LANDFILL CLOSURE OF THE WASTE CALCINING FACILITY ONE OF THE FIRST IN-PLACE LANDFILL FACILITY CLOSURES

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ABSTRACT

The Department of Energy, the State of Idaho, and the Idaho National Engineering and Environmental Laboratory (INEEL) saved the taxpayers over $140 million in the recent closure of the Waste Calcining Facility at the INEEL. The closure to landfill standards demonstrated that radioactive and hazardous mixed constituents can be safely, practically, and cost-effectively disposed.

When the Waste Calcining Facility (WCF) was slated for closure, DOE had two options: clean closure and landfill closure. Clean closure would have required excavation, removal, and long term storage of the structure and all the process equipment, created large amounts of radioactive waste, exposed workers to high levels of radiation, and cost over $150 million. DOE, EPA, and the State of Idaho agreed upon landfill closure because it could meet the RCRA requirements, would reduce waste over ten-fold, would maintain workers exposure to radiation below ALARA (as low as reasonably achievable) standards, and cost an estimated $10 million. All of these goals were achieved. The biggest cost and schedule savings resulted by minimizing waste handling and leaving the WCF in-place: clean closure removal was estimated to take 19 years, whereas landfill closure actually was completed in less than three years. The WCF in-place closure cost a total of $11.3M, wastes were reduced by 13,000 cubic feet (see Table I, Generated Waste Savings), and worker radiation exposure reduced by over 230 person-rem.

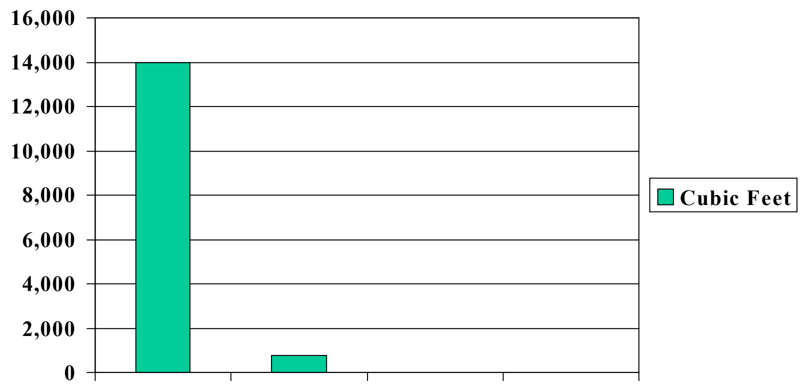
The WCF, operated from 1963 to 1981, solidifying highly radioactive liquid waste. It was a heavily reinforced concrete structure with a footprint of 70 x 108 ft, consisting of a ground level and two levels below grade. The closure of the WCF comprised three phases: (1) isolate the WCF from other buildings and fill the basement levels and vessels with grout, (2) demolish the WCF into a rubble pile, and (3) fill the rubble with grout and place a concrete cap over the footprint of the WCF. With construction of an engineered concrete cap over the grouted cells, vessels, and rubble pile, this procedure meets the RCRA requirements applicable to a landfill closure.

The decision to follow the landfill closure path for the WCF has established a positive precedent for future waste management at the INEEL and throughout the DOE complex.

INTRODUCTION

The WCF, located at the INEEL, is approximately 45 miles west of Idaho Falls, Idaho, at the Idaho Nuclear Technology Engineering Center (INTEC) (formerly the Idaho Chemical Processing Plant (ICPP). The INTEC is situated on the south-central portion of the INEEL site in an enclosed and secured area of approximately 250 acres. The WCF (Building CPP-633) is located near the center of INTEC. The calcining process converted highly radioactive liquid waste into a solid form (calcine) for dry storage.

Table I
Generated Waste Savings
Clean Closure vs. Landfill Closure



The WCF processed more than 15.2 million liters (4 million gallons) of high-level liquid waste to less than 2,180 m^3 (77,000 ft^3) of calcine between 1963 and 1981. The calcined product was transferred to interim storage at the Calcine Solid Storage Facility (CSSF) pending further treatment and ultimate disposition in a geological repository. The liquid wastes processed in the WCF contained varied amounts of hazardous constituents, as well as radiological contaminants.

The WCF is a heavily reinforced concrete structure with a footprint of 70'X 108', a ground level and two levels below grade. Processing areas are below grade in two banks of cells separated by common operating and access corridors. Nonradiation service areas are located in the above ground superstructure constructed of concrete block and steel. Design and operation of the WCF utilized lead shielding in many of the below ground cells, pipe corridors, and sample and monitoring stations to protect workers from high-radiation fields. This shielding is located inside cell walls or in areas heavily contaminated with radioactive constituents.

Nine calcination campaigns were completed at the WCF, beginning in 1963 and ending in 1981 when the WCF was replaced by the NWCF. The calcining process involved using high temperature to evaporate and oxidize the liquid high-level waste in a fluidized bed. Liquid waste was transferred from the INTEC tank farm to the WCF through underground pipelines. The liquid waste, which consisted of metals and nitrates in an aqueous solution, was injected into the calciner vessel, onto the hot, fluidized bed with in-bed combustion of kerosene and oxygen. As the water evaporated, most nitrates were released as nitrogen oxides (NOx), and the dissolved metals formed the calcine of oxides and salts at 500^oC (932^oF). Calcined solids were then pneumatically transferred through underground pipelines to CSSF units 1, 2, and 3. The WCF evaporator and associated tanks were used to concentrate tank farm wastes until the spring of 1987 and then placed in a stand-by condition.

A NEW PATH TO CLOSURE

Landfill closure of the WCF was a innovative approach for closing a nuclear facility at the INEEL. Previous closures concentrated on decontamination and removal the equipment and structures in the nuclear facility. They involved extensive removal, packaging of wastes and remediation of the area after decommissioning. Since the WCF was included on the INEEL RCRA Part A permit application, RCRA required, that a Closure Plan for the RCRA units in the WCF be developed. The Idaho Operating Permits Bureau communicated that if the WCF could not be decontaminated, then the tank systems must be closed in accordance with requirements that apply to landfills IDAPA 16.01.05.009 (40 CFR 265 Subpart N). IDAPA 16.01.05.009 (40 CFR 265 Subpart J) requires that tank units be closed in accordance with the requirements that apply to landfills if the operator cannot practicably remove or decontaminate the soils. IDAPA 16.01.05.009 (40 CFR 265 Subpart L) regulations for waste piles also require preparation of closure and post-closure plans if the operator cannot remove or decontaminate the subsoils. In addition, the State of Idaho wanted the risk of release from the landfill to be consistent with the FFA/CO remediation goals for INTEC. This required the Department of Energy (DOE) to address the risk of release from the radioactive isotopes in parallel with the RCRA closure of the unit for hazardous constituents. The DOE evaluated the landfill closure of the WCF using an Environmental Assessment (EA) to determine the risk of release of the hazardous and radioactive constituents. The risk assessment used to support the EA used the same methodology being followed for the CERCLA program under the FFA/CO.

For the WCF, clean closure presented significantly larger risks in terms of cost, worker exposure and conservation of disposal space than the risk-based, landfill closure path. The cost of a complete D&D removal were estimated to be over $150 million; about 15 times that of landfill closure. This money was not readily available, and could have been a significant roadblock to closure. Some areas of the WCF have extremely high (over 50 rad/hr) radiation fields. Any "cleanup" potentially exposed workers to hundreds of rems of radiation. Total removal of the WCF would also have generated an estimated 230,000 cubic feet of radioactive waste. Efforts to dismantle the WCF, package the waste and transport it to a nearby disposal site did not seem justified. Since it was impractical to remove the process residues, decontaminate the equipment, and remove the HEPA filters in the waste pile, the WCF closure was developed in accordance with the closure and post-closure requirements that apply to landfills. The State of Idaho joined in the desire to protect worker safety and health, particularly radiological safety; concerns most adequately addressed by the landfill closure.

PREPARATION OF SOURCE TERM AND RISK ASSESSMENT

The preparation of the source term and risk assessment for WCF was an innovative phase of the closure project. Efforts at straightforward characterization of the contamination were hampered because some WCF areas were far too radioactive to take comprehensive samples, and much of the process equipment was in areas and configurations that severely limited their access. A computer model was developed to represent the process conditions and contaminants at the time of the WCF closure, and the results of that modeling were used for characterization. This model estimated the quantity of residual material left in the WCF using the operating records, personnel interviews, design specifications, drawings, recent (remote) video inspections of the cells, and safety analysis reports. The vessels and cells are believed to have been flushed with water after the final calcine campaign. However, a conservative approach was taken to estimate the remaining amount of residues in the system. The evaporator and calciner system vessels and piping were assumed to have a 25.4-mm (1-in.) layer of dry sludge on the bottom. Totaling all the floors, walls, piping and vessels resulted in an estimated quantity of 0.39 m^3 (0.51 yd^3) process residue remaining in the system. Because of the dry conditions, it is not expected to find detectable concentrations of these organic constituents in the process residues found in vessels and piping, or on the cell floors. Consequently, any remaining residue of these chemicals would present no significant threat to human health or the environment. Approximately 15.24 metric tons (15 tons) of lead shielding found structurally in cell walls, pipe corridors, sample blister, and doorways were left in place. The quantity of mercury contained in the in-cell instruments is conservatively estimated to be 11.8 kg (26 lb). The quantity of oil contained in the in-cell equipment blowers and observation windows is estimated to be

75.7 and 1,022 liters (20 and 270 gallons), respectively. The blowers contain 40 wt. lubrication oil and the observation windows contain mineral oil.

The chemical and radiological process knowledge characterization of this residue was based on available information on types of calcine similar to those produced at the WCF. The majority of the residual material left in the WCF would be from the last "zirconium" (H-9) calcine campaign. Since zirconium calcine had been well characterized during NWCF (H-3) campaigns, a comparison was made between what was known about the H-9 calcine and corresponding H-3 calcine. Good correlation was obtained and a more complete characterization produced because of filling in missing data with the H-3 calcine analyses. All radioactive isotopes were decayed from the last WCF campaign to give conservative values.

A Listed Waste Determination Report from 1993 identified several waste codes associated with the INTEC systems including both calciners. RCRA characteristically hazardous waste codes included: D002 (corrosive), D007 (chromium), D008 (lead), D009 (mercury), D011 (silver). A potential group of "Listed" waste codes included off-specification commercial chemical products and decontamination solutions identified in an inventory of INTEC facilities and laboratories. All these waste codes, identified in Part A of the INEEL Hazardous Waste Management Act (HWMA) Permit, were a conservative estimate covering chemicals that may have been used.

The Risk Assessment for the RCRA Closure for the Waste Calcining Facility provided the methodology used to support closure of the WCF under RCRA and the National Environmental Policy Act. In addition, this document provides the calculated risk after closure of the WCF that can be used in the comprehensive remedial investigation/feasibility study being performed under the regulatory authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended. Because RCRA did not at that time have established protocols for conducting risk assessments, the general approach presented in Environmental Protection Act (EPA) risk assessment guidance prepared for use at sites evaluated under the regulatory authority of CERCLA, was used. Both a human health and an ecological risk assessment were performed.

Two exposure scenarios were evaluated for human health. These are the current occupational and 30-year future residential exposure scenarios. The conceptual site model developed for the site identifies three exposure pathways (i.e., groundwater ingestion, dermal contact with contaminated groundwater, and external exposure) for the identified receptors. For the current occupational exposure scenario, only the external exposure pathway was evaluated. For the 30-year future residential exposure scenario both the external exposure and groundwater ingestion exposure pathways were evaluated. For ecological receptors, only the groundwater ingestion (as from a stock pond) exposure pathway was evaluated. No toxicity values were available for the dermal contact with groundwater so this exposure pathway could not be evaluated.

Four types of contaminants potentially remain in the WCF. These are: organic compounds (both volatile and semi-volatile organic compounds), metals (as oxides, nitrates, lead shielding, and elemental mercury sources used in instruments), anions, and radionuclides. Organic compounds were not evaluated because it is unlikely that significant quantities would be present after the extended dry status of the system and because of the high temperatures (i.e., 500^{o} C). Inventories for the remaining compounds were obtained via the characterization model and converted to estimated soil concentrations based on the volume of the calciner vessel. The risk for external exposure for both the current occupational and 30-year future residential exposure scenario are less than the lower limit of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) target risk range (i.e., 10^{-6}).

The groundwater transport modeling was performed in two phases. The first phase used conservative assumptions including no concrete cap or grouting of the WCF. Based on the results of this screening phase, the maximum predicted concentrations of all the RCRA hazardous constituents (i.e., nonradionuclides) and all but four radionuclides indicated risks that were below the lower limit of the NCP target risk range and were not evaluated any further. The four radionuclides whose predicted maximum groundwater concentrations indicate a risk within the NCP target risk range (i.e., 10^{-6} to 10^{-4}) are: Np-237, Pu-239, Pu-240, and Tc-99. These four radionuclides were further evaluated using a refined groundwater transport model that took credit for the concrete cap and grout placed in the WCF. The maximum predicted groundwater concentrations from the refined groundwater model indicate that risk to human health from ingestion of groundwater contaminated with Np-237, Pu-239, and Pu-240 is below the lower limit of the NCP target risk range and that the predicted risk from ingestion of groundwater contaminated with Tc-99 is at the lower limit of the NCP target risk range (2E-06). The maximum predicted groundwater concentration that indicates this risk (2E-06) for Tc-99 is 82 pCi/L which is less than the proposed drinking water regulation concentration of 3,790 pCi/L.

This risk is calculated assuming a concrete cap covers the grouted WCF and that the entire inventory of Tc-99 (as process residue) is located in the calciner vessel, when in actuality, it is located throughout the WCF. In addition, it is assumed that the concrete will crack, water will enter the waste, leach contaminants, and pass into the soil. This is a conservative assumption because the closure requirement for RCRA states that the integrity of the cap will be maintained. Because the cap will be maintained, it is not likely that precipitation or other water sources will infiltrate the WCF; therefore, it is likely that the resulting groundwater concentrations for the nonradionuclides and radionuclides should be less than predicted. The resulting risk from ingestion of groundwater contaminated with Tc-99 (2E-06) means that there is an incremental risk of cancer incidence of two people in one million from exposure to Tc-99 in the groundwater. The cancer incidence for the general population is one in four persons. It should be noted that the risk from ingestion of groundwater contaminated with Tc-99 is based on a hypothetical future exposure scenario and does not represent the risk to persons who currently live in the vicinity of the INEEL.

For the ecological risk assessment only the groundwater ingestion exposure pathway was evaluated. Risks to the predicted maximum groundwater concentrations from the screening approach indicated that several ecological receptors are at risk from Np-237, Pu-239, Pu-240, Tc-99, U-234, U-235, U-236, and U-238. Using the maximum predicted groundwater concentrations for these radionuclides from the refined groundwater model and including the biological half-lives of these radionuclides indicate that ecological receptors are not at risk from ingestion of groundwater contaminated with any of the nonradionuclides or the radionuclides.

RADIOLOGICAL CONTROLS

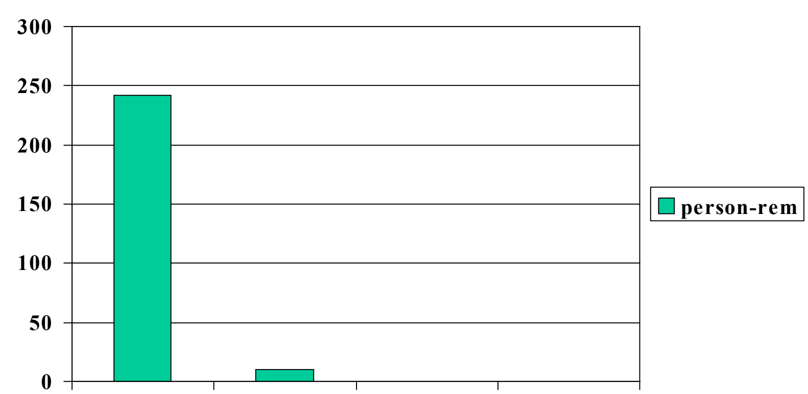
The WCF landfill closure was especially practical from a personnel radiation exposure perspective. Alternative methods for the closure of the WCF were studied, including clean closure, long term surveillance and maintenance (S & M, doing little or nothing) and a risk-based RCRA landfill closure. Clean closure of the WCF was expected to result in significantly more radiation exposure than the other two options mentioned. The WCF was designed with only contact maintenance capabilities, so even with the use of advanced robotic equipment, significant personnel radiation exposure would be received while removing process piping, equipment and tanks, packaging and preparing waste, and transporting and disposing of the waste at a waste landfill. For the clean closure option, estimated at 19 years 4 months in duration, total radiation exposure was estimated at 242 person-rem. The long term S&M was expected to achieve the lowest amount of radiation exposure, however, upgrades for long term S & M were required. Asbestos abatement, electrical upgrades, and decontamination to minimize worker exposure are examples of work that would have totaled an estimated 90 person-rem. Risk based RCRA landfill closure eliminated the need for facility upgrades and minimizes personnel entries, waste packaging and shipping because most wastes are retained in the facility to be grouted in place. The estimated total radiation exposure for the risk-based RCRA closure was only 20 person-rem, (see Table II, Personnel Exposure Savings).

The actual total exposure for the risk-based RCRA closure was below 10 person-rem. This reduction has been accomplished through a variety of controls and techniques employed by the project team. Innovative approaches to problems encountered during demolition and grout activities substantially reduced the need for personnel entry into radiation, high radiation, contamination, high contamination, and airborne radioactivity areas. The project team has refused to accept the idea that personnel entry is the only way to accomplish some tasks or that a spread of contamination is acceptable. Examples are detailed below:

Hot Sump Tank

Teamwork and problem solving reduced the radiation dose while filing the Hot Sump Tank (WC-119). This tank is located in the lowest cell within the WCF and should have been the simplest vessel to fill with desiccant and grout because of the many cell and floor drains connected directly to the tank. Several methods of introducing the heel absorbing desiccant into the tank were identified in the closure plan. But during closure, all identified fill paths proved to be blocked. Personnel entry into the cell was ruled out as radiation fields in the cell were near 8 rad/hr. The team agreed to core drill a three-inch hole through the cell ceiling and into the vessel. The drilling was successful and the crews were then able to insert a 2 ½" pipe through the core hole and into the vessel. As a result, the vessel was successfully filled with only 120 mrem added to the facility total with no spread of contamination.

Table II
Personnel Exposure Savings
Clean Closure vs. Landfill Closure



Large Cell Ventilation Line

A 24 inch cell off-gas line was required to be cut and capped during isolation of the WCF. As the line was excavated, it was found to be structurally unstable. Concerns were raised that the intended method of cutting and capping the line could cause the line to fail and spread large amounts of contamination to the surrounding area. A section further below grade was selected to be filled with grout through a drill hole, allowed to set, blocking the airflow. Then the line was cut and capped, isolating the WCF. This met the Closure Plan requirement, and significantly reduced the radiation exposure anticipated for cutting and capping the line while eliminating the concern for a spread of contamination. A savings of over 800 mrem was realized from this action.

Off-Gas Cell Vessels

The below grade vessels in the Off-Gas Cell were required to be grouted in the RCRA Closure Plan. Four were unable to be filled due to line blockages, earlier grout placements, and leaking valves. The WCF project team concluded that holes had to be cut in the vessels to permit them to be filled during cell grouting. Radiation levels were in excess of 10 rad/hr in-cell and manned entry would have resulted in about 10-15 person-rem of exposure. Options were evaluated and a innovative remote cutting method was developed. A mock-up was established to allow fabrication and training on the equipment. A 10 inch core drill hole was cut into the off-gas cell ceiling, avoiding structural members, piping and other obstructions, yet permitting as much access to the four vessels as possible. Grout holes were successfully cut into all four vessels using the remote tools aided by video cameras. The cutting process took approximately four days, with radiation exposure totaling about 10 mrem at a cost of about $25,000 for the entire operation; an estimated cost saving in person-rem of about $72,500.

Air Flow Pattern Verification

Following each grout lift in the WCF below grade cells and corridors, ventilation flow patterns were required to be verified prior to work continuing in any of the below grade portions of the building. This information was used to establish respiratory protection requirements for those workers venturing below grade to make preparations for additional grout pours. Smoke tubes and candles proved to be inadequate in relation to the large volume of open area remaining in the facility. A smoke generator (similar to those used in theatrical productions) was employed to provide the necessary smoke to verify airflow. The generator produced enough smoke to complete the airflow verification in about a two-minute time frame. The smoke was administered below grade from the above grade area and was dense enough to be discernable at the opposite end of the test area, which eliminated the need for the RCT to enter the radiation/contamination area for verification. Estimated savings are 100-120 mrem and 20 entries into a contamination area.

Product Transport Line (3-in.-TAA-3009)

Line 3-in.-TAA-3009 was used to transport calcine solids from the WCF to the Calcine Solid Storage Facilities (CSSF) 1, 2, and 3. TAA-3009, and the air-return line, 3-in.-TAA-3001, from WCF to CSSF 1 were contained in a 14-inch sleeve surrounded by a concrete encasement. Both of the TAA lines were identified in the Closure Plan as grout addition points for the Calciner Vessel. The Closure Plan indicated that both TAA lines were to be flushed of all solids and liquids and filled with grout to complete closure of the vessel and lines.

Of interest to the Closure Team were notations in Operation logs that indicated a possible blockage in line TAA-3009 to CSSF 1. Closure team members verified presence of a blockage in 3009 during airflow tests on the line; however, the extent of the blockage was still unknown. TAA-3001 was verified open and clear. Radiation levels were estimated to be 25 rad/hr at the blockage.

At a high point in the lines near CSSF 1 (identified in the Closure Plan), a containment tent was erected and the concrete encasement excavated and removed to expose the 14-inch sleeve. Radiation levels were up to 20 mrad/hr on contact with the sleeve. Working through a glove bag, a hole was drilled into the 14-inch line, at which time swipes and swabs were taken to determine if the interior of the sleeve was contaminated. The smears and swab results indicated that the interior of the sleeve was contamination free, so a section of the 14-inch line, approximately 30-inches in length, was removed to permit access to both TAA lines.

A glove bag was positioned on line TAA-3001. The line was drilled to verify negative pressure and contamination levels in the line. The line was then cut to isolate the WCF from CSSF 1. Radiation levels were 100 mrem/hr on contact and 25 mrem/hr at 30 cm from the TAA lines. A cap was attached to the CSSF 1 side of the line and a grout adapter attached to the WCF side. Both the 14-inch sleeve and TAA-3001 were filled with grout.

A glove bag was then attached to TAA-3009 and the line drilled to determine contamination levels and the absence of pressure in the line. A section of the line was removed to provide access to locate and clear the blockage. The CSSF 1 side of the line was capped. A remote video camera was inserted into the line through the glove bag in an attempt to locate the start of the plug material. Plug material was encountered about 20-feet into the line. From this information, team members estimated that the plug could extend up to 32 feet in length.

The material in TAA-3009 appeared to be semi-solid and alternatives for removal were discussed. The first attempt at removal was a "roto-router" system, which was to make a hole through the material to allow the remainder of the material to be flushed into the facility. A mock-up was set-up and used to evaluate the effectiveness of this system. It was discovered that the mock-up material created a plug behind the roto-router head as it was moved into the line, so additional measures were undertaken to alleviate this situation. A vacuum system was employed to remove the loose material from behind the roto-router head and it proved to work very well in the mock-up. The roto-router-vacuum system was deployed on TAA-3009. Initial operations were quite successful and removed a great deal of the plug material, however, after about 12 feet of material was removed, a very hard portion of blockage was encountered and the roto-router was unable to remove the material. In fact, the roto-router head became stuck and could not be retrieved. Based on the adverse conditions encountered, the project team decided to abandon this approach for removal of the obstructions in the line.

New alternatives for closure of TAA-3009 were investigated. The best option available was to excavate the line, cut and remove TAA-3009 and TAA-3001 (because they were both inside the grouted 14-inch sleeve) and place them in the building, below grade, prior to final demolition. Cut points were selected, one on each side of the blockage. The line was excavated and the concrete encasement removed. The radiation level on the 14-inch encasement was 10 rad/hr on contact. Because of the high radiation field, it was decided that the line cut would not be performed "hands-on."

To reduce personnel exposure for the line removal, a set of shears mounted on a trackhoe was enlisted to make the cuts. The shears were first used to remove a portion of the 14-inch sleeve surrounding TAA-3009 and 3001 near the WCF. Radiation levels on line TAA-3009 were 25 rad/hr at contact and 8 rad/hr at 30 cm. Temporary shielding was placed and a hot tap fitting was installed on TAA-3009. The hot tap penetration was performed inside of a glove bag. A video camera was inserted into the line through the glove bag to verify there were no interferences that would prevent grout from reaching the designated areas. Grout was then added to this portion of TAA-3009 and above the plug material on the CSSF 1 side, trapping the blockage between the grout placements.

The track mounted shear was used to make an access hole through a wall in the WCF decon make-up room and through the floor into the operating corridor below for placement of the TAA line upon removal. The TAA lines were cut with the track mounted shears (in the grout filled area of the pipe) and then removed and placed inside the WCF operating corridor and grouted in place. Concrete was poured over the remaining inactive pipe ends to serve as a cap and the excavation was then backfilled.

The collective exposure estimate for cutting and removing the TAA lines if performed by conventional methods was 8.1 person-rem. Personnel exposure was only 2.4 person-rem for all activities associated with the TAA line removal effort using these unconventional methods. As an added benefit, there was no spread of contamination.

Teamwork and use of conventional and unconventional planning and methodology contributed to significant savings of personnel exposure and improved control of radioactive contamination at the WCF.

CLOSURE PLANNING AND PROJECT EXECUTION STRATEGY

The Title Design was provided by the LMITCO in-house design group and issued as the "Comprehensive Work Scope for the Waste Calcining Facility RCRA Closure Project, September 1996". The design was divided into the following focus areas: Asbestos Roofing Removal, Demolition of Building and Equipment, Cap Penetrations and Reroute Utility Lines, Demolition of Decontamination Makeup Room, Electrical and Instrumentation Modifications, Cell Grout Placement, RCRA Cap, and Tank and Line Grouting. Individual work packages were issued to construction to accomplish the work scope defined in the Comprehensive Work Scope. Step-by-step detailed work scope procedures were added to the field work packages which were not provided in the Comprehensive Work Scope. Title designs and fieldwork packages were reviewed and approved by a dedicated WCF project design review committee. Innovative portions of this design were:

Isolation of Utilities and Waste Lines

Utility and nonwaste piping was capped or plugged to prevent water from entering the WCF. Some utilities to the WCF are also associated with other buildings and systems. These were rerouted to provide continued service to these other buildings and systems. The WCF was isolated from plant utilities, and temporary service provided as required for closure activities. Waste piping penetrating the exterior walls of the WCF was flushed by pumping grout through the pipe into tanks in the WCF and capped. The piping was capped from the nearest valve to the WCF. An off-gas duct approximately 2 to 3 m (6.6 to 9.8 ft) below ground level and runs around three sides of the WCF perimeter. The duct, constructed of clay pipe and encased in a concrete shield, was filled during cell grouting. The product transfer and return air lines, enclosed in a steel duct surrounded by a concrete encasement, were to be grouted in place, but a blockage was encountered and the line was excavated and removed.

Grouting of Vessels and Cells

Vessels and cells were grouted to reduce the open voids within the WCF, but the grouting is not required for the structural support of the cap. Major vessels (>55 gallons) were filled with grout as full as practical using the existing piping. If a pipe became plugged and there was not a backup, a hole was core drilled into the concrete ceiling above the vessel and a remotely cut a hole was made into the vessel with a cutting torch through the core drilled hole. The vessel was then filled during cell grouting. Vessel grouting started with the vessel in the lowest cell and proceed upward.

Cells and operating corridors were grouted in "lifts", or stages, to allow for curing and heat dissipation. The lift thickness varied depending on the cell being filled, but are typically 0.3 to 1.3 m (1 to 4 ft). Grout was pumped into cells and operating corridors through 3" diameter PVC fill pipes placed in core holes drilled from the corridors or ground floor. The fill pipes were retrieved to the next lift level as each layer was placed. Many of the cells and operating corridors required multiple access points to maintain a level lift when filling. Cells and operating corridors were considered full when grout was visible in the uppermost observation holes. The ventilation was stopped as the ceiling exhaust ventilation holes at the top of the cells filled with grout. A temporary ventilation system was installed to ensure a negative pressure in the facility during filling.

Measures were taken in the design to control the procedures and sequence to safely achieve the desired filling of the piping, vessels, and subsurface structures of the WCF. High capacity grout pumps were used to pump flowable grout into below grade vessels and cells. Two pumps were purchased for the project. Each pump is capable of supplying 30 cubic yards per hour. Vessel and cell filling were monitored using temperature probes, video cameras and volume calculations to ensure proper filling.

Two basic grout designs were used for grout placement in tanks and cells. The grout design for tank filling consisted of cement, fly ash and water, while the design for the cell filling included some sand with the mixture. Both mix designs included additives for flowability and retardation. Small pilot plant batches and 1 to 2 cubic yard batches of the mix designs were tested to assure the product met the flowability, pumpability and compressive strength requirements. The unfeasibility of grout removal after placement eliminated the necessity to take compressive strength cylinders of the grout. Instead a quality assurance inspector visually inspected raw material proportions used in each batch at the plant.

Above Grade Demolition

The amount of waste removed from the WCF was minimized by the project design. The asbestos roofing and construction materials were placed in the lower portions of the WCF and stabilized (grouted in place). Tanks and piping in the chemical makeup room were dismantled. Equipment that could be reused was sold at government auction. Equipment that could not be reused was sized, placed inside the WCF, and grouted in place. This equipment did not contain hazardous or radioactive contaminants. The WCF above-grade walls are constructed of 12-in. concrete blocks. Following radiation surveys and hot spot stabilization with paint or adhesive fixatives, the roof and walls were dismantled using a trackhoe with a crushing and shear jaw attachment. The walls and roof structure were sized and placed on the floor over the below-grade structure. Bulldozers were used to level and compact the rubble, and grout applied to fill empty spaces and voids. A reinforced concrete cap covers the entire structure. The concrete barriers, the concrete, grout and grouting process makes the potential of a release of contamination to the environment highly improbable.

Key project personnel attended daily pre-, and post-job briefs including safety and radiological support, facility supervision, project and construction management, superintendent and crafts personnel. LMITCO Project Management was responsible for project design, execution and closeout of the project including technical cost and schedule baselines. LMITCO Construction Management over saw the daily construction activities and provided an on the job superintendent. A facility supervisor and operator were an integral part of the daily construction work providing facility support and coordination. Special briefings were organized when the work activities were added or changed during the day.

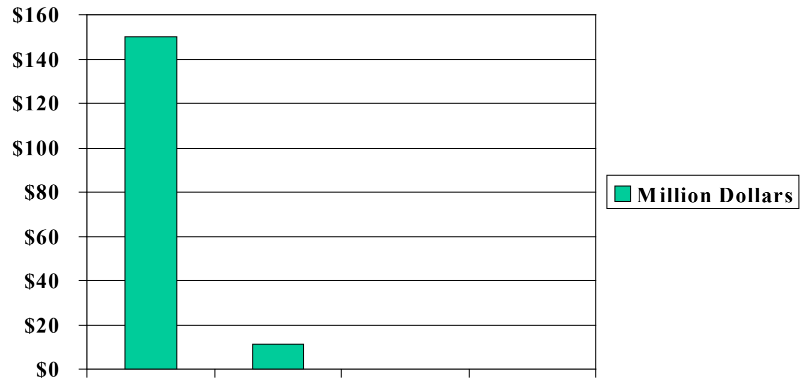
Closure activities were considered complete upon submittal of the Certification of Closure by an independent qualified Idaho-registered professional engineer, Lockheed Martin Idaho Technologies Company, and the Department of Energy – Idaho Office to the director of the Idaho Department of Health and Welfare (IDHW). Certification of Closure verified that the WCF unit was closed in accordance with the specifications of the approved closure plan. Copies of the documentation supporting the independent registered professional engineer's certification will remain at INTEC in the event that this information is requested by the IDHW Director.

CONCLUSION

A substantial cost savings was realized by performing the WCF landfill closure. The cost for clean closure of the WCF was estimated to be $150M. This plan included technology development, stabilizing selected wastes and debris, surveillance and maintenance while preparing for closure phase, removing hazardous waste and performing decontamination work in highly radioactive environments, facility demolition, and handling and storing wastes. However, disposal of the waste (conservatively a $10 million additional cost) was not included in the clean closure estimate. The risk based landfill closure method was estimated to cost approximately $10M. The work plan for this method included utility rerouting and isolation, flush, cut and cap waste lines, fill tanks and cells with grout, demolition building and place concrete cap over demolished building. All work activities were accomplished using conventional equipment, material and labor. The total project cost was $11.3 M at completion, a cost savings of over $138M (see Table III, Cost Savings).

The WCF Closure demonstrates that environmental closure issues can be managed while reducing budget, radiation exposure and overall waste. These are key issues in solving some of the seemingly overwhelming challenges to closing nuclear facilities. Working with the State of Idaho Department of Environmental Quality, a strategy was selected that met laws governing the closure of RCRA facilities and provided real advantages to the DOE. Landfill closure was made more acceptable by conservatively estimating the risks associated and controlling the hazardous materials with effective barriers (capping and grouting). Risks of radiation exposure for characterization, stabilization, removal packaging and disposal were minimized in this process. The personnel radiation exposure for landfill closure is less than 10 Rem; while a traditional clean closure (D&D removal) was estimated to increase exposure to about 250 Rem. Finally, the amount of waste from the landfill closure was roughly one-third that of a D&D removal.

Table III
Cost Savings
Clean Closure vs. Landfill Closure



ACKNOWLEDGEMENTS

The authors would like to acknowledge that this work is supported by the U.S. Department of Energy, Assistant Secretary for Environmental Management.

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