TECHNOLOGY DEPLOYMENTS BENEFIT CANYON DISPOSITION INITIATIVE

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ABSTRACT

The Department of Energy [DOE] owns, and is responsible for decommissioning multiple fuel reprocessing facilities [*canyons*] at its Hanford and Savannah River sites [Hanford & SRS], as well as canyon-like facilities at the Idaho National Engineering and Environmental Laboratory [INEEL]. The Canyon Disposition Initiative [CDI] project is assessing the feasibility of utilizing these massive facilities as waste repositories, as opposed to decontaminating and decommissioning [D&D] the facilities at great cost.

These facilities are in varying degrees of disrepair; some have been shut down for 20+ years. As such, many unknowns exist which must be systematically considered in order to fully assess possible disposition alternatives. The 221-U facility at Hanford was selected to "kick-off" the CDI. Presently, comprehensive characterization of the facility and it contents is underway. The unknowns and the complexity of characterizing the facility, equipment, process systems, and surrounding environment necessarily require the use of improved and innovative technologies to efficiently acquire the needed information. DOE's Office of Science and Technology [OST] has teamed with other Environmental Management [EM] programs at Hanford to provide ready access to the needed technologies.

Situations in which technologies have facilitated characterization include areas where manned-entry is prohibited, i.e., tunnels, process cells, and trenches. Specific benefits derived from the inclusion of improved technologies include: reducing costs by over $100 thousand via deployment of a remotely operated robot in the rail tunnel, and detecting liquids in multiple tanks and piping assemblies at one-tenth to one-sixth the baseline cost.(1,2) Plans are to deploy additional remote/robotic technologies to fully assess the cells and their contents, as well as buried/encased pipes and drains, e.g., the 24-inch drain line which runs the length of the facility.

In the end, the characterization data will support a performance assessment [PA], which in turn, is expected to yield a Record of Decision (ROD). The ROD for the 221-U facility should generate regulatory and technical precedence for future disposition of the other four remaining reprocessing facilities at Hanford, and possibly elsewhere in the complex. It should be quite evident that OST is fulfilling its mission of providing technologies to DOE sites in order to accelerate schedules and reduce costs. In this case, OST is assisting a high profile project with a potential payoff that is substantial, i.e., a cost savings that could approach a billion dollars!

INTRODUCTION

The CDI is a collaborative project that includes participation across the DOE Office of EM, as the forthcoming ROD will have broad and significant impact to many programs. The project is evaluating the feasibility of using the five chemical processing facilities at Hanford as assets for the disposal of low-level waste, instead of a mortgage liability to the Environmental Restoration (ER) Program. Conceptually, the value and associated timing of the CDI to Hanford is shown in Figure 1. And, although CDI involves a Hanford facility, it [CDI] is being managed as a national project, as results may be applicable to reprocessing facilities at SRS, and other canyon-like facilities around the complex.

As previously noted, the 221-U facility at Hanford serves as the pilot project for the CDI, which is being conducted under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 [CERCLA].(3) The facility was placed in standby in 1958 and subsequently retired. Custody of the facility was eventually transferred to the ER program at Hanford. Presently, the cells and canyon deck are being used to store contaminated process equipment. The 221-U facility is the first major fuel reprocessing facility in the DOE complex to begin the final end-state determination process, and as such, CDI will likely establish a new baseline for similar facilities. Interest is considerable not only throughout the DOE, but also from project managers responsible for decommissioning nuclear power plants. Should this project and the resulting ROD prescribe use of the facility as a waste repository, then hundreds of millions to a billion dollars in decommissioning costs could be avoided.(4)

Characterization of the facility, equipment, and process systems is underway, which will support a PA. New and improved technologies are vital to the characterization effort and are helping to meet schedule and reduce workers'

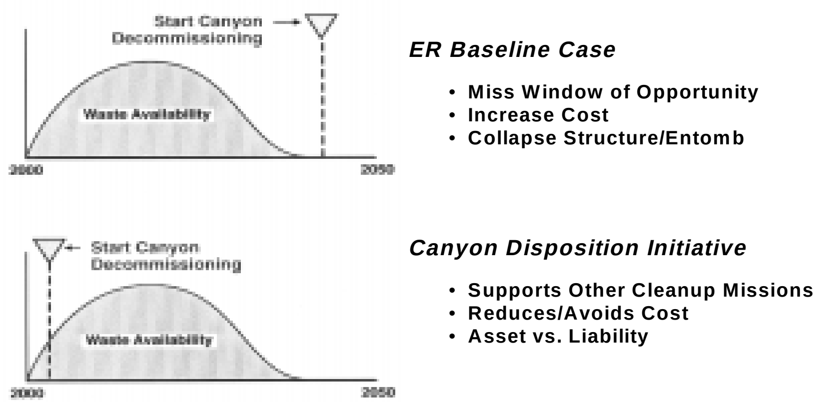

Figure 1. Benefits/timeliness of CDI to DOE's Hanford Site.

exposure, all within the constraint of limited resources. Improved technologies in the areas of remote/robotic systems, radiation surveying, and liquid-level detection have been deployed on the project. The improved technologies have either enabled or enhanced operations in all areas of the 221-U facility. Cost and performance information for the new technologies has been painstakingly recorded, analyzed, and widely disseminated in order to facilitate their continued use at Hanford and elsewhere. Results of the technology demonstrations and deployments are reported herein as a means for disclosing their utility and effectiveness.

BACKGROUND

In the mid-90's, representatives from DOE's Richland Operations Office [DOE-RL], the US Environmental Protection Agency [EPA], and the Washington State Department of Ecology [Ecology] conducted a series of workshops to identify an approach for the long-term disposition of the five reprocessing facilities [B Plant, T Plant, U Plant (facility), Plutonium Uranium Extraction Facility (PUREX), and the Reduction Oxidation Plant (REDOX)] at Hanford. As a result, DOE and regulatory authorities agreed in principle to conduct an evaluation of the disposition alternatives for the canyon facilities. Possible alternatives ranged from removing the facilities, leaving all or part of the facilities in place, to identifying alternative beneficial uses for the facilities. It was concluded that the technical approach for dispositioning any of the facilities could be bounded by the following six alternatives:

- Full removal and disposal
- Decontaminate and leave in place
- Entombment with internal waste disposal
- Entombment with internal/external waste disposal
- Close in-place - standing structure
- Close in-place - collapsed structure.

In addition, the group concluded that the CERCLA regulatory process would be the appropriate decision-making pathway.(3) The project team completed a CERCLA Phase 1 feasibility study that screened potential alternatives that would be considered for detailed analysis. Issues that were important to shareholders were provided to DOE; the issues identified include:

- Characterization
- Sources and availability of non-contaminated fill and barrier construction materials
- Detailed structural analysis

- Qualitative groundwater modeling for performance assessment
- Types of waste for disposal
- Overall impact to Hanford's cleanup mission and 200 Area plateau.

The issues were used as a basis for defining information needs in support of a data quality objective [DQO] process, which was conducted in 1997. Results of the DQO supported the development of the sampling and analysis plan [SAP].(5) Characterization data are being collected in accordance with the DQO and SAP, and will be used to reach a decision on facility disposition.

Facility Description

The 221-U facility is a multi-storied building approximately 246.9m (810 feet) in length. Figure 2 provides an aerial view of the facility. Though the building and equipment were originally designed in support of the production of plutonium, it was never used for that purpose. After construction, it was remodeled and used for the recovery of uranium from tank wastes. The foundation is constructed of reinforced concrete varying from 1.8 to 2.4 m (6 to 8 feet) thick. The outside walls are reinforced concrete which varies from 0.9 m (3 feet) to 1.5 m (5 feet) thick. The roof is concrete varying in thickness from 0.9 m (3 feet) to 1.2 m (4 feet). The building is divided into two main portions by a concrete wall 1.5 m to 2.7 m (5 to 9 feet) thick running the full length of the structure. One portion is called the *canyon*, and the other is called the galleries. The length of the building is divided into twenty sections, at approximately 12.2 m (40 feet) intervals. Figure 3 shows a cross-sectional view of the facility.

Figure 2. Aerial view of the 221-U facility (canyon).

A 30,000-ft^3/minute ventilation system is still active. Exhausting is possible through the 291-U exhaust facility by activating the electrically driven exhaust fans. The crane was inoperable, but has been refurbished and meets all applicable codes. The following utilities are available: electrical power (480-volt) and sanitary water and sewage.

Galleries

The electrical gallery is located below grade, and as the name implies, houses electrical switchgear and controls for controlling process equipment located on the canyon side of the building. The electrical gallery measures approximately 4.3 x 243.8 m (14 x 800 feet). There are no openings between the electrical gallery and the canyon.

The results of past radiological surveys and general area dose rate data for the electrical gallery show alpha contamination to be < 20 dpm, and beta/gamma contamination in the range of < 1,000 to 72 x 10^3 dpm. Dose rate ranges from 9 to 40 *u*R/hr.

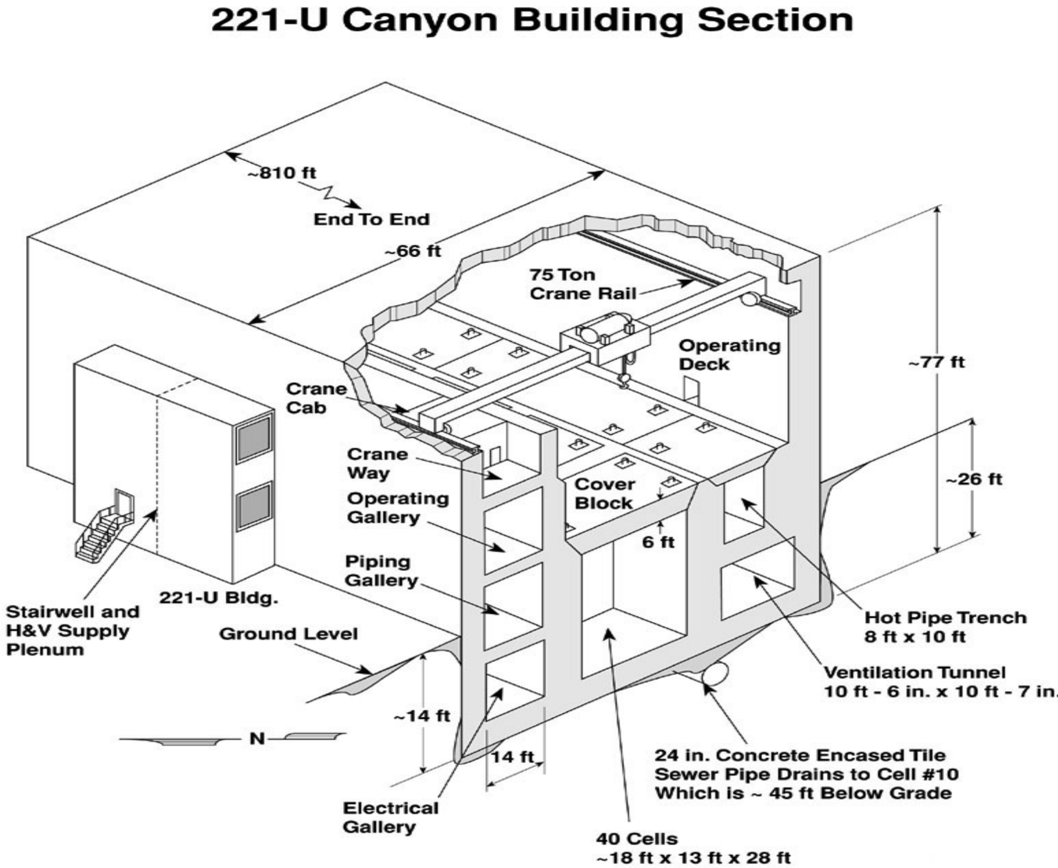

Figure 3. Cross-section of the 221-U facility (canyon).

The pipe gallery is split into two separate sections by the railroad tunnel, as is the electrical gallery. The pipe and electrical galleries have essentially the same dimensions. Clearance is restricted, however, by the mass array of piping suspended from the ceiling and leading through the barricade wall into the canyon side of the building. Like the electrical gallery, there are no openings into the canyon from the pipe gallery. All cell piping, except process transfer lines, was brought to the pipe gallery, terminating in wall connections. From here, connections were made to the weigh tanks and control boards in the operating gallery. Chemical headers, and electrical and steam distribution lines were also located in this gallery. Results of past radiological surveys and general area dose rate data for the pipe gallery show that alpha contamination is < 20 dpm, beta/gamma contamination is in the range of < 1,000 to 125 x 10^3 dpm, while dose rate ranges from 8 to 150 *u*R/hr.

The operating gallery is located above the pipe gallery and is similar to the electrical and pipe galleries, but is unique in that the railroad tunnel does not divide it into two sections. It runs the full length of the building and contains instrumentation and piping manifold stations for controlling the processes in the canyon. Entrance into the operating gallery is possible from the 271-U building. Since the original construction of the building, three openings were made from the operating gallery into the canyon portion of the structure. Two of the openings have since been sealed. The remaining opening is a pedestrian passage through the 2.1m (7 feet) thick wall.

At each section within the operating gallery, a gauge board is present from which control and instrument lines ran to the process cells. Tanks used to weigh chemicals were provided with inlets from appropriate chemical headers in the pipe gallery. Outlets connections to the cell vessels were also present. Results of past radiological surveys and general area dose rate data for the operating gallery show that alpha contamination is < 20 dpm, beta/gamma contamination is in the range of < 1,000 to 40 x 10^3 dpm, and dose rate ranges from 7 to 11 *u*R/hr.

The crane gallery, or craneway, is directly above the operating gallery and is accessible through an air-lock from the attached office building (271-U), or through the stairwells at odd-numbered sections. The crane gallery is a regulated work zone. Electrically operated wire cage doors have been installed in the stairwells between the operating gallery level and the crane gallery level to prevent unauthorized entrance into the canyon. This level of the entire building is considered a radiation zone. Fresh-air openings in the canyon crane gallery have been blanked off. The crane gallery is partitioned from the canyon by a 1.5 m (5 feet) thick wall, but it has no ceiling and is therefore, open to the process area (canyon deck and cells).

There are two cranes in the canyon, both are traveling cranes and ride a common track. The main crane is a 75-ton capacity bridge crane with a ten-ton capacity auxiliary hoist attached. The main hoist is controlled visually through optics located in a specially constructed and shielded crane cab. Results of past radiological surveys and general area dose rate data for the crane gallery show that alpha contamination is < 20 dpm, beta/gamma contamination is in the range of 10,000 to 100 x 10^3 dpm, and dose rate ranges from < 0.5 to 2 mR/hr.

Canyon

The canyon portion of the building is approximately 11.0 m (36 feet) wide and is divided into twenty sections. Each section is approximately 12.2 (40 feet) in length and contains two process cells. The cells contain equipment, such as vessels, centrifuges, piping etc. The cells measure approximately 3.4 x 4.9 m (11 x 16 feet) and are 8.5 m (28 feet) deep from the top of the concrete cell covers to the bottom of the cell. Exceptions are cells in sections 1, 2 and 5. Sections 1 and 2 have slightly larger cells, and one of the two cells in section 5 (cell 10) is designed to accumulate liquids from throughout the canyon. This cell is 14.3 m (47 feet) deep. All cells and the pipe trench drain to cell 10 via a 61 cm (24 inch) concrete-encased tile sewer pipe. The canyon cells housed the processing equipment for feed concentration and centrifugation, solvent-extraction, waste treatment and solvent treatment. Stepped, removable 1.8 m (6 feet) thick concrete blocks cover, and provide access to the cells. All piping, instrument, and sampling and control lines into the cell were encased in concrete, and terminate in connector flanges on the cell walls. Because of the difficulties created by the expansion joint that separated adjacent sections, no piping runs through the walls between sections. The dose rate in the cells is unknown, but may be up to 500 R/hr.

The tops of the cell covers form the deck of the canyon. The deck is level with the floor of the operating gallery. Height from the deck to the ceiling is approximately 12.2 m (40 feet). The canyon deck is a regulated work zone. Entrance into the canyon is possible through air-lock doors at ground level located at each of the odd-numbered sections. The deck of the canyon has been decontaminated to a level that allows reasonable access with a low level of radiation exposure. However, there is equipment stored on the deck that substantially contributes to the radiological inventory of the facility. Equipment contamination levels range from <20 to 14,000 dpm/100 cm^2 alpha and 20 x 10^3 to >1 million dpm/100 cm^2 beta/gamma. Some equipment may contain liquid. Additionally, pieces of equipment that required lubrication may still have oil in their reservoirs. Results of past radiological surveys and general area dose rate data for the canyon deck show that alpha contamination ranges from <20 to 140,000 dpm/ 100 cm^2, beta/gamma contamination ranges from 1,000 to >1 million dpm/100 cm^2, and dose rate ranges from <0.5 to 510 mR/hr. Figure 4 provides a view of the canyon deck.

Piping connections between cells were made through the cell walls and the pipe trench. The hot pipe trench runs parallel to the cells from section 3 to 20 and is 2.4 m wide by 3.0 m deep (8 x 10 feet). It contains intercell process piping and residual material transfer piping. Stepped, removable concrete blocks, similar to those over the cells, cover the hot pipe trench and provide access. Covers for the hot pipe trench are sized to match the adjacent cell's allowing uninterrupted access to contiguous work areas. Lines to and from the cells terminate in connector flanges in the trench. Just as in the cells, the connector flanges are held in a fixed standard position by steel supports embedded in the concrete trench floor. The trench piping was installed in prefabricated sections attached to the flanges with automatic connectors. Between the piping and associated hardware, the hot pipe trench is extremely congested. Alterations and replacements of trench piping could be made with the same remotely operated equipment used for cell maintenance. Dose rate in the trench is assumed to be in the same range as in the cells, i.e., up to 500 R/hr.

The concrete ventilation tunnel, 3.3 m tall and 3.2 m wide (11 x 10 feet), is directly beneath the hot pipe trench and provides ventilation for the cells and pipe trench. Air from the canyon deck flows through slots in the cell cover blocks into the process cells and pipe trench, and then through 25.4 cm (10 inch) diameter terra cotta ducts from each cell and each section of the pipe trench to the ventilation tunnel. The tunnel exhausts to the 291-U stack. A 0.9 x 0.9 m (3 x 3 feet) tunnel access chimney exits on the exterior, South end of the facility. The ventilation tunnel also drains any condensate to cell 10. The contamination levels are unknown for the ventilation tunnel.

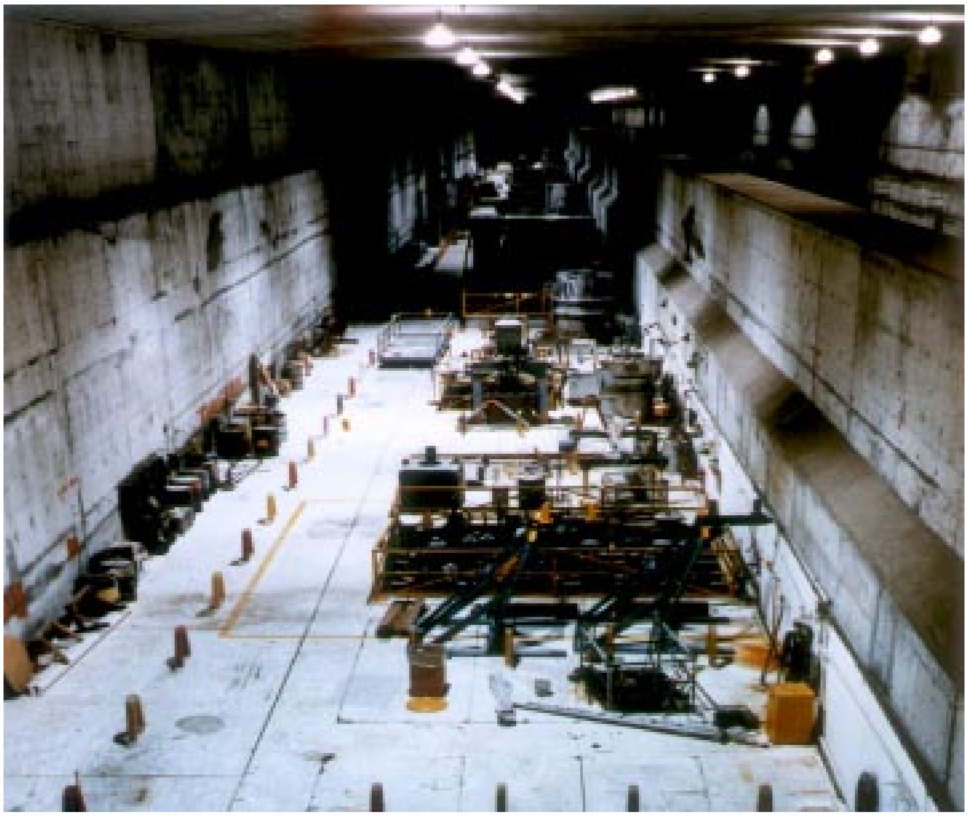

Figure 4. View of canyon deck (note excess equipment, etc.).

The railroad tunnel enters the building and penetrates the electrical and pipe galleries, and continues into the canyon portion of the building. Originally, unloading of a railroad car in the canyon could be performed with the bridge crane by moving the 2-L cell cover block. Later studies however, revealed that the railroad tunnel covers were not necessary. The cover blocks were disposed of and this portion of the canyon deck is open at all times. At the outset of the project, contamination levels were unknown in the railroad tunnel. The tunnel has been surveyed, however; as part of the CERCLA Remedial Investigation/Feasibility Study [RIFS] process. Characterization results are presented later in this writing.

TECHNOLOGY DEMONSTRATIONS AND DEPLOYMENTS

Improved technologies are needed to efficiently characterize the 22-U facility, as part of the CERCLA/RIFS process. Through the Deactivation and Decommissioning Focus Area [DDFA], which is based at the National Energy Technology Laboratory [NETL], the technologies described below have either been demonstrated or deployed. It is prudent that timely transfer of this information take place, as the technologies and benefits thereof, have broad application. Characterization of the 221-U facility continues and additional technologies are being pursued for implementation. Results of these planned technology deployments will be communicated in future reports.

Liquid Level Detection (Infrared)

Technology Description

Infrared thermography is the process of converting heat emitted from an object into a visible, dynamic TV-like picture. The technique is based on the principle that differences in the physical properties of various materials will result in temperature variations that can be detected using infrared cameras. This can be accomplished by means of an infrared mechanical scanning system or by the use of a "phased array" of detector elements. By creating a detailed two-dimensional temperature pattern (thermogram) of the surveyed piece or surface, information on temperature is obtained from several thousand points in the field of view [FOV] of the scanner, or detector array, in about one-thirtieth of a second.

The voltage variations obtained of the surveyed surface are amplified and shown on a cathode-ray tube [CRT] display. The differences in heat radiation appear as tones of gray or color variations in the picture. For example, a black and white thermogram may show a person's face where white indicates hotter and black indicates colder areas. The continuous gray tone makes the interpretation of surfaces possible with temperature differentials as low as 0.2°C. As mentioned, color shades are often used in lieu of a gray scale for added clarity.

These color or gray image contours map the temperature variations of the object being viewed with great precision. Temperature variations are often produced in tanks, vessels or pipes due to the differences in the thermal conductivity of the materials from which these objects are fabricated and the materials that they might contain. These variations result from changes in the ambient temperature surrounding the objects or which are induced artificially by the application of a small amount of external heat. Infrared imaging technology provides an ideal method for non-intrusively detecting the existence of liquids in tanks and pipe networks.

Deployment Situation

DOE's D&D program requires accurate characterization of tanks, vessels, and piping assemblies in order to plan future activities for their use. A first step in evaluating the potential disposition hazards of these objects is the determination of the presence of liquids. The infrared-based liquid level detection technology was initially demonstrated on sample targets at Hanford's 336 Building (infrared signatures) and select targets in 221-U's pipe gallery and canyon deck. Subsequently, ten target vessels and a number of piping assemblies were evaluated. All told, over 500 infrared images were captured and analyzed.

Demonstration Results

Using the infrared technique, the cost to conduct a typical non-intrusive liquid level detection [NLLDT] investigation is as much as a factor of 10 less expensive than the baseline procedure of visual inspection. In the case of piping assemblies, hot-tapping, which is necessary to determine if liquids are present, is avoided. The use of the NLLDT enhances as low as reasonably achievable [ALARA] practices compared to the baseline, by reducing the time the operator spends in the proximity of the potentially contaminated sources. A complete description of the technology demonstration is available in an Innovative Technology Summary Report [ITSR].(2)

Benefits/Impact on Project

A great number of both large and miscellaneous tanks, and piping assemblies are present in the 221-U facility as it had become a warehouse for surplus equipment. Given that the cost of implementing the NLLDT system is from six to ten times less expensive than manual inspection/measurement, a substantially cost savings resulted. With the exception of two targets, the NLLDT systems was able, after post-test analysis, to determine if liquids or other foreign materials were present in the surveyed tanks, vessels or pipes. The NLLDT system functioned in the high radiation environment with no apparent degradation in performance and in such a way as to avoid contamination. If equipment would have become contaminated, it could have been decontaminated using standard cleanup procedures. The system is well suited for minimizing the exposure of operating personnel to radiological hazards (far fewer personnel with far less exposure to the hazardous conditions). The system can be operated at temperatures between 0 ^{o}C and 45 ^{o}C. Data can be be stored and downloaded electronically to a personal computer [PC]. The NLLDT system does not produce any environmentally hazardous waste. Presently, negotiations between site (Hanford) and vendor personnel are underway for further deployments (remote) of the technology at the 221-U facility.

Liquid Level Detection (Ultrasonic)

Technology Description

The ultrasonic liquid detection system uses ultrasonic transducer [UT], pulse-echo based-instruments with custom electronics designed for the manual detection of freestanding liquid in drums, tanks, and pipes. The system provides a real-time, simple "yes/no" electronic detection/determination of a liquid level. The system is light and compact, and is powered by a separate 12-volt battery pack that will operate for 4 hours or more.

The ability for water (i.e. liquids) to couple and support acoustic waves is the principle used to detect liquid levels. If the tank has water or a liquid with a similar acoustical impedance, then the inner wall wave will be transmitted at the interface and coupled into the liquid. The liquid will support the wave transmission across the tank diameter to the far side where some of the wave will be reflected back across the liquid. This reflected wave is coupled back into the near wall where it is detected as an "echo" by the same sensor that launched the wave. The point at which liquid transitions to air is where the return echo disappears. This location is the fill-level line.

Deployment Situation
The ultrasonic liquid detection system was deployed in the 221-U facility for examination of piping sections in the operating gallery, and vessels on the canyon deck. Two instruments, based on similar operating principles, were deployed. These included: a barrel/tank tester that is optimized for use on large diameter tanks or vessels, and a pipe tester that is optimized for smaller diameter piping. All of the targets selected for ultrasonic liquid level detection had been previously examined using baseline methods and/or the infrared-based liquid level detection technology.

Deployment Results
Results from the deployment of the ultrasonic liquid detection system were comparable with results from other technologies utilized for examination of the same sections of piping and vessels. Deployment of the system was performed in concert with normal and routine operations by regularly assigned operations and maintenance personnel, i.e., under existing generic work procedures and authorizations for routine operations and maintenance activities. This was possible because operation of the system proved to be so simple that additional written instructions or procedures were not deemed necessary.

Benefits / Impact on Project
The use of the ultrasonic liquid detection system to detect liquids in vessels and pipes eliminates the need to physically open and inspect these vessels. Risks to workers associated with gaining access to these types of objects, and the possible exposure to radioactive or contaminated materials can be nearly eliminated.

3-D Visual and Gamma Ray Imaging
Technology Description
Two different three-dimensional [3-D] visual and gamma imaging systems were utilized at the 221-U facility. One system marginally met workscope objectives while a second system demonstrated considerable robustness for radiological surveying. Given the value provided by the second system, the ER contractor elected to deploy it. It is this deployed system that is described in the following section.

To remotely survey large areas for gamma ray emissions and display results as combined 3-D representations of the radiation sources and the equipment, AIL Systems, Inc. [AIL] developed it's GammaModeler™ system. The GammaModeler™ is an upgrade of AIL's GammaCam™ which provides two-dimensional [2-D] images of the radiation environment overlaid on video pictures of the scene. The 3-D GammaModeler™ consists of four modules: a sensor head, portable PC compatible computer, pan and tilt controller, and a 3-D workstation. The sensor head incorporates a coded aperture gamma ray imaging detector, a high-resolution video camera, a laser range finder (new) and a pan and tilt assembly (new). The sensor head is controlled remotely by the PC, and by the pan and tilt controller. Remote operation and control of the sensor head allows for safe image acquisition in high radiation environments, thus minimizing operator exposure. During image taking operations, a pseudo-color image of the gamma ray emitting sources is overlaid on a video picture of the scene. For the demonstration, the sensor head operated with a 25^{o} FOV and a gamma spatial resolution of 1.3^{o}. The sensor head could be panned a full 360^{o} and tilted +/- 73^{o}.

At camera locations with observed gamma ray emissions, additional images of key reference features in the scene are taken, along with the measured range, and pan and tilt directions to these features. Viewing the same features from another location allows the relative camera position to be calculated. The relative position can be adjusted to place the object at a relative position or an absolute position. Knowledge of camera locations is essential for triangulating the observed gamma sources in the 2-D images, in order to position the sources in 3-dimensions.

The GammaModeler^{TM} provides a file listing the source locations and a “30-cm” dose estimate is generated for each contaminated object. These data are used to calculate the radiation field resulting from these sources and can be used as input for merging the sources with an AUTOCAD drawing. The resulting “merged’ drawing locates the source positions with respect to visually identified objects, and colors are used to represent their relative intensity. AUTOCAD provides the capability to rotate the merged drawing in order to view the representation from different aspect angles.

Demonstration Situation
GammaModeler^{TM} was used to provide images and radiation measurements of equipment, tanks, etc. on the canyon deck and in the processing cells. Several cells were opened during the demonstration and surveyed. The primary objective of the demonstration was to evaluate the visual and gamma ray imaging system for surveying objects for radiological contamination to yield high-quality, usable characterization information.

Demonstration Results
The system performed well during the demonstration and obtained data on 21 objects of interest in the 221-U facility. Real time display of the gamma ray images to the operator showed that seven of these objects had detectable gamma emissions. Additional views were obtained of these objects, thus allowing 3-D renderings. The 3-D renderings showed the sources in relationship to the visual objects. Furthermore, the pan and tilt capability of the system allowed it to view objects that may have been blocked if a fixed viewing direction system was used.

Several of the 221-U facility cells were imaged. Even with the limited viewing angles that could be obtained for these cases, the 3-D rendering software still allowed 3-D representations of the source locations and strengths to be determined. For one cell, the system was able to determine the source distributions and intensities at distances greater than forty feet. These sources are of high intensities and would not be accessible to radiological control technicians [RCT] using hand-held instrumentation.

Benefits/Impact on Project
The GammaModeler^{TM} system permits additional information to be derived from measurements in order to locate sources internal to objects within in the canyon, and to support 3-D rendering of the visual and gamma radiation. This information is obtained remotely without the need of exposing workers to the radiation source. The remote pan and tilt capability of the system allows the operator ease in locating radiation sources, whereas the 2-D system only points downward (from crane hook) for cell surveys.

The information generated from 3-D imaging can be used for project planning, including planning of future characterization activities. Another benefit of the GammaModeler^{TM} is that the superimposed radiation and visual images and representations can provide regulators and the public with an improved understanding and confidence in the measured data. Knowledge of the absolute positions of the objects, relative to the canyon coordinates, allows the individual source files to be used to generate a dose estimate for any location in the canyon or the entire facility. It should be noted that the percentage of objects with radiation, compared to those with no detectable radiation, will affect the cost of imaging because of the additional effort to acquire data from multiple views, and the effort to complete 3-D rendering.

Tunnel Characterization (Rail)
Technology Description
The robotic characterization platform developed for the rail tunnel characterization is built around an Andros Mark VI-A robot supplied by REMOTEC. The robotic characterization platform is designed for use in facilities which are not accessible by humans, such as high radiation areas. It is designed for fully remote collection of characterization data such as gross gamma readings, video, and smear samples.

The Andros robot is capable of operating off of 110 volts, RF, or battery power, and can drive on and off of custom-designed, crane-deployable lifting fixtures. Communication is via umbilical or fiber optics. The associated lifting fixture has a motorized cable payout and retrieval system, as well as a color camera and lighting system. The railroad tunnel deployment was completed with the following:

- An Andros robot configured with two cameras, a lighting system and a real-time gross gamma detector
- Smear sample pads
- A lifting fixture (with camera and lights) for the robot, cable, and cable payout system
- An operator control station with video recording equipment.

Deployment Situation

The initial mission of the robotic characterization platform was to survey the railroad tunnel. The objective of the railroad tunnel deployment was to complete an initial characterization of the tunnel including visual imaging, radiation survey and sample collection. No human access has been allowed in this tunnel for more than 20 years.

Deployment Results

The robotic characterization platform completed an initial characterization in the railroad tunnel during August 1998. The Andros robot was operationally tested on the canyon deck, then lifted, via the overhead crane, into the railroad tunnel. The robot traversed the entire length of the tunnel and back. The tunnel is about 16 feet wide, 30 feet high, and 220 feet long. Gross radiation data and video footage were taken to document the condition of the tunnel.

The tunnel was found to be predominately empty; however, there were many objects along the walls and in the corners. Some of these items included: boxes, a barrel containing objects in a plastic bag, gloves, a shoe cover, brooms, a fire extinguisher, a telephone, ladders, step-off pads, electrical panels, and plastic-wrapped equipment. Dispersed throughout the tunnel were numerous tumbleweeds and deceased animals (birds and rodents). The floor of the tunnel was heavily laden with dust and dirt. Radiation levels in the tunnel were very low; the highest dose rate was determined to be 5 mR/hr.

Approximately four hours of video coverage was taken in the tunnel. In addition, professional video coverage was taken of the equipment set up process, diagnostic testing of the robot, the lift into the tunnel, and coverage of the robot until it moved out of site. Nine smear samples were taken throughout the length of the tunnel. One sample was taken of the barrel, one on the floor near the rollup door, and one on the floor about mid tunnel. Five samples were taken of visibly-stained floor areas, and one sample was taken from the bottom of an open trough in the floor.

Benefits / Impact on Project

Prior to this deployment, the radiation levels in the railroad tunnel were unknown, and as such, personnel access was prohibited. This remote characterization system was considered an enabling technology. The robotic characterization platform deployment was a complete success and all objectives were met or exceeded. Because of the successful deployment,, this system is being used in other areas of the 221-U facility, including the ventilation tunnel and select zones on the canyon deck . Remote operations allow exposure and health risks to be minimized for laborers during characterization activities in high radiation areas or other areas unsuitable for manned entry. The system allows the safe collection of critical characterization data from hazardous facility areas, which are necessary for the ROD process.

Tunnel Characterization (Ventilation)

Technology Description

The robotic characterization platform developed for the rail tunnel characterization (described above) was redeployed in the ventilation tunnel. The ventilation tunnel deployment was completed with the following:

- An Andros robot configured with two cameras and lighting system
- A real-time gross gamma detector
- Smear sample pads
- Remote spectral gamma sensors [Scout]
- A lifting fixture (with camera and lights) for the robot, cable, and cable payout system
- An operator control station with video recording equipment.

A new lifting platform was required for deployment of the robotic characterization platform into the ventilation tunnel. In addition to fitting through the confines of the access chimney, the new platform integrated a new long-range camera and lighting system.

For this deployment, two Quantrad Scout systems were used for radiation characterization of the ventilation tunnel. The Scout is a lightweight, comprehensive, portable gamma-ray spectroscopy system that provides gross and spectral gamma radiation characterization data. The Quantrad Scout system consists of three parts: the Scout base, a palmtop computer, and a probe. The Scout base includes a 512-channel Multi-Channel Analyzer [MCA], a high voltage power supply, and memory circuitry for storing spectra. The palmtop computer provides an interface to the MCA unit. A number of different probes can be used with the Scout base. The system is small and durable and can operate using a transformer or a 12-volt battery.

Deployment Situation
The objective of the deployment was to complete an initial characterization of the ventilation tunnel. The characterization objectives included visual imaging, radiation survey, and sample collection. No human access has been allowed in this tunnel since its construction, nearly 50 years ago.

Deployment Results
The system was operationally tested outside the 221-U facility, then lifted, via a mobile crane, into the ventilation tunnel via a 3-foot by 3-foot access chimney. During September 1999, the robot traversed the entire length of the tunnel (750 feet) and back, collecting gross radiation data and video taping the condition of the tunnel. Gamma radiation data and video footage were taken to document the condition of the tunnel. Two smear samples were taken off the floor, one at the end of the tunnel, and the second at one of the higher radiation areas (about 600 feet from the entrance).

Measurement of high- and low-energy gamma emissions was accomplished using two separate Scout sensors. One Scout unit included a low-energy optimized detector; the other unit included a high-energy optimized detector. The Scout units were calibrated and configured to perform repeated 3-minute counts until the memory was full, the power dropped below a set value, or the instruments were manually shut off. Scout sensors were contained in steel boxes with “ports” for radiation measurement and wrapped for contamination protection. The boxes included batteries sufficient for 30 hours of operation, much longer than the planned deployment. The Scout system, while commercially available, is usually deployed in a manually operated mode for specific analysis. The ventilation tunnel deployment used the Scout system in a different configuration, in conjunction with a robot deployment platform.

Benefits / Impact on Project
Prior to this deployment, the radiation levels in the ventilation tunnel were unknown, and as such, personnel access was prohibited. As with the rail tunnel deployment, the Andros-based characterization system was considered an enabling technology. Overall benefits are similar to those listed above (rail tunnel deployment). Additionally, use of the Scout sensors provides a means for gamma spectroscopy in remote locations, thus, enhanced radiological characterization data may be obtained for locations where personnel access is prohibited.

Remote Concrete Sampling
Technology Description
The remote concrete sampling system consists of a remotely operated Brokk 150 electro-hydraulic driven platform with an automatic concrete coring attachment. The system includes a color video monitoring system that allows for remote control of the tractor movement, positioning of the arm, and operation of the attachment. The remote concrete sampling system is designed for remote positioning by overhead crane without the necessity for hands-on manipulation of hooks, slings, etc. The Brokk platform is commercially available and can be used for a variety of decommissioning activities. The system is designed to operate with a multitude of attachments including a crusher, shears, and grapple.

Deployment Situation
The remote concrete sampling system will be used to collect concrete samples from throughout the 221-U facility. The remote concrete sampling system will be brought into the canyon through the rail tunnel. The initial use of the system will be to take concrete samples in the rail tunnel. This will provide for operator orientation in a line-of-site operation. The system will subsequently be picked up by the canyon crane and deployed into the process cells for remote collection of concrete samples.

Benefits / Impact on Project

The benefits of the concrete sampling system are similar to those of the Andros characterization platform and revolve around remote operations; worker exposure and health risks will minimized. And again, the collection and analysis of concrete samples from the cells will provide critical characterization data that are necessary for the ROD process.

PROJECT STATUS

Despite funding constraints, the CDI Project made significant progress in fiscal year 1998 [FY98] and FY99. Following are specific activities and accomplishments of the CDI Project, in addition to the technology deployments previously discussed.

Communication

The CDI Project continues to conduct broad information exchange for user organizations (both DOE and contractors), regulators, Native American Tribes, technology providers, and other stakeholders. Over 30 tours were conducted during FY99. Tours were provided for State and Federal Congressional leaders, DOE site and HQ personnel, and other interested groups (e.g. Hanford Advisory Board and Tribal Nations).

The Phase I Interim Characterization Report for the 221-U Canyon Disposition Initiative (6) was produced documenting the results of the radiological surveys and the video/ gamma-camera results from the first three cells accessed.

The Project Internet web site is being periodically updated to provide current information.(7) In FY99, the web site was updated to include additional technology needs statements and project accomplishments.

Canyon Crane Repair

The canyon crane required extensive upgrades to the electrical system in FY99. This required additional project funding and two to three months to bring the crane back to an operational status. The trolley motor for the auxiliary crane that holds the video camera also required repair.

Structural Evaluation

Samples taken for concrete and rebar testing were analyzed, and a structural components report was produced.(8) This report is available on the project web site. A structural walkdown of the facility was completed for all accessible areas and planning for FY2000 analysis was initiated. Structural data needs were integrated with the robotic entry into the ventilation tunnel and the canyon crane video work scope.

Air Monitoring Plan

There are two air monitoring plans for the CDI Project characterization work scope. These plans were reanalyzed during the year for a better definition of the work scope. The results were that the current analysis in the plans bound the changes in the scope definition and no changes were necessary. This conclusion was supported by regulators.

Access Cells

Five additional cells, from different process areas in the canyon, were opened in FY99. Video records and gamma camera images were taken for each cell. So far, there is a poor correlation of existing inventory records to what is being found in the cells. Cells opened thus far appear to have undergone deactivation although records documenting these activities have not been found.

Characterization

Sampling of the sumps in the electrical gallery was completed. These sumps represent low points in the facility that were identified for sampling.

Radiological surveys were conducted on the piping in the galleries to establish a baseline. The infrared-based liquid detection technology was utilized to identify areas that might contain liquid. No sampling was deemed necessary for the piping.

The canyon deck was divided into three areas for concrete sampling, and three samples were collected from each area. These areas represented higher contamination areas identified during the radiological survey of the canyon deck and equipment. Results from the concrete analysis were as expected.

A radiological survey was completed on the equipment located on the canyon deck. The infrared-based liquid detection technology was again utilized to identify areas that might contain liquid. The analysis of results determined that no additional sampling was required of the equipment on the deck (i.e., no liquids were found).

Future Plans

Characterization activities are continuing in FY00, despite limited project funds. Data acquisition and analysis are focused on three key areas of the facility: 1) process cells, 2) 24-inch drain line, and 3) hot-pipe trench. Remote/robotic technologies continue to be sought after since manned entry is prohibited in these areas. These technologies are considered enabling technologies or systems, and may include crawler systems for internal pipe surveying, and generic, but multi-functional platforms to be used with the existing cranes.

Should adequate funding become available, one project objective will be to acquire all outstanding data (characterization) in FY00. Once these data are in hand, the PA can be completed, which supports the ultimate goal of the CDI project, that being, a ROD for the reprocessing facilities.

ABBREVIATIONS

>	greater than
<	less than
^{o}	degree
C	Celsius
cm	centimeter
cm^2	square centimeter
dpm	disintegrations per minute
ft^3	cubic feet
m	meter
mR/hr	R/1000 per hour
RF	radio frequency
R/hr	Roentgen per hour
*u*R/hr	R/(1E^6) per hour

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