Report on Chuitna Coal Project Aquatic Studies and Fish and Wildlife Protection Plan

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Introduction

This report summarizes my review of the following list of documents related to the proposed Chuitna Coal Project.

(A) Aquatic Baseline: Existing Information for the Chuitna Coal Mine Project [Oasis Environmental, Inc.] (June 18, 2006);

(B) 2006 Freshwater Aquatic Biology Study Program [Oasis Environmental, Inc.] (April 4, 2007), including Appendices 1-8;

(C) 2007 Freshwater Aquatic Biology Study Program [Oasis Environmental, Inc.] (March 22, 2008), including Appendices 1-10 and Scanned Data Sheets;

(D) Wetland Functional Assessment [HDR Alaska, Inc.] (March 5, 2008);

(E) ASCMCRA Mine Site Permit Application, Part D7: Fish & Wildlife Protection Plan [PacRim Coal, LP] (July 2007), including all appendices;

(F) Agency correspondence concerning aquatic resources studies and study plans;

(G) 2008 Freshwater Aquatic Biology Study Program [LGL] [Jan. 2009].

My analysis of these reports focused on whether the aquatic resources studies were conducted using sound methodologies; whether the aquatic resources studies collected enough data and the right kinds of data; whether the aquatic resources studies provide an adequate understanding of the aquatic system; whether the reports provide an adequate foundation for a successful fish and wildlife protection plan; whether the fish and wildlife protection plan will successfully protect aquatic resources; and whether the aquatic resources studies provide adequate information for the U.S. Army Corps to make the required determinations under the 404(b)(1) Guidelines.

A. Aquatic biology: Existing information for the Chuitna Coal Project. Oasis Environmental 2006.

Purpose: to summarize existing information on freshwater aquatic biology collected in 1982, 1983, 1984 and 1987 by Environmental Research and Technology, Inc.

Analysis and Comments:

The existing information from the studies in the 1980's provided in the summary is very limited. It isn't clear if the original studies didn't collect a lot of the types of data now known to be necessary to assess the impact of the project or if Oasis didn't include everything in the summary. For example there is no information on phreatic and hyporheic groundwater flow investigations from the early studies.

Assuming that the 1982-1984 studies were equally rigorous, it would have been very helpful if the authors compared the data on fish and macro invertebrates to the data from the 2006-2008 studies in this summary. There are clearly differences in the number of adult Chinook, coho and pink salmon reported in the 1980's and the present studies. Some of the data summarized in Figure 4 Timing of Life History Events for Salmonid Species in the Chuitna Drainage also raises similar questions. For example, the table indicates that chum and pink salmon fry emerged and out migrated from mid-February to mid-May. Did this data come from age zero fry collected during winter sampling in the early 1980's? LGL did not report capturing any chum or pink fry in their winter sampling program in 2007-2008. As another example, the spawning period reported for coho from the 1982-87 studies as reported in Table 4 is September 1 through October 30. In 2008 LGL removed the weirs on Streams 2002-2003 and stopped counting adult coho on September 30. It is unclear whether this means that the timing of coho spawning has changed, that LGL missed a portion of the coho run, that the 1980's data is incorrect, or something else.

Summary: There are significant differences in the findings of the 1980's studies and the 2006-2008 studies. It is unclear if these differences are the result of changes in species composition, numbers and life history or differences in methodology.

B. Chuitna Coal Project 2006 Freshwater Aquatic Biology Study Program. April 4, 2007. Prepared by Oasis Environmental, Inc.

Oasis' study objectives related directly to fisheries:

1. Relative abundance, community composition, juvenile and adult distribution and spawning habitat
2. Water quality at trap locations and physical habitat evaluation locations
3. Channel morphology, habitat types, shape and substrate composition, and:
4. Human use of the fishery.

This information collected would be used to "assist with impact assessment" and "support project mitigation and reclamation plans. The channel morphology information would be "used to rebuild the affected streams to a level comparable with their original state and value."

Analysis and Comments:

Executive summary:

Page xii paragraph: "Adult salmon distribution was determined by aerial and ground surveys." Although aerial and ground surveys are often used to count salmon, these counts tend to underestimate the number of salmon present. There is within and between observer's bias in aerial and foot survey estimates of spawning abundance of salmon (Jones et al 1998 and Bue et al 1998). The ability to see salmon from an aircraft is dependent on many factors, including light level, time of day, skill of the pilot, water clarity and depth, and stream bank vegetation. Aerial and foot counts tend to significantly underestimate the number of salmon present (by 25% to 68%) and are useful only as general indices of abundance (Jones et al 1998). To accurately determine adult escapement in the Chuitna River drainage, a weir or sonar counter is also needed at the river's mouth. Counts should continue over 5 to 10 years because of the large natural fluctuations in population numbers and species composition over time.

2.2.1 Juvenile. Streams. Minnow traps: The 0.32 cm. mesh used to cover the minnow traps is large enough to allow age 0 salmonids to swim through it, so these fish may have not been accurately represented in the catch. Placing traps only in areas believed to be good juvenile salmon habitat likely biased the results.

2.5 Paragraph 2: If aerial surveys were impractical for estimating the number of adult salmon migrating up tributary streams due to poor visibility, and foot surveys were not used to estimate the number of spawning adult salmon, it is unclear how the estimates of adult spawning escapement in the tributaries were derived.

Ground surveys. Page 2.7. If lateral tributaries to streams 2002-2004 without minnow traps weren't surveyed, how did Oasis conclude that no adults spawned there? ADF&G

Habitat Division staff found both spawning adult and juvenile coho salmon in first and second order tributaries to the Hoholitna River in the 1980's.

2.5.1 Reference Reach Stratification page 2-14

2.5.2 Reach Selection Paragraph 3: Because of the great variation in stream morphology, stream flow, groundwater input , substrate, bank composition and other factors, it is not clear how a limited amount of data from a few hundred feet of stream channel in stream 2003 could be used to restore the 17.4 km miles of stream that will be excavated by mining. The report should also explain how information from streams 2002 and 2004 would be used in direct comparison to stream 2003 for restoration and rehabilitation purposes, since there appear to be substantial physical and biological differences between these streams.

It should be noted that Oasis also suggests that the data could be also used to rehabilitate streams 2002 and 2004 in the event that they are "inadvertently" impacted by mining. It seems likely that these streams will be also be impacted by mining to some degree. Studies from other strip mines show that mining within a watershed – as will occur here in portions of the 2002 and 2004 watersheds -- affects surface water quality even when modern erosion and sediment control measures are used (Pond 2004). Mining through existing aquifers and pumping to dewater the mine could also affect groundwater flow in these drainages (National Research Council 1990, Schwartz and Crowe 1985, and Wilson and Hamilton 1978). However, it is not clear how a limited amount of morphological stream data could be used to restore streams affected by the loss of groundwater in the absence of adequate instream flow and groundwater data from streams 2002 and 2004.

Page 2.16-2.20: The use of the Rosgen stream classification system is useful to classify streams and stream reaches; however, there are problems with using classification data as a method to restore streams (Simon et al 2007 and Gillian 1996).

Page 2-20 paragraph 7. The flow of groundwater to streams 2002-2004, particularly during the winter, is one of the most critical factors in salmonid egg and overwintering survival (Baxter and McPhail 1999 and Douglas 2006). To successfully reconstruct a new stream that is equally as productive as the present stream 2003, it would be necessary to reconstruct a new shallow aquifer to provide the same amount of flow, reestablish seasonal flow patterns and duplicate the existing chemical composition of phreatic groundwater.. This is important because: ground water in coal mine tailings often contains elevated levels of salts and metals such as zinc which is toxic to juvenile salmonids from 93 to 815 parts per billion, and ; spawning salmonids use chemical cues to locate their natal streams (Chapman 1978 and Dittman and Quinn 1996). I have searched the scientific literature and haven't found any instances where a new shallow aquifer has been recreated in a large drainage to support salmon spawning, or where premine ground water chemistry was duplicated. .

It is not clear how the flow of groundwater to streams 2002-2004 could be determined by measuring surface water temperatures and noting what appear to be seeps and springs at a few sites. First, groundwater may enter the hyporheic zone at one point but not surface for some distance downstream. In order to accurately measure and map groundwater input, it would be necessary to measure temperatures in the streambed systematically at many locations over the entire drainage. There may be more effective means available than thermometers to identify and measure groundwater input into Chutina drainage streams. A number of recent studies have used thermal infrared remote sensing to detect groundwater input into lakes and streams over a large area (Watershed Sciences 2007, Meijerink 1996, and Ackerman 2003).

Second, many species of salmonids select areas of groundwater input to spawn and overwinter (Bustard 1986, Baxter and McPhail 1999, Cunjack 1996 Swales et al 1986). Salmon eggs are deposited below the streambed and overwintering juvenile fish may move into streambed interstices in the hyporheic zone to escape ice and lethal low temperatures (Bjorn and Reiser 1991). Salmon eggs are deposited at some depth within the streambed. Large fish such as Chinook may dig as deep as 43 cm (17 inches) beneath the streambed and smaller fish 20-30 cm (8-11 inches). Phreatic groundwater at these depths would not be detected by surface water temperature measurements. In cold climates juvenile coho often select areas of groundwater upwelling to overwinter (Bustard 1986).

Stream habitat and abundance as CPUE page 3-11. The report indicates that: "Rosgen stream channel types will be used as the basis for river reconstruction after mining operations with each stream type encompassing a section of river with similar physical and biological attributes. Because of the importance of Rosgen stream channel types, statistical comparison of CPUE is based on Rosgen channel types." The report should explain why Rosgen stream channel types are so important and why they will be used to reconstruct streams after mining.

The problem with simply using the Rosgen classification system to reconstruct 17.4 km of a salmon producing drainage is that it doesn't take into consideration such things as water quality, surface water and groundwater seasonal flow patterns, stream temperature patterns, phreatic groundwater flow, and many other subtle factors that allow salmon to successfully complete their freshwater life cycle. Salmon in streams 2002-2004 are probably genetically adapted to the unique conditions in each of these streams and even small changes will likely result disrupt their life cycle.

Habitat spawning surveys. Page 3-35 paragraph 1. The range of temperatures reported at spawning redd locations (coho 7.32 to 11.36 degrees C, Chinook 11.60 to 15.56 degrees C, and pink 9.78 to 12.13 degrees C) is interesting. The lower temperatures at coho and pink redds could be an indication that coho and pink salmon are selecting sites with upwelling groundwater which in the summer would be colder than surface waters. Stream temperatures in the Cook Inlet basin tend to peak from May 15 to August 15 (Kyle and Brabets 2001). In 2006, Chuitna Chinook spawned from July to August, pinks from mid-July to mid-August, and coho from August 15 to October 15 (Figure 4-1). However, it is not possible to determine from the data provided if salmon are selecting spawning areas with groundwater input, because water temperatures were taken at the surface of the redds instead of 8 to 17 inches into the stream bed where salmon eggs are deposited (Bjorn and Reiser 1991. Stream temperatures may also vary by several degrees daily and tend to be lower during pink and coho spawning.

Adult Distribution page 4-14: My experience is consistent with Oasis's finding that beaver dams do not obstruct adult upstream migration. Because coho, chum and pink salmon runs tend to coincide with late summer and fall rains when beaver dams overflow, salmon and other species of fish are usually able to move upstream around or over the dams with little trouble. I have observed coho, sockeye, chum salmon, white fish, and Dolly Varden moving upstream past beaver dams during high water events. I also agree that given current coho numbers, ERT's findings that "beaver dams were responsible for limiting adult coho access to far reaches of the drainages in 1982-1984" and that no coho were observed in stream 2003 in 1982, seem unusual. It could mean that there has been a major species shift from Chinook to coho salmon in stream 2003 or that coho's were present in the system but earlier studies weren't rigorous enough to detect them. Either scenario warrants additional research on coho and Chinook salmon abundance and life history. I discussed this with ADF&G research biologists and no major shift in relative coho and Chinook abundance was observed in other Cook Inlet streams from 1982 to 2009 (Hasbrouck 2009).

Juvenile fish habitat considerations, pages 4.6-4.7. Recent scientific studies have identified groundwater flow as a critical factor in the selection of adult salmonid spawning habitat, juvenile overwintering areas and the survival of eggs, fry and juvenile salmonids in cold climates (Leman 1993, Giannico and Hinch 2003, Malcolm et al 2004, Baxter and McPhail 1999, Lorenz and Filer 1989, and Douglas 2006). However, there is no discussion of groundwater flow as a habitat factor in the report. The 2006 study didn't identify sources of groundwater or investigate the relationship between phreatic groundwater in the hyporheic zone and salmonid spawning and overwintering in streams 2002-2004. Figures 1 and 2 illustrate how groundwater enters streams. Mining coal to a depth of 300 feet will remove all the layers of sediment or lithological units of low permeability that confine the aquifers (confining units) and currently provide shallow groundwater to stream 2003 and possibly streams 2002 and 2004. To restore fish habitat in these streams after mining it, it would be necessary to restore these confining units and provide the same quality and quantity of groundwater.

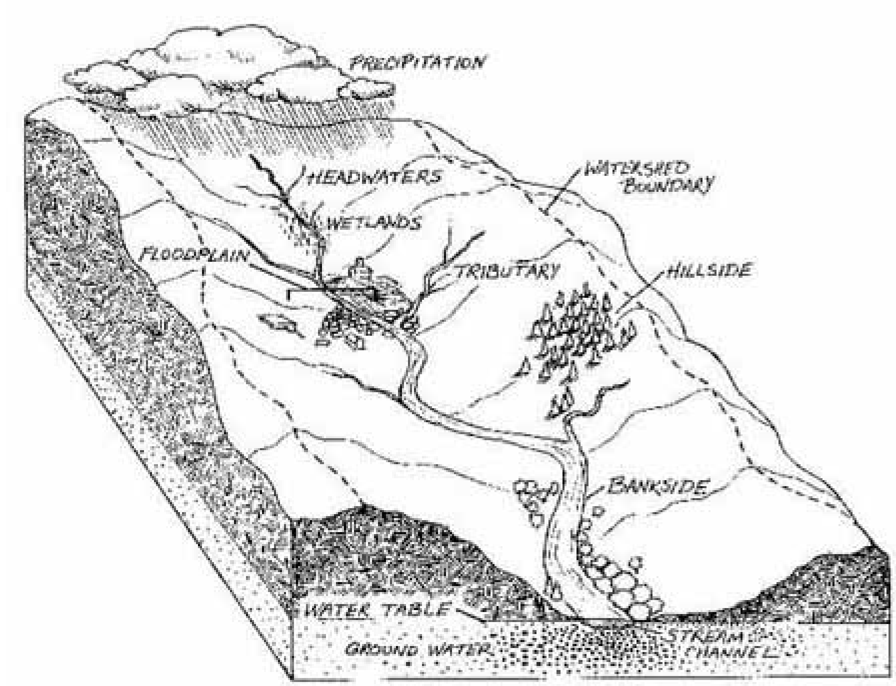

Figure 1: Cross Section of a Watershed (Source USEPA)

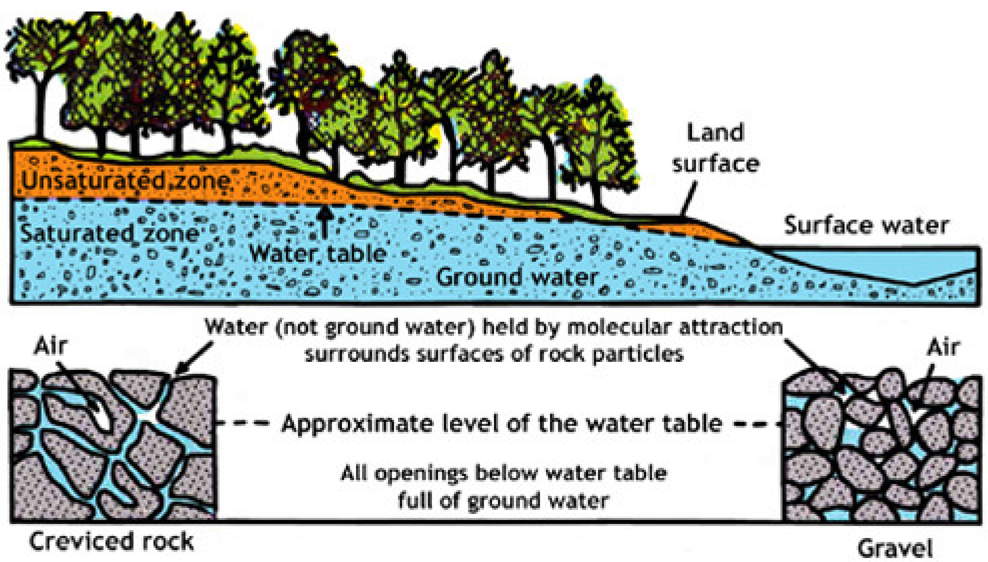

Figure 2: Cross Section of a Stream Drainage (Source: USGS)

Groundwater is critical because it maintains stream base flow and moderates water level fluctuations, particularly during the 5 to 6 months of winter when there is no liquid precipitation. It provides stable temperatures and thermal refugia for fish. It provides water for riparian vegetation which controls bank strength and the rate of erosion (Douglas 2006). It also creates the hyporheic zone (Figure 3).

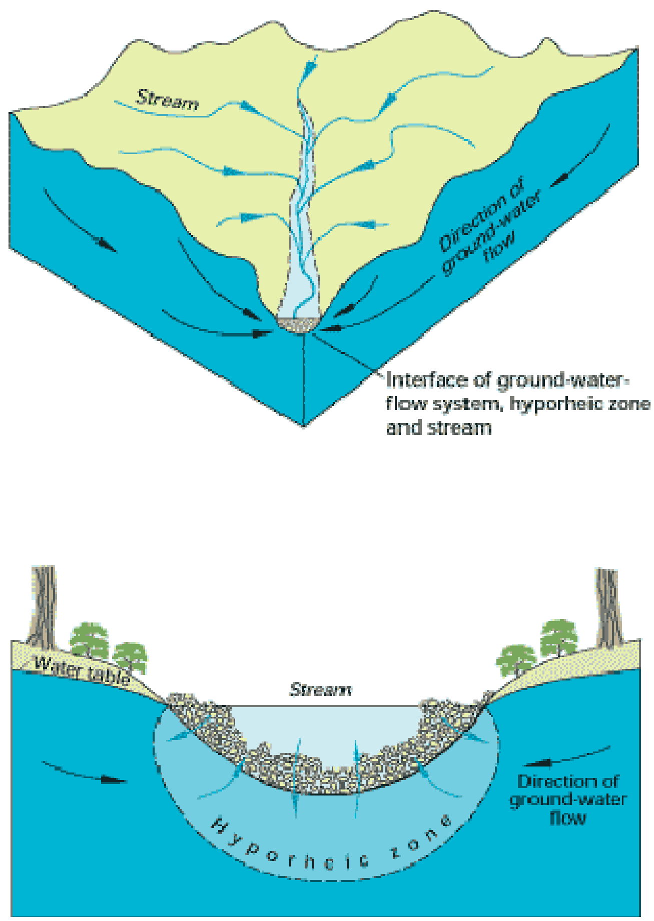

Figure 3: Hyporheic Zone (Source: USGS Circular 1186)

The hyporheic zone is the region beneath and lateral to a streambed where there is mixing of shallow groundwater and surface water. It is an active ecotone between the surface stream and groundwater. Exchanges of water, nutrients, and organic matter occur in response to variations in discharge and bed topography and porosity. Upwelling subsurface water supplies stream organisms with nutrients and cool water in the summer and warm water in the winter. Downwelling stream water provides dissolved oxygen and organic matter to microbes and invertebrates in the stream bottom (Boulton et al 1998). Upwelling groundwater is vital because it protects salmonids and other cold water fishes from water temperatures that exceed their thermal tolerance in the summer (Hayes 2009). Groundwater provides overwintering habitat free of subsurface ice and protects fish eggs, larvae and juvenile fishes from freezing in the winter (Power et al 1999).

Two types of groundwater influence streams: Hyporheic groundwater and phreatic groundwater (Poole and Berman 2001). Hyporheic groundwater is from the alluvial material which underlies the streambed. It travels downstream along localized pathways before emerging further downstream. Phreatic groundwater comes from the catchment's aquifer and feeds a stream by entering the bottom of the alluvial material and mixing with the hyporheic groundwater (USGS 2006). Groundwater from the phreatic aquifer influences stream temperature when it enters the stream. The two-way exchange between the alluvial aquifer and the stream channel is perhaps the most important stream temperature buffer (Douglas 2006).

The hyporheic zone is an area of intense biochemical activity. Biogeochemical processes within the upper few centimeters of sediments have a profound effect on the chemistry of groundwater and surface water that mix in that area. Biogeochemical process is the partitioning and cycling of chemical elements and compounds between the living and non-living parts of a stream. The highly interactive nature of physical, chemical and biological processes in the hyporheic zone play a central role in the functioning of stream ecosystems (Malcolm et al 2003).

Streams can be classified as gaining, losing, or disconnected. Gaining streams gain surface flow from inflowing groundwater and losing streams lose flow through the streambed to the groundwater. Disconnected streams are streams where there is an unsaturated layer of air between the stream and groundwater. Streams can be both gaining and losing.

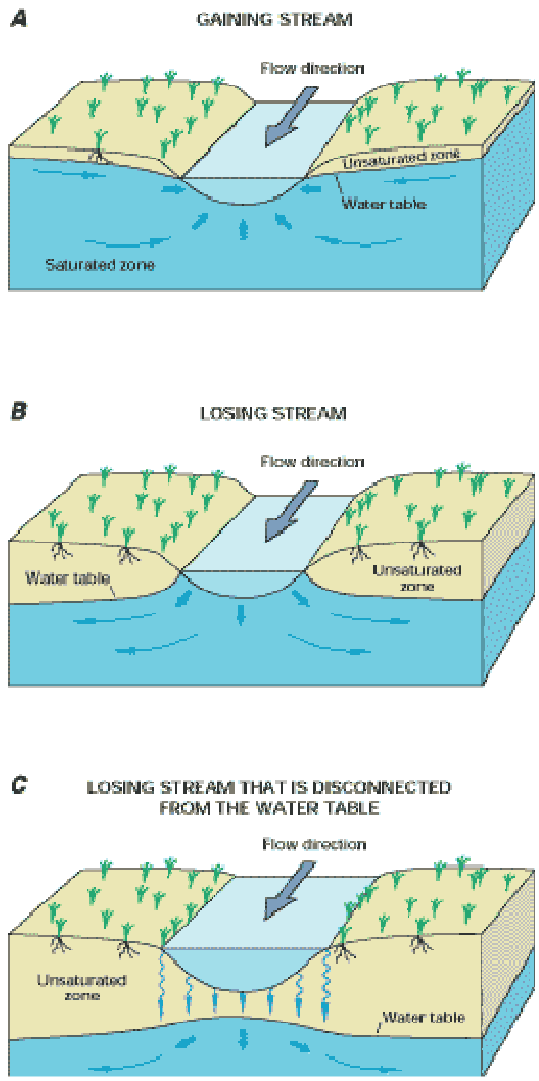

Figure 4: A. Gaining stream, A. Losing stream and C. Disconnected stream
(Source USGS Circular 1186)

Streams 2002-2004 appear to be gaining streams but could have sections which lose water to a deeper aquifer. However, it does not appear that PacRim or its contractors has collected enough data to make a stream segment by segment determination. Deep mining through the existing aquifers and pumping to draw down the aquifers and dewater the pit would likely lower the water table substantially. As a result, Stream 2003 would likely become a disconnected stream and lose water (Figures 4A, 4C, and 5). It is possible that streams 2002 and 2004 could also be affected by the drawdown of the water table.

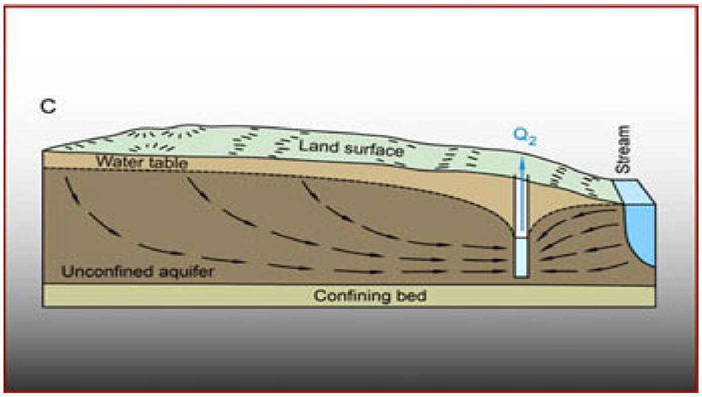

Figure 5: Drawdown of Aquifer From Pumping (Source: www.learner.org)

Monitoring and testing of groundwater in reclaimed strip coal mines indicate that groundwater is stored in and flows through large voids or conduits in spoil. However, these voids are not always connected across a mine site (Hawkins 1998 and Hawkins and Aljoe 1992). Because groundwater does not flow through coal mine spoils as it would through unconsolidated alluvium it would be very difficult to design and restore phreatic groundwater flow to stream 2003 or insure that groundwater flow to streams 2002 and 2004 would be maintained.

4.7. Human Use page 4.34 Commercial, personal and subsistence harvest: Although the reported average commercial harvest of approximately 33,000 sockeye and 33,000 coho from the Beluga and Tyonek Districts (which includes fish from the Chuitna River) may not seem large when compared to other fishing districts in Cook Inlet, these are healthy runs which can continue in perpetuity as long as the habitat is intact. To put this into perspective the sockeye harvest in these districts is almost twice the 2008 Canadian commercial harvest of 16,000 sockeye from the Frazer River (Pacific Salmon Commission 2008). The Frazer River was once one of the largest sockeye salmon producing systems in the world, but since the 1990's the runs have declined precipitously. Some Frazer River coho and steelhead stock are so depressed they have been classified as endangered. Fisheries and Oceans Canada (2008) attributes the decline to watershed development including mining, agriculture, logging and global warming. Even though the Canadian government has attempted to arrest the decline by spending millions of dollars on the same types of habitat restoration and enhancement proposed for the Chuitna Coal Mine, these efforts have been largely unsuccessful.

Summary:

1. The report does not explain how one year of CPUE data from minnow trapping can be used to determine the impact of strip mining on stream 2003 or how it will be used in stream restoration. The assumptions, limitations and problems with using minnow traps are not presented or discussed in the report. CPUE does not provide an estimate of the population size of each species of fish which is needed to assess impacts and restoration success. Juvenile salmon populations and CPUE may change substantially from year to year and from stream to stream. For

example, over a 17-year period the estimated juvenile coho population in the Kenai River ranged from 400,000 to 1,200,000, a change of over 300% (Massengill 2009).

2. Aerial and foot adult escapement surveys do not provide accurate estimates of escapement levels, especially in small streams. A weir or sonar counter is needed to enumerate adult escapement into the Chuitna River and into streams 2002-2004. Because of substantial annual variations in run size, a minimum of 5 to ten years of continuous escapement data is needed.
3. A comprehensive understanding of stream flow and groundwater flow into streams 2002-2004 is necessary to determine the instream flow needs of fish and other aquatic life and to assess impacts of strip mining and to restore watersheds impacted by mining. However, no comprehensive instream flow study and no study of the input of shallow groundwater by sub-basin have been conducted. To account for seasonal and annual fluctuations in groundwater, a minimum of 5 to 10 of years of data are needed (Rice 2009, Zhou et al 2004, and Mouw 2009).

C. Chuitna Coal: 2007 Aquatic Biology Studies Program

I. **Introduction**

Page 1: The purpose of the 2007 Oasis aquatic biology studies program was to supplement and enhance the baseline information gathered in 2006. The purpose of the 2006 study was to determine resources and habitats in the Chuitna drainage that could be affected by the project, including streams 2002, 2003, 2004, Chuit and Three Mile Creeks and the mainstem Chuitna River .

Analysis and Comments:

2.1 Methods:

2.1.1 page 2.1 paragraph 2. The selection of minnow trapping sites based on what the researchers believed to be good habitat (e.g. good cover and low water velocities) may have biased the results. Traps should have been placed using a randomly generated sampling strategy in all types of habitat and the catch rates should have been used to identify preferred coho habitat in streams 2002-2004. Variations in water levels and water velocities at the trap sites over the sampling period would also affect the catch rate. High water levels and increased water velocities would displace coho from trap sites to slower waters. High water velocities could result in a narrower cone of dispersal, carry the scent further downstream, and make it more difficult for fish to swim upstream to the trap. Lower water levels and velocities would have the opposite effect. Catches from traps placed in shallow and faster water would have helped support the researcher's concept of good coho rearing habitat.

Minnow trapping occurred at the same sites in 2006 and , but the report did not indicate whether or not there had been any changes in the stream channel (i.e. cover, water velocities, or substrate) at those sites, which could have affected the catch rate.

2.1.1 paragraph 3 page 2.2. Why were all of the juvenile Coho from streams 2002-2004 and the Chuitna pooled for the length frequency analysis? A separate analysis could have shown if there are morphological differences (i.e. size, condition etc.) between coho stocks in these streams. Morphological differences, which may be the result of genetic isolation, have been documented in scientific studies of coho stocks in nearby tributaries of small coastal watersheds (Bailey and Irvine 1991). This is important because if observed differences were the result of genetic isolation and adaptation to the unique conditions in these streams, it would make the task of successfully restoring stream 2003 fish populations much more difficult.

Figure 2.1.1. It could be problematic that all of the minnow trapping locations were located at or below the road crossing. The effects of road construction include short term elimination of benthic life and fish population for some distance below the crossing site due to siltation and turbidity, as well as obstruction of adult and juvenile upstream migration due to poorly installed and maintained culverts, floods etc. (Barton 2006 and Moore et al 1999).

Figure 2.1.2. Why wasn't there any winter trapping in streams 2002 and 2004 to identify and characterize overwintering habitat? Suitable overwintering habitat associated with the input of groundwater is believed to be a critical factor in freshwater salmonid survival in cold climates (Fisheries and Oceans Canada 2009, Mouw 2005, and Baxter and McPhail 1999). Streams 2002 and 2004 and their fish populations are almost certainly going to be adversely affected by changes in surface and groundwater temperature and flow resulting from deep mining in their watersheds. It is possible that these streams could change from gaining streams to losing streams due to groundwater pumping to dewater the mine (USGS 2008 and Hancock 2002).

2.1.1 Page 2.6 paragraph 1. The statement that "CPUE was calculated by dividing the catch by the number of hours fished and multiplied by 24 hours for a nominalized trap catch for 24 hours" needs some clarification since the same paragraph indicates that the traps were fished for 24 hours! Further, the use of the CPUE's from these traps needs to be qualified because in areas of high population density, catches of juvenile salmonids probably reach a peak after 1-2 hours while catches in areas of lower density may continue to increase over 24 hours (Swales 2008). Because of this phenomenon, the relative densities of coho populations estimated from 24 hour trap soaks may be too low for high density areas and too high for low density areas.

3. Results and Discussion:

3.1.1.1. Fisheries Resources: page 3.1 paragraph 2. The explanation for the use of percent relative composition (i.e. percentage composition provided a way to discuss the relative numbers of species captured in minnow traps and make inferences on the communities which reside in those streams) instead of CPUE is unclear. Why not use both? CPUE gives the reader an idea of the relative population densities by stream. A comparison of CPUE by species by year can also provide an indication of changes in population numbers and community composition (i.e. a 50% decline in CPUE might indicate a change in population numbers). CPUE is also commonly used in fisheries studies for that purpose.

Page 3.1 paragraph 3. It is generally believed that pink salmon fry in coastal streams do not feed in fresh water but migrate directly out to marine waters. In freshwater, chum salmon fry feed on insect larvae for some time before outmigration. It is not likely that they would be captured in smolt traps baited with salmon eggs. Also, age zero fry of all species and possibly some age 1 fry are small enough to swim through the mesh used in minnow traps. This means that these species and age groups may have been present but underrepresented in the catches.

Page 3.1 Coho salmon: The use of percentages of catch by species in the catch does not seem to be that useful for purposes of environmental impacts assessment, permitting and mitigation. The actual number of each species captured would have been more useful. For example, 88% of a catch of a million fish (880,000) is a lot different than 88% of a thousand fish (888). It is unclear whether the percentage figures (63-88%of the fish population) are for coho fry alone or if they include spawning adults.

Page 3.3 Paragraph 3 Sticklebacks: The large increase in stickleback numbers in the Chuitna and Threemile Creek could be explained by the fact that there are anadromous stocks of sticklebacks in Cook Inlet and they enter streams in large numbers in some years.

3.1.3.2 Comparing Rosgen Stream Types Within Study Streams: Page 3.15 paragraph 2: There are many different types of Rosgen B, E and C channels based in part on slope. The statement that “Rosgen type B channels typically exhibit the highest gradient and current velocities compared to C and E channel types” is accurate only for B1a-B6a channel types (Rosgen 1994 and 1996). B1-B6 and B1c-B6c have the same slopes as Type E channels and C 1b-C6b channels. The authors should specify what types of B channels they are reporting on, especially if this information is going to be used in developing mitigation and reconstructing stream channels.

Page 3.16, paragraph 1: The speculation that Rosgen type C channels supported the highest concentrations of spawning adult coho and also had the highest CPUE of all channel types, and that this might be related to nutrients provided by adult salmon eggs and carcasses is important. It is important because mining will eliminate these stream channels and the anadromous fish stocks which spawn in them.

There is a large body of scientific literature showing that Pacific salmon are the major vehicle transporting marine nutrients across ecosystem boundaries from marine to freshwater and terrestrial ecosystems. Nutrients from salmon eggs and carcasses play a major role in the productivity of both freshwater and riparian ecosystems and in perpetuating future salmon runs. Most fisheries scientists and fisheries managers have concluded that stream ecosystem health benefits from having the largest number of spawning salmon possible (WDFW 1997), which in turn produces a large number of carcasses. The eggs and carcasses from these spawning salmon provide an essential source of food for rearing salmon and other fishes which concentrate in these areas. Nutrients from decaying carcasses also provide food and nutrients for insects such as chironomids which are the major food source for salmonids during the rest of the growing season. Bilby et al (1996 and 1998) found that benthic algae, invertebrates and fish in salmon streams were significantly enriched with both marine carbon and nitrogen. The average contribution of marine nitrogen ranged from 11% for invertebrate predators to 31% for juvenile Coho. The highest percentage of marine nitrogen was 46% for adult cutthroat trout and 61% for age 1 plus steelhead. The same researchers also found that the growth rate of juvenile coho doubled after adults spawned in the stream, where as in a nearby stream without spawning salmon juvenile steelhead showed no increase in growth rate during the same time period. This phenomenon is so important that fisheries scientists recommend that escapement goals should be designed to produce "nutrient capital" within watershed that will help support the next generation of fish.

During mining, salmon will be excluded from the middle and upper portions of Stream 2003 where most spawning and rearing occurs for a long period of time. The "nutrient capital" built up over hundreds of years would be lost when the drainage is destroyed. Diminishing or eliminating salmon production (i.e. eggs and carcasses) from a stream due to natural or anthropomorphic causes such as strip mining may be self-perpetuating. Without necessary nutrients from salmon eggs and carcasses remaining downstream, stream 2003 stocks are likely to decline further. A restored stream drainage without nutrients from salmon carcasses is not likely to be very productive (Bilby et al 1996 and Larkin and Slaney 1997). The concurrent loss of most of the wetlands, which are the other major source of stream nutrients in the stream 2003 drainage, will further reduce stream productivity (Hood et al 2008, Meyer et al 2003, and Nagorski et al 2007).

Significant loss of stream productivity from premining conditions has been documented in studies of streams in reclaimed stripmines. Matter and Ney (1981) found that 5 to 7 years after reclamation, "benthic invertebrate and fish populations were significantly lower in abundance in the reclaimed mine streams than in the reference stream and showed less taxonomic richness and stability. Biota of reclaimed streams were similar in these respects to the biota of unreclaimed mine streams."

Page 3.16 Paragraph 3. The authors suggest that with some distinctions, data from streams 2004 and 2002 may be similar to stream 2003, and as "mine development progresses impacting stream 2003, streams 2002 and 2004 can be used for comparative purposes to stream 2003." With enough years of data to determine fluctuations in the abundance and composition of fish populations with statistical confidence, streams 2002 and 2004 might provide some general comparison with stream 2003. However, it seems likely that stream 2004 and possibly stream 2002 may be also impacted by changes in surface and groundwater flow and water quality from mining in their watersheds. If so, these impacts would negate any objective comparisons.

3.1.3.3 Longitudinal Comparison of CPUE between Streams:

3.1.3.4 Study Streams Coho Salmon: page 3.-19 paragraph 3. The admonition that "just because C channel produces higher CPUE than other stream channel types it should not suggest that the length of stream 2003 be rebuilt as a C channel in reclamation planning and construction" is good advise. Reconstructing a stream channel to approximate any of the physical characteristics of Rosgen stream types (i.e. entrenchment ratio, width depth ratio, sinuosity, slope etc.) does not provide any assurance that the new waterway would provide the key characteristics of productive salmonid habitat, such as hyporheic flows, groundwater upwelling, nutrient input from adult salmon, and the 2000 acres of wetlands in this drainage. Although, there are hundreds of thousands of streams in Alaska with Rosgen B, C, and E channels, less than 20,000 are have been found to support spawning, rearing or migrating salmonids and a fraction of those have the unique conditions which provide spawning habitat for coho, or Chinook salmon.

Although there are examples of stream channels that have been reconstructed, rehabilitated or relocated in Alaska, all of these projects have entailed restoration of stream banks, movement of short sections stream channels within an existing flood plain or relocation of a stream to an old stream channel.(ie Moose Creek). I was also unable to find any pre- and post-construction quantitative scientific studies documenting the biological and physical effects of these projects on fish populations.

3.1.3.1.. page 3-36, paragraph 2. The statement that "juvenile Chinook may emerge from the gravel to migrate to sea at age zero: therefore they may not be present during the winter during our trapping" is not consistent with the increased winter Chinook catch rates shown in Table 3.1-11. A large percentage of age zero Chinook do smolt in some systems, but all studies to date indicate that Cook Inlet Chinook smolt at age 1 (Hasbrouck 2009, Kerkvliet 2009). It is important to establish whether the Chuitna Chinook smolt out migration at age 1 or age 0 for impact assessment, permitting and mitigation purposes.

The authors could be correct that pink and chum fry were not free swimming during the time the minnow traps were in the streams; however, in my experience pink, sockeye and chum salmon fry are usually not caught in minnow traps. Often they are so small that they can swim through the mesh in the minnow traps, and they may not be attracted to the salmon egg bait.

Table 3.1-12 page 3-37. There appears to be something wrong with the average length column for table 3.1.12. Aside from the fact that the column has no unit of measurement, e.g. millimeters or centimeters, the average lengths given do not seem to be correct. For example, it seems unlikely that a juvenile coho salmon would ever be as small as 8mm or .323 inches, or that a fish that small could be captured.

3.1.3.12 Electrofishing. Was electro fishing conducted at the same time as trapping so that the same fish populations were sampled? If not, it would not be safe to conclude that the minnow traps were capturing all of the species and age groups present.

3.1.4.1 Spawning surveys page 3-40. Foot and aerial surveys usually significantly underestimate the number of spawning salmon present in a stream (Jones et al 1998). To accurately enumerate the number of salmon spawning in Stream 2003, a weir or sonar counter should have been installed and operated for 5 or more years. Accurate weir or sonar counts of adult salmon from the mainstem Chuitna and streams 2002 and 2004 are also needed.

Page 3-81, paragraph 3. This paragraph states that the majority of the data necessary to reconstruct/design stream 2003 has been collected and all that remains is to establish exact channel positions (plan form) and compile streambed elevations through the mine. It further states that "Data collected to date has been sufficient to characterize existing reference conditions, and to provide evidence of restoration feasibility." Oasis believes that they have almost all of the data and the expertise to reestablish a functioning salmon spawning stream after all of the existing vegetation has been removed, the entire upper stream 2003 watershed is excavated, the underlying substrate excavated to a considerable depth, and the surface hydrology and the existing shallow aquifer completely disrupted.

I disagree that PacRim has collected all the data necessary to reclaim stream 2003 and its drainage. For example, no data is provided on present shallow groundwater flow or the techniques that could be used to successfully restore essential groundwater flow to a reconstructed stream 2003. PacRim has not studied or provided any data on the role of marine nutrients from salmon carcasses or nutrients from wetlands in the productivity of the stream 2003 drainage. There is no explanation of how they would restore the thousands of acres of wetlands that would be destroyed by mining. Most importantly, they haven't provided any examples from the scientific literature of successful restoration of the type and scale they are proposing.

Although I have over 25 years of experience in analyzing and permitting projects affecting fish habitat, including large and small mines in Alaska, I am not aware of any instance where a salmon spawning and rearing drainage has been completely altered in the manner proposed for the Chunitna coal mine and then restored to its original productive state. There have been cases where small sections of previously mined stream channels have been altered to provide more productive salmon habitat and by chance has provided spawning habitat, such as the Forest Service's restoration efforts on the Resurrection River near Hope, Alaska, but no restorations of the type and scale proposed for stream 2003.

After mining the entire stream 2003 drainage and portions of stream 2002 and 2004, the drainages will consist of highly erodeable mine spoils, and water quality, including silt and turbidity, will be an issue that will affect the success of attempts to restore salmon habitat. The recovery of a stream affected by coal strip mining was monitored after mine closure by researchers from USGS (Collier 1963). The study found that mining significantly changed the chemical quality of the groundwater and surface waters, increased the sediment yield, and adversely affected the aquatic life of the stream. Even though the mined area only included 6.4% of the drainage basin, it contributed 96% of the sheet erosion. The stream affected by mining discharged 2,800 tons of sediment per square mile, whereas the control stream in an adjacent unmined drainage discharged only 49 tons per square mile during the same period. Clearing and developing land for mines increases sediment input into streams, lakes and rivers (Environmental Protection Agency, 1999, 2006 and 2008). Glancy (1973), who studied sediment loads in tributaries to Lake Tahoe, estimated that sediment yields from undeveloped areas ranged from 19 to 420 tons per square mile, whereas sediment yields from developed areas ranged from 700 to 5000 tons per square mile.

Because much or all of the vegetation in the mined areas will be removed, it seems likely that stream and groundwater temperatures will increase in summer and decrease in winter to the detriment of spawning and rearing salmonids (Beschta and Taylor 2007, Cunjack 1996, Feller 1982, and Curry et al 2002). There is no mention of this issue in the report, or of how restoration efforts will address detrimental changes in water temperature until mature vegetation is reestablished.

3.8.1 Landscape scale investigations page 3-102 paragraph 2. Upwelling groundwater and adequate instream flow is essential to successful salmonid spawning and juvenile overwintering survival in Southcentral Alaska (Alfredsen and Tesaker 2002, Baxter and Hauer, 2000, Malcolm et al 2004 and Mouw 2005). In section 3-81, Oasis purports to have almost all of the data necessary to restore Stream 2003 to productive salmon habitat. Yet, in this paragraph Oasis indicates that they don't have the detailed information on groundwater location, flow rate, temperature etc necessary to restore stream 2003: "The predominantly glacial alluvium lacked distinct surface nick points in the geological stratigraphy to force hydraulic pressure upward at longitudinal breaks." Also: "Landscape features were not available in steam 2003 that would serve as predictors of hydraulic exchange, and spatial heterogeneity, suggested areas of local hydraulic exchange."

Landscape Scale Investigations Page 3-106, paragraph 2. Although most of the findings in paragraph 2 are consistent with other studies of hyporheic exchange in salmonid spawning areas, the finding that "most adult salmon selected downwelling zones for spawning" may not tell the entire story about the dynamics of these spawning areas. Other researchers have found that in areas where freezing can destroy salmon embryos, salmon seem to favor sites with upwelling groundwater, which will be warmer in winter (Quinn 2005). This behavior is documented in sockeye, coho, Chinook and chum salmon in Alaska (Quinn 2005 and USFWS 2009). A comprehensive study of redd site selection by bull trout (Salvelinus confluentus) found that they selected stream reaches for spawning that were strongly influenced by upwelling groundwater but located redds in transitional bed forms that processed strong localized down welling and high intergravel flows (Baxter and Hauer 2000). Similarly Malcolm et al (2004) found that Atlantic salmon (Salmo salar) selected areas of complex groundwater-surface water interactions and that during critical freezing or low flow conditions hyporheic conditions were dominated by groundwater, whereas surface water dominated during high flow conditions. Additional research is needed on the influence of groundwater on redd site selection for all species of salmonids in streams 2002-2004.

Page 3-113 paragraph 1 . Oasis makes the point that there are significant differences between streams 2002, 2004 and 2003, and that these differences should be taken into consideration when comparing these streams to stream 2003 during mining. This conclusion is correct. The physical and biological differences between these streams and the possibility that these streams may also be affected by mining raises serious questions about using these streams as controls or templates for stream 2003 restoration. The type of comparison which might be appropriate is this: If there were normal populations of adult and juvenile salmon in streams 2002 and 2004 and few or no salmon in the restored sections of stream 2003, it would likely indicate that the restoration efforts were not successful. However, if there were 10 or more years of comprehensive pre-mining physical and biological baseline for stream 2003 to be used as a model for reconstruction, such a comparison would not be necessary.

Page 3-113: Velocity paragraph 2; Velocity: Oasis reports that "water velocity and currents could have significant effect on (minnow trap) catch rates (Bjorn and Reiser, 1991) and both influence habitat use by juvenile fish." This statement is correct. However, catch rates can also be affected by water temperature (too high or low), turbidity, and time of day. These factors were not reported on or discussed in the report (Bjorn and Reiser, 1991).

Oasis measured water velocities at each trap site and found that "Velocities ranged from 2.0 feet per second to 0 feet per second with 50% of the sets having velocities less than .5fps and 90% of the velocities less than 1fps." They reported that "juvenile trout, salmon and char (40 to 180 mm in length) usually occupy sites with velocities up to 1.3 fps (Bjorn and Reiser 1991) and juvenile coho salmon prefer pools with velocities less than .7 fps (Bisson et al 1988)." They concluded that the preferred velocities are close to or below over 90% of typical trap site velocities, therefore velocity was not a limiting factor for catching fish at individual trap sets."

I checked Table 4.10 in Bjorn and Reiser (1991) for depths and velocities at sites used by salmonids in streams. The velocities reported for age 0 coho salmon in natural habitat ranged from .16 fps to .98 fps and for age 1 coho from .59 to .98 fps. This is lower than the range of preferred velocities reported by Oasis and would indicate that the percentage of time that water velocities at the trap sites exceeded preferred water velocities was greater than estimated. Preferred velocities for age 0 Chinook salmon are similar to juvenile coho salmon (Bjorn and Reiser 1991).Water velocities well above preferred velocities would likely reduce catch rates at times, particularly at high flows when turbidity would also increase. At high flows, juvenile salmonids and other fishes would move to areas with lower velocities. Fluctuating catch rates along with the other limitations of minnow traps as a scientific sampling tool add uncertainty to the data and limit the value of the minnow trap data to compare catch rates over time and between streams.

Page 3-115. Depth. I am not sure that it is scientifically sound to conclude that "Given that 90% of trap sites were in water less than 3 feet deep, combined with the belief that preferred water depths will be readily subjugated to access to food, and security to predators, and that traps were set in a minimum depth so that the trap entrances were submerged, it is not likely that water depth limited or biased catch rates."

I could not find any source in the literature cited section for the citation that "Juvenile coho salmon show a maximum preference for depths of 3.3 feet (Beecher et al 2002)." It is also not clear from the Oasis report if this means that juvenile Coho salmon prefer depths of 3.3 feet or that this is the maximum depth that they are found at. The article cited in the North American Journal of Fisheries Management actually stated that "Juvenile coho showed maximum preference for depths of 76-100 cm (2.49 feet-3.3 feet) and velocities of 3-6cm/s (.098- .196 f/s)" (Beecher et al 2002). Velocities of .098- .196 f/s indicate very slow moving water that would typically be found in pools or near stream banks! Other researchers have reported that at water velocities of 0.30 to 0.98 f/s, juvenile coho salmon preferred shallower water (i.e. 0.98-2.2 feet) (Nickelson and Reisenbichler 1977). It appears that there is a relationship between coho presence, water depth and water velocities that is not accounted for in the Oasis conclusions. If coho moved from a trap site in response to fluctuating water levels or velocities, which occurred a number of times over the study, it would affect catch rates. Because Oasis apparently did not constantly monitor water levels or velocities at trap sites there is no way to compare catch rates to these parameters to see what effect they may have had.

The statement that juvenile Chinook salmon have been found in depths ranging from .5 to 4.5 feet (Bjorn and Reiser, 1991) is not meaningful by itself. I have captured juvenile Chinook in dip nets in a few inches of water and in inclined plane traps in 8 feet of water. This does not mean that those depths are preferred habitat for juvenile Chinook salmon, or that minnow traps placed in those areas would provide an unbiased index of abundance. The 5 studies cited in Table 4.10 in Bjorn and Reiser (1991) indicate that most age 0 Chinook fry were found in water depths of .5 feet to 2.0 feet of water at water velocities of 0.20 to 0.98 f/s. It seems likely that when water depths or velocities exceeded those depths and velocities, catches would be reduced to some degree, affecting CPUE.

Another factor that was not discussed, but that could have negatively influenced juvenile Chinook catches, is that juvenile coho could have displaced juvenile Chinook from areas with minnow traps because the traps contained a favored food source (i.e. salmon eggs). Coho fry are aggressive and territorial soon after emergence, and they establish intraspecific dominance hierarchies (Mason and Chapman (1965). Where coho and

Chinook fry occurred together in streams, the coho were socially dominant, defending territory accessible to incoming food (Stein et al 1972).

Page 3-116. Temperature. The Oasis data does not appear to support the conclusion that "since temperatures show a consistent pattern across drainages, temperature is not considered to significantly bias CPUE between drainage. *Rather catch rates changed throughout the season, equally between drainages*." A comparison of Figures 3.1.5-3.1.5 coho salmon CPUE and the accompanying tables by month and location for streams 2002-2004 indicates that CPUE did not change "equally" by stream over the season. The CPUE curves between streams and within streams between May and September appear to be significantly different. For example, as depicted in Figure 3.9.4, catch rates in streams 2002 and 2004 declined in September as water temperatures declined. However, 2007 catch rates for all sections of Stream 2003 actually increased significantly in September! This suggests that either the temperature measurements are incorrect or catch rates were influenced by some other factor than temperature.

Another factor that was not investigated but could have reduced catches of Chinook and rainbow trout is that juvenile salmonids that live in streams are sometimes noctural and may not feed during the day (Bradford and Higgins 2001). Little is known about diel activity of salmonid movement patterns in Alaska, however, researchers in British Colombia found nocturnal diel activity patterns in Chinook salmon and rainbow trout in areas of high flow in the Bridge River. Parr and older fish were more nocturnal in summer than fry, and all fish were nocturnal during the winter. They concluded that habitat-driven variations in activity patterns will likely affect the processes that regulate these populations and could make the prediction of the effects of ecosystem manipulation such as changes in flow very difficult.

Summary:

The problems and limitations of using minnow traps and other types of passive fishing gear in scientific studies are well-known (Hubert 1996). Gear selectivity leads to misrepresentation of certain types (e.g., particular size or species) of fish relative to their actual abundance in the environment (Hubert 1996 and Breen and Ruetz 2006). All passive fishing devises are selective for certain species, sizes or sexes of animals.

There is so much variation in CPUE within and between streams 2002-2004, and between years, that it is difficult to imagine how this data could be used to monitor mining-related changes in stream 2003. If a consistent pattern exists, it would take many more years of data collection to determine whether such a pattern exists and what it is.

It is not clear how the emphasis on CPUE and percent relative composition fits into the regulatory requirements for avoidance, mitigation and replacement. An estimate of the actual numbers of adult and juvenile salmonids produced by streams 2002-2004 from sonar and weir counts would be more useful to assessing impacts and developing mitigation and monitoring. The data from minnow trapping is not likely to produce a population estimate with any degree of confidence. Because of the natural variation in adult and juvenile salmonid populations in Cook Inlet, 5 to 10 years of sonar or weir data would be necessary to provide estimates with any degree of confidence.

It appears that the objective of collecting morphological stream data may be to meet permitting requirements by replacing the stream miles of Rosgen type B, C,and E that will be destroyed with reconstructed habitat that meets the characteristics of B, C, and E habitat. It is not clear how merely duplicating the general physical characteristics of stream 2003 can be considered successful restoration. For example, this is no discussion of how the flow of hyporheic groundwater to stream 2003 would be restored. One of the most critical factors in stream restoration appears to be the input of groundwater to the hyporheic zone. Ground water contributes cooler water to the instream flow during the summer , and warmer water which comprises the total flow during the winter months. This flow, which is near the mean annual air temperature, controls the development rate of salmon eggs and allows juvenile salmonids to successfully overwinter.

D. Wetland Functional Assessment (HDR Alaska, Inc., March 5, 2008);

HDR's report is a supplement to the Baseline Report for Vegetation and Wetlands (HDR Alaska 2007b). The baseline report detailed how wetlands were identified and mapped. This report addresses the assessment of functions performed by wetlands identified in the baseline study.

Analysis and Comments:

This report provides important information on the functions provided by the 3,921 acres of wetlands that will be destroyed by strip mining. HDR lists 6 functions those wetlands provide, including: wildlife habitat, stream flow moderation, shoreline stabilization, groundwater discharge, groundwater recharge, and carbon export food/chain support. Two additional wetlands functions that are not identified in the assessment are water quality maintenance and fish habitat. Wetlands filter out pollutants and trap silt and sediment that would otherwise enter fisheries habitat. This becomes increasingly important in disturbed areas such as a strip mine. Wetlands that are connected to streams can provide important fish habitat, particularly for juvenile coho salmon.

Results: Page 13. HDR estimates that there are 4,000 acres of wetlands in the Chuitna Coal Mine Mapping area, or 43% of the mine area. They estimate that the acreage of wetlands within the mine area providing the following important functions are: Stream flow moderation, 340 acres; groundwater discharge, 1,646 acres; groundwater recharge, 24 acres; carbon export/food chain support, 2,120 acres; and total functional wetlands acreage by component, 3,023 acres (HDR 2008).

According to HDR, the total acreage of wetlands providing groundwater discharge in the project area is 2,171, and the total acreage of wetlands providing carbon export /food chain support is 4,174.

Page 22: Wetlands to be destroyed by strip mining currently provide the following functions in the Chuitna Coal Mine Area: 9% of wetlands providing stream flow moderation, ; 1646 acres or 42% of the wetlands providing groundwater discharge,; 1% of the wetlands providing groundwater recharge,; and: 56.5 % of the wetlands providing carbon export/ food chain support to streams 2002-2004,.

Page 24: Total functional wetlands acreage in the Chuitna Coal Mine Area: 3,023 acres, or 77% of the total of 3,921 acres of wetlands in the mine area, provide essential functions for streams 2002, 2003, and 2004

Summary:

The productivity of a salmon stream is based on marine derived nutrients (MDN) from salmon carcasses and the flow of organic matter, nutrients, and the consistent flow of high quality groundwater and surface water from its drainage basin (Piccolo et al 2009, Mathisen et al 1998, and Schlosser 1991). Wetlands have been identified as a major terrestrial contributor of organic matter and nutrients to salmon streams (Hood et al 2008, Pess et al 2002, and Nagorski et al 2007). All of the wetlands, which currently comprise 43% of the proposed mine area and currently provide groundwater discharge, groundwater recharge, and carbon export/food chain support to streams 2002, 2003, and 2004, would be destroyed by mining. There is no plan to replace these wetlands, and it may not be technically or economically feasible to construct thousands of acres of replacement wetlands. At the same time, both the reservoir of MDN within the mine area and the input of MND from salmon carcasses will be lost when the stream 2003 channel and riparian area is mined. Even if stream 2003 could be reconstructed, the loss of both of the major sources of stream productivity (i.e. marine derived nutrients and wetlands) would make it very difficult to restore it to its former level of productivity. The loss of a portion of the wetlands in the streams 2002 and 2004 drainages will also affect the productivity of these systems.

E. Chuitna Coal Project: Oasis Environmental Inc. Winter Freshwater Fish Habitat Baseline Report, January 2009.

I..Introduction:Oasis'stated objective for the *Oasis Environmental Inc. Winter Freshwater Fish Habitat Baseline Report, January 2009*, was to determine the location, longitudinal movement and habitat use of overwintering fish (primarily juvenile coho salmon and small resident Dolly Varden) within randomly selected segments of stream 2003 within the proposed Chuitna Coal Mine project area during the winter of 2007/2008. The purpose was to satisfy permitting requirements and to obtain an understanding of winter habitat use to assess and mitigate habitat loss and biological impacts of the proposed project.

Analysis and Comments:

II. Methods:

Section 2.3.1. Page 15: Oasis reports that the estimated tagging mortality for juvenile coho salmon was 4% and 0.7% for Dolly Varden. Given the description in Section 2.3.2 of the difficulties encountered in capturing, holding and tagging fish under very adverse conditions (e.g. fish freezing to the tagging boards), it is surprising the mortality was so low. No information was provided in the report on the number of fish that died before being released. Although the process of handling and injection of foreign material into very small fish always entails a risk of infection or physical injury, no estimate of long term mortality after release into stream 2003 was provided. A Peterson mark and recapture population estimate is based on the ratio of the total number of tagged fish released to the number of tagged fish recaptured when the population is sampled. Increased post-release mortality of tagged fish would result in an overestimate of population size.

Section 2.3.1 Page 15. It would be very useful to be able to compare the total number of fish captured during both the tagging and recapture operations. Table 4.1 indicates that a total of 2,198 coho were recaptured, of which 82 were tagged. The results section indicates that a total of 2,032 Dolly Varden were captured and 125 were tagged, but no similar number was provided for coho. It seems unlikely that all coho captured were tagged.

Section 2.3.3. Page 20. Although underwater video recording has the potential to provide some information on the presence and absence of Dolly Varden and coho in riffles and fast run habitat under the difficult conditions the researchers encountered, its use raises some questions. The disturbance from drilling holes in the ice and artificial light seems likely to displace overwintering fish from the area of disturbance. In the 1970's, I was involved in an extensive research project which involved the use of underwater video recording. My experience was that fish rapidly left the area when the camera and light system was introduced. Other researchers have reported that the lighting needed for underwater video cameras caused similar avoidance problems (Rand and Logerwell, 2009). Additionally, while bait can be used to attract fish from downstream to the area of the video camera, there is no way to determine if the fish are coming from shallow riffle habitat rather than deep pools or other habitats downstream.

III. Results:

Page 26: The statement that "variations in the number of fish (tagged per site) generally reflected the abundance of fish that were present in each particular stream segment at the time of trapping" is unclear. Does this mean that Oasis had some way of determining the total number of fish in each stream segment, which seems unlikely; or does it mean that they were not able to capture 200 fish in all sections because of low catch rates in some sections? This should be clarified

Section 3.2 Winter Movement. Page 27. The finding that tagged overwintering Dolly Varden and Coho tended to remain in the same stream sections during the winter is useful. However, there is a possibility that untagged fish from the mainstem Chuitna or other stream sections could have moved into Stream 2003 after tagging ended on October 27. The recapture of tagged fish would not have documented these movements. It is possible that some previous study addressed this issue, but this report did not exclude that possibility.

Section 3.3 Underwater Video Recording Page 28: See previous comments on Section 2.3.3. The report indicates that video recordings were also made in streams 2002 and 2004. No reason was given for looking at these streams and it isn't clear whether or not fish were observed.

IV. Discussion:

Page 31 paragraph 1: I agree that information on the behavior and winter habitat preferences of stream fishes in Alaska is very limited. Because juvenile fish of the same species in Alaska are likely adapted genetically to very severe winter conditions (thick ice, very low temperatures, low oxygen levels, longer winters, different stream flow regimes etc.), it is not clear how much information from southern populations, including British Colombia, is applicable to stream 2003 without verification through independent research (Olsen et al 2003). Because detailed information on the life history and winter habitat preferences of Chuitna drainages fishes is essential to assessment of impacts, potential mitigation of impacts and successful restoration of stream 2003, a great deal of additional research in this area is needed (see conclusions section).

Page 31 paragraph 2: The explanation given for why overwintering juvenile coho salmon in stream 2002 were not captured in large numbers in beaver ponds in the stream 2003 drainage, whereas in more southerly coho populations beaver dams are preferred habitat, is low oxygen levels. This seems plausible. However, the study cited (Ruggerone 2000), actually found that coho fry were present in Black Lake, Alaska, which had very low oxygen and water temperature levels. Ruggerone also found that coho fry could tolerate much lower oxygen levels than sockeye fry. Oasis did not report on either winter oxygen levels or water temperatures in beaver ponds, which would have helped in the interpretation of the report.

Because information on salmonid habitat and behavior from more southerly climatic regimes and streams may not accurately represent what is going on in stream 2003, additional research is needed to determine the fine scale behavioral adaptations of overwintering juvenile coho and Dolly Varden in response to the extreme winter conditions present in the Chuitna River drainage. This information is essential to meeting the objective of avoiding or mitigating habitat loss. For example, do these fishes insinuate themselves into the interstices between the rocks where there are warmer hyporehic flows to avoid freezing? Do they seek groundwater seeps or areas of upwelling phreatic groundwater for the same reason?

Paragraph 4, page 31: The statement that "There was no change in the mean length of fishes captured throughout the winter (Table 4.1)" is not consistent with the information provided in Table 4.1. Table 4.1 indicates that the mean total length MTL of all tagged Dolly Varden was 110.0 ml, the MTL of recaptured tagged Dolly Varden was 103.0mm, and the MTL of all recaptured Dolly Varden was 105.20mm. The mean length of tagged and untagged Dolly Varden measured in the recapture program was 5 to 7mm shorter than the mean length at the time of a tagging. The same is true for juvenile coho. The mean total length MTL of all tagged coho was 72.90ml, the MTL of recaptured tagged coho was 74.70 mm, and the MTL of all recaptured coho was 73.10 mm. Tagged and untagged coho captured in the recapture program were slightly larger than the MTL at tagging. Whether these differences in MTL are significant would depend on a statistical analysis of the two sets of data.

Paragraph 1 page 32. In simple terms, juvenile coho and Dolly Varden migrate into or remain in stream 2003 because the conditions there optimize their chances for survival during the winter. For the purpose of permitting a mine, it is important to know if other tributaries of the Chuitna and the mainstem Chuitna provide similar overwintering habitat. This is important because it appears that mining will destroy a substantial portion of stream 2003 and its aquatic resources, and mining may also adversely affect both the hydrology and water quality of streams 2002 and 2004 and diminish or displace the fish and other aquatic resources using these systems.

Paragraphs 1-3 page 33. The reasons given for lower CPUE in the winter are reasonable, i.e. coho and Dolly Varden are cold-blooded animals, and as water temperatures decline so do their body functions, including digestion and feeding. This makes the bait in traps less attractive and lowers catch rates. An alternate explanation which seems less likely, but has not been excluded, is that some fish leave the system in the fall and early winter to escape declining water levels and temperatures and migrate back in the spring.

IV. Conclusions: The study provided some qualitative information on the 3 objectives but only a limited amount of quantitative information because of the techniques used. Baited minnow traps attract and hold small fish which feed on salmon eggs from some unknown distance downstream. Large fish, age 0 and age 1 fish which are small enough to swim through the screen covering the traps, and species that are not attracted to salmon eggs are not captured. Because the coal mine would destroy a significant portion of overwintering fish and fish habitat in stream 2003 and its tributaries, information on the numbers of overwintering coho salmon, Chinook, rainbow trout and Dolly Varden using this system in relation to the remainder of the Chuitna drainage and their overwintering requirements is important. However, this study did not compare numbers of overwintering fish in stream 2003 with these other drainages. I also searched the scientific literature but was unable to find references to successful substitution of artificial overwintering habitat for natural overwintering habitat in streams that had been destroyed.

Summary:

The report provides limited but useful qualitative information on winter habitat preferences and longitudinal movements of Dolly Varden and juvenile coho tagged before October 27. Because fish were only color marked and no fish were tagged after October 27 there is no way to determine from this report if juvenile coho or Dolly Varden moved into or out of stream 2003 after that date. Because changes in stream conditions (flow, floods, water temperature, ice formation, snow depth, location of pools and riffles), and numbers of overwintering fish could change substantially from year to year, more than one year study is necessary to meet permitting requirements. Because the proposed Chuitna Coal Mine will destroy stream 2003 and all of its aquatic life, additional studies on overwintering behavior, winter habitat preferences , instream flow, groundwater flow, and genetics are necessary to meet permitting and mitigation requirements.

F. Chuitna Coal: Movement and abundance of fish in the Chuitna River drainage, Alaska, May though September 2008, LGL, 2009.

Introduction: LGL's stated objectives: (1) describe fish movements in and out of streams 2002-2004, (2) describe the effects of development on stream 2003 on production of Chinook and coho salmon smolts, (3) estimate the proportion of fish production within the Chuitna River drainage that is contributed by stream 2003, (4) describe overwintering use of stream 2003 by resident rainbow trout or Dolly Varden char, and (5) determine species composition, estimate relative abundance of juvenile Chinook and coho salmon, and establish a time series designed to detect and measure potential effects of mine development on fish production. A time series is a set of regular time-ordered observations of a quantitative characteric of an individual or collective phenomenon taken at successive and in most cases periods or points in time. What would constitue the "time series" is not defined in the context of the proposed Chuitna Coal Mine and no explanation of how it would be used to detect and measure potential effects of mine development on fish production is provided.

Analysis and Comments:

Page 1 paragraph 2: The LGL report indicates that the work was done because stream 2003 will be "developed." A description of how mining would change stream 2004 and its drainage would help to place the study into context and make it more meaningful.

The studies of fish production in streams 2002 and 2004 are important; however, because there appear to be physical and biological differences between these streams and stream 2003, it is unlikely that these streams can be used as controls in the destruction and reconstruction of stream 2003. In addition, hydraulic changes resulting from mining through the wetlands and aquifers, which provide summer base flow and essential winter flows to these streams, may also result in changes in nutrient levels and essential winter groundwater flow. Changes of these types would confound any comparison with stream 2003, and negate the use of streams 202 and 2004 as controls or reference reaches.

1.3.2 Objective 2. Page 4: LGL proposes that coho "smolt will be the life stage monitored because the production of these fish is closely linked to habitat conditions and because the relatively low interannual variability of smolt abundances (relative to adult returns and spawning escapements) increases the power to detect a difference after an impact."

Given the choices, out-migrating coho smolt may be the best life stage to monitor, but it is not clear that coho smolt outmigration would be an effective means to detect impacts from strip mining. First, the assumption that there is “relatively low interannual variability” of abundance in coho smolt out abundances” is not supported by data from streams 2002 -2004 or the scientific literature. I discussed this with several ADF&G fishery biologists and they do not feel that coho smolt production from Alaskan streams can be characterized as having a relatively low interannual variability (Hasbrouck 2009, Hayes 2009, and Massengill 2009). LGL’s assumption appears to be based on a few years of coho smolt data from the Kenai River and Cottonwood Creek. During this period, smolt production may not have fluctuated as much as adult escapement, but there was a reported 20-25% difference in smolt outmigration from the Kenai River and Cottonwood Creek from 2003 to 2004. However, from 1992-2007 estimated Kenai River coho smolt abundance ranged from 374,000-1,227,000, a three hundred percent difference. Massengill (2009). This is not relatively low interannual variability.

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Smolt abundance may have been relatively stable over a 4- to 5-year timeframe in Cottonwood Creek and the Kenai River, but no data is available to support the assumption that smolt production from streams 2002-2004 is similarly stable. Flow, water temperatures, nutrient retention and other habitat factors that influence smolt production are moderated by the large lakes in the Kenai River and Cottonwood Creek systems, but the Chuitna River drainage has no lakes.

The assumption that coho smolt production is relatively stable also assumes that streams 2002-2004 are limited by the amount of available spawning and/or rearing habitat rather than the numbers of adult coho which escape to spawn. This could be correct, but no data has been provided to support this assumption.

It is also possible that there may be natural variations in freshwater smolt survival rates between streams 2002, 2003 and 2004 that could mask the effects of mining on stream 2003. No data on smolt survival by stream is provided in the report.

Habitat related declines in salmonid populations usually occur incrementally and an annual population decline of 20-25% or much more is within the range of natural variability. Population changes of this magnitude might not be recognized as mining related until the factor causing the decline was irreversible. A Washington study evaluated eight native salmonid populations to determine if rapid, sensitive detection of a reduction in abundance was possible. The study concluded that population abundance monitoring may not provide feedback sufficiently sensitive or rapid enough to implement corrective action that prevents impacts from causing harm or exceeding an acceptable level (Ham and Pearsons 1999).

1.3.3 Objective 3, page 4, Paragraph 2: LGL proposes to use habitat modeling to determine theoretical production from stream 2003 and the theoretical contribution of stream 2003 to the Chuitna River system. This may a worthwhile exercise; however, there are some problems. Habitat quality and quantity controls smolt production except in the rare instance where a system is spawning habitat limited. The PacRim studies and reports do not address this issue.

In order to determine how many years of data collection on smolt outmigration are necessary to determine the relative contribution of stream 2003 to the Chuitna River system, it is necessary to know how much variability there is in smolt production within and between streams 2002, 2003 and 2004 over time. One year's data isn't sufficient to make this determination. Smolt production is dependent on many factors, including but not limited to the number of adult spawners, habitat quality, winter survival, predation, and floods. In nearby Upper Cook Inlet streams (Little Sustina River and the Deshka River) where Chinook and coho returns have been monitored for many years, adult returns have varied by as much as 500% over a 20-year period. At times one stream may have high escapements while the other has low for reasons that can't be fully explained. Clearly, many more years of data from the Chuitna River system are needed to determine the full range of smolt abundance. For example, how would permit or mitigation decisions be affected if next year's catches found that stream 2003 produced twice as many smolt as 2002 and 2004? Apparently the current plan appears to be to collect only one year of data before the mine is permitted, and any subsequent studies conducted after that date, would be too late to be a factor in assessing the impact and permitting decisions.

1.3.4 page 5, The Oasis overwintering study did not provide any quantitative data on rainbow trout, a popular sport fishing species, although it acknowledged that rainbow trout were present and spawned in at least one tributary of stream 2003. Different sampling methods need to be used to provide information on species such as rainbows.

3.1: Fish Movement and Abundance in Tributaries, Page 9

3.1.1 Downstream movements and abundance of fish. Page 9.

Weirs: Page 10. The construction and operation of the weirs used to capture and enumerate adult and juvenile fish may have biased the data. Because of debris loads, constriction of flow, fluctuating water levels in streams and the need for constant maintenance, weir design has to be a compromise between blocking fish movements and functioning at most flow levels. LGL described the weirs used to collect data on summer and fall fish movements in streams 2002-2004 as constructed of 1.2 m by 2.4m panels and "faced with 0.64cm mesh, .95 cm mesh, or 1.27 cm mesh." Adult and juvenile upstream migrants were enumerated by video cameras in small weir breeches.

The materials the weirs were constructed of and the manner in which passage was provided for juvenile upstream migrants probably biased the data. First, even the smallest mesh (64cm mesh) is large enough to allow age zero coho, rainbow trout, Dolly Varden and Chinook fry to pass through it and avoid the holding box or the video camera chute (Bramblett et al 2002 and Massengill 2009). As a result these small fry may not have been captured proportionate to their real numbers. Bramblett et al (2002), who used similar weirs in a study of seasonal juvenile coho, rainbow trout, and Dolly Varden movements in Southeast Alaska, reported that "Coho fry were captured at both weirs during May and June in 1996 and 1997, but most fry were able to pass through the 6.4 mm (.64 cm) mesh of the weir panels." The larger mesh sizes LCL used to construct other sections of the weirs might allow a percentage of age 1 and 2 juveniles to pass through also.

3.1.2 Upstream movement and abundance of fish. Page 12. The LGL weirs do not appear to be designed to efficiently pass or count juvenile salmonids that were migrating upstream. Because the weirs used to capture and count fish were designed to force both adult and juvenile upstream migrants to locate and pass through a small breech in the middle of the weir, juvenile upstream migrants may have been undercounted. Newly emerged salmonid fry (25-35 mm) are relatively weak swimmers and seek water velocities of less than 10cm/s (.3 fps). Larger fish (4-18 cm) usually occupy sites with velocities of no more than 40 cm/s (1.3 fps) (Bjorn and Reiser 1991). Juvenile salmonids are relatively weak swimmers and usually migrate at the margins of streams where water velocities are lower and cover is greatest.

LGL did not identify where in the weir the location of the 1.5x1.5x3 foot video breaches were located or record the velocity through these breaches in the report. Figure 6 (Photo 6) shows a weir breach located in the middle of stream 2002. Photo 7 shows water cascading (i.e. high velocity) out of the stream 2003 weir and what appears to be the video breech.

2008 Chuit River Fisheries Monitoring Report – Final Report

Photo 6. The downstream entrance to the underwater video chute, electronics housing, and battery bank at the weir on Stream 2002. The top of the photo is upstream.

Photo 7. The Stream 2003 ramp for adult salmon traveling upstream being inspected on September 3, 2008. Water flow is from top right to bottom left.

LGL Alaska Research Associates, Inc. 131

Figure 6 – LGL Weirs

Because the weirs both constricted the streams and created a hydraulic head, water velocities at the breaches were almost certainly increased significantly over ambient levels and over the velocities preferred by juvenile salmonids. The drop from the weir appears to be as great as one foot and may have also impeded or blocked juvenile upstream migration. Mueller et al (2008) tested the leaping ability of juvenile coho salmon (60-135 mm). They found that 100% were able to pass an outlet drop of 0 inches, 4.7 inches 34 %, 7.7 inches 20%, and 10.2 inches 2%.

Under low flow levels very small up- and downstream migrants could have passed through the weir mesh and not been counted, biasing the results.

Video system design, configuration and operation. The description of how the video system functioned is confusing. Paragraph 4 indicates that the video system was supposed to be operated 24/7 through September. Paragraph 5 states that the system was set to record video at a rate of 7 frames per second. However, the paragraph then states that the system was set to record fish passage events at 5-second intervals through motion detection, and that most debris and juvenile fishes would not trigger the system. Does this mean that juvenile fish weren't counted? Later the report states that fish counts were estimated by subsampling the first 15 minutes of each hour, except when fish counts were estimated by counting the entire hour during period of high adult fish movement.

Page 13 paragraph 4: I am not sure about the accuracy of the method used to subtract upstream migrants from downstream migrants, i.e. if 100 of a particular group or species were sighted going upstream and 50 were sighted going downstream, the upstream count was estimated to be from 50 to 100. If 100 went upstream and 50 came downstream the net should be 50 upstream. I assume that these are adults since it wasn't specified. The method is confusing since the report doesn't indicate how much time elapsed between upstream and downstream observations

In spawning areas, salmon often tend to cycle upstream and downstream. This can be a real problem if a weir is located within a spawning area. When I set up new weirs and counting towers in the Yukon River drainage, we counted salmon upstream and downstream 27/7 all season. We subtracted upstream migrants from downstream migrants to get the net. One complication was that fish spawning in the area would cycle through the weir continuously, and spawned-out fish would often swim downstream past the weir. If LGL encountered this problem, it isn't mentioned in the report.

4.0 Results page 23.

4.1.1 Tributaries: Because the weirs were not in operation or completely sealing the streams for varying periods due to high water, combined with the fact that age zero and some age 1 fish could swim through the mesh on the weirs, it is not possible to conclude with a high degree of confidence that "Fish sampling provided a complete or near complete census of downstream migrating fish."

Video detection of fish moving downstream: Page 26. LGL mentioned species identification as an issue. It is possible that there was some error in distinguishing between juvenile coho and Chinook salmon in the holding boxes, and if so there would have been a similar error in estimating composition of the fish passing through the video chutes. Identifying juvenile Chinook and coho salmon in the field can be challenging. To see how similar juvenile coho and Chinook salmon appear, look at the pictures of juvenile coho and Chinook salmon located at www.fpc.org/bon-da/juvsalmon.html.

Page 27 paragraph 2. LGL did not explain how they distinguished small juvenile rainbow trout from other salmonids on the video tapes. LGL apportioned video coho counts based on composition of the juvenile salmonids in the holding box because it was more reliable than trying to identify juvenile salmon from video tapes under less than ideal conditions. To see how similar juvenile coho salmon and rainbow trout look refer to the pictures located at www.fpc.org/bon-da/juvsalmon.html. Age zero and likely some age 1 rainbow trout were small enough to pass through the weir mesh and an unknown but possibly significant number may not have been counted at the weir or video chute (Bramblett et al 2000). LGL cited mesh size as a reason juvenile rainbow trout were captured in the smaller mesh stream 200401 fyke net but not the larger mesh nets or weirs used in the study.

There are other indications that there may have been problems with using the video chutes as the primary method to enumerate upstream adult and juvenile migration. First, the upstream and downstream counts for adult sockeye salmon in stream 2004. Table 8 indicates that 44 adult sockeye migrated upstream and 48 migrated downstream. Because no more adult sockeye could migrate downstream than upstream, either the upstream counts or the downstream counts are incorrect. Second, the video cameras apparently did not record over the same period of time. Tables 6-8 indicate that the stream 2002 video camera operated from June 8 through September 29, but the cameras on the other two streams only recorded upstream and downstream migrants from June 29 through September 29 and September 30 respectively. I could not find any explanation of how this apparent discrepancy was addressed in the report.

4.2.2 Run timing and biological characteristics of juvenile coho salmon: page 28.

Stream 2002: page 28. There are some anomalies in the stream 2002 catches, which raises questions about the data. First, the disclosure that juvenile coho (less than 90mm) were captured as soon as the weir was installed on June 4 and peaked two days later on June 6 indicates that downstream movement began some time earlier and that a significant portion of the run may not have been counted. LGL also reported that they used partial weirs and fyke traps intermittently between May and June 4 to enumerate migrants. These methods would not capture all fish moving upstream and downstream and calls into question the accuracy of pre-weir counts and species allocations for stream 2002-2004.

Second, in stream 2002, 2,512 fish were caught in the weir and another 6,367 were observed to have moved through the video chute. In contrast, in stream 2003, 7,394 fish were captured at the weir and 366 fish were estimated to have passed through the video chute. In stream 2004, 4,085 fish were captured at the weir and 856 fish were estimated to have passed through the video chute. No explanation is given as to why most of the fish in stream 2002 chose the video chute over the weir. Because LGL rightly considered the weir counts to be more reliable than the video estimates, and used the species composition of the weir counts to apportion the fish in the video counts between species, this discrepancy calls into question the accuracy of the stream 2002 species counts.

Page 32 paragraph 4: Chum salmon. Like other age zero fish species, including rainbow trout, chum salmon fry are relatively small and even if present in large numbers would be less likely to be captured in the weirs and large mesh fyke nets used in the study. Chum fry also feed on small insect larvae in freshwater and might not be attracted to salmon egg bait in minnow traps (Groot and Margolis 1991).

Page 32 paragraph 6. Adult coho salmon: It is surprising that only 13 adult coho were captured in the weirs through September 30 considering the relatively large number of coho spawning in the three study streams. When coho are spawned out they tend to drift downstream and pile up on any obstruction such as a weir. Were the weirs pulled before the end of spawning?

Page 35 paragraph 1: The average size of the rainbow trout sampled in stream 200401 was 35 mm. This means that they would be able to pass through the mesh of the weir panels, which were greater than 0.64 cm and the larger mesh fyke nets and would not have been sampled effectively in the mainstem of streams 2002-2004.

4.3.2 CPUE and run timing of fish groups moving upstream

Page 37 paragraph 4. The authors report that there were distinct pulses of adult coho salmon entering all three streams on September 3 and 7 as shown in appendices E, F and G. This is consistent with data from other Cook Inlet streams which indicates that upstream coho movements are triggered by high water events (Hayes 2009 and Kerkvliet 2009). Pulses also entered 2002 and 2003, and probably 2004, but the authors indicate that "*the water in stream 2004 was too high to count fish by any method*." LGL also reported that the inability to see into the high and turbid water "may have partially accounted for the smaller number of fish seen returning to stream 2004." This makes sense, and yet Appendix G for stream 2004 contains video and video-expanded counts for September 3, 7 and the remainder of September. This discrepancy raises the question of what was the actual size of the coho run into stream 2004, as well as whether the same high water event also affected the accuracy of counts at streams 2002 and 2003. To evaluate the data it would be useful to know what the turbidity levels were and how far from the video camera fish could be seen at various turbidity levels.

4.3.5 *Visual counts during flood events, page 39*: This section indicates that due to flood events in September when the video camera wouldn't work, and when sections of the weir were removed to allow flood waters to pass, salmon passing the weir sites were counted by observers on the banks. These counts may not have been accurate. If the water is shallow and clear, counting salmon in flood waters in a small stream during daylight hours may be feasible. During floods, however, waters are usually high and turbid. If it is raining and cloudy and light levels are low, it is difficult to see fish moving upstream in turbid waters. LGL reported that the inability to see into the high and turbid water "may have partially accounted for the smaller number of fish seen returning to stream 2004" but did not mention this as a problem for the other streams during similar high water events.

I did not find any depiction or description of hourly fish movements in the report. Salmon run upstream 24 hours per day, and upstream movements of adult Chinook and coho salmon in Cook Inlet streams are usually triggered by high water events (Hayes 2009 and Kerkvliet 2009). The report doesn't explain how fish were counted during the hours of darkness when the water was deep and turbid. During the September 9 high water event, for example, the sun rose at 0713 and set at 2039 which means that there was only about 11 hours of daylight. There was no mention of artificial lighting over the streams in the report and no evidence of it in the photos of the weirs. Without supplemental lighting over the creek, it would be extremely difficult if not impossible to accurately count fish at night in a flood.

4.4 *Abundance of coho and Chinook salmon smolt in the Chuitna River drainage, page 39.* More research is needed on the tag and recapture methods used to estimate Chuitna River coho smolt abundance. The accuracy of Peterson type population estimates depends on at least three basic assumptions: the population has to be closed (i.e. no fish die, immigrate, emigrate, or lose their tags), the fish have to be smolting and the marked individuals must distribute themselves within the marked population so they have an equal chance of being captured (Gatz, J, and J. Loar 1988). Because coho smolt are migrating out of the Chuitna River sampling area and leaving the population and other coho smolt are moving into the sampling area from tributaries without weirs, it is not a closed system. It is also not known if smolt out migrating from the different natal streams mix uniformly within the Chuitna River population. Another problem which other Cook Inlet researchers have encountered in estimating smolt numbers from tag and recovery data is uncertainty as to whether all downstream migrants are smolting or just moving (Kerkvliet 2009).

4.5.2 Temperatures, page 40 paragraph 6. The surface water temperatures reported by LGL for Chuitna River tributaries in early May, 0-1 degrees C, are within the range found to be lethal to coho, Chinook, sockeye, and chum salmon and rainbow trout (Bjorn and Reiser 1991). Mid-winter temperatures would likely be lower. To survive the winter, fish would have to move to areas warmed by groundwater (Huusko et al 2007 and Bradford et al 2001). Bradford et al (2001) investigated the overwintering behavior of juvenile stream type juvenile Chinook salmon in Croucher Creek, a small upper Yukon River tributary. They found that most of the fish that successfully overwintered spent the winter in a 700 m reach of the creek that was downstream from groundwater sources and did not experience severe icing conditions. The study concluded that small streams may be important habitats for juvenile salmon in cold climates, especially if there is a year-round source of groundwater flow that creates conditions suitable for overwintering.

Phreatic groundwater flow is clearly the critical factor in enabling juvenile salmon to escape freezing temperatures in cold climates. Locating areas of groundwater and understanding how it is propagated and enters streams 2002-2004 is critical in determining the effects of mining on these three streams and the chances for successful restoration of stream 2003.

4.5.4. Precipitation, page 42, paragraph 2. LGL found that heavy rainfall resulted in high water events and "during these high water events that our sampling equipment was most likely to have reduced effectiveness, and in some cases halted all together." Nets and weirs plug up with debris and are often carried away by high water. This is a common problem with operating weirs, traps and nets in rivers, and it is important because upstream coho and Chinook migration is often triggered by high water and cooler water temperatures associated with increased precipitation (Frazer et al 1983, Hayes 2009, Kerkvliet 2009 and Holtby et al 1984). If most coho moved upstream during the high water periods when LGL's "sampling equipment was most likely to have reduced effectiveness, and in some cases halted all together," the adult coho counts were likely too low. However, I did not find anywhere in the report a clear explanation of how high water and equipment malfunctions may have quantitatively affected adult and juvenile or how LGL compensated for lost or impaired fishing or data collection time.

The scientific literature indicates that age zero salmonid fry may be flushed downstream during high water events (Bjorn and Reiser 1991 and Branbletts et al 2002). Some of these fry could rear in the portion of the Chuitna below the weirs or in the nearshore waters of Cook inlet and return as adults but currently would not be counted as smolts produced by streams 2002-2004. These fry would be too small to be easily seen and counted by shoreside observers in turbid waters.

5.0 Discussion:

5.1. Overview of fish species composition in tributary streams

5.1.2 Basic run timing of key fish species. Page 44 paragraph 1-2. A study of the timing of smolt migration from the Chuitna River to Cook Inlet would help put the Chuitna fish studies in context, including the population estimates.

Page 43 paragraph 1: The revelation that the rainbow fry in stream 2004 and 2004-1 were "caught with a smaller net fyke net than was used in other systems" underscores the problems with catching rainbow fry and other small salmonids in minnow traps identified in the Oasis 2007 winter study. It is possible that rainbow and age zero Chinook fry were present in larger numbers in all three systems but were not captured by the relatively large mesh in the nets, traps and weirs used by LGL.

Page 43 paragraph 3: LGL's explanation of why the estimated 2008 Chuitna coho escapement was much larger and the estimated 2008 Chinook escapement much smaller than ERT estimates from the early 1980, i.e. natural population fluctuations, seems to be the best fit. Other possibilities include errors in the 1980's data or increased harvest of returning adults by the Cook Inlet commercial fishery. As previously discussed, escapement data from the aerial and foot surveys used to enumerate these species have a wide margin of error. Weir and sonar counts are the most reliable. Because only a couple of years of intensive scientific sampling have occurred, it is not possible to accurately estimate what the full range of adult salmon escapements to the Chuitna may be.

5.1.2: Basic run timing of key fish species. Page 44. Paragraph 3. The finding that "The bimodal run of coho into the Chuitna watershed was consistent with observations from 1982 and 1983 (ERT 1984) when coho were detected in late July and again in August" is important. It gives additional support to the likelihood that there are genetically distinct demes of coho salmon in the Chuitna River and its tributaries. There is an increasing body of scientific evidence that coho, Chinook and sockeye salmon that aggregate for breeding at spatially defined habitats have evolved into discrete populations with special genetic or physical adaptations for those habitats or demes (Stewart et al 2004, Fisheries and Oceans Canada 2009, and Brykov et al 2004). The idea that there are reproductively isolated demes in the Chuitna system is supported by recent genetic analysis which found that juvenile coho salmon stocks collected from 8 spawning locations within the Kenai River drainage are genetically subdivided (Crane et al 2009). The genetic makeup of Chinook and coho salmon stocks in the different tributaries of the Chuitna drainage is an important factor in assessing impacts and determining the feasibility of restoring stream 2003 after 20 years of mining. If a coho deme which is adapted to the unique conditions in streams 2002, 2003, or 2004 is destroyed, it is possible it can't be replaced. The genetic composition of stocks in the Chuitna River and the three streams likely to be impacted by mining should be analyzed.

Page 44. Reported differences in Coho and Chinook run timing between the 1980's and 2008 could also be the result of the observed 3- to 5-degree C increase in water temperatures in some Cook Inlet drainages (Kyle and Brabets 2001). If water temperatures in the Chuitna River drainage are increasing, this will stress fish populations adapted to colder temperature regimes and have important implications for restoration. Temperature trends in the Chuitna river drainage need to be determined as part of the environmental studies and factored into the environmental impact assessment process.

Page 45 Rainbow trout: The discovery of a large migration of age zero rainbow trout in stream 2004-01 using a smaller mesh fyke net may be indicative of a bigger problem with the 2008 study. As stated in the report, sampling using weirs and fyke nets with mesh greater than 4 mm was not optimum for capturing small, newly-hatched fish of any species, including Chinook, coho, and Dolly Varden. For example, Bramblets et al (2002) found that most salmonid fry (less than 38mm in length) "were able to pass through the 6.4 mm mesh of the weir panels." Additional systematic quantitative prepremitting sampling needs to be done in streams 2002-2004 with smaller mesh gear to determine if significant populations of these age classes of fish were overlooked in previous studies.

5.2 Juvenile coho ecology within streams 2002, 2003, and 2004.

5.2.1: Life history of juvenile coho salmon:

Page 46: Paragraph 2. If the LGL weirs and fyke nets physically blocked, impeded or created water velocity barriers to upstream migration of age 0 and age 1 salmonids, it could explain why "We (LGL) did not see a reciprocal movement upstream (summer and fall) indicating that these downstream movements represented an overall redistribution in the watershed…" Bramblett et al (2002) studied in-stream coho movements in Southeastern Alaska, but with different results. Bramblett found that juvenile coho left mainstem Staney Creek in late summer and fall and migrated upstream into tributaries, and that a large immigration peak occurred in October. In August through December 1996, 50% of juvenile coho captured in the Tye Creek weir were going upstream. In 1997, more coho were captured going downstream than upstream, indicating that some as yet unknown factors govern instream juvenile coho movements. In 1997, most juvenile steelhead captured at weirs on tributaries moved upstream from mainstem Staney Creek into tributaries during the fall as flows increased and temperatures decreased. Bramblett et al observed that fall juvenile salmonid movements coincided with declining water temperatures and rain-induced fall freshlets common during October in both southeastern and southcentral Alaska. Similar juvenile coho movements have been documented between tributaries in the Kenai River drainage (Hasbrouck 2009). Additional study of juvenile fish movements in the Chuitna is warranted, using sampling gear more suited to small juvenile fishes and extending later in the fall.

Page 46 Paragraph 2-5. Because the question of the contribution of age zero and age 1 downstream migrants to coho salmon production in the Chuitna is important to the permitting and mitigation process, additional pre-permitting study is warranted. Miller and Sadro (2003) found that "Nearly half of each (coho) brood year moved to the estuary as subyearlings, a portion of age zero juveniles that moved downstream during spring lived in the ecotone through summer for 8 months, then most moved back upstream to winter." After these fish spent 1 to 2 years in this ecotone, their scales would show 1-2 years residence in freshwater. Because there was no sampling in the Chuit River below the rotary screw traps or after September 30, there is no way to determine what contribution these age 1 and zero out-migrants may make to total Chuitna River coho production.

Smolt Status page 47 paragraph 1: The reports states that "Prior studies in upper Cook Inlet show that adult coho salmon returns are primarily fish that migrated at age 2 (e.g., two winters spent in freshwater) with the addition of some fish that migrated at age1." This statement doesn't resolve the question of the potential contribution of the age 0 and 1 coho fry that migrated out of streams 2002-2004, because the 2009 study did not look at what those fish did after they left these streams. These fish could spend 1-2 winters in the lower Chuitna, migrate into other Cook Inlet drainages to rear, or migrate upstream after September 30 to winter in streams 2003-2004, smolt and then return as 1-2 check adults.

Page 48 paragraph 1. I agree with LGL's conclusion that existing information on juvenile salmon life history needs to be "augmented with studies within the mainstem river and with studies of habitat survival by age-1 coho salmon to explain the reason for emigration from the tributaries to the river by pre-smolt coho salmon." The current studies leave unanswered a lot of important questions relevant to the environmental and permitting process. (See Appendix 2.)

Page 52 paragraph 1. I agree that LGL's "estimate of smolt abundance in the Chuitna also appears low when considering likely numbers of adult fish that return to this watershed." A 32% smolt to returning adult coho survival rate seems very high. By contrast, coho smolt to adult survival rates from other Alaska coho populations have ranged from 1.1 % to 11 % (McHenry 1977, Dudiak et al 1990, and ADF&G 2007). This high survival ratio could indicate that the number of smolt produced by the streams was much higher than the 2008 estimate indicates. However, it could also mean that LGL's estimates of adult escapement are too low because of problems with the use of aerial and foot surveys to count salmon and with the operation of LGL's weirs during high water events that were discussed in previous sections. Additional research is needed to determine smolt abundance in streams 2003-2004 and the Chuitna River as well as freshwater and marine survival rates. More accurate counts of adult salmon are also needed.

It also seems likely that the lower 8 miles of the Chuitna , which was not sampled, provides coho rearing habitat and that it could support up to 10 percent of the rearing coho in the system. It is possible that a percentage of the age 1 and age 2 coho smolt produced in this section of the drainage consist of coho that migrated downstream from streams 2002-2004 as age zero or age 1 fry. Several studies indicate that coho nomad (ie age 0 downstream migrants) life history strategy includes spring /summer rearing in esturine habitats as age zero fry and an upstream migration in fall for overwintering before smolting (Koski 2009). Estuarine rearing age zero coho have been reported from a number of coastal Alaskan streams's, including streams in Cook Inlet (Koski 2009). Because they would be from the same year classes as the smolt captured in the weirs and screw traps, the percentages of smolt produced by streams 2002-2004 would not change.

5.4 Abundance of Chinook Salmon Smolts in Tributary Streams Versus the Chuitna River Watershed. Any or all of the three possible reasons given in the report (i.e. Chinook fry tend to rear in larger streams, misidentification of Chinook fry and smolt (previously discussed), and low adult escapement into the Chuitna) could explain the low number of Chinook smolt and fry captured in 2008. A number of years of good data (10-20) are necessary to make responsible science-based decisions on the dynamics of salmon stocks. In 2007, adult Chinook escapement into the Deshka River, the closest North Cook Inlet stream where Chinook escapement is monitored, was far below the five-year average, The 2008 Chinook escapement was only 7,533, down from a high of 57,939 fish in 2004; this represents a change of over 700%(ADF&G 2009). Because salmon populations experience large natural fluctuations for reasons we do not fully understand, it is problematic to make decisions on the impacts of a mine based on just one or a few years of data.

6.0 Conclusions and Summary of Key Results

6.1 Objective 1 page 55: Describe the movements and abundance of fish moving into and out of streams 2002, 2003 and 2004. For reasons presented earlier in this review, it is not safe to conclude that "The abundance and timing of numerous fish species moving to and from streams 2002, 2003, and 2004 were described thoroughly from late spring through mid fall in 2008." For example, it was reported that juvenile coho (less than 90mm) were captured as soon as the weir was installed on June 4 and peaked two days later on June 6. This indicates that downstream movement began some time earlier and was not thoroughly documented. A significant number of adult salmon and juvenile fish could also have moved through the weirs during high water events when the weirs and video monitoring equipment was down. The mesh on the weirs and fyke nets was too large to effectively sample age zero and possibly some small age 1 salmonids because they could pass through it.

Page 57 paragraphs 1 and 2: The low numbers of adult and juvenile Chinook salmon in streams 2002-2004 in 2008 was likely the result of natural population fluctuations and cycles rather than any fundamental change in species composition. For example, the 2008 Chinook escapement into the Deshka River, another upper Cook Inlet stream, was 1/5th, and the 2007 escapement was ½, of the 5-year average from 2002-2006.

The 2007 and 2008 Deshka River coho escapements were also ¼ and 1/3, respectively, of the 5-year average from 2002-2006, indicating that both the Chinook and coho runs into the Chuitna during the same time period could have been well below average. Experience from the Deshka River indicates that at least 5 years and up to 20 years of study may be necessary to determine the full range of escapement/production from the Chuitna system.

6.2 Objective 2: Describe the effects of development on stream 2003 on production of Chinook and coho salmon smolts. The report does not describe the effects of development of the PacRim Coal Mine on stream 2003 or the process by which the data collected on smolt outmigration from streams 2002-2004 would be used to describe the effects of strip mining on stream 2003. We can assume that the effect of the mine will be to completely remove the upper 40% of the 2003 watershed as well as the fish habitat and fish stocks that currently exist. Because this area contains most of the spawning and rearing habitat, fisheries production in stream 2003 would decline significantly. Significant portions of the 2002 and 2004 watersheds would also be removed, with attendant effects on groundwater flow, water quality and very likely on fish production. This would bias any attempts to use these streams to monitor effects on stream 2003.

There are many studies which show that the large-scale watershed clearing, excavation, and development associated with strip mining adversely impact salmonid populations through destruction of habitat, increased sedimentation (Cederholm et al 1980, Eglin and Hubert 1993, and Glancy 1973), disruption of groundwater flow (Sengupta 1993 and Garrett et al. 1998) and changes in other physical stream and water quality parameters (EPA 1999, 2006 and 2008).

Unfortunately, the scientific methodology available to estimate cumulative effects from coal mining in the Chuitna River drainage remains limited (Harvey and Railsback 2007). Although other fisheries scientists have proposed methodologies to estimate multifactor cumulative watershed effects on fish populations no plan is laid out in the LGL report (Harvey and Railsback 2007).

6.3. Objective 3. Estimate the proportion of fish produced within the Chuitna River drainage that is contributed by stream 2003. The title of this section is misleading since the only estimate provided for all of the species of fish and age groups of fish produced by stream 2003 (i.e. Chinook salmon, rainbow trout, Dolly Varden and age 0 and 1 coho salmon that did not migrate downstream) was for out-migrating fish judged to be age 1, 2 and 3 coho smolt.

LGL has provided an estimate of the proportion of coho salmon out-migrating from stream 2003 in 2008, but for a number of reasons it is not clear that this is the real number of fish that actually left these streams. There were several problems with the study that raise questions about whether the definitive estimate for coho smolt produced in stream 2003 is really 20.8% of the total. These problems include: the inability to count or accurately estimate the number of fish during high water events ; the fact that an unknown number of fish migrated downstream before the weir was installed); age zero and likely some age 1 coho fry were small enough to pass through the mesh of the weir rather than into the trap or the video chute and were therefore not counted; because most of the downstream migrants on stream 2002 passed through the video chute rather than the trap, an unknown percentage of the fish may have been misidentified as to species or misclassified as smolt because of the difficulty of identifying small, similar-looking fish from fleeting video images; and it isn't clear that all of the basic requirements for a Peterson mark and recapture population estimate (i.e. a closed population) were met. Although LGL based the estimate of pooled 80-161mm coho smolt abundance in stream 2003 on a Darroch-Peterson best estimate of 37,424 smolt in the Chuitna drainage, the 95% confidence limits for this estimate were actually a range of 33,276 to 41,572 fish (Table 14).

Page 79 Figure 3. Figures 3 and 4 indicate that during the study period, peak flows reached as high as 400-1000 cfs, and in some instances these flows lasted for days. Problems such as these resulted in the sampling gear not fishing, partially fishing, or overflowing (weirs). Figure 5 illustrates this problem and how it would have affected counts. This figure indicates that the sampling gear was not "operating normally and fish tight" roughly 40% of the time in stream 2002, 50% of the time in stream 2004, and 60% in stream 200401. This means either no data was collected during these periods or the data collected was compromised. Because high flows would have been accompanied by increased turbidity, it would be very difficult to observe adult salmon and almost impossible to observe small fish and salmon fry. High water velocities (greater than 2-3fps) caused by high flows and constriction of the stream channel by the weir would have prevented or impeded the upstream movements of juvenile salmonids (Bjorn and Reiser 1991). The report did not adequately address this problem.

Page 127-131 Photos 1-7. These photos (Figure 6) illustrate my concern that the weirs appear to have blocked or impeded upstream fish passage particularly for small fish, and may not have effectively sampled upstream migrants. The weirs blocked the entire stream channel and created a hydraulic head and increased water velocity in the sections of the weir that were left open. At higher water levels, the problem would have been greater. Pictures 7, 14 (stream 2002), 17 (stream 2003) and 19 (stream 2004) in particular show water cascading from the weir and creating what appears to be both a velocity and a height barrier for juvenile fish. I did not see any indication in the report that LGL measured water velocities in the breaks in the weirs or the video chutes, which were supposed to allow upstream passage, to determine if the water velocities in these breaks were impeding upstream fry movements. Velocity barriers to juvenile fish passage would have reduced the numbers of juvenile salmonids that would have otherwise moved upstream without the weirs, thereby biasing the results in favor of downstream migrants.

Summary:

LGL installed and operated a weir system to monitor upstream and downstream fish movements on streams 2002-2004. Because of difficult operating conditions and problems with the weir design, which allowed some fish to pass without being counted or identified as to species and which may have blocked or impeded upstream fish migration by small fish, the counts of upstream and downstream migrants were probably low.

Juvenile salmonids that were believed to be smolting were tagged at the weirs and recaptured in rotary screw traps (RSC) at approximately mile 8 of the Chuitna River. The ratio of tagged fish to fish captured in the rotary screw traps was used to make a modified Peterson estimate of the total number of smolt produced in the Chuit drainage and in stream 2003. Because the study area may not have been a closed population, juvenile coho salmon that may be rearing in the lower 8 miles of the Chuitna River were not included in the study; for this and other reasons, the estimate of both the total number of smolt in the Chuitna and of those produced by stream 2003 may not be correct.

This study provided some new information on the movements of fish within these streams between May 8 and September 30, 2008. The report did not, however, meet its objective of "describ[ing] the effects of development on stream 2003 on production of Chinook and Coho salmon smolts." It confirmed that wintering use of stream 2003 by resident rainbow trout and Dolly Varden char occurred, but didn't provide any information on the overwintering population that remained above the weirs and didn't migrate downstream. No information was provided on potential fish movements during breakup and after September 30. Fish were clearly moving downstream prior to installation of the weirs in the spring, and LGL postulated that fish may move upstream in October (Section 6.4 Objective 4).

It is not clear how the report established, as it claimed to, "a time series designed to detect and measure potential effects of mine development on fish production." There was no description of how the mine would affect fish production and how the data provided in this report would be used to detect changes. This would be a very important product, and since it is critical to the environmental and regulatory processes, it is important that these impacts and the proposed process for detecting them be described for agency and public review as soon as possible.

The plan to use streams 2002 and 2004 as controls to detect changes in fish production in streams 2003 is problematic because streamflow, water quality and fish production could be affected by the mining proposed in all these drainages. Shallow groundwater flow, which appears to provide critical summer and winter refugia for fish instreams 2002 and 2004 might also be affected by mining and pumping in the stream 2003 drainage.

The LGL report provides some useful information subject to the previously discussed limitations, but one year's weir and tagging data is insufficient to draw conclusions on the life history, habitat use and requirements, overwintering behavior, abundance, survival rates, species composition and movements of fish within the Chuitna River drainage. Anadromous salmon populations fluctuate substantially from year to year due to changes in the number of spawning adult as well as fresh water and marine survival rates. Freshwater survival rates are controlled by climate variability, which in turn controls critical factors such as winter streamflow and water temperatures (Lawson et al 2004). It could take 10 to 20 years of intensive study to determine how climatic changes affect fish production in the Chuitna River drainage, and an equal amount of study to determine how fish survival is affected by changes in streamflow and water temperature regimes.. There are also questions about some of the 2008 data and how the data was collected that can only be answered with improved study methods and a number of years of additional study.

G. Part D7 Fish and Wildlife Protection Plan, Chuitna Coal Project Kenai Peninsula Borough Beluga Alaska July 2007. PacRim Coal, L.P.

Introduction:Objectives of PacRim's Plan:

1. Provide options to minimize or prevent adverse impacts to freshwater fish resources;
2. Describe mitigation options and plans during operations to offset habitat disturbances; and
3. Present design-build plans in sufficient detail to demonstrate the ability to reconstruct portions of stream channel habitat to be removed during operations and provide a framework for post-reclamation monitoring to assess overall success of habitat construction.

The Fish and Wildlife Protection Plan (hereinafter referred to as the Plan) proposes to employ several types of protection measures to minimize or prevent disturbances to fish habitat to the full extent *practical.* These measures include operational procedures, construction designs, and restoration where disturbance is unavoidable. During and after operations, on-site mitigation in the form of stream reconstruction, modification, and enhancement will occur. Offsite mitigation is an option to consider offsetting habitat loss during operations but before reclamation.

The overall approach of the plan is to minimize impacts to fish habitat; mitigate for those impacts with offsite enhancement and recovery projects; reconstruct impacted channels to a natural state that provides fish habitat in a pre-mining capacity; and measure and assess the effectiveness of these activities.

Analysis and Comments:

Page 1: The Plan states that "Stream designs are prepared as design-build plans to allow for the subtleties of streambed topography that are difficult to describe in detail in a set of plans. An experienced, on-site designer during construction will be integral to this approach, and can easily incorporate these features." Although it's not entirely clear, this seems to indicate that regulators will be asked to approve a conceptual plan for reconstruction of stream 2003 and the final design would be developed during construction. Because there is no evidence that a strip-mined salmon spawning and rearing stream and its associated aquifers and watershed has ever been successfully restored and there are questions about the use of the Rosgen methodology to restore salmon streams, a detailed stream and watershed restoration plan should be required as part of the environmental review process. The restoration plan must include examples of where the proposed methodology and techniques have been successfully used in an analogous situation.

Page 3: The Plan states that "During mining operations, physical conditions will be maintained by keeping base flow and stream flow regimes as close as possible to pre-mine conditions." I could not find any indication in the Plan or in other Chuitna Coal studies that the appropriate reaches of streams 2002-2004 have been adequately gauged or that instream flow needs in stream 2003 are known. To maintain pre-mining instream flow needs of fish and aquatic life in stream 2003, it is necessary to measure flow continuously over a long period of time (5 to 20 years) to determine what these instream flow needs are. The Department of Natural Resources requires the Alaska Department of Fish and Game to have a minimum of five years of stream gauge data to grant instream flow reservations to protect fish spawning and rearing and migration (Klein 2009 and Westphal 2009). It would seem reasonable to require at least as much data for a project that proposes to eliminate and subsequently restore fish habitat and stocks.

The Plan states that "Stream discharges, water temperature, and water quality must be suitable during at least a portion of the migration season." This statement is troubling because some life stages (i.e. eggs, fry, smolt and adult fish) are present in the streams affected by the proposed Chuitna Coal Mine at all times. For this reason stream discharges, water temperature, and water quality must be suitable at all times. Even with modern erosion and water quality protection measures in place, coal mining will likely increase surface water temperatures, silt, and turbidity and alter streamflows (Martin and Platts 1981, May et al 1997, and Ruediger and Ruediger 1999). Altering instream flow regimes in these streams is likely to result in changes in water temperature and the wetted perimeter (ie amount of available habitat) which in turn will negatively impact fish and other aquatic life.

Page 5: The proposal to capture and remove fish from the areas to be mined and release them in the unmined sections of stream 2003 below active mining is commendable but probably futile. If stream 2003 is rearing habitat limited and at carrying capacity, these fish probably wouldn't survive because there probably isn't sufficient rearing capacity in the rest of the system to support them. Eliminating or degrading a substantial part of the rearing area in stream 2003 and possibly streams 2004 and 2002 will reduce both the spawning and rearing capacity of these streams. None of the Chuitna Coal studies have addressed whether stream 2003 and the Chuitna River system is spawning or rearing habitat limited. This needs to be determined before mitigation plans are finalized or approved.

Page 6 Water Management: The Plan claims that all discharges will meet state water quality standards and NPDES limitations and that freshwater habitats downstream of the mining activity in stream 2003 and in streams 2002 and 2004 will be maintained by providing minimum baseline flows in each stream. These claims are easy to make in a permit application but very hard to achieve in practice. For example, similar statements were made in the Red Dog Mine and Kensington Mine EISs and permit applications, but both of these mines have violated state water quality standards. Teck Cominco has been cited by the EPA for hundreds of water quality violations since the Red Dog Mine began operating in 1989 (ADN 2006). Because maintaining existing water quality and instream flows is essential to maintaining and restoring fish populations, a credible plan to maintain existing water quality and instream flows and the data to support it must be part of the environmental review process.

The Plan claims that freshwater habitats downstream of mining activity in streams 2003, 2004 and 2002 will be maintained by providing "minimum base flows" through a "variety of methods and infrastructure" including "sediment ponds, diversion structures, infiltration basins, pumping locations, estimates of water volumes and water-balance information, and runoff control structures." These claims raise a number of concerns given that there has been no comprehensive instream flow study of these streams . First, simply maintaining "minimum base flows" for the decades the mine will be in operation will not maintain downstream fish habitat for salmonids. Baseflow or base runoff is comprised largely of groundwater effluent (USGS 2009). The instream flow needs of salmonids vary by species, stream size, and life stage (Vadas 1999). Spawning salmon require higher flows in small streams than in large rivers. High flows provide the stimulus to coho and Chinook salmon to move upstream to spawning grounds in the Cook Inlet basin (Hayes 2009 and Kerkvliet 2009). Periodic flood flows are also necessary to remove undesirable accumulations of sediment from stream gravels so that it can continue to provide suitable habitat for salmonids and aquatic life (Milhous 1998). Because no long-term instream flow study has been conducted in streams 2002-2004, there is no way to know what flows have to be provided at different times during the year, including high flows during the spawning season, to maintain fish populations, and there is and no way to determine if PacRim's proposed system can provide them.

Second, the complex system proposed to maintain flows presents a substantial risk. One power or equipment failure in the coldest part of the winter could cut off flow to stream 2003, resulting in the loss of fish and other aquatic life. The survival of salmon and other aquatic life in cold climates depends on the continual input of warm groundwater base flow during the coldest winter months. Upstream mining and groundwater pumping will diminish or eliminate this flow. There is also a strong possibility that infiltration basins, settling ponds and bypasses that have been proposed to maintain minimum base flows will freeze up, or deliver during the winter water that is below salmonids' thermal tolerance.

Although infiltration basins have been used in many areas to treat stormwater and recharge groundwater, I was unable to find any studies in the scientific literature documenting the successful use of infiltration basins to maintain groundwater flow to a salmonid steam or to maintain a salmonid steam in a cold climate. The use of infiltration basins to maintain flow to stream 2003 and possibly 2002 and 2004 would be experimental and would be complicated by the fact that the loss of groundwater from these streams would be the result of a cone of depression created by deep mining and pumping to dewater the mine. An independent hydrologist should review the data to make sure that the water from the infiltration basins wouldn't be drawn to the pumps instead of the streams.

Lost Habitat Mitigation:

Pages 7-8. ***Off channel spawning and rearing habitat:*** **The Plan discusses s**ome of the disadvantages of attempting to create artificial spawning and rearing habitat to compensate for the loss of 17.4 km of high-value spawning and rearing habitat for 5 salmon species, Dolly Varden and Rainbow trout, but there are other disadvantages as well. First, there is a substantial probability that a functional spawning channel couldn't be constructed. It appears that only one successful salmon spawning channel has been constructed in Alaska and an attempt to extend it was not successful (Lachmar et al. 2007). Second, not all species of salmonids found in stream 2003 use artificial spawning channels. Most importantly, unless the equivalent of 17.4 km of new rearing habitat can be created for salmon fry produced in a spawning channel, which does not seem feasible, the fry produced in a spawning channel probably would not survive and would not offset the loss of production from stream 2003.

Pages 8-13. Off-Site Mitigation: A number of offsite mitigation measures are proposed, but they do not appear to offset fish losses from mining activities. Any potential benefits of the proposed offsite measures must also be evaluated against the certain loss of 17.4 km of high-value spawning and rearing habitat in stream 2003, and additional potential losses in streams 2002-2004. No such analysis is provided for any of the proposed projects.

Some of the proposed measures -- such as bank stabilization for the Theodore River, constructing a bridge across Threemile Creek, and repair of the Theodore River Bridge, which is owned by an oil company -- offer little or no benefit to fish. Others -- such as restoring Threemile Lake sockeye stocks by eliminating introduced northern pike -- probably have little chance of success because of the limited success of rotenone in removing pike from a system with wetlands, an outlet stream , and ground water inflow.. The proposal to remove the Big Lake dam is puzzling because the dam has already been removed (Ivey 2009).

Replacement of culverts that are blocking upstream fish passage can benefit fish populations if studies show that suitable fish habitat exists upstream of the culvert. There is no indication that any studies have been done to show that replacing these culverts would substantially increase fish habitat. There are already are a number of ongoing programs to identify and fund culvert replacement in the Cook Inlet region. The Department of Fish and Game also has the authority under AS16.05.840 to require the owner of a dam or obstruction to fish passage to remove it.

Page 14: The Plan states that "Technologies and materials now exist that will allow for reconstruction of the 2003 stream channels in a manner that will support pre-mine riverine ecological processes." This statement needs to be supported with examples from the scientific literature of successful salmon spawning and rearing stream/drainage restoration in strip-mined areas. No examples have been provided by PacRim and I have searched the scientific literature and talked to a number of stream restoration experts but have been unable to find any examples.

Similarly, the Plan's statement that Stream 2003 and other Chuitna Coal Mine area streams represent a more comprehensive restoration effort that includes three-dimensional restoration of the entire channel, including floodplain structure and form, is incomplete. Because the entire 2003 aquifer will be altered to a depth of 300 feet or more there also needs to be a plan to restore the shallow aquifers that supply phreatic groundwater flow to stream 2003 and possibly to streams 2002 and 2004. There is no mention in the Plan of how pre-mining groundwater flow would be restored to these streams. I have also searched the scientific literature and found numerous papers that document how groundwater flow has been altered after strip-mining restoration but no examples of reclamation efforts that have restored groundwater flow to pre-mining conditions

I have similar concerns with the statement that "Relative examples of this type of project can be found in the reclamation of placer-mined streams." First, the damage to salmon streams from alluvial placer mining is very different from strip–mining, which may encompass entire drainages and alter both the surface topography and subsurface geology and the aquifers down to several hundred feet. Restoration projects like the USFS projects on Resurrection Creek have attempted to restore both sinuosity and rearing habitat to a stream impacted by placer mining in the early 1900's by moving and grading spoil piles and providing instream cover. Placer miners channelized the stream and left spoil piles in the flood plain but did not destroy the shallow aquifer that provides groundwater flow to the stream. It appears that the USFS projects have increased rearing habitat for Chinook and coho salmon by connecting formerly isolated channels in mine spoils, but no pre-mining data on fish use is available.

Page 15: The statement that the Chuitna Coal Mine area streams occur in a non-urbanized, pristine watershed where natural functions and processes are intact is true. However, the statement that reclamation design and construction will be largely ***non-structural*** in nature with the exception of log jams and where appropriate and grade controls at intervals in active bed reaches is puzzling. First, strip-mining the entire upper stream 2003 drainage and completely altering the surface and subsurface topography and hydrology will have greater effects on fish habitat than urbanization (May et al 1997). Second, construction of a new stream channel will be structural. ***Structure*** means a complex entity constructed of many parts, and the Rosgen system consists of characterizing and categorizing ***stream structure***. To construct a functioning stream channel using Rosgen's system as the basis, the drainage would have to be recontoured and revegetated (which could take decades or longer), a complex new stream channel constructed, and a new shallow aquifer constructed to provide shallow groundwater flow to the new stream. Problems with the use of Rosgen's system to restore streams are discussed earlier in this report.

Page 16 paragraph 1. It may be possible to design a "stable post mine channel plan form, cross section and profile," but there is no evidence in the scientific literature that a functioning salmon spawning and rearing stream could be reconstructed after the mining proposed for the stream 2003 drainage is completed. The Plan does not provide any examples of where a fully functioning 17.5 km long salmon spawning and rearing drainage and associated watershed -- or anything on a similar scale -- has been successfully restored after strip mining. An extensive literature search by this reviewer hasn't turned up any examples either. Without some evidence of previous success, the entire concept of using Rosen's classification system to successfully restore a heavily altered drainage is highly questionable.

Page 16. Existing data: The summary of necessary data associated with the stream reclamation is incomplete. To collect information necessary for restoration of the natural hydrological cycles of stream 2003 and the fish populations whose life cycles revolve around seasonal changes in flow and water quality, it is necessary to install stream gauges in strategic stream reaches in stream 2003 and to conduct an instream flow study for a minimum of 5 years or more (Kondolf et al 2000 and Estes and Orsborn 1987). As stated previously, 5 years of flow data is the minimum required by ADNR to grant an instream flow reservation to protect fish habitat to ADF&G (Kline 2009). The number of years of flow measurement would be dependent on knowledge of the fine-scale variation in flows over time and other factors. This has not been done. It is also necessary to measure groundwater flow into stream 2003, because the influx of shallow groundwater is likely the most important factor in overwinter survival of fish and aquatic life (Swales and Levings 1989 and Bennet 2004). Data should be collected over a long enough period of time to determine the full range of daily, seasonal and annual variations in phreatic groundwater flow. This has not been done and this data is not available to design a new functional channel, new shallow aquifers or determine instream flows needs of stream 2002-2004 fish and aquatic life.

Page 20 Beaver activity: Beaver dams affect stream morphology and riparian zones, and provide important habitat for coho salmon and other fishes (Bruner 1989 and Mitchell and Cunjak 2007). The loss of the numerous beaver dams will affect both fish habitat and stream flow in stream 2003. However, this does not appear to be factored into PacRim's stream restoration plans. Beavers will recolonize the upper Stream 2003 drainage only if and when riparian woody deciduous vegetation is fully restored. No estimate is provided of how long reestablishment of woody vegetation may take, but it could be decades or longer. Forty years after peat mining in the Colorado Rockies, sedges and willows that dominated undisturbed sites were largely absent on mined sites (Cooper and MacDonald 2001). Previously reclaimed strip mines in Alaska have been reseeded with grasses and some types of woody vegetation. Monitoring of revegetation at the Usibelli Mine in interior Alaska found that grasses, particularly, boreal red fescue, were the most successful species in part because of the acid soils left after mining (Elliott et al 1986). The floodplain depressions and backwaters PacRim proposes to replace beaver dams and wetlands will not provide the same functions as the 50 beaver dams, 7 lakes, and thousands of acres of wetlands that would be destroyed by mining.

Page 21. Hydrologic and Hydraulic Analysis. Streamflow is the master variable that limits the distribution and abundance of fish species in rivers and streams. Streamflow typically follows a general pattern but may vary hourly, daily, seasonally, yearly and longer. This characteristic pattern of the magnitude, timing, and variability of streamflow defines a river's flow regime. The life cycles of fishes and other aquatic life are inexorably tied to this flow regime. Alteration of any facet of this natural flow regime can result in significant ecological consequences.

Maintaining natural volumes and patterns of instream flow are essential to preserve fish populations and other aquatic life in the unmined lower reaches of stream 2003. Restoration of premining instream flow patterns to a reconstructed stream 2003 drainage would be extremely difficult. I did not find any examples in the scientific literature of restoration of premining in stream flow patterns and volumes to a similarly altered drainage.

Instream flow is used to identify a specific stream flow in cubic feet per second at a specific location for a defined time, and typically following seasonal variations. Instream flows are the stream flows needed to protect and preserve instream resources and values such as fish, wildlife and recreation (Milhous 1998, Vardas 1999, Estes and Orsborn 1987 and Kondolf et al 2000). Instream flow needs are determined by calculations based on several years of streamflow data and from a network of streamflow gauges placed at key locations within a stream, detailed information on depth, velocity and substrate, and a through understanding to the biology of salmonids. (Estes and Orsborn 1987 and Kondolfet al 2000). However, there is no mention in the Plan of the instream flow needs of fish and aquatic life in the streams likely to be affected by the Chuitna Coal Mine, or any indication in the 2006-2008 Chuitna Coal environmental studies reports that an adequate instream flow study particularly in streams 2002 and 2004 and other Chuitna River tributaries which might be effected by hydrological changes from mining has been conducted. There apparently were some stream gauges in the Chuitna drainage during the 1982-84 studies and the Riverside Technologies Hydrology report indicates that there have been up to 4 gauges in stream 2003. However, there is concern that there weren't enough gauges and they were not in the right location to determine instream flow requirements in streams 2002, 2003 and 2004 (Mouw, 2009).

PacRim has confirmed that there has been no USGS stream gauge in stream 2003, and the USGS web site does not show that there are presently any stream gauges in the Chuitna River drainage (USGS 2009). The Fish and Wildlife Protection Plan does not indiciate there are PacRim gauges in the system either, however, the Riverside Technologies Hydrology Component Baseline indicates that there have been four gauges on stream 2003 with 3 to 16 years of data. According to the Fish and Wildlife Protection Plan PacRim proposes to use USGS flood flow regression equations to calculate flood flows for stream design. This may help design channels that will resist flood flows, but it won't provide data necessary to maintain fish habitat.

Page 22 Hydrologic and hydraulic analysis: Although the Plan acknowledges the potential for avulsion and subsequent unzipping of a newly constructed channel due to flooding, it does not acknowledge the length of time that this risk will continue or the potential consequences. Revegetation of the mined areas could take a very long time, and during this time the exposed soils will be subject to erosion. The erosion rate of mined watersheds reported by Haigh (2000) was 1.7 mm-yr.-1, or 85 times greater than erosion at an unmined watershed (.02mm-yr.-1). A 10-, 25- or 100-year flood on an unvegetated hillside and floodplain would not only wash out a newly constructed stream channel, but would carry tons of sediment into the stream channel (Martin and Platts 1981 and

Ruediger and Ruediger 1999). This sediment would wash downstream, smothering spawning and rearing areas in unmined sections of stream 2003 (Cordone and Kelley 1960).

Page 30 paragraph 2: LGL's description of the hyporheic zone as the region below and laterally to the streambed where there is mixing of shallow groundwater and surface water, and its importance in fish spawning and baseflow recharge, is correct However, the role of shallow groundwater and the hyporheic zone in overwinter survival of fish eggs and fry must also be acknowledged. Unfortunately, the Plan does not explain how the flow of shallow groundwater to the hypohreic zone will be restored after excavation of the existing aquifers down to a depth of several hundred feet below the streambed elevation.

Pages 26-33: Typical construction plans and specifications: The techniques described in this section are all bioengineering techniques which have been used to restore damaged streambanks or relatively short sections of relocated streams. After searching the scientific literature and talking to stream restoration experts, I have not been able to find any examples of where any of the techniques proposed in the Fish and Wildlife Protection Plan have been used to restore the ecological functioning of 17.4 km (or even a smaller scale) of a strip-mined salmon spawning and rearing stream, watershed, and associated aquifers. I also reviewed the references used to support the proposed restoration methodology in the Fish and Wildlife Protection Plan and found only two that might provide information on restoration techniques and successful salmon stream restoration projects in strip-mined areas. These were Rosgen, ***Applied River Morphology*** (1996) and Leedy et al ***Environmental Reclamation and the Coal Surface Mining Industry (***1987)***.***

Rosgen's 1996 steam classification system has been widely used to inventory stream channel topography in watersheds, but it is increasingly drawing criticism from hydrologist and engineers for its use in stream restoration (Simon et al 2007, Gillian 1996, Lacombe and Eaton 2003 and PacRim Coal 2007). Some of the problems with using Rosgen's natural channel design classification system in stream restoration include: (1) alluvial streams are open systems that adjust to altered input of energy and materials, and Rosgen's form-based system largely ignores this component; (2) C5 channels composed of different bank sediments adjust differently and to different equilibrium morphologies in response to identical disturbances, contradicting the fundamental underpinnings of natural channel design and the reference reach approach which PacRim proposes to use to reconstruct a new stream 2003; and (3) Rosgen's system fails to integrate and quantify fluvial processes and channel response. This is important because PacRim has not adequately gauged or conducted instream flow studies on any of the streams likely to be impacted by the project (PacRim Coal 2007).

Although, Rosgen's natural channel design and bioengineering techniques proposed for stream 2003 have apparently not been used to successfully restore salmon spawning streams, they have been regularly used as a cookbook method to restore eroding stream banks and relocate relatively short sections of streams (Gillian 1996 and Simon et al 2007). One of the difficulties in evaluating the potential effectiveness of stream restoration projects using Rosgen's methodology and bioengineering techniques in restoring streams and fish habitat is that there have been few quantitative scientific post-project studies. One group of scientists who evaluated the success of stream restoration projects using this methodology found that fewer than half had any pre- or post-project monitoring, and of those that did, most monitored only riparian vegetation and not stream habitat (Moerce and Lambert 2004). Another study, which looked at 23,000 restoration projects, found that 34% did not do any post-project evaluation. Of the 70% who said that their projects were successful, 43% either did not have any success criteria or were unaware of what success criteria are (Rumps et al 2007). PacRim did not reference any studies in the scientific literature documenting the use of Rosgen's stream classification system to successfully restore a salmon spawning and rearing stream in a deep strip-mined area, and my searches did not reveal any examples either.

I was unable to locate and review the article ***Environmental Reclamation and the Coal Mining Industry. National Institute for Urban Wildlife, by D Leedy, L. Adams, G. L. Dove, and G. Jones (1985),*** **which is** cited in the Plan. The National Institute for Urban Wildlife, which apparently closed in 1995, sponsored research and wrote papers on urban wildlife problems with limited relevance to the Chuitna Coal Project.

Page 34: Construction Sequencing: Restoring the flow of phreatic groundwater into the hyporheic zone of stream 2003 is essential to restore fish habitat in stream 2003. The only statement in the Plan which may refer to groundwater restoration is that stockpiled soil will be placed in a "manner to replicate premined strata and compacting conditions. This effort will include replication of subsurface confining zones segregating confined and unconfined aquifers."

The Plan does not provide any references to support the methodology they have proposed to use to restore groundwater flow or examples of strip mine reclamation projects where groundwater flow was restored to pre-mining conditions by replacing mining tailings or soil. I was also unable to locate any examples in an extensive search of the scientific literature. However, there is a large body of scientific information documenting long-term disruption of both surface and groundwater flow as the result of recently permitted strip mining and reclamation (Bonta 2007, Wilson 1978 and Schwartz and Crowe 1985). Bonta et al (2007) studied the effect of surface mining and reclamation on physical watershed conditions and groundwater hydrology in three watersheds. This study found that mining disturbances in adjacent watersheds affected groundwater levels in the undisturbed watersheds prior to mining. New subsurface flow paths with different characteristics formed during mining and reclamation. Groundwater recovery in the mined upper saturated zone was slow and irregular both temporally and spatially after reclamation. Wilson (1978) found that the impact of a strip mine can extend far beyond its radius of influence at the water table, and mines near regional discharge areas have a more significant effect on the regional system.

Wetlands and Lakes: There are thousands of acres of wetlands and at least seven lakes and ponds that will all be destroyed by the proposed mine, but there is no discussion in the Plan of the long-term consequences of this impact and apparently no plan to restore these wetlands, lakes and ponds after mining. The importance of wetlands to the productivity of salmon streams is well-documented in the scientific literature (Pess et al 2002 and Pollock et al 2004). A recent study of a stream drainage in Southeast Alaska concluded that "Organic nutrients derived from wetlands comprise the bulk of the stream's water organic nutrient budget on an annual basis." (Hood et al 2008). The loss of wetlands has been correlated with declines in salmon production (Pess et al 2002 and May et al 1997). Even if the physical structure of stream 2003 could be restored, the currently level of productivity probably cannot be because of the permanent loss of the extensive wetlands in this drainage.

Summary:

The plan for stream restoration presented in the Fish and Wildlife Protection Plan is conceptual and few specifics are provided. The goal of the Plan appears to be to construct a new stream channel on top of mine tailings using stream measurements based on Rosgen's 1996 stream classification system. Bioengineering techniques would be used to reconstruct the banks. The floodplain would be revegetated at some later time. Because no comprehensive instream flow study has been conducted on stream 2003, the new channel would be designed based on USGS equations and possibly with comparisons with adjacent drainages. During mining, streamflows to stream 2003 would apparently be maintained through a system of bypasses and infiltration galleries. After reconstruction, PacRim expects stream 2003 to evolve to its premining level of productivity.

There are a number of problems with the Plan. First, there is no scientific evidence that stream 2003 could be restored. PacRim does not provide any examples or scientific documentation to support its claim that stream 2003 can be restored to premining productivity. Scientific studies of mines similar to the proposed Chuitna Coal mine concluded that strip mining for coal may affect groundwater flow over a wide area, including adjacent drainages. Even after restoration as required under federal and state regulations, groundwater flow has been altered from premining conditions. An extensive and lengthy search of the scientific literature and discussions with stream restoration and instream flow experts did not yield one example of where a strip-mined salmon spawning and rearing stream and its associated watershed and aquifer have been successfully restored. A list of the databases searched is included in Appendix 1.

Second, there are problems with the proposed stream restoration methodology. The Rosgen stream classification and associated natural stream channel design methods, which are the basis of the proposed PacRim stream restoration plan, has come under increasing criticism from hydrologists and engineers. Some of the problems with using Rosgen's natural design method in stream restoration include: (1) alluvial streams are open systems that adjust to altered input of energy and materials, and a form-based system largely ignores this component; (2) C5 channels composed of different bank sediments adjust differently and to different equilibrium morphologies in response to identical disturbances, contradicting the fundamental underpinnings of natural channel design and the reference reach approach which PacRim proposes to use to reconstruct a new stream 2003; and (3) Rosgen's system fails to integrate and quantify fluvial processes and channel response. This is important because PacRim has not adequately gauged or conducted instream flow studies on any of the streams likely to be impacted by the project (Simon et al 2007, Gillian 1996, Lancombe and Eaton 2003 and PacRim Coal 2007).

Third, the on- and offsite mitigation proposed in the Plan would not compensate for the loss of fish habitat in 17.4 km of stream 2003, alteration of groundwater flow which may also affect streams 2002 and 2004, and the diminishment of stream productivity resulting from the permanent loss of thousands of acres of wetlands. If spawning channels could be successfully constructed, they would offset the loss of spawning habitat only for some species in stream 2003, and only if a corresponding amount of rearing habitat could be created to replace the 17.4 km lost in stream 2003, which seems unlikely. The offsite mitigation proposed, such as the proposal to repair a bridge, restore a section of eroding streambank and remove the Big Lake dam (which has already been removed), is of questionable or no benefit.

Fourth, essential studies of instream flow and the input of groundwater to stream 2003 necessary to support salmon and other aquatic life and reconstruct stream 2003 have not been conducted.

Fifth, there are several thousand acres of riparian and upland wetlands in the stream 2002-2004 drainages that probably provide the bulk of stream 2003's annual organic nutrient budget that will be destroyed as the result of mining. However, there is no mention of reconstruction of these wetlands or of the functions they currently provide; n or does the Plan contain any plans to reconstruct them.

H. Conclusions:

There are serious problems with the data collection methodology, analysis and conclusions of the baseline aquatic resources studies and Fish and Wildlife Protection Plan. These include:

1. There are many problems and questions about the data collection methodology, data analysis and conclusions of the 2006-2008 studies. These are identified and discussed in the comments on each report. In addition, it is problematic to base any conclusions on the limited amount of data that has been collected on key issues such as smolt outmigration, adult escapement, winter fish studies, and smolt production between stream systems. Only one year's data has been collected on most of these issues,. Because salmon populations have historically fluctuated greatly over a 20 or more year cycle, the few years of data collected is not sufficient to determine the natural range in salmon populations that would be

affected by the Chuitna coal strip mine. For example adult Chinook escapement into the Deshka River, another upper Cook Inlet spawning stream ranged from 57,939 fish in 2004 to 7,533 in 2008. Juvenile salmon and other forms of aquatic life show similar variability. A minimum of 5-10 years of additional study is necessary to determine the natural range of variability in fish populations that would be affected by the Chuitna Coal Mine. A credible mitigation and restoration plan cannot be developed without adequate data.

2. PacRim has not conducted adequate surface and groundwater studies necessary to: accurately map and quantify the seasonal and long term cycles of groundwater input into streams 2002-2004; determine impacts to the Chuitna River drainage from strip-mining and groundwater pumping associated with mining; provide assurances that groundwater flow to unmined portions of streams 2003 and 2004 can be maintained, or: restore essential phreatic groundwater flow to a reconstructed stream 2003.
3. The uninterrupted flow of shallow groundwater to salmonid spawning streams is essential for overwinter survival of eggs and fry. Strip-mining will interrupt this flow and destroy the shallow aquifers that currently provide groundwater to streams. PacRim has not acknowledged this as an issue, provided a plan to restore groundwater flow, or referenced any scientific studies showing where an aquifer supplying phreatic groundwater to a salmon spawning and rearing stream has been successfully restored after strip-mining. An extensive search of the scientific literature returned many examples of how strip-mining has altered groundwater flow during and after mining but no examples of where groundwater has been restored to premining conditions.
4. The failure to determine the genetic makeup of salmonid stocks in streams 2002-2003 and the Chuitna River system is a serious deficiency of the Chuitna Coal environmental studies and proposed monitoring program. Data on genetic characteristics of salmon populations are critical for quantifying the status of local reproductive units (demes) and evolutionary significant units. There is mounting evidence that the individual spawning and rearing streams, such as stream 2003, of coho, sockeye and likely other salmonids may be comprised of demes or small locally interbreeding groups that are genetically adapted to the unique conditions in their natal streams. If these streams and the genetically unique salmon demes that use them are destroyed or blocked by strip-mining as proposed, it is unlikely that these local salmon stocks could be restored to their former level of productivity even if a new stream channel could be successfully constructed.
5. It is probably not possible to reconstruct a new stream with the same level of productivity as the current stream 2003. PacRim has not provided any examples of where a strip-mined salmon spawning and rearing drainage the size of stream 2003 (17.4 km) has been restored to premining productivity. An extensive search of the scientific literature and discussions with stream restoration experts in Alaska and elsewhere has also not produced any examples.
6. There are problems with PacRim's plan to use Rosgen's 1996 Applied River Morphology as the basis for stream 2003 reconstruction. Rosgen's 1996 stream classification system has been widely used to inventory stream channel

topography in watersheds, but it is increasingly drawing criticism from hydrologists and engineers for its use in stream restoration. Some of the problems with using Rosgen's natural channel design classification system in stream restoration include: alluvial streams are open systems that adjust to altered input of energy and materials and Rosgen's form-based system largely ignores this component; Rosgen C5 channels composed of different bank sediments adjust differently and to different equilibrium morphologies in response to identical disturbances, contradicting the fundamental underpinnings of natural channel design and the reference reach approach that PacRim proposes to use to reconstruct a new stream 2003,; and Rosgen's system fails to integrate and quantify fluvial processes and channel response. This is important because PacRim has not adequately gauged or conducted instream flow studies on any of the streams likely to be impacted by the project.

7. Even if Stream 2003 could be successfully restored to full physical and ecological function, it may not be possible to restore it to its former level of biological productivity because of the loss of marine derived nutrients (MDN) from salmon carcasses and the permanent removal of all the wetlands in the mine area. Wetlands and MDN are the primary sources of stream nutrients and productivity in salmon streams.
8. The offsite mitigation offered in the plan (i.e. removal of the Big Lake Dam, bridge repair etc.) has little or no potential to offset the loss of fish populations and 17.4 km of high-value fisheries habitat that would be destroyed or altered by mining.
9. There is a good chance that the spawning channels offered as onsite mitigation for the loss would not be successful. Even if these channels were used by spawning adults, any fry produced in spawning channels would probably not survive unless all of the high-value rearing habitat that would be destroyed or blocked by could also be created off site which is very unlikley.

The information provided in the PacRim Coal 2006-2008 Environmental Studies and the summary of the 1980's studies is inadequate to determine the effect of the proposed Chuitna Coal Mine on fish and fish habitat in the Chuitna drainage. It is also inadequate to develop a mitigation plan and a restoration plan for fish populations and habitat that would be impacted by mining. Additional research is needed. Appendix 2 contains a list of research needs identified during this review.

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Appendix 1: Databases Searched

Academic Search Premier
Alaska and Polar Periodicals
Aquatic Sciences and Fisheries Abstracts
Conference Papers Index
Environmental Sciences and Pollution Management
Fish and Fisheries Worldwide
Science Direct
Water Resources Abstracts
Wildlife and Ecology worldwide
Google Science
Transactions of the American Fisheries Society

Appendix 2: Additional Studies Needed

• 5-10 years of sonar and/or weir counts of adult and salmon smolt in the mainstem Chuitna River and streams 2002-2004.
• Genetic analysis of salmonid populations in the mainstem Chuitna River and streams 2002-2004.
• Determine if the Chuitna River and streams 2002-2004 are rearing or spawning limited for all species of salmonids.
• Use remote sensing to identify and map groundwater input into streams 2002-2004 and the Chuitna River.
• Determine the relationship between, and the importance of, groundwater and surface water sources in streams 2002, 2003 and 2004 and relate this to the use of available habitat for incubation, rearing, and overwintering.
• A comprehensive study of marine derived nutrients and terrestrial/wetlands nutrient cycling in the Chuitna River drainage and streams 2002-2004.
• A comprehensive study of freshwater and marine survival rates of Chuitna River salmon populations using coded wire tags and other techniques.
• A comprehensive multiyear study of fish movements within and between Chuitna River tributaries using coded wire tags.
• A comprehensive study of factors, including groundwater, affecting overwinter survival of fishes in Streams 2002-2004. Characterize and quantify overwintering habitat.
• Study juvenile salmon rearing and smolt outmigration in the lower Chuitna River and nearshore waters of Cook Inlet.
• Study the effect of weirs on upstream fish movements in streams 2002-2004.
• A comprehensive study of the overwintering behavior and habitat factors (e.g. groundwater, water temperature, instream flow etc.) affecting the overwinter survival of salmonids, other fishes and aquatic life in streams 2002-2004.
• Locate fish spawning and overwintering areas within streams 2002-2004 and the Chuitna River. Measure hyporheic and phreatic groundwater flow and water temperatures in these areas.
• Study the use of the mainstem Chuitna River as rearing habitat by coho and Chinook salmon.
• Conduct a two-year field study to determine the feasibility of using infiltration galleries to restore streamflow to a stream, especially during the winter months.
• Study the rates at which Chuitna salmonids return to natal and non-natal areas to spawn and rear.
• Determine egg to emergent fry and emergent fry to smolt survival rates in streams 2002-2004 and the Chuitna River. Identify and quantify freshwater mortality factors (e.g. predation, freeze-out, etc.).
• Determine the age and size at which Chuitna River coho and Chinook salmon smolt, using coded wire smolt tags and adults recoveries.
• Determine how and when high water events initiate upstream Chinook and coho spawning movements in the Chuitna River drainage.
• Quantify how floods and high water events affect the accuracy of weir counts of upstream and downstream movements of fish in streams 2002-2004.