Black Canyon Monitoring Plan

Prepared for
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May 17, 2005

Table of Contents

Settlement Agreement Requirements

On December 22, 2003, PacifiCorp received a new license for the Bear River Hydroelectric Project (FERC No. 20). This project includes four hydroelectric developments located on the Bear River in Caribou and Franklin Counties, Idaho. The 30-year license allows for the continued operation and maintenance of the Soda Development, the Grace/Cove Developments, and the Oneida Development.

This Black Canyon Monitoring Plan (Plan), previously known as the Grace Bypass Monitoring Plan, was prepared as required by **Article 407** of the License Order (Order). The Order and Section 3.1.6 of the Bear River Settlement Agreement (Agreement) (signed by agency and NGO stakeholders on August 28, 2002), identifies three monitoring elements to be included in the plan: macroinvertebrate sampling, Grace bypass reach telemetry studies, and creel surveys. It was, however, unanimously decided by the Environmental Coordination Committee (ECC; Article 402) to exclude the telemetry component because of budgetary and biological constraints (See Fisheries Monitoring section, page 7).

As described in section 3.4.4 of the Agreement, whitewater boating may occur in Black Canyon (Grace bypass reach) if sufficient water is available. As per the Agreement and Order (as amended), the Monitoring Plan must include the investigation of: (i) the effects of opportunistic whitewater boating flows (WBF) during license years two through four on fish displacement and invertebrate performance; (ii) the effects of scheduled WBF in license years five through seven on movement and displacement of fish and invertebrates; (iii) the effects of the new minimum bypass flow regime in the Grace bypass reach on fish population composition and distribution, and on the quality of the angling experience; and (iv) the effects of minimum whitewater flows on channel/substrate structure.

The Plan outlines specific questions to be investigated during the study period. Results of this monitoring plan will be reviewed by the ECC to determine whether WBF unacceptably affect the biotic component of the bypass reach. If the ECC determines that WBF are significantly correlated with adverse impacts on biotic components of the Black Canyon, they may develop an adaptive flow management program (amount, frequency, or timing) during year 7 and thereafter. As defined in section 3.1.6 of the Agreement, a significantly adverse effect is a measured change that materially degrades ecological attributes to the extent that the ability to achieve the management objectives of the Bonneville Cutthroat Trout (BCT) Restoration Plan, the *Range-wide Conservation Agreement and Strategy for Bonneville Cutthroat Trout Management* (RCAS) (UDWR 200a), and the *Cutthroat Trout Management: A Position Paper, Genetic Considerations Associated with Cutthroat Trout Management* (CTMAPP)(UDWR 200b), is impaired. Ecological attributes include: water quality, native fish population composition and distribution (including rainbow trout as a monitoring surrogate for native cutthroat trout), macroinvertebrate performance and habitat, and riparian habitat. Under ECC direction, a subcommittee comprised of ECC members with expertise in aquatic systems research

and/or interest in the Black Canyon monitoring component of the license was formed in June 2004 to develop the Plan. At subsequent monthly ECC meetings, summary notes from subcommittee meetings were discussed and outstanding issues were determined. In October 2004 the subcommittee participated in a two-day site visit to verify the feasibility of methods presented in the Plan. Methods were revised and refined based on input from all participating members of the subcommittee. Study methodologies were subjected to peer review by aquatic systems experts from outside the ECC. The ECC reviewed the Plan over a 30-day period concomitant with the time period of external peer review. Comments from the ECC were addressed and incorporated into the Final Black Canyon Monitoring Plan prior to its submission to the FERC. The Plan was filed with the Commission on December 31, 2004. The Commission issued an order approving the Plan on February 17, 2005.

As identified in the Agreement, PacifiCorp is funding costs of monitoring described in the Plan in the amount of $35,000 per year from the second through the eighth anniversary of the issuance of the Order. Monitoring is scheduled to begin in 2005 and continue through 2010. Any funds remaining at the end of a year may be carried over to succeeding license years for monitoring activities specified in the Plan. Should funds remain following the eighth anniversary of the New License, they may be used for the Conservation Hatchery Program (Article 404).

Scientific Background

Flow regime plays an important role in development and maintenance of riverine systems (Ward 1998). Typically, there is an historical correlation between hydrographs of large western river systems and spring snowmelt, but reservoir operation, irrigation, and hydropower diversions have caused large changes in the typical hydrograph, which have had variable effects on aquatic biota.

Fish response to flooding depends on habitat characteristics present in a given system. Coastal cutthroat trout (*Onchorhynchus clarki*) moved little in response to bank full flows when quality habitat was available (Harvey, et al. 1999), and there was little change in fish community structure following an approximate 30-fold increase in flow in a flashy north Texas stream (Matthews et al. 1996). However, various fish species were displaced downstream following recreational and flood-control flow releases in the Nisqually River, Washington (City of Tacoma 2004) and scheduled releases have promoted spawning activity in Clanwilliam yellowfish (*Barbus capensis*) in South Africa (King, et al. 1998).

Because most macroinvertebrate population establishment occurs in a downstream direction following flood events, their response to flooding differs from that of fish species in the same stream. Macroinvertebrate response is also dependent on habitat characteristics and the flood hydrograph. Two species of caddisfly, living in areas with different substrate types, had different responses to flooding in an intermittent stream in Ohio (Kilbane and Holomuzki 2004). In some systems there is a reduction in impacts

from high flow releases on invertebrates in bedrock habitats compared to those in riffle and pool habitats (Robinson, et al. 2005). Macroinvertebrate drift response varied based on grain sorting and size under ramped flow increases in an experimental flume (Holomuzki and Biggs 2003). The percentage of total benthic macroinvertebrates in the drift was significantly greater following abrupt versus stepwise increases in flow (Imbert and Perry 2000).

Methods

Monitoring the effects of opportunistic and scheduled WBF in Black Canyon will include sampling macroinvertebrates, periphyton, organic matter, fish populations and distributions, and channel/substrate structure. Data collected prior to July 2004 will be used as a "no minimum flow" baseline for comparison with data collected after implementation of the minimum flow requirement. Data will be collected twice annually over a three year period to provide baseline data for comparison with data to be collected in years 5-7, when scheduled WBF will occur. A control reach on the Bear River above Alexander Reservoir (exact location to be determined) also will be monitored to track changes in macroinvertebrate and fish community composition and distribution and stream channel/substrate structure unrelated to WBF. Discharge measurements recorded at existing gage stations will be used to determine flow differences attributable to precipitation events versus regulated releases.

Study Questions

The purpose of this study is to characterize and compare the biotic community of the Bear River in the Black Canyon reach under a steady flow regime (consisting of new minimum flow plus spring inflows) with a variable flow regime. Anticipated flows in Black Canyon over the course of this study will consist of a steady flow regime punctuated by abrupt increases and decreases in flow during recreational boating flow releases. Our null hypothesis is that there will not be an overall negative change in macroinvertebrate and fish communities as a result of WBF.

This study is designed to answer the following questions:

Fish:

1) Will adult and juvenile fish (trout, sculpin, dace, suckers) be displaced as a result of WBF?
2) Will fish condition factor change as a result of WBF?
3) Will fish recruitment be affected by WBF?
4) Will fish cohort strengths be affected by WBF?
5) Will fish community composition change as a result of WBF?

Macroinvertebrates:

1) Will macroinvertebrate abundance and community structure be negatively affected by WBF?

Primary productivity:

1) What is the standing crop of periphyton in pre- vs. post-WBF?
2) What is the standing crop of organic matter in pre- vs. post-WBF?
3) What is the chlorophyll *a* content of periphyton in pre- vs. post-WBF?

Study Area

The Black Canyon reach includes approximately 6.5 miles of the Bear River beginning at Grace Dam and ending at the Grace Tailrace (Bounding coordinates: N: 42.357, S: 42.323, E: -111.4338, W: -111.4739). Samples will be collected in the following three reaches, selected based on substrate type and availability of aquatic habitat:

Reach 1 – A low gradient, upper section beginning approximately 0.5 miles below the Grace Dam and ending approximately 0.8 miles upstream of the Turner Bridge. This section includes transects T2-T5 (approximately 0.6 mile; see map in Appendix A).

Reach 2 – A well developed riffle-pool-run section. This section includes survey site #17 and transects T6-T10 (approximately 0.1 mile see map in Appendix A).

Reach 3 – The bedrock ledge habitat section near Grace power plant (approximately 0.8 mile see map in Appendix A).

Pursuant to the Order and Agreement, a base flow (new minimum flow or inflow when this amount is less than the new minimum flow) through Black Canyon began on June 22, 2004. Prior to this, flow in the upper end of the canyon consisted of leakage from Grace Dam, while springs near the Kimball Trout Farm approximately 4.5 miles downstream of the dam supplemented flows in the middle and lower sections. Flow at the lower end of the canyon totaled approximately 30 cfs. Periodically, during PacifiCorp maintenance activities or years of high spring runoff, flows exceeded this amount.

Samples will be collected in each of the three reaches of the study area. Study habitats are separated based on substrate type and availability of aquatic habitat. The riffle habitat in Reach 1 is composed of a variety of substrate sizes from silt to large boulders. The river is wide and shallow with multiple channels in some locations. The riffle-run-pool habitat in Reach 2 contains gravel areas that may be suitable for native fish spawning. Habitat in Reach 3 is characterized by bedrock ledges and solution pockets that contain gravel substrate in certain locations.

Sampling Protocol

Samples will be collected annually during March and October in each of the three study reaches and the control reach.

Sampling and monitoring will include:

1) Macroinvertebrates
2) Organic Matter
3) Periphyton ash-free dry weight/chlorophyll *a*
4) Fisheries
5) Water Temperature
6) Channel Structure and Substrate
7) Filamentous Algae
8) Stream Discharge

Macroinvertebrates
Macroinvertebrates will be sampled twice annually, once in March and once in October. Samples will be collected using Department of Environmental Quality (DEQ) Beneficial Use Reconnaissance Program (BURP) methods (IDEQ 2004). Initial sample collection will occur in October 2005. In riffle habitats located in the control reach and reaches 1 and 2, a modified Surber sampler will be employed to collect samples from 8 randomly selected locations along each transect. These 8 samples will be combined into a single, composite sample per transect to reduce intra riffle variability. A total of 5 transects will be sampled in each reach. Substrate in the sample area will be disturbed to a depth of at least 10 cm and individual rocks will be scrubbed using a stiff-bristled brush. In the bedrock ledge/solution pocket habitat located in Reach 3, a modified Surber sampler will be used to collect macroinvertebrates from ledge habitat. As in reaches 1 and 2, 8 samples will be combined into one composite sample for each of the 5 transects. A Ponar sampler will be used to collect macroinvertebrates from solution pockets, once again the 8 samples collected will be combined into a single composite sample for each of five transects. Cost per composite sample for enumeration and identification of taxa is estimated at $250.00, resulting in a total cost of approximately $10,000 (40 x $250) annually.

Organic Matter
In riffle habitat, organic matter and macroinvertebrates will be sampled concurrently. Organic matter will be separated out from the surber samples, and ash-free dry weight (AFDW) will be determined on a weight per area basis using standard methods (APHA 1995).

Periphyton Ash-Free Dry Weight and Chlorophyll a
Periphyton will be monitored to help explain macroinvertebrate community response. Ten periphyton samples will be collected in each of the study reaches and the control reach. Periphyton will be brushed from a known area of an unglazed ceramic tile (Lamberti and Rush 1985), filtered onto a pre-weighed glass fiber filter, and frozen at <4° C until analysis. Samples will be extracted with methanol or acetone, and chlorophyll *a* and ash-free dry weight will be determined using standard methods (APHA 1995).

Fisheries
The subcommittee, and subsequently the ECC, determined that methods in addition to a telemetry study in the Black Canyon section of the Bear River are necessary to answer questions concerning the effects of opportunistic and scheduled WBF on various size cohorts of fish. Therefore, fisheries monitoring will have three components; radio telemetry, fish population sampling and a voluntary creel survey.

The information gathered from these monitoring techniques will answer questions concerning the effects of opportunistic and scheduled WBF on various size cohorts of fish.

Radio Telemetry
Radio transmitters will be implanted in a sample of between 10 and 20 adult (at least 350 mm) rainbow trout at three locations in Black Canyon at least one month prior to implementation of WBF. Location of the transmitters will be monitored weekly prior to the WBF, multiple times daily during the WBF and at a reduced level after WBF. Recorded movements will be correlated with changes in water flow parameters. This study will contain quantitative documentation of the extent of fish displacement resulting from WBF and how soon after WBF fish return to their pre-WBF feeding stations.

Fish Population Sampling
Electrofishing samples will be collected annually in October at three reaches in the Black Canyon and in the reference or control site used for macroinvertebrate sampling. Reaches will be at least 100 m in length. The Black Canyon sites will be: (1) near the foot bridge upriver from the Grace Power Plant, (2) upriver from the Black Canyon Hatchery (Kimball) springs and (3) between the town of Grace and Turner Bridge.

Sampling a river section will involve collecting all fish possible during two consecutive, downriver electrofishing passes. All fish will be identified to species, measured and weighed. Relative species composition and number of fish by species will be reported and compared over time. Condition of the fish will be determined from the length and weight data. Fish condition will be an indicator of food availability and/or general suitability of the environment for fish growth and survival.

Sterile rainbow trout are stocked by Idaho Fish and Game to provide sportfishing opportunities in the area. In order to stock study and reference reaches consistently, one cohort of 500 ten-inch long rainbow trout, each marked with a freeze-brand, will be stocked every May for seven years at three locations: above Alexander Dam, below

Grace Dam and above Grace Power Plant. Freeze-brands will identify when and where each fish was stocked. Trout will be stocked at approximately the same density/mile in control and study reaches.

Abundance and growth of the marked cohorts will be recorded. Persistence of individual cohorts of rainbow trout as indexed by rate of decline in numbers through a series of years will be recorded. All the above fishery parameters will be monitored and related to WBF.

Creel Surveys
As stated in section 3.1.6.1.1 of the Agreement, Idaho Department of Fish and Game (IDFG) will conduct creel surveys to assess angler effort and the quality of the fishery under the new river management regime. Due to budget limitations, a voluntary creel survey system will be used to collect angler use, catch, and relative satisfaction. Kiosks will be established at three locations to survey angler creels. Black Canyon locations will be near the foot bridge upriver from the Grace Power Plant and near the town of Grace. The third kiosk site will be located on the road coming into the Alexander Dam. Signs at the kiosks will request anglers to complete the following survey questions: how many anglers were in their fishing group, how many hours they fished, how many fish of what species they caught and how many of the captured fish were kept and how many released. The sign will also ask the surveyed anglers to record the lengths of the fish they kept using measuring boards provided at the kiosks. The forms will have a space for surveyed anglers to provide general comments. The kiosks will be maintained year-around through the seven years of evaluations. Seasonal estimates of fishing effort, catch rate, catch and harvest will be generated from the completed kiosk forms. Anglers participating in the creel survey will be included in an annual drawing of a $500.00 cash award.

Water Temperature
Continuous temperature monitoring devices (Onset computer corporation, Optic StowAway Temp) were placed in the river (2002 and 2003 field season) as part of water quality monitoring prior to the minimum flow being instituted in June 2004. Placement of temperature recorders followed IDEQ's Water Quality Monitoring Protocol – Report No. 10 (Zaroban, 2000). Temperature monitors were placed below Grace Dam, 100 m downstream of the footbridge near the sportsman's access upstream of Grace power plant, and in the control reach above Alexander Reservoir. Temperatures will be recorded hourly at these sites throughout the study period.

In 2005, an aerial thermal infrared survey of the Bear River will be completed. In general, the objectives of this work are to map thermal refugia and identify ground water sources. The project will provide a longitudinal temperature profile showing the median stream temperature and temperature of point source inflow plotted versus stream mile. Observations of thermal features along the survey reach will be included. This effort is not part of the Black Canyon monitoring proposal, but is a related project that will add to the data set and knowledge base of the spring areas in the Black Canyon section of the Bear River. This information will be used to determine whether loggers are in the most

suitable locations and/or additional logger placement is necessary to accurately characterize temperature regime(s) in the study and reference reaches.

Channel Structure and Substrate
Prior to the implementation of minimum flows in June 2004, permanent cross-sectional transects were established in the study area. Five transects are located below Grace Dam and five additional transects are in the vicinity of site #17 in Black Canyon (See Appendix A – Map of Study Area). Data associated with these level-surveyed transects is contained in the Black Canyon Substrate Survey Report (IDEQ 2005). Permanent transects also will be established in the reference reach (in as geomorphologically-similar areas as possible). These transects will be surveyed annually in late October to assess bed elevation, bankfull width, and channel morphology. Wolman pebble counts will be conducted annually at each transect to assess substrate size distribution. A minimum of 100 substrate particles will be measured along the intermediate axis and percent embeddedness (0, 25, 50, 75, 100) will be estimated for each particle less than 7mm in diameter.

Filamentous Algae
In conjunction with other stream morphology work, percent cover of filamentous algae on stream-bottom substrate will be determined along 5 permanent transects in each study reach and the control reach in late October. Presence or absence of filamentous algae in the wetted channel will be recorded at the beginning of each one-foot interval along each transect cross section.

Stream discharge
Discharge measurements are recorded every 15 minutes at USGS gages (USGS 10080000) operated by PacifiCorp downstream of Grace Dam (located just upstream of the railroad trestle bridge) and upstream of Soda Reservoir (Alexander Reservoir) (PacifiCorp 2005).

Data Analyses

Impact Analyses
The significance level for rejecting null hypotheses for statistical comparisons in this study will be $\alpha = 0.1$. By adopting this significance level over the more traditional $\alpha = .05$ we will decrease the chance of committing type II errors, thereby reducing the possibility of falsely accepting the null hypothesis (no effect of WBF on macroinvertebrate and fish community populations and distributions). A biologically-significant impact is defined as a statistically significant ($\alpha \leq 0.1$) change of $\geq 10\%$ in any metric between non-WBF years and WBF years. Data will be analyzed using a weight of evidence approach to evaluate all biologically-significant results (included in this evaluation will be comparisons with reference reach data) and determine their overall impact (positive or negative) to the system. If the ECC determines that an overall negative change has occurred due to WBF, adaptive flow management to minimize those effects will be considered.

Macroinvertebrates

Macroinvertebrates will be identified to the lowest possible taxonomic level and counted in the laboratory. Data will be analyzed using standard metrics for assessing macroinvertebrate communities (IDEQ 2002a, IDEQ 2002b). Table 1 outlines selected metrics for assessing changes in macroinvertebrate community structure that could result from the release of whitewater boating flows in the study area (IDEQ 2002a, IDEQ 2002b).

Table 1. Definitions of the potential macroinvertebrate metrics for use in the Black Canyon Monitoring Plan and the predicted direction of metric response to increasing perturbation.

Metric	Definition	Change
Richness measures		
Number of taxa[1]	Number of distinct taxa	decrease
Number of EPT taxa[1]	Number of distinct taxa in the orders Ephemeroptera, Plecoptera, and Trichoptera	decrease
Number of Ephemeroptera taxa	Number of distinct taxa in the order	decrease
Number of Plecoptera taxa	Number of distinct taxa in the order	decrease
Number of Trichoptera taxa	Number of distinct taxa in the order	decrease
Composition measures		
Percent Elmidae[1]	Relative abundance of the riffle beetles (Coleoptera: Elmidae)	decrease
Percent Hydropsychidae	Relative abundance of the net-spinning caddisflies (Trichoptera: Hydropsychidae)	increase
Percent Chironomidae	Relative abundance of midges (Diptera: Chironomidae)	increase
Percent Hirudinea	Relative abundance of leeches	increase
Percent Gastropoda	Relative abundance of snails	increase
Percent Pteronarcys	Relative abundance of the stonefly nymph Pteronarcys (Plecoptera: Pteronarcyidae)	decrease
Percent Amphipoda	Relative abundance of	increase

	amphipods	
Percent Oligochaeta	Relative abundance of aquatic worms	increase
total biomass	Total abundance of invertebrates (mg/m^2)	variable
total density	Total abundance of invertebrates ($No./m^2$)	variable
Pollution Tolerance Measures		
Hilsenhoff's biotic index	Calculated using tolerance values for Idaho invertebrates	increase
Diversity measures		
Simpson's dominance index	An index measuring the dominance of the community by one or a few taxa	increase
% dominant taxon[1]	Relative abundance of the most common taxa	increase
Feeding measures		
Percent scrapers	Relative abundance of this functional group	decrease
Percent predators[1]	Relative abundance of this functional group	variable
Percent gatherers	Relative abundance of this functional group	variable
Percent shredders	Relative abundance of this functional group	decrease
Percent filterers	Relative abundance of this functional group	increase
Percent miners	Relative abundance of this functional group	increase
Voltinism measures		
Semi-voltine taxa	Number of taxa that have aquatic life cycles lasting more than one year	decrease
% Semi-voltine	Percent of sample that are semi-voltine	decrease

[1] Metrics used to calculate a River Macroinvertebrate Index (RMI) score. RMI scores will be compared over years of the study to determine general changes in macroinvertebrate community condition.

Organic Matter, **Periphyton Ash-Free Dry Weight, and Chlorophyll a**

The autotrophic index (AI) will be calculated by dividing periphyton ash-free dry weight by chlorophyll *a*. AI, chlorophyll a and organic matter data will be compared using a repeated measures analysis of variance (ANOVA) and Tukey's posthoc test for

significant differences. Relationships between these factors and macroinvertebrate metrics under different flow regimes and in the control reach will be investigated to better understand potential mechanisms for changes in the macroinvertebrate community.

Fisheries
Relative species composition and number of fish by species will be compared over time. Fish condition index will be compared before and after WBF. Other metrics to be used in fishery evaluations include: relative weights of trout and whitefish, cohort or recruitment variability, and Catch Per Unit Effort (CPUE).

Water Temperature
Maximum and minimum daily and weekly temperatures will be determined. Cumulative degree days also will be determined annually.

Channel Structure and Substrate
Survey transect cross section data will be used to monitor maximum depth, wetted perimeter, channel width, channel area, and bed elevation. A repeated measures ANOVA will be used to assess changes in these metrics over time.

Filamentous Algae
The presence/absence determinations of filamentous algae on stream-bottom substrate will be used to create filamentous algae total percent cover diagrams for each of the five transects in each of the study reaches and the control reach. These diagrams will be used to assess changes in percent filamentous algal cover through the duration of the study.

Literature Cited

American Public Health Association. 1995. Standard methods for the examination of water and wastewater. A.D. Eaton, L.S. Clesceri, and A. E. Greenberg eds. American Public Health Association.

City of Tacoma department of public utilities, light division, Nisqually hydroelectric project, FERC No. 1862. 2004. License article 421, LaGrande bypass reach fish monitoring study report. Nisqually hydroelectric project, FERC No.1862.

Grafe, C.S., C.A. Mebane, M.J. McIntyre, D.A. Essig, D.H. Brandt, and D.T. Mosier. 2002. The Idaho Department of Environmental Quality Water Body Assessment Guidance, Second Edition-Final. Idaho Department of Environmental Quality; Boise, Idaho.

Grafe, C.S. (ed.). 2002. Idaho River Ecological Assessment Framework: An Integrated Approach. Idaho Department of Environmental Quality; Boise, Idaho.

Grafe, C.S. (ed.). 2002. Idaho Small Stream Ecological Assessment Framework: An Integrated Approach. Idaho Department of Environmental Quality; Boise, Idaho.

Harvey, B.C., Nakamoto, R.J., and J.L. White. 1999. Influence of large woody debris and a bank full flood on movement of adult resident coastal cutthroat trout (*Onchorhynchus clarki*) during fall and winter. Canadian Journal of Fisheries and Aquatic Science 56: 2161-2166.

Holomuzki, J.R. and J.F. Biggs. 2003. Sediment texture mediates high-flow effects on lotic macroinvertebrates. JNABS. 22(4):542-553.

IDEQ (Idaho Department of Environmental Quality). 2002. Idaho River Ecological Assessment Framework. Boise, Idaho.

IDEQ. 2002. Idaho Small Stream Ecological Assessment Framework. Boise, Idaho.

IDEQ. 2004. Beneficial Use Reconnaissance Program Field Manual for Streams. Boise, Idaho.

Imbert, J. B.; Perry, J. A. 1999. Invertebrate responses to stepwise and abrupt increases in non-scouring flow: the role of refugia. Archiological Hydrobiology 146: 167-187.

Kilbane, G.M. and J.R. Holomuzki. 2004. Spatial attributes, scale, and species traits determine caddisfly distributional responses to flooding. J.N. Am. Benthol. Soc. 23(3):480-493.

King, J., J.A. Cambray, and N.D. Impson. 1998. Linked effects of dam-released floods and water temperature on spawning of the Clanwilliam yellowfish *Barbus capensis*. Hydrobiologia 384:245-265.

Lamberti, G.A. and V.H. Resh. 1985. Comparability of introduced tiles and natural substrates for sampling lotic bacteria, algae and macroinvertebrates. Freshwater Biology 15:21-30.

Matthews, W.J., M.S. Schorr, and M.R. Meador. 1996. Effects of experimentally enhanced flows on fishes of a small Texas (U.S.A.) stream: assessing the impact of interbasin transfer. Freshwater Biology 35:349-362.

PacifiCorp. February 9, 2005. PacifiCorp Water Release Information. Available at http://www.pacificorp.com/hydro_hiws.

Robinson, C.T., S. Aebischer, and U. Uehlinger. 2004. Immediate and habitat-specific responses of macroinvertebrates to sequential, experimental floods. JNABS. 23(4)853-867.

UDWR (Utah Division of Wildlife Resources). 2000a. Range-wide Conservation Agreement and Strategy for Bonneville Cutthroat Trout Management (RCAS). Publication No. 00-19.

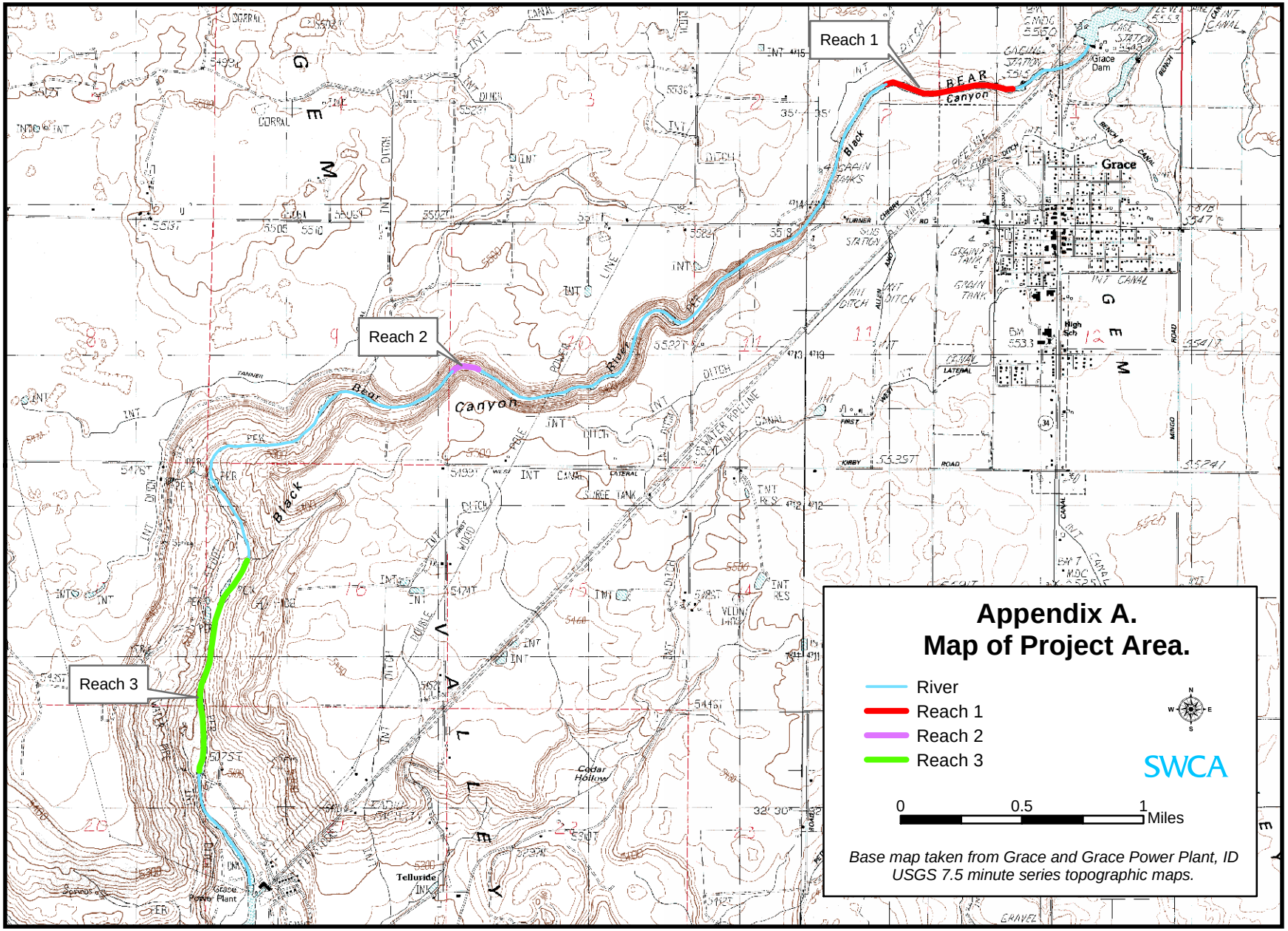
UDWR. 2000b. Cutthroat Trout Management: A Position Paper, Genetic Considerations Associated with Cutthroat Trout Management (CTMAPP). Publication No. 00-26.

Ward, J.V. 1998. Riverine landscapes: biodiversity patterns, disturbance regimes, and aquatic conservation. Elsevier Science Ltd.

Zaroban, D.W. 2000. Water Quality Monitoring Protocols – Report No. 10. Protocol for placement and retrieval of temperature data loggers in Idaho streams. Idaho Division of Environmental Quality, Boise, Idaho.

Appendix A

Study Area Map
(attached separately as a PDF file)



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