INNOVATIVE TECHNOLOGY
Summary Report

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Surveillance and Measurement System (SAMS)

Deactivation and Decommissioning Focus Area

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INNOVATIVE TECHNOLOGY
Summary Report

Surveillance and Measurement System (SAMS)

OST/TMS ID 2977

Deactivation and Decommissioning Focus Area

Demonstrated at
Idaho National Engineering and Environmental Laboratory
Large Scale Demonstration and Deployment Project
Idaho Falls, Idaho

INNOVATIVE TECHNOLOGY
Summary Report

Purpose of this document

Innovative Technology Summary Reports are designed to provide potential users with the information they need to quickly determine whether a technology would apply to a particular environmental management problem. They are also designed for readers who may recommend that a technology be considered by prospective users.

Each report describes a technology, system, or process that has been developed and tested with funding from DOE's Office of Science and Technology (OST). A report presents the full range of problems that a technology, system, or process will address and its advantages to the DOE cleanup in terms of system performance, cost, and cleanup effectiveness. Most reports include comparisons to baseline technologies as well as other competing technologies. Information about commercial availability and technology readiness for implementation is also included. Innovative Technology Summary Reports are intended to provide summary information. References for more detailed information are provided in an appendix.

Efforts have been made to provide key data describing the performance, cost, and regulatory acceptance of the technology. If this information was not available at the time of publication, the omission is noted.

All published Innovative Technology Summary Reports are available on the OST Web site at www.ost.em.doe.gov/ost under "Publications."

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SECTION 1
SUMMARY

Technology Summary

The United States Department of Energy (DOE) continually seeks safer and more cost-effective technologies for the decontamination and decommissioning (D&D) of nuclear facilities. The Deactivation and Decommissioning Focus Area (DDFA) of the DOE's Office of Science and Technology sponsors large-scale demonstration and deployment projects (LSDDPs) to identify and demonstrate technologies that will be safer and more cost-effective. At these LSDDPs, developers and vendors of improved or innovative technologies showcase products that are potentially beneficial to the DOE's projects as well as others in the D&D community. Benefits sought include decreased health and safety risks to personnel and the environment, increased productivity, and decreased cost of operation.

The Idaho National Engineering and Environmental Laboratory (INEEL) LSDDP generated a list of need statements defining specific needs or problems where improved technologies could be incorporated into ongoing D&D tasks. Advances in characterization technologies are continuously being sought to decrease the cost of sampling and increase the speed of obtaining results. Currently it can take as long as 90 days to receive isotopic analysis of radioactive samples from laboratories on soil, liquid, and paint samples. The cost to analyze these types of samples for radionuclides is about $150 per sample.

This demonstration investigated the feasibility of using the Surveillance and Measurement System (SAMS) (innovative technology) to make in situ isotopic radiation measurements in paint and soil. Sample collection and on-site laboratory analysis (baseline technology) is currently being used on D&D sampling activities. Benefits expected from using the innovative technology include:

- Significant decrease in time to receive results on radiological samples
- Decrease in cost associated with sample collection, preparation, analysis, and disposal
- Equivalent data quality to laboratory analysis
- Fewer samples will be required to be sent to the laboratory for verification.

This report compares the cost and performance of the baseline laboratory analysis to the cost and performance of the SAMS.

Baseline Technology

Many facilities at the INEEL and other DOE sites have become obsolete and are being demolished or dismantled. Prior to performing any decontamination or dismantlement work, these facilities must be characterized. Part of the characterization includes isotopic radionuclide analysis. The results of the characterization are used to plan D&D work at that site. It is important that characterization work be performed quickly and results be provided to the project managers in a timely manner so that D&D planning and preparation work can proceed.

This demonstration has two parts. The first part of the demonstration consists of comparing laboratory analysis to the results from the innovative technology.

Currently, D&D project managers rely on on-site laboratories to provide isotopic radionuclide characterization and activity levels. Typically, at least two workers collect sample media to be sent to the laboratory (Figure 1). The laboratory specifies the amount of sample material needed in order to provide quantifiable, reproducible results. This typically consists of 100 grams of material per sample, and generally two (duplicate) samples are submitted to the laboratory.

Once the samples are collected, samplers follow specified protocols to ensure that the samples remain intact and representative of the media present in the original location. Holding times are specified for each type of analysis and the samples must remain at a specified temperature (4˚C) during the interim between collection and analysis. Once the sample has been taken, it may take as long as 90 days for results to be received.

Figure 1. Collection Samples for Isotopic Analysis.

The second part of this demonstration compared the SAMS innovative technology to other hand-held survey equipment. Hand held detectors are used at the INEEL to perform routine gross radiation measurements in contaminated areas. Radiation control technicians at the INEEL use portable survey equipment, such as the Ludlum 2A to these gross measurements. The baseline equipment, however, does not provide isotopic identification.

Innovative Technology

Engineers at the INEEL have identified a field instrument that can provide real-time isotopic analysis for radiation technicians and workers. The SAMS, shown in Figures 2 and Figure 3, is a handheld detector that can provide isotopic analysis in the field. By using the SAMS, isotopic radionuclide data can be provided to the D&D project managers on a near real time basis instead of waiting weeks for laboratory results.

In this demonstration, the SAM model 935 was demonstrated as the innovative technology. All future references in this document will refer to the innovative technology as the SAMS. The SAMS was compared against both laboratory analysis and against portable radiation detectors used at the INEEL, which only provide gross radiation levels.

Figure 2. Demonstration of the SAMS.

Figure 3. Radiation detection using the SAMS.

Demonstration Summary

The SAMS was demonstrated in March and April of 2000. Part 1 of the demonstration compared the results from laboratory analysis with field measurements using the SAMS. Paint chips were sampled and analyzed from a scabbling project being performed at the Test Area North (TAN) facility. Soil samples were also collected from a soil contamination area at TAN and sent to an on-site laboratory for isotopic analysis.

Part 2 of the demonstration compared the SAMS with the Ludlum 2A. Prior to releasing the scabbling equipment from the TAN facility, the equipment had to pass an inspection by the radiation control technicians. The SAMS was used in conjunction with the baseline detectors to free release the scabbling equipment. The SAMS was also used to take radiation measurements on a contaminated soil site. Ten locations or points were selected across the contaminated site. The SAMS was used to take radiation measurements at these points. Radioactive field strength and isotopic measurements were recorded during this process. The baseline hand-held detectors were used to provide activity levels of the soil at these same locations. Data from the SAMS was then compared to the handheld baseline technology.

Table 1 shows the type of analysis and number of samples taken for part 1 of this demonstration. Table 2 shows the number and type of samples for part 2 of this demonstration.

Table 1. Radiation Analysis Comparison between the SAMS and Laboratory.

Type of Analysis	Number of Samples with SAMS	Samples Sent to the Laboratory
Soil	18	18
Paint	5	5

Table 2. Radiation Analysis Comparison between the SAMS and Ludlum 2A.

Type of Analysis	Number of Samples with SAMS	# of Measurements Using the Ludlum 2A
Soil	10	10
Equipment	Used to Check Scabbling unit, 3"rubber tubing, filters, and collection container	Used to Check Scabbling unit, 3"rubber tubing, filters, and collection container

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Web Site

The INEEL LSDDP Internet web site address is http://id.inel.gov/lsddp

Licensing

No licensing activities were required to support this demonstration.

Permitting

No permitting activities were required to support this demonstration.

Other

All published innovative Technology Summary Reports are available on the OST Web site at http://www.em.doe.gov/ost under "Publications." The Technology Management System, also available through the OST Web site, provides information about OST programs, technologies, and problems. The OST reference number for the SAMS is OST 2977.

SECTION 2
TECHNOLOGY DESCRIPTION

Overall Process Definition

Demonstration Goals and Objectives

The overall purpose of this demonstration was to assess the benefits that may be derived from using the SAMS over the baseline method. The demonstration collected operational data so that a legitimate comparison could be made between the innovative technology and the baseline technology in the following areas:

- Safety
- Productivity rates
- Ease of use
- Benefits/limitations
- Cost.

Description of the Technology

The Berkeley Nucleonics SAM Model 935, which was used in this demonstration, uses a thallium-activated sodium iodide ((Th)NaI) detector to provide the isotopic identification capability in a hand-held survey instrument. The Berkeley Nucleonics Model 935's time slicing, data compression technique results in shorter acquisition times, accurate isotopic identification, and spectroscopic capabilities. Quadratic Compression Conversion is a data compression technique used to enhance the algorithm, allowing the operators to identify multiple isotopes in one-second intervals. The Berkeley Nucleonics Model 935 can detect up to 70 nuclides using an internal library of nuclides, which is expandable to 95 nuclides and has an optional neutron detector. In this demonstration the optional neutron detector was not used. The basic Model 935 comes with an internal 1.5 by 2-inch (Th)NaI crystal. Two other sizes (2 x 2-inch and 3 x 3-inch) are also available. The particular model used in this demonstration contained the 3 x 3-inch crystal and costs approximately $10,500. The basic model with the 1.5 x 2 inch crystal costs approximately $7,500.

Specific advantages of the SAMS over the baseline include the following:

- A much faster turnaround on the sample results relative to laboratory results
- Compared to other portable detectors, the SAMS provides important isotopic identification
- Data can be stored and downloaded after returning to the office
- Reduced cost relative to laboratory analysis
- The new technology may eventually minimize or eliminate the need to ship samples to a laboratory.

System Operation

Table 3 summarizes the operational parameters and conditions of the SAMS demonstration.

Table 3. Operational parameters and conditions of the SAMS demonstration.

Working Conditions	
Work area location	TAN Facility
Work area access	By radiation work permit
Work area description	Contaminated soil site and contaminated paint and concrete
Work area hazards	Radioactive contamination
Equipment configuration	D&D workers maintain the SAMS.
Labor, Support Personnel, Special Skills, Training	
Work crew Sampling	Minimum work crew: • 2 samplers
Labor, Support Personnel, Special Skills, Training (cont'd)	
Additional support personnel	• 1 data collector • 1 health and safety observer (periodic) • 1 test engineer • 1 Site Supervisor
Special skills/training	A hands on training of one hour is needed to operate the SAMS. Radiation Worker Training is required to enter radiation contaminated areas. 40 hour OSHA training is required to enter CERCLA
Waste Management	
Primary waste generated	No primary wastes generated
Secondary waste generated	No extra waste is generated. Generally to enter a contamination area, PPE is required. This is the case for both the baseline and innovative technologies.
Waste containment and disposal	All secondary wastes were collected and packaged for disposal with the D&D project waste.
Equipment Specifications and Operational Parameters	
Technology design purpose	Provide real-time on-site isotopic radionuclide determination and activity levels.
Portability	Weighs about 5 lbs. and is easily transported.
Materials Used	
Work area preparation	Nothing required.
Personal protective equipment (the equipment needed for this demonstration was specific to the sampling tasks involved and could vary greatly from job to job.	• Cotton glove liners • Tyvex coveralls • Pair of rubber gloves • Shoe covers • Steel toe shoes • Hard hats • Safety glasses
Utilities/Energy Requirements	
Power, fuel, etc.	Battery operated

SECTION 3
PERFORMANCE

Demonstration Plan

Problem Addressed

D&D project managers are required to characterize the conditions present at each D&D site. This allows them to properly plan and estimate schedules and budgets for the project. For instance, paint and soil must be characterized to determine removal and disposal requirements. At the INEEL, environmental samples are sent to an on-site laboratory for radionuclide analysis. This process involves the collection of samples ranging from 100-200 grams each. The samples are then sent to the laboratory and may take as long as 90 days to receive results. There is need for a method of quickly providing isotopic determination along with activity levels, while minimizing the generation of secondary waste. Therefore, the new technology should offer quick results while minimizing the volume of material that needs to be collected. The specific need statements sited are ID-S.1.04 and ID-6.1.02.

The purpose of this demonstration was to compare the performance of the innovative technology, the SAMS, to the baseline technology, which is laboratory analysis of samples and the use of hand-held radiation detectors. Soil and paint samples were collected from various locations at TAN for analysis.

Demonstration site description

The INEEL site occupies 569,135 acres (889 square miles) in southeast Idaho. The site consists of several primary facility areas situated on an expanse of otherwise undeveloped, high-desert terrain. Buildings and structures at the INEEL are clustered within these primary facility areas, which are typically less than a few square miles in size and separated from each other by miles of primarily undeveloped land.

Many buildings at these primary facilities have become obsolete and are being removed, or renovated for future use, by the INEEL D&D group. As part of this process, a variety of environmental sampling is performed to determine the extent and nature of the contamination and how the waste may be disposed of. For this demonstration, samples were collected from the TAN Facility during scheduled D&D characterization projects. Samples were shipped to an on-site laboratory for analysis.

Major objectives of the demonstration

The major objective of this demonstration was to evaluate the SAMS and compare it to the baseline method of monitoring in the following areas:

- Safety
- Productivity rates
- Ease of use
- Benefits/limitations
- Cost-effectiveness.

Major elements of the demonstration

This demonstration was performed in two parts. Part 1 of the demonstration compared the collection of samples in the field and shipment to an onsite laboratory for analysis (baseline) with the use of the SAMS to measure samples in the field. Part 2 of the demonstration compared a baseline handheld detector (the Ludlum 2A) with the SAMS in providing routine radiation surveys. The intent of part 1 of the demonstration was to gather information helpful in deciding if the innovative technology could provide results equal in quality to the laboratory's but with a faster turnaround or process time and at a more economical rate. The intent of part 2 of the demonstration was to collect information that would be helpful in determining if the use of the SAMS would provide an added benefit over the use of baseline handheld detectors by providing isotopic identification as well as gross beta/gamma readings. Common elements of the demonstration included:

- Sample collection time
- Sample preparation time
- Number of workers required
- Safety
- Worker comments
- Cost
- Advantages/disadvantages.

Results

Every attempt was made to allow work to proceed under normal conditions with no bias. All parties involved in the demonstration were requested to perform the work normally with no special emphasis on speed or efficiency. The demonstration took place during March and April of 2000. For part 1, samples were collected and shipped to the laboratory immediately following collection. The samples were also analyzed using the innovative technology.

The same samplers were used throughout the project to collect, prepare, ship, and/or analyze the samples. A video was taken of the sample collection and of the SAMS being used. Video recordings were not made of the laboratory analysis activities. The performance of the SAMS and baseline technologies are compared in Table 4.

Table 4. Performance comparison between the SAMS and baseline method for Part 1.

Performance Factor	**Baseline Technology** **Hand-held detectors and Laboratory Analysis**	**Innovative Technology** **Surveillance and Measurement System (SAMS)**
Personnel/equipment/ time collect Soil Samples	Personnel: • 2 Samplers • 1 RCT (provide periodic inspection) Equipment: • shovels and spades Time: • 3 hours (1,000 grams) • 4 week to receive results	Personnel: • 2 Samplers • 1 RCT (provide periodic inspection) Equipment: • SAMS Time: • 10 minutes
Time required to prepare the samples for shipment or analysis	Personnel: • 2 samplers Equipment • Sample bottles Time: • 5 minutes/sample 18 samples	
Personal protection equipment (PPE) requirements	Both technologies require the same number of workers to wear the same level of PPE to complete the job.	
Superior capability	• EPA approved method of analysis.	• Less sample material required resulting in fewer labor hours and less time spent in potentially hazardous environments. • Cost savings over laboratory analysis. • Much faster turnaround time for receiving sample results.

For part 2, the SAMS was compared to a baseline handheld detector for routine radiation surveys.

The same samplers were used throughout the project with both detectors. A video was taken of the sample collection and of the SAMS being used. Video recordings were not made of the laboratory analysis activities. The performance of the SAMS and baseline technologies are compared in Table 5.

Table 5. Performance comparison between the SAMS and the baseline technology, Part 2.

Performance Factor	Baseline Technology Hand-held detectors	Innovative Technology SAMS
Personnel/equipment/ time to perform routine survey measurements	Personnel: • 2 Samplers • 1 RCT (provide periodic inspection) Equipment: • baseline detector Time: • 10 minutes	Personnel: • 2 Samplers • 1 RCT (provide periodic inspection) Equipment: • SAMS Time: • 10 minutes
Time required to prepare the samples for shipment or analysis	• na	• na
Personal protection equipment (PPE) requirements	Both technologies require the same number of workers to wear the same level of PPE to complete the job.	
Superior capability	• Lighter in weight	• Provides isotopic identification • Can store measurements in memory

Part 1 Comparison to Laboratory Results

Paint samples from a scabbling project were sent to a laboratory for analysis. Split samples were also measured using the SAMS. It was anticipated that we would detect some level of radiation from these samples, however, neither the laboratory nor the SAMS were able to detect any radiation.

The SAMS was also compared to the results of laboratory analysis for providing isotopic characterization soil. Eighteen soil samples were collected from contaminated soil surrounding the PM-2A tanks at TAN which are currently being excavated and disposed of. The soil samples were collected and compared using the SAMS and laboratory results. The results from the SAMS were available that day for the project manager. The report from the laboratory did not arrive until months later. The results are compared in Figure 4. A statistical comparison between the sample means showed no statistical difference between the means of the laboratory data and the SAMS (t=.19 and t(crit)=2.0). Based on these results, the SAMS appears to provide equally accurate results to laboratory analysis and does so much faster and at a much lower cost.

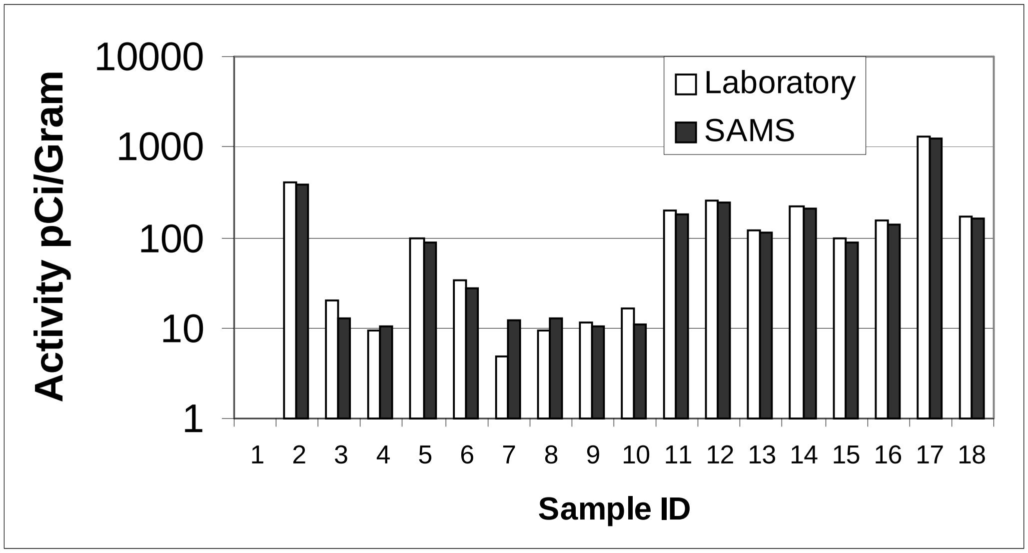

Figure 4. Comparison of SAMS and laboratory results.

Part 2, Comparison between the SAMS and Baseline Detector

The SAMS and the baseline technology, Ludlum 2A, were used to release the scabbling equipment used to remove paint during a scabbling project at TAN. It was believed that the equipment may become contaminated due to radiation contamination present in the paint. Radiation control technicians were unable to locate any radioactive contamination on the scabbling equipment using either the Ludlum 2A or the SAMS.

The PM-2A Tanks site consists of two abandoned 50,000 gallon underground storage tanks and the contaminated soil around them. The tanks contained low-level radioactive waste from the TAN evaporator, which operated from 1955 until 1981. The soil above the tanks was contaminated by spills containing Cs^{137}. Soil radiation measurements were taken using the SAMS and baseline detector to determine when sufficient soil contamination has been removed.

Ten grid points were selected across the contamination area. First the baseline hand-held detector was used to measure radiation levels at these 10 points. Then the SAMS was used to measure radiation levels at these same points. Both measurements were taken at a 1foot distance above the soil. The SAMS also provided isotopic identification of the radiation present. Figure 5 provides the results of the gross contamination reading comparison between the SAMS and the baseline detector.

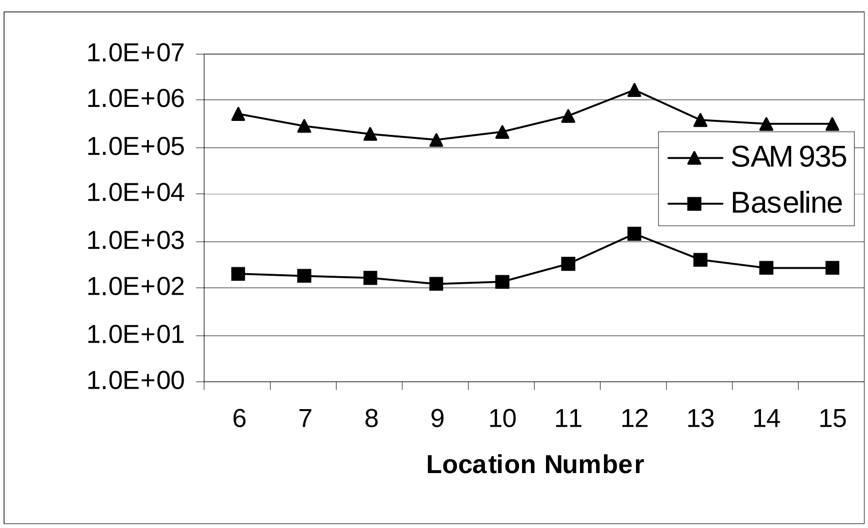

Figure 5. SAMS and baseline detector comparison.

From Figure 5, it can be seen that the trends from both detectors coincide very well. The magnitude of the readings are different, but can be attributed to the differences in the instruments used. The baseline detector, a Ludlum 2A, has an efficiency of about 10% while the SAMS has an efficiency of almost 100%. The detector for the SAMS has a larger surface area than the detector for the baseline. This means that the SAMS will see a larger area and thus have a higher counts per minute (cpm) reading.

While both the baseline and the SAMS were able to provide accurate results as far as gross gamma radiation, the SAMS was able to show that Cs-137 represents over 92.5% of the contributor of the gamma emitting contamination. Less than 5% of the gross contamination could be attributed to cobalt and less than 2.5% was associated with other gamma emitters.

The cost of the SAMS exceeds the cost of the baseline technology, however, the baseline technology does not have the ability to provide isotopic identification. As shown here, only the SAMS was able to identify Cs-137 as the major contributor of contamination. The added cost for the SAMS may be justified by the additional information gained.

Additional Data

Although outside the scope of the planned project, readings of the SAMS were also compared to an in-situ spectrometer, the DART/M1, which was being used at the INEEL. Figures 6 and 7 can be used to compare the readings from these two instruments. Although the units are different, the trends are consistent between the two Figures.

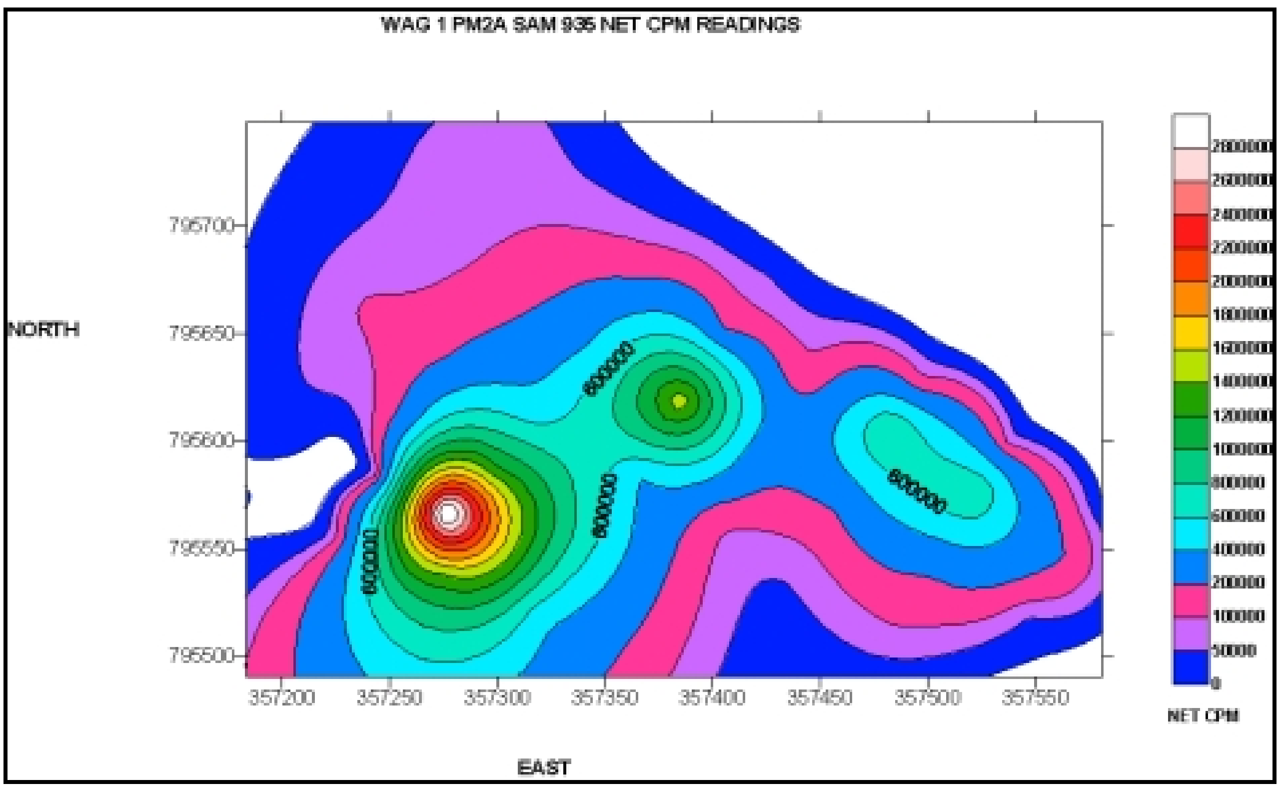

Figure 6. PM-2A radiation map generated from SAMS readings.

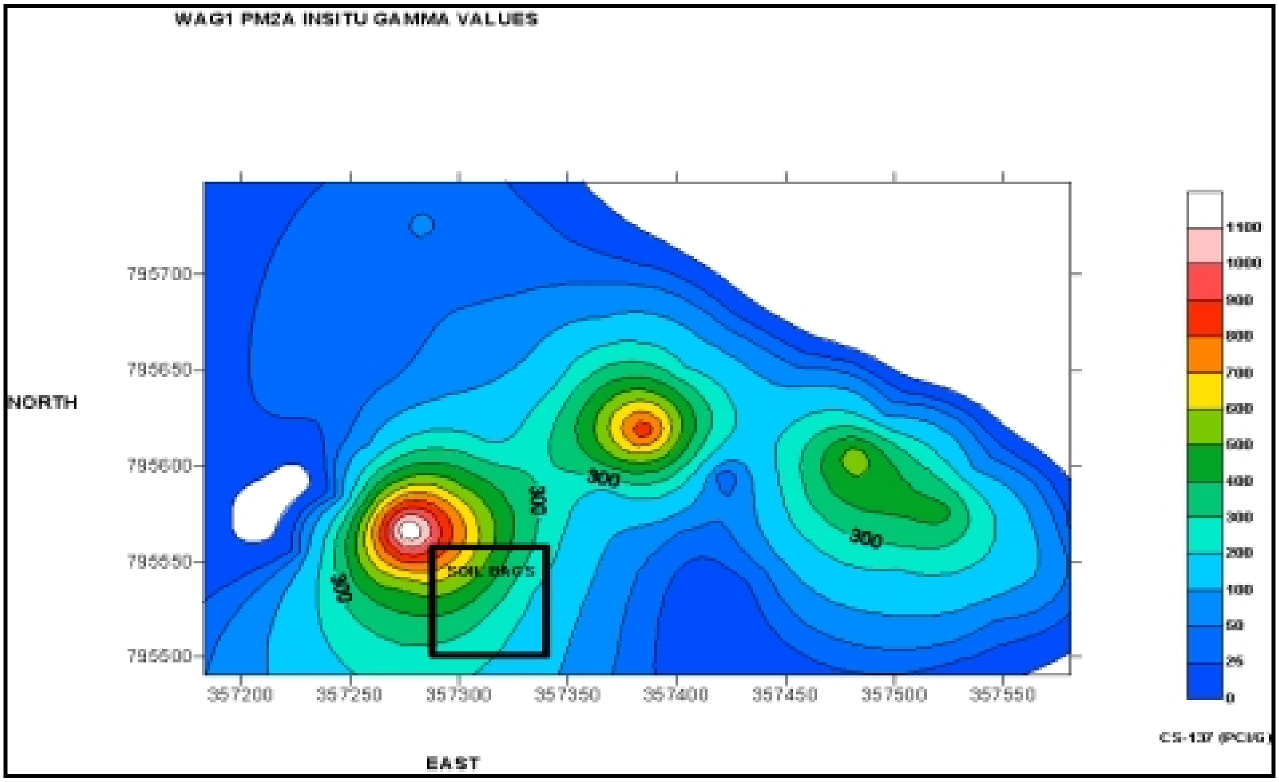

Figure 7. PM-2A radiation map generated from DART/M1 in situ gamma readings.

SECTION 4
TECHNOLOGY APPLICABILITY AND ALTERNATIVES

Competing Technologies

Baseline technology

The baseline technology for providing isotopic identification for this demonstration was to collect samples and ship them to a laboratory for analysis.

Hand-held radiation detectors are available, which provide measurements in radiation field strength. These hand-held detectors, however, do not provide isotopic identification of the radiation, as does the SAMS.

Other competing vendors:

Ludlum

Ludlum provides a variety of portable detectors ranging including detectors for alpha, beta, gamma, or neutron detection. There are a variety of detector sizes and capabilities. For additional information view the vendor website: http://www.ludlums.com

Quantrad

Quantrad also manufactures a detector that can provide the user with isotopic characterization. Technology capabilities include: Counter-smuggling, Material Control and Accountability, Transportation qualifications, Weapons verification, Inventory control, Safeguard inspection, Risk assessment, Non-proliferation, and Source management. For more information, visit the vendor website at: http://www.quantrad.com

Technology Applicability

The SAMS is fully developed and commercially available. Its advantage is derived from its ease of use and ability to provide field strength and isotopic data on a real-time or near real-time basis. This advantage can save time and money across the DOE complex by reducing costs for many D&D projects. The INEEL is currently investigating the possibility of eliminating the need for analysis at laboratories and replacing it with technologies such as this.

Patents/Commercialization/Sponsor

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SECTION 5
COST

Introduction

This section compares the cost of the innovative and the baseline technologies for two parts of use: 1) part 1 compares the SAMS with sample collection and analysis at a laboratory, and 2) part 2 compares the SAMS with baseline handheld detectors for routine radiation sampling. The innovative technology costs is approximately 20% of the cost of the laboratory analysis for characterization of a contaminated soil material for a job where 18 samples of waste material are collected. The innovative technology is more expensive than the baseline technology for routine surveys conducted for personnel entry and exit from the radiological control zones, but the innovative technology provides isotopic characterization information that is not available using the baseline technology.

Methodology

The laboratory analysis for part 1 is based on government ownership of the innovative technology and baseline technology equipment. This cost analysis assumes that the data collected by means of the innovative technology must be similar to the data quality obtained by laboratory analysis for precision, accuracy, repeatability, and tacking/control. The baseline methodology includes collection of 18 samples with three duplicate samples and laboratory data package validation for quality assurance purposes. The innovative technology methodology includes calibration at the beginning of work, after every 10 samples, laboratory analysis of two quality assurance samples, and data validation of the data from SAMS and from the laboratory analysis samples.

For part 1 comparison, the laboratory analysis, the observed activities for both the innovative technology and the baseline include prejob briefings, donning/doffing PPE, collection of soil samples from the stockpile, operation of the innovative technology equipment to characterize the samples, laboratory sample analysis, and moving from one sample location to another. This analysis estimates the cost for several activities that were not included in this demonstration, but would be part of a typical job. The cost for sample preparations (chain of custody, label preparation, etc.), set up of a SAMS lab station (shielded area for counting of the samples), sample validation, and retrieving/returning the equipment to a storage area were estimated based on the test engineer's judgment. This cost analysis assumes that both the innovative technology and the baseline technology use site labor, and the cost analysis is based on the standard labor rates used at INEEL. This cost analysis uses rates for common construction equipment and vehicles that are based on the standard rates that INEEL charges projects for use of equipment from the fleet pool.

In some cases, the demonstration's observations of the activity durations do not represent the cost of typical work situations because of the artificial affects on the work imposed by the need to collect data, first time use of the equipment at INEEL, and other effects associated with the demonstration. In these cases, the observed durations are adjusted before using them in the cost analysis. For example, during the demonstration, the crew waited while the innovative technology equipment was calibrated. In typical work situations, the crew could proceed with sample collection while the equipment was calibrated.

The cost analysis for part 2, the routine radiological survey use scenario, is based on routine radiological surveys. This analysis is based on government ownership of the innovative technology and baseline technology equipment. During the demonstration, it was observed that the amount and type of labor required for operating the equipment is the same for the innovative technology and the baseline technology. Also, the durations are essentially the same for the innovative technology and the baseline technology. Consequently the labor and the activity durations do not play any significant role in the cost comparison. To simplify the comparison, the estimate is based on the hourly equipment rates. The equipment rates are based on amortizing the purchase price of the equipment over the service life of the equipment. In this analysis, the innovative technology is assumed to have a service life of seven years and the baseline technology is assumed to have a service life of 10 years based upon the length of time that similar survey meters have remained in services at DOE sites. An equipment rate of \$0.31/hr is computed for the survey meter used for the baseline technology. An equipment rate of \$3.07/hr is computed for the SAMS. The remainder of this cost analysis narrative focuses on the part 1, where the SAMS is compared with laboratory analysis.

It should be noted, however, that the innovative technology (SAMS) provides more information for these routine surveys. The additional information (isotopic identification) may justify the higher cost where the potential for contamination is relatively high and the possibility for different radionuclides being present exists. For example, the cutting and removal of piping systems could potentially result in liquid spills, or exposure of other radionuclide contaminants in the work area where cutting is occurring. The SAMS could be used to inspect workers for contamination and provide the user with the ability to identify where the contamination originated.

Additional details of the basis of the cost analysis for the comparison of the SAMS to laboratory analysis are described in Appendix B.

Cost Analysis

Costs to Procure Innovative Equipment

At this time, the innovative technology is only available by purchasing the equipment from the vendor. The vendor is developing an option to lease the equipment, but this is not yet available. The detail costs of the equipment used in this demonstration are shown in Table 5.

Table 5. Innovative technology costs.

Acquisition Option	Item Description	Cost
Purchase	SAMS Crystal Window 3-in. x 3-in. Sources (not available from vendor) Cesium-137 Europium – 152	$7,850 $2,600 $125 $165
Rent Equipment	SAMS (three month minimum 12 month maximum)	10% /month of the purchase price

Unit Costs and Fixed Costs

Table 6 shows the unit costs and fixed costs for the innovative and baseline technologies. The fixed costs are the sum of the line items shown in Table B-2 and B-3 (Appendix B) that do not vary directly with the size of the job. The unit costs are the sum of the line items shown in Table B-2 and B-3 (Appendix B) that do vary with the size of the job and, this sum is divided by the number of samples analyzed or scanned (21 samples for the baseline technology and 18 for the innovative technology).

Table 6. Summary of costs (comparing SAMS with laboratory analysis)

COST ELEMENT	INNOVATIVE COST	BASELINE COST
Fixed Costs	$247.03	$240.97
Unit Costs	$47.77 each	$287.41 each

Note, in Table 6, the fixed costs for the innovative technology includes the following line items shown in Table B-3: staging sample equipment, transport to work area, set up SAMS lab station, and return equip. to storage. The fixed costs for the baseline technology includes the following line items shown in Table B-2: staging sample equipment, transport to work area, and return equipment to storage.

The unit costs for the innovative technology includes the following line items shown on Table B-3: pre-job briefing, don PPE, calibrate SAMS, collect samples, SAMS counts samples, move to next sample area, pack/deliver samples, sample lab analysis, sample validation, doff PPE and exit. The unit costs for the baseline technology includes the following line items shown on Table B-2: pre-job briefing, don PPE, collect samples, move to next sample area, pack/deliver samples, sample lab analysis, sample validation, doff PPE and exit.

Break-Even Point

A break-even analysis tracks total costs for innovative and baseline technologies and determines the job size where the two lines cross on a cost vs. job size curve. This point is where the costs for both technologies are identical. In this case, fixed costs for both the innovative and baseline technologies are so close the break even point turns out to be one sample. Using the innovative technology begins to provide cost savings after a single sample.

Payback Analyses

The payback analysis calculates the job size at which the capital cost of the equipment will be recovered through cost savings achieved by the innovative technology compared to the baseline technology. The SAMS saves $315.91/sample over the laboratory analysis for a characterization job where 18 samples are collected (baseline total cost $6,277 - innovative total cost $1,107 for 18 samples = $285/sample). At this rate of savings, it would require approximately 36 samples to make up for the differences in purchase price of the innovative and baseline technology equipment (SAMS $7,850 + 3 x 3 crystal $2,600 - baseline miscellaneous sampling tools $150 = $10,300 and $10,300/$285/sample savings = 36 samples). A payback analysis for the routine survey use was not performed because the innovative technology does not provide any savings over the baseline technology.

Observed Costs for Demonstration

Figure 8 summarizes the observed costs for the SAMS and laboratory analysis based a characterization job consisting of 18 samples. The details of these costs are shown in Appendix B and includes Tables B-2 and B-3 which can be used to compute site-specific cost by adjusting for different labor rates, crew makeup, etc.

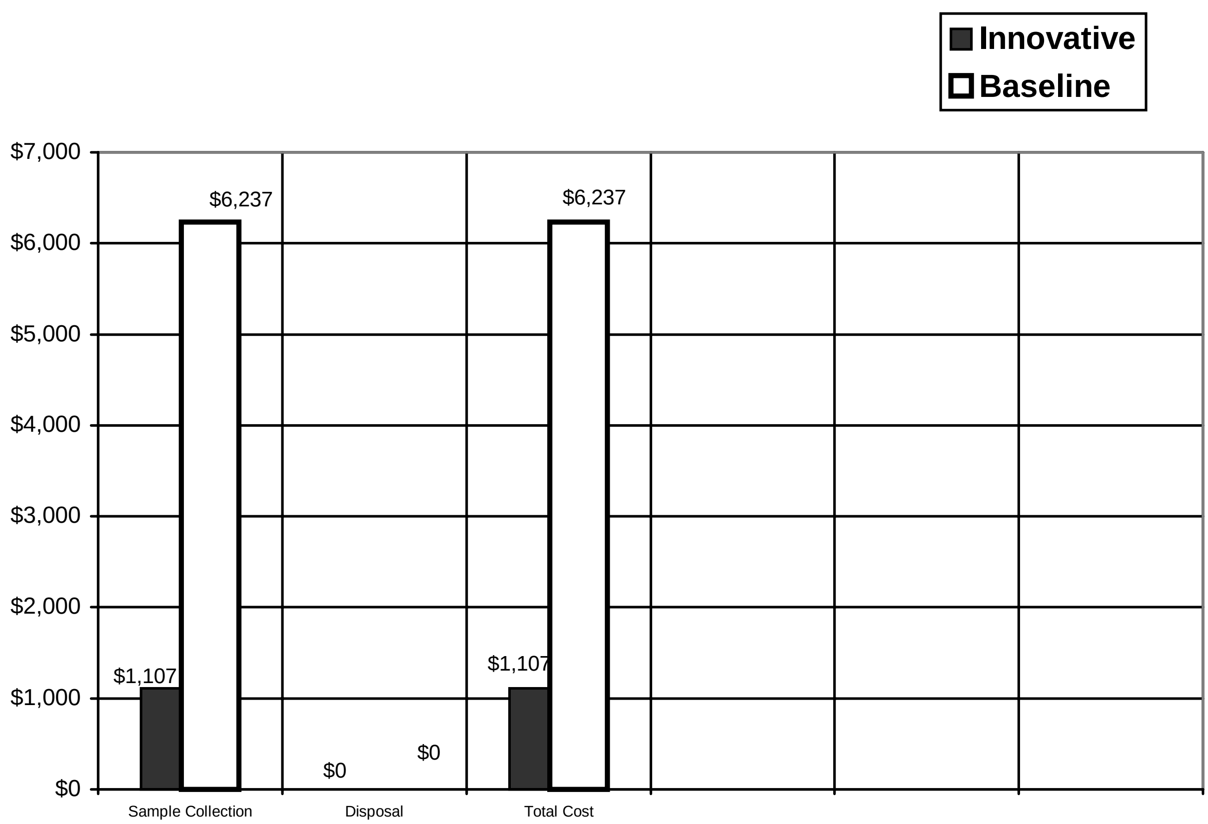

Figure 8. Summary of technology costs.

Cost Conclusions

Mobilizing and demobilizing for the baseline technology costs more than for the innovative technology because of the preparation required for sample collection (chain of custody, bottle labels, etc.). Some sample collection preparation is required for the innovative technology, because of the quality assurance samples that must be collected and analyzed by the laboratory. But, the innovative technology has only two quality assurance samples to prepare for as compared with 18 samples plus three duplicate samples for the baseline technology.

The primary reason for the difference in cost between the innovative technology and the baseline technology is due to the lab analysis costs. The only lab analysis costs incurred for the innovative technology are for quality assurance purposes. The cost comparison for the innovative technology with the baseline technology will vary depending on the type of laboratory analysis required. The innovative technology's cost savings will be more where the laboratory analysis costs are higher and the savings will be less where the laboratory analysis costs are less. The savings associated with data validation costs will vary depending on the data quality and quality assurance requirements of the individual job.

The innovative technology and the baseline technology require the same labor and tasks take the same amount of time to complete for routine radiological survey uses of the equipment. The innovative technology's cost comparison with the baseline technology will vary depending upon the type of baseline survey equipment used. But, it is anticipated that the innovative technology will cost more than the baseline technology for most DOE sites for routine surveys.

SECTION 6
REGULATORY AND POLICY ISSUES

Regulatory Considerations

The only regulatory issues associated with this technology deal with accessing CERCLA sites or radiation areas. In order to access areas where radiation is present or which are the job occurs on a CERCLA site, the following training at a minimum is necessary:

- Radiation Worker I or II
- OSHA 40 hour training

At the INEEL, the SAMS is used routinely to provide isotopic identification in the field for regulatory purposes. It has the capability of being used to provide quantitative results in the field for the isotopes present when the following conditions are met: 1) a balance must be available in the field to provide a mass measurement of the sample so that results can be presented in a pCi/g format, 2) shielding must be provided in the field to eliminate background interference's, and 3) a QA/QC method must be followed such that the instrument calibration is checked routinely. When these conditions are met, the data can be used by the regulators and planners to make remedial decisions.

Safety, Risks, Benefits, and Community Reaction

The use of the SAMS will promote safe practices by allowing workers to spend less time in radiation areas. This is made possible because samplers will be required to take fewer samples. There are no perceived risks associated with the use of the SAMS. It is expected that community reaction will favor this or any technology that promotes safe practices and minimizes waste.

SECTION 7
LESSONS LEARNED

Implementation Considerations

Some steps that can be taken to improve results from the SAMS would be to provide portable shielding such that background radiation can be blocked out of measurements. Because the SAMS is so sensitive it is important to shield or account for background radiation levels when using it in a high background area.

Technology Limitations and Needs for Future Development

The SAMS performed well during this demonstration. There were no significant technology limitations. The performance of the SAMS could be enhanced by creating a user-friendly software that will allow for an easier download process to a personal computer.

Technology Selection Considerations

Based on the INEEL demonstration, the innovative technology is better suited than the baseline technology for most sampling activities. The innovative technology is easier to use, more cost-effective in the long run, and increases worker safety. Since the SAMS is a gamma detector, a baseline technology is still needed where alpha and beta radiation emitters are present.

Conclusions

The SAMS is a mature technology that performed very well during the INEEL demonstration. The workers found it to be very easy to use and it provided results on a real-time basis. Laboratory analysis can take as long as 90 days to receive results. Following is a list of items that should be considered when using the SAMS.

- The SAMS has advantages over other detectors by its capability to store data internally for later processing.
- While the cost of the SAMS is greater than other hand held detectors, the SAMS is able to provide information (isotopic identification on a real time basis) that the other detectors can not provide. The additional information (isotopic identification) may justify the higher cost where the potential for contamination is relatively high and the possibility for different radionuclides being present exists.
- Sample results are obtained on a real-time basis. Sending samples to a laboratory often requires up to 90 days or longer to receive results.
- Based on the cost analysis, the SAMS saves $315.91/ sample. Based on this, it would take 36 samples to be analyzed to recover the cost of the innovative technology.
- The innovative technology does not require samples to be removed from the job site. This means that costly shipping, documentation, time, and costs can be avoided.
- Because the time involved in sampling can be reduced, safety for the workers is increased since they spend less time in hazardous environments. As low as reasonably achievable (ALARA) dose savings will be achieved.

APPENDIX A

REFERENCES

Lockheed Martin Idaho Technologies Company, 9/15/99, Management Control Procedure-138, INEEL.

ID-6.1.02 and ID-S.1.04 Real-time Field Instrumentation for Characterization and Monitoring Soils and Groundwater. 6/22/00

APPENDIX B
COST COMPARISON DETALS

Basis of Estimated Cost

The activity titles shown in this cost analysis come from observation of the work. In the estimate, the activities are grouped under higher-level work titles per the work breakdown structure (WBS) shown in the ***Environmental Cost Element Structure*** (ECES).

The costs shown in this analysis are computed from observed duration and hourly rates for the crew and equipment. The following assumptions were used in computing the hourly rates:

- The innovative technology and the baseline technology equipment are assumed to be owned by the Government.
- The equipment hourly rates for the Government's ownership are based on general guidance contained in Office of Management and Budget (OMB) Circular No. A-94, ***Cost Effectiveness Analysis***.
- The equipment rates for Government ownership are computed by amortizing the purchase price of the equipment, plus a procurement cost of 5.2% of the purchase price, and the annual maintenance costs.
- The equipment hourly rates assume a service life of seven years for the innovative technology equipment, and ten years for the survey meters used in the baseline technology, routine survey scenario. An annual usage of 800 hours per year is assumed.
- Some of the equipment used in the course of the demonstration is commonly included in the site motor pool, such as vehicles. The equipment rates for these types of equipment are based on standard fleet rates for INEEL.
- The standard labor rates established by the Idaho National Engineering and Environmental Laboratory (INEEL) are used in this estimate and include salary, fringe, departmental overhead, material handling markups, and facility service center markups.
- The equipment rates and the labor rates do not include the Bechtel BWXT Idaho, LLC (BBWI) general and administrative (G&A) markups. The G&A are omitted from this analysis to facilitate understanding and comparison with costs for the individual site. The G&A rates for each DOE site vary in magnitude and in the way they are applied. Decision makers seeking site-specific costs can apply their site's rates to this analysis without having to first back-out the rates used at the INEEL.

The analysis does not include costs for oversight engineering, quality assurance, administrative costs for the demonstration, or work plan preparation costs.

Activity Descriptions

The scope, computation of production rates, and assumptions (if any) for each work activity is described in this section.

Investigations and monitoring/sample collection, contaminated buildings/structures samples

Sampling Preparation: This activity consists of making preparations for the laboratory sample collection. This work includes reviewing the "Sampling Checklist" at the supply shop prior to traveling to the job site. It includes chain of custody requirements, paper work, label preparation, tool organization, etc. The duration is based on the judgment and experience of the test engineer and two hours are assumed for preparations for the quality assurance samples for the innovative technology and four hours for all of the baseline technology samples.

Transport to Work Area: The baseline technology supplies and tools and innovative technology equipment will be stored in a sample equipment/supplies storage area. The time required to transport the equipment to the work area is based on the judgment of the test engineer.

Set Up SAMS Lab Station: This activity includes set up of a worktable in the vicinity of the sample collection. This provides shielding and other set up arrangements that are necessary for the SAMS data to be comparable to data from the conventional laboratory. The time required for this activity is based on the judgment of the test engineer.

Pre-Job Briefing: The duration for the pre-job safety meeting is based upon the observed time for the demonstration. The labor costs for this activity are based upon an assumed crew (rather than the actual demonstration participants, and all subsequent activities are based on the assumed crew).

Don PPE and Enter: This activity includes the labor and material cost for donning the articles of clothing listed below and entry of the radiological control zone. The RCT that allows the crew into and out of the radiological control zone and the Job Supervisor do not enter the zone with the crew (do not don or doff PPE).

Table B-1 Cost for PPE (per man/day)

Equipment	Cost Each	Number of Times Used Before Discarded	Cost Each Time Used ($)	No. Used Per Day	Cost Per Day ($)
Rubber over boots (pvc yellow 1/16 in thick)	$12.15	1	$12.15	1	$12.15
Glove liners pr. (cotton inner)	$0.40	1	$0.40	2	$0.80
Rubber Gloves pr. (outer)	$1.20	1	$1.20	2	$2.40
Coveralls (white Tyvek)	$3.30	1	$3.30	1	$3.30
Hard Hat	$11.45	30	$0.38	1	$0.38
Safety Glasses	$4.80	30	$0.16	1	$0.16
TOTAL COST/DAY/PERSON					**$19.19**

Calibration for SAMS: This activity includes the initial calibration for SAMS using the Cs-137 source and Am-241 source. The calibration for each source was observed to take five minutes during the demonstration. Calibrations are performed throughout the sample counting process when a level of confidence that is comparable to laboratory data is desired. This might involve calibrations for every ten samples. The time required to calibrate SAMS is not shown separately in the cost estimate because the RCT can perform this concurrent with the sample collection activities.

Collect Samples: This activity includes collection of samples from the stockpiles, placement in the sample bottles, documenting each sampling event (sample log, bottle labels, etc.). The production rate for sample collection used in this estimate is based on the duration observed in the demonstration, as shown below:

Stockpile 1 - 6 samples plus one duplicate in 29 minutes (14.48 samples/hr)
Stockpile 2 - 6 samples plus one duplicate in 27 minutes (15.56 samples/hr)
Stockpile 3 - 6 samples plus one duplicate in 30 minutes (14 samples/hr)
Average Production Rate = 14.68 samples/hr

This cost analysis is based on the demonstration where 21 samples are collected for the baseline technology with 6 samples and 1 duplicate sample being collected from each of three stockpiles. The analysis assumes that for the innovative technology, six samples are collected from each stockpile and brought to the SAMS lab station for counting. Of the 18 samples collected for the innovative technology, 10% (two samples) will be used for quality assurance samples and sent to the laboratory for analysis.

SAMS Counts Samples: The time required to count each sample varies depending on the isotope and strength of the field emitted and varies form one second to ten seconds. This is conducted concurrently with the sample collection and a separate cost for counting is not shown in this estimate.

Move to Next Sampling Area: This activity consists of moving the sampling crew from one stockpile to the next for a total of three stockpiles. The activity duration used in the cost analysis is based on the test engineer's judgment.

Pack/Deliver Samples: This activity includes packing and transporting the samples to an on-site laboratory for analysis. All of the samples for the baseline technology are transported to the laboratory and only the quality assurance samples for the innovative technology are transported to the laboratory. The activity duration used in the cost analysis is based on the test engineer's judgment.

Sample Laboratory Analysis: This activity includes the fee for performing isotopic determination for soil and paint samples. All of the samples for the baseline technology receive laboratory analysis and only the quality assurance samples for the innovative technology receive laboratory analysis. The fee amount used in this cost analysis is based on lab fees at INEEL.

Sample Validation: This activity includes validation of the lab analysis data for all the samples for the baseline technology. For the innovative, it includes a review of the quality assurance samples sent to the laboratory and the SAMS data. The amount of effort assumed in this cost analysis for the validation of the baseline data is based on typical validation times for other projects where three hours of review is required per sample. The validation of the innovative technology data is assumed to require three hours for each day of sampling and is based on the test engineer's judgment.

Doff PPE: This activity accounts for the labor costs for doffing PPE and is based on the duration observed in the demonstration.

Return to Storage: This activity includes transporting the equipment back to the storage area and unloading. The activity duration is based on the test engineer's judgment.

DISPOSAL FACILITY, DISPOSAL FEES AND TAXES

Disposal: The laboratory samples remains are disposed of by returning the remains to the location where the sample was collected. The laboratory analysis fee includes the cost of returning the sample remains and that effort is not shown as a separate cost in this analysis.

Cost Estimate Details

The cost analysis details are summarized in Tables B-2 and B-3. The tables break out each member of the crew, each labor rate, each piece of equipment used, each equipment rate, each activity duration and all production rates so that site specific differences in these items can be identified and a site specific cost estimate may be developed.

Table B-2. Baseline Technology Cost Summary

Work Breakdown Structure	Unit	Unit Cost $/Unit	Quantity	Total Cost	Computation of Unit Cost							Comments
					Prod Rate	Duration (hr)	Labor Item	$/hr	Equipment Items	$/hr	Other $	
Facility Deactivation, Decommissioning, & Dismantlement								**Total Cost =**				**$ 6,236.97**
INVESTIGATIONS AND MONITORING/SAMPLE COLLECTION, CONTAMINATED BUILDING/STRUCTURES SAMPLES (WBS 4.07.14)										Subtotal =		$ 6,236.97
Sampling Preparation	ls	155.34	1	$ 155.34		2.00	2 ST	77.34	ST on standby	0.33		
Transport to Work Area	ea	45.99	1	$ 45.99		0.58	2 ST	77.34	P, ST on standby	1.95		
Pre-Job Briefing	ea day	64.60	1	$ 64.60		0.50	2 ST, JS	128.87	ST on standby	0.33		
Don PPE and Enter	ea day	79.70	1	$ 79.70		0.25	2 ST, RCT, JS	164.64	ST on standby, SM	0.64	38.38	$19.19/PPE X 2=$38.38
Collect Samples	ea	8.80	21	$ 184.82	14.68		2ST, JS	128.87	ST	0.33		Production rate=14.68sampl
Move to Next Sample Are	ea	3.88	3	$ 11.63		0.03	2ST, JS	128.87	ST	0.33		
Pack/Deliver Samples	ea	59.47	1	$ 59.47		0.75	2ST	77.34	ST, P	1.95		
Sample Lab Analysis	ea	140.00	21	$ 2,940.00							140	Lab fee isotopic determinatio
Sample Validation	ea	147.45	18	$ 2,654.10		3.00	CH	49.15				
Doff PPE and Exit	ea day	41.32	1	$ 41.32		0.25	2 ST, RCT, JS	164.64	ST, SM	0.64		
Return to Storage	ea	39.65	1	$ 39.65		0.50	2 ST	77.34	P, ST on standby	1.95		
DISPOSAL FACILITY, DISPOSAL FEES AND TAXES (WBS 4.13)										Subtotal =		$ -

Labor and Equipment Rates used to Compute Unit Cost											
Crew Item	**Rate $/hr**	**Abbrev-iation**	**Crew Item**	**Rate $/hr**	**Abbrev-iation**	**Equipment Item**	**Rate $/hr**	**Abbrev-iation**	**Equipment Item**	**Rate $/hr**	**Abbrev-iation**
Sampling Technician	38.67	ST	Driver	34.35	TD	Lab Sample Tools	0.33	ST			
Laborer	32.86	LB	Chemist	49.15	CH	Pickup	1.62	P			
Radiation Control Tech	35.77	RCT				Flatbed Truck	12.50	FB			
Job Supervisor	51.53	JS				Survey Meter	0.31	SM			

Notes:

1. Unit cost = (labor + equipment rate) X duration + other costs, or = (labor + equipment rate)/production rate + other costs
2. Abbreviations for units: ls = lump sum; ea = each; and, loc = location; ft^3 = cubic feet.
3. Other abbreviations: PPE = personal protective equipment.
   Decon = decontaminate.
   Equip = equipment.

Table B-3. Innovative Technology Cost Summary

Work Breakdown Structure	Unit	Unit Cost $/Unit	Quantity	Total Cost	Computation of Unit Cost: Prod Rate	Duration (hr)	Labor Item	$/hr	Equipment Items	$/hr	Other $	Comments
Facility Deactivation, Decommissioning, & Dismantlement							**Total Cost =**					**$ 1,106.97**
INVESTIGATIONS AND MONITORING/SAMPLE COLLECTION, CONTAMINATED BUILDING/STRUCTURES SAMPLES (WBS 4.07.14)										Subtotal =		$ 1,106.97
Sampling Preparation	ls	77.67	1	$ 77.67		1.00	2 ST	77.34	ST on standby	0.33		
Transport to Work Area	ea	47.77	1	$ 47.77		0.58	2 ST	77.34	P, ST, SAM	5.02		
Set Up SAM Lab Station	ls	80.41	1	$ 80.41		1.00	2ST	77.34	SAM	3.07		
Pre-Job Briefing	ea day	66.14	1	$ 66.14		0.50	2 ST, JS	128.87	ST, SAM	3.40		
Don PPE and Enter	ea day	99.66	1	$ 99.66		0.25	2 ST, RCT, JS	164.64	ST, SAM, SM	3.71	57.57	$19.19/PPE X 3=$57.57
Calibration SAM												Concurrent with sampling
Collect Samples	ea	9.01	18	$ 162.18	14.68		2 ST, JS	128.87	ST, SAM	3.40		Production rate=14.68sample
SAM Counts Samples												Concurrent with sampling
Move to Next Sample Area	ea	3.97	3	$ 11.90		0.03	2 ST, JS	128.87	ST, SAM	3.40		
Pack/Deliver Samples	ls	59.47	1	$ 59.47		0.75	2 ST	77.34	ST, P	1.95		QA samples Only
Sample Lab Analysis	ea	140.00	2	$ 280.00							140	Lab fee for QA samples only
Sample Validation	ea day	147.45	1	$ 147.45		3.00	CH	49.15				
Doff PPE and Exit	ea day	33.15	1	$ 33.15		0.25	2 ST, JS	128.87	ST, SAM, SM	3.71		
Return to Storage	ea	41.18	1	$ 41.18		0.50	2 ST	77.34	P, ST, SAM	5.02		
DISPOSAL FACILITY, DISPOSAL FEES AND TAXES (WBS 4.13)										Subtotal =		$ -

Labor and Equipment Rates used to Compute Unit Cost

Crew Item	Rate $/hr	Abbrev-iation	Crew Item	Rate $/hr	Abbrev-iation	Equipment Item	Rate $/hr	Abbrev-iation	Equipment Item	Rate $/hr	Abbrev-iation
Sampling Technician	38.67	ST	Driver	34.35	TD	Lab Sample Tools	0.33	ST	Surveillance Measurement S	3.07	SAM
Laborer	32.86	LB	Chemist	49.15	CH	Pickup	1.62	P	Calibration Sources	0.14	CS
Radiation Control Tech	35.77	RCT				Flatbed Truck	12.50	FB			
Job Supervisor	51.53	JS				Survey Meter	0.31	SM			

Notes:

4. Unit cost = (labor + equipment rate) X duration + other costs, or = (labor + equipment rate)/production rate + other costs
5. Abbreviations for units: ls = lump sum; ea = each; and, loc = location; ft^3 = cubic feet.
6. Other abbreviations: PPE = personal protective equipment.
   Decon = decontaminate.
   Equip = equipment.

APPENDIX C
ACRONYMS AND ABBREVIATIONS

ALARA	As Low As Reasonably Achievable
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Cs^{137}	Cesium 137
D&D	Decontamination and Decommissioning
DDFA	Deactivation and Decommissioning Focus Area
DOE	Department of Energy
INEEL	Idaho National Engineering and Environmental Laboratory
ITSR	Innovative Technology Summary Report
LSDDP	Large Scale Demonstration and Deployment Project
MCP	Management Control Procedure
NETL	National Energy Technology Laboratory
OSHA	Occupational Safety and Health Act
OST	Office of Science and Technology
PPE	Personal Protective Equipment
RCT	Radiation Control Technician
SAMS	Surveillance and Measurement System
TAN	Test Area North
(Th)NaI	Thallium-activated sodium iodide