Colorado Coldwater Fish
Stream Habitat

General Information:
Coldwater streams as discussed in this Technical Note refer to streams that maintain temperatures of 70 degrees Fahrenheit or less for most of the year. Most coldwater streams in Colorado are located at high elevation or are spring fed by cold ground water. Dissolved oxygen levels are usually higher than in warmer streams. The combination of cold temperatures and high oxygen levels, make many of these streams suitable habitat for trout.

A number of factors work together to make a coldwater stream either suited or not suited as trout habitat. Aquatic ecosystems are like terrestrial ecosystems in that they must provide food, shelter, and other life requisites for the species living there. A limiting factor may restrict the number or species of fish found in a stream. Oftentimes limiting factors for trout in coldwater streams are food production, shelter, and/or spawning habitat (Hooper 1973). If a coldwater fishery is the goal, the NRCS planner should evaluate stream habitat in relation to the life requisites described below then make recommendations that address any missing or deficient elements.

Water Quality:
Water quality may be a limiting factor for trout in streams. Trout are cold water fish species and as such, have specific water quality requirements that must be met in order to survive and to reproduce. In Colorado, our State water quality standards for cold water aquatic life are as follows:

Dissolved Oxygen:	6 mg/L
Dissolved Oxygen (spawning):	7 mg/L
pH	6.5-9.0
NH_3 (chronic)	0.02 mg/L
NO_2	0.05 mg/l
NO_3	10 mg/L

Standards for individual stream segments may be found on the Colorado Department of Health web page at: http://www.cdphe.state.co.us/op/waterqualitycontcommregs.asp

Streams with temperatures frequently exceeding 70 degrees Fahrenheit are not suited to trout. Warm water generally contains less dissolved oxygen than cold water and trout have trouble using oxygen in water when temperatures are above 70 degrees, even if oxygen levels are high. Brown and rainbow trout can tolerate slightly warmer temperatures than brook and cutthroat trout. Temperatures ranging from 37-55 degrees Fahrenheit are desirable for spawning, 42-54 degrees for incubation, and 55-66 degrees for growth (Hooper 1973).

Excess nutrients such as nitrates and phosphorus in a stream drive algal growth and photosynthesis which, in turn, affects oxygen and carbon levels and pH fluctuations. The pH of a water body affects the species of ammonium/ammonia found there with the more toxic forms at high pH.

Sediment may cause water quality problems by covering spawning gravels, reducing places for the fry to hide, smothering invertebrate food sources, and interfering with the gills and respiration.

Heavy metals are another possible limiting factor found in Colorado. Some indicators of metals pollution are mining history, low pH, and local knowledge of metals problems. Remediation of metals problems is often expensive and usually requires teams of specialists. NRCS planners suspecting a metals problem should refer the landowner to a qualified remediation expert.

Improving water quality:
Temperature control is usually achieved by encouraging or planting native trees that will shade the water. On very narrow streams, overhanging herbaceous vegetation may help with shading and temperature control. Temperature control will also contribute to high dissolved oxygen levels. Aeration, such as running water over rocks and riffles, will also help increase dissolved oxygen levels.

Nutrient and sediment levels in streams may be improved by controlling water erosion in the drainage area and the riparian area. Planting and managing native plant species in the upland drainage area and in riparian buffers will filter pollutants before they reach the water. Livestock exclusion may be needed to achieve the proper level of protection for riparian plants. Streambank stabilization measures may be needed to control sloughing of banks. A number of good reference materials are available explaining bank stabilization techniques. Recommended references include: NRCS Standard 395, Stream Habitat Improvement and Management; NRCS Standard 580, Streambank and Shoreline Protection; NRCS's National Engineering Handbook, Chapters 16 and 18 (Streambank and Shoreline Protection and Soil Bioengineering for Upland Slope Protection and Erosion Reduction); and The Practical Streambank Bioengineering Guide (USDA-NRCS Plant Materials Center, Aberdeen, ID, http://www.nhq.nrcs.usda.gov/BCS/PMC/pubs/IDPMCpubs-sbg.html).

Physical habitat:
Physical habitat that provides places for feeding, hiding, resting, and spawning is another important consideration when looking at trout habitat. An assessment of the following habitat components/conditions can help reveal limiting factors to self-sustaining trout populations.

Spawning: Colorado's trout species migrate upstream to spawn in gravel. Ideal gravel sizes range from 1/4 to 2 inches in diameter although a range of sizes from pea gravel to 3 inch diameter is usable. Water depths from 6 inches to 3 feet are used and velocities ranging from 1/2 to 3 feet per second are desirable (Hooper 1973). The lower ends of pools seem to be the preferred locations for redds. Colorado trout species generally do not spawn in lakes.

Water flows, sedimentation, and gravel permeability are important factors that affect egg survival. The volume and velocity of flowing water are important factors influencing permeability of the gravel. Flowing water brings dissolved oxygen to the eggs, removes wastes, and transports fine sediment away from the eggs. Exposed gravels, even if just for a part of the year, tend to be less permeable than gravel that is continuously under water.

Improving Spawning Habitat:
Artificial gravel beds may be created to encourage spawning. Before installing artificial spawning beds, the planner must evaluate the likelihood of their success in a given location. Potential barriers to successful use include low velocities, low water levels, and/or high levels of sedimentation. Consult your Area Engineer or Biologist for help with designs and installation.

Culverts are another potential barrier to successful spawning. When installing culverts, consult your Area or State Biologist for design assistance to insure the culvert isn't creating a migration barrier for fish. Biology Technical Note #29 provides a brief overview of important points to consider when installing culverts.

Food: Aquatic insects and their larval stages comprise the bulk of the diets of trout species. When temperatures reach 50-55 degrees Fahrenheit, trout begin feeding. At temperatures above 65 degrees, feeding slacks off. Optimum feeding temperatures range from 60-63 degrees Fahrenheit (REI 2000). When water temperatures reach 45 degrees Fahrenheit and lower, trout tend to stop feeding almost completely.

Good places for trout to feed are riffles, around logs, behind rocks, or at seams (water moving at different speeds). These areas tend to have higher invertebrate populations than in the pools where fish like to rest. The fish will rest at the edge of the slower water, waiting for the faster water to bring the food to them. Overhanging vegetation often contributes terrestrial insects (grasshoppers, beetles, etc.) to a stream ecosystem.

Food sources may be improved by increasing habitat for macroinvertebrates. Maintaining or improving instream substrates where insects might attach (logs, rocks, plant materials), increasing the amount of overhanging vegetation which will provide terrestrial insects as a food source, and improving input of plant material from the watershed will help increase foods. Controlling the amount of sediment in the water will prevent burial of insect eggs and larvae, thus improving food supplies.

Cover/Resting Areas: Resting areas tend to be where water current is slow such as behind rocks, in pools, or in areas of slow water velocity (between 0.3 and 1.0 feet per second). During winter fish spend more time near the bottom of deep pools, eating very little, and spending little energy. Hooper (1973) says brook trout spend 70 percent of their time on the bottom, brown trout 80 percent, wild rainbows 65 percent, compared with hatchery trout that spend 65 percent of their time at mid-depths.

Riffle:Pool ratio: The general rule of thumb is to try for a 1:1 ratio of riffles:pools, however, this number may not be the best for all stream types or for all trout species. The geomorphology of the stream must be considered when optimizing riffle:pool ratios. Rosgen (1996) recommends spacing of riffles and pools in alluvial channels at one-half a meander wavelength when re-engineering stream morphology. This equates to 5-7 bankful widths. Rosgen (1996) and Ward and Kondratieff (1992).

Improving Cover, Resting Areas, and Riffle:Pool Ratios:
Boulders and logs may be used to provide cover and resting areas. Before installing any of these types of instream structures or alterations, consult with a trained fluvial

geomorphologist. It is possible to do more harm than good if instream practices are installed improperly. In extreme cases, it may be beneficial to re-engineer the stream course to achieve the sinuosity, width/depth ratio, meander length, pools, riffles, and other morphologic chartacteristics desired. This should only be attempted by someone trained in fluvial geomorphology techniques.

Elevation: Trout species tend to distribute along an altitudinal gradient in headwater streams with rainbow and brown trout at lower elevations and brook trout and cutthroat at higher elevations (Raleigh, Zuckerman, and Nelson. 1986). Brown trout in particular show an abrupt altitudinal limitation, thought to be caused by the changes in water temperature from one elevation to another (Vincent and Miller. 1969).

Trout Species:

Cutthroat trout (*Oncorhynchus clarki):* Colorado has three native subspecies of cutthroats: Greenback, Colorado River, and Rio Grande. In addition, other subspecies have been stocked extensively throughout the state. Cutthroats have black spots on their tails, backs, and dorsal and adipose fins. They exhibit the characteristic throat slashes under their jaws. Cutthroat numbers have declined because of land use changes, habitat alterations, and from competition with other, non-native trout species. Hybridization with rainbow trout combined with competition for food and space with the more aggressive brown and brook trout contributed to the decline of cutthroats.

Greenbacks are found east of the Continental Divide in the Arkansas and South Platte River headwaters. It has fewer, but larger spots than the Colorado River cutthroat (CDNR 2000).

Rio Grande cutthroats were originally found in the upper Rio Grande River in Colorado. Rio Grandes have a yellowish-green to grayish-brown body with black spots. The fins are also spotted and the number of spots increases at the tail end.

Colorado River cutthroats were found in all cold-water segments of the Colorado River basin at one time. Today, they are primarily limited to headwater steams.

Ideal cutthroat habitat will have clear, cold water; less than 10% fine sediments in riffles; a 1:1 pool:riffle ratio; well vegetated, stable stream banks; plenty of instream cover; and stable water flow. Cover, in the forms of overhanging vegetation, undercut banks, submerged vegetation, deep pools, surface turbulence, and instream objects (rocks, debris piles, logs) is an essential component of good trout habitat. For adults, optimal habitat will include at least 25% of the total stream area in cover. This number is 15% for juveniles (Hickman and Raleigh 1982).

Cutthroats eat terrestrial insects, aquatic invertebrates, zooplankton, and crustaceans. As the fish grow, they add small fish to their diets.

Optimal water quality for adult cutthroats consists of dissolved oxygen levels of at least 7 mg/liter, water colder than 59 degrees Fahrenheit (15 degrees Celsius), and turbidity below 35 ppm (Hickman and Raleigh 1982).

Spawning is from April to early July at water temperatures of 45-55 degrees Fahrenheit (53 is considered optimum), 0.25-3.0 inch gravel, and 1.0-3.0 feet per second flow rate (Hooper 1973).

Rainbow trout (*Salmo gairdneri*): Rainbow trout are usually greenish on their backs and have a reddish band running the length of their body along their sides. Their spots are smaller than the spots on a brown trout, and extend into the tail and dorsal fin. Raleigh, et. al. (1984) describe optimal rainbow trout riverine habitat as "clear, cold water; a silt-free, rocky substrate in riffle-run areas; an approximately 1:1 pool:riffle ratio with areas of slow, deep water; well-vegetated stream banks; abundant instream cover; and a relatively stable water flow, temperature regimes, and stream banks."

Lethal temperatures for adult rainbow trout are 32 degrees Fahrenheit on the lower end and about 75 degrees Fahrenheit on the upper end. The upper temperature (75 degrees) should not be exceeded for long periods of time. Optimal temperatures are from 55-60 degrees Fahrenheit.

Spawning occurs from February through May, depending on elevation, when water temperatures are between 45 and 56 degrees Fahrenheit (52 is optimum). Gravels from 0.25 to 1.5 inches in diameter are preferred although sizes up to 3.0 inches are used. Preferred flow velocity is 2.0 feet per second with a range from 1.4-2.7 being suitable (Hooper 1973). The female usually lays 1,000-4,000 eggs in the 4-12 inch deep redd. Time of incubation varies with water temperature. The young hatch and the fry absorb the yolk sac over a period of a few weeks. At this point they leave the gravel and seek cover in rocks, woody debris, undercuts, and other areas that provide cover. Plankton is the main food source for this life stage. Preferred adult rainbow trout foods include aquatic and terrestrial insects and larval stages of these insects, small fish, fish eggs, zooplankton, and crustaceans.

Brown trout *(Salmo trutta):* Brown trout are usually green to brown on the back and have black, brown, or red spots surrounded by lighter rings. The spots are found on the dorsal fin, but not on the tail or the belly. The tail is slightly forked. The most prevalent factor limiting distribution of brown trout adults is water temperature. The upper limiting lethal temperature is 27 degrees Celsius (81 degrees Fahrenheit). Ideal temperatures for growth are 12-19 degrees Celsius (54-66 degrees Fahrenheit).

The lethal dissolved oxygen level is around 3 mg/L, however most trout will avoid streams with concentrations less than 5 mg/L. The State water Quality Standard of 6 mg/L (7 mg/L during spawning) is the minimum level to target in planning.

Brown trout may be found in waters with a pH ranging from 5.0 to 9.5, with optimal growth between 6.8 and 7.8.

Fall spawning migrations begin when water temperatures are 43-55 degrees Fahrenheit (44-48 is optimum). This is usually from October to late November. Preferred gravel size for spawning is 0.25-1.5 inches diameter although sizes up to 3.0 inches are useable. Flow rates of 1.3-1.7 feet per second are ideal with 1.0-3.0 being suitable (Hooper 1973).

Water depth preferred for spawning ranges from 9.5-18 in. although anything from 5-36 in. is probably useable. Water velocities from 1.3-2.3 ft/sec are ideal, but 0.5 to 3 ft/sec are tolerated.

Embryo development is optimized between 36 and 55 degrees Fahrenheit (2-13 Degrees Celsius). Time needed to go from fertilization to hatching were 148 days at 36 degrees Fahrenheit (1.9 degrees Celsius), 34 days at 52 degrees Fahrenheit (11.2 degrees Celsius), and 30-33 days at 57 degrees Fahrenheit (13.9 degrees Celsius**)**. Sedimentation affects embryo development and hatching success by reducing gravel permeability, water flows, and dissolved oxygen that reaches the embryos.

Raleigh, et. al. (1986) describe optimal brown trout riverine habitat as "clear, cool to cold water, a relatively silt-free rocky substrate in riffle-run areas, a 50%-70% pool to 50%-30% riffle-run habitat combination with areas of slow, deep water, well vegetated stable stream banks, abundant instream cover, and relatively stable annual water flow and temperature regimes. Brown trout tend to occupy the lower reaches of low to moderate gradient areas in suitable, high gradient river systems."

Brook trout (*Salvelinus fontinalis*): Brook trout are native to the eastern states, but were successfully introduced in Colorado in 1872. They are often found in montane pools or beaver ponds on clear, cold streams. Streams with summer temperatures of 50 to 66 degrees Fahrenheit provide the good brook trout habitat. Water temperatures above 75 degrees may be lethal to brook trout (Needham 1969). Brook trout are identified by the white front edge of the ventral (bottom) fins and the vermiculations or worm-like markings on their backs.

This species spawns in the fall, from September to December, laying up to 5000 eggs in coarse sand to 3.0 inch diameter gravel. Optimum spawning temperature is 52 degrees Fahrenheit with a range of 45-56 being adequate. Velocities from 1.4-2.7 feet per second are suited to spawning with 2.0 fps being optimum (Hooper 1973). It takes 90 days for eggs to hatch in 40 degree water and about 45 days in 50 degree water. The fry remain in stream gravel while they absorb the yolk sac. Once water temperatures warm in the spring, the fry begin feeding on small insects. Larger brook trout may supplement their diets with crayfish, snails, scuds, small fish, and small terrestrial animals such as mice and snakes.

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