SECOND BI-ANNUAL

NORTHERN LATITUDES MINING RECLAMATION WORKSHOP

FAIRBANKS, ALASKA

JUNE 4TH - JUNE 6TH, 2003

General Schedule

Tuesday, May 3rd

7:00-9:00 pm	Welcoming Reception Aboard the Sternwheeler Tanana Chief A short walk from the River's Edge Resort

Wednesday, May 4th

8:30 am	Opening Remarks
9:00 am	History of Mining in Alaska by Tom Buntzen
10:00-5:00 pm	Technical Sessions
lunch	River's Edge Resort

Thursday, June 5th

8:30-5:00 pm	Technical Sessions
lunch	River's Edge Resort
7:00-9:00 pm	Riverboat Cruise and Dinner (Optional, not covered in the registration fee

Friday, June 6th

8:00-4:00 pm	Field Trip (Bag lunch included) Ft. Knox Mine and placer mining sites.

Technical Schedule

Wednesday, June 4th

Opening Remarks

8:30 U.S. DOI, Bureau of Land Management
Yukon Government – Energy, Mines and Resources
State of Alaska – Department of Natural Resources

9:00 History of Mining in Alaska by Tom Buntzen

9:45 COFFEE BREAK

Placer Reclamation

10:00 Reclamation Design and Demonstration for three placer mined sites in Interior Alaska
Robert F. Carlson, Brian Schalk E.I.T., and Amy Tidwell

10:30 Natural revegetation/restoration on sites that have been contoured and sloped and creeks have been stabilized vs. old, unreclaimed placer mining areas
Marion E. Dejean, Government of Yukon, Dawson City, Yukon

11:00 Bioengineering Trials at Noname Creek, Yukon
Bonnie Burns

Stream Restoration

11:30 Arctic Grayling and Burbot studies in the Fort Knox water supply reservoir, stilling basin, and developed wetlands, 2003
Clyde Gillespie, Alvin G. Ott, William A. Morris, and Stacy Staley

12:00 – 1:00 LUNCH

1:00 Stream channel stabilization through a waste rock dam at the abandoned Clinton Creek Asbestos Mine, Yukon, Territory.
Werner Liebau and Gil Robinson, Canada

Abandoned Mine Land

1:30 "Mitigating hazards associated with abandoned underground mines on National Park Service Lands in Alaska."
Jeff Bennett, U.S. DOI, National Park Service

2:00 "Abandoned Mine Land Revegetation in Sutton, Alaska."
Nancy Moore, Alaska DNR, Plant Materials Center

2:30 BREAK

3:00 "Abandoned Mine Shafts: Fill It, Grill It, or Plug It?"
Ginger Kaldenbach, U.S. DOI, Office of Surface Mining

3:30 "McKinley Lake Mine Project."
Carol S. Huber, Forest Geologist

4:00 "Chemical variations in the waters draining the HI-YU Mine, Fairbanks, Mining District, Alaska."
John M. Clark, U.S. DOI, Bureau of Land Management

Thursday, June 5th

Mine Reclamation

8:30 "Alaska Coal Program, Successes and Challenges."
Bruce Buzby and Justin Ireys, Alaska DNR, DMLW

9:00 "Permitting and Reclamation of Placer Mining and Hard Rock exploration projects in Alaska."
Leo John Kerin, Fairbanks, Alaska, DNR, DMLW

9:30 "Mount Washington revisited – Importance of considering local geology in mine reclamation."
Y.T. John Kwong, CANMET, Natural Resources Canada

10:00 BREAK

10:30 "Evolution of revegetation success criteria and monitoring for Usibelli Coal Mine, Alaska."
Dot Helm, University of Alaska, Fairbanks

11:00 "Top Down approach for the closure of northern mines."
Daryl Hockley, Cam Scott, Peter Healey, and Michael Nahir, Canada

11:30 "Planning for subarctic reclamation costs."
Larry P. Jackson, Fairbanks Gold Mining, Inc.

12:00 — 1:00 LUNCH

1:00 "Permitting and Reclamation of Hard Rock Mines in Alaska."
Steve McGroarty, Alaska NDR, DMLW

Contaminants and Treatment Systems

1:30 "Cross-border assessment and remediation on the 40-mile River."
Rob Rosenfield and Paul Erhart, Yukon River Inter-Tribal Watershed Council

2:00 "Passive or biological treatment systems."
Andre Sobolewski, Microbial Technologies

2:30 BREAK

3:00 "Spatial and temporal trends of arsenic uptake in medicinal plants: Lessons from Yukon mine reclamation practices."
Heather Nicholson, University of British Columbia

3:30 "Containment of spilled petroleum in soil using activated coal."
Terril E. Wilson, Debasmita Misra, Wei Zhou, Abhijit Dandekar, and Neil D'Cunha

4:00 "Thermal characterization of an oxidizing waste dump using snow coverage and ambient temperature."
Michael Noel, John Chapman, Stephan Day, Kelly Sexsmith and Daryl Hockley

4:30 "Solidification of Arsenic-Bearing Mine Tailings, Beauty Bay Mine, Kenai Fjords National Park, Alaska."
Mark S. Lockwood, Shannon & Wilson, Inc.

Abstracts

Abandoned Mine Shafts: Fill It, Grill It, or Plug It?

Abandoned mine shafts pose a serious safety hazard to unknowing people who use abandoned mine lands for recreation or development. To reduce this safety hazard the Surface Mining Act of 1977 provides for funding of various State and Federal abandoned mine reclamation programs. These programs have been reclaiming shafts for more than 20 years.

There are three general approaches to reclaiming an abandoned mine shaft: you can fill it, you can grill it, or you can plug it. There are many variations of each of these approaches. Choosing which approach to use is based on a variety of factors. The most important factors are: cost, geotechnical conditions, life span of the method, degree of hazard elimination, future maintenance requirements, construction safety, environmental concerns, and design concerns.

In general, filling a shaft is preferable to grilling or plugging because filling is a simple, low-tech method. Filling a shaft is usually feasible, however, for only relatively shallow, vertical shafts whose dimensions are fairly well known. Grills are best for providing bat access, and preserving the historic resource of the shaft, and have the added advantage of providing air flow, and future access. Plugs are best for openings prone to caving, are sloped, or are too deep to fill.

For most old shafts, a project begins with an exploration phase, and then progresses to a design phase, and finally the construction phase. The exploration phase usually is a small portion of a project's total cost, although some projects require exploratory excavation to determine the depth to and condition of competent rock. Unpredictability of a shaft's geotechnical conditions often is a primary factor in the selection of a reclamation method. The chosen reclamation method must be compatible with the existing geotechnical conditions. Then, the other factors above can be prioritized and considered.

Ginger Kaldenbach
Sr AML Program Manager
Office of Surface Mining
1999 Broadway, Suite 3320
Denver, CO 80202
303-844-1400 x1503
gkaldenb@osmre.gov

Mount Washington revisited - Importance of considering local geology in mine reclamation

The Mount Washington copper mine, located on the north side of Mount Washington at an elevation of 1320 m on Vancouver Island, British Columbia, exploited a porphyry copper deposit for two years between 1964 and 1967. Twenty years after mine abandonment, acidic drainage enriched in copper emanating from the site was found to seriously affect salmon fishery in a major river downstream. From 1988 to 1993, the British Columbia Ministry of Energy, Mines and Petroleum Resources spent close to one and a half million Canadian dollars attempting to reclaim the abandoned mine site. An engineering approach was adopted for the mine reclamation, which emphasized on reducing the availability of air and water to identified and suspected acid-generating rocks. Major activities involved recontouring a waste rock dump and covering it with glacial till as well as hydraulically cleaning a small section of a shallow open pit to bedrock so as to reduce the extent of sulfide oxidation. However, no reduction in acidity and copper loading were evident from the work for a long time. Since shallow bedrock at the abandoned mine site still contained abundant sulfides, intense disturbance of the pit area during mine reclamation could have reopened the shallow fracture systems and exposed more fresh sulfides for oxidation. Thus, whatever gains derived from covering the waste rock dump were apparently cancelled out by new acid generation in the pit area. Furthermore, contributions to the overall contaminant loading from mineralized rock between the mine site and a downstream monitoring station were not investigated. It was only in the last two years that the copper loading from the site appeared to have ameliorated. It is not known if this is due to gradual closing of the fracture systems with secondary oxidation products or other causes. The Mount Washington case study demonstrates that to avoid unpleasant surprises, the local geology and mineralogy must be seriously considered in devising appropriate schemes for reclaiming abandoned mine sites.

Y. T. John Kwong
CANMET Mining and Mineral Sciences Laboratories
Natural Resources Canada
555 Booth Street, Ottawa, Ontario, Canada K1A 0G1
(Phone: 613-943-0525; Fax: 613-996-9041; E-mail: jkwong@NRCan.gc.ca)

Arctic Grayling and Burbot Studies in the Fort Knox water supply reservoir, stilling basin, and developed wetlands, 2002[1]

The Fort Knox Mine is located in the headwaters of Fish Creek, 25 miles North of Fairbanks Alaska, in an area where gold mining began in the early 1900s. Bucket line dredges operated from 1930 to the early 1940s, and cat mining continued from the mid 1970s to the early 1990s. Stream and associated riparian habitats throughout the valley were severely disturbed, nonpoint sediment pollution was common, and flooded abandoned mine cuts used as settling basins were present. Despite the high level of disturbance, a population of stunted Arctic grayling was identified living within the valley in Last Chance Creek. A young population a burbot also was identified living in old settling ponds in the valley. Fairbanks Gold Mining Inc. began construction of the Fort Knox Mine in 1995. The project includes an open-pit mine, mill, tailing impoundment, water supply reservoir, and related facilities. Habitats for fish and wildlife were greatly enhanced through construction and concurrent reclamation of the water supply reservoir and the mechanical reconfiguration and rehabilitation of the valley between the water supply reservoir and the upstream tailing impoundment. This area is located in the lower portion of Fish Creek. Immediately upon construction of the water supply reservoir stunted Arctic grayling began to exhibit high growth rates and soon exhibited a similar size distribution to other Interior Alaska Arctic grayling populations. However, production of age-0 Arctic grayling was low. A channel was constructed to connect the water supply reservoir to the rehabilitated valley upstream, and theoretically to provide spawning habitat for Arctic grayling and rearing habitat for age-0 fish. Production and recruitment of juvenile Arctic grayling improved immediately. The Arctic grayling population is no longer stunted and numbers have more than doubled. Burbot numbers also increased dramatically after development of the water supply reservoir and their numbers appear to be stabilizing. The biology driven rehabilitation work conducted by Fairbanks Gold Mining Inc., within the valley has, in large part, returned the valley to a highly productive area for fish and wildlife.

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[1] Paper was published in the Alaska Department of Fish and Game, Habitat and Restoration Division Technical Report Series as Technical Report No. 02-06 in December 2002.

[2] Alvin G. Ott is the Regional Supervisor for the Habitat and Restoration Division, Alaska Department of Fish and Game, Region III, Fairbanks AK 99701.

William A. Morris is a Habitat Biologist for the Habitat and Restoration Division, Alaska Department of Fish and Game, Region III, Fairbanks AK 99701.

Michelle Roller is the Senior Environmental Specialist for Fairbanks Gold Mining, Inc., Fairbanks AK 99707

Stream Channel Stabilization through a Waste Rock Dam at the Abandoned Clinton Creek Asbestos Mine, Yukon Territory

From 1968 to 1978, approximately 12 million tonnes of serpentine ore were extracted from the Clinton Creek Mine, located about 100 km northwest of Dawson City, Yukon. The open pit mining operation produced 60 million tonnes of waste rock and 10 million tonnes of tailings. A significant slope failure of the Clinton Creek waste rock dump occurred in 1974, blocking the natural drainage of Clinton Creek and creating a land slide dam and a 115 ha reservoir now referred to as Hudgeon Lake. The new drainage of Clinton Creek has since continually eroded its channel along the waste rock dam, undercutting the toe of the waste rock pile and causing localized slope instabilities.

During 1998/99, an extensive environmental review and a risk assessment were initiated by DIAND Waste Management. The studies concluded that existing and future conditions at the abandoned mine site have the potential to expose individuals, property and the environment to various degrees of risk associated with downstream flooding, channel sedimentation and chronic redistribution of eroded waste rock and tailings. The largest risk to public safety and to the environment was identified as the sudden breach of the waste rock dam that may result in loss of life and property and as certainty in loss of fisheries and habitat through downstream smothering and flooding.

DIAND Waste Management has consulted with government and non-government agencies and UMA Engineering Ltd. to investigate possible mitigation methods. To accommodate and possibly reduce anticipated creep movements of the waste rock the channel stabilization will be achieved by partial infilling of the existing channel and the construction of gabion weirs [1].
The first phase of stream channel stabilization was successfully undertaken in the fall of 2002 at the Hudgeon Lake outlet. The work was completed under a Contribution Agreement between DIAND and the Tr'on Dëk Hwëch'in First Nation with the use of local work force and sub-contractors. Site supervision was provided by UMA Engineering and DIAND Waste Management. Further construction work is anticipated for the summer and fall 2003.

Werner Liebau, Indian and Northern Affairs Canada (DIAND), Yukon
Gil Robinson, UMA Engineering Ltd., Winnipeg Manitoba

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1 *Gabion Structures* are arrays of rock-filled baskets of wire mesh, designed to reduce and disperse the destructive force of fast flowing water.

Thermal characterization of an oxidizing waste rock dump using snow coverage and ambient temperature

This paper presents an innovative but simple approach to increase the level of confidence of the characterization program of waste rock dumps in cold climates.

Waste rock dumps are sometimes a source of acidity and metal contaminants in drainage at mine sites as a result of oxidation of sulfidic components. The characterization of the dump for environmental purposes to develop closure plans to address this issue typically requires a number of different often expensive field activities, which may provide limited representation of the complex geological, geochemical and thermal conditions. In addition the construction history of waste rock dumps is often not available.

One of the properties of the oxidation of sulfidic material is the release of heat, which can be transported by thermal conduction and sometimes by advective gas transport. Since this heat generation is proportional to the oxidation rate, the surface temperature would likely be higher in the areas where the waste rock is more reactive. Depending on the oxidation rates, the heat released may not be significant, e.g. the surface temperature may only increase by a few degrees. In the early part of winter, the ambient temperature is often in the vicinity or slightly below 0°C. When a snowfall occurs during mild winter temperature, the ground surface may remain above 0°C in the areas where oxidation occurs, thus thawing the snow as it comes in contact with the surface. The areas with a high oxidation rates would have higher temperature and require colder ambient temperatures before the snow can remain frozen on the surface. The method presented herein consists of monitoring the ambient temperature and by monitoring the snow cover over the entire waste rock dump. Mapping the areas without snow coverage as a function of ambient temperature can provide a characterisation at the scale of the entire waste rock dump. This approach was tried at a mine site in Yukon Territory, Canada, and provided valuable information in mapping the areas where oxidation was more active. Some thermal modelling is presented as part of the interpretation.

Michel Noël*, John Chapman, Stephen Day, Kelly Sexsmith, Daryl Hockley,

SRK Consulting
800, 1066 West Hastings Street
Vancouver, BC.
Canada
V6E 3X2

Email: mnoel@srk.com
Tel: 604.681.4196
Fax: 604.687.5532

* Corresponding author

Mitigating hazards associated with abandoned underground mines on National Park Service Lands in Alaska.

Mitigating Hazards Associated with Abandoned Underground Mines on National Park Service Lands in Alaska. Since 1980, approximately 450 abandoned mine openings have been identified on National Park Service lands in Alaska. Beginning in the early 1990s, the Alaska Region of the National Park Service, in partnership with the Geologic Resource Division of the National Park Service and the State of Alaska, Division of Mining, Land, and Water, initiated a program to systematically prioritize and deal with health and safety issues associated with these features. To date, this partnership has secured 29 openings in four different park units.

Due to the short field season in Alaska and the multitude of necessary tasks, the closure process requires about three seasons to complete for any given mine opening. Prioritization is accomplished by targeting areas of high visitation and/or easy access. Closure methodology requires determination of: air and water flow from the portal, underground connections, historic significance, wildlife use of the portal or adit, and slope, aspect and bedrock condition.

Four different methods to secure openings have been used to date: urethane foam plugs, steel gates, hand tool assisted collapse, and blasting. Differing degrees of success with each of these methods has required revision of the general approach in order to improve efficiency and outcome. The program has been very successful, in part, because we have relied heavily on established procedures and materials while improvising for unique Alaska conditions.

Jeff Bennett, US, Department of the Interior, National Park Service

Evolution of Revegetation Success Criteria and Monitoring for Usibelli Coal Mine, Alaska

Concepts of revegetation success have changed over the decades in Alaska and elsewhere as we learn from long-term succession and interactions among natural colonization and amendments (seed, fertilizer) applied by operators. Original goal for Usibelli Coal Mine (UCM) in the early 1970s, when revegetation in Alaska was in its infancy, was to establish some vegetation cover. The mine company monitored the vegetation visually – on the ground, from the air, and with permanent point photographs, which provide a historical record.

The Surface Mining Control and Reclamation Act of 1977, which required bond-release standards and quantification, was applied to Alaska in the 1980s. Consultants used quantitative vegetation sampling techniques to estimate cover, diversity, and woody species density in a traditional stratified random sampling design. Revegetation still focused on grasses. As we learned more about successional patterns, we realized that grasses were still needed for short-term surface erosion control, but needed to emphasize woody plants more. Both natural colonizers and woody transplants formed the core of desirable plant communities.

In the 1990s revegetation efforts focused on initiating a success ional sequence integrating aerial seeding and woody transplants with natural colonization to establish wildlife habitat. We explored use of systematic grids for monitoring when we saw the rapid expansion of shrub communities and GPS and GIS were more available. Long-term goals now concentrate on woody plants, the predominant components of long-term communities as well as the surrounding vegetation, while short-term goals emphasize grasses for short-term surface erosion control.

Contact: Dot Helm ffdjh@uaf.edu
Palmer Research Center, Agricultural and Forestry Experiment Station, University of Alaska Fairbanks

"Top Down" Approach for the Closure of Northern Mines

Mine closure is a complex technical, environmental and social exercise, anywhere. In northern areas, the complexity is increased by factors such as remote locations, high costs and the interests of local First Nation stakeholders. As a result, mine closures in the north can become bogged down in analysis paralysis." This paper reviews approaches used to select mine closure measures. Approaches based on the "contaminated sites" model, the "risk assessment" model and the "regulation driven" model are shown to be inferior to an approach that has recently been developed and used on several major mine closures in the Canadian north. The "top down" approach is described and guidelines for its application are developed. Case histories are presented to demonstrate use of the "top down" approach in the closure of four northern Canadian mines.

Daryl Hockley,	SRK Consulting, Inc.
Cam Scott,	SRK Consulting, Inc.
Peter Kealey,	SRK Consulting, Inc.
Michael Nahir,	Public Works and Government Services, Canada

Passive or Biological Treatment Systems

Passive or biological treatment systems, such as treatment wetlands, are believed to be ineffective in the North because living organisms become dormant during the winter. However, recent research findings contradict this commonly-held view. This presentation will provide four case studies of passive treatment systems that operate year-round in the North, focusing on their effectiveness during the winter. Additional examples that identify some of the processes active during the winter will be presented. Taken together, these examples make a case for using and further developing passive treatment systems for mine reclamation in the North.

Andre Sobolewski, Microbial Technologies

<u>Planning for Subarctic Reclamation Costs Before, During and After Mining Operations</u>

An Overview Of Reclamation Costs and Planning Methods Used By the Mining Industry In Alaska

Successful mine reclamation demands detailed planning and cost analysis. Environmental regulations today require mining companies to thoroughly address environmental issues before, during and after mining. Mining in a subarctic climate calls for specialized technical and operational experience and knowledge. Every facet of mining entails consideration of environmental and reclamation issues. The viability of a mining project involves detailed cost estimates of not only mining but also the cost of reclamation of the land once mining is complete. Subarctic reclamation cost items that need special consideration include analysis of permafrost conditions, water resource design, postmining geotechnical design, and native soil and waste/overburden material quality as it relates to the revegetation potential and postmining water quality. Reclamation costs can easily make up 5-10% of the total cost of mining. If there is coordination in planning of both the mining plan and the reclamation plan, total project costs can be reduced significantly. This paper details the reclamation cost items and planning methods used to develop a comprehensive subarctic reclamation plan before, during, and after mining.

Larry P. Jackson

Containment of Spilled Petroleum in Soil Using Activated Coal

Investigation to determine the feasibility of containment of spilled petroleum in soil or near surface mineral matter, using finely-divided, heat-activated sub-bituminous coal as a sorbent and binder, has begun. Cylindrical samples (75mm diameter x 150 mm height) prepared separately from organic-rich soil and an underlying silt-clay horizon, both typical of substrates in the central Alaskan zone of the Trans-Alaska petroleum pipeline, were studied, along with a well-sorted sand (used in concrete-making) as a reference material. Downward permeation of run-of-pipeline crude petroleum through the organic soil, clay-rich subsoil, and sand, at one hour, eight hour, and 24 hour intervals, with and without a 30-minute delayed topical application of fine coal, is determined. Direct adsorption of the crude petroleum and formation of coal-oil agglomerates occurs when supernatant oil remains on the sample surface (as in the case of the clay-rich substrate). Wicking and partial adsorption occurs if the crude petroleum has migrated below the sample surface. Separation of the coal-oil agglomerate may be possible by simple mechanical means – or if necessary, by froth flotation – to yield a value-added fuel which can be briquetted for ease of handling. Phase One of this study, reported here, addresses phenomena at ambient indoor temperature. Phase Two will address similar phenomena under frozen conditions, typical of Alaskan continuous and discontinuous permafrost zones. Phase Three will address the absorption of oil remaining in the substrate long after an oil spill or leak has occurred.

Terril E. Wilson,
Debasmita Misra,
Wei Zhou,
Abhijit Dandekar,
Neil D'Cunha

Cross-border Assessment and Remediation on the 40-mile River

The YRITWC formed in response to the historic Yukon River Summit in December of 1997 in Galena, Alaska in the geographic center of the watershed. At this Summit, Chiefs and representatives from the Tlingit, Gwich'in and Koyukon Athabascan, and Yup'ik Nations gathered to share stories and perspectives on protecting the many diverse human and animal populations that depend on the Yukon River. From elevated rates of human cancers and leukemia, to documented physical and behavioral abnormalities in the fish and wildlife upon which the Indigenous Peoples depend, it became clear to the Summit participants that the Yukon River watershed has endured many serious impacts. All Summit participants committed to initiate culturally based Environmental Education efforts in their communities and reduce contaminant loading in the watershed and to conduct river-wide assessment and monitoring efforts. Environmental and human health threats along the River include mining operations, military waste, oil and chemical spills, municipal solid waste, global climate change, bioaccumulation of toxins in wildlife, persistent organic pollutants concentrating in the polar regions, and poor coordination and communication among the various Indigenous and non-Indigenous communities and governments in the area.

The Presenters will speak about a unique project focused on the 40-mile river that is being funded by the Department of Interior, Bureau of Land Management, Department of Abandoned Mines. Paul and Rob will speak about the Draft 2 Fortymile River Assessment results. In addition, the presenters will speak about next assessment steps and anticipated remediation priorities. Time is anticipated for questions and answers.

Rob Rosenfeld, MA / Alaska Region Director
Paul Erhart, BS / Assessment and Monitoring Coordinator
Yukon River Inter-Tribal Watershed Council

Reclamation Design and Demonstration for Three Placer Mined Sites In Interior Alaska

The purpose of this study was to develop improved techniques for reclaiming placer-mined streams in Interior Alaska. Placer mining results in alteration of original stream channels and removal of riparian vegetation. Stream channels left after mining, and in many cases after reclamation activity, are unstable, requiring decades or more to reach a final state of dynamic equilibrium.

Phase I of this study was an assessment of past reclamation activities on 13 Interior Alaska placer mined streams. A combination of hydraulic and morphologic analyses was used to determine channel stability. Channel parameters used in these analyses were sinuosity, channel slope, vegetation, floodplain geometry and channel development. Approximately 77% of the sites were found to have greater widths than the predicted stable widths, with the same approximate percentage being too shallow as compared to the predicted stable depths. Low rates of revegetation, characteristic of subarctic climates, and large width/depth ratios, steep energy gradients, and low sinuosities, have resulted in continued erosion and bank instability for nine of the thirteen sites.

The results of the initial study were used in Phase II to develop stable channel design and construction guidelines for three demonstration sites. The demonstration sites, Fairbanks Creek, Bonanza Creek and Hammond River, were all located within 200 miles of Fairbanks, Alaska. Each site underwent hydraulic, hydrologic and fluvial geomorphic analyses. Stable channel parameters were determined based on site-specific data and stream classification.

To date, the post construction results indicate that a stable stream channel can be constructed with modest additional cost. Each site has experienced at least two field seasons and show promising results. The demonstration sites present an opportunity for observation by public and private mining interests and will be the basis for long-term assessment of the stability of the channel and riparian zone.

Amy Tidwell[1], Brian Schalk E.I.T.[2], and Robert F. Carlson[3]

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[1] Research Assistant, Department of Civil and Environmental Engineering, University of Alaska Fairbanks, Fairbanks, Alaska 99775
[2] Research Assistant, Department of Civil and Environmental Engineering, University of Alaska Fairbanks, Fairbanks, Alaska 99775
[3] Professor, Department of Civil and Environmental Engineering, University of Alaska Fairbanks, Fairbanks, Alaska 99775

Natural Revegetation/Restoration on sites that have been contoured and sloped and creeks have been stabilized vs. old, unreclaimed placer mining areas

Changes in legislation/ regulations that have affected how reclamation/restoration is done – very short reference to requirements that may have improved the recovery of placer mining sites.

A pictorial comparison of Klondike placer sites where vegetation has begun to occur on early dredge tailings, or cat mining sites, creek stabilization or erosion, *the timelines involved* and those sites where restoration and stabilization of the creek channel and contouring and re-sloping of tailings has been done. This will include references to permafrost, natural subsidence, unstable slopes, conditions which contribute to continued erosion

The adequacy of current regulations/legislation based on site reclamation successes.

Marion E. Dejean, Natural Resource Officer,
Mining Inspections, Area North
Energy, Mines and Resources
Government of Yukon
Box 334, Dawson City, Yukon
YOB 1G0 (867) 993-7304

Bioengineering Trials at Noname Creek, Yukon

In the fall of 2001, bioengineering techniques were employed for stabilizing a permafrost-rich slope damaged by heavy equipment on a placer claim near Noname Creek, west of Carmacks, Yukon. The heavy tracked mining equipment moving up and down the slope resulted in an eroded gully, one to two meters deep and up to eight meters wide. The water flowing in the gully during the summer season is primarily the result of melting permafrost and drains into Noname Creek. No stream had existed on this slope prior to the disturbance. Live willow cuttings were used in the construction of 12 gully breaks and two pole drains, treating approximately 150 meters of the incised gully. The willows were collected from riparian locations near the site, after the leaves had fallen and the plants were entering dormancy. Live staking of willows was also tested between the gully breaks.

The bioengineering installations were surveyed in July 2002. Most of the willow cuttings had survived and were producing abundant new growth during the first growing season after installation. All of the live gully breaks had remained structurally sound and most had been effective in trapping sediment. Graminoids, particularly blue-joint grass and sedges, were colonizing areas were sediment had been trapped. However, channels had eroded under the wattle fences at some of the gully breaks in the narrower, steeper sections of the gully. The two live pole drains remained intact, although some erosion was occurring at the drain inlets and along the sides. Except for the live willow stakes planted on the higher, drier sides of the gully, all survived. Root growth was also observed as well as abundant leaf growth. There was evidence of considerable browsing by rodents on the new willow leaves and shoots. Fresh moose tracks were also observed in and around the gully at the site of the bioengineering installations.

Future work will concentrate on controlling the erosion through the use of biodegradable geotextile material at the upstream base of the gully breaks and constructing larger diameter or multiple pole drains.

Bonnie Burns

Spatial and temporal trends of arsenic uptake in medicinal plants: Lessons from Yukon mine reclamation practices

This project examined the uptake of arsenic in plants growing near tailings from three Yukon gold mine sites at different stages of reclamation. The sites occupy land traditionally used by the Little Salmon/Carmacks and the Carcross/Tagish First Nations, who are concerned about health risks associated with direct or indirect consumption of plants growing in the area. Soil and nine plant species were analysed for inorganic and organic arsenic content following sample collection at three mine site locations: adjacent to the point source(s) of contamination, approximately 1-3 km away, and background samples. Species were chosen for their ethnobotanical significance to the First Nations, based on interviews with Elders from the Carmacks and Carcross communities.

At the Venus Mine tailings site, concentrations in raspberries were low despite high soil concentrations in the area. A comparison of pre and post-reclamation data revealed a strong decrease in concentrations since the tailings cap was constructed in 1995. At the Arctic Gold and Silver site, reclaimed in 2000, arsenic concentrations in soapberries were less than the ICP-MS detection limit. At the Mt. Nansen site where the tailings pond water is still being treated, concentrations in blueberries, lowbush cranberries, and mossberries did not reflect soil concentrations. The pattern of low and undetectable levels of arsenic in berries at all three sites suggests these species are considered safe to eat under Health Canada tolerable daily intake guidelines for inorganic arsenic.

Bolete mushrooms, willow, Labrador tea, and "caribou moss" lichen (an important caribou forage) had high arsenic concentrations around the point sources of contamination or at sites approximately 1 km away. These localized high concentrations will not likely affect foraging animals, given their constant movement. However, Carmacks residents could avoid gathering all species with elevated arsenic around the Mt. Nansen mining property until reclamation has taken place.

Heather Nicholson, University of British Columbia

Solidification of Arsenic-Bearing Mine Tailings, Beauty Bay Mine, Kenai Fjords National Park, Alaska

The discovery of a deceased moose calf on the tailings at the Beauty Bay Mine site, in Kenai Fjords National Park, Alaska, prompted the collection of tailings samples from the site. The results of the initial sampling indicated that arsenic concentrations within the uncontained fine-grained tailings exceeded established human health risk-based limits. A transient, white, crystalline precipitate coating the tailings ponds was noted during initial site visits following the moose's death, but not at other times; no samples of the precipitate were collected. Due to the abundance of arsenopyrite in the tailings, it was assumed that the precipitate may have been toxic, arsenic-bearing compounds. Subsequent removal of the moose corpse by a bear prevented performing an autopsy to conclusively link the death of the moose to the arsenic. Results of subsequent arsenic speciation studies indicated that arsenic is present as a component of relatively insoluble arsenopyrite, and within soluble arsenic-bearing oxides. This led to uncertainty regarding whether the arsenic in the tailings is currently of a form that could have caused the death of the moose and what conditions, if any, may have resulted in an increase in toxicity. An Engineering Evaluation/Cost Analysis (EE/CA) studied six alternatives for corrective action at the Beauty Bay Mine site. These included no action, cover placement, fencing, containment, off-site disposal, and solidification. The objectives of corrective action were to limit the potential of exposure to the tailings and minimize redistribution of the tailing by surface water. Based on comparative analysis of the alternatives and comments on the EE/CA by the Environmental Protection Agency, solidification of the tailings with a concrete mixture was chosen as the preferred corrective action alternative. A corrective action plan was developed specifying a tailings/cement ratio, a phased approach for the stabilization, and rerouting of surface water drainage patterns. The largest central pond was first solidified and tailings from small outlying areas were then moved to the central location and solidified. This created a convex surface that was well drained. Mixing of the tailings and cement was accomplished with a tractor-mounted rototiller. Due to the remote nature of the site, logistics were complicated by heavy rainfall, the need to stage the work crews on a barge, and transportation of cement to the site by helicopter. Recent visits to the site indicate the solidified mass is stable.

Mark S. Lockwood, Shannon & Wilson, Inc. 907-479-0600

McKinley Lake Mine Project, Chugach National Forest, Cordova Ranger District, Alaska

The McKinley Lake Mine project consisted of an abandoned and inactive mine hazards inventory, identification of hazards, evaluation, and mitigation. This project began in 1992 with a hazard investigation conducted by the Forest Service and U.S. Bureau of Mines on Chugach National Forest lands. The investigation consisted of researching the literature for geology and mining history, and a site investigation. Both physical and environmental hazards were identified. After the initial investigation, The Forest Service determined that serious hazards were present and more detailed information was needed concerning the nature of these hazards. An environmental contractor was subsequently hired to investigate the site in greater detail then the original reconnaissance level investigation provided. About the same time, Tom Trainor a graduate student from the Colorado School of Mines studied the water quality of the McKinley Lake District. He was particularly interested in the anomalous mercury concentrations and arsenic in the standing water of the mine workings. Personnel from the State's Abandoned Mine Lands (AML) Program visited the site at the request of the Forest Service in 1999. They determined that serious safety hazards existed and concluded that the State could assist with the mitigation.

Identified hazards consisted of dangerous unstable mine workings, and a collapsed mill site structure with considerable heavy machinery present. Public visitation at the site is high because it is the destination of a popular, well-maintained Forest Service hiking trail, and only ¼ mile from a Forest Service recreation cabin and the shore of McKinley Lake. Preparation for mitigation included a determination by Alaska DGC regarding the coastal zone consistency of the project, NEPA documentation, an archeological survey and a determination of eligibility to the National Register of Historic Places. Mitigation of safety hazards consisted of two phases. Phase 1 was preparatory work by a Forest Service trail crew that included excavating to bedrock around the shafts, collapsing the sides of the adit, temporary shaft closures, and compacting the rubble at the millsite. Phase 2 consisted of final closure of 3 shafts completed by a contractor. Finally, the interpretation work consists of signs placed at the site, and a brochure.

The project from start to finish is an outstanding example of the value of partnerships, communication, and working together to accomplish a mutual goal. Throughout this report, I mention a number of people who worked on the project in different capacities' there are many more that I did not mention by name but were none-the-less important. Project goals accomplished were increased safety for site visitors, preservation of the integrity of the site, and mining history interpretation.

C. S. Huber, Forest Geologist

Chemical variations in the waters draining the HI-YU Mine, Fairbanks Mining District, Alaska

Mining and milling of gold bearing ore release metals into the environment when sulfides contained in the ore and mine tailings are exposed to water and oxygen. There are two sources of contamination at the Hi-Yu mine: the 'mill seep' and the mine tailings. The 'mill seep' has an acid pH (4.8) containing ~21 parts per billion (ppb) Cd and ~2400 ppb Zn. Water draining the mine tailings contains ~284 ppb As and 27 ppb Sb. These concentrations are above the EPA and Alaska state Maximum Contaminant Levels (MCL). The source of As and Sb in water draining the tailings is weathering arsenopyrite and stibnite in the tailings. The 'mill seep' water flows through a portion of the tailings, keeping the pH near 4, picking up more metals before mixing with Moose Creek. Once the mill seep mixes with Moose Creek, the pH increases, leading to the precipitation of iron and manganese hydroxides with associated As, Cd, Sb, and, Zn. Samples of the iron precipitate contain > 10,000 parts per million (ppm) As, 19 ppm Cd, 240 ppm Sb, and 2600 ppm Zn. Precipitation of metals along with interaction of organic material and dilution brings the metal contaminant levels down to below MCL levels within 0.8 km from the mixing point.

Although technically a point source of pollution, the seep and tailings cause no significant increase in the metal content of Fairbanks Creek 1.2 km downstream of the Hi-Yu mine. In fact, Fairbanks Creek, which drains several other mines, has higher As and Sb concentrations than does Moose Creek. The relatively low sulfide content of the ore, the presence of secondary carbonates within the ore, and the adsorption of metals onto Fe and Mn oxide and hydroxide phases make the discharge relatively benign, despite the unsightly iron hydroxide precipitate locally present.

John Clark, US DOI, Bureau of Land Management

Abandoned Mine Land Revegetation in Sutton, Alaska

The abandoned mine land (AML) program of the State's Division of Mining, Land and Water began a joint reclamation project with the Division of Agriculture's Plant Materials Center (PMC) in 1996. The PMC was responsible for design and implementation of the revegetation plan; the AML program prepared the site and administered the equipment and labor contracts. This partnership continues and to date nearly 100 acres have been revegetated.

These abandoned mine lands occur within the Matanuska Valley Moose Range and are administered by Departments of Natural Resources and Fish and Game. Special habitat needs for ruffed grouse were identified as one of the goals for the first revegetation plan. Erosion control and enhancing the natural process of plant colonization were also important revegetation goals.

The first site, Lower Knob Creek contained rocky soils with a high percentage of silt and clay and several steep south-facing slopes exposed to the winds both in the summer and winter. The soils cracked when dry and became sticky and slimy when wet. Several soil bioengineering techniques were carefully selected to try and satisfy the multiple revegetation goals. They included brush layering, willow bundles, live stakes and aspen and grass seeding.

The successes experienced during this first year of abandoned mine land reclamation at Lower Knob Creek have served as the foundation for reclamation in the Sutton area since 1996. The various sites, Lower and Upper Knob Creek and several phases of the Jones Mine will be described.

Nancy Moore, State of Alaska, DNR, Plant Materials Center

Alaska's Coal Program Past, Present, and Future

In 1977 the United States Congress, under the Jimmy Carter administration, passed the Surface Mining Control and Reclamation Act (SMCRA). SMCRA was passed to establish a nationwide program to protect society and the environment from the adverse effects of surface coal mining operations. After the Act was passed the Federal government gave each State the opportunity to take primacy of the program as long as State laws were as stringent as the Federal regulations. In 1983, the State of Alaska, under the Department of Natural Resources, began regulating all coal mining, reclamation, and exploration activity in the state.

This presentation will focus on the past, present, and future of Alaska's coal mining industry and associated reclamation. While Alaska's coal industry is quite small by nation wide standards, there is long history of coal mining in the state, and the reserves are plentiful.

Justin Ireys, State of Alaska, Department of Natural Resources
Bruce Buzby, State of Alaska, Department of Natural Resources

Permitting and Reclamation of Hard Rock Mines in Alaska

By law, the Department of Natural Resources is the lead state agency responsible for the coordination of the permitting of mine projects in Alaska. State agencies involved in the review of proposed mines include the Departments of Natural Resources, Environmental Conservation, and Law. A large mine project team is established with representatives of these agencies to conduct the review and permitting of each large mine project.

All mine projects in Alaska, regardless of land ownership are subject to the State Reclamation Act. The act requires mining operations be conducted in a manner that prevents unnecessary and undue degradation of land and water resources, and the mining operation must be reclaimed as contemporaneously as practicable with mining to leave the site in a stable condition. Large mine projects are required to have an Approved Reclamation Plan and post a reclamation bond prior to initiating mine development. Projects located on state land also require a Plan of Operations Approval.

The Department of Environmental Conservation regulates the placement of mine tailings, heap leach facilities and waste rock (where there is an environmental problem associated with the waste rock) through the application of the State of Alaska Solid Waste Management Regulations and the Alaska Water Quality Standards.

The specific permits required for a large hard rock mine project are primarily a function of the location of the mine, the water balance and hydrology at the site, and the geochemistry of the deposit. If a proposed mine is located on federal lands, will impact wetlands, or there will be a discharge of treated process water to surface waters of the United States, the project review and permitting by federal agencies such as the Bureau of Land Management, U.S. Forest Service, U.S. Army Corps of Engineers, and the U.S. EPA will need to fulfill the requirements of the National Environmental Policy Act (NEPA) and will probably trigger the development of an Environmental Impact Statement (EIS). In these circumstances, the State of Alaska Department of Natural Resources may participate as a cooperating agency for the EIS.

The manner in which project location, water balance and geochemistry affect the permitting and reclamation requirements will be discussed for specific large mines in Alaska.

Steve J. McGroarty
State of Alaska – Department of Natural Resources
Division of Mining, Land & Water
Abandoned Mine Land Program
3700 Airport Way
Fairbanks, Alaska 99709-4699

Email: steve_mcgroarty@dnr.state.ak.us

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