# Report on Chuitna Coal Project of PacRim Coal


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This report is in relation to a proposed coal mining project that will impact the Chuitna River watershed which is situated near Anchorage, Alaska and to the west side of Cook Inlet. The coal is located in a 20,571-acre lease tract. The project will involve putting in access roads to the mining site, building housing, adding an airstrip, power facilities, logistics support facilities, and various other mining-related infrastructure (e.g., transport conveyors). The watershed is ~150 square miles but the area to be impacted is much larger due to all the infrastructure and access needs for mining.

As context for my comments, I am a Professor at the University of Maryland where I oversee a scientific research laboratory with approximately 120 staff, 20 buildings, and a research fleet (see attached Curriculum vitae). I have over 25 years of experience in research and teaching on coastal ecosystems, watershed science, and stream ecology and restoration. Past work includes leading a large team of scientist in developing the first national database on river restoration in the U.S., co-authoring a book on *The Foundations of Restoration Ecology* and serving as an expert advisor on the design of multiple stream and river restoration projects.

I have reviewed a number of documents including the 2007 Fish and Wildlife Protection Plan (Part D7), the Protection of the Hydrological Balance (Party D12), the Hydrology Component Baseline Report, the Annual Water Management Plans (Addendum D12-A), the Baseline Report for Vegetation and Wetlands, a Wetlands Functional Assessment, and portions of the 1990 Final Environmental Impact Statement by the EPA and other related documents including some appendices.

I begin with comments on the impacts of the mining activities; however, my report focuses primarily on concerns with the mitigation that is for the streams.

## Ecological impacts of the project

The Chuitna River watershed is characterized largely by tundra vegetative cover, spruce-birch forest (almost 50% of the mine site), alder scrub, and various fen and wetland species. Many of the plants and habitat types are very sensitive ecologically and yet will be destroyed or degraded severely. The impacts of the mining activities include destruction of forest, wetlands, habitat for wildlife, habitat for aquatic species, and the entire loss of 17.4 km of streams that support healthy populations of invertebrates and fish, including many highly valued salmon and other game fish. Tributaries of the Chuitna River that will be impacted include in particular, the headwater stream called “2003 Creek” (sometimes called Middle Creek) which drains the mine site; other tributaries likely to be impacted include “Lone Creek” and “2004 Creek”.

**Critical habitat.** The areas to be impacted are in pristine regions of the watershed and while one could argue that all of the habitat types are critical ecologically, there are three that are unusually so: tundra, wetlands, and headwater streams (Elmqvist et al. 2003)

*Tundra* ecosystems are considered among the most fragile ecosystems on earth (Reynolds and Tenhunen 1996). They are extremely sensitive to disturbances (even dust from nearby roads), slow to recover (Myers-Smith et al. 2006) and a huge fraction of the carbon in tundra ecosystem is stored in soils (Mack et al. 2004) which will be severely disturbed by the proposed mining activity. Yet the ability to restore the tundra regions and peatlands after the Chuitna Coal Project is complete is highly questionable. Peatland restoration has not been studied very extensively but current work indicates that only under the following conditions are restoration efforts likely to be successful: some remnant vegetation, a seed bank [in the soil], and connection to other healthy peatlands (Gorham and Rochefort 2003). For much of the region that is impacted by the mining, these conditions will not be met.

*Wetland* areas are also well known as ecologically critical ecosystems. The reports from PacRim indicate that approximately 4,000 acres of wetlands are in the Chuitna Coal Mine mapping area and there are at least 7 plant species designated as 'rare' by the Alaska Natural Heritage Program. Wetland types include riverine lowlands, bogs, fens, and areas around ponds. The project is in a broad region of Alaska well known for its ecologically important wetlands (Tiner 2003). These wetlands have high rates of primary production and store large amounts of organic matter, both of which are critical to the overall food web of the region as well as to long term carbon storage (Chimner et al. 2002). Wetlands such as these support both photosynthetically-based food webs and food webs dependent on detritus (decaying organic matter) and are home to a very diverse community of permanent and migratory wildlife (Mitsch and Gosselink 2007). Such wetlands are also critical sites for water storage and groundwater recharge (Brauman et al. 2007). Finally, wetland ecosystems play pivotal roles in biogeochemical processes including nutrient transformations, denitrification, removal of some contaminants from the water, and decomposition (Palmer and Richardson 2009, see Table 1). There is an extensive literature on wetland restoration indicating that hydrological flow paths are essential to success and the Chuitna mining project will fundamentally alter these paths. Further, results from wetland creation efforts suggest that while mitigation projects may meet compliance requirements, full ecological or functional success is low or unknown for most projects (Ambrose et al. 2007; Euliss et al. 2008; Mathews and Endress 2008). A 2008 review prepared for Congress stated: "Both scientists and policymakers debate whether it is possible to restore or create wetlands with ecological and other functions equivalent to or better than those of natural wetlands that have been lost over time" (Copeland and Zinn 2008).

*Headwater streams* are those smallest of all tributaries that reflect 'where rivers are born' – that is, they feed the complex network of larger and larger downstream tributaries. Their position within watersheds (they impact all downstream waters), their high rates of key biogeochemical processes, and the high levels of biodiversity they support have been emphasized in a great deal of scientific research (Lowe and Likens 2005; Meyer et al. 2007). Headwater streams such as those that will be destroyed or impacted by watershed disturbance during mining may be small in size, but they provide habitats for a rich array of species, which enhances the biological diversity of the entire river system. This is discussed later but briefly: they provide a source of food and colonizing flora and fauna to downstream waters, they are important spawning and nursery grounds for fish and insects that live in larger rivers the rest of their lives, and they provide a refuge from predators and changes in temperature for some species. Their role in biogeochemical processing and particularly nitrogen dynamics is disproportionately related to their size (Peterson et al. 2001). As I discuss later, the potential for headwater streams to be restored varies with the amount of degradation; however, there is no scientific evidence that streams that are mined through in the manner PacRim proposed can ever be restored ecologically.

**Biodiversity loss and functional consequences.** The loss of 17.4 km of streams will remove habitat that is essential to the life cycle of salmonids and other groups of fish that reside all or part of the year in the Chuitna tributaries. Mining through the streams to a depth of > 300 feet will lead to severe and permanent environmental impacts to the existing channel and living resources. Attempts will be made to re-locate valued fish but survival is not certain. Mobile animals like bear, moose, and birds may be able to move to other areas when their local habitat is destroyed although some mortality is inevitable. Flora and smaller fauna within the streams to be mined will be killed including amphibians, invertebrates, algae, and microbial communities. Previous reports for the Chuitna watershed indicate that invertebrates include not only taxa such as chironomids and simulid blackflies (Dipterans) but sensitive insect taxa in the orders Ephemeroptera, Plecoptera, and Trichoptera. Thus, biodiversity losses will be very significant in the streams that are mined and in downstream reaches which are impacted by the upstream disturbances.

Biodiversity loss in the Chuitna watershed is of great concern not only because valued species will be lost but because biodiversity is integral to ecosystem function. Biodiversity loss is often associated with a decline if one or more ecosystem functions (Hooper *et al*., 2005; Cardinale *et al*., 2006) and since different species contribute differentially to different functions, the maintenance of multi-functional ecosystems requires maintenance of high species diversity (Hector & Bagchi, 2007). Because diverse ecosystems are typically associated with higher functional and response diversity (different species vary in their vulnerability and response to change), ecosystems with many species exhibit more resilience in the face of environmental changes (Elmqvist et al. 2003). Ecological resilience is the ability to resist perturbations or recover from disturbances such as unusual climatic events (storms, droughts) or even anthropogenic disturbances (e.g., global warming, tree harvest). Once biodiversity is degraded, ecosystems are more vulnerable to collapse due to higher temporal and spatial fluctuations in species and performance; in short, species diversity contributes to the stability of biotic communities and ecosystem function (Naeem et al. 1994; Tilman et al. 1996).

## Deficiencies of the Mitigation Plan

The proposed mitigation includes the construction of artificial off-channel spawning and rearing habitat, off-site mitigation options (culvert improvements, bridge repairs, erosion control on the Theodore River, lake "enhancement", removal of a dam on Fish Creek), and stream "reclamation". I focus my comments on the latter since it is the only activity that directly addresses compensation for the destruction of the 17.5 km of Stream 2003 and associate tributaries.

The PacRim *Fish and Wildlife Protection Plan* describes the objective of fully reconstructing an "undisturbed" channel and floodplain to "ensure pre-mined ecological functions and values are restored" (page 15). A natural channel design (hereafter, NCD) or Rosgen approach is proposed. They will attempt to mimic the morphological attributes (channel dimension, pattern, profile) of a 'reference reach' that is selected from the existing, pre-mined channel. Their goal is to "replicate the pre-mine channel geometry…" (page 24). They have extensive data from geomorphic surveys, streambed particle size measurements, and habitat surveys and they have classified existing channels based on the Rosgen classification scheme. Stream 2003 is apparently not gauged at present and so they will estimate hydraulic parameters needed for the design. It also appears they do not have direct measurements of bedload or tractive force in existing channels but indicate they will get "direct sediment discharge collections across a range of flows" (page 24) in order to develop a sediment rating curve. Descriptions of the ecological aspects of the reclamation are extremely limited and mostly deal with riparian vegetation.

**1. Failure to directly assess ecosystem functions.** The mitigation plan does not include direct assessment of the ecological functions that will be lost when the streams are destroyed by the mining activities. Healthy streams are living, functional systems and the most essential ecological functions include: the purification of water, the removal of excessive levels of nutrients and sediments before they reach downstream waters, the processing of organic material (decomposition or biological utilization), and primary and secondary productivity (growth of photosynthetic organisms and consumers) (Fischenich 2006, Allan and Castillo 2007). The most common stream functions are shown below in Table 1.

These functions are supported by ecological processes including: the processing of nutrients at the same rate and form as unimpacted streams, the decomposition of organic matter at rates typical of nearby unimpacted streams, and, microbial, primary and secondary production the same as nearby healthy streams (Palmer et al. 1997a; Naiman et al. 2005; Palmer and Richardson 2007). These processes must be measured in order to determine how and whether they may be brought back to the right levels and direction through restoration. No data or measurement plans for these processes are provided in the mitigation plan despite abundant scientific studies outlining how to make and interpret such measurements (e.g., Peterson et al. 2001; Gessner and Chauvet 2002; Hall and Tank 2003) and how such measurements can be used to evaluate the success of a restoration project (Buckveckas et al. 2007; Roberts et al. 2007).

Use of well-accepted methods for measuring ecological functions (e.g., see Hauer and Lamberti 1996, 2006) is important because ecological functions evaluate dynamic properties of ecosystems that underlie an ecosystem's ability to provide vital goods and services (Gessner and Chauvet 2002, Falk et al. 2006, Fischenich 2006, Palmer and Richardson 2007). The units of an ecological function are a process *rate* and *direction* (Table 1). Functions reflect system performance (http://www.epa.gov/eerd/functional.htm) and their measurement requires quantification of ecological processes such as primary production or nutrient uptake (Hauer and Lamberti 1996, 2006). This should be reflected in the mitigation plan if the plan is to mitigate functions that are lost due to the mining through of streams. Functional measures have been used to compare degraded vs. restored vs. reference streams[1] and have been shown to be quite sensitive to degradation and restoration.

[1] Roberts et al. 2007. Effects of upland disturbance and restoration on hydrodynamics and ammonium in headwater streams. Journal North American Benthological Society 26:38-53; Buckveckas, PA. 2007. Effects of restoration on water velocity, transient storage, and nutrient uptake in a channelized stream. Environmental Science and Technology **41**: 1570-1576; Kaushal, S., P. Groffman, P. Mayer, E. Striz, E. Doheny, A. Gold. 2007. Effects of stream restoration on denitrification at the riparian-stream interface of an 2 urbanizing watershed of the mid-Atlantic U.S. *Ecol. Appls.*.

| TABLE 1 ECOLOGICAL FUNCTIONS OF HEADWATER STREAMS | | | |
|---|---|---|---|
| **Ecosystem function** | **Ecological Process that supports this** | **Measurements required** | **Without it what happens** |
| Water Purification<br>a) Nutrient Processing | Biological uptake and transformation of nitrogen, phosphorus | Direct measures of **rates** of transformation of nutrients; for example: microbial denitrification, conversion of nitrate to $N_2$ | Excess nutrients can build up in the water making it unsuitable for drinking or to support life |
| Water Purification<br>b) Processing of contaminants | Biological removal of materials such as excess sediments (removed by riparian plants for example) or such as toxins (some taken up by plants or processes by microbes thereby removing them from the water) | Direct measures of contaminant flux (e.g., the movement of sediment into and down streams). This is a **rate.** | Toxic contaminants kill biota; excess sediments smother invertebrates (kill them), foul the gills of fish (kill them), etc; water not potable |
| Decomposition of organic matter (organic matter processing) | The biological (mostly by microbes and fungi) degradation of organic matter (could be leaf material or other input such as sweater or organic wastes) | Decomposition is measured as a **rate**. Usually expressed as the slope of a line showing weight loss over time of organic matter heated to high temperatures to convert the particulate carbon to gas (CO2) | Without this, excess organic material builds up in streams, leading to low oxygen levels which leads to death of invertebrates and fish and the water is not something anyone would want to drink |
| Production (Primary = algae & aquatic plant; Secondary = growth of organisms like insects, fish, etc | Measured as a rate of new plant or animal tissue produced over time | Primary - measure the **rate** of photosynthesis in the stream; for secondary, you measure growth rate of organisms | Primary production supports the food web; secondary production (fish) we often eat or it (inverts) supports fish. |
| Temperature Regulation | Water temperature is "buffered" (i.e., does not change dramatically) if there is sufficient infiltration in the watershed & riparian zone (due to vegetation) AND shading of the stream by riparian vegetation keeps the water cool. | Measure the **rate** of change in water temperature as air temperature changes or as increases in discharge occur. | If water infiltration or shading reduced (due to clearing of vegetation), the stream water heats up beyond what biota are capable of tolerating (due to high sunlight reaching the stream and an increase in overland runoff) |
| Flood Mediation/Control | Slowing of flow from land to streams so flood frequency and magnitude reduced; intact flood-plains buffer increases in flow. The flow spreads out over floodplain & energy absorbed; also healthy riparian vegetative cover in the watershed increase infiltration into soils and uptake of water (e.g., by plants) before it reaches the stream | Measure the **rate** of infiltration of water into soils OR discharge in stream in response to rain events (discharge = **rate** of water flow measured in volume per time…$m^3$/sec) | Without the benefits of floodplains, healthy stream corridor and watershed vegetation you see increased flood frequency and flood magnitude |
| Biodiversity support | All of the processes above contribute to the maintenance of biodiversity. For example, primary production and the flux of organic materials into streams help support diverse living assemblages | Measure the number of species and how abundance varies among them; this function is not a rate per se but because it is critical to the support of all other functions, it is included in the table. | Headwater streams support extremely high biodiversity and many rare species that contribute food for higher trophic levels and help maintain functions such as organic matter processing |

**2. Channel creation approach outside the scope of accepted science.** The Chuitna mining project will destroy fully healthy Alaskan streams in a relatively pristine region as they clear approximately 5000 acres and mine through the streams. During this process they will divert water from the streams then dig through the streambed and surrounding area to remove more than 300 feet of 'overburden' so they can reach the coal seams. Many years later, they will replace the overburden, add topsoil back, and use heavy machinery to construct a channel that has similar dimensions (width, depth, slope, sinuosity, etc) to the one they destroyed. Thus they will attempt to create a stream after all the natural flow paths and landscape topography have been destroyed. This is not even in the realm of anything that has been scientifically tested and is certainly not within the realm of what is considered ecological restoration. In practice, ecological stream restoration varies along a continuum from: removing on-going impacts to a stream (e.g., preventing toxic inputs) and letting the system recover on its own; to enhancing in-stream habitat or the surrounding riparian zone (e.g., adding coarse woody debris to streams and planting vegetation) in an otherwise healthy stream; to full scale restoration that involves manipulations of an *existing* stream channel (e.g., re-grading banks and planting trees along a stream with eroding banks) (Williams et al. 1997, FISRWG 1998, Karr and Chu 1999).

While the plan refers to this proposed mitigation project as "reconstruction", it is in fact a new channel construction or creation plan. While the latitude and longitude of the streams may be similar to what they were before, everything else that defines an ecologically healthy stream will be gone or will have been dramatically altered at the end of the mining period (e.g., flow paths, riparian soil and streambed biogeochemistry, groundwater-surface water (hyporheic) exchange rates, mature riparian vegetation, etc). The mining project is a major earth-moving project that will impact a significant amount of land. While they outline plans to attempt to restore recharge capacity of the lands, these plans are based on assumptions and model output that even if correct, in no way assure restoration of the hydrologic and biogeochemical properties that the riparian, streambed, surface water, and hyporheic zone flora and fauna presently rely on. There is no evidence provided that the groundwater-surface water exchange, the concentration of suspended sediments, or the water quality in the new channel will be similar to what is in the undisturbed streams presently.

Based on my work leading a national project that developed the first comprehensive database on stream and river restoration for the U.S. (38,000 projects in the database; Bernhardt et al. 2005, Palmer et al. 2005) and on my extensive work with scientists and restoration practitioners, I do not know of a single case in which building streams in the manner they outline has been shown to work much less fully compensate for ecological functions lost when a stream is destroyed. Contrary to suggestions made in the mitigation plans, the very concept of creating streams with levels of ecological functioning comparable to natural channels on sites that have been mined-through as they propose remains untested and quite unlikely to succeed.

Interestingly, from the plan prepared by PacRim, there seems to be a clear understanding that what they propose is outside the accepted range of current science and practice. From page 14 of the Fish Protection Plan:

> "Historically the majority of stream restoration practice has involved alterations of modifications of an existing water body that has been impaired in some way. Stream 2003 and other Chuitna Coal Mine area stream represent a more comprehensive restoration effort that includes 3-D restoration of the entire channel including floodplain structure and form" (page 14).

In other words, they acknowledge that what they propose is not typical NCD type restoration, which involves alterations of existing channels, but instead goes well beyond what has been done in other settings. This leaves us with determining if they provide any new evidence of the feasibility of their mitigation streams. They do not. There are no data provided in the plan, nor are there peer-reviewed scientific studies referenced that demonstrate healthy streams can be created after this level of impact to the land has occurred. Even with far less damage to a site, stream restoration projects that involve channel modification have an extremely high failure rate (Smith and Prestegaard 2005; Tullos et al. 2009; Palmer et al. 2009).

**3. Morphologically based channel designs are not ecologically based.** The mitigation plan argues that they will use the Natural Channel Design (NCD or Rosgen approach) approach for constructing stream 2003 which is based on 'tested methods' (page 29, Fish Protection Plan) that will "ensure pre-mined ecological functions and values are restored" (page 13). But the NCD approach to stream restoration has in fact never been evaluated for its *ecological* effectiveness. This approach was designed by Rosgen (1994) to address channel stability based only on building a channel structure (shape, slope, etc) that is able to transport the sediment and water inputs that are expected to be delivered to the stream prior to completion. There is no scientific evidence supporting the assumption that restoration of channel form will lead to full restoration of function (Palmer et al. 1997; Hilderbrand et al. 2005; Falk et al. 2006). How a stream looks (its *form)* is simply not the same as how it processes (its *function)* material and supports life (primary producers, invertebrates, etc). The present mitigation plan provides no evidence that restoration of channel form will lead to restoration of function.

Not only does the plan assume that selection of a channel type (e.g., "D channel") from a channel classification scheme such as those proposed by Rosgen (1994) will necessarily result in full ecological restoration, but it also assumes that use of the NCD or Rosgen approach guarantees successful creation of a channel from a geomorphic and hydrologic perspective. However, channel designs based on a classification system that has not been fully evaluated at the site can lead to serious failures (Smith and Prestegaard 2005). As indicated in Palmer et al. (2005): "Attempts to develop restoration designs based on application of a single classification system across many environments have led to many failures in North America (e.g., Kondolf et al. 2001), because the specific processes and history of the river under study were not adequately understood." If the mitigation projects fail and channels are unstable, this could cause new environmental degradation. However, even if they are geomorphically stable, this does not address restoration of function. Indeed, the Rosgen scheme of classification does not deal with ecological functions at all.

The Rosgen classification is based on channel morphology and uses a hierarchical key to demarcate stream types based on specified ranges of quantitative variables, including entrenchment ratio, bankfull width:depth ratio, channel sinuosity, gradient, and dominant substrate (Rosgen 1994). While use of the Rosgen scheme for stream restoration has been very common in the past, current science (published in many peer-reviewed scientific journals) has documented numerous reasons that use of this scheme for restoration can be extremely problematic (Gillilan 1996; Miller and Ritter 1996; Shields et al. 1999; Doyle and Harbor 2000; Kondolf et al. 2001; Juracek and Fitzpatrick 2003; Niezgoda and Johnson 2005; Smith and Prestegaard 2005; Slate et al. 2007; Simon et al.

2007; Roper et al. 2008). In fact, an analysis of > 75 channel reconfiguration projects overwhelmingly showed that restoration of biodiversity failed (Palmer et al. 2009).

The fundamental problem with classification based restoration approaches is that they assume fixed endpoints and rigid classification schemes in which the type of stream desired can be achieved by constructing a specific channel form. Yet, streams are living systems – far more than rock-lined ditches. Even from a practical point of view, restoration is far more than creating some design based on external appearance. The fundamental distinction between form and function of stream channels is not acknowledged by the plan, which focuses on structural aspects of the channels and ignores functional aspects. The method in no way takes into account a whole array of biophysical factors that determine the ability of the channel to support all of the living resources in pristine streams in the area. Such factors include: intensity and duration of sunlight reaching the stream, which is determined in part by the vegetative structure; inputs of organic matter upon which the food web depends; nitrogen and carbon levels in the soil and streambed; etc.

**4. Downstream impacts are not addressed.** The mining activities will fundamentally and permanently alter the chemical, hydrologic and sediment regimes which are master variables controlling the suitability of running-water systems for supporting downstream reaches. Further, since watersheds act as a unit and a considerable amount of land in the watershed is to be cleared, the impacts are expected to extend far beyond the mined-through streams. Even if the overburden and topsoils are stored during the mining for use later during reclamation, they will not have the same biogeochemical properties as prior to disturbance. Many of the soils in this region are highly organic. Disturbing them will result in dramatic changes including different microbial communities, alterations to the soil C:N:P content and changes in porosity. Even given the planting (reclamation) that is proposed, there is no clear evidence that conditions would be likely to return to pre-mining mature conditions. Biogeochemical processes in watershed and riparian soils influence the delivery of nutrients and other materials to streams and because these processes are greatly influenced by the flow rates and paths that water takes as it moves through surface and subsurface soils, disruption of the magnitude proposed for this project will certainly alter water quality. Even actions that are less disruptive than the mining that is proposed such as road building and land clearing) are well known to influence water quality and the movement of materials to downstream waters (Naiman et al. 2005; Nadeau and Rains 2007).

Since the streams to be destroyed are primarily headwater streams which play disproportionate roles in nutrient processing and supporting biodiversity, it is particularly problematic that > 17 km of them will be destroyed and yet the ability to re-create them is unlikely. Because headwater streams provide food (organic matter and prey) for biota in downstream waters, when they are lost food supplies are likely to be inadequate downstream (Wipfli et al. 2007). This is particularly the case if surrounding riparian vegetation is lost, which will be the case for Creek 2003 and some of the other streams within the mining area. This could result in decreased growth of fish and other organisms (Freeman et al. 2007) in the Chuitna waters. Biota may also be subjected to higher rates of suspended sediment and other forms of water quality impairment since sediment flux and dissolved constituents post mining are unknown.

Thus, the massive disturbance to the entire watershed, but particularly headwater streams, will have impacts in downstream waters. Changes in key ecological processes can have cascading effects on nearby ecosystems, particularly in river networks where the movement of materials can effectively link very distant ecosystems (e.g. headwater streams to rivers). For this reason, ecologists have increasingly focused research on broader spatial contexts and multi-scale processes (Palmer 2009). Nakano and Murakami (2001) showed that across-habitat prey flux accounted for 25.6% and 44% of the total annual energy budget of bird and fish assemblages in a Japanese stream. Subsidies such as these have been extensively studied both theoretically and empirically (e.g. Polis and Hurd 1996).

## Summary of Major Conclusions

This is a very large project that will seriously impact a sensitive ecosystem that currently supports highly valued fisheries, rare plant species, and ecologically important habitats including wetlands and streams. The wetland and stream ecosystems that will be lost or damaged perform essential functions in the provision of important ecosystem services and it is very unlikely (and no evidence is provided to indicate) that the ecosystem functions can be recovered. The surrounding habitats such as the tundra are extremely fragile and as the project proceeds the risk that surrounding habitats will suffer direct or indirect degradation will increase. Across all habitats, but particularly the aquatic ones, biodiversity loss will be substantial yet this diversity is critical to ecological functions that ensure the long term health and stability of the ecosystems. Basic concerns about the mitigation plan fall into four categories. First, the applicants have not directly measured ecosystem functions and thus have not applied current science to the mitigation issues. Without these functional assessments, they do not know exactly what natural resource values are being lost and thus what they need to mitigate for. Second, the approach proposed for replacing the lost streams (especially Stream 2003) is outside the realm of stream restoration or rehabilitation practices. Their approach basically amounts to channel "creation" in an area in which the earth has been disturbed to depths of 300- 500 feet, the natural flow paths destroyed, and landscape topography reshaped. Channels that are created on these mined sites may have the same latitude and longitude of the original streams however everything else that defines an ecologically healthy stream will be gone or will have been dramatically altered. Third, the channel creation plans are based on a method (Natural Channel Design) that is morphologically based (reference templates) but there is no evidence that creation of channel form (pattern, plan, profile) will lead to restoration of ecological function. Indeed, there is ample evidence in the peer-reviewed literature that the approach they propose is problematic and that ecological outcomes typically fail. Fourth, impacts to the watershed and the headwater streams from the mining activities will fundamentally alter the chemical, hydrologic and sediment regimes which are master variables controlling the suitability of running-water systems for supporting downstream reaches.

In sum, based on the most current and rigorous science, the impacts of this project are very significant and there is no evidence that the restoration and mitigation plans that are proposed will either succeed or compensate for the natural resource losses.

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