COAL CREEK
MERCURY CONTAMINATION
MITIGATION PROJECT

YUKON-CHARLEY RIVERS NATIONAL PRESERVE, ALASKA

1996-1997

FINAL PROJECT REPORT

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INTRODUCTION

The Coal Creek Hazardous Waste Mitigation Project was conducted in 1996 and 1997 to mitigate the hazards of mercury contamination to human health and the environment at Coal Creek, a site of former dredge mining operations in east central Alaska (see Figures 1 and 2). Coal Creek, a tributary of the Yukon River, is located within the boundaries of the Yukon-Charley Rivers National Preserve and was extensively mined between 1937 and 1975. The National Park Service (NPS) assumed responsibility for the site's hazardous waste when it acquired the donation of the Coal Creek mining claims in 1986.

NPS initiated a series of investigations at the site under the authority of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) in 1990. The investigations identified numerous hazardous waste issues at the site including elemental mercury contamination at an assay building where sluice box concentrates had been processed. At that site, approximately 40 cubic yards of soil were identified as having mercury levels above those safe for human exposure.

Due to the remote nature of the site, NPS elected to conduct a soil washing effort to concentrate the mercury contamination to a smaller volume of soil and then ship that concentrate off-site for final treatment. The Coal Creek Mercury Contamination Mitigation Project was initiated in 1996 to complete that task. At the conclusion of the project, approximately 55 bank cubic yards (bcy) of contaminated soil above a 23 PPM cleanup target had been excavated and processed through an on-site soil wash system. The process reduced the volume of contaminated soil to one third of a cubic yard. This concentrate was shipped to a retort facility that extracted the mercury and sold it as an industrial metal.

The project was managed by the NPS-Alaska CERCLA Program, Alaska Support Office, Anchorage, Alaska and was conducted with NPS in-house equipment and personnel. The project was an innovative application of the soil wash methodology for mercury contaminated soils. It successful mitigated the human and environmental risks associated with the contamination and did so in a safe and economic fashion. The significant reduction of contaminant levels on-site, and the final recovery and recycling of the contaminant as an industrial metal, relieved NPS of any long-term liability associated with mercury contamination at the site.

HISTORIC BACKGROUND

Mining claims were first staked on Coal Creek in 1901 following the massive gold rush into the Klondike in 1896. Coal Creek was prospected by Dawson stampeders who were searching for new ground at the same time that many were migrating to the newly discovered gold-rich beaches at Nome. The early miners worked their claims with hydraulic sluice methods and some limited subsurface drifts. In 1935, General Alexander D. McRae, from Vancouver, British Columbia, with the assistance of Ernest Patty, from the Alaska Agricultural College and School of Mines, organized Gold Placers, Inc. to acquire the earlier claims and develop the property.

In 1935 the company ordered a 4-cubic foot bucket line dredge, constructed by the Walter W. Johnson Co. in San Francisco. The dredge was built in California, disassembled, crated and transported by ship, railroad and finally sternwheeler to Coal Creek. From there the pieces were hauled seven miles up the valley where it was reconstructed. Operations began in July of 1936 and continued intermittently for the next forty years. The bulk of the dredging took place from 1936-42, 1945-48, 1950-51 and 1954-57. Although several attempts were made in the late 1960s and early 1970s to operate the dredge, nothing substantial was accomplished.

The diesel-powered dredge operated from a barge made of compartmentalized steel pontoons. Functioning as a floating wash plant, gold bearing gravel was excavated with a revolving chain of steel buckets positioned at the bow of the dredge and lowered between two pontoons. As the buckets reached the top of the line, the excavated gravel was deposited into a large revolving screen/trommel. Punch plate on the sides classified the gravel by size. “Oversized” material passed through the trommel to a conveyor belt equipped stacker at the rear of the dredge. The "fines" washed through a series of gold separating tables and sluice boxes and were deposited at the rear of the dredge.

At the stern, a large metal "spud" acted as the dredge's pivot point. From the spud, the dredge swung from side to side using a system of winches and on-shore anchors called "deadmen." With each arc, the bucket line was lowered a few feet to cut further into the gold bearing gravel. Upon reaching bedrock, the bucket line was raised, the dredge "stepped" forward a few feet and the process begun again. This method of advancing left a characteristic pattern of sinuous fanlike tailings behind the dredge.

The lower sluice boxes on the dredge were "charged" with mercury to aid in fine gold recovery. The boxes were cleaned approximately every ten days throughout the season and the captured heavy sands, mercury amalgam and free gold was transferred to the camp assay building for further concentration and cleaning. At the assay building, the gold and mercury were separated in a retort process.

Dredge operations were supported by three different locations during the course of mining. The camp buildings were built on log skids to allow them to be moved. The original camp was located at the confluence of Cheese Creek and Coal Creek. A second camp was located near the Coal Creek-Woodchopper Creek Road, roughly half-way between Cheese Creek and Boulder Creek. The camp made its final migration to its present location at Beaton Pup in 1952. Camp facilities include six bunk houses, a recreation hall, a mess hall, maintenance and machine shops, an office and a building used for assay and concentration processing. Between 20 and 60 people worked at the camp at any one time.

Dredging operations ran during the short summer seasons, beginning in early May and generally shutting down because of ice in early November. The dredge shut down altogether in 1944 and 1945 because of the Second World War. The dredge also sat idle in 1949 and again in 1952-53. The dredge, under Gold Placers, Inc.'s management, was shut down in 1957 due to the high cost of labor and the low price of gold. It restarted in the middle 1970s under the ownership of Dan Coben and Dr. Ernest Wolffe of Fairbanks. Coben and Wolffe eventually sold their operation to a Texas group working under the name of A.U. Placers, Inc. This operation was short lived however and the dredge shut down permanently in 1976. Beginning in the 70s, owners also worked the ground using bulldozers and sluices. Historic records indicate that approximately 83,000 ounces of gold, along with 9,700 ounces of silver, were recovered from the Coal Creek valley from 1936 to 1962.

In 1980, the Alaska National Interest Lands Conservation Act (ANILCA) established Yukon-Charley Rivers National Preserve. Congress established the 2.5 million acre preserve to protect the natural and cultural resources of this upper Yukon River ecosystem. At the time, the unpatented Coal Creek mining claims were inholdings within the Preserve boundaries.

The National Parks and Conservation Association facilitated a donation of the mining claims to the National Park Service in 1986. The National Park Service gratefully accepted the donation as it consolidated park holdings and contained unique mining history artifacts including the intact and nearly functional dredge located approximately one mile up the valley from the Yukon River. In addition, park managers hoped to utilize the site's airstrip and camp as a base to support resource management activities within the Preserve.

When the property changed ownership in 1986 there was no documentation of the environmental impacts from its 35 year mining history. In particular, no one could account for the mercury that had been used in the mining process. NPS needed to identify those impacts and determine if any of the mercury remained in the area and if so, whether it posed a long term environmental hazard to the natural resources of the Preserve.

Since that time, NPS has identified and mitigated all of the hazardous waste issues at the site. In addition, it has stabilized and preserved much of the area's historic mining artifacts and has renovated the camp facility so that it now supports public environmental workshops, in-house management workshops, natural and cultural resource management and research activities. Today NPS continues to make improvements to the area to increase the camp's utility and improve opportunities for visitor use and enjoyment.

HAZARDOUS WASTE SITE INVESTIGATIONS

Shortly after accepting the donation NPS initiated its investigations at Coal Creek. Reconnaissance work conducted in 1988 identified hundreds of abandoned fuel drums, scatters of heavy equipment, numerous sites with petroleum stains, and suspected areas of heavy metal contamination. In 1991, NPS directed Ecology and the Environment (E&E), an environmental consultant firm, to conduct a Preliminary Assessment (PA) of the Coal Creek site. The PA confirmed the presence of numerous contamination issues at the site and recommended that a Site Investigation (SI) be conducted. Based upon the SI findings, NPS reported the site to the federal Environmental Protection Agency (EPA) in December of 1991.

In response to a 1992 request by the EPA to collect additional samples for scoring and evaluating of the site for possible inclusion on the National Priorities List, the Alaska District U.S. Army Corps of Engineers (USACE) collected samples and prepared a Chemical Data Report for the site in February, 1993. The Report provided specific information on a number of hazardous waste concerns. These included mercury contamination at an assay building where sluice box concentrates had been processed. Because of the high values reported, NPS constructed a fence around the assay building area to control environmental exposure to the contaminants.

Following fieldwork conducted in September of 1993, E&E prepared a draft Site Characterization study. Following review and field data checking, the Site Characterization was finalized in 1995. That study addressed all of the concerns identified in the SI. Concerning the mercury issue, the study estimated that 280 bank cubic yards (bcy) of soil adjacent to the assay building were contaminated with mercury above an initial 5-PPM field screen level. The study also identified and evaluated seven remedial alternatives to address the mercury contamination: No Action, Physical Access Restriction, Thermal Recovery, Acid Leaching, In Situ Solidification/Stabilization, Capping and Soil Washing. The large volume of soils and the remote nature of the site limited the viability of several of these alternatives. The SI identified Soil Washing with off-site treatment of recovered concentrates as the recommended alternative.

NPS carefully reviewed the proposed treatment alternatives. The No Action alternative was not considered acceptable because of the level of public and agency exposure at the site. The NPS felt that the Physical Access Restriction and Capping alternatives didn't do enough to relieve the agency's environmental liability. In addition, they required a long-term maintenance commitment and would significantly alter the historic character of the site. The Thermal Recovery and Acid Leaching alternatives were crippled by elements of scale -the volume of contaminated soil was too large to be economically transferred to a treatment facility and too small to warrant constructing an on-site treatment facility. The In-Situ Solidification/Stabilization alternative was not considered a proven technology for mercury.

The Soil Washing alternative, in contrast, appeared ideally suited for the site. This was true for a number of reasons. First, as a primary treatment system, soil washing would reduce the volume of contaminated soils. This had two advantages: 1). It would greatly reduce the cost of shipping soil off-site for secondary treatment; and 2) It would reduce the cost of that final treatment. Second, soil wash technology is relatively simple. This would facilitate its application in a remote field locations like Coal Creek where high-tech support is not available. And three, equipment requirements could be easily matched to the logistic limitations and estimated soil volumes of the site. The only downside to the alternative was its estimated cost of 650,000 dollars.

PROJECT PLANNING

In 1995, NPS began developing a soil wash mitigation response plan for the mercury contamination site at Coal Creek. The cost estimate identified in the Site Characterization study far exceed NPS budgetary allowances so NPS began to evaluate individual elements of the soil wash approach to help coral costs. The first element was to refine soil volume estimates.

The Site Characterization Study had estimated that 240 bcy of soil were contaminated above a 5 PPM contamination level. Since neither the State of Alaska nor the federal EPA had well defined elemental mercury cleanup values, NPS contracted E&E to develop a Risk Evaluation Report for the site. The Evaluation was designed to analyze the expected environmental and human health risks at the site and make recommendations on alternate cleanup levels.

The Report concluded that the potential for bioaccumulation of mercury in the site was extremely low due to cold soil temperatures. This limited the likelihood of the uptake and toxic concentration of contaminants by wildlife in the upper levels of the food chain; therefore, the more sensitive risk parameter was human exposure. For humans, the report developed two exposure scenarios: a residential and an industrial worker scenario. For these two scenarios the report suggested the following alternative mercury cleanup values: a 45-PPM cleanup value, which ensured protection for long-term residents on the site; and a 420-PPM cleanup value, which ensured protection for short-term seasonal workers with limited site exposure. Volume estimates for those two alternatives where 24 bcy for the residential exposure scenario and 3 bcy for the industrial scenario.

The NPS elected to proceed with a mitigation strategy designed to meet the requirements of the more conservative residential exposure scenario. This decision was based upon the potential that NPS could post full time staff at the site sometime in the future. With staff, comes the potential of families taking up residence and since children are much sensitive to exposure and are much more like to be exposed (since they often play in the dirt) the more conservative approach seemed warranted.

The second element to be examined in detail was the actual character of the site and the suitability of the soils for soil washing. In March of 1996, NPS CERCLA staff visited the site and collected a small bulk sample for laboratory bench-scale testing. Field observations led the team to conclude that it would be extremely difficult to "surgically" excavate the contaminated soils to a specific cleanup value without an inordinate amount of hand shovel work. This was impractical considering the volume of soil requiring excavation. NPS concluded that the site would require the use of heavy equipment and would have to be "over excavated" to ensure remove of soils over the cleanup target. This led NPS to increase the cleanup volume to approximately 40 bcy.

To evaluate the suitability of the soil for soil washing, Bescorp, an environmental consultant firm active in heavy metal remediation work for the Department of Defense, conducted a treatability test on the bulk sample in May of 1996. Bescorp's bench scale testing determined that the soils at the site were amenable to soil washing, and that such an approach should significant reduce the volume of soil requiring secondary treatment.

With this information in hand, NPS felt confident that the soil wash alternative was the best mitigation approach for the site. Unfortunately the reduction in the original volume estimates from 240 bcy to 40 bcy did not proportionally reduce the estimated costs of conducting the project. This was because "set costs" remained the same regardless of the volume of soils washed. Getting people and equipment to and from the site, and setting up and dismantling the equipment were considerably more expensive than doing the actual soil processing. Because of this, NPS began to evaluate the potential of conducting the effort with in-house expertise, labor and equipment.

That evaluation took the following considerations into account:

1). The hazards associated with elemental mercury are such that simple engineering controls and the use of basic personnel protection equipment (PPE) would ensure that NPS employees would not be exposed to harmful mercury products. Therefore, there were no major health and safety risks to NPS site workers.

2). An administrative system could be readily developed to provide for site health and safety. This would be developed from CERCLA, OSHA and NPS health and safety protocols. Therefore, the project would be conducted under a well established health and safety management framework. This would include employee screening, baseline physicals and blood tests, an extensive Site Health and Safety Manual, an on-site Safety Officer, preseason and daily safety briefings and the rigorous application of health and safety procedures in the field.

3). The proposed mitigation approach was technically, rather simple, and was very similar to fieldwork routinely conducted by staff NPS geologists.

4). NPS had a significant amount on in-house expertise to apply to the project including CERCLA Regulatory compliance, program management, project supervision, logistics planning, site safety, OSHA compliance, field operations, and geologic material handling.

5). The scale of the effort was an appropriate professional progression for project managers. It was well in line of their previous project management experience and it would provide excellent experience for planned programmatic work at other high cost sites.

6). NPS had the bulk of the equipment required for the project in its inventory. This included a D3 bulldozer/backhoe and soil washing equipment.

7). Program managers had developed creditability with the local staff while conducting previous cleanup efforts at the site; therefore, local park management and staff were very supportive of the proposed effort.

8). The mitigation effort was not expected to be controversial.

9). Program managers estimated that the project could be completed for under 250,000 dollars using in-house expertise, labor and equipment. Conducting the project in-house would also have distinct secondary benefits: equipment and supplies purchased for the project would be retained for future NPS programmatic work; and equipment staged on-site would be available for local park projects.

With these considerations the decision was made to proceed with an in-house approach.

A Project Manager was assigned to oversee the fieldwork portion of the project. The CERCLA Program Manager and the Project Manager worked as a Project Management Team (PMT) to coordinate the effort and prepared a number of project planning documents. Staff at the Alaska Support Office provided personnel for field supervisors, a safety officer and day laborers. Seasonal hires from the park provided a heavy equipment operator and an additional laborer.

The Regional Safety Officer was enlisted to collaborate with the PMT in preparing the Site Health and Safety Plan (SHSP). The Plan was developed to meet all of the regulatory requirements of 29 CFR, Part 1910 and 1926, Department of Interior Manual 485 and NPS Manual 50. The document received extensive input from the federal Occupational Health and Safety Administration (OSHA) during its development and was reviewed in its entirety upon completion. The SHSP had chapters that provided detailed information on: Site Description and Contamination Characterization, Organization and Responsibilities; General Hazard Analysis; Task Descriptions; Personal Protective Equipment; Exposure Monitoring; Site Delineation; Decontamination Procedures; Safe Work Practices; Contingency Planning; Heath and Safety Training Program; Medical Surveillance; Documentation; and Visitors.

The inhalation of mercury vapors and direct absorption of mercury from physical contact were identified as the two greatest health risks. Workers were to be equipped with neoprene steel-toed boots, Tyvex coveralls, safety glasses, ear protection, neoprene gloves, hard hats and respirators as standard Personal Protection Equipment (PPE). The PPE would prevent direct physical contact with mercury thus eliminating the absorption pathway. A simple engineering control of wetting the soil during handling was identified as a method to prevent the generation of harmful vapors. A Jerome Mercury Vapor Detector was to be employed to monitor the site for vapor generation. Vapor action levels were established which would trigger the use of half-face or full face respirators. With the use of the simple engineering control the inhalation hazard could be easily managed. The vapor monitor would provide for on-site monitoring while the respirators would provide backup protection.

The SHSP also identified that site workers would have a complete Physical Examination prior to the project. The physician conducted Physicals would include tests to ensure workers capability to wear respirators and base-line blood testing for heavy metals. Workers would also receive 40 hours of CERCLA required Hazardous Site Worker (HAZWOPER) training from an independent contractor before reporting on-site. An extensive safety briefing at the beginning of the project to review the contents of the SHSP and daily safety briefings were also outlined in the Plan. The plan also outlined the long term monitoring. The use of mercury vapor detection tags by site workers and post season urine tests would be used to document any exposure site workers received during the field season.

The SHSP was updated and expanded for the 1997 summer field season. The revised SHSP was once again reviewed by OSHA and an OSHA inspector was invited to make project inspection at the beginning of the 1997 field operation. The inspection occurred June 18^{th} and 19^{th}, 1997. The inspector recommended a few minor improvements to the plan and operation procedures. These included improving documentation procedures for plan modifications and providing aprons to project site workers to reduce water spray exposure.

A Project Work Plan was developed and submitted for review by the Alaska Department of Environmental Conservation (DEC) in June of 1996. DEC expressed interest in the proposed approach because of similar mercury contamination issues in other parts of the State, but made no formal comments on the submitted Plan.

As part of project planning, a Public Participation Plan was developed. The Plan provided for public notification of the proposed effort and a public comment period. A formal Public Notice was published in the Fairbanks Daily News-Miner on June 4-10, 1996. The comment period ran until June 30th. No comments were received during the public comment period.

LOGISTICS AND SITE PREPARATION

Site work associated with the project began in early July 1996. A Caterpillar D3 Dozer/931 backhoe, 5 yard dump truck and other misc. equipment and supplies were air lifted to the site with a DC-3 and C-130 aircraft. The air operations utilized the camp's 4,000-foot gravel airstrip. A Bobcat 873 skid-steer loader was also freighted down river from Eagle on a NPS landing craft.

Once the heavy equipment was on-site, a work pad was constructed on an nonvegetated maintenance yard work area approximately 500 feet from the assay building. A 120 by 100-foot area was cleared of debris and an 80 X 50-foot work pad surface was carefully graded with a 1-1.5% slope along a center drain channel and side slopes of 1-2%. At the base of the pad a 14,000-gallon impoundment was excavated. The impoundment was designed to capture runoff from the work pad and function as recycle pond for the soil washing operation. Both the pad and the pond were lined with two layers of 20 mil liner which were placed over a carefully raked soil surface. The pad liner was placer to overlap the pond liner by a minimum of 3 feet and was sealed with factory-supplied two-sided tape. Water was pumped from a nearby creek to charge the pond with an initial 8,000-gallons of process water.

Soil washing equipment was placed on the pad, water supply hoses were run and the entire area was surrounded with boundary tape and signs to define a treatment area exclusion zone. A small decontamination zone was established along the edge of the exclusion zone and general support equipment and supplies were staged in an adjacent area.

The fence surrounding the assay building site opened at two points to provide access. Tape and signs were used to provide controlled access at those points and second decontamination zone was established adjacent to the area. The ground surface was cleared of vegetation and a short spur road was constructed below the site to provide access.

FIELD SCREENING AND EXCAVATION SAMPLING

The excavation area had been enclosed by a six foot tall chain link fence following the discovery of the contamination issue in 1992. As site work began, the fence was opened in two places to provide access but a barrier tape boundary was established to delineate a restricted contamination zone. Adjacent to the contamination zone a decontamination area was established. Site entry and decontamination procedures were established and enforced in the area for the duration of the excavation work.

The soils at the contamination site consisted alluvial sands, silts and gravel with small clay lenses. The surface soils were silty and graded to sandy gravel approximately 6-10 inches below the surface.

After roughly delineating the contaminated area based on upon data derived from the Site Characterization drilling program, an X-ray fluorescence device (XRF) was used to further refine the limits of the contamination. A cleanup threshold of 23 PPM was used to establish outer boundaries of the excavation area.

The 23 PPM value was used for two reasons. First, at 50% of the Project's Risk Evaluation 45 PPM cleanup value, the 23 PPM value provided a good initial screening target. Managers felt that if all the material testing above 23 PPM was excavated then final site sampling should readily meet the 45 PPM target. Secondly, during an extensive literature search conducted during project scoping, program managers discovered that EPA Region 3 utilized a 23 PPM cleanup value for mercury cleanups at residential sites. This was the *only* specific cleanup value found in the literature. Project Managers felt that meeting that target value would eliminate any controversy over the selected cleanup target. A final consideration was that the excavation procedure would not necessarily be sensitive to the narrow difference between the two values. The use of heavy equipment and the need to over excavate 45 PPM soils would likely result in an ultimate cleanup values in the 10-30 PPM range.

Observations made during the delineation process revealed that the soil's mercury contamination was in the form of fine “micro-beads” of elemental mercury. The micro-beads tended to be concentrated in the soil's silty surface layer and were most evident near the assay building's doorway. This distribution suggested that the contamination might have been derived from floor sweepings taken from the assay building following processing sessions. Small amounts of gold intermixed with the mercury tended to support such a hypotheses. In one small area however, large mercury beads with no associated gold were readily visible in the exposed soil. There, mercury may have been intentionally dumped or accidentally spilled.

EXCAVATION AND CONTAINMENT

Once the area to be excavated was defined, contaminated soils were removed by the Caterpillar D-3 backhoe. Fine detail work was conducted with hand shovels. The soils were kept wet to prevent mercury vapor generation and workers wore appropriate PPE to prevent direct mercury contact. The soils were typically stripped in shallow "lifts" -one bucket width at a time. The backhoe bucket or shovel was positioned to undercut a contaminated layer to prevent the mercury from sifting down through the loosened soil. This was the "over excavation" process. Once a layer was removed the newly exposed surface was screened for contamination. The XRF was used for that screening process.

The XRF had been factory calibrated with soils from the site. Although well suited for heavy metal detection the XRF tended to confuse the flourescence values for gold, mercury and lead. This often created a recalibration problem at the site. The instrument required a full time person to prepare samples and constantly recalibrate the instrument. Since the person operating the XRF had to be licensed by the Nuclear Regulatory Commission and only the CERCLA Program Managers was so licensed, she had to assume those duties. This significantly reduced her availability for more general PMT duties.

As a result of the difficulties with the XRF, hand-panning techniques were often used as a quick field screening method in areas of visible mercury contamination. Since several of the crewmembers were geologists and skilled gold panners it didn't take too long to apply the technique and develop a rough correlation with visible mercury and PPM contamination levels.

Once all of the contaminated layers had been removed in one area, an adjacent surface area was excavated. In this manner, only a small area of contaminated soil was exposed at any one time and the backhoe operation always worked off decontaminated surface.

Following soil removal, the excavated soil was loaded into a 1/4 cu. yd. capacity, double-axle ATV trailer positioned on a liner adjacent to the excavation site. The bed and sides of the trailer were lined with two layers of the 20 mil liner material and a heavy wooden box was constructed to fit inside the lined trailer bed to protect the liner. Once loaded, the soil was sprayed with water and was transported to the work pad area by a 4-wheel drive ATV.

SOIL WASH METHODOLOGY

Site workers at the wash pad site wore PPE to protect them for direct exposure to mercury particles. Tyvex coveralls were taped at the ankles and wrists to ensure a good seal with boots and gloves. The extremely wet environment of the soil wash process eliminated the generation of any mercury vapors.

SLURRY PREPARATION-

Once delivered to the work pad, workers transferred the contaminated soil to a large plastic holding bin. While being held in the bin the soils were kept moist. The bin sat next to a 0.6 cu. yd. capacity cement mixer. The mixer was filled with approximately 8 gallons of water and then up to 30 shovels of soil were added to it as it ran at a very slow idle speed for approximately 20 minutes. The operator would modify water and soil volumes, and run times dependent upon the characteristics of the soil. Up to 16ounces of "R-38", a commercial surfactant manufactured by Action Mining Service Inc. of Reno, Nevada was added to the mixer. The cement mixer broke up soil clods and clay balls, and reduce the soil to a thin milkshake consistency slurry.

After mixing, the slurry was poured into a 250-gallon plastic bin. The slurry was then bailed out of the bin into 5-gallon plastic pails. After rinsing the outside of the pails, they were carried to the wash plant. Since the cement mixer only produced 30-40 gallons of slurry per batch, the soil washing operation was not initiated until 2-3 batches had accumulated in the bin.

GRAVIMETRIC SEPARATION-

The soil washing system consisted of standard off-the-shelf equipment designed for gravimetric separation of earth materials based upon their differences in specific gravity. Much of it was designed for precious metal and diamond recovery but since mercury has a specific gravity of 13.6 which is similar to gold (15-19.3) and platinum (21.4) the same equipment was well suited for mercury recovery effort. The system consisted of a hydraulic jig, a series of small sluice boxes and a sand trap. In addition, a copper sheet integrated into the wash circuit served as an amalgamation surface.

The wash plant was mounted on an elevated platform to allow for gravity flow throughout the system. Wash water was supplied from the recycle pond at approximately 30 gpm by a 5-hp gasoline engine and a 2” water line. Twenty-five pounds of R-38 was added to the wash water cycle at the beginning of each five-hour wash period.

The Jig Plant was a 1 cubic yard/hour capacity Goldfield Exploration Inc. "Explorer" Jig Wash Plant. The Jig Plant had a vibrating screen feed hopper that was equipped with a $1/8^{th}$ inch classification screen.

Standing on a bench adjacent to the jig plant, an operator hand fed the wash plant from the 5-gallon pails filled with the slurry produced by the cement mixer operation. The operator slowly poured the pails of slurry into the vibrating screen hopper. A spray bar supplied water to help wash the slurry across the screen. Material larger than $1/8^{th}$ inch, called "oversized" was discharged from the Jig Plant into a 10-gallon rubber tote where larger stones were carefully cleaned of any adhering soil and the rest of the oversized material carefully rinsed. The oversized material was then stockpiled on the lined work pad and allowed to drain. After laboratory testing it was discharged from the work pad and stockpiled for replacement in the excavation.

Minus 1/8th inch material was carried by the wash water through the feed hopper to a 16-inch diameter, steel shot charged Pan-American jig bed. The jig bed was the primary mercury recovery device. The pulsating action of the jig bed drew heavy specific gravity particles, including "black sands" and mercury, through the jig bed into a collection hopper and a five-gallon collection bucket placed beneath the wash plant.

The action of the jig could be controlled in a number of ways: length of the stroke, speed of the stroke and water pressure beneath the jig bed. Over the course of the operation, these controls were varied to maximize mercury recovery. The best indicator of success was the relative amount of black sand recovered under various settings. Maximum black sand recovery appeared to be associated with long, slow strokes and adequate back-pressure to prevent clogging of the jig bed.

"Lighter" material that passed over the jig bed was directed over a 12” wide by 24” long riffled sluice box. The sluice box acted as a secondary mercury recovery device and a method of evaluating the effectiveness of the jig operation.

From the sluice box, the wash water was directed in a shallow sheet flow across an inclined box lined with a 36 X 72 inch copper sheet. Fine micro beads of mercury, which had escaped the previous traps, settled through the 1/4" deep water column and bonded to the copper plate. An operator monitored the water flow across the copper plate and swept mineral sediments off the surface of the plate with a rubber squeegee as they accumulated. When the system was going to be shut down the outlet of the box was plugged and the box was allowed to flood with water. This kept mercury vapors from being generated from the copper plate during idle periods.

From the copper plate the wash stream was directed into a plastic tote which functioned as a sand trap. From the sand trap the wash stream was directed across two short sluice boxes and finally discharged on the work pad surface. Once on the pad surface, the wash water flowed down a shallow sloping out fall channel to the recycle pond.

The sand trap, along with the inclined wash pad surface was used to capture and roughly classify different soil size fractions carried by the wash water. The sand trap captured the bulk of the sand-sized fraction while a high percentage of the silt-sized soil particles settled out along the 40-foot outflow channel. By segregating the soil fractions they could be individually tested with the XRF for the effectiveness of the soil wash procedure. In addition, they were prevented from entering the recycle pond thereby maintaining its water capacity, increasing recycle water quality and reducing pond "bail out" work at project conclusion.

Site workers bailed the sand trap several times during each 5-hour wash period and swept the out fall channel at the end of each half day wash period. The bailed sands and silt-sized "sweeps" were then stockpiled and allowed to drain on the surface of the lined work pad.

PROCESS SAMPLING METHODOLOGY

The process system was tested twice daily by collecting sediment samples at the point where the system discharged wash water onto the pad surface. Sediment samples were collected by periodically bailing wash water off the pad surface and allowing it to settle in a 5 gallon pail. After settling for 30-40 minutes the water and suspended solids in the bucket would be poured off and the bucket filled again. In this manner, the bucket was refilled filled 7-10 times each wash period and small volume of sediment was collected in the bottom of the bucket. Sand Trap and sweep samples were also collected as a quality control measure. The samples were air-dried and tested with the XRF following each 5-hour wash period. Any process period's sand trap deposits or sweeps which failed to pass the 23 PPM cleanup level were rerun through the soil wash system. Materials that passed that initial screening were placed in a stockpile and subject to laboratory confirmation. Confirmation testing from Northern Testing Laboratory in Fairbanks was obtained prior to transferring *any* processed material off of the lined work pad.

DECONTAMINATION AND SITE CLOSURE

After soil washing operations were completed for the 1996 season, the wash plant and pad area were decontaminated, and water and pond sediment samples were collected from the recycle pond and sent to the Fairbanks lab for analysis. The lab results verified that the water column was free of mercury contamination. The pond was then decanted and the water discharged in a broadcast spray over a heavily vegetated area adjacent to the maintenance yard. The pond's settled solids, that contained a low level of residual contamination, were pumped to a double lined holding pond constructed adjacent to the main work pad. The pond was then covered with a rigid water proof structure for over winter storage.

Wash plant concentrates were consolidated in six, 5-gallon pails and placed in 55-gallon drums. The drums were placed in a covered and sealed storage area on a section of the lined pad. The work pad area and the excavation site were then secured with an exclusion tape barrier and warning signs.

In 1997, the site was reactivated and an additional 40 cu. yds. of material was processed along with the pond sediments stored from the previous season's operations. At the end of the 1997 season, the accumulated pond sediments were recycled through the wash plant system twice by utilizing a diaphragm pump and a series of holding ponds constructed along the southern edge of the processing area. Laboratory analysis obtained after the final cycle documented that the remaining fine sediments contained less than 20 PPM mercury. The wash plant and pad were then decontaminated and dismantled, and the pond was allowed to settle for several days. The clear surface water was tested and decanted. The remaining pond sediments were then pumped to the excavation site and capped with the processed oversized and sweeps. Finally, the site was graded and covered with approximately 6 inches of organic soil to provide a seed bed for natural revegetation.

The accumulated mercury concentrates were packed into five, 15-gallon plastic-lined, steel drums. The copper sheet with amalgamated mercury was rolled and packed in an additional 15-gallon drum. The drums were labeled and banded to a single shipping pallet. The NPS let a contract with Burlington Environmental Inc. to transport and dispose the mercury concentrates and amalgam sheets. Burlington flew the palletized material out of Coal Creek then trucked it to their Kent Washington facility prior to transporting it to the Mercury Refining Company of Albany, New York were it was processed in a retort recovery process. The recovered mercury was then sold as industrial mercury. The NPS received a Certificate of Treatment, Recycling, and/or Disposal for the mercury waste dated March 3, 1998.

RESULTS

The soil wash system was used to process approximately 55 bank cubic yards of mercury contaminated soil excavated from the assay building location. Soil was excavated from an area of approximately 1,000 square feet along the south and western sides of the assay building. Average excavation depth ranged from approximately 1 to 3 feet. The contamination resulted from the processing of sluice box concentrates from mining operations conducted within the valley by a bucket-line dredge. Processing operations at the site were conducted from 1951 to 1975. From the distribution of mercury at the site it is suspected that the contamination resulted from the disposal of floor sweepings taken for the assay building following processing sessions.

The original distribution of mercury was mapped during the preparation of a Site Characterization Study prepared by Ecology and Environment in 1995. Mercury contamination at the site was documented as high as 4,060 PPM during that effort. During actual excavation contamination values tended to be somewhat higher that the Site Characterization study documented. The distribution was similar but suggested out laying concentrations of mercury were not found.

The excavation process removed all soil from the excavation area that had contamination values greater than a field screening level of 23 PPM. Final excavation laboratory testing of 10 sites within the excavation confirmed cleanups ranging from non-detect to 19.6 PMM. Approximately 1,400 gallons of suspended sediment was pumped to the excavation at the conclusion of the soil wash operation. This material had a residual mercury contamination value of 21.4 PPM. Approximately 30 cubic yards of washed oversize (>1/8th inch) material with no residual contamination was placed over the sediment and 20 cubic yards of washed sands and silts with residual values from two composite samples of 23.4 and 10.5 PPM were placed and graded over the oversize. The site was then topped dressed with 6 inches of organic soil and left to revegetation from natural reseeding.

The soil wash system processed the contaminated soil over a 29 day processing period spanning two field seasons. The soil wash procedure reduced the soil volume requiring secondary, off-site treatment to approximately 1/3 cu. yd. -the volume of 5, 15-gallon drums. It reduced initial soil contamination levels ranging up to 4,060 PPM to more uniform value below the 23 PPM field screening level.

The project required the efforts of a five person crew during wash periods. Two people manned the excavation site and conducted on-site XRF screening, four people operated the wash plant, one person functioned as the Site Safety Officer. The CERCLA Program Manger and the Project Manager both functioned as full-time crew members.

The project was conducted for 189,000 dollars.

CONCLUSIONS

The project successfully mitigated the mercury contamination threat to human health and the environment at the site and allowed the NPS to reopen the assay building area to public visitation.

The project was completed with no health or safety impacts. No work hours were lost due to injury and no hazardous substance exposures were documented by on-site monitoring, mercury vapor tag monitoring or post season urine analysis.

By the end of the 1998 field season, the excavation site was supporting a vigorous growth of native vegetation. There is no physical evidence remaining of the soil wash operation site.

The project was successfully completed within the in-house capabilities of the NPS. The CERCLA Program Manager and Project Manager are applying their improved management skills to mitigation efforts in Wrangell-St. Elias National Park and Preserve, Denali National Park and Preserve, Katmai National Park and Bering Land Bridge National Preserve. Crew members from the Alaska Support office and the local Park are presently fully qualified hazardous waste site workers and are available for future project assignments.

Tangible secondary benefits were received by the park: the project brought heavy equipment on-site which was used to improve roads, bury water and sewer lines, haul supplies and transport gravel; the project provided a base for hiring seasonal laborers which the park extended to accomplish other park work; and the project's on-site housing requirements provided support to upgrade the camp's water system. These secondary benefits will continue to contribute to the park for many years to come.

Other secondary benefits included the addition of a Bobcat 873 skid-steer loader/forklift, a 0.6 cubic yard capacity cement mixer, and other smaller equipment and supplies into the CERCLA Program inventory. This equipment is available for other CERCLA and general NPS project work. The dozer and the Bobcat loader will remain in the park until other project work justifies their removal. They provide significant support for park operations.

The project wasn't completed without significant challenges however. A major challenge was the gravimetric separation process. The Treatability Study had concluded that the site's soils were very amenable to soil washing. This was based upon soil samples collected in the early spring of 1996. Once in the field however, Project managers found that the thin surface soil layer, which contained the bulk of the mercury, was high in organics, silt and clay. These soil constituents bonded the mercury in physical and chemical bonds that were difficult to break. Not being able to separate the mercury from lighter soil fractions initially foiled the gravimetric separation process and early test runs failed to meet cleanup standards. Not completely understanding the problem, several reconfigurations of the physical wash and separation process were tried with only limited success.

Continued investigation led to the discovery that the mercury droplets that were recovered in early test runs had a very high surface tension and often would not aggregate with other mercury droplets or amalgamate on the copper sheet. Research into that problem led to the discovery that the mercury's exposure to the soil organics had created a condition known as "dirty" or "floured" mercury. NPS Project managers were advised to add a surfactant commonly used by the mining industry to "clean" the mercury and reduced its surface tension. That product was "R-38", a cleaning agent with a high ammonia content.

Experimenting with the surfactant, NPS Managers were able to dramatically increase recover rates and consistently meet cleanup goals. Maintaining a consistent concentration of the surfactant proved difficult however, and the effectiveness of the recovery process varied depending upon the concentration of mercury contamination, the soil character and other factors not completely understood.

As a result, NPS would not recommend this soil washing methodology on sites with high percentages of organics, silts or clays. NPS would also recommend a relatively extensive bench scale testing program in the project planning phase.

NPS was fortunate that the flexibility of its in-house effort allowed for the lengthy field trial period necessary to develop an effective process procedure. A more rigid contract arrangement may have lead to significant change order requests and budget over runs.