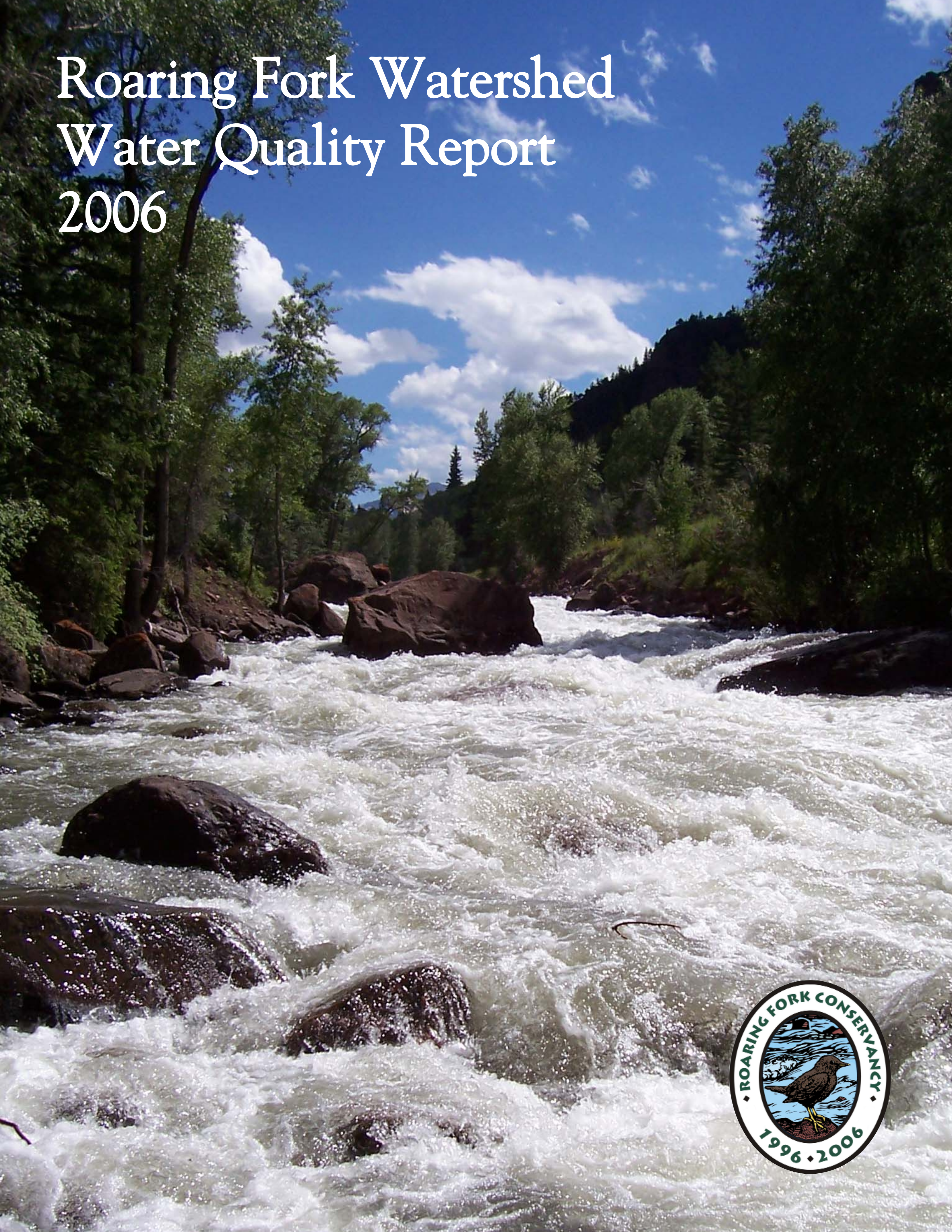
Roaring Fork Watershed Water Quality Report 2006



1. Introduction

Having sources of abundant, high quality water is vital to maintaining clean drinking water, agriculture, tourism, and the ecosystem health of the Roaring Fork Watershed. In 1997, the Roaring Fork Conservancy began a monitoring program to determine water quality conditions and trends throughout the watershed. The Roaring Fork Conservancy's first State of the River Report synthesized data collected during 2000 and established a baseline inventory of water quality (Hempel & Crandall, 2001). The data indicated high water quality throughout most of the watershed, and recommended that:

1) chemical data be supplemented by physical and biological evaluations, and

2) some changes in sample site locations be made. Incorporating these changes resulted in additional data for this report providing a more accurate portrayal of water quality and identification of issues to address.

This 2006 report covers the Roaring Fork water quality monitoring program, causes of pollution, health assessment of different stream reaches in the watershed, threats to healthy streams, and local efforts underway to protect water quality and educate citizens about the need for plentiful high quality water. Overall, water quality has remained high since 2000. However, some stream sections regularly exceed state health standards for drinking water supply and/or aquatic biological communities.

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2. Roaring Fork Conservancy

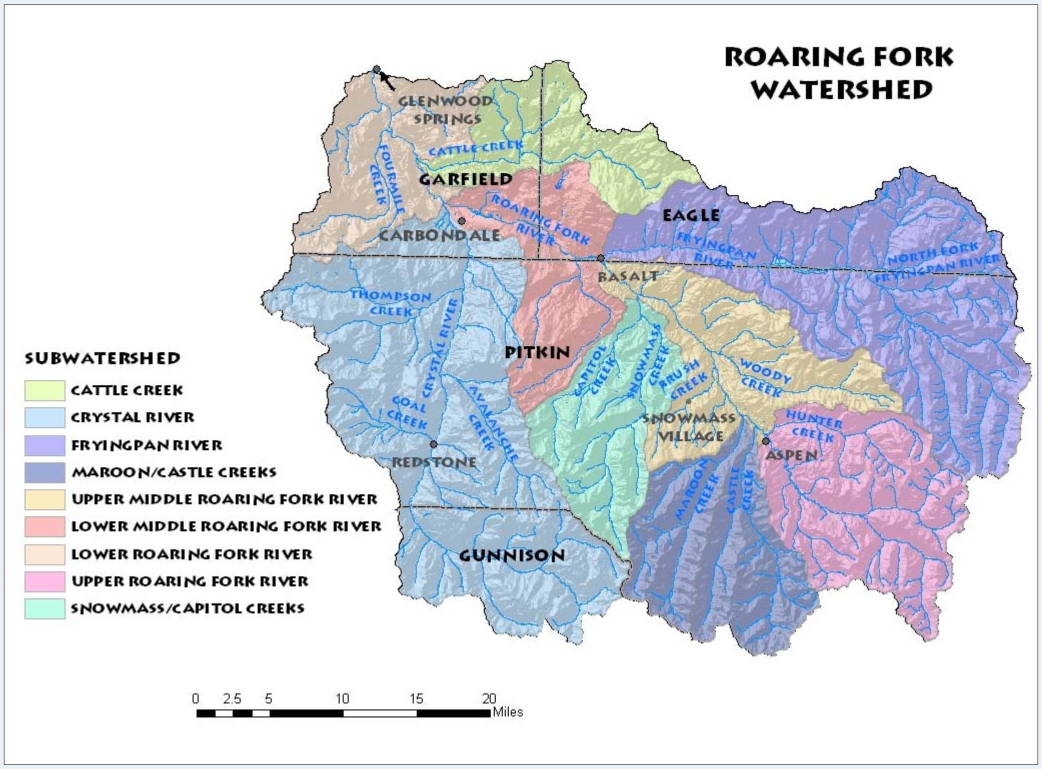
Roaring Fork Conservancy is a community supported non-profit watershed conservation organization for the Roaring Fork Watershed in central Colorado. Since 1996 the Roaring Fork Conservancy has worked "to inspire people to explore, value and protect the Roaring Fork Watershed." Supporting this mission are our four program areas:

- Water Quality Monitoring
- Conservation Easements
- Watershed Education
- Water Resources Research

Sound scientific analysis and collaboration are vital for protecting the watershed's rivers and riparian areas. Roaring Fork Conservancy has close working relationships with other non-profits, municipal, county, regional, state and federal agencies, and the business community. Its water quality program works closely with the Colorado Division of Wildlife (CDOW), Colorado Department of Public Health and Environment (CDPHE), U.S. Environmental Protection Agency (EPA), and U.S. Geological Survey (USGS).

For more information on the Roaring Fork Conservancy and its water quality monitoring program, visit the organization's website: www.roaringfork.org.

3. Roaring Fork Watershed



The Roaring Fork Watershed is comprised of a network of streams and rivers that flow into the Roaring Fork River which then empties into the Colorado River at Glenwood Springs. The Roaring Fork's main stem flows for over seventy river miles, starting near Independence Pass at over 12,000 feet on the Continental Divide. On its journey to the confluence with the Colorado River the Roaring Fork drops over 6,000 feet and travels from high alpine tundra to semi-desert pinõn-juniper woodlands.

The Roaring Fork River is the second largest tributary to the Colorado River in the state of Colorado, and contributes about five percent of the total water in the Colorado River Watershed. The Roaring Fork Watershed covers an area of 1,451 square miles (approximately the size of the state of Rhode Island). Major tributaries of the Roaring Fork are the Fryingpan and Crystal rivers. All of the valley's major communities, Aspen, Basalt, Carbondale, and Glenwood Springs, are located along the Roaring Fork River. Smaller communities are located on main tributaries. The watershed contains parts of three counties: Eagle, Garfield, and Gunnison, and most of Pitkin County. In 2000, the U.S. Census estimated that the population of the watershed was approximately 40,000 people and growing in all four counties.

Annual mean snowfall in the watershed is 65 to 70 inches and the annual mean rainfall is 11 inches. Basalt beds, the Maroon formation, the Eagle Valley gypsum formation, Mancos shale, and Mesa-Verde sandstone occur along the lower valley. Above Aspen, granite, gneiss, and schist rock formations are dominant. Plant communities along the river include canopy species of ponderosa pine, narrow-leaf cottonwood, box elder, and juniper; understory species include water birch, Gambel's oak, wild rose, and willow.

Fish species found in the watershed's rivers and streams include the non-native brook, brown, and rainbow trout; and the native Colorado River cutthroat trout. Additional cold water species include the mountain whitefish; mottled sculpin; speckled dace; and bluehead, flannelmouth, and mountain suckers. Caddisflies, stoneflies, mayflies, and midges represent the most common macroinvertebrates found in and along the valley's rivers (Spackman et al., 1999). The watershed also provides habitat for many bird, mammal, amphibian, and reptile species.

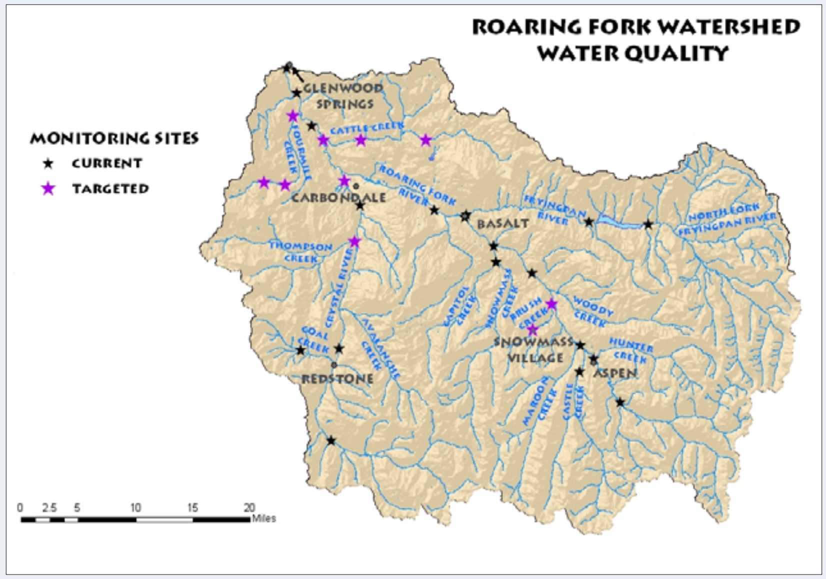
Additional information, including facts and figures about the Roaring Fork Watershed, is available at: www.roaringfork.org/watershed.

4. Water Quality Sampling Program

Background

In 1997, the Conservancy helped coordinate efforts to establish a watershed wide water quality sampling program in partnership with the River Watch program coordinated by CDOW, Colorado Watershed Network (CWN), and CDPHE. As of 2006, there are a total of 24 water quality sampling sites throughout the Roaring Fork Watershed. The River Watch program's first-class water quality testing protocol is used statewide to monitor stream health and quality. River Watch trains middle and high school students and teachers during a comprehensive multi-day class overseen by CDOW biologists and River Watch staff.

Dedicated citizen volunteers and local schools (Aspen High, Aspen Country Day, Basalt High, Carbondale Middle, Marble Charter, Colorado Rocky Mountain, Glenwood Springs High) make water quality sampling in the Roaring Fork Watershed possible!



Conservancy staff are trained to implement this protocol and are responsible for training the citizen volunteer 'stream teams' throughout the valley. Key to the consistency of the monitoring program is a strict sampling schedule, adherence to holding times for all samples, and regular quality assurance and quality control checks administered by the River Watch and Conservancy staff. River Watch partner schools and Roaring Fork Conservancy staff enter data they have collected into the River Watch data base (www.wildlife.state.co.us/riverwatch).

Data Users

All data from the volunteers and labs are scrutinized for precision and accuracy by River Watch staff and incorporated into the River Watch web page and STORET, the national water quality database administered by the EPA (River Watch, 2005). At a local scale, the Conservancy's water quality monitoring program collects accurate and consistent data to inform local decision-makers, citizens, and Roaring Fork Conservancy staff. This information aids watershed management decisions and identifies areas for either remedial efforts or targeted studies. At a broader scale, the data are used by CDOW, EPA, and the CDPHE's Water Quality Control Division (WQCD) to monitor drinking water quality and aquatic habitat. The WQCD use these data to assess the physical, biological and chemical integrity of Colorado's waters (CDPHE, 2005).

Sampling Protocol

For every sample taken, monitoring participants:

- sample for total and dissolved metals;
- run chemical analysis for hardness, alkalinity, pH, and dissolved oxygen;
- record temperature of air and water; and
- note any physical changes in the site.

Family Biotic Index (FBI)

In a polluted stream, there typically are large numbers of only a few specific species, while in a clean stream there is greater diversity of species. Because both pollution sensitive and tolerant forms are present in 'clean' waters, it is the absence of sensitive species and presence of tolerant species that may indicate pollutants. The Family Biotic Index (FBI), a form of the Biotic Index, is based on grouping macroinvertebrates into categories depending on their response to organic pollution (Hilsenhoff, 1988).

Water Quality based on Family Biotic Index
(Hilsenhoff, 1977)

Biotic Index	Water quality	Degree of organic pollution
0.00 - 3.50	Excellent	Organic pollution unlikely
3.51 - 4.50	Very Good	Possible slight organic pollution
4.51 - 5.50	Good	Some organic pollution probable
5.51 - 6.50	Fair	Fairly substantial pollution likely
6.51 - 7.50	Fairly poor	Significant organic pollution
7.51 - 8.50	Poor	Very substantial organic pollution
8.51 - 10.0	Very poor	Severe organic pollution

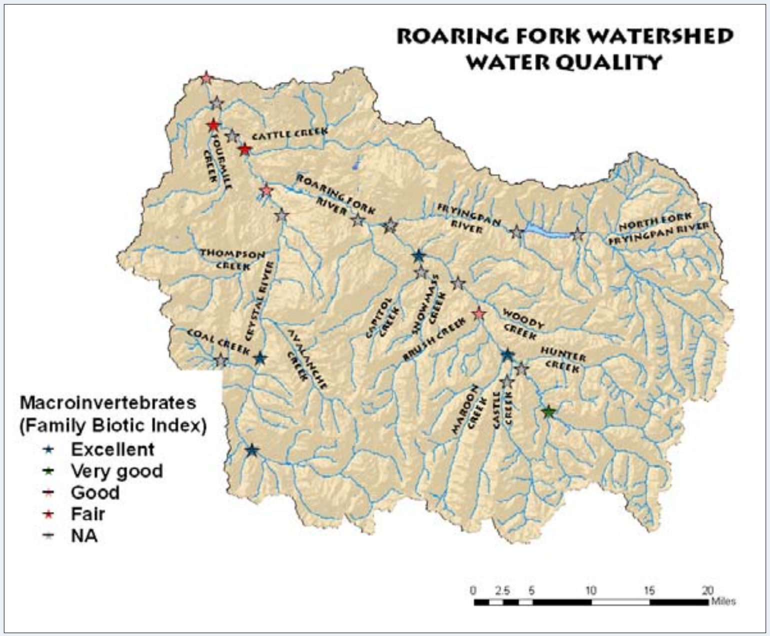
Data Collection and Analysis

Most sample sites are monitored on a monthly basis while a few streams that have shown consistent high quality are sampled on a quarterly basis. Field parameters are analyzed by the Conservancy and stream team volunteers while tests for metals, nutrients, and macroinvertebrates are sent out for analysis. Field parameters, metals, and nutrient amounts are important in establishing baselines for analysis and future threat assessments. Macroinvertebrate data (sidebar) is important because it provides information on the biological integrity of the stretch of water. Macroinvertebrates reflect stream conditions over a period of time rather than on the day of sampling.

Frequency of water quality testing and the parameters tested are based on state standards for stream health (CDPHE, 2005) and the significance of each parameter (Colorado Watershed Network, 2005). Nutrients are collected twice per year and macroinvertebrates are collected only for targeted studies. The chemical, physical, and biological parameters sampled by Conservancy staff, volunteers, and schools are as follows:

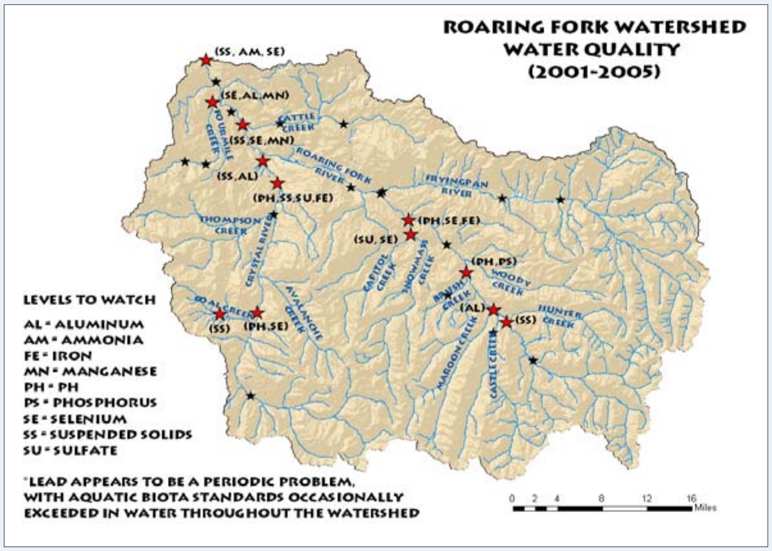
- **Metals analysis:** Cadmium, copper, lead, zinc, magnesium, iron, selenium, arsenic, aluminum, calcium, and manganese (total and dissolved metals for all stations).
- **Nutrient analysis:** Nitrate, phosphate, sulfate, chloride, ammonia, and total suspended solid concentrations.
- **Field parameters:** Temperature, pH, total alkalinity as $CaCO_3$, total hardness as $CaCO_3$, and dissolved oxygen.
- **Physical assessment:** Flow, riparian and in-stream habitat assessments (e.g. bank stability, percent cover, substrate type and size), and river/stream reach assessments.
- **Biological conditions:** Macroinvertebrates are studied to evaluate the ability of water to support aquatic life using the FBI.

See the Appendix for detailed descriptions of each water quality monitoring parameter.



5. Most Common Pollutants

As described in the previous section, the Conservancy and River Watch test water for a wide range of chemical, biological, and physical parameters. The following information focuses more specifically on the parameters that cause most of the pollution problems in the Roaring Fork Watershed. In Colorado, water quality standards exist for drinking water supply, recreation, agriculture, and aquatic life. The source for toxicity and state standard information is CDPHE (2005); information on pollution sources and their effects on water quality is taken from CWN (2005). For more information on the parameters tested and their importance, visit www.roaringfork.org/wqm.



Metals

Selenium (Se): Toxic to rainbow trout at 5.0 µg/l. Geology, naturally disturbed soils, and areas of development and agriculture all introduce selenium into our waterways.

Aluminum (Al): Occurs naturally and makes up eight percent of earth's surface. Low levels of aluminum are not thought to be harmful. Toxicity is affected by pH levels, staying in dissolved form below 6.5 and contaminating fish gills.

Lead (Pb): Toxic to aquatic life in the 10-100 µg/l range. Causes delays in normal physical and mental development in babies and young children, probable carcinogen. Enters environment from industry, mining, plumbing, gasoline, coal, and as water additive.

Iron (Fe): Precipitates may cover fish spawning habitat, egg, and macroinvertebrate habitat. Occurs naturally as a mineral from sediment and rocks or from mining, industrial waste, and corroding metal.

Manganese (Mn): Primarily occurs as mineral from sediment and rocks and secondarily from pesticides, fertilizers, and livestock feed. Manganese can stain laundry, affect taste of water, and at high levels is toxic to plants.

Nutrients

Phosphorous: CDPHE is proposing a state standard of 0.1mg/l for drinking water supply. High concentrations can lead to algal blooms that reduce the amount of dissolved oxygen available in the water.

Sulfates: State drinking water supply standard is 250 mg/l. When a combination of sulfur and certain metals enter a body of water there is a reaction with oxygen that lowers the pH of the water (becomes acidic).

Ammonia: State standard for aquatic biota is 20 µg/l. Ammonia is a form of nitrogen combined with oxygen that, in high concentrations, inhibits ability of fish to excrete their own ammonia waste, leading to brain damage.

Suspended solids

- National average for suspended solids is 150 mg/l.
- High levels of suspended solids can impair aquatic ecosystems by increasing the temperature of the water, abrading and clogging fish gills, and smothering plants, insects, and trout spawning beds.

pH

- State standard of 6.5 - 9.0 for aquatic life and 5.0 - 9.0 for drinking water supply.
- pH affects what can live and reproduce successfully in a body of water.
- Most aquatic organisms prefer a pH of 6.5 - 8.0.

6. Importance of Healthy Streams

• **Drinking water:** Rivers and streams are used in 55 percent of Colorado's communities for drinking water, with ground water supplying the remaining 45 percent (CDPHE, 2004). Increased pollution and sediment loads in surface and ground water create a need to increase treatment of drinking water supplies.

• **Irrigation:** Surface water is the primary source of irrigation water (Perlman, 2005) and if this supply is polluted, or diminished, agriculture and its products are affected. In the short term, irrigation removes water from streams, but typically contributes to return flows and groundwater recharge.

• **Economic impacts:** All of the following recreational activities and related economic benefits depend on high quality water:

A Conservancy study found that **fishing and recreation** on the Fryingpan River and Ruedi Reservoir contribute approximately $3.9 million per year to the Roaring Fork Valley's economy (Crandall, 2002).

The 2005 year end report of the Colorado River Outfitters Association (CROA, 2005) reports that the **white water rafting** industry on the Roaring Fork River is responsible for over $594,000 in total economic impact, while the Colorado River through Glenwood Springs boasts an economic impact of nearly $14 million.

Additionally, data compiled by the CDOW shows that **hunting and angling** contribute over $1.5 billion to the state economy and **wildlife viewing** accounts for over $940 million (Pickton, Sikorowski, 2004). The Roaring Fork Watershed has 42 continuous miles of Gold Medal water along the lower Fryingpan and Roaring Fork rivers.

• **Wildlife:** About 80 percent of Colorado's wildlife species are dependent on our rivers, streams, wetlands, and riparian areas at some point in their life in order to survive and successfully reproduce. Pollution of the valley's rivers adversely affects riparian and aquatic habitat, and the species dependent on them. Recent returns of breeding bald eagles and osprey, high quality great blue heron rookeries, and increased designation of Gold Medal fisheries are indicators of good riparian habitat and generally high water quality.

• **Quality of life:** Most people who live in or visit the Roaring Fork Valley are attracted to the area because of its natural setting, which contributes to a high quality of living. Healthy streams are the basis for healthy ecosystems and provide for a great diversity of plant and animal species that help make the Roaring Fork Valley so unique. There is intrinsic value in protecting these resources because of the interrelatedness of water to all life.

"We enjoyed our short time on the Fryingpan. We only caught a couple fish, but any day fishing is better than working. We also enjoyed watching a bald eagle roosting in a large tree along the river. Every bald eagle sighting is a special and treasured experience."

- Survey participant from the Fryingpan Valley Economic Study (Crandall, 2002)

7. Healthy Stream Reaches

Healthy streams are not only important to healthy wildlife populations but are also critical to the valley's economic sustainability. Providing clean drinking water, aesthetically pleasing recreational experiences, and supporting a booming tourism industry, rivers are the life blood of the valley.

Roaring Fork River at Hooks

The Roaring Fork Conservancy's water quality data indicate that many reaches of stream in the watershed are in good health and are considered in this report as Healthy Streams. Stream reaches with good water quality typically have not exceeded state standards for any parameters tested, although on occasion a single parameter may test high. Healthy Stream reaches and water quality sampling sites that show good water quality are:

Roaring Fork River at Basalt

Difficult Campground: (Roaring Fork River above Aspen) within the White River National Forest; no major sources of pollution; excellent riparian habitat

Castle Creek: much of basin in pristine condition and within National Forest; low levels of development; excellent riparian habitat

Gerbaz Bridge: (Roaring Fork River) the river has increased in volume enough to dissipate the pollution seen in Aspen and along Brush Creek; good riparian habitat

Fryingpan River at Baetis Bridge

Meredith: (Fryingpan River above Ruedi Reservoir) upper reaches are above most development; affected only by flow alterations; excellent riparian habitat

Baetis Bridge: (Fryingpan River below Ruedi Reservoir) excellent tail-water fishery with high water quality; altered temperature and flow regimes; good riparian habitat

Roaring Fork River near Westbank

Upper Basalt/Pueblo Bridge: (Fryingpan River) continued high quality water to confluence with Roaring Fork River; low development densities in Fryingpan basin, good riparian habitat

Basalt/7-11 Bridge: (Roaring Fork River) increased volume with the addition of Snowmass/Capitol Creeks creates high water quality; no major pollution sources in this reach; marginal riparian habitat

Hooks Bridge: (Roaring Fork River) continued high water quality which is improved by high flows from the Fryingpan River; good riparian habitat

Crystal River below Redstone

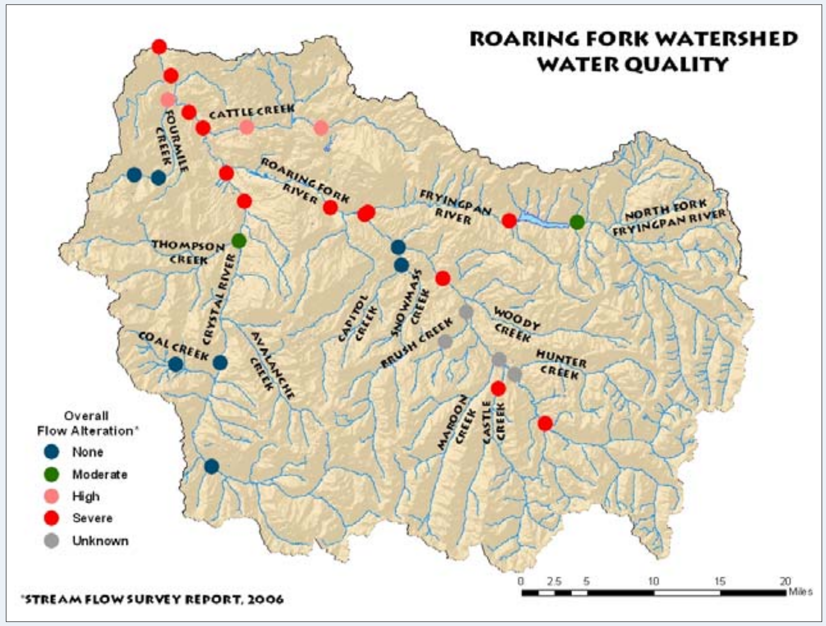
Westbank Bridge: (Lower Roaring Fork) overall good water quality; like most of the Roaring Fork, occasional high levels of lead and sediment; good riparian habitat

Genter Mine Bridge: (Crystal River below Marble) pristine, free-flowing headwaters basin with very little development pressure currently; excellent riparian habitat

8. Threats to Healthy Streams

Pollution

Growing public awareness and concern for controlling water pollution led to the enactment of the Federal Water Pollution Control Act Amendments of 1972. As amended in 1977, this law is known as the Clean Water Act (CWA). The Act established the basic structure for regulating discharges of pollutants into the waters of the United States. The CWA imposes fines, and remediation efforts are undertaken when violations occur. The CWA also requires that each metropolitan area in the United States prepare a storm water runoff remediation plan. The Conservancy has worked closely with Aspen, Basalt, and Glenwood Springs to help implement these plans.

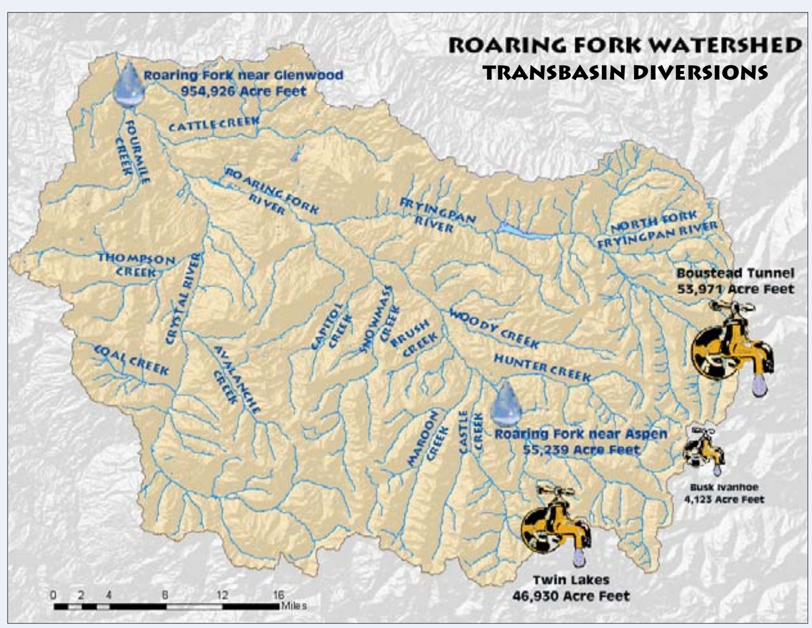


Point source pollution has an identifiable source, such as a pipe dumping waste directly into a stream, which makes assessment of responsibility relatively easy. In the Roaring Fork Watershed where there is little industry, point sources of pollution are most common from wastewater treatment facilities.

Non-point source pollution (NPS) is more difficult to track and treat than point source pollution and and is the number one source of pollution in the Roaring Fork Valley. NPS pollution is not discharged from a single source; instead many sources that are spread out over a large area combine to create this problem. A large source of NPS pollution in the watershed is storm water runoff that carries sediment and pollutants from streets and parking lots through storm drains and into valley streams. Over-fertilization of lawns, golf courses, and agriculture as well as improper septic tank construction or maintenance can increase non-point source pollution, especially affecting groundwater.

Flow Alteration

The phrase "the solution to pollution is dilution" sums up the importance of an adequate water supply for maintaining high water quality. Low flows intensify pollutant problems and increase sediments that can smother trout eggs and aquatic vegetation. The Conservancy's recently completed Stream Flow Survey report describes in detail flow alteration in the watershed (the full report is available at: www.roaringfork.org/publications). The Roaring Fork Watershed's flows have been, and continue to be,



Threats to Healthy Streams (cont.)

Basalt and Glenwood Springs

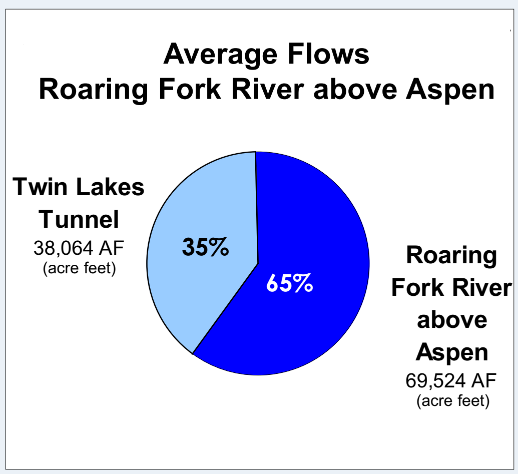
The Conservancy received grants and support from several other entities to conduct storm water assessment reports for both Basalt (Matrix Group, 2001) and Glenwood Springs (Matrix Group, 2003). Studies show that a wide range of activities affect these communities' water quality:

- construction of buildings, roads and bridges,
- filling of the river channel and flood plain,
- degradation and removal of natural vegetation,
- increased recreational use,
- increased residential and commercial construction and development in riparian habitats, and
- a growing number of contributors to non-point source pollution runoff.

altered to meet agricultural, municipal, and industrial demands within and beyond the watershed boundaries. Aspects of the flow regime, including flow magnitude and timing, duration of high and low flows, and rate of change are related to important biological and geomorphological processes that influence overall stream health. The Stream Flow Survey found that much of the significant hydrologic alteration is seasonal, influenced by activities such as irrigated agriculture (summer) and snowmaking (winter). Although alterations from these activities can be severe (i.e. occur over all months in a season), there is a significant return flow of water to streams from these seasonal uses.

Other water uses cause hydrologic alteration throughout the year, including trans-mountain diversions, Ruedi Reservoir management, and diversion for domestic water supplies. The trans-mountain diversions are one hundred percent consumptive. With about 80 percent of the state's water found west of the Continental Divide and 80 percent of its population east of the Divide there is intense political pressure to provide water to the large population centers on Colorado's Front Range.

All consumers in the Roaring Fork Valley, including agriculture and municipalities, use only four percent of the Roaring Fork Watershed's surface water; the rest of the water continues downstream or is diverted to the Arkansas River drainage on the east side of the Continental Divide.



- Over 14 percent of the total surface water in the Roaring Fork Watershed is diverted to the Arkansas River (from headwaters of the Fryingpan and Roaring Fork Rivers), through the Charles H. Boustead, Busk-Ivanhoe, and Twin Lakes tunnels.
- Presently the Roaring Fork River near Aspen flows at only 65 percent of the average historic flow annually. Diversions through the Twin Lakes tunnels account for the remaining 35 percent.

The Fryingpan Fisheries Study (Ptacek, Rees, & Miller, 2003) reveals that both maximum and minimum flows and temperatures of the lower Fryingpan River, and to some extent the Roaring Fork River (at the confluence), have been altered since 1968 due to the impact of Ruedi Dam. The large reduction of periodic flooding is thought to have negative effects on aquatic life, while higher flows during late summer, fall, and winter (in good snow years) contribute to a greater amount of macroinvertebrates in both the Roaring Fork and Fryingpan rivers that otherwise would not be present.

Storm water impacts on streams

- **Stream Hydrology:** Impermeable surfaces, such as roads and parking lots, lead to a decrease in rain and snowmelt infiltration, increasing runoff.
- **Stream Morphology:** widening and erosion due to hydrological changes.
- **Stream Water Quality:** Increases in turbidity (cloudiness), metals concentrations, temperature, nutrient loads, bacterial contaminants, trash, organic matter, salts, and debris.
- **Aquatic Ecology:** Pollutant loading can significantly alter aquatic ecology.

Altered Habitat

The vegetation along the river, also know as riparian vegetation, plays an important role in maintaining high water quality. A healthy riparian zone with its build up of decayed vegetation and sediment acts like a sponge soaking up water. This helps reduce the velocity of the water entering the stream, which decreases erosion and associated sedimentation. Plant roots also stabilize stream banks, reducing erosion. Filtration of water through soils and plant roots helps remove pollutants. Trees also provide shade helping to decrease summer water temperatures. Alteration or removal of riparian vegetation can have severe impacts on water quality. The most severe effects are seen when the vegetation is completely removed and replaced by an impervious surface such as a driveway or parking lot, which does not allow water to permeate the surface to recharge groundwater supplies.

Increased Growth

Colorado is experiencing rapid growth in many communities and this will exacerbate an already serious problem of water allocation issues. According to state demographers, the population in the Roaring Fork Watershed is likely to double in the next 25 years. Population is also increasing rapidly on the Front Range, and with this development the need for consistent water supplies increases the chance for more diversions from the Roaring Fork Watershed to the Arkansas River Watershed.

Continued development could worsen the existing pollution problems in the watershed. As more parking lots, roads, and driveways are built, storm water runoff problems will continue. Additionally, development brings more septic system and wastewater treatment pressure, not to mention a higher demand on drinking water within the valley.

Invasive Species and Disease

Invasive animal and plant species (commonly known as weeds) harm ecosystems due to their lack of natural predators and their ability to out-compete native species. Some wetland weeds rob waterfowl and mammals of their food sources, nesting areas, and access to water. Noxious weeds establish themselves in soil disturbed by construction, travel, and recreation. They spread via wildlife, humans, vehicles, wind, and water. The Colorado Weed Management Association (CWMA) estimates that of the 1,300 native species of plants in Colorado, 130 (10 percent) have already been displaced by non-native weeds. Unfortunately, the biology of non-natives allows them to progress from a small, manageable problem to a large, economically and environmentally challenging one (CWMA, 1996). Some estimates by the U.S. Department of Agriculture (USDA) place the nationwide cost of eradication, control, and loss of productive land at $3.6 to $5.4 billion per year (USDA, 2006). Some particular weed problems in the watershed are tansy, houndstongue, oxeye daisy (above), thistle, knapweed, Russian olive, and tamarisk.

Tamarisk, or salt cedar, is a highly invasive plant that in some places has completely taken over as the dominant riparian zone plant leading to the loss of diverse native plants, and the quality habitat they represent. This invasive consumes large amounts of water on a daily basis. The Colorado Water Conservation Board (CWCB) estimates future water loss in Colorado due to tamarisk at over 290,000 acre-feet per year. For reference, in 2001 Denver Water

Threats to Healthy Streams (cont.)

supplied 250,000 acre-feet of water to 1.1 million customers (CWCB, 2003). Tamarisk is not widespread in the Roaring Fork Watershed, and there is the possibility to eradicate it totally within the next decade.

Whirling Disease can affect ecosystems by eliminating or severely impacting species that are an integral part of an ecosystem. Whirling disease is an animal parasite present in our streams and rivers. It is most prevalent along the Fryingpan River and causes fish to have serious spinal deformations. There is no known way to eradicate this disease, but we can all help prevent its spread by following the guidelines listed at www.roaringfork.org/invasives.

Bark beetle infestations have been a problem in other parts of Colorado and are a concern in the Roaring Fork Watershed, as well. Bark beetles, typically spruce and pine beetles, feed on the inner layer of bark within spruce or pine trees. They typically feed on fallen or dead trees, but when their food supply is exhausted they will begin feeding on living trees. The most effective solution to dealing with beetle infestations is cutting down infested trees. This solution could adversely impact a watershed by increasing erosion and reducing species diversity. An infestation around the Vail area is slowly creeping towards the upper reaches of the Roaring Fork Watershed, making this issue something to closely monitor.

New Zealand mudsnails are not currently found in the Roaring Fork Watershed, but studies have shown that this snail has the potential to become the dominant macroinvertebrate in western river systems, and once established is nearly impossible to eradicate. Trout derive very little nutrition from this single source of food and often snails will pass through the digestive system intact. This snail has been found in Boulder Creek and in the Green River in Colorado, (and could soon find its way into the watershed through inadvertent transporting by anglers and boaters).

In summary, invasive plant and animal species will no doubt continue to plague water and land managers throughout the watershed. Continued residential and industrial development, interstate travel, and increased recreational activity all lead to the potential spread of non-native plant and animal species. Approximately 4,600 acres of the country's natural areas are lost to invasive plant species every day (USDA, 2006). This loss displaces desirable plants that provide: 1) forage for livestock and wildlife 2) critical habitat and food for native species, 3) protection from predators, and 4) diverse wildlands for recreation.

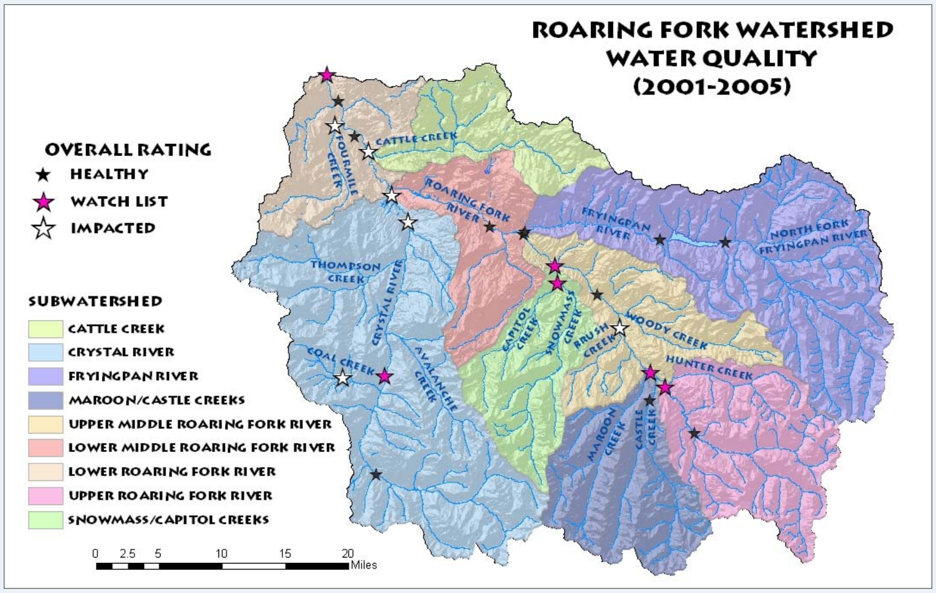
Invasive Species

Learn what you can do to stop the spread of invasive species in Colorado by visiting: ww.roaringfork.org/invasives.

Oil and Gas Development

A looming prospect for the Roaring Fork Watershed is the resurgence of natural resource extraction. The western part of the watershed, particularly the Thompson and Coal Creek drainages, face the greatest threat from resource extraction, specifically natural gas. Ground and surface water sources are in danger of contamination by gas (and by-products) during extraction, as well as the threat of pollution associated with new roads needed to access well pads and establish an infrastructure for transporting oil and gas. Roads are harmful in that they contribute to increased runoff of suspended solids and other pollutants, the destruction of riparian habitat, and the introduction of pollutants from dust suppression techniques. For additional issues related to road building in the watershed, visit www.roaringfork.org/news.

9. Streams on Watch List



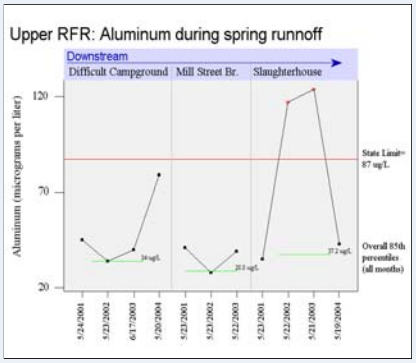
Stream sections that are on the Conservancy Watch List have good overall water quality but also exhibit data that prevent them from being identified on the Healthy Stream list. In most instances, the stream reach in question has exceeded a particular state standard several times since 2000 but at levels close to the state standard. Some stations/reaches show more than one parameter exceeding state standards, but only sporadically. Lastly, a station/reach may exceed state standards but have an FBI rating of 'excellent' that indicates only a slight possibility of organic pollution. These Watch List sites may need more attention and targeted studies in the future if the FBI rankings drop or the state standards are exceeded on a regular basis at very high levels.

Roaring Fork at Mill Street Bridge (Aspen)

• Mill Street outfall has suspended solids levels up to 8,370 mg/l, 55 times higher than the national average of 150 mg/l.
• The new storm water retention work that the City of Aspen voters approved will help ensure that storm water runoff no longer directly enters the river, reducing the impact of this pollution source.

Roaring Fork at Slaughterhouse Br. (Aspen)

• Aluminum levels above chronic standards for aquatic biota in May of 2002 and 2003.
• These results may indicate that storm water retention ponds such as Jenny Adair and others around Aspen are unable to handle the higher volume of water during runoff.



• Jenny Adair is between the Mill Street and Slaughterhouse Bridge sampling sites and historically has high levels of aluminum. Data from other sample sites, including Mill Street and Castle Creek do not show high aluminum levels.

Snowmass Creek

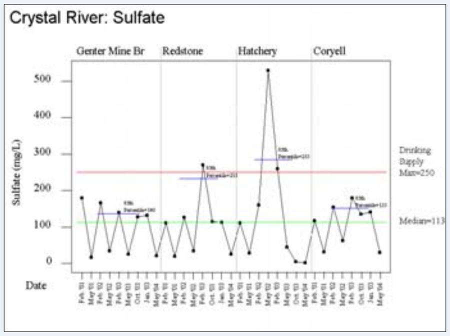
• Selenium and iron levels are above state standards on occasion.
• Macroinvertebrate data show water quality as 'excellent' with 'possible slight organic pollution.'

Capitol Creek

• Selenium and sulfate levels are above state standards on occasion.

Upper Crystal River (Redstone site)

• Redstone site shows pH spikes during drought years and has one occurrence of high sulfate levels in 2003.



Coal Creek

• On CDPHE watch list for suspended solids (sediment).

Lower Roaring Fork (Park East & Veltus Park)

• Selenium and total suspended solids standards exceeded on regular basis.
• Ammonia levels at Veltus Park site reach 300 µg/l, 15 times the state standard.

Data Results

10. Impacted Streams

Impacted stream reaches in the Roaring Fork Watershed have been identified by both the Conservancy and the State of Colorado. Impacted reaches typically have a combination of the following: 1) a number of pollutants above state standards, 2) a long history of pollution, 3) placement on state watch list, and 4) only 'good' or 'fair' FBI ratings for biological health. Fortunately, no streams in the watershed had a FBI rank lower than fair. Four impacted streams within the watershed are profiled in this section. Additional studies are being undertaken to more accurately assess their condition.

Crystal River

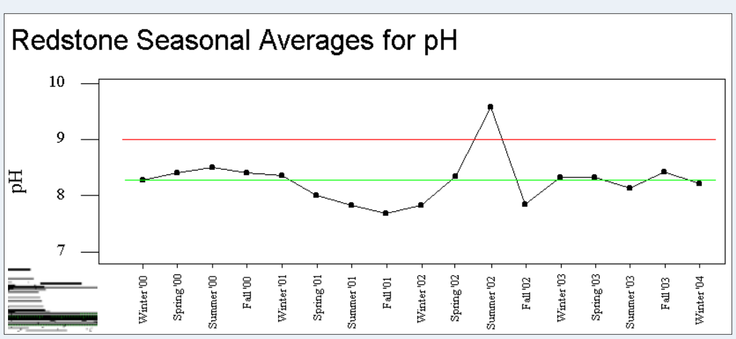
The Crystal River is classified by the Roaring Fork Conservancy as an impacted stream because in the 25 miles from the uppermost study site (Genter Mine Bridge) to the Fish Hatchery site, the water quality drops from excellent to impacted. Upper and middle reaches have high quality water with pH and sulfate-related concerns placing it on the Conservancy's Watch List.

Chemical concerns:

• Iron is of with levels as high as 15,192 µg/l above the Fish Hatchery (state standard is 1,000 µg/l).
• A seasonal spike of pH at the Redstone site.
• The Fish Hatchery site has shown levels above state standards for sulfates on two occasions.
• The Colorado Rocky Mountain School (CRMS) Bridge site shows aluminum spikes in the spring that exceed the state standards for aquatic life.
• Sulfate and aluminum, highest in the spring of 2003, are often associated with poor water treatment practices.

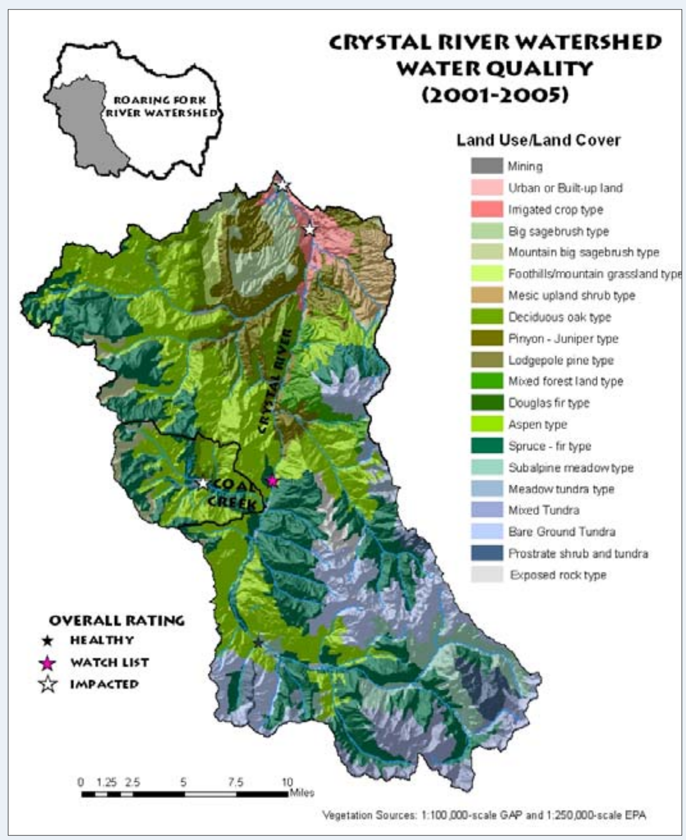
Biological Concerns:

• Macroinvertebrate data collected in 2001 near the confluence with the Roaring Fork River indicates an FBI rank of 'good' water quality with 'some organic pollution being likely.'



Physical Concerns:

• Stream flow results from the Conservancy's Stream Flow Survey project (Clarke, 2006) indicate that late summer flows in the lower Crystal are significantly lower than natural conditions and often did not meet the Colorado Water Conservation Board's in-stream flow amounts between 2000 and 2004.
• The entire reach is on a state monitoring and evaluation list for sediment.



Cattle Creek

Based on the chemical, physical, and biological data that was analyzed, the Conservancy has determined that Cattle Creek is one of the most impacted creeks in the Roaring Fork Watershed. As a result, two sites have been identified for future studies. With the addition of these sample sites, it will be possible to isolate the industrial, agricultural and residential pollution sources to determine where and why the stream is degraded.

Chemical Concerns:

• High selenium readings are above the state standard of 4.6 µg/l. Selenium is toxic to trout at levels of 5.0 µg/l.
• High manganese readings of 994.3 µg/l are well above the state standard of 50 µg/l for drinking water supply and 200 µg/l for agriculture.

Biological Concerns:

• Macroinvertebrate data indicates that 'fairly substantial organic pollution is likely' based on a 'fair' rating from the FBI.

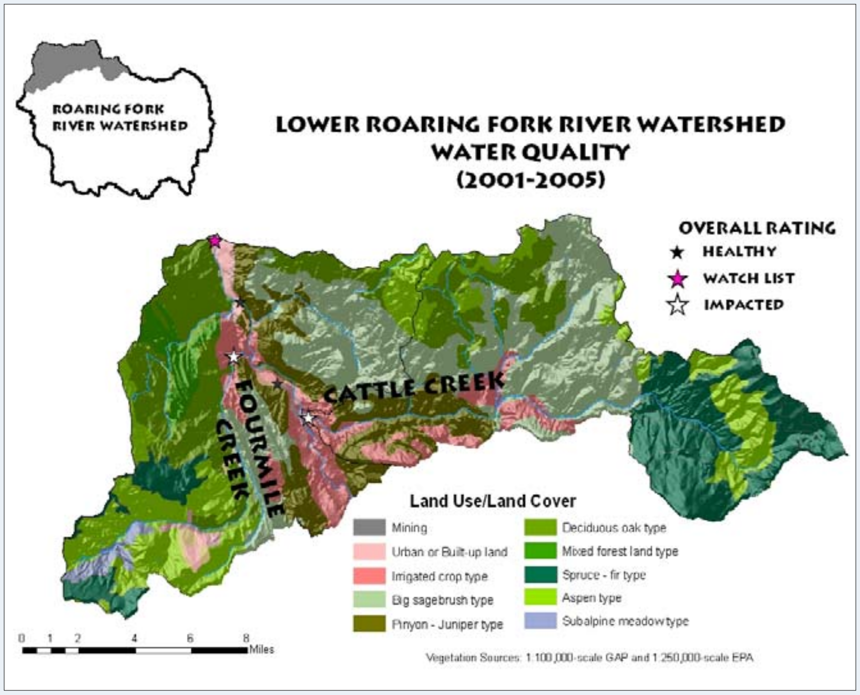
Physical Concerns:

• Low flow issues are a concern, particularly from April through October.
• High levels of suspended solids are present.
• Damage to or loss of riparian vegetation is found throughout much of the lower stream length.

Development, stream bank degradation, and over appropriated water are the major contributors to the stream's poor health. Improved land use planning, riparian protection and restoration, and elimination of large sediment input would improve stream health. The targeted study should help pinpoint the major causes for concern in Cattle Creek.

Fourmile Creek

Along with Cattle Creek, Fourmile Creek is one of the most impacted streams in the watershed. A number of state standards are exceeded and the macroinvertebrate data indicate only 'fair' water quality with substantial organic pollution likely. Only Cattle Creek and Fourmile share this low rank; in fact, these streams are alike and face similar pressures. The two creeks are roughly the same size, flow at comparable volumes, and flow through areas facing increased development pressure and water demands. Two additional study sites on Fourmile Creek have been added for 2006 to identify pollution sources and provide input for future developments and remediation projects. The new sites include a control site above most development and a site that will isolate water quality effects from Sunlight ski area (and future development in this area), and the residential developments along the creek. The hope is that this more in-depth monitoring will increase awareness of pollution-causing activities and lead to water quality improvement efforts on Fourmile Creek.



Impacted Streams (Cont.)

Chemical concerns:

• High selenium readings are above the state standard of 4.6 µg/l. Selenium is toxic to rainbow trout at levels of 5.0 µg/l.
• High manganese readings (173.8 µg/l) are above state standards of 50 µg/l for water supply and 200 µg/l for agriculture.
• Aluminum levels above the state standard of 750 µg/l for aquatic biota.

Biological concerns:

• FBI indicates only 'fair' water quality with fairly substantial organic pollution likely.

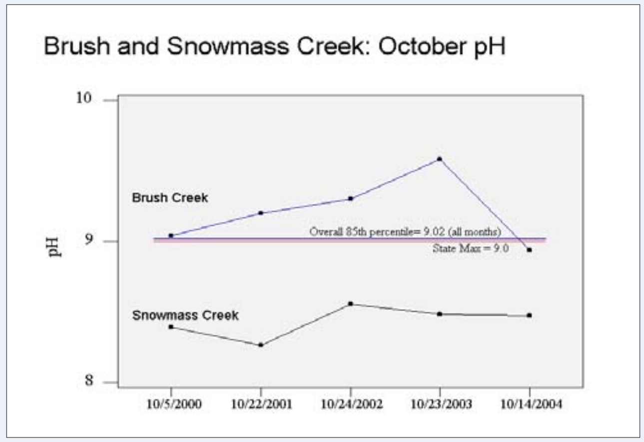
Physical concerns:

• Significant alteration of natural flows is seen from May through October.

Brush Creek

Several factors led the Conservancy to place Brush Creek on its impacted list. These concerns include:

consistently high pH and phosphorous levels, only a 'good' FBI rank indicating that organic pollution is probable, continued development, and the need to establish a water quality baseline for a Pitkin County Open Space and Trails parcel surrounding the creek. As a result additional monitoring sites have been added for 2005 and 2006. One site has been established above the agricultural zone (just below the golf course), and another has been added near the divide of Snowmass and Brush creeks.

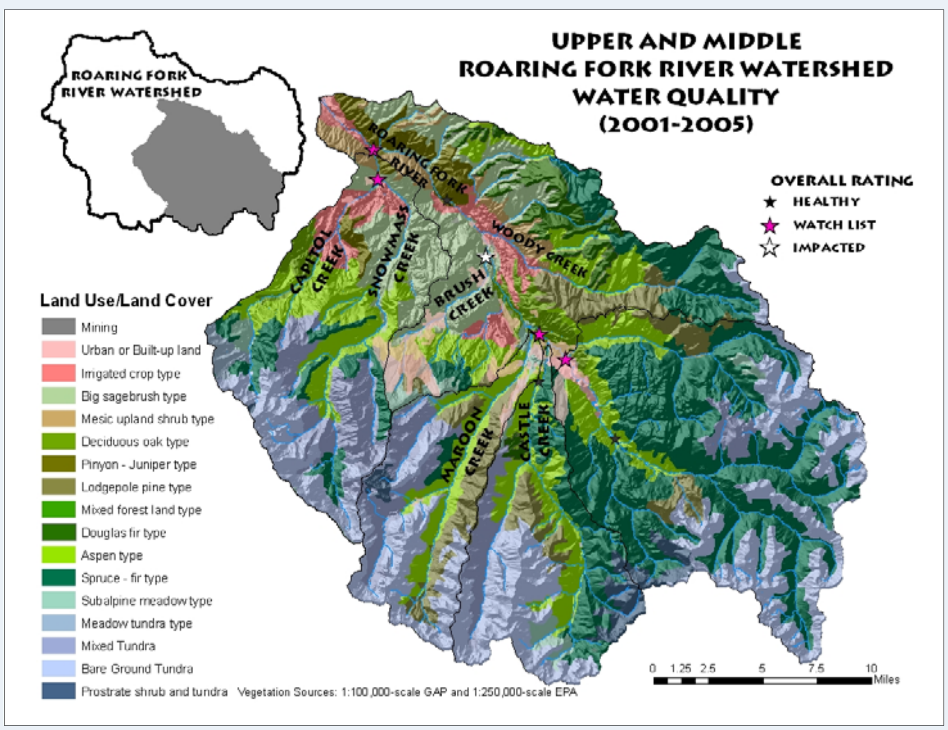


Chemical concerns:

• pH is above the state maximum of 9.0 every October, while sampling on Snowmass Creek to the west does not show these high numbers.
• Phosphorous: levels reach 1.1 mg/l (proposed standard is 0.1 mg/l); high amounts like this can decrease oxygen in water by contributing to algal blooms.

Biological concerns:

• FBI indicates 'good' water quality with some organic pollution probable. For comparison, Snowmass Creek, which does not have the large scale development seen on Brush Creek, has an FBI rating of 'excellent.'



11. What is Being Done

The following projects represent efforts to address watershed health and water quality issues.

Roaring Fork Conservancy

Stream Flow Survey Project: The overall project goal is to respond to in-stream flow issues and pursue approaches for achieving sustainable stream flows. This study compared modeled pre-development flows to developed flows within the watershed. Analysis contained in this report helps identify the watershed's most flow-altered stream segments. The project will assist in developing a strategy to improve overall stream health for aquatic life and recreation by maintaining or restoring stream flows.

Targeted Water Quality Study: Initiated by the Conservancy in the fall of 2005 on the most impacted streams: Fourmile Creek, Brush Creek, and the lower Crystal River. A study site on Thompson Creek was added to establish a baseline water quality inventory prior to potential gas and oil development.

Education and outreach programs: These Conservancy programs provide ongoing education for children and adults, emphasizing issues that affect the watershed, such as pollution and flow issues, riparian and aquatic ecology, and stream dynamics.

Roaring Fork Watershed Collaborative Water Group

In 2002, the Conservancy helped found the Roaring Fork Watershed Collaborative Water Group, comprised of entities with an interest in the health of the Roaring Fork Watershed. The Collaborative provides a forum for an ongoing dialogue and assembly of related work efforts to ensure that watershed protection efforts compliment each other, avoid duplication, and pool resources to complete major studies (www.roaringfork.org/collaborative).

U.S. Geological Survey

Roaring Fork Watershed Retrospective: The USGS is working with local partners, including the Conservancy, to collect and analyze all available water quality data for the watershed:
http://co.water.usgs.gov/cf/roaringforkcf/

Roaring Fork Biological Inventory of Plant and Wildlife Species

This inventory was originally conducted in 1999 by the Colorado Natural Heritage Program (CNHP) in cooperation with Pitkin County, Wilderness Workshop, and the Roaring Fork Audubon Society to assess which natural areas should be preserved in the valley. CNHP focuses on protecting species that are declining, rare, or threatened. Aspen Valley Land Trust recently updated this inventory on private lands.

The Nature Conservancy

Conservation Action Plan: The Action Plan is being conducted by The Nature Conservancy in support of its overall mission to conserve a set of places that will ensure long-term survival of all native life and natural communities.

Aspen Field Biology Lab

Stream Health Initiative: This project aims to document riparian and in-channel habitat conditions and create a baseline inventory to identify areas for restoration and protection opportunities.

Conservation Easements

Roaring Fork Conservancy, Aspen Valley Land Trust, The Nature Conservancy, and Pitkin County Open Space and Trails are working to protect open space along riparian corridors in the watershed.

Municipalities

The cities of Aspen and Glenwood Springs and the Town of Basalt have taken steps to improve their storm water runoff management and will continue to monitor and manage their runoff sources and entry points into the river.

Appendix

Monitoring Parameters

The chemical, physical, and biological parameters sampled by Roaring Fork Conservancy staff, volunteers, and schools are listed below. Information includes the significance and a brief description of each (CWN, 2005), and the Colorado Department of Public Health and Environment standards for stream health (CDPHE, 2005).

- **Metals analysis:** Cadmium, copper, lead, zinc, magnesium, iron, selenium, arsenic, aluminum, calcium, and manganese (total and dissolved metals for all stations).
- **Nutrient analysis:** Nitrate, phosphate, sulfate, chloride, ammonia, and total suspended solids are evaluated for nutrient concentrations.
- **Field parameters:** Temperature, pH, Total alkalinity as $CaCO_3$, total hardness as $CaCO_3$, and dissolved oxygen.
- **Physical assessment:** Flow, riparian and in-stream habitat assessments (e.g. bank stability, percent cover, substrate type and size), and river/stream reach assessments.
- **Biological conditions:** Macroinvertebrates are studied to evaluate the ability of water to support aquatic life.

Metals

Significance: Excess amounts of metals, especially in the dissolved form, can cause subtle impacts to aquatic life, from stunted growth to inability to reproduce and death.

Description: Most metals are found in trace amounts in rivers. The CDPHE has developed standards for acute (high short exposure resulting in death) and chronic (lower long term exposure resulting in slow death, disease, or inability to function in some capacity) water quality levels that cannot be exceeded for drinking water and biotic uses.

Nutrients

Significance:

- **Phosphorous:** High concentrations can lead to algal blooms that reduce the amount of dissolved oxygen in the water.
- **Sulfates:** When sulfur combined with metals reacts with oxygen in water, the pH of the water lowers (becomes acidic).
- **Ammonia:** Ammonia is a form of nitrogen combined with oxygen that in high concentrations inhibits ability of fish to excrete their own ammonia waste, causing brain damage.

Description: Nutrients are essential to all living organisms and include: nitrogen (nitrate, nitrite, and ammonia), phosphorus (phosphates), sulfur (sulfates), and chlorine (chloride).

State Standards:

- **Phosphorous:** currently no state standard
- **Sulfates:** Water supply standard is 250 mg/l.
- **Ammonia:** Aquatic biota standard is 20 µg/l.

Suspended solids

Significance: High levels of suspended solids can impair aquatic ecosystems by increasing the temperature of the water, abrading and clogging fish gills, and smothering plants, insects, and trout spawning beds.

Description: National average for suspended solids is 150 mg/l. Levels at the Mill Street water quality monitoring station in Aspen can reach 8,370 mg/l.

CDPHE State Metals Standards

Metal	Amounts (microgram/liter [ug/l])
Selenium*	4.6 µg/l (cab)
Aluminum*	750 µg/l (cab)
Manganese*	50 µg/l (ws); 200 µg/l (ag)
Lead*	50 µg/l (ws), 100 µg/l (ag)
Iron*	1,000 µg/l (cab); 300 µg/l (ws)
Arsenic	150 µg/l (cab); 50 µg/l (ws); 100 µg/l (ag)
Zinc	50-200 µg/l (cab)
Cadmium	1.4 µg/l (cab)
Copper	20 µg/l (cab)

cab = chronic aquatic biota ws = water supply ag = agriculture

Appendix

pH

Significance: pH affects what can live and reproduce successfully in a body of water. Most aquatic organisms prefer a pH range of 6.5-8.5.

Description: State standard of 5.0-9.0 for drinking water and 6.5-9.0 for aquatic biota. This is a measure of the acidity of water that varies on a scale from 0-14. Acids are found lower on the scale, a pH of 7 is considered neutral and above 7 is basic.

Hardness

Significance: Aquatic systems with hard water generally have more biological productivity, produce more biomass, and have greater species diversity. Hardness appears to protect fish from the affects of elevated metal concentrations.

Description: Hard water has more calcium, magnesium, and other cations. Water is softened by replacing calcium and magnesium ions with sodium and potassium ions.

Alkalinity

Significance: What is being measured is the ability of a body of water to withstand a change in pH when an acid (H^+) or base (OH^-) is added (buffering capacity). The higher the alkalinity the harder it is to adversely affect the pH of a stream. When fish are in high alkalinity waters, they can withstand higher concentrations of metals given equal water volumes.

Description: Balance of carbon dioxide in the river is measured by the amount of bicarbonates and carbonates present. When pH is 3-4 all of the carbon dioxide present is in the form of carbonic acid. Conversely, a pH of 11-12 indicates nearly all of the carbon dioxide is in the form of bicarbonate.

Temperature

Significance: Temperature affects the rate of many biological and chemical processes in the water and the amount of oxygen that is dissolved in the water. Additionally, different life stages and individual organisms have different temperature requirements.

Description: The state standard for cold water aquatic biota is a maximum of 20° C (68° F).

Dissolved Oxygen

Significance: Dissolved oxygen is necessary for all living things and many of the chemical processes that take place in water. Water with a consistently high level of dissolved oxygen will support a wider range of aquatic animals while declining O_2 levels will cause more sensitive animals to die or migrate.

Description: The amount of oxygen at the molecular level that is dissolved in the water. Water gains oxygen from the atmosphere, from photosynthesis of aquatic plants, and through the churning action of running water. Oxygen levels in the water vary with temperature, altitude, and depth.

Flow

Significance: Regular flow patterns and levels are important to sustaining aquatic ecosystem functions. Spring flushing flows replenish subsurface water sources, support riparian and flood plain vegetation, and help establish various types of fish habitat.

Description: Flow patterns in the valley are naturally highest in the spring when the snowpack melts and lowest in the fall and winter. Human impacts include diversions to the Front Range, impoundments such as Ruedi Reservoir, and diversions for agriculture and municipal/industrial uses in the valley.

Macroinvertebrates

Significance: Because both pollution-sensitive and pollution-tolerant forms of macroinvertebrates are present in 'clean' water, it is the absence of the former coupled with the presence of the latter which may indicate damage. This is the basis of the Family Biotic Index.

Description: Macroinvertebrates are animals that have no internal skeleton of cartilage or bone, and are large enough to see without magnification. In freshwater environments, these animals make up over 96 percent of known species (CWN, 2005), are the primary food for fish and other riparian animals, and are responsible for the breakdown of organic material and nutrients.

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Maps: Sharon Clarke/Roaring Fork Conservancy

Photos: Cover: Spring runoff on the Crystal River by Tim O'Keefe; page 2: Hunter Creek by Tim O'Keefe; page 3: Kayaker on the Roaring Fork River by Miah Wheeler, Maroon Lake by Eliza Hotchkiss; page 4: volunteer monitor Lina Polvi by Rick Lofaro, Carbondale Middle School students by Rick Lofaro; page 5: stonefly nymph; page 6: Glenwood Spring High School river watch student by Tim O'Keefe; page 7: drinking water, lawn irrigation, angler by Rick Lofaro, chicks by Robin Henry, American dipper by Robin Henry, rafting the Roaring Fork River by Rick Lofaro; page 8: river photos by Tim O'Keefe; page 9: storm water drain; page 11: Maroon Creek by Eliza Hotchkiss, Carbondale from the air by Jeanne Beaudry, oxeye daisy, tamarisk; page 12: trout affected by whirling disease by Tim O'Keefe, New Zealand Mudsnails courtesy the Colorado Division of Wildlife, gas rig in western Colorado; page 14: the Crystal River and Chair Mountain from Filoha Meadows Open Space by Tim O'Keefe; page 15: Cattle Creek by Tim O'Keefe, Fourmile Creek by Tim O'Keefe; page 16: Brush Creek looking toward Snowmass Ski Area by Tim O'Keefe; page 17: low flows on the Roaring Fork River in Aspen in 2002 by Rick Lofaro; page 18: Rick Lofaro and River Watch students by Wendy Boland; page 19: Osprey by Jonathan Lowsky; page 20: Leigh Gillette collecting macroinvertebrates by Carlyle Kyzer.

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