfowl species most commonly seen in the project area include mallard, Canada geese, blue-winged and green-winged teal, gadwall, American wigeon, wood duck, redhead, canvasback, and ring-necked duck. There are also infrequent observations of bufflehead, lesser scaup, American black duck, snow geese, and white-fronted geese. Significant populations of migratory waterfowl are observed on the project area only when flood conditions are right. Because the area was previously converted to agricultural land, the natural flooding and flow conditions of a bottomland hardwood forest that promote wildlife were lost. Therefore, the benefits to fish and wildlife resources from the proposed management activities would be greatly enhanced by improvement of water quality in the Green River system.

## Species of Concern

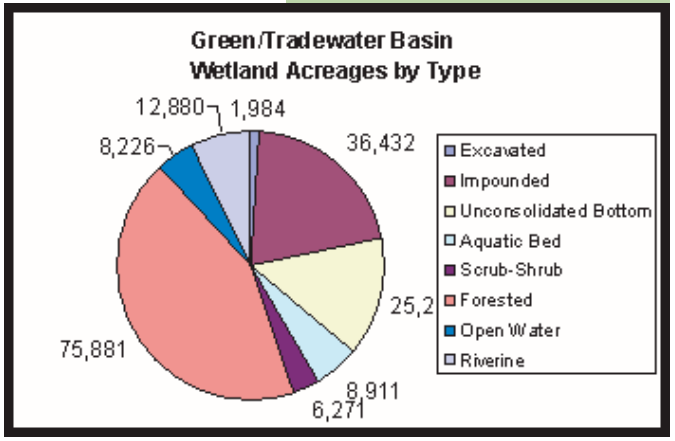
The quality of spawning habitat in the basin for fish species that need hard, relatively sediment-free stream floors has been significantly degraded by the development and maintenance of navigation corridors in the Green/Tradewater River basin and from gravel dredging and flood control efforts in the rivers and their tributaries. Of particular concern are the sturgeon chub, sicklefin chub, lake sturgeon, paddlefish, northern cavefish, eastern sand darter, spotted darter, and longhead darter. The alligator gar has also experienced population declines throughout the basin, most likely a result of the loss of floodplain waters and wetlands adjacent to the major rivers. The copperbelly water snake also occurs in the basin. This species is currently protected by a Candidate Conservation Agreement to preclude its listing as federally threatened in Kentucky.

**State Nature Preserves**

Preserves within the watershed include the John James Audubon State Park Nature Preserve. This area is managed by the Kentucky State Nature Preserves Commission to protect resident plants and animals, including many threatened and endangered species. Nine stream segments within the Lower Green and Tradewater basin, totaling 217 stream miles, contain rare species.

**Wetlands**

Wetlands provide essential watershed functions related to floodwater storage, groundwater flow moderation, sediment removal, nutrient cycling, and water purification. They provide diverse habitats for wildlife foraging and reproduction, and essential refuge for a wide variety of mammals, reptiles, amphibians, and fish. Three broad categories of wetlands exist within the Green/Tradewater River basin: lacustrine (lake-like), palustrine (swamp-like), and riverine (associated with surface water channels). Water permanence, gradient, water velocity, substrate, extent of floodplain development, and vegetation types further define these systems.



The Green River

## Upper Green Impaired Stream Data

### Kentucky Report to Congress on Water Quality

| STREAM NAME | SOURCE OF POLLUTANTS | POLLUTANTS |
|---|---|---|
| Bacon Creek | Agriculture, Land disposal, Other Wastewater Systems | Pathogens |
| Dismal Creek | Silviculture | pH |
| Little Pitman Creek | Municipal Point Sources, Unknown Sources | Nutrients, Metals, Unknown Toxicity |
| Nolin River | Agriculture | Pathogens |
| South Fork Russell Creek | Petroleum Activities, | Salinity/TDS/chlorides |
| Taylor Fork | Urban Runoff/Storm Sewers, Habitat Modification, Agriculture | Other habitat alterations, Organic enrichment/Low DO |
| Barren River | Urban Runoff/Storm Sewers, Agriculture, Unknown Sources | Metals, Pathogens |
| Black Lick Creek | Municipal Point Sources | Unionized Ammonia, Organic Enrichment/Low DO, Suspended Solids |
| Boyds Creek | Natural Sources | Oil and grease |
| Cypress Creek | Resource Extraction, Acid Mine Drainage | pH |
| Drakes Creek | Industrial Point Sources | PCBs |
| West Fork Drakes Creek | Industrial Point Sources | PCBs |

**Lower Green and Minor Ohio River Tributaries data on the next page**

# Lower Green and Minor Ohio River Tributaries Impaired Stream Data

## Kentucky Report to Congress on Water Quality

| STREAM NAME | SOURCE OF POLLUTANTS | POLLUTANTS |
|---|---|---|
| Bat East Creek | Hydromodification | Siltation |
| Beech Creek | Acid Mine Drainage, Resource Extraction | pH |
| Brier Creek | Acid Mine Drainage, Resource Extraction | pH |
| Butchers Branch | Resource Extraction, Acid Mine Drainage | pH |
| Cane Run | Resource Extraction, Acid Mine Drainage | pH |
| Caney Creek | Collection System Failure | Pathogens |
| Cash Creek | Hydromodification, Channelization | Siltation |
| Clear Creek | Collection System Failure, Package Plants (Small Flows), Municipal Point Sources | Pathogens |
| Craborchard Creek | Acid Mine Drainage, Resource Extraction | pH |
| Crooked Creek | Collection System Failure | Pathogens |
| Drakes Creek | Acid Mine Drainage, Industrial Point Sources, Resource Extraction | pH, PCBs |
| Elk Creek | Collection System Failure | Pathogens |
| Flat Creek | Resource Extraction, Acid Mine Drainage, Collection System Failure | pH, Pathogens |
| Green River/Pond Creek | Resource Extraction, Land Disposal, Agriculture | Other Habitat Alterations, pH, Salinity/TDS/Chlorides, Pathogens |
| Horse Fork | Construction, Agriculture | Other Habitat Alterations |
| Jarnells Creek | Agriculture | Siltation |
| Knoblick Creek | Agriculture, Habitat Modification (other than Hydromodification) | Other Habitat Alterations, Siltation, Organic Enrichment/Low DO |
| Lead Creek | Package Plants (Small Flows), Municipal Point Sources | Organic Enrichment/Low DO, Pathogens, Unionized Ammonia, Nutrients |

| STREAM NAME | SOURCE OF POLLUTANTS | POLLUTANTS |
|---|---|---|
| Lewis Creek | Resource Extraction, Surface Mining | Siltation |
| Lick Creek | Channelization, Hydromodification | Siltation |
| Long Falls Creek | Agriculture | Other Habitat Alterations |
| Mud River | Industrial Point Sources | PCBs |
| North Fork Panther Creek | Channelization, Hydromodification | Flow alteration, Other habitat alterations |
| Piney Creek | Habitat Modification (other than Hydromodification), Agriculture | Other habitat alterations, Siltation |
| Pleasant Run | Acid Mine Drainage, Resource Extraction | pH |
| Plum Creek | Inappropriate Waste Disposal/Wildcat Dumping, Land Disposal | Salinity/TDS/chlorides |
| Pond River | Resource Extraction | Other Habitat Alterations, Siltation |
| Render Creek | Acid Mine Drainage, Resource Extraction | pH |
| Rhodes Creek | Channelization, Agriculture, Hydromodification | Other Habitat Alterations, Siltation |
| Richland Slough | Hydromodification, Agriculture, Channelization | Siltation |
| South Fork Panther Creek | Hydromodification | Flow alteration, Other Habitat Alterations |
| Sugar Creek | Surface Mining, Resource Extraction | pH |
| Thompson Creek | Habitat Modification (other than Hydromodification) | Other Habitat Alterations |
| Town Branch | Industrial Point Sources | PCBs |
| Tradewater River | Resource Extraction, Agriculture | Siltation, Pathogens |
| UT of Casey Creek | Major Municipal Point Source, Municipal Point Sources | Pathogens, Unionized Ammonia |
| Whiskey Run | Habitat Modification (other than Hydromodification) | Other habitat alterations |

# What is the condition of the Upper Green River watershed?

## Description

The Upper Green River drains approximately 5,413 square miles of south central Kentucky and about 454 square miles of north central Tennessee. This region contains many karst flow systems that affect underground water movement and quality. This area includes all or part of 19 counties in Kentucky and part of 3 counties in Tennessee. Cities in the basin include Bowling Green, Campbellsville, Columbia, Elizabethtown, Franklin, Glasgow, Greensburg, Hodgenville, Munfordville, and Russellville plus numerous smaller communities. Major impoundments in the basin include Green River Lake, Barren River Lake, Nolin Lake, Herndon Lake, Lake Malone, and Lake Beshear.

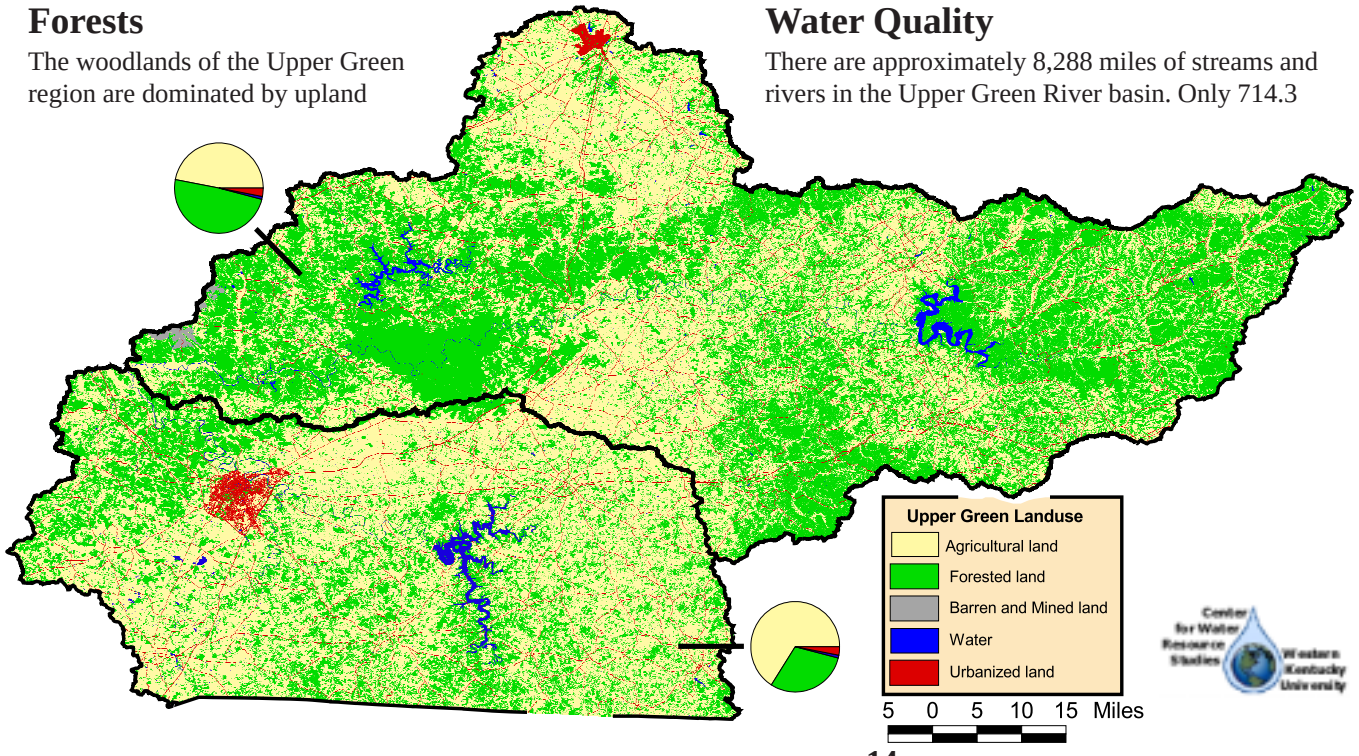
## Forests

The woodlands of the Upper Green region are dominated by upland hardwood tree species particular to oak-hickory forests. The variations in soil types throughout the basin influence the vegetation communities. For example, because much of the soils of the Upper Green are well-drained upland soils that originated from limestone, chinquapin oak forests grow well in this region. The woodlands of this region play a pivotal role in water quality, as they help filter pollutants before they enter the many sinkholes and underground rivers and streams in the area. As with the Lower Green, the timber in this area provides important economic benefits. Due to the amount, quality, and maturity of timber here, there are a number of wood-using industries in the watershed that generate numerous jobs throughout the area.

## Water Quality

There are approximately 8,288 miles of streams and rivers in the Upper Green River basin. Only 714.3

Bottomland hardwood forest



**The American Cave Conservation Association (ACCA)**, in partnership with the city of Horse Cave and numerous contributors, has established the American Cave Museum, which provides the nation's only museum devoted heavily to cave and karst issues. This is a success story which is providing ongoing educational outreach in the Green River watershed. The ACCA, in cooperation with the Ky. Division of Conservation, operates "Farming in Cave Country," an educational program in the Mammoth Cave area targeted at farmers. Other champions of environmental protection efforts in the Green River basin are the Kentucky Waterways Alliance, Western Kentucky University's Center for Cave and Karst Studies, and its Center for Water Resource Studies

miles (9%) have been assessed to determine whether they meet water quality standards for swimming and fishing. Many of the streams in the upper watershed are relatively pristine, but others have been negatively impacted by agriculture and development, while the lower watershed has been impacted by resource extraction such as coal mining, oil and gas well development, and timber harvesting, as well as poorly planned development and other nonpoint source pollution. The limited monitoring data available in the Upper Green River basin indicates that streams have documented impairments due to agriculture (98.3 miles of stream impaired), industrial and municipal wastewater discharges (61.5 miles), urban runoff and development (17.9 miles), and other unknown sources (394.7 miles). A more detailed listing of streams and where the pollutants are coming from is provided at the center of this document. The centerfold map depicts the location of streams and their impairment status.

## Agriculture

The Upper Green River basin includes the headwaters of the Green River and Barren River basins as far west as the edge of the Western Kentucky Coalfields. Agricultural production in this basin is very diversified with land uses devoted to specialty crops including tobacco, livestock production of beef and dairy operations, and conventional row crops of small grains, corn, and soybean production. Based on statewide statistics for 1999, the county with the top cash receipts for tobacco was Barren County in 1999. Barren County was also ranked as Kentucky's number one county in dairy livestock and milk production and ranked number nine in cash receipt sales for crops and beef livestock. Adair County was ranked number two in milk production. Warren County was ranked second in all cattle and calves, second in beef cows, and fifth in milk production (Kentucky Agricultural Statistics 1999-2000).

Row crop agriculture in Green River Basin

## Karst Landscapes and Aquifers

Karst landscapes and their associated aquifers are very important features in parts of the Green River Basin. These are areas of soluble limestone bedrock where the bedrock has dissolved, leading to the development of caves, sinkholes, sinking streams, and underground rivers. Indeed, the Green River Basin contains some of the world's most famous and well-developed karst areas, including the longest known cave, the Mammoth Cave System. Due to the spectacular nature of karst development within the basin, parts of Hart, Barren, and Edmonson counties have not only been protected with the establishment of Mammoth Cave National Park, but have been designated by the United Nations as a World Heritage Site and International Biosphere Reserve. In this area, more than 497 miles of cave passages and underground rivers have been explored and mapped, including more than 310 miles in Mammoth Cave alone, far more than any similar sized area on Earth.

Within the Green River Basin, contaminants can be introduced to karst groundwater from urban, industrial, and agricultural sources. Nowhere is this a more significant concern than in the sinkhole plain. The sinkhole plain extends from Hart County, to the northeast, through the Mammoth Cave National Park, into Logan County, to the southwest. An especially severe and widespread problem is bacterial contamination from human and animal waste. Because of the high velocities in a karst aquifer, groundwater contaminated by septic tanks or feedlot runoff can travel long distances to a well or spring with insufficient time for potentially harmful bacteria to die. A particular irony is that while many people have the idea that limestone cave and spring water is often very pure, in reality bacteria levels in karst areas can exceed drinking water standards by thousands of times.

A critical aspect of groundwater in these areas is that unusual and fragile species, and related underground ecosystems, have evolved within the underground rivers of the karst aquifers.

Many of these organisms, including several species of eyeless fish and crayfish, have developed special characteristics to be able to survive in a lifetime of total darkness. While some have lost the ability to see, they have compensated with special sense organs that allow them to move around and find food. Pollution sources, however, pose a significant threat to the health of these ecosystems and their inhabitants. The federally endangered Mammoth Cave Shrimp was thought for some years to have become extinct, but still lives in small numbers in the groundwaters of the Green River Basin. Other endangered species in the watershed, particularly mussels in the Green River itself, are subject to threats by water quality impairment.

Significant research is underway in the basin to develop karst-sensitive Best Management Practices (BMPs), which are land-use strategies that strive to strike a balance between minimizing impairment to the basin's water quality and the economic and cultural needs of the area's residents. Some of these are strictly win-win propositions. Storage and carefully timed application of animal waste as a fertilizer, for example, has in some cases been shown to simultaneously reduce the levels of bacteria entering the groundwater and reduce the need for expensive chemical fertilizers.

**Karst sinkhole plain**

## Special Resources

Nature Preserves within the watershed include the Vernon-Douglas State Nature Preserve. This area is managed by the Kentucky State Nature Preserves Commission to protect resident plants and animals, including many threatened and endangered species. The Kentucky Department of Fish and Wildlife Resources is the regulatory agency responsible for managing rare and endangered species within the state. Twenty stream segments within the Upper Green basin, totaling 665.5 stream miles, contain rare species.

There are two state parks in the Upper Green basin: Green River Lake and Barren River Lake state parks. Both of these state parks have state wildlife management areas associated with them. The Kentucky Department of Fish and Wildlife Resources administers these areas.

A large segment of the Upper Green River has been designated a state Wild River in recognition of its outstanding natural qualities and pristine setting. The designated stream segment is the highest quality, least-impacted stream in the basin. It consists of 26 stream miles of the Green River (Hart and Edmonson counties) and has a corridor area of 6,500 acres. This is part of a larger 157-mile segment, from Green River Lake Dam to Lock & Dam #4, that winds through Taylor, Green, Hart, Edmonson, Warren, and Butler counties. This stream segment is managed by the Division of Water to protect its natural features and undeveloped character. In addition, Mammoth Cave National Park, managed by the National Park Service, also protects much of the Wild River segment of the Green River in Edmonson County, as well as portions in Hart County. Portions of four streams have been designated as Outstanding Resource Waters: a 15-mile segment of the Barren River from Lock and Dam #1 (Warren County) to its confluence with the Green River (Butler County); a 4-mile segment of Echo River (Edmonson County) from east edge of Mammoth Cave National Park to Green River; an 8-mile segment of Hawkins River, an underground flow from Park City (Barren County) to Green River at Turnhole Bend Spring (Edmonson); and a 4-mile segment of Logsdon River from east of Roppel Cave near Cave City (Barren County) to Hawkins River (Edmonson County).

**What does the presence of karst mean for water quality?**

- Waters in karst areas are extremely vulnerable to contamination.
- While groundwater may travel only a few feet per year through sandstone, it can reach velocities of several miles per day in karst aquifers.
- Stormwater runoff may carry contaminants directly into caves without any filtration through the soil.
- Contaminants may percolate through the thin soils into the cave drainage system below.

Due to the ease with which contaminants can be introduced into, and rapidly carried through, karst aquifers, it is generally safe to assume that <u>any</u> water entering karst aquifers has the possibility of introducing contaminants.

**State Parks**

There are two state parks in the Upper Green basin: Green River Lake and Barren River Lake state parks. Both of these state parks have state wildlife management areas associated with them. The Kentucky Department of Fish and Wildlife Resources administers these areas.

Northern red-bellied salamander

Threatened freshwater mussels.
Top: fanshell; bottom: rough pig toe

**Species of Concern**

Federally listed endangered animal species known to occur in the Green/Tradewater River basin include the bald eagle, Indiana bat, gray bat, Interior least tern, fanshell, catspaw, Northern riffleshell, pink mucket, ring pink, Orange-foot pimpleback, clubshell, fat pocketbook, rough pigtoe, American burying beetle, and Kentucky Mammoth cave shrimp. The bald eagle is also the only federally threatened animal species known to occur in the basin. Federally listed threatened plant species known to occur in the basin are Price's potato bean and Eggert's sunflower.

## Exotic Species

The zebra and quagga mussels pose a realistic threat to the continued diversity of native unionid mussels and snails in the Green/Tradewater River basin. These invasive, non-native mussels attach themselves to any available hard surface, including water plant intakes and discharge structures, which can become heavily encrusted with these barnacle-like infestations. Frequently required removal of the mussels increases maintenance costs, which get passed on to drinking water customers. Additionally, these exotic mussels attach themselves to other mussels and snails, causing harm to the hosts by restricting their ability to move about and feed themselves. Exotic species often have no natural predators and can continue to reproduce to levels that will displace and out-compete other species.

Barren River

## Freshwater Mussels

Historically, the Green River supported one of the most abundant and diverse freshwater mussel faunas in the world. More than 70 species of mussels once flourished in the riffle and shoal habitats of the Green River and its tributaries. Recent surveys of the river from Lock and Dam 6 upriver to Munfordville indicate that 50 species still exist, including 8 species that are currently listed as federally endangered. Although significant reductions in the fauna have occurred, the Green River still supports one of the best remaining native mussel faunas known in the nation.

Because mussels feed by filtering particulates from the water column and because they tend to accumulate pollutants, including heavy metals and organic compounds such as pesticides, they can serve an important role as biological indicators of water quality.

The decline in diversity of freshwater mussel species in the basin can be attributed to infrastructure development (roads, dams, locks, etc.), agriculture, surface and underground coal mining, oil and gas drilling, impoundments, channelization, commercial mussel harvesting, gravel mining, and exotic species.

## Waste and Wastewater

Proper management of wastewater is a major issue in the Upper Green basin. Kentucky Pollutant Discharge Elimination System (KPDES) permits, provided for under federal and state laws, allow the disposal of treated effluent into the water. This effluent can be relatively clean wastewater from properly operating municipal and industrial wastewater treatment plants, discharges from sedimentation or treatment ponds near mines or oil/gas wells, or stormwater from culverts that drain city streets.

Most rural households in the Upper Green basin are not connected to municipal wastewater treatment systems and therefore rely on some form of onsite treatment for wastewater. Few municipal wastewater treatment systems presently exist except in some of the larger communities. However, numerous households in the Upper Green basin do not have any form of wastewater treatment, and the untreated wastewater from these households is discharged directly to a creek, onto surface soil, or into underground cavities. This is known as a "straight-pipe" discharge.

The presence of straight-pipe discharges and failed septic

systems has greatly impacted water quality in the Upper Green basin. Elevated levels of fecal coliform bacteria (from human and animal waste) have been detected in numerous portions of the basin. Moreover, the levels of fecal coliform bacteria are so high that numerous streams and creeks are unsafe for swimming or any other human contact, such as wading and fishing.

The passage of Senate Bill 18 in 1998, which requires that a wastewater treatment system be approved prior to electrical hook-up, has slowed the proliferation of straight pipes. Other state and federal resources, in the form of loans and grants, are becoming available to help with this problem (see the end of this document for contact information).

The good news is that people are working together to make a difference through the efforts of various volunteer organizations and participating local governments. During 1998 and 1999, various groups adopted streams for cleanup. In addition, 1,179 open dumps have been identified. These efforts have resulted in 3,315,000 tires being collected from the drainage areas of the Upper Green River Basin and sent to a recycling facility. A major success story is the $15 million effort by local taxpayers, EPA, and other federal agencies to build a regional sewage treatment system for Horse Cave, Cave City and Park City. This has contributed substantially to the quality of water that enters the Green River through the largest spring in Kentucky.

## How do we determine watershed health?

Healthy watersheds produce clean water – water that is fishable, swimmable and suitable as a drinking water source. Watersheds that meet these criteria support a wide variety of aquatic life and are a valuable resource. State agencies primarily use the guidelines in the federal Clean Water Act to determine whether or not the quality of river and stream water is acceptable. Under the Clean Water Act, states set standards for the water based on how it is being used. These uses can consider the high-quality values of a wild and scenic river, a stream's importance as a drinking water source, wildlife habitat, or other uses. The standards include benchmarks for various parameters like dissolved oxygen, temperature, acidity, and other measurable qualities (see side-bar).

If a lake, river, or stream meets the standards for fishing, swimming, and drinking water sources, it is said to fully support its designated uses (see centerfold map and tables). If it falls short on a few measures, it may only partially support its uses. Failure on additional counts can mean that it is not supporting its designated uses. The condition of these waters is reported to Congress as required by the Clean Water Act, Section 305(b). Bodies of water that do not support their designated uses must have cleanup plans that identify and quantify the problem pollutants and specify how they will be reduced. Sometimes the pollutants come from point sources such as residential and industrial wastewater treatment systems; other times they are carried into the water from nonpoint sources such as runoff from towns, farms, new developments, or other areas.

Watershed health means more than good water chemistry. In addition to chemical analyses, watershed health can be measured by observing plant and animal life. For example, certain species are indicators of water quality. Also, habitat is important to watershed and stream health. Vegetation in the riparian area - especially shrubs and trees - provides food and cover for terrestrial and aquatic life. Riparian vegetation also holds stream banks in place and helps to filter soil erosion and other polluted runoff. The amount and type of vegetation along a stream, lake, or sinkhole determines riparian health.

Watershed health also means having good storage and retention capabilities in the basin. That is, under ideal conditions, as rain falls upon the earth, water either evaporates, soaks into the ground, or runs off into streams, lakes, and rivers. For water to soak into the ground, the water must encounter some obstacles that slow its flow-rate, such as retention basins, trees, leaf litter in a forest, even grass. All these things cause water flow to slow down enough for it to soak into the ground. A hard-packed clay field or a parking lot will simply shed the water, forcing it to run downstream. Conversely, if the water can soak into the ground, it recharges the groundwater for wells and will slowly release it to our streams and lakes. In an unhealthy watershed, this runoff/

**Septic Systems**

Septic systems help clean up sewage from homes and businesses in areas not served by wastewater treatment plants. On most systems, the first stage of treatment is the septic tank, where wastewater is digested and solids settle out. After the septic tank, the liquid waste is directed to a drain field, lagoon, or wetland for further treatment. If the process is working correctly, the relatively clean wastewater then soaks into the ground. Septic tanks require periodic maintenance pumping.

Septic system installation

**Organisms as indicators**
Healthy streams have low levels of contaminants and contain a diversity of plants and animals. Certain mussels and insect larvae (caddisfly, stonefly, mayfly) are often used as indicators of good water quality, similar to the coal mine canaries used to detect poisonous gases. Since these mussels and larvae can live only in relatively clean water, their presence usually indicates that problems are few in that section of the stream.

**Kentucky Water Quality Standards**
The following parameters, or measurable criteria, are only a few of those used to define Kentucky's water quality standards. The standards and units for each parameter are listed below. For example, if a water sample shows more than 400 fecal coliform CFUs in a 100-milliliter sample, the water would be considered contaminated.
• Dissolved Oxygen: >4.0 Milligrams per liter
• pH (measures acidity): 6-9 Standard units (7.0-neutral)
• Fecal coliform: 400 Colony-Forming Units per 100 milliliters of water
• Temperature: ≤89 degrees Fahrenheit

soak-in cycle can have two negative effects: In times of high flow, it can cause all the water to run off so rapidly that it results in flooding. Or, in times of low flow, it can result in streams that run completely dry because there is no runoff or spring seepage to keep the rivers flowing.

During times of low stream flow, which occur more often in the late summer and early fall, streams may have less suspended silt but may be rich and green from algae growth. During times of low flow, most of the water in streams comes from groundwater inflow.

While state officials have information from samples collected on the Green River, the Tradewater, and the minor tributaries to the Ohio River, much of the water in the basin has not been tested. An interagency workgroup is coordinating efforts to increase the amount of monitoring conducted in the region. By working together, tax dollars can be stretched and better information provided on the condition of the watershed. Also, citizens active in the Tradewater/ Lower Green River Watershed Watch and the Upper Green River Watershed Watch have collected data to supplement public agency information and raise public awareness. Watershed Watch volunteers are trained to conduct habitat and biological assessments, perform regular field chemistry measurements, and take specific chemical samples of their site to a lab for analysis. Reducing concentrations of pollutants that exceed state standards will require a considerable amount of cooperative action and analysis.

**Land activities that can impact water quality**

| Activity | Impacts |
|---|---|
| Row cropping | Siltation, erosion, chemical and fertilizer runoff. |
| Livestock production | Manure runoff (excessive nutrients and bacteria), damage to streamside vegetation, bank erosion. |
| Logging | Loss of streamside trees, bank erosion, siltation from roads, increased runoff. |
| Mining | Acidity and sulfates from iron sulfide rocks, sediment, runoff surges. |
| Oil and gas drilling | Brine from drilling, sediments, oily runoff. |
| Residential yards | Lawn and garden chemical and fertilizer runoff, higher runoff velocities. |
| Urban development | Siltation from land clearing, runoff surges (oils and metals) from roofs, roads, parking lots. |
| Industrial facilities | Chemical runoff from material storage areas, soot deposits, runoff surges, spills. |
| Commercial development | Runoff surges (oils and metals) from parking lots, roofs; sediment from land clearing. |
| Stream clearing | Sedimentation, loss of wildlife/mussel habitat, loss of shading (increased temp.), flooding. |
| Channelization | Increased flooding, sedimentation, loss of fish/insect habitat, loss of mussel beds. |
| Construction in floodplains | Increased flooding, siltation, danger to life and property. |
| Boating | Fuels, oils, and pathogens from discharge of sanitary waste. |
| All terrain vehicles (ATVs) | Erosion, loss of habitat. |

## What can I do to help?

A variety of actions is needed to improve water quality in the Tradewater River and the Green River region. Everyone who lives in the watershed can help. Support, encouragement, and financial assistance will be required to help farmers, loggers, and developers to adopt erosion and sediment controls. Farmers, homeowners, and golf course managers need to reduce the amount of fertilizers and chemicals they apply to their lands. Significant research is underway in the basin to develop karst-sensitive Best Management Practices (BMPs), which are land-use strategies that strive to strike a balance between the need for minimized impairment to the basin's water quality and the economic and cultural needs of the area's residents. Some of these are strictly win-win propositions. Storage and carefully timed application of animal waste as a fertilizer, for example, has in some cases been shown to simultaneously reduce the levels of bacteria entering the groundwater and reduce the need for expensive chemical fertilizers. In addition, people who own property along the creeks and rivers must recognize the importance of trees, shrubs, and tall grasses along the banks and in the floodplains.

The U.S. Dept. of Agriculture's Conservation Reserve Enhancement Program is an important program. It will cover approximately 1 million acres of lands associated with the Upper Green River, including the entire watershed from the dam at Green River Lake to the mouth of Nolin River. This program provides farmers with more flexibility when applying for assistance and provides favorable incentives to farmers for implementing best management practices on their land. Conservation practices that offer the greatest protection of water quality (e.g., riparian buffer) will receive up to twice the payments as under the current continuous conservation program. Other practices that will earn incentive payments include filter strips and sinkhole protection. The program will also feature incentive payments to farmers when they apply in the amount of $100 or $150 per acre for entering into 10- to 15-year contracts, respectively. In addition, the program will allow a farmer to place practices under 30-year or permanent easement protection for additional payment. The overall project will bring approximately $110 million to farmers in eight counties of the Upper Green River Basin.

Better dissemination and use of educational materials and technical information are needed to help people understand the importance of leaving streams alone - avoiding the temptation to channelize them, clearing their vegetation, straightening them out, digging up their gravel bars, and controlling their flows. People who dump trash along creeks or toss litter from their vehicles also need to be educated about how they are hurting their environment. Several new initiatives are under way to address water pollution caused by activities on the land. The 1998 Forest Conservation Act

**Practices that reduce impacts from land activities**

| Activity | Management practices |
|---|---|
| Row cropping | Use conservation tillage, targeted chemical use, strip cropping, and streamside buffers. |
| Livestock production | Move facilities uphill, install waste treatment systems, stream fencing, and setbacks. |
| Logging | Skid on the contour, avoid streams, preserve streamside trees, and install water bars. |
| Mining | Reclaim mined areas, mix acid and alkaline material, add erosion/sediment controls. |
| Oil and gas drilling | Store or treat wastes from drilling, control sediments and oils. |
| Residential yards | Reduce/eliminate lawn/garden chemical use, preserve streamside vegetation. |
| Urban development | Sediment/erosion/stormwater controls, minimize land clearing and pavement, preserve existing trees. |
| Industrial facilities | Cover stored materials, control/treat runoff, minimize air/water discharges. |
| Commercial development | Minimize land clearing, control/treat runoff, reduce parking lots/road sizes. |
| Stream clearing | Minimize clearing, preserve vegetation, promote greenways/buffers. |
| Channelization | Decrease flooding by reducing or slowing runoff, restore streamside wetlands. |
| Construction in floodplains | Limit or eliminate development in floodplains. |
| Boating | Use marine sanitation devices and pumpout facilities. |
| ATVs | Use ATVs only in designated areas and maintained trails. |

**What is Watershed Watch?**
Watershed Watch is a citizen-led effort organized to get people down to the river and raise their awareness of watershed issues. The Upper Green River and Tradewater/Lower Green River Watershed Watch groups provide volunteers with extensive training on water quality issues, assessment data, and monitoring methods -- and have a good time while doing it. Several hundred volunteers have visited stream sites all over the basin, collecting field observations on habitat and land use and collecting water samples for pesticides, nutrients, metals, and conventional parameters. Data are analyzed with the assistance of professionals and incorporated into maps. Each fall, the public is invited to attend a watershed conference held in each basin to discuss the results and other watershed issues. There is no cost to participate in the Watershed Watch program -- call or visit the Web site to inquire about becoming a volunteer.

Watershed Watch

**Get Connected - Web links**
Check out these sites to learn more about the science and practice of watershed management in Kentucky and the nation.

**Kentucky's WatershedFramework** - http://kywatersheds.org

**Ky. Division of Water, Water Watch volunteer monitoring** -http://water.nr.state.ky.us/ww/

**Ky. Division of Water** - http://water.nr.state.ky.us/dow/

**Green and Tradewater Rivers Watershed Watch volunteer monitoring projects** - http://water.nr.state.ky.us/watch/

**Kentucky Dept. for Fish and Wildlife Resources** - http://www.kdfwr.state.ky.us/

**Kentucky Division of Forestry** - http://www.kyenvironment.org/nrepc/dnr/forestry/dnrdof.html

**Kentucky Natural Resources and Environmental Protection Cabinet** - http://www.kyenvironment.org/

**Kentucky Department for Natural Resources** - http://www.kyenvironment.org/nrepc/dnr/dnrhome2.htm

**Kentucky list of priority impaired ("TMDL") streams** - http://water.nr.state.ky.us/303d/

**Kentucky District of the US Geological Survey** - http://130.11.24.1

**Western Kentucky University Technical Assistance Center for Water Quality** – http://water.wku.edu

**Stream corridor restoration guide** - http://www.usda/gov/stream_restoration/newtofc.html

**Recreational boating** - http://www.kdfwr.state.ky.us

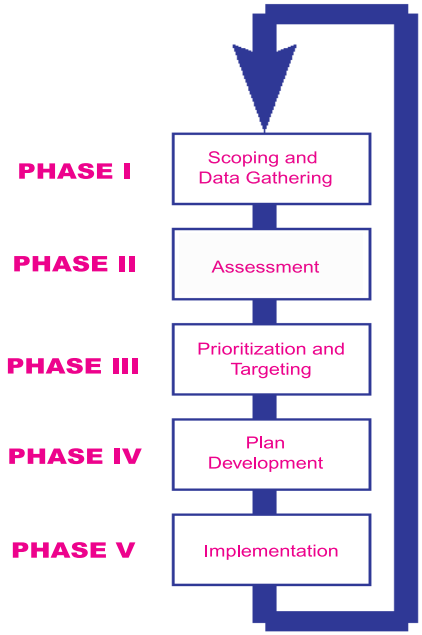
requires trained Master Loggers to be present where timber is being cut, skidded, and loaded to ensure that proper measures are taken to preserve streamside trees, minimize road-building impacts, and reduce erosion. The Kentucky Agricultural Water Quality Act requires farmers to develop soil and water conservation plans to address impacts from plowing, fertilizing, chemical applications, livestock production, and other activities

But progress cannot be realized just by passing laws - people have to get involved if improvements are to be made. Some people may want to help collect water quality information by becoming monitoring volunteers, while others might spread the word that trees and native vegetation should be preserved, especially in new development tracts and along streams in our towns and cities. Those who care about the impacts of trash and other debris may wish to participate in cleanup projects to remove these eyesores from the river and its tributaries. We are beginning to have a better understanding of how we should treat the land and its waters in order to maintain a high level of water quality in our Commonwealth. All of us can become more involved in protecting water quality in our communities simply by paying more attention to activities occurring around us. What is the status of water quality in your community? What industries, mining, or logging activities are currently in existence? What new ones may be coming to your area? How do - or will - any of these impact water quality?

If you would like more information, please contact the Kentucky Division of Water or other members of the Green-Tradewater River Basin Team or check out the Internet addresses listed.

## Kentucky Watershed Management Framework

This report has been produced as part of Kentucky's Watershed Management Framework, which is a cooperative approach to improving the health of the state's watersheds. The year 2000 was the first year of a five-year planning and management cycle for the Green and Tradewater River basin. During the second year, several agencies and organizations will conduct extensive monitoring in the region. During the third year, people throughout the region will confer to decide which small watersheds should receive intensive attention during years four and five of the cycle. In year four, improvement plans will be made for the small watersheds selected, and in year five, many agencies and organizations will implement those plans. The cycle then begins again in 2005, with a new evaluation and a new status report. Contributors to this document include members of Green and Tradewater River Basin Team under the Watershed Management Framework.



# For Educators

**Listed below are educational references and contacts**

**Always a River**
Available from NTIS (#PB93-200905) for $70 plus S&H. Call 1-(800) 553-6847 8 a.m. to 8 p.m. ET

**Aquatic Project WILD Education Activity Guide (K-12)** For Kentucky training opportunities or to receive a Guide, call Lonnie Nelson at (502) 564-7109.

**A Teacher's Guide to Man and the Biosphere: Protecting, Conserving, and Using Our Narural Resources (Middle and High School)**
For training opportunities or to receive a Guide, call Mammoth Cave National Park's Environmental Education Office at (502) 758-2354.

**Curriculum and Resource Guide (Middle and High School)**
For training opportunities or to receive a Guide, contact American Cave Conservation Association at (502) 786-1466.

**Learning to Live With Caves and Karst: a Cave and Karst Project WET (Water Education for Teachers) Curriculum and Activity Guide (K-12)**
For Kentucky training opportunities or to receive a Guide, contact Jennifer Lynn at (606) 289-5308

**Teacher's Guide To Kentucky's Environment (Middle & High School)**
To receive a Guide, call Kentucky Environmental Quality Commission at (502) 564-2150 ext. 160.

**WOW! The Wonders of Wetlands: An Educator's Guide (K-12)**
For information or to purchase a Guide, contact one of the co-publishers: The Watercourse at (406) 994-5392 or Environmental Concern at (410) 745-9620

**For More Information**

**Contact a local office:**
Conservation District, for assistance with projects (502) 564-3080.
Cooperative Extension Service, for fact sheets related to water quality issues (859) 257-1846.

**Contact a regional office**:
Area Development District, for technical resources (502) 875-2515.
Lower Green and Tradewater Rivers Watershed Watch (volunteer monitoring): (270) 685-2034
Ohio River Valley Sanitation Commission: (800) 359 - 3977
RC &D (agricultural practices) (859) 224-7403
University-based environmental education center, for related resources and workshops.
Western Kentucky University Center for Water Resource Studies: (270) 745-5945

**Contact a state office:**
County Solid Waste Coordinator (illegal dumping): (502) 564-6716
Dead animal removal reports (Ky. Dept. of Agriculture): (502) 564-3956
District Health Department (cleanup days, septic problems and illegal dumping): (502) 564-4856
Division of Water (grants, loans, permits, enforcement): (502) 564-3410
Forest Conservation Act (Ky. Division of Forestry): (502) 564-4496
Illegal dumping (Ky. Division of Waste Management): (888) NO DUMPS
Karst information (American Cave Conservation Association): (270) 786-1466
Kentucky Agricultural Water Quality Act: (502) 564-3080
Kentucky Department of Fish and Wildlife Resources: (800) 858-1549
Kentucky Environmental Education Council, (502) 564-5937, for telephone numbers of agencies, organizations and programs.
Kentucky Environmental Quality Commission, (502) 564-2150 ext. 160, for reports on the environmental condition of the State ($10/7 reports).
Kentucky Nature Preserves Commission: (502) 573-2886
Kentucky Water Watch Program, (502) 564-3410, for information about water monitoring programs.
Kentucky Waterways Alliance, Inc. (river protection groups): (270) 524-1774
Ohio River Sweep (Ohio River Valley Sanitation Commission [cleanups]): (800) 359-3977
Upper Green River Watershed Watch (volunteer monitoring): (270) 524-1774
U. S. Army Corps of Engineers: (502) 315-6471
U.S. Natural Resources Conservation Service, (859) 224-7350, for technical advice.

**More Web Sites**

**N.C. water quality research center -- for agriculture** - http://www.bae.ncsu.edu/bae/programs/extension/wqg/

**Resource management practices photos** - http://earthl.epa.gov/owow/nps/ex-bmps.html

**Volunteer monitoring** - http://www.epa.gov/owow/monitoring/vol.html

**Nonpoint source information for local officials** - http://www.lib.uconn.edu/canr/ces/nemo/nsmodule/nsdetail.html

**Center for Watershed Protection** - http://www.pipeline.com/~mrrunoff/

**US EPA nonpoint source pollution** - http://www.epa.gov/owow/nps/

**US EPA wetlands information** - http://www.epa.gov/owow/wetlands/

**EPA's Watershed Information** - http://www.epa.gov/win/

**Small-scale wastewater treatment** - http://www.estd.wvu.edu/nsfc/

**American Rivers, a river protection organization** - http://www.amrivers.org/

**River Network, a river protection organization** - http://www.rivernetwork.org/

**Conservation Technology – good source for agricultural practice recommendations** - http://ctic.purdue.edu/

**Mammoth Cave threats** - http://hoffman.wku.edu/gis/macathreat.htm

**Threatended and endangered species** - http://www.kdfwr.state.ky.us and http://www.usfws.gov

**Cooperating members of the Green and Tradewater River basins:**

Bob Adams, Ky. Division of Water
Steve Alexander, US Fish & Wildlife Service
David Burton, Barren River District Health Dept
Sheryl Chino, Barren River ADD
Dr. Nicholas C. Crawford, Western Kentucky University
Aloma Dew, Sierra Club
Jack Eversole, Barren River ADD
David Foster, American Cave Conservation
Buddy Giesecke, NRCS
Dr. Christopher G. Groves, Western Ky. University
Dr. Scott Grubbs, Western Ky. University
Jill Hartley, Bowling Green Municpal Utilities
Margi Jones, Ky. Division of Water
Dr. Richie Kessler, The Nature Conservancy
Stephen Kessler, Ky. Division of Waste Management
Bonny Laflin, Ky. Dept. Fish and Wildlife
Owen "Kayo" Maddox, Ky. Division of Forestry
Dr. Ouida Meier, Western Ky. University
Joe Meiman, National Park Service
Patrick Neichter, U.S. Army Corps of Engineers
Judy Petersen, Ky. Waterways Alliance
Dale Reynolds, Green/Tradewater Basin Coordinator
Sue Anne Salmon, Kentuckians for the Commonwealth
Ritchie Taylor, Western Ky. University
Jim Widlak, U.S. Fish and Wildlife Service
Dr. Terry Wilson, Western Ky. University

Green River Bluffs, Mammoth Cave National Park

Kentucky Division of Water
14 Reilly Road
Frankfort, KY 40601

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To request materials in an alternative format, contact:
Kentucky Division of Water
14 Reilly Road
Frankfort, KY 40601
(502) 564-3410

For more information
or additional copies visit the Kentucky Watershed Management Home page at
kywatersheds.org or call (502) 564-3410