



to address short and long-term environmental concerns. These actions include removal of material, final cover, in-situ treatment or collection and treatment.

The sites are well monitored and controlled by the ongoing KGCMC efforts. We reviewed historical site-specific information maintained in the KGCMC database and files for this report. Ongoing monitoring and attention to these sites will provide useful information in our tracking of the status of environmental issues. The monitoring information reviewed for this report included the following sources:

- 1) Technical Review ARD/Metals Leaching and Freshwater Monitoring Plan Greens Creek Mine, Shepherd-Miller, Inc., February 18, 2000
- 2) General Plan of Operations, Appendix 1, Freshwater Monitoring Plan
- 3) Annual Report to ADEC, April 2002
- 4) Aquatic Biomonitoring at Greens Creek Mine, 2001
- 5) Kennecott Greens Creek Mine Production Rock Site Characterization Study, March 1995
- 6) Update Of Information And Action Plan On Seeps West Of The Current Tailings Disposal Facility by KGCMC, January 2002
- 7) General Plan of Operations, Appendix 11, Attachment C, Inactive Site Environmental Monitoring Program

Data are being collected at inactive sites under a recently implemented Inactive Site Environmental Monitoring Program (ISEMP) GPO, Appendix 11, Attachment C. This program will afford the collection of site specific information and a useful method to track ARD and ML at each site through time. Thus far the ISEMP has collected data from the last quarter 2002. Analysis from the ISEMP is pending at the laboratory, and will be available in the next annual report that will be submitted to the USFS. This monitoring includes the following:

- 1) visual inspections.
  - a. monthly inspection to detect oxidation on the surface and adverse effects to vegetation that may indicate development of acid drainage.
- 2) geochemistry of production rock
  - a. net neutralizing potential (NNP) and the paste pH will be measured annually on samples that are collected from representative locations within each facility. One of every 5 paste pH samples will be randomly selected for NNP analysis. Each sample with a paste pH value less than 6 will be analyzed for NNP. If more than 10% of the paste pH values are below 5 in any one facility, then an expert in ARD will be asked to review the information and suggest a management plan.
- 3) pore water chemistry
  - a. seepage survey. Quarterly inspection of the perimeter of each pile and borrow area for evidence of seeps or springs. A sample of each visible flow should be collected and analyzed for common ions and selected trace metals. A mitigation plan is required for all seeps or springs with sustained flow that have elevated metal concentrations and that are not collected or treated.
  - b. analysis of interstitial water. Chemistry of water that contacts production rock at inactive sites should be analyzed in determining long-term mass loads of metals

that may be released. The chemistry of contact water will be determined by sampling surface water at selected internal stations. Surface runoff from selected stations in the inactive production rock areas will be collected from the following stations on a monthly basis and sampled for various metals in their dissolved form.

- 1) Seeps. Quarterly if the flow is greater than 0.5gpm near the margin of any inactive pile.
- 2) 1320 adit. Monthly. Flow and chemistry if flow is present
- 3) Pond C. Monthly. Water level and chemistry

At Greens Creek pyrite is available within tailings, waste production rock and in some cases material from road-building activities. The 1.8 mile pull-out of the B-Road, road-cut between milepost 2.4 to 2.6 of the B-Road and the Zinc Creek bridge abutment have been found to contain some pyritic rock.

The KGCMC site-wide Reclamation Plan (General Plan of Operations – Appendix 14 and Appendix 11) addresses reclamation at all sites, including those that have wastes that may cause long-term problems. At closure of the mine, most sites where waste rock was placed will be excavated and the material placed at secure locations such as underground or in the tailings or production rock sites. The pyritic material from Sites 1350, 960 and 920 will be placed underground. The pyritic material from Site D berm, the Zinc Creek bridge abutment and B-Road (mile 1.8 pull-out and milepost 2.4 to 2.6 road cut) will be placed in the tailings or production rock piles.

Site E, possibly Site 860/C and Pit 405 will be covered in place using a similar engineered soil cover as the initial system installed and being tested at Site 23. It utilizes design profile #4 from the Unsaturated Soils Engineering Ltd. (USE), December 1998 report. The Department has approved the use of this profile in the waste disposal permit for the tailings and Site 23/D and it is incorporated into the reclamation plan. Site E will receive this engineered cover system in 2003. Site 860/C will either be capped in place, or excavated and hauled back underground.

This inspection also covered several rock pits where reclamation materials were stored. The source of the stored reclamation material was reported by KGCMC officials to be colluvial material from the development of the waste disposal sites or above-ground mine support facilities. Information collected to date indicates this material does not pose an ARD or ML risk. These materials were specifically segregated and saved for use in final reclamation of the KGCMC facilities. Annual sulfur and paste pH samples will continue to be taken from various locations across these sites under the ISEMP. However, data analysis is pending and will be available in the next annual report. Data is available for the colluvium from the 1998 excavation and 1994 drilling of the Site 23 backslope and millsite till. Information shows NP/AP well above 3.0 at 8 of the 11 data points. Four of the eleven data points were of mill till material (from the initial construction of the mill) that went to the initial development of sites E and D in 1988. Minor amounts also went to Pits 405 (2000) and 6 (1995). Two of these samples had a NP/AP between 1 and 3, and two samples had results of greater than 3. One data point was of a pyritic rock (NP/AP = 0.1) in the site 23 colluvium. However this data point was selectively sampled

and represents a very minute portion of the overall volume. Samples were not taken at random. Rather the various materials of interest were targeted for sampling. Upslope background monitoring well #50 at Site 23 (annual report 2001) provides data that shows the lack of metals loading that would have leached through the colluvium at the site 23 backslope. Monitoring well MW-23-00-02 is a well located at a lower aspect of Site 23 completed in the same till unit that is exposed at the millsite and therefore would be representative of millsite till referenced in other areas of this report. The sampling of water in this well indicates a pH of 8.06 and zinc of 1.43 ug/l. These results are unremarkable.

All of the sites visited have been bonded for reclamation as specified in the *Detailed Cost Estimates for the Reclamation plan, General Plan of Operations Appendix 14, Attachment "A"*. The bonding amount is stated for each site in the body of this report below.

The Greens Creek drainage supports the poly-metallic underground Kennecott Greens Creek Mine, developing one of the richer mineralized areas known on the island. This area of Admiralty Island is highly mineralized with naturally occurring pyritic rock. Naturally occurring features have contributed oxidation products, ARD and metals to the area for quite some time and will continue to do so into the future. Rust staining found in seeps, on the back-walls in rock pits and along road cuts provided evidence of this.

Those sites visited during the site inspection were:

Site 1350 (Initial mine underground development/exploration)  
Site 960 (Mine development waste rock)  
Site 920 (Mill site)  
Site 860/C (Mine safety and laboratory buildings)  
Site D berm (Adjacent to Greens Creek stream)  
Pit 405 (B-road construction material)  
Site E (Mill site development material and waste rock)  
Pit 6 (Mile 4.6, B-road)  
Pit 174 (Mile 3.3, B-road)  
Zinc Creek Bridge Abutment (Mile 3.0, B-road)  
B-road roadbed, mile 1.8 to 2.5  
Old access road to the south of the tailings site seepage pond  
Pit 5 (Tailings facility, location of wastewater plant)  
Pit 7 (Mile 1.8, A-road)

Observations from the November 4, 2002 site visit follows:

## Site 1350



*Site 1350 Slope*



*Old, breached Sediment Pond at Site 1350*

This site is located approximately 1.5 road miles above the main (920) mine portal entrance, and 100 yards northeast of the 1350 adit, approximately ¼ mile above sea level. This adit currently serves as the ventilation exhaust conduit for the underground mine workings. There were approximately 78,000 cubic yards of waste rock placed over an area of 5 acres. This waste was placed intermittently between 1978 and 1985 with development of the 1350 adit for exploration drilling prior to the mine development. The site has been inactive since 1985. Buildings and materials associated with the previous exploration campsite have been fully removed.



*Oxidized pyrite in rock at Site 1350*

The site was observed to be densely revegetated with grass. Spruce, and a few western hemlock trees were noted to have naturally seeded from the surrounding forest into the planted grass cover. The surface was uneven and side slopes were very steep (approximately 1(H):1(V) slope).

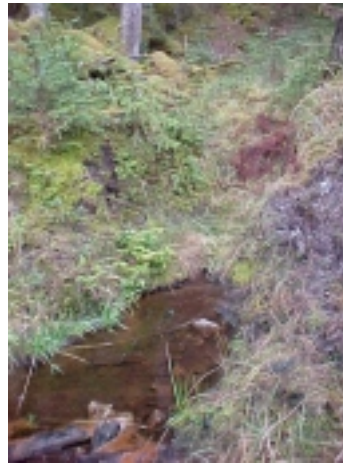
The eastern aspect revealed one small flow (1 gpm) seepage. This seepage was last sampled as part of the 2000 Shepherd-Miller report. The pH of this seep was 7.1. Dissolved zinc was 373 ug/l, lead was less than 1 ug/l, copper was 5.58 ug/l. The nearest sensitive environmental receptor is Greens Creek (1000 feet through dense foliage).

The southeastern aspect of the site had a small (approximately 10 gpm) seep with a rusty orange colored precipitate. The likely source of the seep was an observed small natural stream located approximately 100 feet upgradient of the seep where water appeared to flow along the toe of the fill from an upslope, natural area. The seep area appeared to be fed by exfiltration contact waters from within the pile. An old sedimentation pond was located on the fill nearby and the retaining wall had been removed. There is now no ponded water at this location. However, the flat surface may provide an opportunity for run-on. Monitoring of the seep under the stormwater monitoring program (2 samples) shows a neutral pH with a possibly slightly elevated zinc (see

Appendix B to this report). Sampling under the Freshwater Monitoring Program with several more sets of data shows neutral pH and zinc levels within water quality standards. This station was not sampled under the 2000 Shepherd-Miller report.



*Southeastern seep water*



*Run-on "east adit" water*

It appears that diversion of run-on water at the southeastern edge may help to minimize or prevent the seepage condition. It was noted this water source was designated in the FWMP as the "mine adit discharge" even though it does not emanate from, or even flow past the adit. At one time there was a mine drainage component, but this no longer exists. The water from this site is now a natural surface source of water augmented by exfiltration waters seeping from the toe of the pile. KGCMC refers to it in their spring, summer and fall FWMP monitoring as the "east adit discharge".

In addition paste pH and NP/AP ratio are monitored annually under the ISEMP as per the GPO, Appendix 11, Attachment C. However, data analysis is pending and will be available in the next annual report.

This area was studied under the March 1995 Kennecott Greens Creek Mine Production Rock Site Characterization Study prepared by KGCMC. The results showed this site is not carbonate dominated. It has an NP/AP value of 0.37. However, this sampling targeted areas of the fill that had higher ARD potential. A low ratio indicates that ARD could occur if measures to prevent it were not taken.

This site was also reviewed by the inter-agency review team and their independent consultant (Shepherd-Miller) in 2000. Results from grid sampling (37 samples) indicate a neutral paste pH in all samples. The NP/AP ratio ranged from 0.4 to 6.6. Most samples appear to be between 1 and 3. The grid sampling procedure was unbiased and a completely random event.

The site will be excavated at the end of the mine life and the waste placed underground via the ventilation adit. The material will not be placed underground earlier than this because the adit is presently in use for ventilation purposes. The reclamation bond amount for this site is \$347,000. It includes elements for backfill, growth layer, seed/plant and engineering, and monitoring.



### **Site 960**

This site is located a few hundred yards above the 920 mine portal along the Site 1350 access road. This site contained approximately 10,000 cubic yards of waste rock in an area of approximately one-acre. The material was end-dumped, and spread with a dozer, leaving the slopes rather steep, at approximately 1(H):1(V) slope. Vegetation growing on the undisturbed surfaces of the fill varied from sparse to dense. Any seepages would flow toward Greens Creek located approximately 450 feet away.

On inspection an orange colored precipitate was observed in the drainage at the lower aspect of the fill. The flow was approximately 3 gpm however, this may increase after precipitation events.



*Site 960 Slope*



*Downgradient Drainage Water at Site 960*

The seep flow infiltrates into the muskeg within a short distance. According to Shepherd-Miller 2000 study this seep had a zinc concentration 9.75 mg/l (dissolved) and pH of 6.4. Storm water monitoring conducted at the site indicate a pH of 6.8 and a zinc concentration of 4.7 mg/l. Storm water sample results remain fairly consistent over time, see Attachment “B” to this report for the sample results. There is a FWMP monitoring station located 1750 feet downstream on Greens Creek. Zinc concentrations at that station over the last 5 years remain well within water quality limits.

This area was studied under the March 1995 Kennecott Greens Creek Mine Production Rock Site Characterization Study prepared by KGCMC. Of 5 samples taken at the site. The NP/AP ratio ranged from 0.1 to 1.5 and paste pH varied from 7.6 to 8.2. The report discusses the results of a single hole at this site. The hole was placed within the only area that showed signs of acidification. The shake flask results show a pH of 2.9. Therefore, some oxidation is occurring at the site and there is some localized ARD. However, this is not expressed in sustained flows leaving the site.

This material at this facility was reviewed by the 2000 interagency review team and their independent consultant (Shepherd-Miller). The data are consistent with earlier findings.

In addition paste pH and NP/AP ratio are monitored annually under the ISEMP as per the GPO, Appendix 11, Attachment C. However, data analysis are pending and will be available in the next annual report.

The reclamation bond amount for this site is \$83,823. This includes costs for backfill of the material into the mine, the growth layer, seeds/plants and engineering, instrumentation and monitoring. Work commenced in 2001 to excavate and transport the waste to the underground facility. Of the original 10,000 cy of material, approximately 8,500 cy remained at the site at the time of the inspection. The company intends to place all remaining material underground, possibly in 2003.



**Site 920 Mill site**



*Site 920 Millsite Backslope*



*Site 920 Millsite Backslope*

The 920 area comprises the portal area and 21 acre mill site area. Production rock and fill have been placed at both areas. The 920 portal was not examined during this inspection due to time constraints. This area will be examined at a later date.

An approximately 5-acre area of the mill back slope was initially excavated and contoured. Approximately 100 horizontal slope drains and 11 collection manifolds were placed to collect run-on water from the up-slope area. Approximately 1-10 feet (6,000-10,000 tons) of waste rock were placed over the drains. Generally the depth of fill is 1-3 feet. This was done to control erosion, and to assure stability of the area behind the mill during the operational period. The area has been hydro-seeded and has limited growth (in some areas this was marginal), with some areas supporting stands of waist-high “volunteer” spruce trees naturally seeded from the surrounding forest.

There are no results showing the NP/AP ratio values. Monitoring under the ISEMP requires 10 samples be taken annually for paste pH and NNP (in conjunction with Site C) from various locations across the combined Area 920/C area. However, data analysis are pending and will be available in the next annual report. It is assumed pyritic rock exists at the site.



In some areas where revegetation was unsuccessful there was an observed rust colored precipitate/staining that indicated an oxidation process occurring in the underlying substrate and possibly localized acidic conditions. It was reported by KGCMC that lime and polymer has been applied to the surface of the area on several occasions to neutralize any acid generation.

*Oxidation of Exposed Pyritic Rock*

A small flow of water was observed from two of the drains. The drainage outflow had a rusty orange colored precipitate. Internal monitoring conducted at this site in 1995 and 1996 revealed neutral pH. Metals results indicated no exceedance of water quality standards. It was reported by KGCMC that precipitation events will flush acidic run-off from portions of the surface into the lined ditch which collects run-off. Both surface run-off and underdrain flows are collected and treated under a NPDES permit.

There is no stormwater monitoring associated with the 920 mill site area since all waters are collected as a part of the overall water containment system at the 920 facilities, and treated prior to discharge under the NPDES permit.



*Underdrain at Site 920 Millsite flowing into lined containment ditch*

The waste rock in this area will ultimately be excavated and placed underground at the end of the mine life. In the interim, all runoff waters are captured and treated, while KGCMC management continues addressing the materials, while monitoring documents the status of the area. The bonded cost estimates for this site is \$362,548 for backfill, recontouring and revegetation.

**Site “C” also known as Site “860”**



*Site “C” Panorama of Downgradient Aspect – Note Proximity of Greens Creek*

This 2-acre site is located approximately 100 yards down the B-Road from the mill where the mine safety building and laboratory are situated. Waste rock was placed here over 10 years ago. Approximately 28,400 cubic yards of production rock and fill have been placed at this site. The slopes were rather steep at approximately 2(H):1(V). They were sparse to heavily revegetated. A sedimentation basin with decant overflow pipe was placed below the fill in order to manage flows and reduce sediments to Greens Creek located nearby. The basin is called “Pond C”. A small flow of water was observed at the toe within the sedimentation basin area.



This area was studied under the March 1995 Kennecott Greens Creek Mine Production Rock Site Characterization Study prepared by KGCMC. The results of one drilling at this site showed the material was carbonate dominated. It had an NP/AP value of 1.48 (i.e. predominantly neutralizing).

Two test pits were dug in 1998 prior to the development of the structures located on top of Site C. Seven samples of ABA analysis and paste pH were taken. Paste pH ranged from 7 to 8 with one sample result of 5.9. NP/AP ranged from 0.2 to 1.8. The average NP/AP ratio was 0.6 (predominantly acid generating).

*Small Flow at Toe of Site “C”*

The material at this facility was not reviewed by the 2000 interagency review team and their independent consultant (Shepherd-Miller).

Monitoring under the ISEMP is for 10 samples to be taken annually for paste pH and NNP (in conjunction with Site 920 from various locations across the combined Area 920/C area. Data analysis is pending and will be available in the next annual report.

There is a stormwater monitoring station located at the outflow of the upper settling basin of Site C. Only a portion of Site C would be represented in a sample from this stormwater station.

Storm water sample results remain fairly consistent over time, see Attachment “B” to this report for sample results.

The seepage at the bottom aspect of Site C was studied by the 2000 interagency review team and their independent consultant (Shepherd-Miller). Their report stated the drainage had elevated zinc that was consistent with baseline studies at 3.8 mg/l. The field pH of Pond C seepage was 6.63, and flows were less than 1 gpm.

There are two FWMP sites downstream of Pond C on Greens Creek that are monitored monthly for metals and pH. Site #6 of the FWMP program is located within 200 feet and Site #54 is located approximately 1,500 feet from of the bottom of Pond C. All data are well within water quality standards.



*Site “C”*



*Sediment Pond Site “C”*

According to the reclamation plan this area may be excavated and backfilled into the mine at the end of the mine life. The site is also bonded and being considered for the application of a closure cover system using a similar engineered soil cover system to that installed and being tested at Site 23. This final cover system utilizes profile #4 from the Unsaturated Soils Engineering Ltd. (USE), December 1998 report. The Department has approved the use of this profile in the waste disposal permit for the tailings and Site 23/D and it is incorporated into the reclamation plan. The bonded cost estimates for Production Rock Site “C” is \$193,430



## Site D Berm



*Site D Berm - Inside*



*Site D Berm – Inside and pump house over wet well*

Site D is located downslope from the B-Road between mile markers 8.0 and 8.2 and is directly below Site 23. It sits between Site 23 and Greens Creek. The site is located within Millsite Lease Area “H”. Site D was approved for active waste rock placement during 1987. Waste placement, on an intermittent basis, began during October of 1987 and continued through 1989. During placement activities a total of 210,000 cubic yards of material were placed over seven acres. This waste site has been inactive since 1989.

The berm at the lower aspect of Site D was constructed to contain the surface and groundwater runoff from Site 23/D and to provide sedimentation control. The berm was composed of pyritic quarry rock from the development Pit 405 in 1988. There have been reports of seeps through the berm when the pond contained behind the berm was full. However, at the time of this inspection there was no evidence of seeps as active pumping maintains the pond empty or very low other than during major storm events. There was no evidence of iron staining or stress to vegetation outside of the berm. Keeping the pond level down prevents leaching through the dike. Any seepage that passes through the dike would flow into the adjacent Greens Creek wetlands. Greens Creek is located within 100 feet of the berm.



*Site D Berm – Outside Aspect*

The 2000 interagency review team, and their independent consultant, Shepherd-Miller, did not study the berm to Site D. There are no results showing the paste pH or the NP/AP ratio. There is no specific requirement for sampling the berm. Sampling and assessment of the material in the berm for ARD and ML may not be needed if it is assumed that pyrite rock exists within the berm.

There is a stormwater station located at the Pond D site. The storm water site monitors overflow water from the pond and does not monitor seepage or run-off water from the berm itself.

There is a FWMP station downstream of Site D that is monitored monthly for metals and pH. Site #54 of the FWMP program is located within 350 feet downstream. The data are within water quality standards.

At the end of the mine life the berm will be excavated and placed at Site 23 or underground following installation of the final engineered cover system over Site D. In its place there may be an infiltration gallery or a natural attenuation system. The reclamation bond amount for all of Site D is \$831,562. This includes costs for earthwork, the final cover system, revegetation, engineering, instrumentation and monitoring.

### **Pit 405**



*Pit 405*

Pit 405 is a rock quarry that was developed to construct the B-Road. The site contains approximately 12,000 cubic yards of waste rock that was placed in 1988 during the initial construction of the mine. This material is assumed to be similar in character to that placed at Site D during the same time. Site D material has been characterized to be potentially acid generating.

The area has subsequently been filled (1994-5) with mixed rock and colluvial material that was excavated from the back-slope of site 23. This material is reported not to have ARD potential. Data is available on the colluvium from the 1998 excavation and 1994 drilling of the Site 23 backslope and millsite till. Please refer to this discussion at the beginning of this report. In 2000 till material from the millsite expansion was placed at the rear of the pit.



*Pit 405 – Looking downhill*

The site was covered with soil by 1994, seeded and revegetated. The site was noted to be mostly revegetated. However, revegetation has not occurred on the newer, seeded material placed in 2000. The site was contoured appropriately with gentle slopes. Any water that did manage to enter the fill at the back of the pit likely drains to the ditch on the B-road. Visual inspection of the drainage ditch was unremarkable.

Both the material placed within the pit in 1988 and the pit wall are assumed to be acid-generating. Cover of the pyritic rock with the colluvial material from the Site 23 backslope and millsite till is expected to work favorably in preventing short-term environmental problems with regard to ARD and ML.



Monitoring under the ISEMP requires 3 paste pH and NNP samples to be taken annually from various locations across the site. Because of the pyritic material that was placed in 1988 the program is to include a more intensive site investigation in 2001 and reclaim the site if ARD generating material is found. This site investigation is on-going. KGCMC continues to monitor the drainage, paste pH and NNP under the ISEMP. Data analysis is pending and will be available in the next annual report.

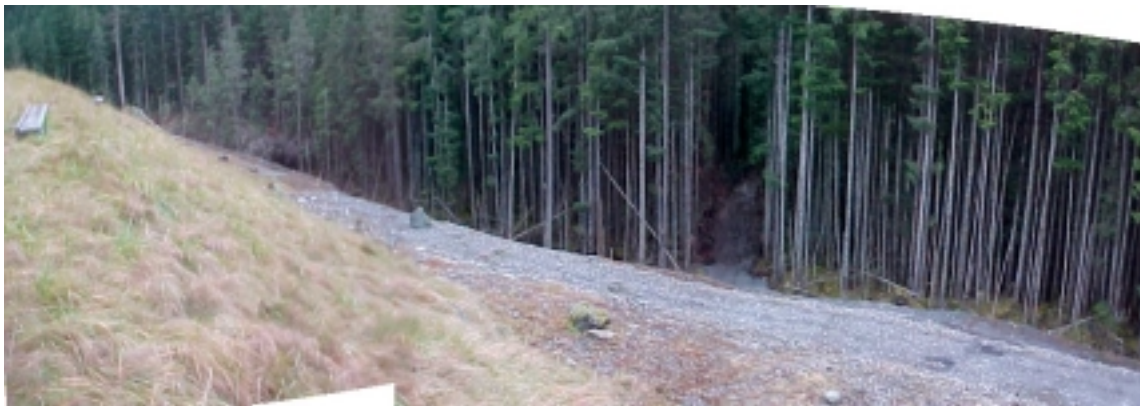
In 1995 and 1996, stormwater monitoring and other internal monitoring was conducted at this site. Results in 1996 show a pH of 7.8 and total zinc concentrations of 57 ug/l. This is typical of the other monitoring conducted.

KGCMC intends to use the colluvial material and the till material from the mill in the reclamation of roads at the end of the mine. The waste rock placed in 1988 will be either excavated and placed either back in the mine or in Site 23 or a final cover system will be placed over it. The reclamation bond amount for this site is \$20,696. This is for topsoil and contouring but does not include costs for a final cover system or for ARD mitigation.

## Site E



*Waste Site E Southwestern Aspect*



*Waste Site E Southeastern Aspect: Looking into the access clearing for Well DH-02-09*

Site E is located on a bench on the hillside adjacent to the B-road near mile marker 4.6, about halfway between Hawk Inlet and the mine service area. Greens Creek is located approximately 300 yards south of the site down a steep slope.

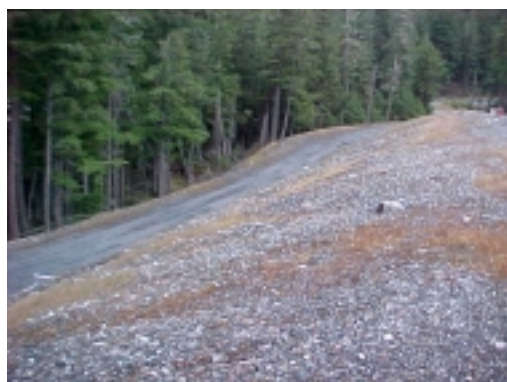
Site E is located on a local hydrologic high point. There is therefore no surface or ground water run-on to the site, however contact water may intermingle with upslope groundwater beneath the pile. Good engineering practice identifies prevention of run-on when locating landfill sites as an important siting criteria, making this is a good site for placing waste materials. Standpipe and pneumatic piezometers installed between 1991 and 2002 indicate that the water table is approximately 80 feet below the pile and that localized, thin lenses of perched water may exist in the pile and foundation.

Waste placement began during 1988 with wet mill back slope clays placed into constructed dewatering cells. Approximately eleven drainpipe finger-drains were installed during the initial placement in order to allow contact water to escape. Through 1994 additional mine rock was placed over the dewatered clays. In 1994 a one- to three-foot cover of carbonate-rich mine rock (argillite) was placed on the then active northwestern portion of the pile. During placement activities a total of approximately 365,000 cubic yards of material was placed over an area of

about nine acres. Many of the finger drains were covered when waste was placed and are no longer exposed.

The company has also stockpiled about 10,000 cubic yards of reclamation materials on a portion of the top of the pile. These materials were then hydro-seeded. Growth appeared to be successful with good grass growth, and spruce trees naturally seeded from the surrounding forest. Reclamation materials were not placed over the lower aspects of the fill. Here, revegetation success was limited following depletion of the hydro-seed mix fertilizer. Plant growth is now minimal on these areas directly seeded onto the exposed waste rock surface, although volunteer Spruce have taken root in the moss/lichen mat which formed with the loss of the grass.

On November 20, 2002, Kenwyn George (ADEC), Bill Oelklaus and Kerry Lear (KGCMC), Steve Hohensee and David Cox (USFS) conducted a review of three drill holes as well as surface



waters down-slope from the site. A spring was observed some 70-80 feet downslope from the waste pile, near well DH-02-03. Apparently at springtime there is a band of wetter soil at this elevation and location that supports ferns and other vegetation more lush than that in the surrounding forest area. During periods of high rainfall, an incised gully near DH-02-09 drains runoff that collects at the base of the pile's southeast side, an area soon to be covered during re-contouring and cap placement.

*Waste Site E – Northeastern Aspect*

During the 2000 interagency review Shepherd Miller performed solids monitoring at this site, which resulted in the collection of 26 paste pH and NNP samples taken from a grid across the site. These produced pH values in a fairly tight range from 7.3 to 7.8, and NP/AP ratios from 0.2 to 4.5. The GPO ISEMP specifies 15 paste pH samples annually from a grid located across the pile, 12 of which are to be from exposed production rock. The first of these samples were collected in 2002, with results to be presented in the next annual report.

Site E was studied during 1994, and reported under the March 1995 Kennecott Greens Creek Mine Production Rock Site Characterization Study by KGCMC. Holes drilled in the pile during this study showed the pH of this deep material to range between 6.4 and 8.0 from 20 samples. The results showed that this site has an average NP/AP ratio of 0.79 (i.e. there is insufficient neutralizing material for the whole pile) but that carbonate minerals in the mine rock are currently maintaining alkaline conditions.

Storm water flows from the site in several directions via small ephemeral drainages. Measurable flow is not persistent and typically occurs only after high precipitation events. An NPDES storm water monitoring site collects runoff from a small natural channel running along the north side of the pile (between the B-Road and the site). Storm water results are presented in Attachment “B” of this report.

The 2000 interagency review followed a particularly wet period in the fall and Shepherd Miller was able to sample runoff from the southeast aspect of the pile. The results indicated that the pH was slightly alkaline (6.9), zinc levels were elevated but consistent with baseline studies of waste rock (22 mg/l) and flow was low (approximately 2gpm). There is no evidence of stress to vegetation downgradient of this area, and the planned reclamation of the site with an engineered cover in 2003 will prevent future runoff from contacting mine rock. A sample was also taken from a drainpipe located on the eastern side of the pile. The results indicated that the pH was slightly alkaline (6.9), zinc levels were elevated but consistent with baseline studies of waste rock (26.6 mg/l) and flow was low (less than 1gpm).

It was reported that water flows from at least one (but not all) of the finger drains after large or prolonged rainfall events. With the exception of the 2000 Shepherd-Miller study of the finger drain on the eastern aspect of the pile, there is no information available of specific sampling conducted of the finger drains. The finger drains will not be exposed after the application of the final cover system planned in 2003.



*Waste Site E – Northwestern Aspect*

Recent expanded field parameter sampling conducted in conjunction with the planned site reclamation have shown surface ephemeral drainages around the Site E pile to produced pH values generally ranging from 6.5 to 8.4.

Geotechnical drilling holes intercepted water bearing zones some 70 and 150 feet beneath the pile. Because several previous well attempts had failed to locate groundwater associated with the Site E pile, casing were installed in these holes in the hope that they would prove to serve as monitoring wells for the site. The three wells were conditioned shortly after installation, and Greens Creek is monitoring field parameters for stabilization prior to pulling initial samples. These early results show water pH values from the wells near the pile have ranged from 7.0 to 7.9 . The more distant well produces pH values of 8.5 to 8.7. A spring discovered near this well produced pH values ranging from 6.1 to 6.5.

KGCMC will update monitoring requirements for Site E specified in the ISEMP to incorporate new information provided by the 2002 drilling program and topographic survey. Anticipated changes to the pile resulting from closure activities will also be addressed. Details of the proposed updates to the ISEMP will be presented in the 2002 GPO annual report, which will be available in April 2003.

Final reclamation of the site is currently planned for 2003. The final cover will be a similar engineered soil cover design to that system installed and being tested at Site 23. However, the lower capillary break layer is not needed for Site E, and currently plans are to not install this layer. The final cover system utilizes profile #4 from the Unsaturated Soils Engineering Ltd.



(USE), December 1998 report. The Department has approved the use of this profile in the waste disposal permit for the tailings and Site 23/D and it is incorporated into the reclamation plan. The approximately 5-foot thick, 1-acre composite cover has been in place at Site 23 for approximately 2 years and monitoring has indicated success thus far in quickly achieving and maintaining design saturation levels, as well as soil temperature profiles (i.e. the saturation layer does not experience freezing conditions).

The application of this final cover system will decrease the rate of infiltration of both water and oxygen into the pile. Contact water characteristics will change as oxygen is used up beneath the cap and prevented from entering the pile. Changes in seep and groundwater quality and quantity will doubtless occur due to this cover system.

The final reclamation of this site will help with the understanding of the long-term effectiveness of the engineered final cover system because of the site's perched location and lack of ground or surface water intrusion. Installation of the cover system in 2003 will provide at least 10 years of quality assurance monitoring history before final covers would be applied at the larger sites at Greens Creek. The final cover system will be fully instrumented and monitored in order to document its performance. The monitoring plan will include measurements of key climate, infiltration, thermal, water and oxygen saturation parameters and will be submitted to the agencies for approval.

Trees have recently been removed from a 1-acre area to the southeast of the fill in order to enable grading the waste pile to a 3:1 slope, preparatory to installing the cover system. The reclamation materials at the top of the pile will be segregated prior to recontouring of the rock material over the eleven-acre lease area.

The reclamation bond amount for this site is \$787,702. With reclamation by the Company scheduled for 2003, this bond amount will drop to that required for ongoing monitoring and maintenance following determination of successful reclamation closure.



*Well DH-02-03*



*Wet area near well DH-02-03 where fern growth indicated a band of increased groundwater flow*



*Well DH-02-12*



*Well DH-02-09*

## **Pit 6**



*Pit 6*

Pit 6 is a rock quarry located at milepost 4.6 (across the road from Site E) on the B-road that was developed to construct the road. The area has been partially filled with material that was excavated from the back-slope of site 23 and some mill site till that was reported to come from the ore pad expansion done in 1995. The till material is reported not to have ARD potential. Data is available on the colluvium from the 1998 excavation and 1994 drilling of the Site 23 backslope and mill site till. Please refer to this discussion at the beginning of this report.

The material in this pit will be used in the reclamation of the adjacent Site E in 2003, and the B-road at the end of the mine life. The slope between the pit and the B-Road was noted to be revegetated successfully. All of the material in the pit was not hydro-seeded; it shows limited revegetation. The site was contoured appropriately with gentle slopes. Any water that did manage to enter the fill at the back of the pit likely would be expressed in the drainage ditch on the B-road. Visual inspection of that drainage ditch was unremarkable.

Monitoring under the ISEMP is for 3 samples to be taken annually for paste pH and NNP. If after 3 years, all samples have less than 0.2% S, then monitoring can be terminated. Data analyses are pending and will be available in the next annual report.

An underdrain system was installed prior to placement of material. The drain system is connected to a pipe that discharges into the access road ditch. This would provide a monitoring station for both run-off and contact water. Plans are to monitor this station under the ISEMP for metals and pH quarterly. Data analyses are pending and will be available in the next annual report.

There is a storm water monitoring station located on the B-Road related to the site. Storm water sample results remain fairly consistent over time, with near neutral pH and low zinc. See Attachment “B” to this report for the sample results.

The bonded cost estimates for Pit 6 totals \$20,696 for topsoil and contouring, no ARD reclamation is necessary at this site.



## **Pit 174**



*Pit 174*

Pit 174 is a rock quarry located at milepost 3.3 near Zinc Creek on the B-road. The site was developed to construct the road. The area has been partially filled with material that was excavated from the back-slope of site 23. Data indicates the Site 23 back-slope did not contain material that could generate ARD (please refer to this at the beginning of the report). After placement with this material in 1995, the site was seeded and revegetated. The material in this pit will be used as soil cover in the reclamation of the B-road at the end of the mine life, or other reclamation efforts. The site was completely revegetated at the time of this inspection. The site was contoured appropriately with gentle slopes. Any water that did manage to enter the fill at the back of the pit likely would be expressed in the drainage ditch on the B-road. Visual inspection of that drainage ditch was unremarkable.



There was an observed iron stained rock material at the periphery of the site. Additionally, there were areas in the cliff at the entrance to the site that had an observable orange rust stain. This did not appear to be hydrologically connected to the material that was placed in the pit.

Monitoring under the ISEMP is for 3 samples to be taken annually for paste pH and NNP. If after 3 years, all samples have less than 0.2% S, then monitoring can be terminated. Data analysis is pending and will be available in the next annual report.

### ***Pyritic Iron Staining***

An underdrain system was installed prior to placement of material. The drain system is connected to a pipe that discharges into the road ditch. This would provide a monitoring station for both run-on and contact water. Plans are to monitor this station under the ISEMP for metals and pH quarterly. Data analyses are pending and will be available in the next annual report.

Stormwater and internal monitoring information was collected at this site from 1995 to 1997. Results from the most recent event show the pH to be 6.3 and zinc at 10.4 ug/l. The stormwater was likely a mixture of both surface run-on and contact water from the underdrain system.

The bonded cost estimates for Pit 174 totals \$20,500. This is for topsoil and contouring. There are no provisions for mitigating ARD as at this time as the site shows no signs of needing such reclamation.

### Zinc Creek Bridge Abutment



*Zinc Creek Bridge Abutment*

The Zinc Creek bridge abutment is located at milepost 3.0 on the B-Road at Zinc Creek. The abutment supports the bridge at its northernmost aspect. It contains pyritic rock that was reported to be blasted from rock outcrops during the development of the B-Road in the vicinity of milepost 2.5 (discussed in the next section). The variable presence of pyritic rock was observed on inspection.



*Pyritic Rock at Abutment*

This site is considered an engineered structure and is not a repository for reclamation materials. This site is not considered an inactive site in GPO Appendix 11 and is not covered under the ISEMP. It is considered under Appendix 14 as a reclamation site.

In 1996 and 1997 a program to provide in-situ treatment with lime and polymer to localized seepages associated with the site. This has the effect of neutralizing acidity and attenuating metals. The plan is to do this in the future if it is needed.

A sample of inferred source material was collected from 2.5 mile B-Road in 1999. Results show a paste pH of 4.2 and the NP/AP ratio of less than 0.1. Therefore, the material has the potential to form ARD.

There is a storm water monitoring site on the northeast side, down-gradient of the abutment. The stormwater monitoring site is sufficient to detect ARD and ML from the site. See Attachment “B” to this report for the sample results.

All roads will be reclaimed at closure of the mine. The Zinc Creek bridge abutment is to be excavated and deposited inside the tailings disposal site. The reclamation bond amount for this site is \$76,086. This includes funds for the removal and haulage of the potentially ARD forming, pyritic rock.

### **B-Road, mile 1.8 pull-out and mile 2.5 road-cut**



*Blasted Rock Along Mi 2.5 B-Road*

The bedrock cliff in the area of 2.4 to 2.6 mile was blasted in order to develop the B-road through this area. Evidence of pyritic rock and iron staining were observed on the uphill rock faces at several places along this stretch of road. This material was reported by KGCMC to be used in the bridge abutment at Zinc Creek and the pull-out at milepost 1.8 of the B-Road. The nearest sensitive environmental receptor from the mile 1.8 pull-out is located approximately 2,500 feet downgradient at Tributary Creek. The nearest sensitive environmental receptor from the mile 2.5 road-cut is located approximately 200 yards at Zinc Creek.

There was a reported drainage of water through the road prism from the uphill ditch at the pull-out at milepost 1.8. Flows ranged between 1 and 5 gpm. In 2002 KGCMC recontoured the uphill road ditch to improve drainage away from the pull-out at milepost 1.8. This was intended to minimize infiltration through the road prism and the pyritic material.

Data have been collected in this area from the previous storm water sample site 535, and internal monitoring ISEMP sample site 376 (both the same site). The pull-out at milepost 1.8 was also monitored quarterly for pH, metals, flows and other field parameters. Recent results showed a pH of 3.4 and dissolved zinc of 108 ug/l. However, zinc values were an order of magnitude



*Pyritic Rock Iron Staining*

higher prior to the 2002 road enhancements discussed in the previous paragraph. Within 100 feet of the pull-out, pH values returned to background levels. KGCMC will continue to monitor the site quarterly for flows and chemistry similar to the requirements in the ISEMP.

A sample of the material was collected from the road-cut at 2.5 mile B-Road in 1999. Results show a paste pH of 4.2 and a NP/AP ratio of less than 0.1. Therefore, the material has the potential to form ARD, and is currently oxidizing (picture below). However, the flow from this site is very low, such that effects are not evident immediately beneath the site (note grass cover in picture).

Storm water is not monitored in the area of 2.4 to 2.6 mile. There are numerous small low flow “weeps”, but no appropriate place to sample.

Biological monitoring results conducted under the Freshwater Monitoring Plan at a site #9 down-gradient of both sites in Tributary Creek showed “no indication of either chronic or acute toxicity in the water”.

All roads will be reclaimed at closure of the mine. Pyritic material in this road section is planned to be excavated and deposited inside the tailings disposal site at closure. The bonded cost estimates for reclamation of this section of road is \$46,412. This includes funds for the removal of the potentially ARD forming pyritic rock from the road base.



*Pyritic Rock Iron Staining*



**Old access road to the south of the tailings site seepage pond**



*Old Road Downgradient of the South Main Embankment Slurry Wall – Photo Taken From Embankment*

This old road to the tailings disposal site was located immediately down-gradient of the original effluent treatment area and the embankment to the storm water storage pond to the south of the tailings facility. It is located at the head of the Tributary Creek drainage. The road contained pyritic rock. In late-June 2002 the road material was removed according to the action plan prepared and submitted by KGCMC in January 2002.

It is not likely there will be a significant ARD or metals leaching issue related to this area since the material was removed. However, the area is to be hydro-seeded, revegetated and monitored. The best way to monitor the site for residual effects from the old road is being considered.



## **Pit 5**

Pit 5 is an active quarry located at the northwestern aspect of the tailings site. Within inactive parts of the overall pit area is the water treatment plant, stored reclamation material, and other material such as old core samples. KGCMC has reported some pyritic rock in this pit, but it was not visually evident at the time of the inspection. Pit 5 may be encompassed by the tailings placement footprint when the tailings facility expands under the Phase II tailings expansion EIS that is under way. If so, this area will also be regulated under a future state waste disposal permit.

Monitoring under the ISEMP is for 3 samples to be taken annually for paste pH and NNP. If after 3 years, all samples have less than 0.2% S, then monitoring can be terminated. Data analysis is pending and will be available in the next annual report.



The site has been studied in the *January 2002 Update Of Information And Action Plan On Seeps West Of The Current Tailings Disposal Facility* by KGCMC. In the study, Pit 5 was a potential contributor of sulfate loading to 3 wells in the bedrock at Pit 5 and 1 well near the Pit 5 access road. The pyritic rock in the pit is one potential source of sulfate to bedrock. The wells continue to be monitored quarterly for metals, sulfate, and pH.

*Pit 5 – Active area*

Surface waters flow to the north retention pond facility within the adjacent tailings site. There is a storm water monitoring station located at the outflow of the pit. Storm water sample results remain fairly consistent over time, see Attachment “B” to this report for the sample results.

The reclamation bond amount for this site is \$19,401.

### Pit 7 on A-Road



*Pit 7 Panorama*

Pit 7 is located at about 1.8-mile on the A-road, between Young Bay and the KGCM Hawk Inlet facilities. It is similar to the other pits along the road system that were developed for road construction and have become staging areas for material that will be used to reclaim roads after closure of the mine. The materials stored at the site are similar to the backslope materials at site 23 in that they do not contain ARD generation capability. The material stored at the site had been seeded with grass and revegetated.

The screened material from the construction of the blanket drain of the east expansion area is representative of the bulk material stored at this site. The material that was not used in the construction of the blanket drain was hauled to Pit 7. This material had a NP/AP ratio of approximately 4.0 and a paste pH of 8.9.

A monitoring well was developed in the eastern expansion area of the tailings disposal site and has acquired representative background information for the tailings monitoring program for a number of years (since 1988). Monitoring of this well shows a pH of 7.6 (3-year average 1996-1998), dissolved zinc 5-15 ug/l, lead less than 0.1 ug/l and iron less than 10 ug/l.



There was an observed orange colored precipitate/staining in the run-off water. This staining appears to have resulted from the material that is stored as it only appeared following placement of that material, rather than the result of the pyritic rock observed on the side-wall of the rock pit. The orange colored precipitate was likely due to a non-sulfidic iron redox reaction. This is less of a concern with regard to metals leaching.

#### *Downgradient Run-off Water Pit 7*

Monitoring under the ISEMP is for 3 solids samples to be taken annually for paste pH and NNP. If after 3 years, all samples have less than 0.2% S, then monitoring can be terminated. Data analysis is pending and will be available in the next annual report.

Storm water monitoring is conducted at Stormwater Site #520 at the Pit 7 entrance. Site 520 samples the drainage from this quarry area on the north side of the access road. See **Attachment**

“B” to this report for the sample results. In addition, this site is monitored quarterly under the ISEMP for metals and pH. Data analyses are pending and will be available in the next annual report.

The reclamation bond amount is \$13,890. This includes contouring and topsoil, but there is no additional amount specifically for ARD mitigation.

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## Attachment “B” – Storm water sampling results

Note: Storm water samples are Total Recoverable for metals; they are taken at times of storm events when sediments may be suspended in the water. High metal results may therefore be from particles in the water, rather than in a dissolved form. Those sites at the pits are located alongside access roads prior to the access road drainage combining with the main road ditch. The sample point at the Zinc Creek Buttruss is at the base of the buttruss. The sample point at Site E has a combination of road runoff and site E runoff waters; most of the flow is from the road. Site 009 is designated as a mine adit drainage. There used to be drainage from the adit, but this has been diverted; the flow is now seepage through the waste rock from a small stream beside the pile, or, during high rainfall events, from a combination of seepage and surface waters. It should also be noted that when storm waters are sampled, any stream that the storm water drains to will be experiencing a high flow from the storm event.

Site #	Location	pH	TSS	Lead µg/l	Zinc µg/l
Date: 5/09/2001					
004	Pit 7	6.7	6.0	<150.00	96.90
005.1	Pit 5	7.6	4.0	<150.00	108.00
005.2	Zinc Crk bridge	7.6	6.0	<150.00	282.00
005.3	Site E	7.6	<4.0	<150.00	<20
005.4	Pit 6	7.6	<4.0	<150.00	<20
007	Pond C	7.8	8.0	161.00	350.00
008	Site 960	6.8	4.0	<150.00	5,020.00
009	Site 1350	7.3	<4.0	<150.00	199.00
Date: 11/15/2000					
004	Pit 7	6.2	<4.0	<150.00	145.00
005.1	Pit 5	7.7	300.0	415.00	493.00
005.2	Zinc Crk bridge	7.2	27.0	<150.00	178.00
005.3	Site E	7.9	47.0	<150.00	79.8
005.4	Pit 6	7.5	<4.0	<150.00	<20
007	Pond C	7.9	9.0	169.00	313.00
008	Site 960	6.8	43.0	<150.00	4,680.0
009	Site 1350	7.3	<4.0	<150.00	161.00