# 4.0 Economic Analysis

This economic analysis presents two cost estimates for the application of Envirobond™ (not including profit) to commercially remediate soil contaminated with lead. The estimates are based on assumptions and costs provided by RMRS; data compiled during the SITE demonstration; and additional information obtained from current construction cost estimating guidance, as well as experience under the SITE Program. Costs for the technology can vary, depending on soil conditions, regulatory requirements, and other site- and waste-specific factors.

Two estimates are presented in this analysis to determine the costs of applying Envirobond™. The first estimate (Case 1) is based on costs incurred during the SITE demonstration. The total volume of soil treated at the CRPAC demonstration site was approximately 5 cubic yards. That volume was spread over ten 5-foot-by-5-foot-by-0.5 foot plots and one 6-foot-by-3-foot-by-0.5 foot plot. The second estimate (Case 2) is for a hypothetical one-acre site at the CRPAC that would be treated to depth of 0.5-foot. Case 2 represents a typical application of Envirobond™. The cost estimate for Case 2 is based on extrapolation of data from the costs of the SITE demonstration. For Case 2, the total volume of soil to be treated is 807 cubic yards. Two scenarios are presented because of certain "fixed" costs related to the use of the technology, the unit cost per volume drops significantly when it is applied to larger volumes of material.

This section summarizes factors that influence costs, presents assumptions used in the analysis, discusses estimated costs, and presents the conclusions of the economic analysis. Table 4-1 presents the estimated costs generated by the analysis. Costs have been distributed among 12 categories that are applicable to typical cleanup activities at Superfund and RCRA sites (Evans 1990). Costs are presented in 1998 dollars, are rounded to the nearest 100 dollars, and are considered to be minus 30 percent to plus 50 percent order-of-magnitude estimates.

## 4.1 Factors that Affect Costs

Costs for implementing Envirobond™ can be affected by site-specific factors, including the regulatory status of the site, waste-related factors, total volume of soil to be treated, site features, and soil conditions. The regulatory status of the site typically depends on the type of waste management activities that occurred at the site, the relative risk to nearby populations and ecological receptors, the state in which the site is located, and other factors. The site's regulatory status affects costs because it makes the site subject to mandates related to ARARs and remediation goals that may affect the system design parameters and the duration of the remediation project. Certain types of sites may be subject to more stringent monitoring requirements than others, depending on the regulatory status of the individual site. Soil conditions at the site determine the possible treatment depth, which can affect costs.

Factors related to the waste that affect costs include the volume, distribution, and type of contamination at the site, which have a direct effect on site preparation costs; the amount of Envirobond™ needed; and the amount of time necessary to treat the soil. The type and concentration of the contaminant also will affect disposal costs for wastes generated by the remediation effort.

The location and physical features of the site will affect the cost of mobilization, demobilization, and site preparation. Mobilization and demobilization costs are affected by the distances that system materials must be transported to the site. For high-visibility sites in densely populated areas, stringent security measures and minimization of obtrusive construction activities, noise, dust, and air emissions may be necessary. Sites requiring extensive surficial preparation (such as constructing access roads, clearing large trees, or working around or demolishing structures) or restoration activities also will incur higher costs than sites that do not require such preparation. The availability of existing electrical power and water supplies may facilitate construction activities and lower costs. In the United States significant regional variations may occur in the costs of materials, equipment, and utilities.

## 4.2 Assumptions of the Economic Analysis

For Case 1, existing technology and site-specific data from the demonstration were used to present the costs of applying Envirobond™ at the CRPAC demonstration site. Certain assumptions were made to account for variable site and waste parameters for Case 2. In general, most system operating issues and assumptions are based on information provided by RMRS and observations made during the SITE demonstration. For both cases, costs were based on information provided by RMRS, observations made and data collected during the SITE demonstration, current environmental restoration cost guidance (R.S. Means [Means] 1998), and experience under the SITE program.

**Table 4-1.** Cost Distribution for Envirobond™

| Cost Categories | Case 1 (5 $yd^3$) | | | Case 2 (807 $yd^3$) | | |
|---|---|---|---|---|---|---|
| | Costs | Cost/$yd^3$ | % Costs | Costs | Cost/$yd^3$ | % Costs |
| (1) Site Preparation | | | | | | |
| Rental Equipment | $30 | | | $115 | | |
| Labor and Per Diem | $1,350 | | | $1,350 | | |
| Total Site Preparation Costs | $1,400 | $280 | $5.41 | $1,500 | $1.86 | $4.52 |
| (2) Permitting and Regulatory | —- | —- | —- | —- | —- | — |
| (3) Mobilization | | | | | | |
| Mileage | $400 | | | $400 | | |
| Labor and Per Diem | $3,100 | | | $3,100 | | |
| Total Mobilization Costs | $3,500 | $700 | $13.52 | $3,500 | $4.34 | $10.54 |
| (4) Equipment | | | | | | |
| Rental Equipment | $50 | | | $700 | | |
| Purchased Equipment | $250 | | | —- | | |
| Total Equipment Costs | $300 | $60 | $1.16 | $700 | $0.87 | $2.11 |
| (5) Labor | | | | | | |
| Labor | $12,100 | | | $7,320 | | |
| Per Diem | $2,480 | | | $800 | | |
| Total Labor Costs | $14,580 | $2,916 | $56.34 | $8,120 | $10.06 | $24.44 |
| (6) Supplies and Materials | | | | | | |
| Envirobond™ | $100 | | | $8,900 | | |
| Sampling Supplies | $200 | | | $400 | | |

Note: 1998 dollars.

(continued)

| **Table 4-1.** Cost Distribution for Envirobond™ (continued) | | | | | | |
|---|---|---|---|---|---|---|
| Cost Categories | Case 1 (5 $yd^3$) | | | Case 2 (807 $yd^3$) | | |
| | Costs | Cost/$yd^3$ | % Costs | Costs | Cost/$yd^3$ | % Costs |
| PPE and Decontamination Supplies | $500 | | | $800 | | |
| Misc. Field Supplies | $200 | | | $900 | | |
| Total Supplies and Materials Costs | $1,000 | $200 | $3.86 | $11,000 | $13.63 | $33.11 |
| (7) Utilities | —- | —- | —- | —- | —- | — |
| (8) Effluent Treatment & Disposal | —- | —- | —- | —- | —- | — |
| (9) Residual Waste Shipping | —- | —- | —- | $700 | $0.87 | $2.11 |
| (10) Analytical Services | $1,600 | $320 | $6.18 | $4,200 | $5.20 | $12.64 |
| (11) Equipment Maintenance | —- | —- | —- | —- | —- | — |
| (12) Site Demobilization | | | | | | |
| Mileage | $400 | | | $400 | | |
| Labor and Per Diem | $3,100 | | | $3,100 | | |
| Total Site Demobilization Costs | $3,500 | $700 | $13.52 | $1,500 | $4.34 | $10.54 |
| Total Costs | $25,880 | $5,176 | $100.00 | $33,220 | $41.16 | $100.00 |
| Note: 1998 dollars. | | | | | | |

For both cases, assumptions made about site- and waste-related factors for both cases include:

- The two sites are located in the CRPAC, where disposal of broken and "off-spec" pottery having lead-based glazes has contaminated the soil with lead.
- The total volume of material treated for Case 1 is approximately 5 cubic yards. The total volume of soil to be treated for Case 2 is 807 cubic yards.
- There is an existing access road, and there are no accessibility problems associated with the two sites.
- There are no structures on either site that require demolition. No utilities are present that require relocation or that restrict operation of heavy equipment.
- For Case 1, it is assumed that the sod covering the site can be removed with sod cutters and can be replaced after the soil has been treated. For Case 2, it is assumed that some clearing and grubbing will be necessary to prepare the site for the application of Envirobond™.
- Electricity for both sites can be provided by a portable generator.
- For both cases, the highest levels of contaminated soil extend from the ground surface to a depth of approximately 6 inches below ground surface.
- This estimate assumes that the wastes generated during the application of Envirobond™ are limited to those produced during decontamination of equipment used during the application. For Case 1, residual waste will be disposed of on site. For Case 2, waste generated during the decontamination activities can be treated and disposed of at easily accessible facilities. Wastewater can be discharged to a POTW for $1 per gallon. Nonhazardous solid waste can be transported and disposed of for $60 per ton.

For both cases, the assumptions about system design and operating parameters for both cases include:

- RMRS provides on-site personnel during all phases of the treatment.

- An hourly labor rate of $47.40 is used for site preparation and sampling activities. The rate represents the average labor rate, based on the demonstration. A labor rate of $54 per hour is used for all other activities. That is the rate used by RMRS for a field chemist.

- A per diem of $80 per worker per day is assumed.

- Routine labor requirements consist of soil preparation, sampling of untreated and treated soil, and application of Envirobond™.

- Maintenance costs are included in the equipment rental cost.

- Envirobond™ liquid and powder are transported from the office of RMRS in Golden, Colorado, to the CRPAC.

- It is assumed that 22 samples are collected for Case 1, and 58 samples are needed for Case 2.

- Costs are presented as 1998 dollars.

- There are no utility costs for either case.

## 4.3 Cost Categories

Table 4-1 presents cost breakdowns for each of the 12 cost categories for Envirobond™: (1) site preparation, (2) permitting and regulatory, (3) mobilization, (4) capital equipment, (5) labor, (6) supplies and materials, (7) utilities, (8) effluent treatment and disposal, (9) residual waste shipping and handling, (10) analytical services, (11) equipment maintenance, and (12) site demobilization. Each of the 12 cost categories is discussed below. The costs for each category have been rounded up to the nearest $50 or $100.

### *4.3.1 Site Preparation Costs*

For the purposes of this economic analysis, it is assumed that preliminary site preparation will be performed by the responsible party (or site owner). The amount of preliminary site preparation required will depend on the site. Site preparation responsibilities include site design and layout, surveys and site logistics, legal searches, access rights and roads, preparation for support and decontamination facilities, utility connections (if needed), and potentially, fixed auxiliary buildings. Since these costs are site-specific, they are not included as part of the site preparation costs in the estimates.

For this cost analysis, only technology-specific site preparation costs are included. These costs are limited to preparing the site for the application of the Envirobond™ process by tilling the soil to the appropriate treatment depth, and removing the grass covering the site with a sod cutter or by tilling it into the soil. The treatment depth for both cases is 6 inches. Site preparation costs for both cases are presented in Table 4-2.

For Case 1, sod covering the site is assumed to be removed with sod cutters and stored until it can be replaced after the treatment. Site preparation costs for Case 1 include rental costs for sod removal and tilling equipment, labor, and per diem. Assuming three workers, earning an estimated labor rate of $47.40 per hour, can prepare the site in 8 hours (one business day), the total labor cost associated with site preparation activities for Case 1 is approximately $1,100. A per diem of $80 per worker per day is assumed, adding an additional $240 to the total site preparation cost. Weekly rental costs for the tiller and sod cutters, determined from actual demonstration costs, are approximately $200, bringing the daily rental cost to approximately $30. Therefore, the total cost for site preparation for Case 1 is estimated to be approximately $1,400.

For Case 2, site preparation costs include costs associated with tilling equipment, labor, and per diem. Since the site will have to be tilled with larger, production-sized equipment, it is assumed that the 1-acre site can be prepared in 8 hours and that all grass covering the site will be tilled into the soil. Tilling equipment for the 1-acre site would include a medium-duty tractor with a plow. Based on several vendor quotes, the weekly rental rate for this equipment is estimated to be $800, bringing the daily cost for this equipment to approximately $115. Assuming three workers, earning an estimated labor rate of $47.40 per hour, labor costs associated with Case 2 will be $1,100. The total per diem for the 3 workers is $240. This brings the total site preparation costs for Case 2 to an estimated $1,500.

### *4.3.2 Permitting and Regulatory Costs*

Permitting and regulatory costs are generally the obligation of the responsible party (or site owner), and not that of the vendor. These costs may include actual permit costs, system monitoring requirements, the development of monitoring and analytical procedures, and health and safety monitoring. Permitting and regulatory costs can vary greatly because they are site-and waste-specific. In applications of the Envirobond™ process as part of a soil remediation program, permitting and regulatory costs will vary depending on whether remediation is performed at a Superfund or RCRA corrective action site. Superfund site remedial actions must be consistent with ARARs of environmental laws, ordinances, regulations, and statutes, including federal, state, and local standards and criteria.

**Table 4-2.** Site Preparation Costs

| Cost Category | Case 1 | Case 2 |
|---|---|---|
| Rental equipment | $ 30 | $ 115 |
| Labor (24 hours total) ($47.40/hour x 8 hrs x 3 workers) | $ 1,100 | $ 1,100 |
| Per diem ($80/worker/day x 1 day x 3 workers) | $ 240 | $ 240 |
| Total Site Preparation Costs | $ 1,400 | $ 1,500 |

Note: 1998 dollars.

Remediation at RCRA corrective action sites requires additional monitoring and recordkeeping, which can increase the base regulatory costs.

No permitting costs are included in this analysis; however, depending on the treatment site, they may be a significant factor since permitting can be expensive and time consuming. These costs are not included in this analysis because no regulatory permits were required for Case 1. This was due to the fact that the demonstration sites were neither Superfund nor RCRA sites. Permits may be needed for air emissions if the site preparation activities produce significant quantities of dust. However, air emissions can be controlled by wetting the soil to be treated during the tilling activities. These costs are expected to be negligible and are not included in this estimate. For Case 2, it is assumed that no permitting and regulatory costs will be incurred for air emissions or for the transportation and disposal of residual wastes generated during the treatment activities. This is based on the assumption that wastes generated for Case 2 will be nonhazardous and can be transported and disposed of at a Subtitle D landfill for $60 per ton. Residual wastes generated at other sites may be classified as hazardous waste, and would require the transport and disposal facility to have appropriate RCRA permits.

### *4.3.3 Mobilization Costs*

Table 4-3 presents the mobilization costs for both cases. Mobilization costs consist of mobilizing personnel and transporting materials to the site. For both cases, it is assumed that some equipment and materials are transported by a medium-duty truck from the office of RMRS in Golden, Colorado, to the CRPAC. The distance between Golden, Colorado, and the CRPAC site in Crooksville/Roseville, Ohio, is approximately 1,350 miles. RMRS mobilized two field personnel and one truck for the SITE demonstration. It is assumed that for Case 2, two personnel and one truck will also be mobilized. Assuming the standard government mileage reimbursement rate of 31 cents per mile, mileage costs from Golden, Colorado, to the CRPAC were approximately $400. The drive from Golden, Colorado, to the CRPAC site requires approximately 24 hours of driving time. Labor costs for mobilizing two personnel (for a total of 48 hours of labor) earning an estimated labor rate of $54 per hour are approximately $2,600. Assuming the trip is completed in 3 days, and a per diem of $80 per worker per day, the total per diem charges for two people is $480. The total mobilization cost for both cases is approximately $3,500. Mobilization of personnel and materials to other sites could be accomplished in a number of ways. For example, materials could be shipped by a carrier service and personnel flown to the site. These options should be explored to minimize the cost of mobilization.

### *4.3.4 Equipment Costs*

Equipment costs for both cases are presented in Table 4-4. Rental equipment used for Case 1 consisted of a tiller to loosen and mix the soil at the site. This equipment was used over a 2-day period. The daily rental cost for the tiller is approximately $23 (when rented for 1 week). Therefore, the total cost of rental equipment for Case 1 was approximately $46. Purchased equipment used for Case 1 consisted of a watering can, fertilizer spreader, a graduated cylinder for mixing the Envirobond™ process, and a pressure sprayer for decontamination. The total cost for purchased equipment for Case 1 was approximately $250. Therefore, the total cost of equipment for Case 1 is approximately $300.

It is assumed that for Case 2 the application of the Envirobond™ process will require larger, production-sized equipment. The equipment necessary for Case 2 should be rented in order to minimize costs. Equipment for Case 2 is assumed to be a tractor with both a plow and a fertilizer spreader, and a 2500-pounds per square inch (psi) pressure washer for decontamination. For Case 2, it is assumed that the treatment will require 3 days. The daily rental cost for the tractor and plow is approximately $115, bringing the cost for this equipment to $345 for the 3-day period. The combined 1-week rental rates for the pressure washer and the fertilizer sprayer are estimated to be $800, bringing the daily rental cost for this equipment to $115. For the 3-day time period assumed for Case 2, the cost for the pressure sprayer and the fertilizer sprayer is $345. Therefore, the total equipment cost for Case 2 is estimated at approximately $700.

### *4.3.5 Labor Costs*

Once the site has been prepared and the technology has been mobilized, labor requirements for applying the Envirobond™ process are minimal. Labor costs are summarized in Table 4-5. Sampling labor costs for Case 1 con-

**Table 4-3.** Mobilization Costs

| Cost Category | Case 1 | Case 2 |
|---|---|---|
| Mileage | $ 400 | $ 400 |
| Labor (40 hours total) ($54/hr x 20 hrs x 2 workers) | $ 2,600 | $ 2,600 |
| Per diem ($80/worker/day x 3 days x 2 workers) | $ 480 | $ 480 |
| Total Mobilization Costs | $ 3,500 | $ 3,500 |

Note: 1998 dollars.

**Table 4-4.** Equipment Costs

| Cost Category | Case 1 | Case 2 |
|---|---|---|
| Rental equipment | $ 50 | $ 700 |
| Purchased equipment | $ 250 | — |
| Total Capital Equipment Cost | $ 300 | $ 700 |

Note: 1998 dollars.

sisted of five field personnel for 5 days, at an estimated labor rate of $47.40 per hour. During the demonstration project, sample collection efforts included collecting significantly more samples than would be expected for Case 2. Therefore, it is assumed that two field personnel will be required for Case 2 sampling activities, at an estimated labor rate of $47.40 per hour. It is also assumed that two workers will be required for the treatment activities, at a rate of $54 per hour. All workers are assumed to receive a per diem of $80 per day to cover lodging, food, and expenses. For Case 1, it is assumed that the amount of time required to sample and treat the site will be the same as that required for the SITE demonstration. Pretreatment and post-treatment sampling activities lasted 5 days, and required a total of 200 hours of labor. Labor costs associated with the sampling activities for Case 1 were approximately $9,500. The treatment performed by RMRS required 24 hours and lasted 3 days, for a total of 48 hours of labor. The total labor cost for the treatment activities associated with Case 1 was approximately $2,600. The total per diem for two workers over the 5-day period was $800. Therefore, the total labor costs associated with Case 1, including per diem, was $5,500.

For Case 2, sampling activities will require a total of 64 hours of labor, bringing the total labor costs for the sampling activities for Case 2 to $3,000. It is assumed that treatment activities for Case 2 will require approximately 80 hours of labor over a 5-day period, bringing labor costs associated with treatment activities for Case 2 to an estimated $4,320. The total labor cost for Case 2 is estimated to be approximately $7,320. The total per diem for two workers over the 5-day period is $800. Therefore, the total labor costs associated with Case 2, including per diem, is estimated to be $8,120. Labor costs associated with laboratory analytical costs are included in Section 4.3.10, Analytical Services.

### 4.3.6 Supplies and Materials Costs

The necessary supplies for the soil sampling activities and the application of the Envirobond™ process include the Envirobond™ mixture, sampling supplies, Level D disposable PPE (latex rubber gloves), decontamination supplies, and miscellaneous field supplies. The costs for supplies and materials are presented in Table 4-6. The total cost of the Envirobond™ mixture reported by RMRS for Case 1 was $55 (RMRS 1999). Disposable PPE typically consists of latex inner gloves and nitrile outer gloves. Decontamination supplies consist of soap, deionized water, and Alconox. PPE and decontamination supplies cost approximately $500 for Case 1. Sampling supplies include sample bottles, labels, a 5-gallon bucket with lid, sieves, and shipping containers. Sampling supplies cost approximately $200 for Case 1. Field supplies include water for personnel, coolers, field notebooks, an outdoor canopy, and other miscellaneous supplies. Field supplies cost an estimated $200. Total supply and materials costs for Case 1 were approximately $1,000.

For Case 2, it is assumed that approximately 161 times as much soil (by volume) will be treated with the Envirobond™ mixture. Assuming a linear cost to volume ratio, the total cost of the Envirobond™ mixture for Case 2 is estimated to be approximately $8,900. Because Case 2 represents a larger application of the technology, expenses for PPE, decontamination supplies, sampling supplies, and field supplies are expected to be higher than the costs associated with Case 1. PPE and decontamination supplies are estimated to cost approximately $800 for Case 2. Sampling supplies are expected to cost approximately $400 for Case 2. The cost of field supplies for Case 2 is estimated to be $900. This brings the total supply cost for Case 2 to approximately $11,000.

### 4.3.7 Utilities Costs

Electricity is not required for the application of the Envirobond™ process. For this reason, no electrical utility connection costs are associated with either case. Water is required to mix the Envirobond™ solution on site, for personnel, equipment decontamination, and possibly ground wetting to control dust. Water costs are insignificant and are therefore not included in the estimate.

### 4.3.8 Effluent Treatment and Disposal Costs

No effluent is produced during the application of Envirobond™.

### 4.3.9 Residual Waste Shipping and Handling Costs

One of the key features of the Envirobond™ process is that it does not produce significant amounts of residual waste. Residual wastewater is generated during decontamination

**Table 4-5.** Labor Costs

| Cost Category | Case 1 | Case 2 |
|---|---|---|
| Sampling Labor ($47.40/hr x hours) | 9,500 (200 hours total) | 3,000 (64 hours total) |
| Treatment Labor ($54/hr x hours) | 2,600 (48 hours total) | 4,320 (80 hours total) |
| Per Diem ($80/worker/day x 5 days x 2 workers) | 2,480 | 800 |
| Total Labor Costs | 14,580 | 8,120 |

Note: 1998 dollars.

**Table 4-6.** Supplies and Materials Costs

| Cost Category | Case 1 | Case 2 |
|---|---|---|
| Envirobond™ Mixture | $100 | $8,900 |
| Sampling Supplies | $200 | $400 |
| PPE + Decontamination Supplies | $500 | $800 |
| Miscellaneous Field Supplies | $200 | $300 |
| Total Supplies and Materials Costs | $1,000 | $11,000 |

Note: 1998 dollars.

of equipment and personnel. For Case 1, the amount of residual wastewater was negligible. OEPA determined the residual wastewater would not further impact the soil or groundwater on the site, and allowed the disposal of the wastewater on site by pouring the wastewater onto the soil in the demonstration area. Therefore, no costs for disposal of wastewater are included in the analysis for Case 1. It is assumed that the only solid wastes generated from the application of the Envirobond™ process are used disposable PPE and soil derived during the decontamination of field equipment. For Case 1, the amount of residual solid waste was negligible. The small amount of residual waste produced during the demonstration was classified as nonhazardous. The waste was disposed as solid waste. The owner of the property provided a dumpster for the disposal of the waste. Therefore, no costs for residual waste disposal are included in this estimate for Case 1.

For Case 2, it is assumed that one 55-gallon drum of residual wastewater will be generated during the decontamination activities. For this cost estimate, it is assumed that the disposal cost is $500 per 55-gallon drum. It is also assumed that one 55-gallon drum of nonhazardous solid waste will be generated. The disposal cost for non-hazardous solid waste is estimated at $200 per 55-gallon drum. Therefore, the total estimated cost for residual waste disposal for Case 2 is $700. If the residual solid waste was hazardous, disposal costs would likely be more expensive.

### *4.3.10 Analytical Services Costs*

Analytical services include costs for laboratory analyses, data reduction, and QA/QC. Sampling frequencies and number of samples are highly site-specific. Therefore, the costs reflected in this analysis may not be applicable to other sites. A total of 292 samples were collected at the CRPAC demonstration site, which included 145 samples collected during the pretreatment stage and 147 samples collected during the post-treatment stage of the demonstration. The large number of samples were taken to make certain that the stringent demonstration objectives could be thoroughly evaluated.

For Case 1, which represents a demonstration-sized or pilot-scale application of the technology, fewer samples will be needed. It is assumed that one composite sample will be taken from each of the 11 plots during the pretreatment and post-treatment sampling events, for a total of 22 samples for Case 1. It is also assumed that for both cases the TCLP will be the only parameter analyzed, since this will determine whether the treatment has reduced metal concentrations to below the regulated levels. The average unit cost per sample for the TCLP analyses performed for the SITE demonstration was $73. This figure includes analytical services costs for standard QA/QC samples. Since the site characteristics for both cases are assumed to be identical to the CRPAC demonstration site, it is assumed that the average cost per sample will remain the same. For Case 1, the total analytical costs for the TCLP analysis of 22 samples is approximately $1,600.

For Case 2, it is estimated that 58 composite samples must be taken to obtain a statistically valid population. In order to estimate the number of samples, treated TCLP data from the SITE demonstration was used and assumed to be representative of the variance (0.35 $[mg/L]^2$ ) of treated lead concentrations at the Case 2 site. It was assumed that this data set could be adequately described by a normal distribution. A hypothesis test was set up to compare the treated concentration to 7.5 mg/L (10 times the UTS, and the regulatory action level), with the null hypothesis stating that the average treated concentration is greater than 7.5 mg/L.

Sample size calculations are based on using the one sample t-test statistic. Equation 4-1 was used to determine the appropriate number of samples.

$$n = Var(\Delta)\,[(Z_\alpha + Z_\beta) / \delta^2] \qquad (4\text{-}1)$$

where

| | | |
|---|---|---|
| Var ($\Delta$) | = | Variance of the treated data from the SITE demonstration |
| $\delta$ | = | Minimum detectable difference from 10 times the UTS |
| $Z_\alpha$ | = | Value from standard normal such that $\alpha$ is the area under the curve to the right of this value |
| $Z_\beta$ | = | Value from standard normal such that $\beta$ is the area under the curve to the left of this value |

The variables $\alpha$ and $\beta$ are probabilities associated with Type I and Type II errors, respectively. For this analysis, an $\alpha$ level of 0.1 was defined as acceptable to meet the goals of the study. A $\beta$ level of 0.1 was used with a minimum detectable difference ($\delta$), of 0.2 mg/L. Values for $Z_\alpha$ and $Z_\beta$ were obtained from a table of standard normal values.

In order to obtain the desired confidence levels (90 percent) and minimum detection level (0.2 mg/L), at least 58 composite samples must be analyzed at the site. Therefore, the 58 samples to be analyzed by the TCLP bring the total analytical costs for Case 2 to an estimated $4,200.

### *4.3.11 Equipment Maintenance Costs*

All equipment used in the application of the Envirobond™ process can be rented. This option, coupled with the fact that the Envirobond™ process can be applied in a short period of time, eliminates the need for on-site equipment maintenance. For these reasons, no maintenance costs are included in this analysis. Equipment maintenance costs, for projects other than the two cases considered in this analysis, may need to be considered depending on the volume of soil to be treated, soil conditions, and the length of time required to treat the contaminated soil.

### *4.3.12 Site Demobilization Costs*

Site demobilization costs consist of demobilizing personnel and transporting materials from the site. For both

cases, it is assumed that some equipment and materials are transported by a medium-duty truck from the demonstration site to the office of RMRS in Golden, Colorado. The distance between the CRPAC site in Roseville, Ohio, to Golden, Colorado, is approximately 1,350 miles. RMRS demobilized two field personnel and one truck. It is assumed that for Case 2, two personnel and one truck will also be demobilized. Assuming the standard government mileage reimbursement rate of 31 cents per mile, mileage costs from the demonstration site to Golden, Colorado, were approximately $400. The drive from the demonstration site to Golden, Colorado, requires approximately 24 hours of driving time. Labor costs for demobilizing two personnel (for a total of 48 hours of labor) earning an estimated labor rate of $54 per hour are approximately $2,600. Assuming the trip is completed in three days, and a per diem of $80 per worker per day, the total per diem charges for two personnel is $480. The total site demobilization cost for both cases is approximately $3,500. Demobilization of personnel and materials to other sites could be accomplished in a number of ways. For example, materials could be shipped via a carrier service and personnel flown from the site. These options should be explored to minimize the cost of demobilization. Table 4-7 presents a summary of site demobilization costs for Case 1 and Case 2.

## 4.4 Summary of the Economic Analysis

Two cost estimates are presented for applying the Envirobond™ process to remediate lead-contaminated soil in the CRPAC. Both cases are based directly on costs from the demonstration. The first case (Case 1) involves a cost estimate for a demonstration-scale application, and the second case (Case 2) involves a larger 1-acre site having conditions identical to those encountered at the Case 1 site. Table 4-1 shows the estimated costs and the percent distributions associated with the 12 cost categories presented in this analysis for both cases.

For Case 1, important cost categories included site preparation (5.41 percent), mobilization (13.52 percent), labor (56.34 percent), supplies and materials (3.86 percent), analytical services (6.18 percent) and site demobilization (13.52 percent). No costs were incurred in the other cost categories (permitting and regulatory, utilities, effluent treatment and disposal, residual waste shipping and handling, and equipment maintenance) for Case 1. For Case 2, important cost categories included mobilization (10.54 percent), labor (24.44 percent), supplies and materials (33.11 percent), analytical services (12.64 percent), and site demobilization (10.54 percent). The costs for site preparation (4.52 percent), equipment (2.11 percent), and residual waste shipping and handling (2.11 percent), were also significant for Case 2. No costs were incurred in the other cost categories (permitting regulatory, utilities, and equipment maintenance) for Case 2.

**Table 4-7.** Site Demobilization Costs

| Cost Category | Case 1 | Case 2 |
|---|---|---|
| Mileage | $400 | $400 |
| Labor (40 hours total)<br>($54/hr x 20 hrs x 2 workers) | $2,600 | $2,600 |
| Per diem<br>($80/worker/day x 3 days x 2 workers) | $480 | $480 |
| Total Demobilization Costs | $3,500 | $3,500 |

Note: 1998 dollars.