Elk Creek Fish Habitat Evaluation
Prepared for the Environmental Protection Agency (EPA)

by

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Introduction

The Standard Mine near Crested Butte, CO has severely impacted the water quality of Elk Creek, which is a small headwater tributary to Coal Creek. The Elk Creek watershed is mixed ownership with federal lands managed by the Gunnison Ranger District of the Grand Mesa, Uncompahgre, and Gunnison National Forests (GMUG) (Figure 1). Superfund restoration efforts in 2007 have focused on reducing heavy metal pollution to the creek. In conjunction with the cleanup effort, EPA has been monitoring water quality in Elk Creek and adjacent drainages through multiple lines of evidence: hazard quotients, water and sediment toxicity tests, fisheries cage studies, and benthic macroinvertebrate samples. The Colorado Division of Wildlife (CDOW) has conducted fish sampling in Elk Creek, and found brook trout are present in the lower 200-300 feet upstream from its confluence with Coal Creek (Brauch 2008). Upper reaches above this point are currently fishless.

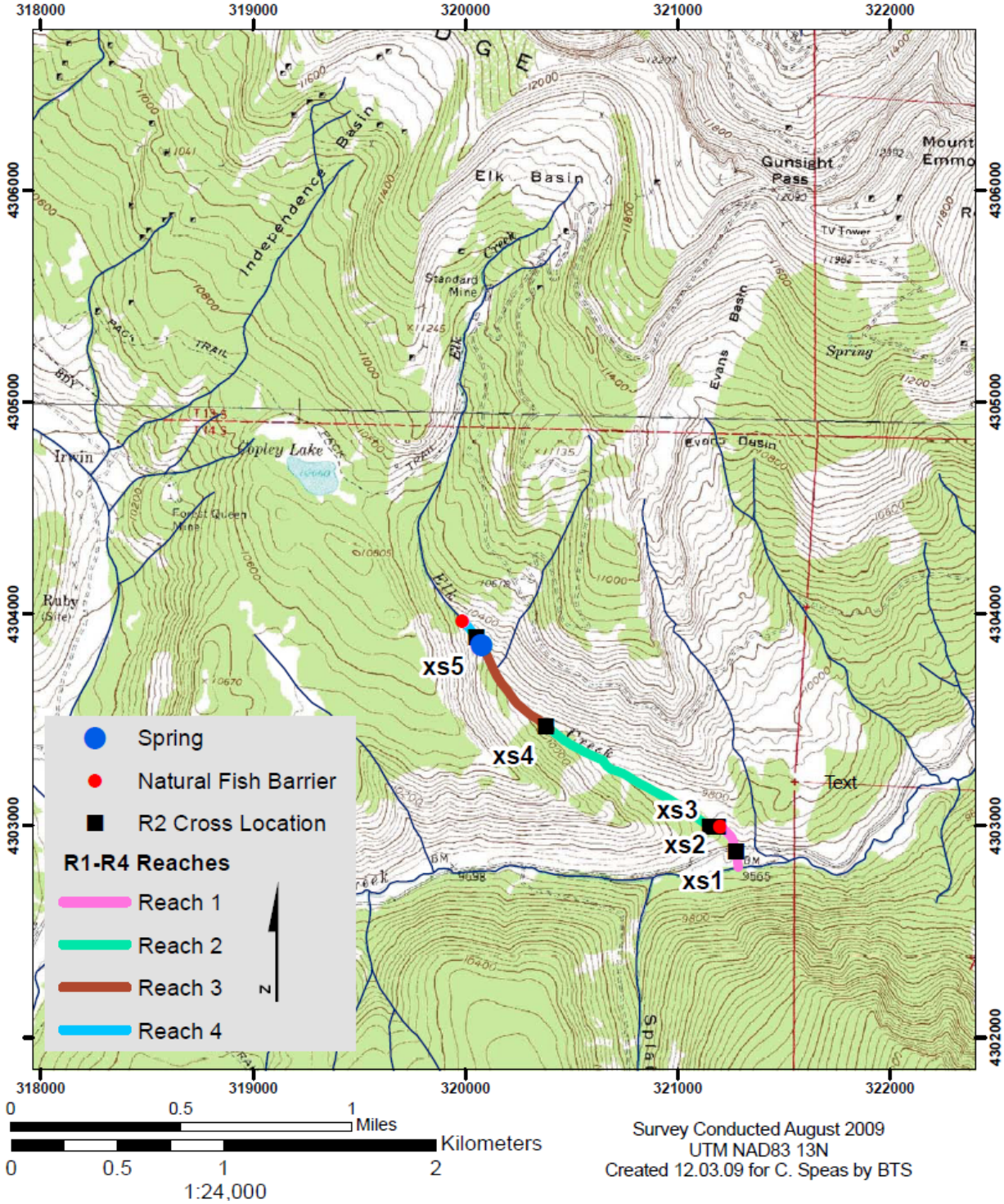
The purpose of this report is to assess the quantity and quality of aquatic habitat on Elk Creek to determine how suitable the stream is to support a trout population. The report assumes water quality is suitable (dissolved oxygen, heavy metal levels, etc.) to support a fish population.

Methods and Sampling Design

Field surveys of Elk Creek were conducted on August 5-7, 2009 by biologists from the GMUG Nationals Forests. The R1/R4 Fish and Fish Habitat Standard Inventory Procedures were used to assess suitability of Elk Creek to support a cold water fishery (Overton et. al. 1997). Habitat data was entered into the Forest Service Natural Resource Inventory System (NRIS) for analysis. Stream flows were assessed using the R2 Cross (Nehring 1979). Cross sectional data were analyzed using WinXSPRO Channel Cross Section Analyzer (WinXS Pro 2005).

Habitat data collected from Elk Creek was compared to a core set of habitat variables collected from over 62 miles of stream from 224 reaches on the Forest. Data was collected from 2001-2007 using the Stream Condition Inventory (SCI) (Frazier et al 2005), R1/R4 fish habitat inventory (R1/R4) (Overton et al 1997), and Pacfish Infish Biological Opinion (PIBO) (Heitke et al 2006). These data represent the best available information of current habitat conditions supporting trout populations (brook and cutthroat trout) on the Forest.

Elk Creek Aquatic Survey
Figure 1



Thermographs were deployed within reach 1 by Colorado Division of Wildlife (CDOW) personnel and recorded continuous temperatures for the months of July and August 2009. Data are summarized as average daily temperature.

Results

Approximately 1.13 miles of Elk Creek were inventoried in 4 discrete stream reaches (Figure 1). Stream reaches were based on Rosgen channel types or changes in discharge from inputs from tributaries or springs. Reaches were first delineated on 1:24,000 quads in the office and validated in the field. Reach breaks were recorded using Global Positioning Systems (GPS). Key habitat and streamflow variables are presented in Table 1 and 2 for all inventoried reaches. A summary of habitat, streamflow and pebble count data are provided below.

Table 1. Comparison of selected habitat variables from reference streams to the same habitat variables on Elk Creek, GMUG National Forests.

Reaches	Stream Gradient	Water Tempt. ^{O} F	Spawning Substrate (3-50mm) (%)	Pool Density (Per mile)	Residual Pool Depth (ft)	Large Wood (pieces/mi)	Boulder (%)	Bank Stability (%)	Under Cut banks (%)
Reference	1-7%	52-61	>25%	60	1.1	208	>25	>80	30
Elk Cr. 1	6-15%	42-52	27	72	1.0	129	27	>95	4
Elk Cr. 2	7-9%	42-52	39	75	.86	667	17	>95	5
Elk Cr. 3	8-10%	42-52	32	83	1.1	2150	17	>95	5
Elk Cr. 4	15%	54	NA	NA	NA	NA	NA	NA	NA

Table 2. Comparison of measured and modeled stream flow at 5 cross sections on Elk Creek, GMUG National Forests.

Cross-section Number	Manning's N	Base flow discharge (cfs)	Base flow velocity (ft/sec)	Modeled bankful discharge (cfs)	Modeled bankful velocity (ft/sec)
1	0.026	0.79	0.62	3.73	4.88
2	0.185	1.09	1.28	10.90	1.86
3	0.27	0.92	0.59	5.80	1.07
4	0.27	0.87	0.95	3.26	1.07
5	0.093	0.50	0.57	7.71	3.04

Reach 1

Habitat

Reach 1 extends from the confluence of Coal Creek upstream 0.15 miles (820 feet). Gradient at cross section 1 is 6.5 percent and at cross section 2, 15%. The upper section of reach 1 transitions into a steep (15% slope) incised canyon composed of chutes and two waterfalls, each approximately 4 feet high. Average wetted width is 8.1 feet with a mean depth of 0.7 feet. Of the 0.15 miles of stream, 39 percent of the length is composed of fast water riffles, 27 percent cascades and 44 percent is a combination of pool types including pocket pools, mid channel

scour pools, and lateral scour pools. Pools are primarily formed by boulders and large wood. Residual pool depth is 1.01 feet.

Streamflow

Cross sections 1 and 2 fall within reach 1 (Figure 1). Gradient through the reach ranges from 6% at cross section 1 to 15% at cross section 2. Measured base flow at cross section 1 and 2 was 0.79 cfs (velocity 0.62 ft/sec) and 1.09 cfs (velocity 1.28 ft/sec) respectively. Since both cross sections were completed the same day and the weather was clear, Elk Creek appears to lose approximately 0.3 cfs over a 300-400 foot section of stream. Modeled bankful discharge is 3.73 cfs and 10.9 cfs at cross sections 1 and 2 respectively. Cross section 2 was placed in a steep (15%+) chute which may explain the higher modeled bankful discharge.

Pebble count

The D84 at cross section 1 is 8.2 inches which means 84% of the particles in the cross-section have a mean diameter equal to or smaller than 8.2 inches. The lower section of reach 1 with a gradient of 6.5% and a D84 of 8.2 inches is an A3 channel type (Rosgen 1996).

Cross section 2 is located near the end of reach 1, in s steep chute. The D84 at cross section 2 is 8.3 inches. Stream gradient at cross section 2 is 15%. While the stream is considerably steeper at this location, the reach still classifies as an A3 channel type.

Photo 1. Beginning or reach 1 immediately upstream of confluence with Coal Creek.

Photo 2 – First of two waterfalls 4 foot high on upper end of reach 1.

Reach 2

Habitat

Reach 2 extends from the terminus of reach 1 upstream 0.56 miles (2958 feet). Gradient through the reach averages 7-8 percent and is classified as a Rosgen A4 channel type with short section of B3 channel type. Average wetted width is 7.9 feet with a mean depth of 0.63 feet. Of the 0.56 miles of stream, 63 percent of the length is composed of fast water riffles, 9 percent slow riffles and 28 percent is a combination of pool types including pocket pools, mid channel scour pools, lateral scour pools and plunge pools. Pools are primarily formed by boulders and large wood. Residual pool depth is 0.86 feet.

Streamflow

Cross section 3 is at the beginning of reach 2 (Figure 1). Stream gradient at the cross section is 8.5 percent. Measured base flow at cross section 3 is 0.92 cfs and an average velocity of 0.59. Modeled bankful discharge is 5.80 cfs with a modeled velocity of 1.07 ft/sec.

Pebble count

The D84 at cross section 3 is 5.7 inches. With a stream gradient of 8.5 percent and a D84 of 5.7 inches this section of the reach types out as an A4 channel type.

Photo 3 – Beginning of reach 2

Reach 3

Habitat

Reach 3 extends from the terminus of reach 2 upstream 0.33 miles (1715 feet). At the terminus of reach 3, a large spring enters Elk Creek from the north nearly doubling the streamflow in Elk Creek. Gradient through the reach averages 8-10 percent and is classified as a Rosgen A4 channel type. Average wetted width is 8.1 feet with a mean depth of 0.6 feet. Of the 0.33 miles of stream, 33 percent of the length is composed of fast water riffles, 30 percent cascades and 37 percent is a combination of pool types including pocket pools, mid channel scour pools, lateral scour pools and plunge pools. Pools are primarily formed by boulders and large wood. Residual pool depth is 1.07 feet.

Streamflow

Cross section 4 is at the beginning of reach 3 (Figure 1). Stream gradient at the cross section is 9.8 percent. Measured base flow at cross section 4 is 0.87 cfs and an average velocity of 0.95 ft/sec. Modeled bankful discharge is 3.26 cfs with a modeled velocity of 1.07 ft/sec.

Pebble count

The D84 at cross section 4 is 5.2 inches. With a stream gradient of 9.8 percent and a D84 of 5.2 inches this section of the reach types out as an A4 channel type.

Photo 5 – near beginning of reach 3

Reach 4

Because of the lack of water and steep gradient only 475 feet of reach 4 was inventoried. The inventory ended at a 6 foot high water fall (Photo 6). Cross-section 5 is located at the beginning or reach 5. Stream gradient at the cross section is 16% and increases upstream turning into a series of chutes and 2-6+ foot waterfalls. The D84 at cross section 5 is 6.4 inches. The gradient and D84 make this section of Elk Creek an A3/A4 channel type. Base measures flow at cross section 5 drops to 0.5 cfs. Immediately below cross section 5 a large spring enters the channel from the North nearly doubling the flow (0.5 cfs to 0.87 cfs).

Due to the lack of flow, steep gradient and the lack of fish habitat and presence of fish barriers, reach 4 is not considered suitable trout habitat and will not be evaluated further.

Photo 6 – Six foot high barrier at the end of reach 4.

Discussion

Brook Trout Evaluation

Elk Creek data are examined to determine the streams ability to support a brook trout population. Selected habitat values from Elk Creek are compared to literature values and streams of similar size on the Forest known to support trout populations. Data from approximately 224 stream reaches of similar size to Elk Creek (<20 feet wetted width) were used to establish reference conditions for comparison to Elk Creek (Table 1). Fish population estimates from reference streams range from 9 to over 700 fish per mile.

Elk Creek has an average wetted width of approximately 8-9 feet which is on the lower end of the range of inventoried streams. Elk Creek tends to be steeper than most inventoried stream on the Forest with portions of reach 1 and reach 4 composed of steep cascades and waterfalls. The steep chute with two 4 foot waterfalls at the top of reach 1 400-600 feet above Kebler Pass Road acts as a barrier preventing upstream migration of fish into upper reaches of Elk Creek.

Selected habitat variables from reaches 1-3 are compared to the same variables in reference streams (Table 1). Water temperatures on Elk Creek are generally lower than reference streams. Water temperatures between 52 degrees and 61 degrees are optimal for growth and survival of brook trout (Fish and Wildlife Service 1982). Water temperatures were taken in the morning, around noon and late afternoon and ranged from 42-52 degrees F. Thermograph data collected from July 1 until the end of August showed an average daily temperature of 45 degress F. Low water temperatures are probably limiting both growth and survival of brook trout in currently occupied sections of Elk Creek and would limit brook trout populations in upper reaches of Elk Creek if it were occupied.

Substrate between 3mm and 50 mm is optimal size for brook trout spawning habitat (Reiser and Wesche 1977). Pebble count data from 5 locations on Elk Creek (Figure 1) indicate substrate of this size makes up over 25 percent of reaches 1-3. The greater than 25 percent figure is in line with reference reaches. The data suggests suitable sized spawning substrate is available randomly throughout inventoried reaches. Brook trout have been found to utilize small areas (<1.0yd^2) as long as suitable size substrate exists (James 2001). Spawning areas with suitable size substrate are at or above reference conditions and therefore adequate to support reproduction in reaches 1-3.

Pool density and depth play an important role in the survival of trout species, particularly during low flow periods (Meehan 1991). Pools comprise the majority of fish habitat in small streams and pool depth appears to be one of the primary factors influencing abundance and size of trout (USFS 1994). Pools per mile are at or above reference reaches on inventoried reaches. High quality pools range from a depth of 3 – 6 feet in depth (USFS 1994, Raleigh et al. 1986). Pools greater than 3 feet deep occur on less than 1% of all reaches (n=224) inventoried on the Forest. On reference streams, residual pool depth ranges from 0.07 ft to 5.25 ft, with an average of 1.1 ft (Adams et al. 2008). The lack of high quality pools limits trout survival, particularly during low flow periods in late summer and during the winter months. However many streams on the Forest do not have the potential to produce high quality pools due to watershed size, geomorphology and water production. Even though pool depth is not optimal, residual pool depth on Elk Creek are identical to reference streams and therefore are of sufficient depth and quality to support trout populations.

Cover is an important feature for survival of trout, including brook trout. Large woody debris (LWD), boulders, and undercut banks are critical components of good trout habitat (Bjornn and Reiser 1991, Raleigh et al. 1986). Reference reaches range from 0 to 1,400 pieces per mile. The average is 208 pieces per mile. Large wood in Elk Creek is abundant with 2 out of 3 reaches exceeding reference conditions. Large wood in Elk Creek is an excellent source of cover and therefore does not appear to be limiting trout populations.

Large wood has also been documented to create velocity breaks for fish during high water events on steep mountain streams (Wesche 1974). Predicted water velocities at bankful flow on Elk Creek, range from 1.07 fps to almost 5.0 fps. For salmonids, water velocities in excess of 4 ft/sec. can reduce their population if slower water refugia are not available (USFS 1982). Reach 1 is the only reach where predicted bankful flow velocities exceed this value. However the abundance of large wood should provide sufficient velocity breaks (refugia) to allow trout to hold themselves during spring high flows.

Another source of cover important to trout is small boulders (5-10 inches in diameter) and large boulders (> 10 inches) (Born and Reiser 1991). Boulders comprise between 17 and 27 percent of the substrate composition on reaches 1-3. Percent of the substrate boulder size or larger in reference streams is generally greater than 25 percent. While some reaches of Elk Creek are below reference conditions, boulder composition is near reference and provides an important source of cover.

Stable and undercut banks are an important cover component for brook trout (Binns and Eisermann, 1979). The amount of stable banks directly relate to the amount of cover provided by undercut banks. Bank stability on reference reaches averages >80%. Elk Creek reaches are over 95% stable. Increased stability on Elk Creek is primarily due to the armored nature of the channel. Percent undercut on Elk Creek ranges from 4-5 percent which is less than reference streams. Reference streams are generally lower gradient and include both A and B channel types. Lower gradient streams tend to be more depositional and therefore a greater tendency to form undercut banks. Undercut banks do not appear to be a major cover component for trout on Elk Creek.

Colorado River Cutthroat Trout Evaluation

Elk Creek data were also examined to determine the streams ability to support a Colorado River cutthroat trout (CRCT) population. A "best fit" logistic regression models were used to predict the probability of success if CRCT were translocated into upper reaches of Elk Creek (Harig and Fausch, 2002). Data presented in Table 3 from reach 2 and 3 were used to run the model. Reach 2 and 3 were modeled because they are currently fishless and therefore a possible translocation site for CRCT.

Table 3. Stream habitat variables used to predict likelihood estimates For successful translocation of Colorado River cutthroat trout (Harig and Fausch, 2002).

Reach	Stream Gradient	Mean daily temp (F)	Mean bankful pool width (ft)	No. Deep Pools (>1 ft)
2 and 3	7-10%	45	8.9	48

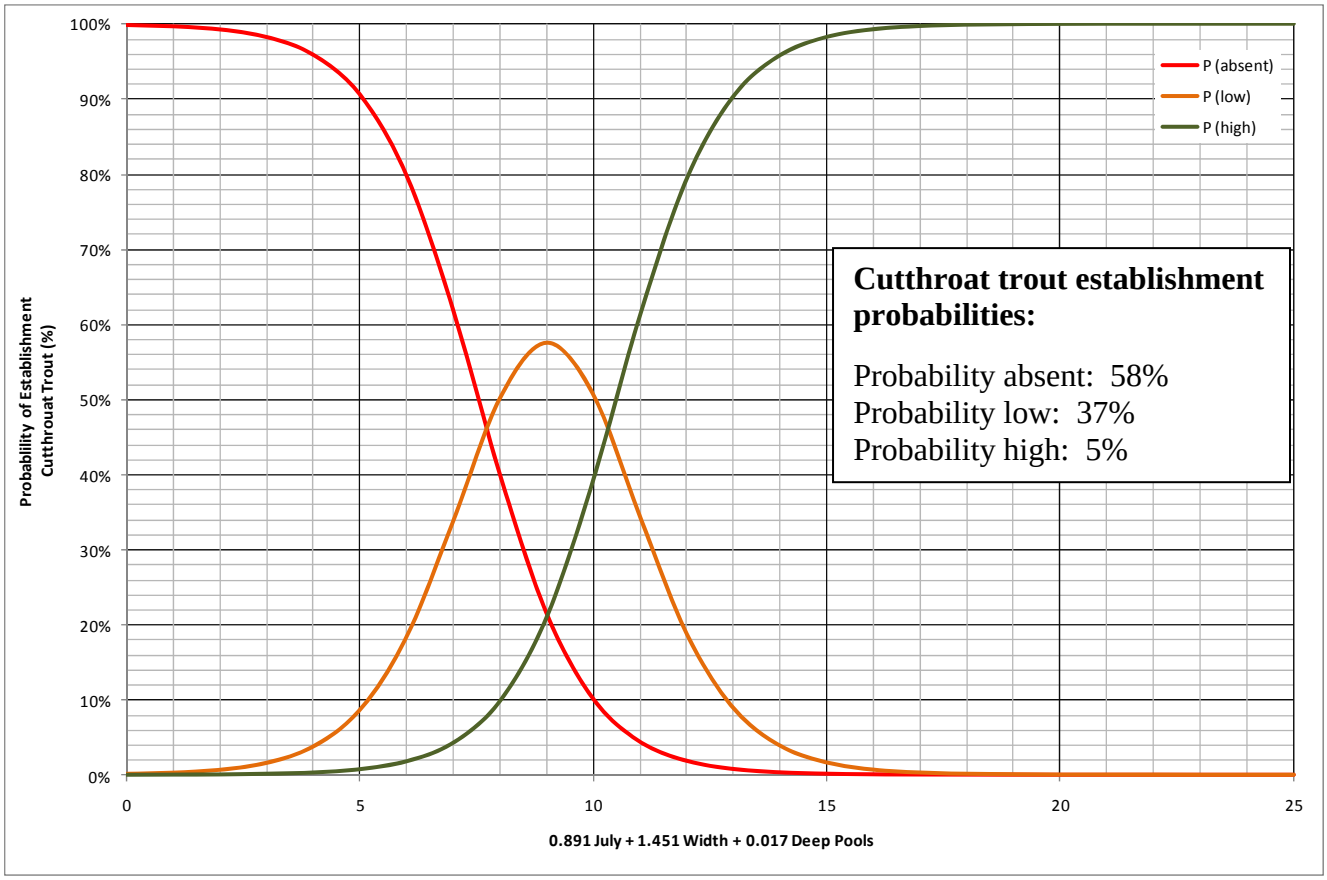
Reaches 2 and 3 has a mean daily water temperature of 45 degrees F (7.2 C), a mean bankful pool width of 8.9 feet (2.7 m) and 48 pools having a maximum residual pool depth of greater than or equal to 1.0 ft. (30cm).

Based upon these data, reaches 2 and 3 have a 5% probability of supporting a high number of cutthroat trout, a 37% probability of supporting a low number of cutthroat trout and a 58% probability of not supporting a cutthroat trout population (Figure 2). Cold water temperatures in July (avg. 45 F) and the small size of the stream appear to be the primary factor affecting the probability of establishing a cutthroat trout population. Harig and Fausch (2002) found many translocation sites for cutthroat trout to be too cold to support natural reproduction. Cutthroat trout spawn in the spring, stimulated by rising water temperatures. Cold water can delay spawning into mid to late summer, prolonging egg incubation resulting in low embryo survival or fry emergence (Hubert et al 1994).

Even though reaches 2 and 3 of Elk Creek are currently fishless, they are not a good candidate for translocation of CRCT. Small stream size and cold water temperatures would limit recruitment in the population and therefore at best a small population could be established (37%). Another factor limiting Elk Creek as a potential translocation site for CRCT is the lack of connectiveness to downstream areas and other adjacent populations of CRCT. Numerous

studies have documented the importance of connecting several populations of fish to form meta-populations (Riemann and McIntyre 1995, Dunham and Riemann 1999). Large watersheds composed of lower elevation habitats that provide warmer temperatures for CRCT, and have wide stream channels of sufficient length to provide good quality habitat are key factors in the establishment of a CRCT population (Harig and Fausch 2002).

Figure 2. Habitat model for prediction the probability of establishing cutthroat trout in Elk Creek based on mean average water temperature for July (^{o}F), mean bankful width (ft), and the number of deep pools > 1 ft)



Conclusion

The first 200-300 feet of Reach 1 of Elk Creek currently supports a brook trout fishery. Upstream movement of these fish is limited because of the presence of two 4 foot high waterfalls approximately 600 ft upstream from the confluence of Elk and Coal Creeks. Reaches 2 and 3 have similar habitat characteristics as reference streams of similar size documented to support trout populations on the GMUG National Forests. However, water temperatures in Elk Creek are generally colder than reference streams and therefore may limit reproduction and growth of trout. If brook trout were stocked into reaches 2 and 3 they would most likely persist at low numbers. Upstream of reach 3, the amount of flow and usable habitat is greatly diminished and therefore not suitable to support a trout fishery.

Habitat and water temperatures in reaches 2 and 3 were also examined to determine suitability to support a CRCT fishery using a logistic regression model. The model predicted a 5 percent probability of Elk Creek supporting a high number of CRCT, a 37 percent probability of supporting a low population of CRCT, and a 58 percent probability of not supporting a CRCT population. Cold water temperatures and small stream size appear to be primary factors limiting establishment of a CRCT fishery.

If a brook trout or a CRCT population were established in Elk Creek they would be reproductively isolated because of the presence of two 4 foot high water falls approximately 400-600 feet upstream from the confluence with Coal Creek. Genetic exchange would be limited so long-term persistence of a reproductively healthy population is doubtful.

GLOSSARY

Rosgen channel types descriptions:

Type "A" – steep (>10%), entrenched, cascading, step/pool streams. High energy, debris transport streams, generally very stable.

Subtype A1 – substrate dominate by bedrock.
Subtype A2 – substrate dominated by boulders
Subtype A3 – substrate dominated by cobbles
Subtype A4 – substrate dominate by gravels

Type "B" – moderately entrenched, moderate gradient (0.4 to .10), riffle dominated, with infrequently spaced pools.

Subtype B1 – substrate dominate by bedrock.
Subtype B2 – substrate dominated by boulders
Subtype B3 – substrate dominated by cobbles
Subtype B4 – substrate dominate by gravels

LITERATURE CITED

Adams, P. James, C. and C. Speas, 2008. Brook trout (*Salvelinus fontinalis*) Species and Conservation Assessment. Grand Mesa, Uncompahgre and Gunnison National Forests. 29 p.

Binns, N.A. and Eiserman, F.M., 1979. Quantification of fluvial trout habitat in Wyoming. *Trans. Am. Fish. Soc.* 108**,** pp. 215–228.

Brauch, D. Fisheries Evaulation of Elk Creek, Gunnison County Co. Colorado Division of Wildlife Resources internal report.

Bjornn T.C. and D.W. Reiser. 1991. Habitat requirements of salmonids in streams. *In* Meehan 1991.

Fish and Wildlife Service, 1982. Habitat Suitability Index Models: Brook Trout. U.S. Department of Interior. FWS/OBS-82/10.24.

Frazier, J.W., K.B. Roby, J.A. Boberg, K. Kenfield, J.B. Reiner, D.L. Azuma, J.L. Furnish, B.P. Staab, S.L. Grant. 2005. Stream Condition Inventory Technical Guide. USDA Forest Service Pacific Southwest region – Ecosystem Conservation Staff

Harig, A.L. and K.D. Fausch, 2002. Ecological Applications. Volume 12, No. 2.pp. 535-551.

Heitke, J.D., Archer, E.J., Dugaw, D.D., Bouwes, B.A., Archer, E.A., Henderson, R.C., and Kershner, J.L. 2006. Effectiveness monitoring for streams and riparian areas: sampling protocol for stream channel attributes. Unpublished paper on file at: http://www.fs.fed.us/biology/fishecology/emp. 75 p.

Hubert, W.A., R.W. Stonecypher, W.A. Gern, and J. Bobbit. 1994. Response of cutthroat embryos to reduced incubation temperatures at different developmental stages. Progressive Fish Culturalist 56: 185-187.

James, C.J. 2001. An Inventory of Stream Habitat and Fish Populations in Upper Henson Creek, Hinsdale County, CO. U.S. Department of Agriculture, Forest Service Report. Ouray Ranger District, Montrose, CO.

Meehan, W.R. 1991. Influences of Forest and Rangeland Management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19.

Nehring, R. 1979. Evaluation of instream flow methods and determination of water quality needs in the State of Colorado. Colorado Division of Wildlife, Fort Collins Co.

Overton, C.K. and S.P. Wollrab, B.C. Roberts [and others]. 1997. R1/R4 (Northern/Intermountain Regions) fish and fish habitat standard inventory procedures handbook. INT-GTR-346. Ogden, Utah: USDA Forest Service: 1-72.

Rosgen, D. 1996. Applied River Morphology. Dave Rosgen Wildland Hydrology.

WinXS Pro. 2005. Software version 3.0. USDA Forest Service. Rocky Mountain Research Station, Stream Systems Technology Center. Fort Collins, CO.

Raleigh, R. F., L. D. Zuckerman, and P. C. Nelson. 1986. Habitat suitability index models and instream flow suitability curves: Brown trout, revised. U.S. Fish Wildl. Serv. Biol. Rep. 82(10.124). 65 pp. [First printed as: FWS/OBS-82/10.71, September 1984-J.

Reiser, D.W. and T.A. Wesche. 1977. Determination of physical and hydraulic preferences

brown and brook trout in the selection of spawning locations. Water Resources. Res. Inst., Water Resources. Res. Ser. 64. 100pp.

USFS. 2004. Pathfinder Project Steering Committee Report: Strategies for Instream Flow Management. Grand Mesa, Uncompahgre, and Gunnison National Forests. Delta, CO.

Wesche, T.A. 1974. Evaluation of trout cover in smaller streams. Proc. Western Assoc. Game and Fish Commissioners. 54:286-294.