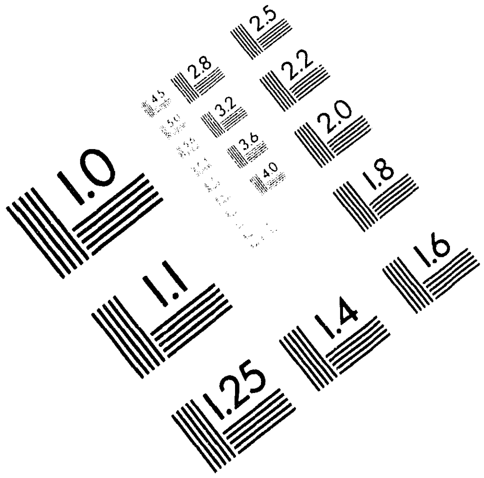

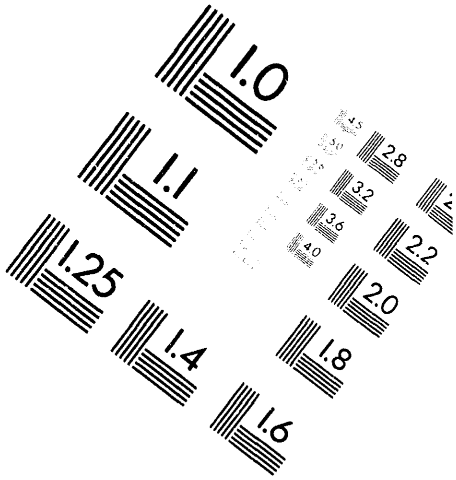

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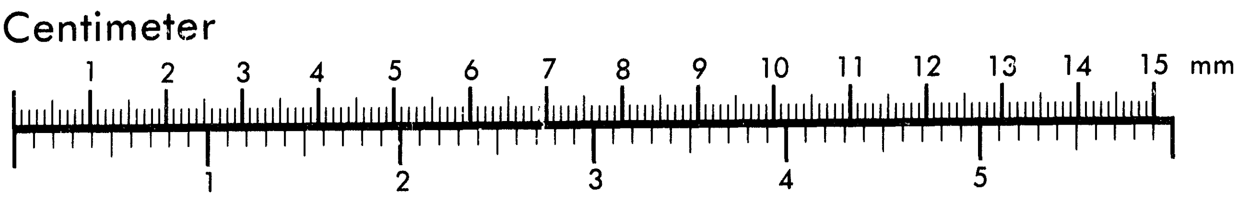

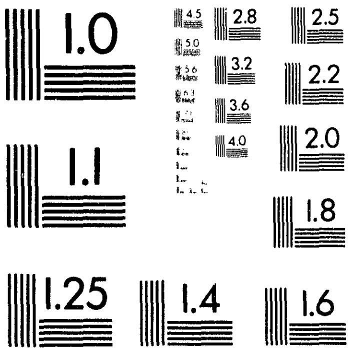

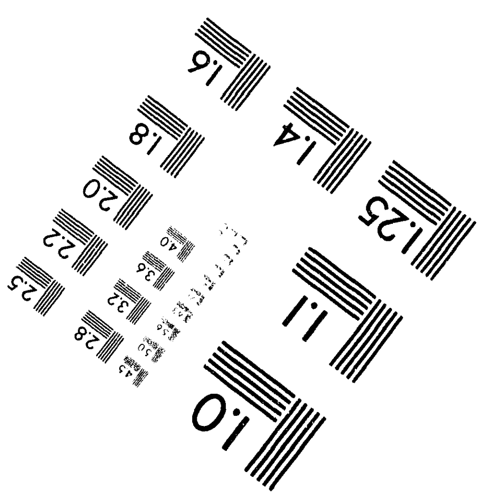

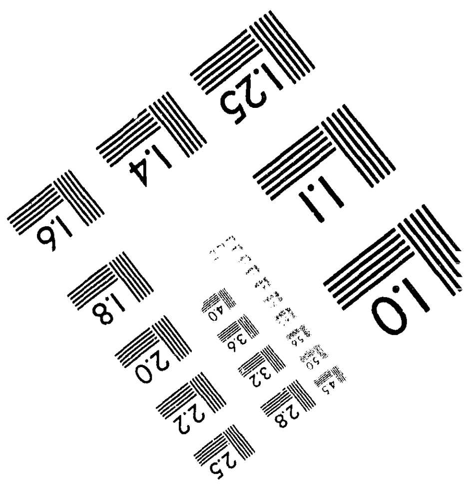

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COST COMPARISON OF LABORATORY METHODS AND FOUR FIELD SCREENING TECHNOLOGIES FOR URANIUM-CONTAMINATED SOIL

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Cost Comparison of Laboratory Methods and Four Field Screening Technologies for Uranium-Contaminated Soil

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ABSTRACT

To address the problem of characterizing uranium-contaminated surface soil at federal facilities, the Department of Energy (DOE) has funded the development of four uranium field screening technologies, under the direction of the Uranium-in-Soils Integrated Demonstration (USID) Program. These four technologies include: a long-range alpha detector (LRAD), a beta scintillation detector, an *in situ* gamma detector, and a mobile laser ablation-inductively coupled plasma/atomic emission spectrometry (LA-ICP/AES) laboratory. As part of the performance assessment for these field screening technologies, cost estimates for the development and operation of each technology were created.

A cost study was conducted to compare three of the USID field screening technologies (LRAD, beta scintillation, and *in situ* gamma detectors) to the use of traditional field surveying equipment (i.e., beta and gamma detectors) to adequately characterize surface soils of a one-acre site. The results indicate that the use of traditional equipment costs more (23%) than the *in situ* gamma detector, but less than the beta scintillation detector and LRAD. The use of traditional field surveying equipment results in cost savings of 4% and 34% over the use of the beta scintillation and LRAD technologies, respectively.

A study of single-point surface soil sampling and laboratory analysis costs was also conducted. Operational costs of the mobile LA-ICP/AES laboratory were compared with operational costs of traditional sampling and analysis, which consists of collecting soil samples and conducting analysis in a radiochemical laboratory. The cost study indicates that the use of the mobile LA-ICP/AES laboratory results in cost savings of 23% and 40% over traditional field sampling and laboratory analysis conducted by characterization groups at two DOE facilities.

INTRODUCTION

The principal objective of the USID is to develop an optimum integrated system of technologies for the removal of uranium substances from soil, which has been demonstrated to be effective in terms of cost reduction, waste minimization, risk reduction, and user applicability. The Performance Assessment Group furnishes a systematic evaluation process for the USID by providing information to establish whether the technologies have been successful and to support decision-making for future applications. As part of this effort, cost estimates were created for the development and operation of the following surface soil field screening technologies: a beta scintillation detector, an *in situ* gamma detector, a LRAD, and a mobile LA-ICP/AES laboratory.

The operational costs of the four field screening technologies were obtained from a scenario evaluation form which was provided to and completed by the developers of the technologies. Cost analysis reports were then created for each technology based on responses to the scenario evaluation. These detailed cost reports are presented in a report entitled, "Cost Estimates for the Uranium-in-Soils Integrated Demonstration Field Screening Technologies" (Douthat et al., 1993). Based on these cost estimates, as well as on discussions with the USID technology developers and characterization groups from two DOE facilities, two cost studies were conducted in order to compare the USID field screening technologies to traditional field sampling and laboratory analysis. The first cost study compares three of the field screening technologies (the LRAD, beta scintillation detector, and *in situ* gamma detector) to the use of traditional field surveying equipment. The second cost study, on single-point surface soil sampling and analysis, compares the operational costs of the mobile LA-ICP/AES laboratory to the operational costs of traditional field sampling and laboratory analysis.

Although a major cost of any field sampling activity is the documentation that must be completed before the initiation of field work (e.g., a statement of work, health and safety plan, sampling and analysis plan, and a quality assurance and project plan), these costs were excluded from the cost estimates used to conduct the cost studies. The amount of documentation that is required depends on many factors, including site-specific requirements, contaminants at the site, the equipment that will be used at the site, and the level of effort required by site representatives. In many cases these costs will greatly exceed the operational costs necessary to actually conduct the site characterization. For the purposes of this study, it is assumed that documentation costs will be approximately the same for all the USID technologies, as well as for traditional field sampling and laboratory analysis.

BODY

Cost Study Comparing Three Detector Field Screening Technologies and Traditional Field Surveying Equipment

Cost input questionnaires for equipment development and operation information were prepared by the Performance Assessment Group and sent to the developers of the USID field screening technologies. A scenario evaluation was also included in the questionnaire to determine the cost to adequately characterize a 1-acre site in a given timeframe. A description of the site follows: it was used as a storage area for uranium-contaminated scrap metal and drums containing mill tailings. The site is level with the only vegetation being grass which is approximately 6 inches high. Five years ago, the material and drums were removed, no remedial action was conducted, and the site was abandoned. The developers of the technologies were given a maximum of 24 hours (three 8-hour working days) for surveying the site (excluding the time required to establish the sampling grid and locate survey locations). It is important to note that each developer was responsible for determining the number of samples to be taken in order to create an "adequate" characterization of the site.

Two cost analysis reports were created for each technology based on responses to the questionnaires. One report develops the "basic cost", shown in Table 1, which reports the following tasks and their associated labor costs: 1) site preparation costs such as cutting the grass and weeds (if applicable for each technology) and establishing a sampling grid and locating survey locations, 2) labor costs to conduct the field work based on the "minimum time" that personnel are required to be in the field, and 3) maintenance costs for the technology based on the number of days of use. This estimate excludes all transportation, lodging, and per diem for the crews operating the technology. The following example provides an explanation of the "minimum time" that personnel are required to be in the field. For the *in situ* gamma detector, the developer reported the following: 8 hours are required for a technician to establish sampling grid and locate survey locations, 3 hours are required for a technician to conduct the field work (survey the number of areas shown in Table 1), and 2 hours are required for a scientist to compile the data. The costs for each of these tasks (along with the maintenance cost for the detector for 1 day of sampling) are summed and the results ($1,083) are shown in Table 1.

The second cost analysis report develops the "total expected cost" for the scenario, which includes the total costs to characterize the site if an interested party asked each characterization group to provide a bid for site characterization. This report includes the total cost to characterize the site from start to finish. In other words, from the time the technology developers leave their facility for the site until they complete their characterization work and return to their original destination. Therefore, travel costs and personnel salaries for the travel days to and from the site were included in these cost estimates. In addition, the labor cost for the additional hours personnel are required to be on the site were included in the "total expected cost" report. For example, to perform data compilation a scientist using the *in situ* gamma detector is required to be in the field for only 2 hours during the 2 days of characterization (one day for establishing the sampling grid plus 1 day of surveying). As stated in the previous paragraph, the cost for only 2 hours of labor time for the scientist is reported in the "basic cost" report. However, realistically (if they were providing a work proposal to a potential customer), the scientist still has to be on the site while the sampling grid is being established (8 hours on the first day), as well as during the remaining 6 hours of the 1 day of surveying. Therefore, an additional 30 hours (16 hours for 2 travel days plus 14 hours during the 2 days of characterization) of the scientist's labor costs were included in the "total expected cost" report for the *in situ* gamma detector. Likewise, an additional 21 hours (16 hours for 2 travel days plus 5 hours during the one day of surveying) of the technician's labor costs were included in the "total expected cost" report as compared to the "basic cost" report.

Beta Scintillation Detector. The wide-area beta detector will consist of multiple layers of a solid (plastic) organic scintillating material, which will detect beta particles emitted from the near-surface uranium and its associated daughter products. The field version sets directly on the ground and detects contamination from an approximate surface area of 1,000 to 2,000 cm^2 (FEMP 1992). The developer of the beta scintillation detector reported that it would take 3 days to adequately characterize the 1-acre site. The weeds and grass on the site would need to be cut to approximately one inch high. A technician is required for one day to establish a sampling grid and approximately 100 evenly spaced survey locations. The remaining 2 days would be devoted to surveying the site, including 16 hours for a technician to collect the data (including physically moving the sensor) and 4 hours for a scientist to compile the data. As shown in Table 1, the "basic cost" for characterizing the site is **$2,438**, or $24 per sample (2438/100).

The cost analysis report which develops the "total expected cost" for the beta scintillation detector includes 2 days of round trip travel costs, since the site was assumed to be 250 miles from the developer's facility location. These travel costs include lodging for 4 nights, per diem for 5 days, and transportation in a company van for the two-member crew needed to operate the technology. In addition, 2 days (16 hours) of labor costs for the technician were included for the required travel days. Thirty-six hours of labor costs for the scientist were also included in this cost estimate because of the 2 travel days (16 hours) and the additional time (20 hours) that the scientist would be on the site while the sampling grid was being established and during the 2 days required to survey the site. Referring to Table 1, the total expected cost to characterize the 1-acre site for this scenario is **$8,898**, or $89 per sample (8898/100).

In Situ Gamma Detector. The *in situ* gamma detector is composed of a intrinsic germanium diode which is suspended from a tripod one meter above the ground. The detector is designed to survey areas as large as 100 m^2 within a relatively short amount of time and provide output regarding local surface and shallow ($<$ 1m) subsurface contamination (FEMP 1992). The developer of the gamma detector reported that it would take 2 days to adequately characterize the 1-acre site. The weeds and grass did not have to be cut for this field screening technology. A technician is required for one day to establish a sampling grid and approximately 20 evenly spaced survey locations. The technology developer stated that only one day of surveying was required to provide an adequate characterization of the site. During this one day of field work, 3 hours are required for the technician to collect data at the 20 survey locations and 2 hours are required for the scientist to compile the data. Referring to Table 1, the "basic cost" for characterizing the site is **$1,083**, or $54 per sample (1083/20).

The cost report which calculates the "total expected cost" for the *in situ* gamma detector includes 2 days of round trip travel costs, since the site was assumed to be 250 miles from the developer's facility location. These travel costs include lodging for 3 nights, per diem for 4 days, and transportation in a company van for the two-member crew needed to operate the technology. Twenty-one hours of labor time for the technician were included in the cost estimate because of the 2 days of travel (16 hours) and the additional 5 hours he or she is on the site during the one day of surveying. Also, 30 hours of labor time for the scientist were included because of the 2 travel days (16 hours) and the additional 14 hours he or she is on the site while the sampling grid is being set up and during the one day of field work. Referring to Table 1, the total expected cost to characterize the 1-acre site for this scenario is **$6,973**, or $349 per sample (6973/20).

Long-Range Alpha Detector. Alpha contamination monitoring has traditionally been limited by the short range of alpha particles in air and through detector windows. The LRAD circumvents that limitation by detecting alpha-produced ions rather than alpha particles (FEMP 1992). The LRAD is composed of a detector assembly which is maneuvered in the field by a small tractor. The developer of the LRAD reported that it would take 4 days to adequately characterize the 1-acre site in the scenario evaluation—one day to establish the sampling grid and locate survey locations and 3 days to collect the data. The weeds and grass would need to be cut to ensure proper operation of this technology. A technician is required for one day to establish the sampling grid and approximately 100 survey locations. During the 3 days of field work, the technician would drive the tractor and move the detector equipment, and the scientist would collect readings, record the data, and plot these data at the end of each sampling day. Referring to Table 1, the "basic cost" for characterizing the site is **$5,560**, or $56 per sample (5560/100).

As with the scenario evaluations for the other technologies, the report which develops the "total expected cost" for the LRAD includes 2 days of round trip travel costs for the two-member crew needed to operate the technology. These travel costs include lodging for 5 nights, per diem for 6 days, and transportation in a rental vehicle large enough to house the equipment (a U-Haul is normally used to transport the equipment). Two days (16 hours) of labor time for the technician were included because of the required travel days. In addition, 24 hours of labor time for the scientist were included in the cost estimate because of the 2 travel days (16 hours) and the additional 8 hours he or she is on the site while the sampling grid is being established. Referring to Table 1, the total expected cost to characterize the 1-acre site for this scenario is **$12,900**, or $129 per sample (12900/100).

Traditional Field Surveying Equipment. The cost input questionnaire given to the developers of the USID field screening technologies was also completed by a DOE-site group experienced in the characterization of radioactive-contaminated surface soils. Based on their responses to the questionnaire and on follow-up discussions, cost estimates were created for the characterization of the 1-acre site containing uranium-contaminated surface soils. The cost estimate reflects a gamma scan of the entire 1-acre site using a sodium iodide gamma scintillation detector, beta-gamma measurements using Geiger-Muller (G-M) "pancake" detectors at gamma scan hot spots in order to detect beta emitters, and the collection and laboratory analysis of 4 soil samples. These tasks are normally standard operating procedure for sites similar to the one presented in the questionnaire that formed the basis for this study. In addition, labor hours were added to the estimate for liaison efforts with health physics personnel, as well as data management, project coordination, and report preparation responsibilities. Other labor efforts included the cutting of weeds and grass on the site to approximately one inch high. The work was estimated to be completed in two days: one day to establish the sampling grid and sample locations and the second day to conduct the gamma scan, beta-gamma scan at gamma scan hot spots, and the collection of 4 surface soil samples, using two personnel. Group members stated that typically a one-acre site is divided into four-100 ft x 100 ft quadrants, with 4 soil samples collected (one in each grid block) for verification of the field surveying results. The 4 samples would be analyzed by gamma spectrometry at the DOE-site laboratory to obtain isotopic analysis results for uranium and other gamma emitters. Referring to Table 1, the "basic cost" for this level of effort by the DOE-site group is **$3,880**.

The "total expected cost" includes 2 days of round trip travel costs for the two-member crew. These travel costs include lodging for 3 nights, per diem for 4 days, and transportation costs for the two personnel. Thirty-two hours of labor time were included because of the travel days for the two personnel. In addition, 8 hours of labor time for a technician were included in the cost estimate because he or she will be on the site while the sampling grid is being established the first day (the labor cost of only one technician is accounted for in the "basic cost" report for establishing the sampling grid). Referring to Table 1, the total expected cost to characterize the 1-acre site for this scenario is **$8,548**.

General Observations from the Cost Study. The labor rates for each USID field screening technology user, as well as the DOE facility group conducting traditional field surveying, are approximately the same. Therefore, the "total expected cost" figures shown in Table 1 are directly proportional to the number of days that are required to characterize the 1-acre site for each technology. For example, 4 days are required to collect data at 100 survey locations by technicians using the LRAD, with a "total expected cost" of $12,900, whereas only 3 days are required to collect data at 100 survey locations with the beta scintillation detector, with a "total expected cost" of $8,898. Likewise, only 2 days are required to collect data at 20 survey locations by technicians using the *in situ* gamma detector, with a "total expected cost" of $6,973. A factor which disproportionally increased the LRAD cost estimate is a transportation cost of $2,000 (not required for the beta scintillation and *in situ* gamma detectors) for the rental vehicle used to transport the equipment to the site.

The developer of the *in situ* gamma detector (the only technology with a lower cost estimate than that of the traditional field surveying cost estimate) stated that once the sampling grid was established and the 20 surveying areas were located, the entire 1-acre site could be characterized in one day. Even though the cost estimate for the *in situ* gamma detector was less than the traditional field surveying estimate from the DOE facility, one must consider that the level of effort undertaken by the DOE facility characterization group included a gamma scan of the entire site, as well as the collection and laboratory analysis of surface soil samples for verification of the field survey results. The cost to collect and analyze soil samples for verification of the *in situ* gamma detector results, as well as the other USID field screening technologies, was not included in their respective cost estimates because the technology developers deemed it unnecessary for an adequate site characterization.

Cost Study of Single-Point Surface Soil Sampling and Laboratory Analysis for Uranium-Contaminated Soil

A study of single-point soil sampling and laboratory analysis costs was conducted by comparing operational costs of the mobile LA-ICP/AES laboratory with the operational costs of traditional sampling and analysis. The traditional method consists of collecting soil samples and conducting analysis in a radiochemical laboratory. Cost input questionnaires were sent to characterization groups experienced in field sampling and laboratory analysis at two DOE facilities. Based on these questionnaires and on follow-up discussions with each group, cost estimates were created for the characterization of the 1-acre site in the scenario evaluation.

To achieve adequate site characterization, the developer of the mobile LA-ICP/AES laboratory stated that 44 samples could be collected and analyzed over a 3-day period. Therefore, in order to compare this technology to traditional field sampling and laboratory analysis, the cost input questionnaire sent to the two DOE facilities was based on collecting and analyzing 44 surface soil samples. For all three characterization technologies, 4 of the 44 samples are to be analyzed by an EPA-certified laboratory to obtain isotopic and total uranium data, which are required in order to confirm the results of the field measurements. For the traditional field sampling and laboratory analysis cost estimates, the remaining soil samples (40) are analyzed by gamma spectrometry at each respective DOE site laboratory to obtain isotopic uranium results.

Two cost analysis reports were created for each characterization technology. One report develops the "direct cost", shown in Table 2, which includes the costs associated with characterizing the site once the crew is set up and ready to begin collecting soil samples. This estimate excludes all transportation, lodging, and per diem for the crews operating the technology, as well as labor costs for personnel during the two travel days. The second cost analysis report shows the "total expected cost" for the scenario, which includes the total cost to characterize the site from start to finish. In other words, from the time the technology developers leave their facility for the site until they complete their characterization work and return to their original destination. Therefore, travel costs (transportation, lodging, and per diem) and personnel salaries for the travel days to and from the site were included in this cost estimate.

Mobile LA-ICP/AES Laboratory. The ICP/AES instrument has been used for years to measure both qualitative and quantitative information for inorganic analytes. Laser ablation is a relatively new concept in preparing samples for direct injection into the plasma of the ICP torch. The mobile LA-ICP/AES laboratory places the ICP/AES instrumentation into a mobile configuration for real-time *in-situ* sampling and analysis at the sampling site. This technology is configured to analyze soils for 18 different inorganic elements simultaneously, including uranium and thorium (FEMP 1992). The developer of the mobile LA-ICP/AES technology reported that it would take 3 days to adequately characterize the 1-acre site. The cost estimates include salaries for the 4 personnel required to conduct the field work and laboratory analysis, as well as maintenance and supply costs associated with this technology. Field work involves first establishing a grid of 12 m × 12 m squares on the 1-acre site. Forty of the 44 samples would then be collected and analyzed in the mobile laboratory during the 3-day period. The remaining 4 samples would be sent to an EPA-certified laboratory to obtain isotopic and total uranium results. As shown in Table 2, the "direct cost" for this effort is $11,745, or **$267** per sample (11745/44).

The cost analysis report which develops the "total expected cost" includes 2 days of round trip travel costs for the four-member crew operating the technology. Travel costs include lodging for 4 nights, per diem for 5 days, and transportation to and from the site (250 miles away from developer's facility location) for the personnel. Two technicians can travel in the diesel truck that pulls the fifth-wheel mobile laboratory and the other two personnel can use a company truck or van to travel to the site. Referring to Table 2, the cost to characterize the 1-acre site for this scenario is $16,985, or **$386** per sample (16,985/44).

Traditional field sampling and laboratory analysis from DOE facilities A and B. Cost estimates were created based on discussions with representatives from two DOE facilities. The estimates were based on collecting 44 surface soil samples in the field and sending them to a radiochemical laboratory for analysis. The DOE facility A characterization group stated that it takes approximately 30 minutes (including set-up time) to auger, collect, bag, and label the sample, as well as decontaminate the equipment. They normally use 3 personnel in a work crew. Therefore, 3 personnel can collect 2 samples in one hour, resulting in 1.5 manhours per sample. Based on this rate, it would take 3 days to complete the field work. The labor rate for personnel is $96.20 per hour. As shown in Table 2, the "direct cost" for this sampling scenario is $16,029, or **$364** per sample (16029/44). This includes the labor for the field characterization work, miscellaneous equipment charges, isotopic uranium results by gamma spectrometry analysis at the DOE-site laboratory for 40 samples, and isotopic and total uranium results from an EPA-certified laboratory for 4 samples. The cost analysis report which develops the "total expected cost" includes 2 days of round trip travel costs since the site was assumed to be located 250 miles from the characterization groups' facility. Travel costs include lodging for 4 nights, per diem for 5 days, and transportation for the 3-member crew. In addition, 2 days (48 hours at $96.20/hour) for travel to the site for the 3 crew members were included in the cost estimate. The "total expected cost" for this scenario (Table 2) is $22,107, or **$502** per sample.

In contrast to the DOE facility A characterization group, the group from DOE facility B stated that the charge rate for the field work involved in collecting the soil samples (auger, collect, bag, label sample, and decontaminate equipment) is approximately 4.5 manhours per sample. Based on this rate, it would take 5 days to complete the field work with 4 personnel. However, although the number of manhours is three times the amount that is charged at DOE facility A, facility B's labor rate is much less at $56 per hour. This results in DOE facility B's labor costs being approximately twice the amount as that charged by DOE site A for the same field work. Laboratory analysis costs for the two DOE facilities were approximately equal, although facility B's costs were somewhat higher due to an additional alpha/beta screening test that was required and a higher EPA-certified laboratory analysis cost. From Table 2, the "direct cost" for the sampling scenario is $21,784, or **$495** per sample (21784/44). This represents the same level of effort required from the characterization group from DOE facility A. The cost analysis report which develops the "total expected cost" includes lodging for 6 nights, per diem for 7 days, and transportation costs to the site for the 4-member crew. In addition, 2 days (64 hours at $56/hour) for travel to the site for the 4 crew members were included in the cost estimate. The "total expected cost" for this scenario (Table 2) is $28,068, or **$638** per sample.

General Observations from the Cost Study. Traditional approaches for site characterization require that the samples be sent or delivered to a radiochemical laboratory. The amount of time it takes to receive data results from the radiochemical laboratory can vary greatly depending on many factors, including the laboratory's existing workload and previous commitments for analysis work. The mobile LA-ICP/AES laboratory provides both time savings and cost savings when compared to traditional field sampling and laboratory analysis. Because the ICP/AES technology is placed into a mobile configuration for real-time site characterization, laboratory results are obtained within a short period of time without ever leaving the site.

The major reason for the cost savings of the mobile LA-ICP/AES laboratory versus traditional sampling and laboratory analysis at DOE facility A is that the personnel labor rates at facility A are approximately 92% higher than those for technicians using the mobile LA-ICP/AES technology. Even though the personnel labor rates at DOE facility B are only 12% higher than those for technicians using the mobile LA-ICP/AES technology, facility B's "total expected cost" was much higher due to the high number of manhours necessary to collect the soil samples. Five days are required by the DOE facility B characterization group to conduct the field work, whereas only 3 days are required by the mobile LA-ICP/AES technology and the DOE facility A group to conduct the same field work.

CONCLUSIONS

Two cost studies which compare four USID field screening technologies to traditional field sampling and laboratory analysis were created as part of the performance assessment for these technologies. In order to compare field screening detectors, a cost study was conducted which compared the beta scintillation detector, *in situ* gamma detector, and LRAD to traditional field surveying equipment (i.e., beta and gamma detectors) for the characterization of surface soils. The cost estimates indicate that although the use of traditional field surveying equipment is 23% higher than the *in situ* gamma detector, it costs less than the use of the beta scintillation detector or LRAD. The use of traditional field surveying equipment results in cost savings of 4% and 34% over the use of the beta scintillation and LRAD technologies, respectively. Because the labor rates for personnel using the USID field screening technologies and the traditional field surveying equipment were approximately the same, the cost figures are directly proportional to the number of days that are required to characterize the 1-acre site for each technology. Therefore, the use of the *in situ* gamma detector and the traditional field surveying equipment result in lower cost estimates because only 2 days are required for each technology to characterize the site. However, advantages of the use of traditional field surveying equipment over the USID field screening technologies include the following: a survey of the entire 1-acre site and the collection and laboratory analysis of 4 surface soil samples for verification of the traditional field surveying results.

The second cost study investigated single-point surface soil sampling and laboratory analysis by comparing the mobile LA-ICP/AES laboratory technology to traditional field sampling and laboratory analysis. Results of the cost study indicate that significant cost savings are achievable by using the USID-developed mobile LA-ICP/AES laboratory for site characterization. The use of the mobile LA-ICP/AES laboratory results in cost savings of 23% to 40% over traditional field sampling and laboratory analysis. Cost savings of the mobile LA-ICP/AES laboratory over traditional sampling and laboratory analysis are due primarily to the fact that personnel labor rates and amount of time required for sampling and analysis are higher than those required for operation of the mobile LA-ICP/AES laboratory.

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Table 1. Cost Study of Three USID Field Screening Detector Technologies and Traditional Field Surveying Equipment

PARAMETER	CHARACTERIZATION TECHNOLOGY			
	Beta Scintillation Detector	**In Situ Gamma Detector**	**Long-Range Alpha Detector**	**Traditional Field Surveying Equipment[1]**
Number of days to characterize 1-acre site[2]	3	2	4	2
Number of field personnel	2	2	2	2
Number of areas surveyed	100	20	100	NA[3]
Basic Cost[4]	**$2,438**	**$1,083**	**$5,560**	**$3,880**
Cost/Sample (based on basic cost)	$24	$54	$56	NA
Total Expected Cost[5]	**$8,898**	**$6,973**	**$12,900**	**$8,548**
Cost/Sample (based on total expected cost)	$89	$349	$129	NA

[1] Includes the following tasks: a gamma scan of the entire area using sodium iodide gamma scintillation detectors, beta-gamma measurements using Geiger-Muller (G-M) "pancake" detectors at gamma scan hot spots for beta detectors, and 4 soil samples collected and analyzed in DOE-site laboratory for verification of field surveying results

[2] For all technologies, this includes one day to establish sampling grid and locate survey locations and the remaining day(s) to survey the site

[3] Not applicable because entire area is scanned for gamma emitters (see footnote #1)

[4] Estimate **excludes** all transportation, lodging, and per diem costs for the crews operating the technology, as well as labor costs for personnel during the two travel days. The estimate reflects the minimum time that personnel are required to be in the field during site characterization

[5] Estimate **includes** all transportation, lodging, and per diem costs for the crews operating the technology, as well as labor costs for personnel during the two travel days and the additional hours they are required to be on the site during site characterization

Table 2. Cost Study of Single-Point Surface Soil Sampling and Laboratory Analysis for Uranium-Contaminated Soil

PARAMETER	CHARACTERIZATION TECHNOLOGY		
	Mobile LA-ICP/AES Laboratory	Traditional Field Sampling and Lab. Analysis from DOE Site A[1]	Traditional Field Sampling and Lab. Analysis from DOE Site B[1]
Number of days to characterize 1-acre site	3	3	5
Number of field personnel	4	3	4
Number of samples collected	44	44	44
Direct Cost[2]	$11,745	$16,029	$21,784
Cost/Sample (based on direct cost)	**$267**	**$364**	**$495**
Total Expected Cost[3]	$16,985	$22,107	$28,068
Cost/Sample (based on total expected cost)	**$386**	**$502**	**$638**

[1] Traditional field sampling and laboratory analysis conducted by Characterization groups from two DOE sites. 90% of the samples (40) analyzed by gamma spectrometry at DOE site laboratory for isotopic uranium results and 10% of the samples (4) analyzed at an EPA-certified laboratory to obtain isotopic and total uranium results

[2] Estimate **excludes** all transportation, lodging, and per diem costs for the crews operating the technology, as well as labor costs for personnel during the two travel days

[3] Estimate **includes** all transportation, lodging, and per diem costs for the crews operating the technology, as well as labor costs for personnel during the two travel days

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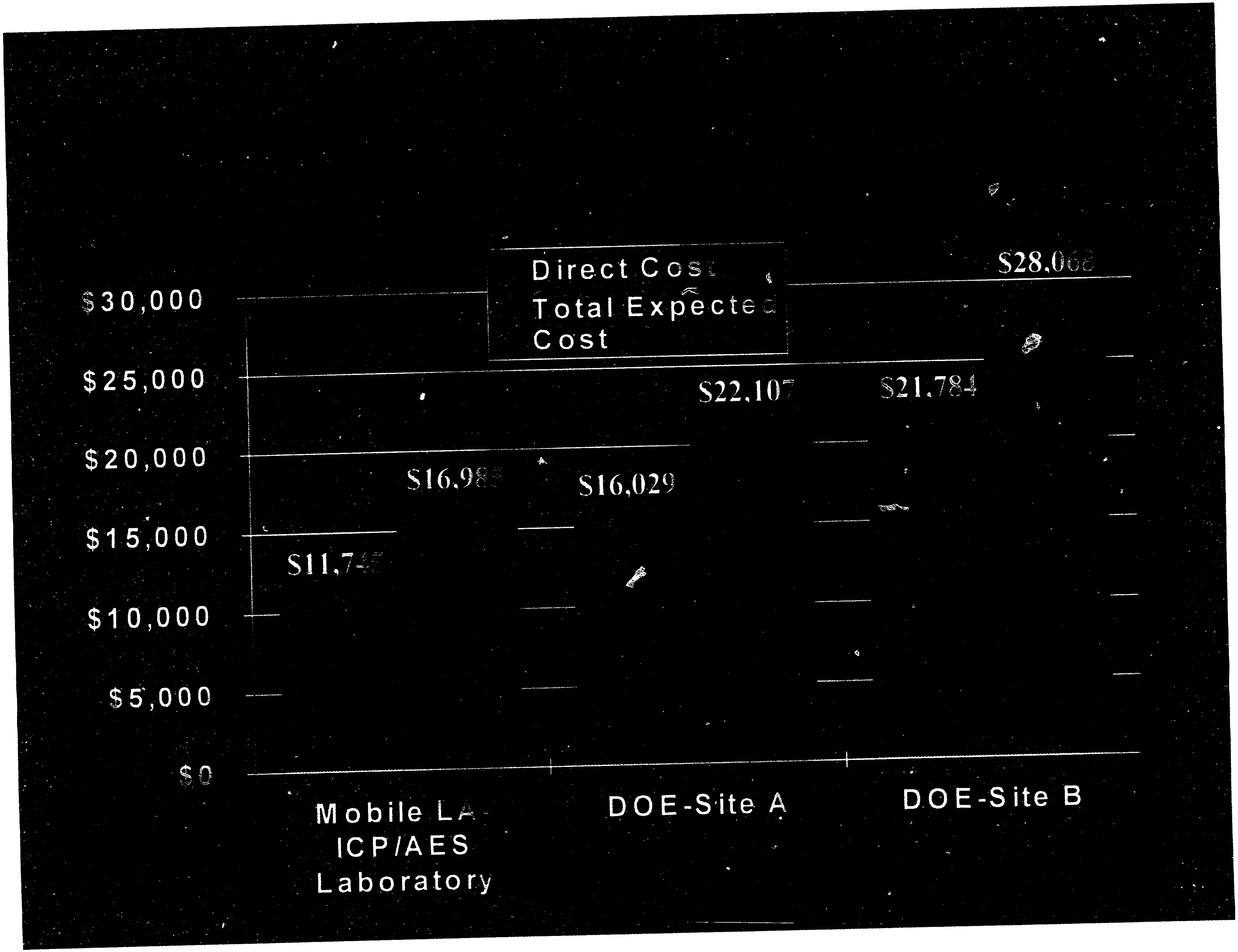
Mobile Laser Ablation-Inductively Coupled Plasma/Atomic Emission Spectrometry (LA-ICP/AES) Laboratory

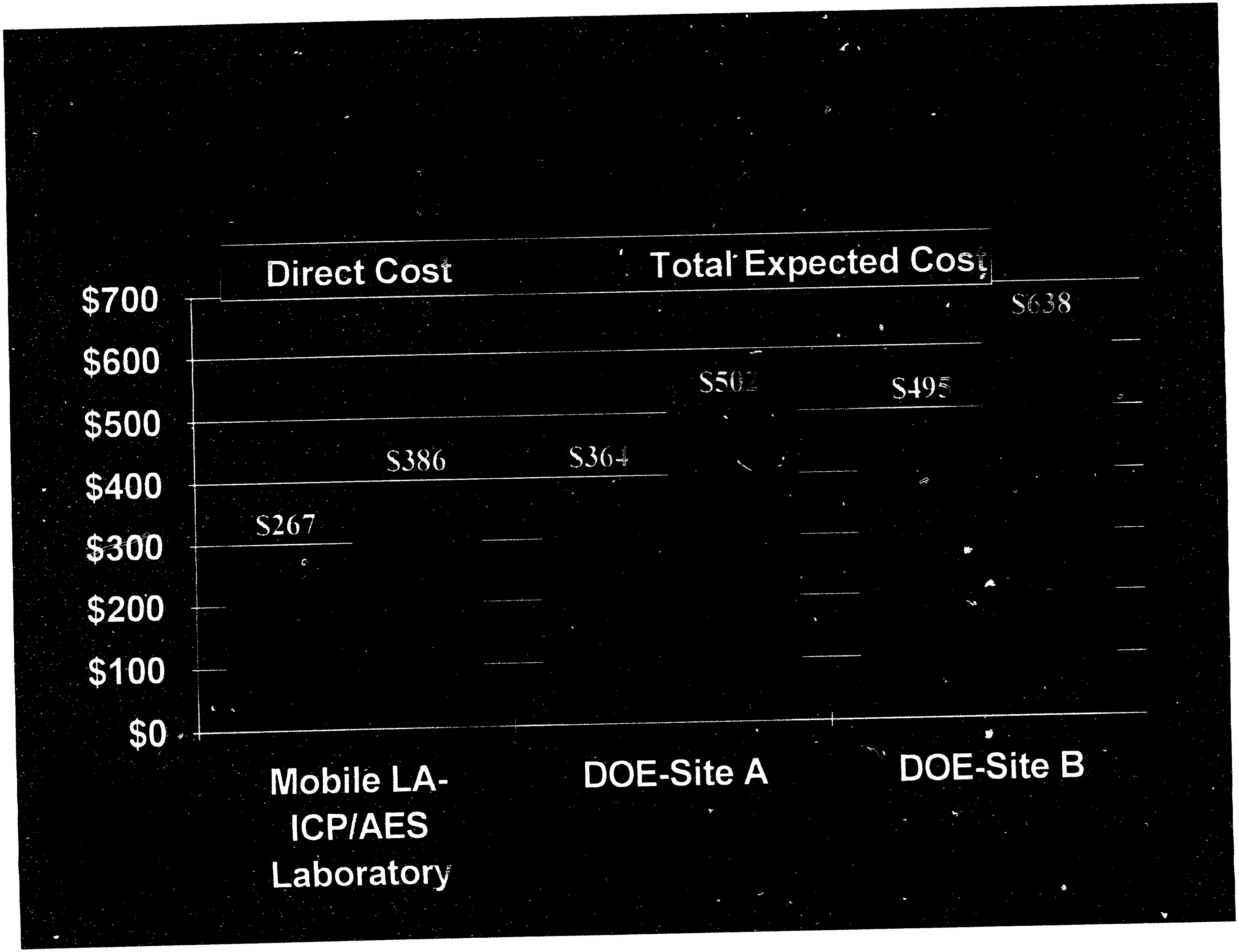
VS

Traditional Field Sampling and Laboratory Analysis conducted by Characterization Groups at 2 DOE sites

- A level 1-acre site with uranium-contaminated surface soil, with the only vegetation on the site being 6-inch high grass
- The technology developers' were responsible for determining extent of sampling necessary to create an adequate characterization of site over a 3-day period
- 44 samples collected by field personnel
- The site is 250 miles away from Characterization groups' site



Direct Cost
Total Expected Cost
$30,000
$25,000
$20,000
$15,000
$10,000
$5,000
$0
$11,745
$16,985
$16,029
$22,107
$21,784
$28,068
Mobile LA
ICP/AES
Laboratory
DOE-Site A
DOE-Site B


Direct Cost
Total Expected Cost
$700
$600
$500
$400
$300
$200
$100
$0
$267
$386
$364
$502
$495
$638
Mobile LA-ICP/AES Laboratory
DOE-Site A
DOE-Site B

The use of the mobile LA-ICP/AES lab. results in cost savings of 23% over traditional field sampling & laboratory analysis at DOE-site A

The use of the mobile LA-ICP/AES lab. results in cost savings of 40% over traditional field sampling & laboratory analysis at DOE-site B

Cost savings for mobile LA-ICP/AES lab. due [illegible] lower personnel labor rates and reduced time required for sampling and analysis

Beta Scintillation, *in situ* gamma, and long-range alpha detectors, funded by the DOE under the direction of the Uranium-in-Soils Integrated Demonstration Project

vs

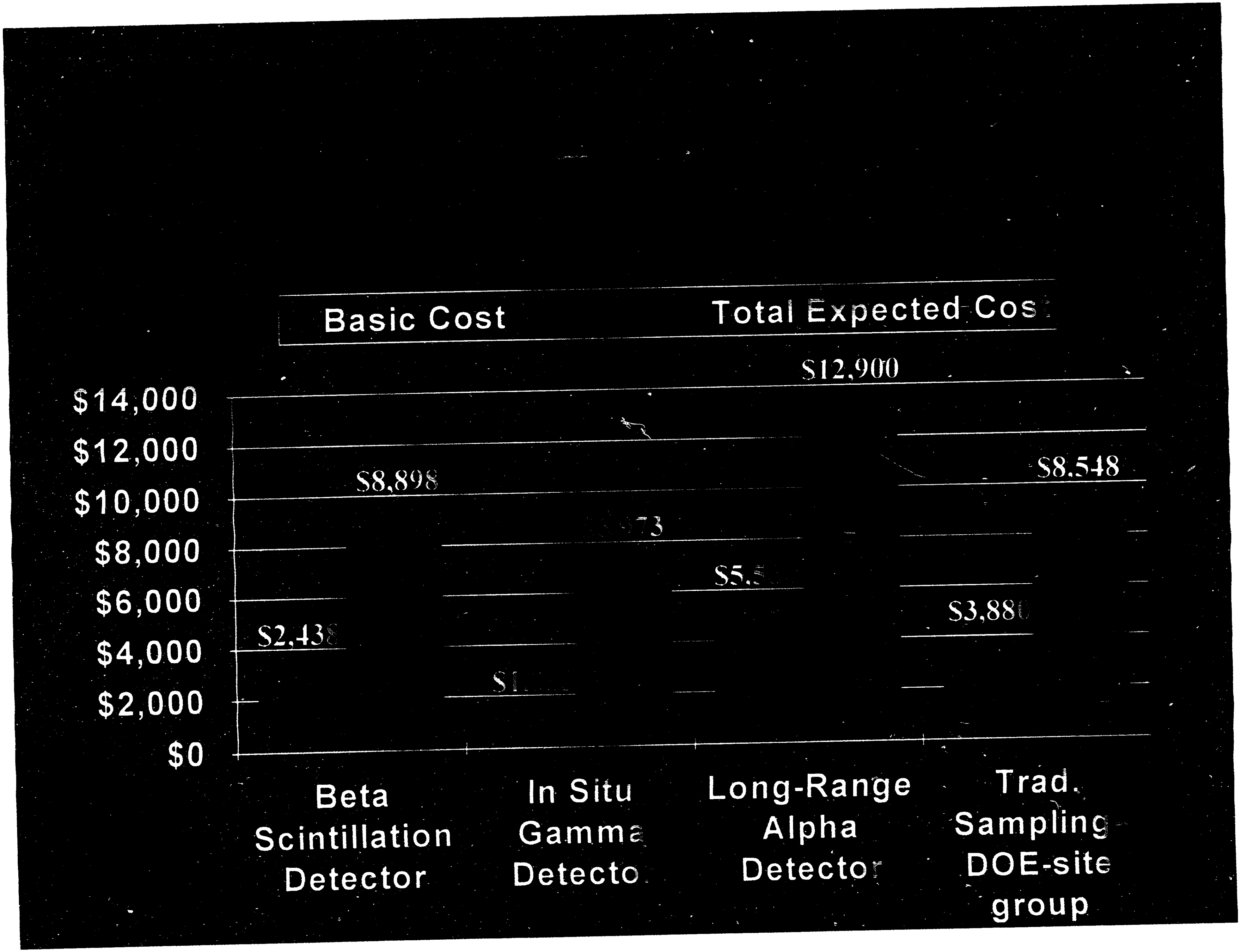
Traditional Field Surveying Equipment conducted by a DOE-site group experienced in the characterization of radioactive-contaminated surface soils

This estimate includes the following:

- Site preparation costs, such as cutting grass & weeds, establishing sampling grid and locating survey locations
- Labor cost to conduct field work based on "minimum time" that personnel are required to be in the field
- Maintenance cost for technology based on the number of days of use

This estimate includes the total cost [illegible] characterize site if a bid for site characterization was provided to an interested party. It includes:

- "Basic cost" elements
- Transportation costs for crew
- Lodging costs for crew
- Per diem costs for crew
- Personnel labor costs for the 2 travel days
- Additional hours personnel are required to be on the site


Basic Cost
Total Expected Cost
$14,000
$12,000
$10,000
$8,000
$6,000
$4,000
$2,000
$0
$2,438
$8,898
$12,900
$5,5
$3,880
$8,548
Beta Scintillation Detector
In Situ Gamma Detector
Long-Range Alpha Detector
Trad. Sampling DOE-site group

The cost figures shown are directly proportional to the number of days that are required to characterize the 1-acre site for each technology. This is due to the labor rates for each technology being approximately the same

The use of traditional field surveying equipment resulted in cost savings of 4% and 34% over the use of the beta scintillation and long-range alpha detectors, respectively

The use of the *in situ* gamma detector resulted in cost savings of 18% over the use of traditional field surveying equipment

Even though the use of the *in situ* gamma detector resulted in cost savings over the use of traditional field surveying equipment, the level of effort undertaken by the DOE-site group included a gamma scan of the entire 1-acre site, beta-gamma measurements at gamma scan hot spots for beta emitters, and the collection and laboratory analysis of 4 soil samples for verification of the traditional field surveying results