Use Attainability Analysis

Bucktail Creek

Lemhi County Idaho

Idaho Department of Environmental Quality

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Use Attainability Analyses

Bucktail Creek

Lemhi County Idaho

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Except as noted, photos by Elton Modroo, P.G., Idaho Department of Environmental Quality, Idaho Falls, Idaho

Cover photos – View from the waste rock dumps from the former Blackbird open pit mine at the headwaters of Bucktail Creek, downstream into the South Fork Big Deer Creek and Big Deer Creek drainages (top)

Lower Bucktail Creek following CERCLA "Early Action" remedial activities. Compare with *National Geographic* photo of baseline conditions in the Appendix 1.

CONTENTS

1. INTRODUCTION 1

2. WATERSHED DESCRIPTION AND HISTORY 3

3. SURFACE WATER CHEMISTRY 6

a. Naturally occurring pollution concentrations 6

4. PHYSICAL HABITAT CONDITIONS 7

5. BIOLOGICAL CONDITIONS 9

a. Macroinvertebrates 9

b. Fish 10

6. RECREATIONAL USES 10

7. FEASIBILITY OF REMEDYING POLLUTION SOURCES 10

c. Results of pollution controls 11

8. CONCLUSIONS AND RECOMMENDATIONS 15

9. REFERENCES 17

1 Introduction

The objectives of this report are to describe in the context of a use attainability analysis, "Bucktail Creek," a small, un-named stream which drains the north side of Blackbird Mine site in the Panther Creek watershed, Lemhi County, Idaho. The stream is not named on the U.S. Geological Survey 7.5 minute map of the area, as is typical for tributary streams of its size in the area. However, the stream is locally known as "Bucktail Creek," and for convenience it will simply be referred to as Bucktail Creek here as well.

A use attainability analysis (UAA) is a process under the Clean Water Act to help achieve the act's goal of maintaining and restoring the physical, chemical, and biological integrity of our waters. Use attainability analyses are required by the Clean Water Act whenever a State designates uses for a water body that do not include the "fishable-swimmable" goals of the act. These goals are:

> "...wherever attainable, provide water quality for the protection and propagation of fish, shellfish, and wildlife for recreation in and on the water...."

A UAA is a structured scientific assessment of the factors affecting the attainment of a use which may include physical, biological, and economic factors as described in 40 CFR 131.10(g). The §131.10(g) factors include:

(1) Naturally occurring pollution concentrations prevent the attainment of the use; or

(2) Natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating State water conservation requirements to enable uses to be met; or

(3) Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or

(4) Dams, diversions, or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in way that would result in the attainment of the use; or

(5) Physical conditions related to the natural features of the water body such as lack of proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude the attainment of aquatic life protection uses; or

(6) Controls more stringent than those required by §301(b) and §306 of the Act would result in substantial and widespread economic and social hardship.

In the preamble to EPA's 1983 water quality standards regulations[1], a UAA is further defined as containing a water body survey and assessment, a waste load allocation, and economic analysis, if appropriate. A water body survey and assessment evaluates the physical, chemical, and biological characteristics of a water body to define its existing uses. A waste allocation uses mathematical models to predict the amount of reduction necessary in pollutant loadings to achieve a given concentration, such as a water quality standard. An economic analysis is used in determining whether more stringent requirements would cause substantial and widespread economic and social impacts disproportionate to benefits.

According to draft guidance from EPA' Region 10, depending upon the circumstances a UAA may be simple or may need to an extensive analysis. The present UAA is of intermediate complexity due to the following factors: (1) contamination results from both natural and human sources; (2) in DEQ's view, sufficiently detailed studies have been conducted to estimate the effects and major sources of contamination, necessary allocations (reductions) needed to restore water quality, and on the feasibility of successfully achieving those allocations in order to support a use attainability conclusion.

Idaho Code Section 39-3604 requires uses to be designated for waters taking into consideration such physical, geological, chemical, and biological measures as may affect the surface waters. Waters which have uses which exist or have existed after November 28, 1975 (the effective date of the Clean Water Act) are to be protected.

1.1 Bucktail UAA Approach

Because three of the attainability factors have been suggested as potentially limiting aquatic life communities or recreational uses in Bucktail Creek, they each will be considered. These potential cases are 1) naturally occurring pollution concentrations, 2) low flow conditions, and 3) human caused conditions prevent attainment and cannot be remedied. It is possible that if more than one factor occur, aquatic communities could be more limited than if only a single stressor occurred. These factors are evaluated as follows:

Table 1. Potentially applicable use attainability factors and evidence evaluated in the UAA

Case	Attainability Factor	Evidence evaluated
1	Naturally occurring concentrations	Water and sediment concentrations reported from historical pre-mining conditions in Bucktail Creek, and recent concentrations from nearby reference streams
2	Low flow conditions	Seasonal flow records, macroinvertebrate collections at nearby, reference streams of similar size
3	Irremediable human caused conditions	Recent data on the effectiveness of pollution controls and projected results of implementing alternative additional actions

[1] 48 FR 51401

2 Watershed Description and History

Bucktail Creek is a small, 1st order stream draining the north side of the Blackbird Mine, in Lemhi County, Idaho. At its headwaters are located an open pit mine and numerous waste rock piles (cover photo). The stream drains north from the open pit for about 1.8 miles before joining the South Fork of Big Deer Creek, and about 100 yards downstream, the South Fork Big Deer Creek joins Big Deer Creek (Figure 1). Bucktail Creek drops precipitously from its emergence as springs at about 7200 feet to its confluence at about 4000 feet elevation.

Open pit mining began around 1954, resulting in contaminated mine drainage being transported to Panther Creek via Bucktail Creek and Big Deer Creek. Environmental investigations in the cause and effects of mining on Panther Creek began as early as 1967 with detailed analyses conducted from 1979-1981 as part of an environmental impact statement (EIS) being conducted prior to a planned re-opening of the mine. In 1985 a restoration investigation was funded by the Bonneville Power Administration (Reiser 1986). In 1983 the State of Idaho filed suit for recovery of damages for injuries to natural resources against current and former owners and operators of the site. Ten years later, the EPA, NOAA, and U.S. Forest Service joined the suit, which was resolved in 1995. In lieu of paying damages for the natural resource trustee agencies to restore the site, the responsible parties agreed to restore water quality and biota in Panther Creek below the confluence of Blackbird Creek to levels capable of supporting all life stages of anadromous and resident salmonids, and to restore water quality and aquatic biota in Big Deer Creek below the confluence to levels capable of supporting all life stages of resident salmonids. Blackbird Creek, Bucktail Creek, and the South Fork of Big Deer Creek were omitted from the restoration requirements due to consensus reached during settlement negotiations that their full restoration (i.e. meet water quality standards) was probably infeasible. A "Biological Restoration and Compensation Program" of additional habitat improvements in and beyond the Panther Creek basin, and chinook salmon restocking was agreed to in order to mitigate for the loss of salmon and salmon habitat over the years that these services were injured by pollution from the mine. No specific restoration or compensation was included for Bucktail Creek, which had been evaluated as a pathway for discharges to impair downstream waters, not for its own biological resources. Likewise, no specific restoration or compensation measures were included for Blackbird Creek, since those measures were based upon biological injury to anadromous fish and Blackbird Creek likely only historically supported resident fish.[2]

EPA has overseen cleanup actions and site investigations since 1993. These investigations are ongoing, however, sufficient information is presently available to evaluate existing and estimate foreseeable physical, biological, and chemical conditions in Bucktail Creek.

In 1995, engineering design and construction of "early action" measures (i.e. actions implemented prior to EPA's selection of a final remedy) to improve water quality in Panther and Big Deer Creeks began. Construction of most major features was completed by fall of 1998. This "Early Actions" phase has been followed by three years of monitoring the attenuation and stabilization of areas disturbed by the remedial construction, and further evaluations and iterative cleanups of remaining sources. Water quality is expected to be fully restored in Big Deer Creek

[2] *State of Idaho et al. v. The M.A. Hanna Company, et al*. United States District Court (Idaho), Consolidated Case No. 83-4149 (R). 1995 Consent Decree

and Panther Creek. About $60 million dollars has been spent by responsible parties since 1995 implementing "early actions" to reduce risk to the environment, remedial investigation/feasibility studies, and biological actions (Jackson and Myers 2001). EPA has not yet selected a final remedy for the site, as defined in the National Contingency Plan (NCP, 40 CFR 300).

In addition to these activities under CERCLA authorities, by 1988 Bucktail Creek and its downstream receiving waters were listed on Idaho's Clean Water Act section 303(d) list of impaired waters. Water quality problems of Bucktail Creek were also described in the regional news media and popular press, including *National Geographic* (Appendix 1).

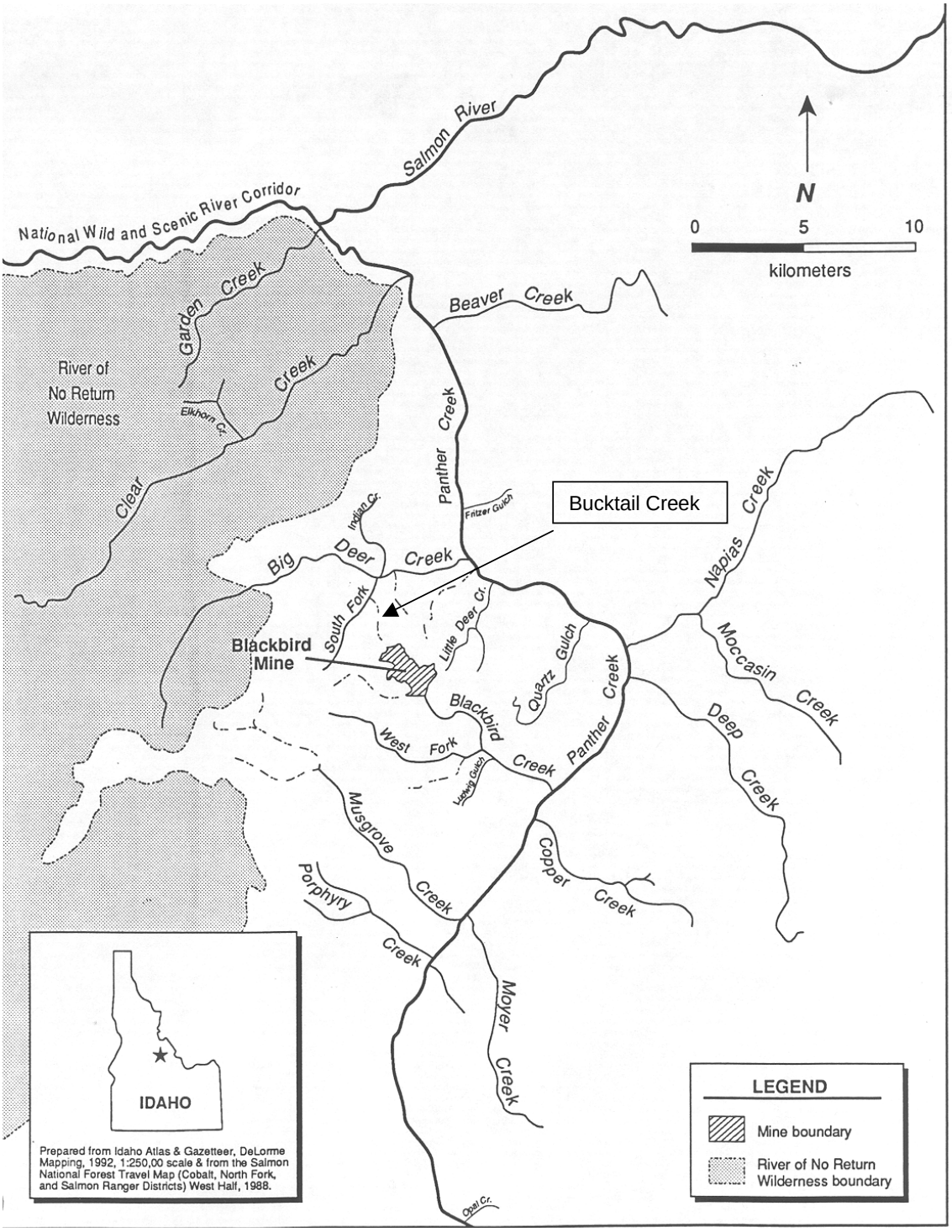

Figure 1. Blackbird Mine site vicinity and Bucktail Creek.

3 Surface Water Chemistry

Following the development of open pit mining, acid rock drainage developed in the Bucktail Creek drainage. This in turn resulted in extraordinarily high copper concentrations in headwater areas of the Bucktail Creek drainage (>100,000 µg/l copper). Aquatic life criteria for copper at typical hardnesses reported from the drainage range from maximum concentrations of 9 to 17 µg/l dissolved copper. As the acidic-metals laden water was diluted downstream, pH increased and copper concentrations decreased as copper precipitated out of solution onto the substrate. This resulted in rocks, tree roots, and even soil taking on a spectacular blue hue (cover, Figure 4, Appendix 1). The copper co-occurs with cobalt at approximately similar concentrations (Mebane 1994).

3.1 Naturally occurring pollution concentrations

No data on pre-mining naturally occurring copper concentrations have been located, but pre-mining cobalt data from Bucktail Creek and sediment copper and cobalt data from Bucktail Creek and reference streams allow relative comparisons. Table 1 summarizes pre-mining data for Bucktail Creek and recent copper and cobalt concentrations in reference streams. Sediment concentrations are often indicators of mineralization and elevated concentrations often correspond with elevated surface water concentrations. If copper to cobalt proportions in surface water and sediment were similar in Bucktail Creek before mining, and in other creeks draining mineralized watersheds that have not had large scale disturbances, pre-mining copper concentrations at the mouth of Bucktail Creek were likely less than about 20 µg/l. Therefore it is unlikely that naturally occurring pollution concentrations prevented the establishment of aquatic life in Bucktail Creek.

Table 2. Naturally occurring pollutant concentrations in Bucktail and reference streams that occur within regional copper-cobalt mineralized areas (maximum values when more than single data points available).

	Copper in water (µg/l)	Cobalt in water (µg/l)	Copper in sediments (mg/kg)	Cobalt in sediments (mg/kg)
Bucktail Creek – headwaters pre-mining	No data	200	10,000	400
Bucktail Creek – mouth pre-mining	No data	0.5	400	200
Reference streams				
Little Deer Creek – spring at headwaters	250	312	780	278
Little Deer Creek - mouth	4.4	10.7	542	261
Indian Creek	3.5	7.9	500	200
Elkhorn Creek	13	0.4	100	500
Copper Creek	4.9	0.3	77	8

Data from Mebane (1994) and RCG/HB (1994)

4 Physical Habitat Conditions

Bucktail Creek is a small, 1st order stream that averages an extremely steep gradient of 32%. Stream width generally ranges from <0.3 – 1 meter with depths of 5 – 15 cm. Measured flows have ranged from <0.1 cfs to 0.8 cfs (Figure 3). Two sediment control dams have been constructed on Bucktail Creek as part of the cleanup projects to reduce sediment transport downstream during construction of remedial projects. Figure 3 illustrates physical habitat conditions that are typical in the middle-and lower-reaches of Bucktail Creek.

For purposes of applying aquatic life standards to intermittent streams, water quality standards apply to intermittent streams only when flows exceed 1.0 cfs (WQS § 070.07). Streams with flows less than 0.1 cfs may be considered intermittent (WQS § 003.51). These recent flow records suggest that at times very little volume of water would be present for aquatic life to life in. Available depths probably preclude fish populations from establishing. Fish obviously need a minimum depth to swim. Minimum depths for adult trout to move upstream are about 12 cm (Bjornn and Reiser 1991). Often stream depths would be insufficient for fish movement, thus, populations would be unlikely to occupy and persist in Bucktail Creek based on flow alone.

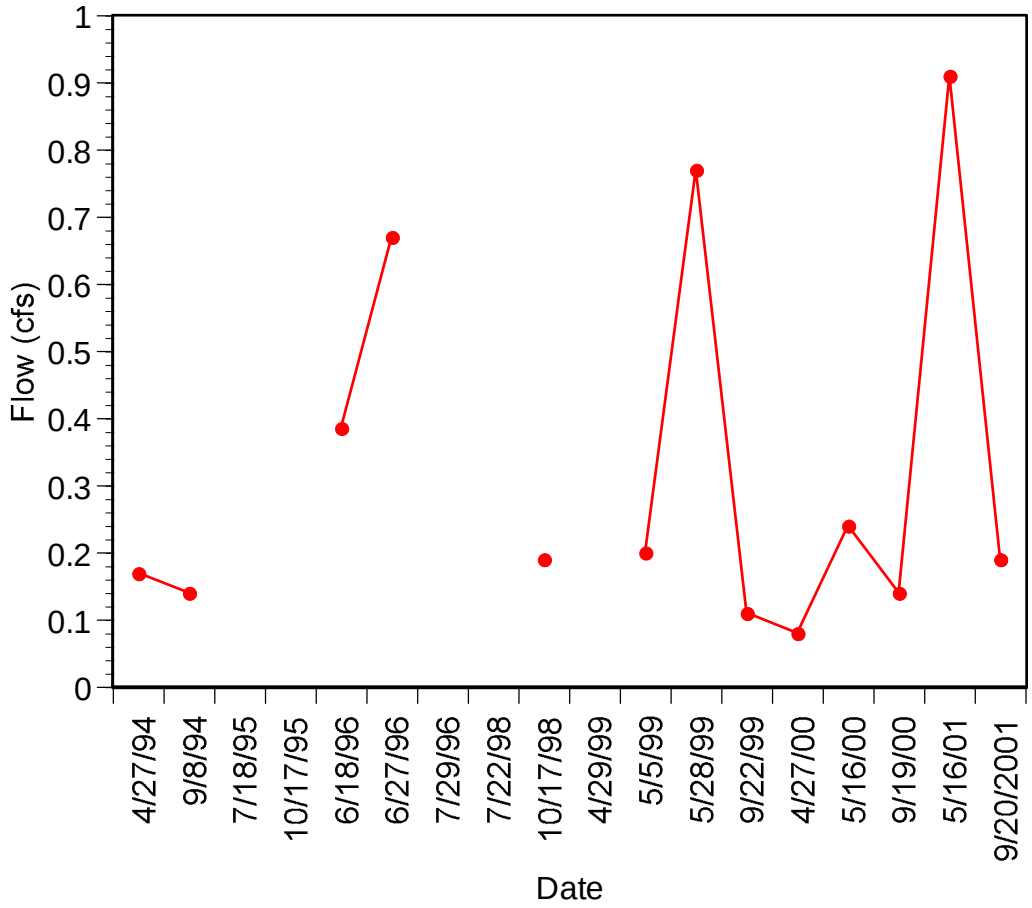

Figure 3. Measured flows in Bucktail Creek from 1994-2000. Data from RMC (1994) and the Blackbird Mine Site Group database, accessed June 2001, and Golder 2002.

Mid Bucktail Creek, Post Clear Creek Fire Photo Taken 9-19-00 Flow is 40 gpm.

Figure 4. Top: Typical physical habitat conditions in the middle and lower Bucktail Creek drainage at typical base flow conditions (flow was 40 gpm, 0.09 cfs). The watershed had burned about 1 month before the photo was taken.

Bottom: Gravels in the streambed and banks of Bucktail Creek are visibly contaminated with copper.

Copper Carbonates in Gravels Along Lower Bucktail Creek. Note 16 inch Rock Hammer for Scale, 10-2000

5 Biological Conditions

5.1 Macroinvertebrates

Benthic macroinvertebrates have been sampled in Bucktail Creek twice by the IDEQ beneficial reconnaissance program (BURP) in 1995, and benthic macroinvertebrates have been sampled several times in downstream waters affected by metals from Bucktail Creek. Most investigators likely did not sample Bucktail Creek because it was likely considered a foregone conclusion that there would be no invertebrates because of the high metals concentrations. Concerns for personal safety and damaging aluminum Hess samplers by working in the low pH and high metals water also discouraged sampling. Although diluted by about 5-10 times, macroinvertebrate communities in South Fork Big Deer Creek were also extirpated downstream of the Bucktail Creek drainage, after being diluted over100 times, macroinvertebrate communities in Big Deer Creek (a 3rd order stream) were nearly extirpated, and after 500-1000 times diluted into Panther Creek (a 5th order stream), macroinvertebrate communities were still significantly altered (Figure 1, Mebane 1994, Beltman et al. 1999). Macroinvertebrate communities in Big Deer Creek and Panther Creek are expected to be restored at least to the point of providing adequate food supply for salmonids (CH2M Hill 2001).

While macroinvertebrates were nearly eliminated from Bucktail Creek, nearby small (1st and 2nd order) reference streams had abundant and diverse macroinvertebrates. The generally pollution intolerant mayfly, stonefly, and caddisfly orders were well represented in reference streams but were completely absent from the Bucktail Creek samples (Table 2). The only life observed in Bucktail Creek was one Dipteran in the upper sample and one Oligochaete in the lower sample. It is unlikely that the lack of aquatic macroinvertebrates in Bucktail Creek can be attributed to its small size, since other small, nearby streams have abundant and diverse macroinvertebrate communities, including some from naturally-mineralized drainages.

Table 3. Macroinvertebrate community metrics in Bucktail Creek and nearby reference streams.

Site	Number of Taxa	Number of different mayfly, stonefly, and caddisfly taxa	Total number in sample
Bucktail Creek, upper site	1	0	1
Bucktail Creek, lower site	1	0	1
Copper Creek (reference)	41	26	449
Little Deer Creek (reference)	29	18	478
Little Jureano Creek (reference)	38	15	484
Big Jureano Creek (reference)	49	24	590

5.2 Fish

Bucktail Creek is too small to sample by electrofishing. The likelihood of fish entering and persisting for more than a few hours in waters with copper concentrations >2 orders of magnitude higher than the mean acute toxicity values for species such as rainbow trout (~ 40 µg/l) is very low. Bucktail Creek drains into Big Deer Creek, with dilution factors of about 100-200 times. During fish surveys in 1993 and 1995 no fish could be found in South Fork Big Deer Creek below the Bucktail Creek influence, despite the 5-10 times increase in dilution, nor even further downstream in Big Deer Creek, despite its greater than 100-fold dilution (Mebane 1994, IDEQ BURP database).

6 Recreational Uses

No reasonable scenario of water recreational use of Bucktail Creek could be imagined, because of its tiny size, remote and rugged location, and proximity of larger waters. Since this lack of existing or potential water based recreational use was self-evident, no formal analysis was performed.

7 Feasibility of remedying pollution sources

Copper and cobalt from the Blackbird Mine have flowed downstream through the Bucktail Creek drainage and has caused the near extirpation of aquatic life in Big Deer Creek and has had significant adverse effects on macroinvertebrate, resident fish, and anadromous fish populations in Panther Creek. Because of this, reducing metals loading from the Bucktail Creek drainage has been a high priority for the Blackbird Mine Site Group (BMSG) and environmental oversight agencies. The BMSG, a group of present and previous owners of the Blackbird Mine, is taking actions to restore water quality from the site, among other activities. The restoration project is overseen by the EPA, IDEQ, U.S. Forest Service, and NOAA. The cleanup activities have resulted in a large number of technical reports and major cleanup construction activities. As of writing, EPA has not issued a Record of Decision under the National Contingency Plan (40 CFR 300) for remediation of the site. All conclusions in this UAA, are those of DEQ, solely for the purposes of the UAA.

The physical (as opposed to biological restoration) of the overall restoration project is progressing in two major phases:

I. Early Actions consist of measures that could be designed and constructed relatively quickly (two to four year time frame). Design of the “early actions” began in 1995; construction was mostly completed by late 1998. Major features under construction affecting the Bucktail Creek watershed include:

a. Capping the bottom of the open pit mine to lessen infiltration;

b. Construction of a dam in Bucktail Creek to collect contaminated water;

c. Drilling a tunnel into the mountain to connect with existing underground mine workings and to route water from the dam into the mine and to a water treatment plant; and,

d. Upgrading the capacity of an existing water treatment plant to treat all collected contaminated water from the mine area[3].

While specific costs for completing these actions relating to the Bucktail Creek drainage have not been publicly released, they can be conservatively estimated to be on the order of $15 million so far. As of 2001, the overall cost of the Early Action phase of the project for design, construction, operations and maintenance, investigations, and oversight was nearly $60 million (Jackson and Myers 2001). The Bucktail related actions are assumed to account a third or more of the overall costs.

II. Remedial actions are potential measures that cannot be implemented until after completion of the "early actions" and the selection of a final remedy by EPA through a record of decision. These include monitoring the effectiveness of the "early actions" and natural attenuation of contaminated sediments downstream of the mine, and identifying and remedying relatively minor contamination sources which may currently be masked by the major uncontrolled copper and cobalt loads prior to construction of the dam and the reduction of sources from high in the Bucktail watershed. These investigations are ongoing.

A draft feasibility study investigated (among other factors) the technical practicality, short- and long-term effectiveness of alternatives ranging from natural attenuation to extensive seep collection and treatment, and sediment removals (Appendix 3, Golder 2001a). Under the most extensive alternative evaluated (BT-4), post-remediation dissolved copper concentrations in *South Fork Big Deer Creek*, were projected to be about 45 µg/l during spring, about 5X greater than maximum copper criteria (Appendix 3, Table 7-6). Concentrations at the mouth of Bucktail Creek were not modeled in Golder 2001a, but would probably be about 7X higher, about 35X greater than the copper maximum criteria. This estimate is based upon the 7.5 to 1 ratio of South Fork Big Deer to Bucktail flows measured during May 2001 synoptic sampling.

7.1 Results of pollution controls

Copper loadings in Bucktail Creek below mine sources declined with natural attentuation from 1974 to 1994, then increased dramatically while cleanup construction was underway, and then were greatly reduced by 2001 (Figure 5). After completion of the Bucktail dam and diversion of collected waters through a tunnel in the mountain to the Blackbird water treatment plant in the fall of 1998, loadings in lower Bucktail Creek declined. By fall 2001, loadings were about 10% of loadings measured in 1994, prior to the recent cleanup activities.

Copper concentrations in Bucktail Creek below the copper sources approached 500,000 µg/l in the mid-1970s, declining to around 10,000 µg/l by 1994 through natural attenuation. Concentrations increased dramatically during the construction disturbances around 1995-1996. These apparent disturbance caused increases were despite measures designed to reduce runoff from disturbed areas. The construction activities employed a variety of measures to limit short-

[3] The existing plant was constructed in 1980 to only treat discharges from the lowest mine portal which were considered "point source" discharges and contributed about 5 percent of the overall metals loading to Panther Creek.

term disturbances such as erosion barriers on haul roads, and two sediment control dams which retained some water allowing settling during runoff. Since completion of major source reductions in the fall of 1998, copper concentrations appear to be stabilizing at about 500 µg/l (Figure 6). The is on the order of a 95% reduction in copper concentrations from 1994 to 2001 downstream of the dam and water treatment plant diversion. These recent conditions are greatly improved from historic conditions and may ultimately result in full recovery of Big Deer and Panther Creeks, the downstream receiving waters. However, even after about a 95% improvement dissolved copper concentrations are still about 40 to 70 times higher than the aquatic life criteria for copper.

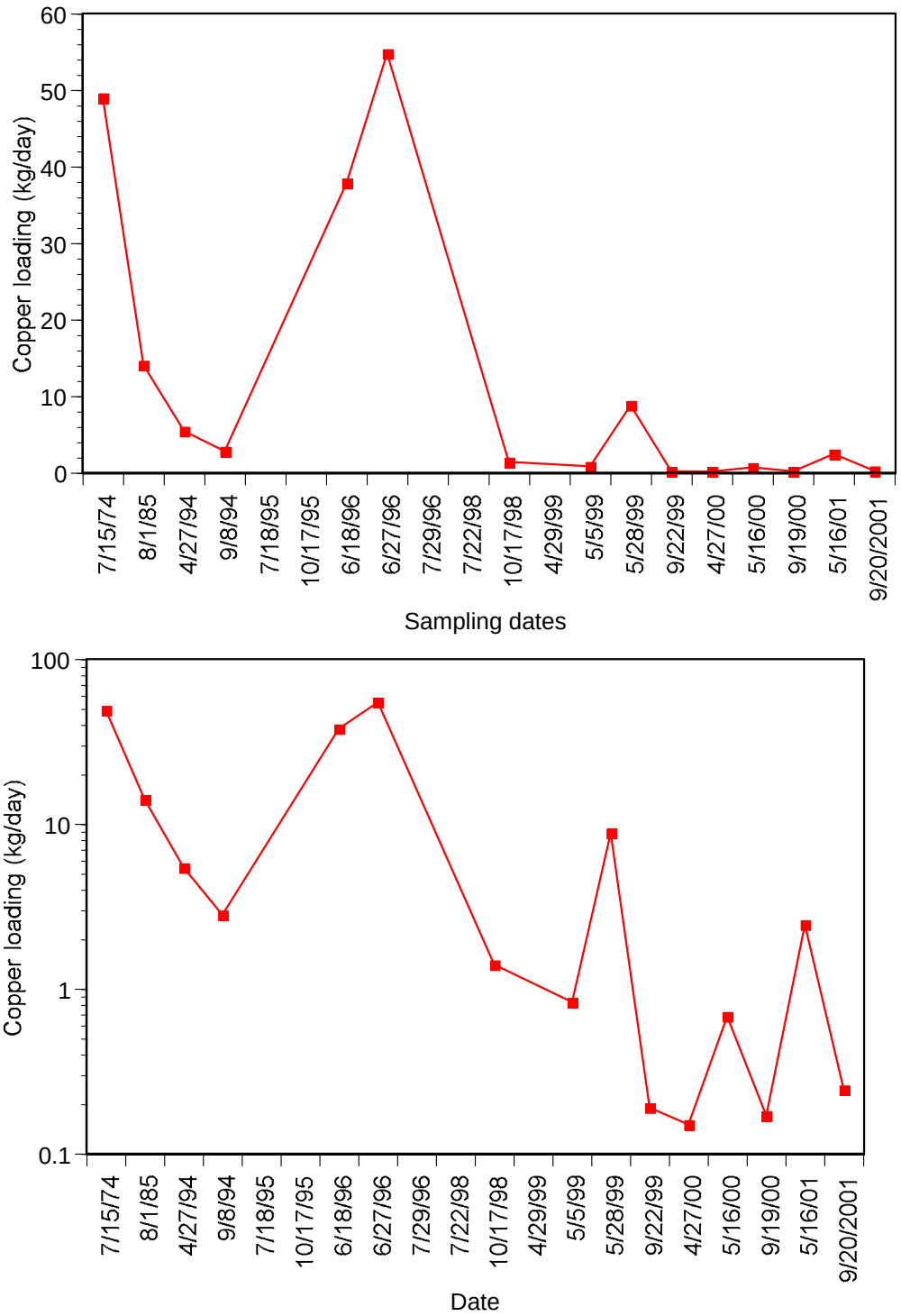

Figure 5. Bucktail Creek copper loads (kg/day) measured below major sources (referred to as the "upper road crossing" in most study reports. The graphs are identical except the lower graph is plotted on log scale to spread out the low load data points. Data from Baldwin (1978), Reiser (1986), RMC 1995, BMSG data base (accessed June 2001), and Golder 2002.

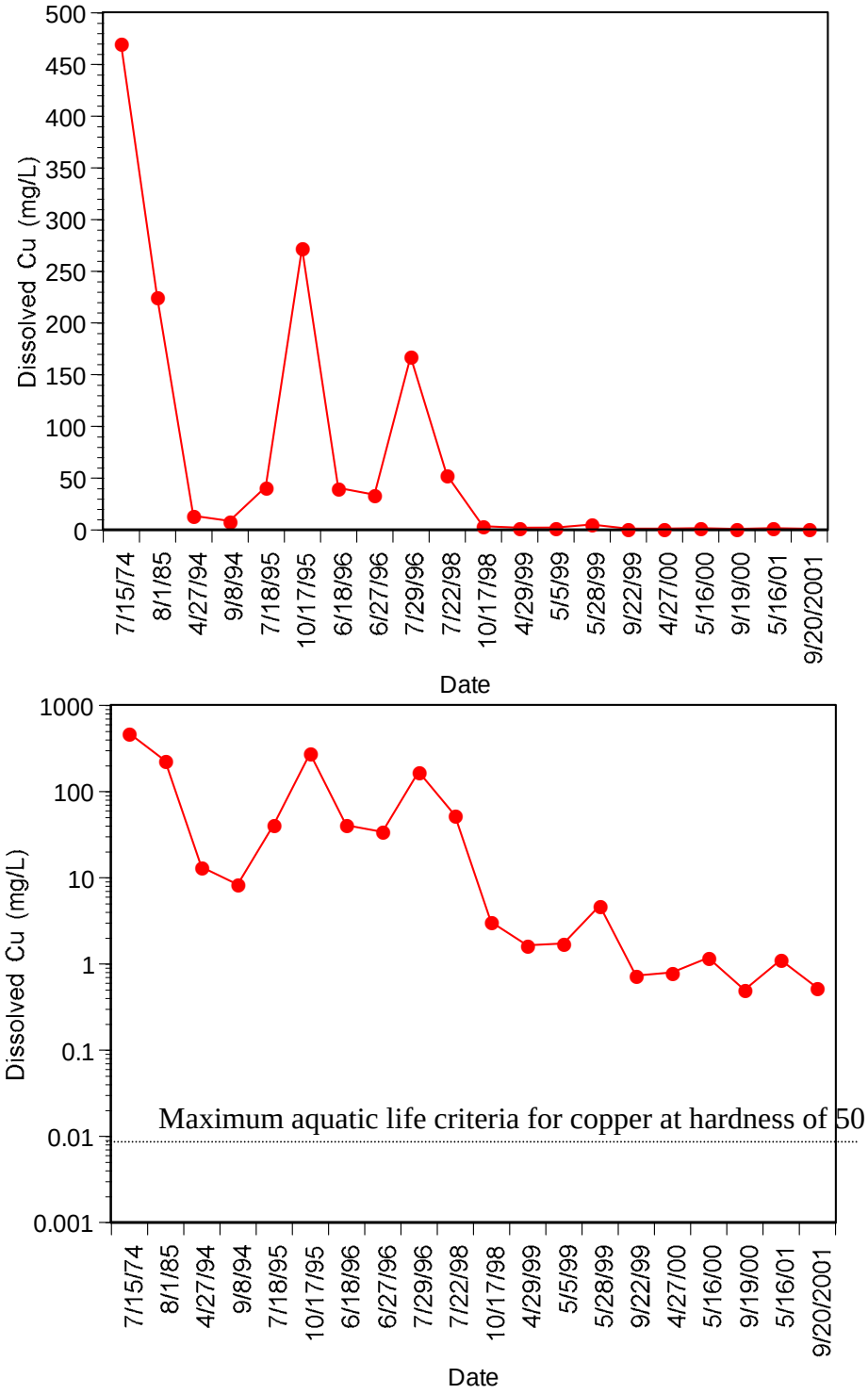

Figure 6. Bucktail Creek dissolved copper concentrations (mg/l) measured below major sources. The graphs are identical except the lower graph is plotted on log scale to spread out the low concentration data points. Data from Baldwin (1978), Reiser (1986), RMC (1995), the BMSG data base (accessed June 2001), and Golder (2002).

8 Conclusions and Recommendations

The data reviewed support the following conclusions relating to existing uses and attainability of uses:

8.1 Aquatic Life Existing Uses

Conclusions: Aquatic life is not an "existing beneficial use." Contact recreation is not an "existing beneficial use."

Aquatic life has virtually been extirpated from Bucktail Creek (Section 5). This has likely been the case since the stream began receiving mine drainage and copper concentrations began greatly exceeding aquatic life criteria for copper by the early 1970s. Bucktail Creek is too small to have any real likelihood of contact recreation such as wading, fishing, swimming (Section 6).

8.2 Attainability of Aquatic Life Uses

The feasibility of attaining aquatic life and recreational use in or on the water was evaluated for three potential lines of evidence (Table 4).

Table 4. Summary of potentially limiting attainability factors

Case	Attainability Factor	Evidence evaluated and conclusions	Applicable?
1	Naturally occurring concentrations	Water and sediment concentrations reported from historical pre-mining conditions in Bucktail Creek, and recent concentrations from nearby reference streams suggest naturally occurring copper concentrations were around the range of <1-4X CMC. While CMC might have been exceeded, the magnitude of exceedences probably was not sufficient to eliminate or greatly limit aquatic life	No
2	Low flow conditions	Seasonal flow records, macroinvertebrate collections at nearby, reference streams of similar size. Stream is too small for human recreation. Reference streams have abundant and diverse macroinvertebrate communities.	Yes (recreation only)
3	Irremediable human caused conditions	Recent data on the effectiveness of pollution controls and projected results of implementing alternative additional actions. Post-remediation modeling of copper reductions indicates concentrations would still be many times the copper CMC.	Yes (aquatic life)

Recent chemical conditions are greatly improved over historical conditions, and are projected to decline further. However copper concentrations exceed aquatic life criteria by many times. Physical conditions related to the natural features of Bucktail Creek such as steep gradient and small size and flow likely precluded its use by fish.

Copper concentrations in Bucktail Creek were greatly increased during cleanup construction activities, despite attempted controls. Further major cleanup disturbances would cause additional environmental damage that would offset environmental benefits, at least on a short-

term basis. More fundamentally, the rate of decline in copper concentrations has tapered off since major interception and treatment of major contaminated sources began. It is unlikely that in the foreseeable future (e.g. 10 – 20 years) that copper concentrations will decline to the point of meeting aquatic life criteria. *Therefore, within the foreseeable future, human caused sources of pollution preclude the attainment of use and cannot be remedied.*

9 References

Baldwin, J.A., D. R. Ralston, and B. D. Trexler. 1978. *Water resource problems related to mining in the Blackbird mining district, Idaho.* Completion report 35 and 48 to cooperative agreement 12-11-204-11 USDA Forest Service. Moscow, Idaho: College of Mines, University of Idaho. 232 pages.

Beltman, D., W.H. Clements, J. Lipton, and D. Cacela. 1999. Benthic invertebrate metals exposure, accumulation, and community-level impacts downstream from a hard-rock mine site. *Environmental Toxicology and Chemistry* 18:299-307.

Bjornn, T. C., and D. W. Reiser. 1991. *Habitat requirements of salmonids in streams*. Pages 83-138 *in*, volume American Fisheries Society Special Publication 19.

CH2M Hill. 2001. *Aquatic ecological risk assessment, Blackbird Mine Site.* Final Report. Prepared for U.S. EPA, Boise, Idaho. Prepared by CH2M Hill, Denver, CO. August 27.

Golder Associates. 2001a. *Focused feasibility study for the Blackbird Mine site, Lemhi County, Idaho.* Prepared for the Blackbird Mine Site Group. Prepared by Golder Associates, Redmond, WA. December 28.

Golder Associates. 2001b. *Technical Impracticability of Achieving copper and cobalt Preliminary Remediation Goals in Blackbird and Bucktail Creeks.* Appendix C to Golder (2001a)

Golder Associates. 2002. *Blackbird Mine Site Remedial Investigation Addendum, 2001 Sample Results, Lemhi County, Idaho.* Prepared for the Blackbird Mine Site Group. Prepared by Golder Associates, Redmond, WA. January 8.

Jackson, D. and D. Myers. 2001. Letter to Fran Allans, EPA, Boise (transmittal letter for the Blackbird Mine FS Report). Blackbird Mine Site Group, P.O. Box 1645, Salmon, ID 83467. December 28.

Mebane, C.A. 1994. *Blackbird Mine preliminary natural resource survey.* Prepared for EPA Region 10. NOAA Hazardous Materials Assessment and Response Division, Seattle, WA. 90 pp. plus appendix.

RCG/HB. 1994. *1993 Surface Water Resource Injury Assessment, Blackbird Mine Site NRDA.* Prepared by: RCG/Hagler Bailly, Inc., Boulder, CO. Prepared for: State of Idaho and NOAA. December.

Reiser D.W.(Project Manager). 1986. Habitat Rehabilitation - Panther Creek, Idaho. Final Report 1985. BPA Pro. No. 84-29. Report No: DOE/BP/17449-1 NTIS No: DE86015222/HDM . Portland. Oregon: Bonneville Power Administration, Division of Fish and Wildlife. 446 pp.

Rocky Mountain Consultants (RMC). 1995. Physical Restoration Analysis, Blackbird Mine, Lemhi County, Idaho. Prepared by Rocky Mountain Consultants and Industrial Economics, Inc. for NOAA. March 10.

10 Appendices

Appendix 1: Excerpt from *National Geographic*, February 1994, pp. 24-25. Conditions in Bucktail Creek before remedial "early actions" and before a stand-replacing forest fire that burned through the drainage in September 2000, changing its appearance.

Appendix 2: Bucktail Creek excerpts from:
CH2M Hill. 2001. *Aquatic ecological risk assessment, Blackbird Mine Site.* Final Report. Prepared for U.S. EPA, Boise, Idaho. Prepared by CH2M Hill, Denver, CO. August 27.

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