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Report to Congressional Requesters

February 2010

SUPERFUND

Information on Cost and Other Issues Related to the Cleanup of the Federal Creosote Site

GAO-10-277

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Highlights

Highlights of GAO-10-277, a report to congressional requesters

SUPERFUND

Information on Cost and Other Issues Related to the Cleanup of the Federal Creosote Site

Why GAO Did This Study

In the 1990s, creosote was discovered under a residential neighborhood in Manville, New Jersey. Creosote, a mixture of chemicals, is used to preserve wood products, such as railroad ties. Some of the chemicals in creosote may cause cancer, according to the Environmental Protection Agency (EPA). EPA found that creosote from a former wood-treatment facility (known as the Federal Creosote site) had contaminated soil and groundwater at the site. Under the Superfund program—the federal government's principal program to clean up hazardous waste—EPA assessed site risks, selected remedies, and worked with the U.S. Army Corps of Engineers to clean up the site. As of May 2009, construction of EPA's remedies for the site had been completed; however, total site costs were almost $340 million and remedial construction costs had exceeded original estimates.

In this context, GAO was asked to examine (1) how EPA assessed risks and selected remedies for the site, and what priority EPA gave to site cleanup; (2) what factors contributed to the difference between the estimated and actual costs; and (3) how EPA and the Corps divided responsibilities for site work. GAO analyzed EPA and Corps documents and data on the cleanup effort and its costs, and interviewed officials from these agencies. This report contains no recommendations. EPA generally agreed with GAO's findings on the agency's cleanup costs and actions, while the U.S. Army Corps of Engineers had no comments.

View GAO-10-277 or key components.
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What GAO Found

The extent of the contamination in a residential area at the Federal Creosote site was the primary factor influencing EPA's risk assessment conclusions, remedy selection decisions, and how EPA prioritized site work, according to site documents and agency officials. EPA assessed site contamination through multiple rounds of evaluation and concluded that soil and groundwater contamination levels were high enough that EPA needed to take action. Then, EPA evaluated remedies to achieve cleanup goals that it had established for the site and that were consistent with its residential use. EPA selected off-site treatment and disposal of the contaminated soil and long-term monitoring of the groundwater contamination as the remedies for the site. In selecting these remedies, EPA considered a range of alternatives but ultimately determined that certain options would be potentially infeasible or ineffective due to the residential setting. For example, EPA chose not to implement certain alternatives on-site because the agency found that there was insufficient space and they would be too disruptive to nearby residents. In addition, EPA chose not to implement certain alternatives because the agency found that they would be unlikely to achieve the cleanup goals for the site, especially considering the high level of treatment required to allow for unrestricted residential use of the area and the high levels of contamination found at the site. EPA made cleanup of the site a high priority because the contamination was in a residential area. For example, EPA took steps to shorten the cleanup period and prioritized the use of regional Superfund resources on the Federal Creosote site over other sites in the region.

The $338 million in total site costs exceeded EPA's estimated remedial construction costs of $105 million by about $233 million, primarily because EPA's estimates focused only on construction costs, and EPA discovered additional contamination during the cleanup effort. EPA prepared preliminary cost estimates during the remedy selection process; however, EPA requires that these estimates include only the costs associated with implementing different remedies it was considering, not all site costs. Also, as a result of the movement of contamination in the ground and sampling limitations during EPA's site investigation, a greater-than-expected amount of contamination was discovered during the cleanup effort, which increased costs. Other factors, such as contractor fraud, affected total site costs to a lesser extent.

EPA was responsible for managing the overall site cleanup and community relations, while the Corps was responsible for implementing the cleanup. EPA dedicated a full-time staff member to manage the site cleanup who, according to EPA, maintained a significant on-site presence to ensure that the project remained on schedule and was adequately funded and to work with residents. EPA also oversaw the work of the Corps and its costs. To conduct the actual cleanup work, the Corps hired contractors to design or implement cleanup activities who, in turn, hired subcontractors for some tasks. The Corps oversaw the activities and costs of its primary contractors but, according to Corps officials, was less involved in selecting and overseeing subcontractors.

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Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
BEI	Bennett Environmental, Inc.
CEFMS	Corps of Engineers Financial Management System
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
EPA	Environmental Protection Agency
IDIQ	indefinite-delivery/indefinite-quantity
LTTD	low temperature thermal desorption
NJDEP	New Jersey Department of Environmental Protection
NPL	National Priorities List
OU	operable unit
PRAC	pre-placed remedial action contract
RI/FS	remedial investigation/feasibility study
ROD	record of decision
RPM	Remedial Project Manager
SCORPIOS	Superfund Cost Recovery Package Imaging and On-Line System

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United States Government Accountability Office
Washington, DC 20548

February 25, 2010

The Honorable Harry M. Reid
Majority Leader
United States Senate

The Honorable James M. Inhofe
Ranking Member
Committee on Environment
and Public Works
United States Senate

In the 1990s, creosote contamination was discovered at the Federal Creosote site, a former wood-treatment facility in the Borough of Manville, New Jersey, that had been developed into a residential community of single-family homes and a retail mall. Creosote—a mixture of approximately 300 chemicals—is used to preserve wood, and the Environmental Protection Agency (EPA) has identified some of these chemicals as probable human carcinogens. Under the Superfund program—the federal government's principal program to clean up hazardous waste sites—EPA worked with the U.S. Army Corps of Engineers (the Corps) to construct remedies to address site contamination. This work was completed in 2008, although some maintenance and groundwater monitoring efforts continue. Early construction cost estimates for these remedies totaled $105 million.[1] However, as of May 2009, EPA had spent almost $340 million on the cleanup, including $246 million to construct site remedies and $92 million in other response costs that were not part of EPA's early estimates.[2] The increase in actual remedial construction costs over the agency's original

[1]This figure represents the total of EPA's estimated costs for remedial construction activities conducted through the spring of 2009 to address contamination at different areas of the site, which we discounted using a present value analysis and adjusted to fiscal year 2009 constant dollars. As a result of the methodology we used to adjust these costs, this figure does not match EPA's published estimates for completed and remaining work at the site, which totaled about $118 million in nominal dollars. As per GAO internal guidance, we are reporting all costs in fiscal year 2009 constant dollars, unless otherwise noted.

[2]We developed these data on actual site costs using data provided by EPA and the Corps. As a result of the methodology we used to adjust the data to fiscal year 2009 constant dollars, these figures do not match other EPA-published information on site costs.

estimates raised questions about whether EPA had selected the most cost-effective remedy, given site risks and the extent of contamination. Furthermore, the Department of Justice (Justice) and the state of New Jersey are pursuing civil claims against the site's alleged responsible party related to cost recovery and—as part of the claims brought by the state of New Jersey—damages;[3] Justice has also filed criminal charges against several parties involved in the cleanup, asserting claims related to alleged fraud in awarding subcontracts by contractor personnel.[4]

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 established the Superfund program to protect human health and the environment from the effects of hazardous substances. Under this program, EPA has the authority to (1) clean up hazardous waste sites and then seek reimbursement from the parties responsible for contaminating them or (2) compel the responsible parties to clean up these sites. The Superfund cleanup process begins with site discovery or notification to EPA of the possible release of hazardous substances posing a threat to human health or the environment. On the basis of an initial evaluation, EPA may select a site for inclusion on the National Priorities List (NPL), which catalogs many of the nation's most seriously contaminated sites. For sites that EPA lists on the NPL, the agency initiates a more extensive investigation process to identify the nature and extent of contamination at the site, quantify potential risks to human health and the environment, and evaluate potential remedies to address site contamination. Selected remedies are then planned in the remedial design phase and implemented in the remedial action phase.[5]

EPA's initial investigation at the Federal Creosote site identified contamination from the lagoons and canals of the former wood-treatment facility beneath the residential portion of the site. After listing the site on the NPL, EPA conducted additional investigations to quantify site risks; evaluated potential remedies to address contamination, including preparing cost estimates; and selected remedies for the site. EPA tasked the Corps with designing and implementing these remedies. The Corps

[3]Justice files claims on behalf of the federal government, including agencies such as EPA.

[4]In addition, a site contractor that was tasked with implementing the cleanup also filed a civil litigation action against several of these parties asserting claims related to alleged fraud.

[5]EPA also can take removal actions at any time; these are generally short-term or emergency actions to mitigate immediate threats.

hired contractors to perform the design and construction work, and, in turn, the prime contractor for the construction work hired subcontractors to perform certain tasks, such as soil transportation, treatment, and disposal; landscaping; and wastewater treatment.

In this context, you asked us to review issues concerning the Federal Creosote site. Our objectives were to examine (1) how EPA assessed the risks and selected the remedies for the Federal Creosote site, and what priority EPA assigned to site cleanup; (2) what factors contributed to the difference between the estimated and actual costs of cleaning up the site; and (3) how responsibilities for implementing and overseeing site work were divided between EPA and the Corps. We also summarized information on criminal and civil litigation related to the Federal Creosote site (see app. I).

To examine how EPA assessed risks and selected remedies for the site as well as what priority EPA assigned to the cleanup, we analyzed site documents detailing the results of the agency's activities and decisions at the site. We also interviewed relevant EPA and other federal, state, and local officials. To determine what factors contributed to the difference between the estimated and actual costs of site cleanup, we obtained and analyzed data on estimated construction and total site costs from site documents that detailed EPA's planned activities, EPA and Corps cost-tracking databases, and contractor cost summary reports. To compare estimated construction and total site costs, in accordance with our policy, we adjusted the estimated construction costs using a present value analysis and, to adjust for inflation, converted all dollar figures into fiscal year 2009 constant dollars. We also analyzed site documents describing the cleanup effort, reviewed EPA cost-estimating guidance, and conducted interviews with EPA and Corps officials. To describe how responsibilities for implementing and overseeing the site work were divided between EPA and the Corps as well as EPA's oversight actions, we reviewed EPA interagency agreements with the Corps, site documents, and EPA guidance and interviewed EPA and Corps officials. To describe actions that the Corps took to implement its site responsibilities, we reviewed Corps guidance, Corps correspondence to the contractor, and contractor requests for approval of certain subcontracts and also interviewed Corps and EPA officials. To identify civil and criminal litigation related to the Federal Creosote site, we collected and reviewed information from publicly available court documents to summarize the cases and, where applicable, their outcome. We evaluated the reliability of the site actual cost data used in our analyses by, for example, comparing the data across different sources and reviewing agency data reliability controls. We

determined that these data were sufficiently reliable for our purposes. See appendix II for a more detailed description of our scope and methodology.

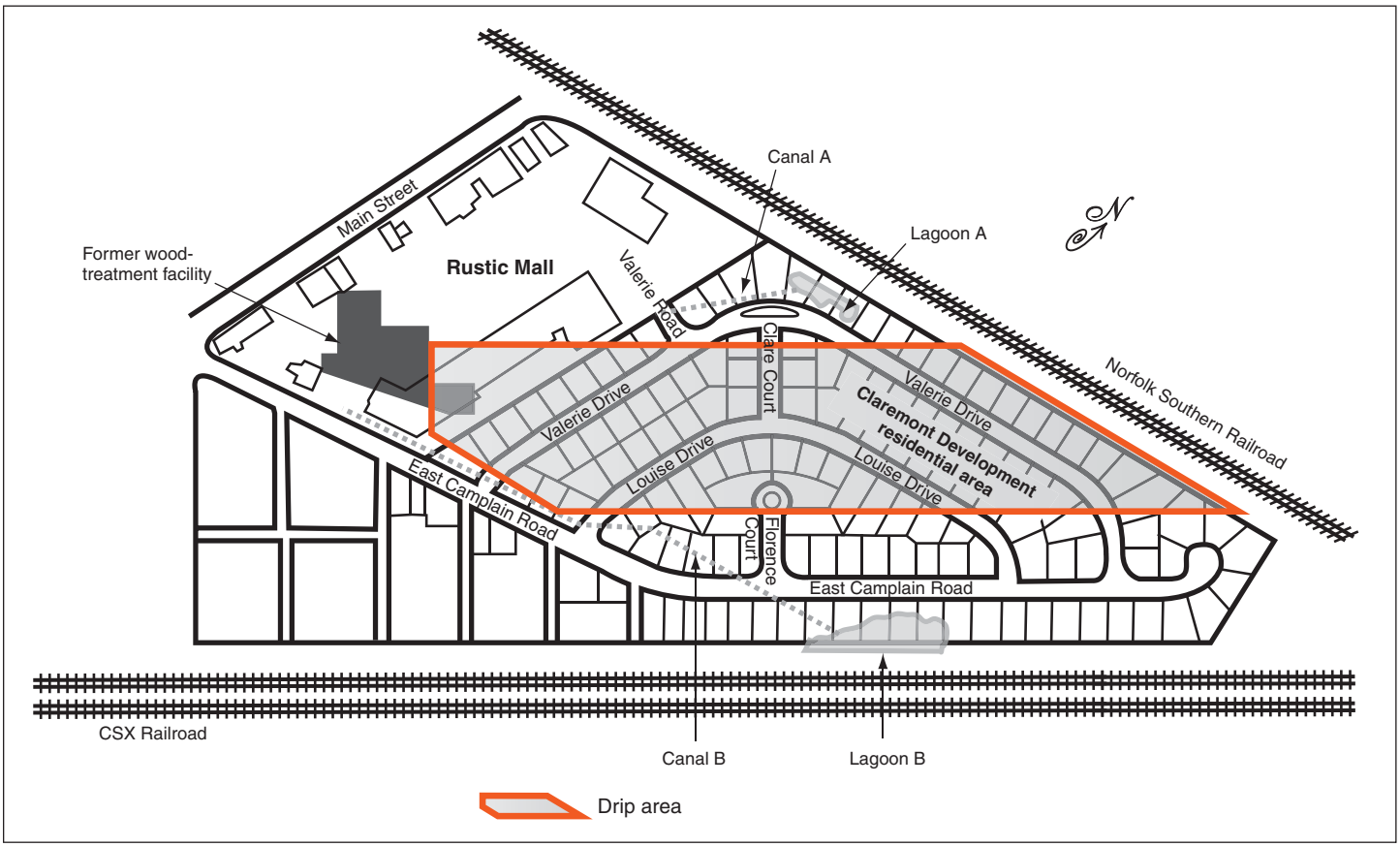
We conducted our work from May 2008 through February 2010 in accordance with all sections of GAO's Quality Assurance Framework that are relevant to our objectives. The framework requires that we plan and perform the engagement to obtain sufficient and appropriate evidence to meet our stated objectives and to discuss any limitations in our work. We believe that the information and data obtained, and the analyses conducted, provide a reasonable basis for any findings and conclusions in this product.

Background

Creosote is derived by distilling tar; the type of creosote most commonly used for wood-treating is manufactured from coal tar. Polycyclic aromatic hydrocarbons—chemicals formed during the incomplete burning of coal, oil, gas, or other organic substances—generally make up 85 percent of the chemical composition of creosote. EPA classifies some of the polycyclic aromatic hydrocarbons in creosote, such as benzo(a)pyrene, as probable human carcinogens. Some polycyclic aromatic hydrocarbons also may have noncarcinogenic health effects, such as decreased liver or kidney weight.

From approximately the early 1910s to the mid-1950s, the Federal Creosote site was a wood-treatment facility. Untreated railroad ties were delivered to the site and, to preserve them, coal tar creosote was applied to the railroad ties at a treatment plant located on the western portion of the property (see fig. 1 for an illustration of the site). Residual creosote from the treatment process was discharged into two canals that led to two lagoons on the northern and southern parts of the site, respectively. After treatment, the railroad ties were moved to the central portion of the property, where excess creosote from the treated wood dripped onto the ground. The treatment plant ceased operations in the mid-1950s. During the late 1950s and early 1960s, the area where the treatment plant was formerly located was developed into a 15-acre commercial and retail property known as the Rustic Mall. Through the mid-1960s, other areas of the property, including the former canal, lagoon, and drip areas, were developed into a 35-acre residential neighborhood known as the Claremont Development, which was made up of 137 single-family homes that housed several hundred residents.

Figure 1: Map of the Federal Creosote Site in the Borough of Manville, New Jersey



Source: GAO analysis of EPA site documents.

Issues with creosote contamination at the site became apparent in April 1996, when the New Jersey Department of Environmental Protection (NJDEP) responded to an incident involving the discharge of an unknown thick, tarry substance from a sump located at one of the residences in the Claremont Development. Later, in January 1997, the Borough of Manville responded to complaints that a sinkhole had developed around a sewer pipe in the Claremont Development. Excavation of the soil around the sewer pipe identified a black, tar-like material in the soil. After an initial site investigation, EPA found contamination in both the surface and subsurface soils as well as in the groundwater beneath the site. In 1999, EPA placed the site on the NPL and divided it into three smaller units,

called operable units (OU).[6] OU1 consisted of the source contamination (free-product creosote) in the lagoon and canal areas of the Claremont Development. OU2 included other soil contamination in the Claremont Development, such as residually contaminated soil at properties over and near the lagoon and canal areas and the drip area of the former wood-treatment facility. OU2 also included contamination at a nearby day-care facility. OU3 included the Rustic Mall soil contamination as well as groundwater contamination throughout the site.[7]

EPA completed all major site cleanup work in November 2007, and the site was declared "construction complete" in March 2008.[8] Ultimately, EPA performed cleanup activities on 93 of the 137 properties in the residential area as well as on the commercial portion of the site. EPA's ongoing activities at the site include monitoring groundwater contamination, conducting 5-year reviews of contamination levels to ensure that the remedy remains protective of human health and the environment, and selling properties that EPA acquired during the remedial action. According to EPA officials, the agency could remove the site from the NPL as early as 2011; however, this decision will depend on the results of contamination monitoring at the site.

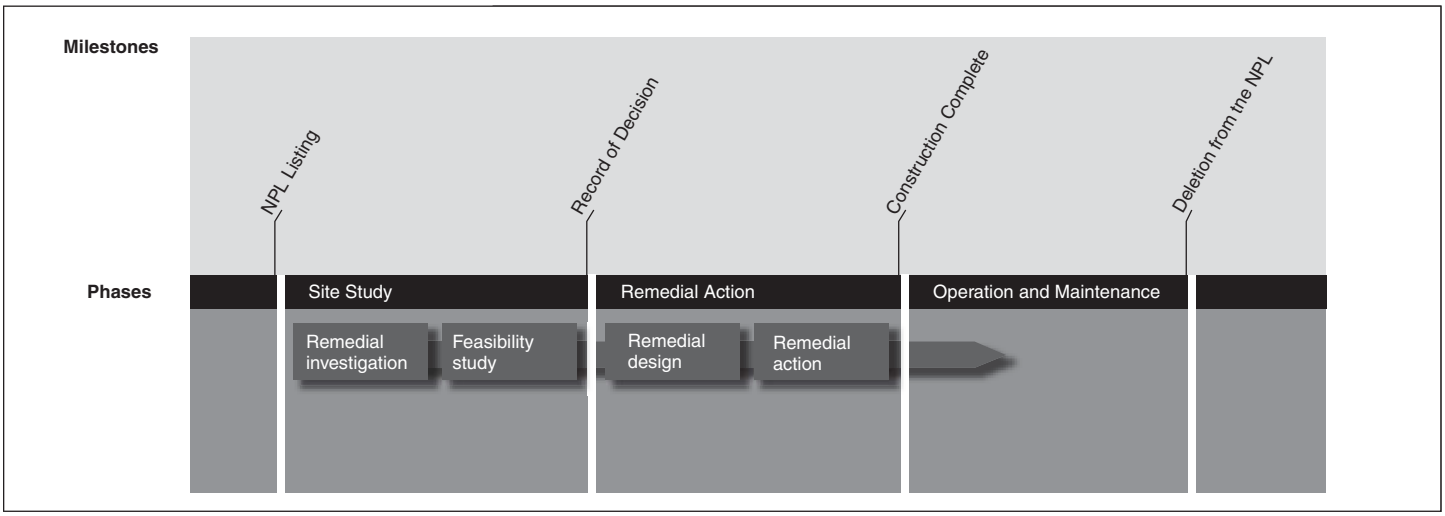
Most Superfund sites progress through the cleanup process in roughly the same way, although EPA may take different approaches on the basis of site-specific conditions. After listing a site on the NPL, EPA initiates a process to assess the extent of the contamination, decides on the actions that will be taken to address that contamination, and implements those actions. Figure 2 outlines the process EPA typically follows, from listing a site on the NPL through deletion from the NPL.

[6]Sites are often divided into OUs by geography, pathways of contamination (e.g., groundwater), or type of remedy.

[7]As part of the OU3 groundwater investigation, EPA also looked at off-site groundwater, surface water, and sediment contamination that may have been related to the site.

[8]EPA Region 2, which covers New Jersey, New York, Puerto Rico, the U.S. Virgin Islands, and seven federally recognized Indian tribes, was responsible for the Federal Creosote site.

Figure 2: EPA's Site Cleanup Process



Source: GAO analysis of EPA data.

In the site study phase of the cleanup, EPA or a responsible party conducts a two-part remedial investigation/feasibility study (RI/FS) process.[9] The first part of this process—the remedial investigation—consists of data collection efforts to characterize site conditions, determine the nature of the waste, assess risks to human health and the environment, and conduct treatability testing as necessary to evaluate the potential performance and cost of the treatment technologies that are

[9]According to EPA guidance, the RI/FS process is a dynamic, flexible process that can be tailored to the circumstances of individual sites. The objective of the RI/FS is not to remove all uncertainties associated with the site cleanup but, rather, to gather sufficient information to support informed decision making regarding which remedy appears to be the most appropriate for a site.

being considered.[10] During the second part of the RI/FS process—the feasibility study—EPA identifies and evaluates various options to address the problems identified through the remedial investigation. EPA also develops cleanup goals, which include qualitative remedial action objectives that provide a general description of what the action will accomplish (e.g., preventing contamination from reaching groundwater) as well as preliminary quantitative remediation goals that describe the level of cleanup to be achieved.[11] According to EPA guidance, it may be necessary to screen out certain options to reduce the number of technologies that will be analyzed in detail to minimize the resources dedicated to evaluating less promising options. EPA screens technologies on the basis of the following three criteria:

- *effectiveness:* the potential effectiveness of technologies in meeting the cleanup goals, the potential impacts on human health and the environment during implementation, and how proven and reliable the technology is with respect to the contaminants and conditions at the site;
- *implementability:* the technical and administrative feasibility of the technology, including the evaluation of treatment requirements and the relative ease or difficulty in achieving operation and maintenance requirements; and
- *cost:* the capital and operation and maintenance costs of a technology (i.e., each technology is evaluated to determine whether its costs are high, moderate, or low relative to other options within the same category).

[10]To assess site risks during the remedial investigation, EPA generally follows a four-step process: (1) contaminant identification—narrowing down the list of contaminants for risk analysis on the basis of which contaminants present the biggest threats to human health; (2) exposure assessment—identifying current and future pathways for how individuals could be exposed to contamination on the basis of how the site is or could be used; (3) toxicity assessment—examining the potential health effects of contaminants on the basis of their toxicity; and (4) risk characterization—estimating the potential risks from exposure to contaminants. EPA's acceptable levels for carcinogenic human health risks are based on a range of values—between 1 in 10,000 individuals and 1 in 1 million individuals—that represent the excess probability a person will develop cancer over a lifetime as a result of exposure to contamination. If human health risks are greater than 1 in 10,000, they are considered to be above EPA's acceptable range. For noncarcinogenic risks, EPA calculates a hazard index value that sums the values for individual noncarcinogenic effects from site contaminants. If the hazard index exceeds a value of 1, EPA assumes there is a potential for noncarcinogenic health effects to occur from exposure to site contamination.

[11]Generally, final remediation goals are determined when a remedy is selected.

After screening the technologies that it has identified, EPA combines selected technologies into remedial alternatives. EPA may develop alternatives to address a contaminated medium (e.g., groundwater), a specific area of the site (e.g., a waste lagoon or contaminated hot spot), or the entire site. EPA guidance states that a range of alternatives should be developed, varying primarily in the extent to which they rely on the long-term management of contamination and untreated wastes. In addition, containment options involving little or no treatment, as well as a no-action alternative, should be developed. EPA then evaluates alternatives using the nine evaluation criteria shown in table 1 and documents its selected alternative in a record of decision (ROD).[12]

Table 1: EPA's Remedial Alternative Evaluation Criteria

Criterion	Description
Overall protection of human health and the environment	An alternative's ability to protect human health and the environment through engineered systems and institutional controls that eliminate, reduce, or control risks.[a]
Compliance with applicable or relevant and appropriate requirements	An alternative's ability to comply with federal, state, and local environmental and health regulations, and other advisory or guidance criteria.
Long-term effectiveness and permanence	The degree of certainty that an alternative will be successful, considering the risks remaining after the remedial action and the adequacy and reliability of engineering and institutional controls.
Reduction of toxicity, mobility, or volume through treatment	An alternative's ability to permanently and significantly reduce the toxicity, mobility, or volume of hazardous substances through treatment.
Short-term effectiveness	An alternative's effects on and risks to workers, surrounding communities, and the environment during the remedial action as well as the time required to achieve the remedial action objectives.
Implementability	The relative ease or difficulty associated with implementing an alternative, considering the technical and administrative feasibility of remedial technologies, and the availability of required labor, equipment, and materials.
Cost	An alternative's capital and operation and maintenance costs.
State/Agency acceptance	The extent to which the state and other regulatory agencies support an alternative.
Community acceptance	The extent to which the community supports an alternative.

Source: GAO analysis of EPA site documents.

[12]These criteria were developed to incorporate the remedy selection requirements and preferences of section 121 of CERCLA, which mandates, among other requirements, that remedial actions be protective of human health and the environment and be cost-effective. CERCLA also indicates a preference for actions that reduce the toxicity, mobility, or volume of contamination through treatment.

Note: These criteria are not weighted equally in EPA's evaluation. The first two are threshold criteria that must be met for an alternative to be eligible for selection. The third through the seventh (long-term effectiveness through cost) are balancing criteria used to compare trade-offs between the alternatives. The last two are modifying criteria that are considered after a public comment period on EPA's proposed plan.

[a]Institutional controls, such as deed restrictions on future land use, are limited measures that are intended to minimize potential human exposure to contaminants. These measures are typically implemented along with other technologies because they do not reduce contaminant levels or prevent migration.

Next, either EPA or a responsible party may initiate the remedial action that was documented in the ROD. Like the RI/FS, implementation of the remedial action is divided into two phases. The first phase is the remedial design, which involves a series of engineering reports, documents, and specifications that detail the steps to be taken during the remedial action to meet the cleanup goals established for the site. For EPA-led remedial actions, EPA may either select a private contractor to perform the remedial design or, under a 1984 interagency agreement with the Corps, assign responsibility for designing the remedial action to the Corps, which may select and oversee a private contractor to perform the design work.[13] The second phase is the remedial action phase, where the selected remedy, as defined by the remedial design, is implemented. Similar to the design phase, for EPA-led remedial actions, EPA may either select a private contractor to perform the remedial action or assign the remedial action to the Corps, which would be responsible for contractor selection and oversight during the remedial construction.

When physical construction of all remedial actions is complete and other criteria are met, EPA deems the site to be "construction complete." Most sites then enter into an operation and maintenance phase, when the responsible party or the state maintains the remedy while EPA conducts periodic reviews to ensure that the remedy continues to protect human health and the environment. For example, at a site with soil contamination, the remedial action could be to build a cap over the contamination, while the operation and maintenance phase would consist of monitoring and maintaining the cap. Eventually, when EPA determines, with state concurrence, that no further remedial activities at the site are appropriate, EPA may delete the site from the NPL.

[13]EPA referred to the 1984 interagency agreement with the Corps as an "umbrella" agreement. If EPA chooses to assign work to the Corps, EPA establishes site-specific interagency agreements that document the type of work to be performed and an initial budget.

EPA's Risk Assessment, Remedy Selection, and Prioritization Decisions for the Federal Creosote Site Were Primarily Influenced by the Extent of the Contamination in a Residential Area

The extent of the contamination in a residential area at the Federal Creosote site was the primary factor that influenced EPA's risk assessment conclusions, remedy selection decisions, and site work priorities. EPA determined that risk levels were unacceptable given the site's residential use. EPA then selected remedies for the site, taking into account space constraints and other challenges associated with a residential cleanup. Finally, EPA placed a high priority on scheduling and funding site work because the contaminated area was residential, thereby reaching key cleanup milestones relatively quickly.

EPA Assessed Risks and Selected Cleanup Goals on the Basis of the Site's Residential Use

From the spring of 1997 to the summer of 2001, EPA conducted multiple rounds of sampling and risk assessment at the Federal Creosote site and concluded that human health risks exceeded acceptable levels.[14] Specifically, EPA assessed the air, groundwater, surface soil, and subsurface soil as part of an initial site investigation and an RI/FS process. See appendix III for a timeline of EPA's risk assessment activities.[15]

EPA's initial investigation of site contamination, which began in 1997, included such efforts as assessing whether contamination was affecting public drinking water supplies; investigating the nature of the bedrock and the aquifer underlying the site; collecting soil samples from 30 properties selected on the basis of their proximity to the lagoons, canals, and drip area of the former wood-treatment facility; and collecting approximately 1,350 surface soil samples (up to 3 inches below the ground surface) from 133 properties in and near the residential development. From this initial

[14]Although these efforts were largely conducted by EPA contractors, the agency provided direction and oversight to the contractors, and, therefore, we refer to them as EPA efforts.

[15]We excluded EPA's Hazard Ranking System evaluation results from our discussion of EPA's risk assessment because EPA officials said that the risk assessment process is different from the Hazard Ranking System evaluation that is conducted as part of the NPL listing process. The officials said that the goal of the listing process is to determine whether a site requires additional evaluation, and that a site's Hazard Ranking System evaluation score does not relate to EPA's human health risk assessment.

investigation, EPA concluded that site contamination posed unacceptable human health risks. For example, while EPA found that contamination did not pose short-term health risks that could require an evacuation of residents, EPA found that the contamination was extensive and uncontrolled; had impacted soil, sediment, and groundwater in the area; and likely posed long-term health risks. For soil contamination in particular, EPA determined that, in some areas, the contamination was within 2 to 3 feet of the ground surface; in other areas, EPA found that the contamination was covered by little or no fill material.[16] According to a site document, one resident had discovered a large amount of buried tar when installing a fence on his property. As a result of its concerns that surface soil contamination could pose a risk to residents, EPA developed a surface soil risk assessment in January 1999. EPA concluded that soil contamination levels at 27 properties in the residential area posed long-term human health risks, including carcinogenic or noncarcinogenic risks (or both), that exceeded acceptable levels. In addition to soil contamination, EPA's initial investigation determined that creosote had contaminated groundwater in the soil as well as in fractures in the bedrock underlying the site, which was a potential source of drinking water. Furthermore, EPA's aquifer investigation showed that groundwater from the site had the potential to influence the Borough of Manville's municipal water supply wells, although Region 2 officials said the nature of the fractures made it difficult for EPA to determine whether site contamination would actually affect the wells.

According to Region 2 officials, the purpose of a remedial investigation is to collect enough data to determine whether there is a need to take a remedial action. These officials said that an RI/FS for OU1 was not necessary because EPA had obtained much more information from its initial investigation on the extent of contamination at properties over the lagoon and canal source areas than is typically available to support taking an action. Also, according to EPA, the data that were collected during this initial investigation were equivalent in scope to that of a remedial investigation. Therefore, because EPA was trying to address the source contamination in the residential area on an expedited basis, the agency chose to incorporate these data into an Engineering Evaluation/Cost Analysis because it allowed EPA to evaluate remedial alternatives in a

[16]EPA found that 19 properties had high levels of surface soil contamination. To limit potential exposures at certain properties, in July 1998, EPA took removal actions, such as applying topsoil or other materials.

more streamlined way, as compared with an RI/FS report.[17] However, for OU2 and OU3, EPA initiated an RI/FS process in 1998 to more fully characterize the extent of soil and groundwater contamination throughout the site.[18] EPA's OU2 soil evaluation determined that elevated levels of creosote contamination close to the surface in the residential area were generally found near the lagoons and canals, while the drip area generally had residual levels of contamination close to the surface. Underlying the site, EPA found that free-product creosote rested on a clay layer approximately 6 to 10 feet below the surface, although in some areas the layer was not continuous, and the creosote had migrated as deep as the bedrock, roughly 25 to 35 feet underground. On the basis of these findings, in April 2000, EPA developed a human health risk assessment for soil contamination in the residential area using a sample of six representative properties: two properties each represented the lagoon and canal areas, the drip area, and the remaining residential area, respectively.[19] EPA found that soil contamination exceeded acceptable risk levels at the lagoon and canal and drip areas, but not at properties representing other areas of the Claremont Development.

[17]At the Federal Creosote site, EPA initially began evaluating whether to address site contamination under its removal program and, therefore, started preparing an Engineering Evaluation/Cost Analysis, which is required under the National Contingency Plan to support certain types of removal actions. The National Oil and Hazardous Substances Pollution Contingency Plan, referred to as the National Contingency Plan, is published in the *Federal Register* and can be found in the *Code of Federal Regulations* at 40 CFR Part 300. This plan, which was revised pursuant to CERCLA, establishes the procedures and standards for responding to releases of hazardous substances. According to EPA guidance (see EPA, *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA*, EPA 540-R-93-057 (Washington, D.C.: August 1993)), the goals of an Engineering Evaluation/Cost Analysis are to identify the objectives of a removal action and to evaluate various alternatives that may be used to satisfy these objectives on the basis of their cost, effectiveness, and implementability. EPA's guidance also states that an Engineering Evaluation/Cost Analysis, although less comprehensive, is similar to the RI/FS conducted for a remedial action.

[18]To evaluate OU2 soil contamination, EPA took approximately 2,000 soil samples, among other activities. EPA's investigation of OU3 soil contamination included taking almost 250 soil samples, while its groundwater investigation included taking samples from monitoring wells and collecting data on the movement of groundwater contamination in the soil and bedrock.

[19]EPA officials said it would have been labor-intensive to assess the risks for each residential property because of the large number of properties and the amount of data and calculations involved. Also, according to EPA, an equally important consideration was the time involved in assessing the risks for each individual property, since this would have potentially delayed remediation of the site and prolonged residents' exposure to contamination.

Furthermore, EPA's OU3 soil analysis revealed that contamination was generally in three main areas of the mall, with several other "hot spots" of contaminated material. EPA also determined that most of the soil contamination was within the first 2 feet below the ground surface; however, in certain areas, contamination was as deep as 35 feet below the surface. EPA noted that it did not collect soil samples from under the mall buildings, although, according to a site document, EPA thought it likely that contamination remained under at least a portion of one of the buildings. EPA assessed the human health risks from exposure to soil contamination in June 2001. At the time of EPA's assessment, OU3 was a commercial area. However, the Borough of Manville and the mall owner had indicated that the area could be redeveloped for a mixed residential/commercial use. Therefore, EPA evaluated risks for OU3 under both residential and commercial use scenarios, and found that risks exceeded acceptable levels for residential use at some areas of the mall and for commercial use at one area.[20]

Finally, EPA's OU3 RI/FS investigation determined that contaminated groundwater in the soil above the bedrock had not migrated far from the original source areas of the lagoons and canals. However, free-product creosote had penetrated as deep as 120 feet into the fractured bedrock, and groundwater contamination in the bedrock had moved through the fractures toward two nearby rivers.[21] On the basis of these results, in July 2001, EPA evaluated the potential human health risks from groundwater contamination to on-site and off-site residents (i.e., residents who lived on or near the site) and commercial workers, and found that risks for on-site residents and workers exceeded acceptable levels for carcinogenic and noncarcinogenic contaminants.

The Department of Health and Human Services' Agency for Toxic Substances and Disease Registry (ATSDR) also evaluated the risks from site contamination and published a series of studies that expressed concern about site contamination levels.[22] Between May 1997 and

[20]To calculate risk levels, EPA broke OU3 into six areas, primarily on the basis of where higher levels of contamination were present within 10 feet of the ground surface.

[21]According to EPA, these two rivers are a source of drinking water and the intake for the public water supply was approximately 2,700 feet away from the site.

[22]Pursuant to CERCLA requirements, ATSDR performs health assessments at all sites proposed for the NPL. ATSDR looks at sites from a public health and medical needs perspective and provides individuals with medical assistance to respond to conditions identified as stemming from exposure to site contamination.

February 1999, ATSDR published five health consultations that responded to EPA requests to answer specific questions, such as whether consuming vegetables grown in site soils posed a health threat. For example, ATSDR's first consultation concluded that subsurface soil contamination levels posed a threat to residents if the contamination was dug up, or if similar levels of contamination were discovered in surface soils. Then, in September 2000, ATSDR published a public health assessment that evaluated site contamination and concluded that past and present exposures to surface soil (at that time) did not represent an apparent health hazard.[23] However, the assessment also stated that this conclusion did not rule out the need for remedial action because subsurface contamination posed a long-term hazard if soil 2 feet below the ground in certain areas was disturbed.

ATSDR and EPA officials told us that ATSDR's conclusion that surface soil contamination did not pose a public health hazard did not mean that EPA's action to remediate the site was unwarranted. In particular, officials from both agencies cited differences in the agencies' risk assessment views and processes as a reason why they could reach alternative conclusions about site risks. For example, ATSDR officials indicated that ATSDR's assessment focused on conditions in the first 6 inches of soil to evaluate what contamination exposures residents may have been subject to in the past and at the time of the assessment. However, the officials said that EPA's risk assessment would have been more focused on the hypothetical situation where subsurface soil contamination is brought to the surface in the future.[24] Therefore, the officials said that, in fact, ATSDR would have had very serious concerns if the site had not been remediated because of the potential for high levels of contamination in the subsurface soil to be brought to the surface through activities such as tree planting or house remodeling. ATSDR also had concerns about potential exposures to groundwater contamination.[25] As a result, the officials stated that ATSDR's

[23]ATSDR officials said the assessment pulled together the various health consultations that it had developed.

[24]Both ATSDR and EPA officials also noted other differences between the two agencies' risk assessment processes, such as different underlying data and assumptions, which could yield different results.

[25]ATSDR found that groundwater contamination posed a future hazard if public water supplies became affected; however, EPA's groundwater investigation was still ongoing at the time of ATSDR's assessment.

assessment recommended that EPA continue its plans to implement a remedial action to remove source material from the site.

On the basis of its conclusions about site risks, EPA set cleanup goals for different areas of the site that, when achieved, would reduce risks to acceptable levels for residential use. For example, EPA established site-specific qualitative objectives for its remedial actions, such as preventing human exposure to contamination, cleaning up areas of source contamination to allow for unrestricted land use and prevent future impacts to groundwater quality, and minimizing disturbance to residents and occupants of the Rustic Mall during a remedial action. EPA also developed quantitative remediation goals to identify the level at which remedial actions would need to be implemented to protect human health. According to site documents, there were no federal or state cleanup standards for soil contamination at the time of the cleanup effort. Therefore, EPA established risk-based remediation goals that would reduce excess carcinogenic risks to a level of 1 in 1 million, and that were consistent with New Jersey guidance for residential direct contact with soil.[26] For the groundwater contamination, EPA used both federal and state chemical-specific standards to set risk-based remediation goals.

According to site documents and Region 2 officials, risk levels required a remedial action regardless of the site's future use. The officials said that EPA considered what level of waste could be left on-site while still allowing for unrestricted residential use of properties; however, they noted that, with unrestricted residential use, there is a very low threshold for the level of waste that can be left on-site. They said that even the residually contaminated soil was sufficiently contaminated that EPA dug between 10 and 14 feet deep to allow for unrestricted use of residents' properties. Similarly, EPA determined that source material in the Rustic Mall needed to be remediated because of the potential future residential use of the site.[27] According to a site document, EPA determined that, under a current use scenario (at the time of its risk assessment in 2001), there were likely no unacceptable human health risks from contamination

[26]EPA's remediation goal for OU1 was based on visible levels of contamination. However, according to site documents and Region 2 officials, the agency did not plan to begin excavation in OU1 areas until it had developed quantitative remediation goals following its assessment of the OU2 soil contamination.

[27]However, EPA found that residually contaminated soil could remain at depths greater than 10 to 14 feet.

under the mall because contaminants were covered by buildings and pavement. However, the contamination could be exposed if these covers were removed during site redevelopment. Therefore, EPA identified the level of site cleanup required on the basis of the most conservative future use scenario.[28]

EPA's Remedy Selection Decisions Were Influenced by the Residential Nature of the Site

To select remedies to address the soil and groundwater contamination at the Federal Creosote site, EPA identified potential remedial technologies from agency guidance[29] as well as from other publications and databases that listed potentially available technologies.[30] After identifying potential technologies, EPA screened out less viable technologies, combined selected technologies into remedial alternatives, evaluated the alternatives, and selected a preferred remedy for each OU. See appendix III for a timeline of EPA's remedy selection efforts.

Region 2 officials told us that, to identify technologies for site remediation, EPA identifies a range of technologies on a site-specific basis. According to agency guidance, EPA prefers three technologies for treating the type of soil contamination found at the Federal Creosote site: bioremediation—using microbes to degrade contaminants and convert them to carbon dioxide, water, microbial cell matter, and other products; low temperature thermal desorption (LTTD)—heating contaminated material to temperatures less than 1,000 degrees Fahrenheit to physically separate contaminants from soils; and incineration—heating contaminated material

[28]A contractor's study of site contamination found that applying nonresidential rather than residential cleanup standards in the Rustic Mall area would have reduced the amount of material requiring remediation by only about 1.4 percent of the estimated total.

[29]The primary guidance that EPA relied on to identify potential remedial technologies for the soil contamination was the agency's guidance entitled *Presumptive Remedies for Soils, Sediments, and Sludges at Wood Treater Sites* (December 1995). EPA developed this guidance as part of an initiative to speed up remedy selection and reduce the cost and time required to clean up similar sites, among other purposes. Region 2 officials said that a goal of the initiative was to avoid conducting treatability studies to assess innovative or emerging technologies—technologies that have been implemented on a small scale and show promise for being able to remediate similar types of contamination—if EPA already had proven technologies.

[30]As with efforts to assess the risks of contamination at the site, EPA contractors did much of the work to identify and evaluate remedial technologies and alternatives. However, EPA provided direction and oversight to the contractors, and decided which remedial alternatives to select for the site. Therefore, we refer to all of these activities as EPA efforts.

to temperatures greater than 1,000 degrees Fahrenheit to destroy contaminants.[31] EPA also identified other technologies to cap, contain, excavate, extract, treat, or dispose of site soil or groundwater contamination, including a number of emerging or innovative technologies.

For the soil contamination, the range of technologies EPA considered varied among the OUs at the site. During its remedy selection process for OU1, EPA primarily evaluated the three technologies preferred by agency guidance for soil contamination at wood-treatment sites. According to Region 2 officials, EPA considered a limited range of technologies for OU1 because, originally, the agency was evaluating whether it would need to evacuate residents to protect them from site contamination. Consequently, EPA conducted a more streamlined remedy selection process for OU1 to speed decision making. Alternatively, for OU2 (and later for OU3), EPA evaluated a wider range of technologies, including several emerging technologies. In addition, Region 2 officials stated that differences in the contamination between the OUs impacted the range of technologies considered. Specifically, the officials said that the OU1 material was the more sludge-like, free-product creosote, whereas the OU2 contamination might not have been visible. The officials noted that, with less contaminated soils, more treatment options might become viable, since some options that might have difficulty treating more highly contaminated material might successfully treat less contaminated material. However, while EPA considered a wider range of technologies for OU2 and OU3, in general, EPA screened out the emerging technologies in favor of those that were identified as preferred in its guidelines.[32] Ultimately, EPA determined that off-site thermal treatment and disposal of the soil contamination would best achieve its cleanup goals and were consistent with residential use of the site. In implementing this remedy, EPA determined that it would need to purchase some houses—where contamination was inaccessible without demolishing the houses—and permanently relocate these

[31]Bioremediation may be performed either *in situ* (in place in the ground) or *ex situ* (after material is excavated).

[32]Region 2 officials said that innovative or emerging technologies were screened out because EPA found they would not be a good match for the site, not simply because they required a treatability study to assess their viability.

residents, while residents in other houses would only need to be relocated temporarily.[33]

For the groundwater contamination, Region 2 officials said that EPA tried to determine how to clean up the contaminated groundwater in the fractured bedrock but ultimately concluded that none of the options would be effective; moreover, many of the options would be expensive and take a long time to implement.[34] As a result, EPA determined that attenuation of the groundwater contamination over time, long-term monitoring, and institutional controls to prevent the installation of wells at the site would be the best alternative to address contamination in the fractured bedrock. To select this remedy, EPA invoked a waiver for technical impracticability, which allowed it to select an alternative that would not comply with requirements to clean up the groundwater to levels that would meet site cleanup goals.[35] Region 2 officials stated that one of the presumptions EPA makes in using a waiver for technical impracticability is that it has put forth its best effort to remove source contamination. Therefore, according to the officials, on the basis of agency guidance, EPA needed to clean up the source material that was contaminating the groundwater to justify a waiver for technical impracticability.[36] Moreover, the officials said that by removing the source material, EPA may have helped prevent the contaminated groundwater area from getting larger. Also, the officials said that, in their judgment, EPA's action would help the contamination in the bedrock attenuate more quickly, although they were unable to quantify this impact.

In selecting these remedies, EPA's decisions were influenced by several challenges associated with a residential cleanup, including (1) space constraints that limited on-site implementation of actions, (2) a

[33]EPA noted that all remedial alternatives it considered, with the exception of a no-action alternative, would have required that the agency relocate residents.

[34]EPA treated contaminated groundwater in the soil that it encountered while excavating the soil contamination.

[35]Under the National Contingency Plan, EPA is allowed to select an alternative that does not comply with requirements applicable to a site, such as meeting groundwater guidelines, if the agency determines that certain circumstances exist. One such circumstance is when the agency determines that compliance with the requirement would be technically impracticable from an engineering perspective.

[36]EPA, *Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration*, Office of Solid Waste and Emergency Response Directive 9234.2-25 (Washington, D.C.: September 1993).

determination that some options would not achieve the site cleanup goals, and (3) concerns about some options' community impacts.

Space constraints. According to Region 2 officials, space constraints posed by the residential nature of the site limited EPA's ability to remediate contamination on-site. For example, the officials said that soil contamination in the lagoons and canals was interspersed throughout the residential area. As a result of the lack of available open land and the residential nature of the site, a site document indicated that options for on-site treatment and disposal of excavated material were not considered for OU1.[37] Also, while EPA considered on-site treatment technologies and alternatives for OU2 and OU3, Region 2 officials said EPA did not consider buying additional houses to create more open space.[38] They said that once EPA determined that the majority of houses in the residential area could be saved, it tried to avoid demolishing as many homes as possible.[39] The officials also noted that EPA could have placed a treatment facility in a corner of the Rustic Mall, but that the mall was still a functioning commercial area at the time EPA was selecting remedies. The mall was in the middle of the town, and, according to the officials, feedback from local citizens indicated that the community relied heavily on the mall. As a result, EPA did not formally consider taking over additional areas of the mall to create more open space as part of a remedial alternative. Region 2 officials acknowledged that, after EPA began the cleanup, the owner decided to demolish the mall. However, they stated that, when EPA made its remedy selection decisions, it did not have sufficient justification to purchase or demolish the mall.

In particular, EPA Region 2 officials told us that the challenge of space constraints was a key factor in why EPA chose not to implement

[37]One area of the mall was used as a staging area to support site work, including EPA and contractor offices; a soil staging area to store excavated material; and an area for backfill soil, equipment, and other required materials. The need to have these facilities at the site contributed to the lack of open space.

[38]Region 2 officials also stated that EPA considered placing a treatment facility on a nearby Superfund site. However, they said it would have been very difficult to get the required state and local approvals.

[39]According to EPA, agency guidance indicates a preference for actions that address contamination risks using methods of cleanup that allow people to remain safely in their homes and businesses. See EPA, *Interim Policy on the Use of Permanent Relocations as Part of Superfund Remedial Actions*, Office of Solid Waste and Emergency Response Directive 9355.0-71P (Washington, D.C.: June 1999).

bioremediation or LTTD—two of EPA's preferred remedies for treating creosote contamination—on-site. For example, the officials noted that bioremediation of excavated material on-site would have required a lot of space to store the material while it was being treated with microbes that would help degrade the contamination. Similarly, the officials said that there was not sufficient space to stockpile material for treatment using LTTD. That is, to operate an LTTD unit efficiently, the officials said that EPA would have needed to feed material into the unit constantly. However, they said doing so was not possible at the site because, while EPA might excavate 100 tons of soil on some days, on other days, EPA was unable to excavate as much since it needed to work by hand around residents' houses. Given EPA's inconsistent rate of excavation, the agency would have needed to stockpile material to ensure a constant flow into an LTTD unit. However, according to Region 2 officials, there was not enough space to stockpile contaminated material awaiting treatment, and, as a result, the officials estimated that EPA could have operated an on-site LTTD unit only 25 percent of the time, which they said would not have been cost-effective. Specifically, the officials said that it would take around 60,000 square feet for all of the operations associated with an LTTD unit. They noted that a space roughly this size was available in the northeast corner of the Rustic Mall. However, because of constraints, such as fire code access requirements for a bowling alley that bordered this area, the officials estimated that the total available space was actually only about 43,000 square feet. Also, EPA would have needed additional space for other facilities related to the cleanup. In addition, while EPA determined that bioremediation and LTTD could be used to treat contamination off-site, EPA found that they would be difficult to implement because of a lack of permitted commercial facilities.[40] As a result, EPA relied on incineration because incineration facilities were the most readily available for off-site treatment of material from the site.

Level of cleanup required. EPA had concerns about whether certain technologies would effectively treat contamination to required levels, given the residential nature of the site. For example, EPA determined it was unlikely that such technologies as bioremediation of contaminated material in place would achieve the agency's soil remediation goals,

[40]Region 2 officials said that EPA attempted to reach out to identify permitted vendors who could perform off-site LTTD, but none of the LTTD vendors responded to bid requests for site work. Similarly, EPA learned of one commercial facility that may have been able to treat site soils using bioremediation; however, the company did not respond to bid requests for site work.

because EPA was uncertain whether the bioremediation microbes could be distributed evenly in contaminated areas since some of the contamination was under residents' homes.[41] Region 2 officials also said it was unlikely that EPA could have achieved its cleanup goals using bioremediation because of the high levels of soil contamination at the site. They said that if contamination levels are high, the microbes introduced into the soil could be killed before they have a chance to degrade the contaminants. Moreover, because of the high contamination levels and treatment requirements at the site, the officials said they had concerns about the effectiveness of using LTTD. They stated that LTTD treats material using lower temperatures than incineration, and that it removes about 80 percent of the contamination each time material is passed through the unit. As a result, sometimes material must be treated multiple times before it meets residential standards. The officials indicated that this would have probably been the case with the Federal Creosote material because it was so highly contaminated. They said, given the nature of the contamination at the site, incineration was a more efficient method of treatment to achieve the agency's remediation goals.

While the high treatment levels required because of the residential nature of the site impacted EPA's choices about individual soil remediation technologies, they also influenced decisions about whether to dispose of treated and untreated material on-site, or at an off-site location. According to Region 2 officials, if EPA disposed of excavated material on-site, the agency would have had to ensure, through treatment and testing, that the soil met residential standards. Consequently, the officials concluded that if EPA disposed of excavated material on-site, it would have had to treat and test the material more extensively than it did for off-site disposal. The officials said that only about 35 percent of the material excavated from the site needed to be thermally treated before it could be disposed of off-site.[42] The rest of the excavated material could be disposed of without treatment at a hazardous or nonhazardous waste landfill. However, they said, if EPA had disposed of material on-site, it would have had to test and possibly treat 100 percent of the material to ensure that it met residential

[41]EPA had similar concerns about using chemical grouting to immobilize contaminants.

[42]EPA found that contamination from wood-preserving operations is a "listed waste" under the Resource Conservation and Recovery Act, which gives EPA the authority to control hazardous waste from the "cradle-to-grave," including the generation, transportation, treatment, storage, and disposal of hazardous waste. As a listed waste under the act, EPA could not dispose of contaminated material without ensuring that it had been treated to specified standards.

standards. Due to the potential expense of additional treatment and sampling, EPA determined that off-site disposal would be more cost-effective.

For the groundwater contamination, according to site documents, EPA found that none of its remedial alternatives, including those based on extracting or treating the contamination in place, would be able to achieve its cleanup goals effectively and reliably within a reasonable time frame. For example, EPA found that some of the groundwater contaminants could take decades to move through the groundwater, and, as a result, it would take an extremely long time to remediate these contaminants using an extraction technology. Moreover, EPA estimated that the technology that was most likely to be able to achieve its remediation goals—extracting contaminants using steam—would cause significant disruption to the residential neighborhood and would be much more expensive than EPA's other alternatives. On the basis of its experience at other sites, EPA determined that complete removal of the groundwater contamination in the bedrock at the site was not practicable. In addition, EPA found that several of the treatment technologies it considered would not be effective at treating the highly contaminated free-product creosote found in portions of the site.

Community impacts. The residential nature of the site and the importance of the Rustic Mall to the community also influenced EPA's remedy selection, given the effects that different technologies and alternatives might have on the community. For example, according to EPA, some of the substances that could be used to immobilize soil contamination in the ground were potentially more toxic than the creosote contamination. Also, certain options that treated contamination in place or extracted it from the soil or groundwater would have emitted heat or gas that could have posed risks to residents and the community. Moreover, EPA determined that some options would have significantly disrupted the community because of the need to install equipment, wells, and piping throughout the residential and commercial areas.

Also, because EPA was implementing a remedial action in a residential neighborhood at the site, it was concerned about the length of the cleanup and other timing impacts on the community. Region 2 officials said that EPA generally does not use certain alternatives unless the agency has the flexibility to accomplish remediation over a long time frame on the basis of the current land use (e.g., the site is abandoned). Under these circumstances, EPA could use a remedy like bioremediation of contaminated material in place, which would cause long-term disruption if

implemented in a residential neighborhood. Also, Region 2 officials said that, if EPA had used on-site LTTD to treat contaminated material, it could not have operated the unit in the most efficient way—24 hours a day—because the residents in houses within 200 feet of where the unit would have been located would have been negatively affected by its lights and noise during the night. However, the officials said, if EPA had only run the LTTD unit 8 hours a day, the cleanup effort would have taken much longer.[43] The length of time involved was a particular concern in EPA's evaluation of groundwater remediation alternatives. According to the Region 2 officials, the best alternative to extract contaminated groundwater from the bedrock would have taken 18 to 20 years to implement and would have covered the site with machinery.

Finally, EPA factored future land use impacts into its remedy selection decisions.[44] For example, EPA found that options that relied on containment or deed restrictions, but that left contamination under and around the residential community, were not viable alternatives. Region 2 officials said capping the contamination would not have supported use of the land as a residential area because residents would have had to sign agreements not to disturb the cap, which would have restricted their use of the properties. Also, because of these restrictions, the officials said it is likely that some owners would have refused to sign the necessary agreements, and EPA would have had to take an enforcement action. Similarly, EPA avoided certain remedies for the Rustic Mall because of the impacts that they could have on the community's ability to redevelop the mall as well as on the operation of the mall. A Borough of Manville official told us that the Rustic Mall was the "hub of the town" and was located directly behind buildings on the town's Main Street. As a result, he said the community was very opposed to alternatives that would have left or

[43]Region 2 officials said that EPA placed an LTTD unit in a residential area at another site. However, at this other site, the officials noted that none of the residents' houses were within 200 feet of the unit, and there was enough space to build a large earthen berm to lessen the unit's impacts on the community.

[44]According to EPA guidance, remedial alternatives should be consistent with reasonably anticipated future land use. See EPA, *Land Use in the CERCLA Remedy Selection Process*, Office of Solid Waste and Emergency Response Directive 9355.7-04 (Washington, D.C.: May 1995).

treated contamination on-site.[45] He said that, in the town's view, the contamination under the mall needed to be cleaned up. Otherwise, it would have been difficult to get tenants into the mall in the future, and the town might have ended up with a blighted area in the center of the community. He also said the community was concerned that no one would want to come and shop at the mall if there was a treatment facility in the parking lot.

EPA Placed a High Priority on Cleaning Up the Federal Creosote Site

EPA placed a high priority on scheduling and funding the Federal Creosote site work because the contamination was in a residential area. According to Region 2 officials, it is rare to find source contamination, such as the free-product creosote, under a residential area, and most sites with the level and extent of contamination found at the Federal Creosote site are abandoned. The officials said EPA places the highest priority on addressing the principal threats at residential sites first. As evidence of this prioritization, EPA initiated efforts to study, select a remedy for, and begin cleanup of the residential part of the site before undertaking similar efforts for the Rustic Mall. For example, Region 2 officials said that EPA decided relatively early in the cleanup process to break the site into three OUs to allow work to proceed as quickly as possible. EPA determined that it needed to get to work immediately on OU1, and that the groundwater contamination and commercial area could wait until after EPA had decided what to do with the residential area. The Region 2 officials said that breaking the site into different OUs was important because EPA knew that it needed to relocate some OU1 residents, and this process can be time-consuming—one official noted that residents who must permanently relocate have 1 year to do so. While this process took less time at the Federal Creosote site, EPA did not know that would be the case initially. Moreover, the Region 2 officials said that the first couple of years EPA spent studying the site caused a great deal of anxiety for residents, because they did not understand the risks of remaining in their homes and could not sell their homes if the homes would need to be demolished. The officials said the OU1 ROD informed residents that most of the homes in

[45]Region 2 officials said the state of New Jersey was also opposed to on-site treatment and disposal options. The Region 2 officials said that while EPA occasionally signs a ROD without state concurrence, the agency generally tries to avoid doing so because, under CERCLA, EPA cannot carry out a remedial action without the relevant state's agreement to provide a 10 percent cost share. Also, the officials noted that community acceptance of EPA's remedial action is one of the selection criteria, and the agency prefers not to store large amounts of contamination for treatment near a residential area.

the neighborhood would not need to be demolished, and this helped reduce residents' anxiety.[46]

EPA also took steps to shorten the time needed to select, design, and implement the remedial actions. For example, Region 2 officials said that, because of the residential nature of the site, the site investigation process was both unusually extensive and expedited in comparison to other sites. Region 2 officials said that EPA began sampling early because, when the site was discovered, the agency was concerned that contamination risks could be so significant that residents might need to be evacuated. As a result, they said that the agency gathered a large amount of information about site contamination before listing the site on the NPL. The officials said this data collection effort helped EPA move forward with site work quickly because, with a large amount of data to use to gauge its overall approach to the site, EPA was able to compress the removal evaluation, listing process, and RI/FS into a relatively short amount of time. In addition, EPA tried to streamline work by configuring its sampling efforts to satisfy postexcavation requirements to confirm that contaminated material no longer remained on-site. Specifically, site documents show that to meet New Jersey requirements, EPA took samples on 30-by-30 foot grids to confirm that contamination was no longer present along the sides and bottom of an excavated area. Rather than wait until the excavation was completed to take additional samples to confirm that contamination was not present, EPA incorporated these requirements into earlier sampling efforts. As a result, if samples were clean, EPA could immediately backfill an area, which reduced the overall length of the cleanup effort.[47] Finally, in an effort to expedite the cleanup effort, EPA Region 2 officials said that more of the region's resources were devoted to

[46]The officials emphasized that the OU1 remedial action was an early interim action and that EPA did not begin the excavation until the OU2 ROD was issued, which set quantitative remediation goals for the cleanup of the Claremont Development. The officials stated that when EPA's National Remedy Review Board reviewed the OU1 decision and recommended that Region 2 complete its sitewide RI/FS before beginning source material excavation, the board meant the investigation of the residential area and not that Region 2 should complete its RI/FS of OU3 before beginning excavation of OU1. Region 2 agreed with this recommendation.

[47]Region 2 officials said that EPA did not have as much data for the Rustic Mall but maximized resources by coordinating RI/FS efforts for this area with design activities for other parts of the site. Additionally, while EPA had signed the ROD and designed the excavation for OU3 by the time that the owner of the mall decided to demolish it, EPA revised the design concurrently with the excavation rather than delay work.

the site relative to other sites that the region needed to address at that time.

As a result of these efforts to prioritize and expedite site cleanup work, the Federal Creosote site reached key cleanup milestones in less time than some other site cleanups. Region 2 officials said that they completed the three RODs for the site in about 3 years, which they said is a very quick time frame to complete such analyses. They noted that issuing a ROD is an intensive process that at another site, for example, took over a decade. Also, the Federal Creosote site reached EPA's construction complete stage more quickly than other megasites—that is, sites at which actual or expected total cleanup costs, including removal and remedial action costs, are expected to amount to $50 million or more. In July 2009, we reported that, based on EPA data through fiscal year 2007, the median length of time it took for megasites to reach construction complete after NPL listing was 14.8 years.[48] However, according to EPA data, the Federal Creosote site reached construction complete in just over 9 years.[49]

[48]GAO, *Superfund: Litigation Has Decreased and EPA Needs Better Information on Site Cleanup and Cost Issues to Estimate Future Program Funding Requirements*, GAO-09-656 (Washington, D.C.: July 15, 2009).

[49]In our July 2009 report (GAO-09-656), we raised concerns about the usefulness of EPA's "construction complete" measure as an indicator of the status of site cleanups because, for example, sites with groundwater contamination (as at the Federal Creosote site) may take decades to reach selected standards, even though EPA declares the site construction complete. By presenting statistics in this report that compare the median length of time from NPL listing to construction complete for the Federal Creosote site with other megasites, we mean only to contrast the length of time it took to reach key agency milestones and not to compare the status of the site cleanup with EPA's remediation goals.

Total Site Costs Exceeded Early Construction Cost Estimates Largely because of the Nature of these Estimates and the Discovery of Additional Contamination

Total site costs exceeded construction estimates at the Federal Creosote site by roughly $233 million, primarily because (1) EPA's early construction estimates were not designed to include all site-related expenses and (2) additional quantities of contaminated material were discovered during the cleanup effort. Other factors, such as methodological variation for estimating site costs and contractor fraud, accounted for a smaller portion of the cost difference.

Total Site Costs Exceeded Construction Estimates by Approximately $233 Million

According to our analysis, total site-related costs, including remedial construction and other response costs at the Federal Creosote site through the spring of 2009, were approximately $338 million,[50] a roughly $233 million difference from the estimated remedial construction costs of $105 million.[51] Total site costs were higher than construction estimates for several reasons.[52] As shown in figure 3, of the $233 million difference, 39.6 percent (or about $92 million) is due to other response costs that were not

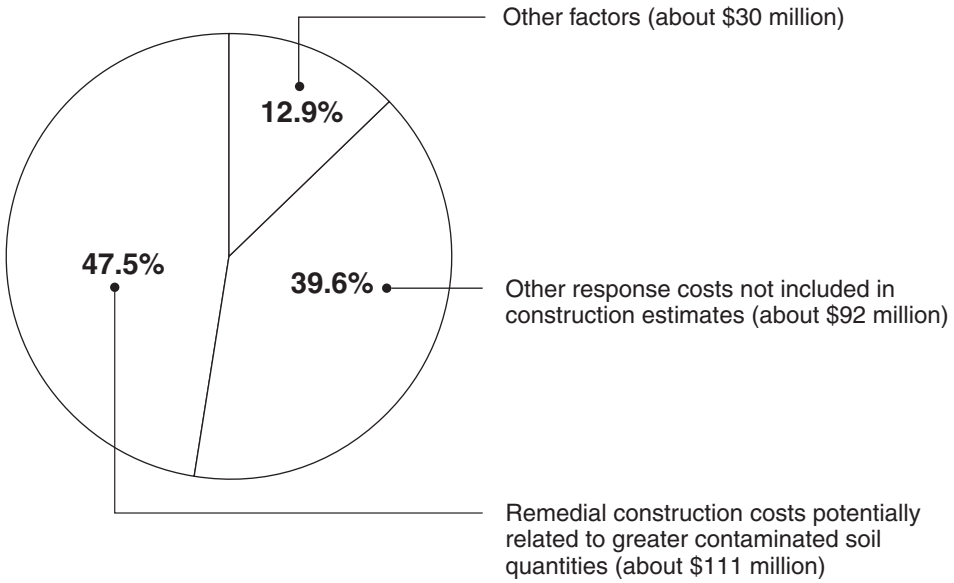
[50]We developed these data on actual site costs using data provided by EPA and the Corps. As a result of the methodology we used to adjust the data to fiscal year 2009 constant dollars, these figures do not match other EPA-published information on site costs.

[51]This figure represents the total of EPA's estimated costs for remedial construction activities conducted through the spring of 2009, to address contamination at different areas of the site, which we discounted using a present value analysis and adjusted to fiscal year 2009 constant dollars. To identify the estimated costs of activities that had been completed as of the spring of 2009, we added EPA's estimates for the construction costs of these activities for each OU and, following GAO guidance, applied a discount factor to reflect that EPA's estimates pertained to future costs. In this report, when we discuss "estimated costs," we refer to GAO's revised estimated cost figure. As a result of the methodology we used to adjust these estimates, our calculated total does not match EPA's published estimates for completed and remaining work at the site, which totaled $118 million in nominal dollars. Unless otherwise noted, we adjusted all dollar values presented in this report to fiscal year 2009 dollars as per GAO guidance. See appendix II for more information on our methodology for estimating site costs.

[52]We recognize that total site costs, which include other response costs, will always be different from remedial construction costs. However, for the purposes of this report, we determined that it was necessary to report total site costs as a point of departure to discuss how construction costs, as well as other response costs that were not included in EPA's original construction cost estimates, contributed to the total amount EPA spent on the site.

included in EPA's construction estimates;[53] 47.5 percent (or about $111 million) is from an increase in remedial construction costs—mostly directly related to the discovery of additional contaminated material; and 12.9 percent (or about $30 million) is due to other factors—primarily differences in cost estimation methodology and, to a smaller extent, contractor fraud.

Figure 3: Difference between Estimated Construction and Total Site Costs at the Federal Creosote Site



Total = $233 million

Source: GAO analysis of data obtained from EPA, the Corps, and court documents.

Note: Site costs were drawn from several sources, including Corps data on construction contractor costs updated through February 15, 2009, as well as Corps and EPA sources updated through various dates from April to early May, 2009. Due to several reasons, including our methodology for adjusting costs to fiscal year 2009 dollars, the percentages in this figure are considered to be approximate.

[53]"Other response costs" refer to costs associated with the site that were not directly related to construction of a particular remedy (discussed in greater detail in the next section of this report).

EPA's Construction Cost Estimates Intentionally Did Not Include All Site Costs

EPA intentionally included only costs related to the construction and maintenance of the selected remedies rather than total sitewide costs in its early cost estimates, which follows its guidance, according to the agency.[54] EPA prepares these preliminary estimates during the remedy selection process to compare projected construction costs across different remedial action alternatives. Specifically, the National Contingency Plan directs EPA to consider the capital costs of construction and any long-term operation and maintenance costs as part of the remedial alternative screening process.[55] According to EPA guidance, these estimates are not intended to include all site-related expenses, and certain expenses, such as early site investigation and EPA enforcement costs, are beyond the scope of these early estimates because these costs are not linked to a specific remedial alternative and, therefore, would not affect the relative comparison of alternatives. For example, while site investigation studies were conducted for each operable unit, these studies were completed prior to remedy selection to inform the selection process and, therefore, were not linked to any particular remedy. Similarly, the removal cleanup of surface soils in the residential area occurred prior to remedy selection and, therefore, was not related to the construction costs of any particular remedial alternative. Table 2 summarizes costs for activities that were not included in EPA's remedial construction cost estimates—other response costs—at the Federal Creosote site.

Table 2: Other Response Costs Not Included in Construction Estimates for the Federal Creosote Site

Cost description	Total costs[a] (FY 2009 dollars)
Indirect support costs related to site construction work[b]	$72,679,000
Site investigation and risk assessment study	11,038,700
Indirect support costs related to other response efforts[b]	4,209,100
EPA payroll and travel	2,085,100

[54]EPA, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, Office of Solid Waste and Emergency Response Directive 9355.0-75 (Washington, D.C.: July 2000).

[55]According to EPA guidance, capital costs include all labor, equipment, and material costs associated with construction activities as well as costs for professional/technical services, such as engineering support for the construction of the remedial action. Operation and maintenance costs are those postconstruction costs necessary to ensure or verify the continued effectiveness of a remedial action.

Cost description	Total costs[a] (FY 2009 dollars)
Enforcement	1,579,800
Analytical and technical support	319,300
State cooperative agreement	278,500
Emergency removal cleanup	32,200
Miscellaneous	8,400
Total	**$92,230,100**

Source: GAO analysis of EPA data.

Note: Other response costs were drawn from EPA data through April 30, 2009. As a result of the delay between when a cost is incurred and when it may be submitted and entered into EPA's cost-tracking systems, the total costs listed in this table are approximate.

[a]Certain categories in this table include contractor annual allocation costs. These costs include money spent by government contractors doing site-related work not traceable to a particular site, such as hazardous materials training. Government contractors allocate these costs across the sites on which they have worked during the course of each year, and EPA treats them as direct costs.

[b]Indirect support costs are overhead costs for activities related to managing the Superfund program, such as guidance development, that EPA allocates across all Superfund sites.

The Need to Remediate Greater-than-Expected Quantities of Contaminated Material Contributed Most to the Gap between Estimated and Actual Construction Costs

During excavation, contractors discovered greater-than-expected amounts of contaminated material requiring remediation across all OUs, which contributed most to the difference between estimated and actual construction costs. Based on our analysis of EPA documents, the initial ROD estimates for the site indicated that approximately 154,100 to 164,400 tons of material would need to be excavated for treatment or disposal; however, EPA ultimately found that roughly 456,600 tons of material needed to be excavated—an increase of at least 178 percent. As shown in table 3, according to our analysis, increased amounts excavated from the OU1 and OU3 areas contributed the most to the difference between the estimated and actual excavated amounts across the site as a whole.

Table 3: Difference between Estimated Soil Quantities in the RODs and Final Soil Quantities at the Federal Creosote Site, by OU

Hundreds of tons

OU	Estimated soil quantity from RODs	Final soil quantity	Soil quantity increase from RODs	Percentage increase
OU1	66,200 to 70,700[a]	210,800	140,100 to 144,600	198% to 218%
OU2	31,700 to 33,800	67,900	34,200 to 36,300	101 to 115
OU3	56,300 to 60,000	177,800	117,800 to 121,600	196 to 216
Total[b]	**154,100 to 164,400**	**456,600**	**292,200 to 302,500**	**178% to 196%**

Source: GAO analysis of EPA documents.

Note: Soil quantities are presented in a range because EPA updated its conversion factor for calculating soil weights from volumes at the site as additional information regarding the density of the soil became available. The lower bound in this table generally represents soil quantities using a conversion factor of 1.5 cubic yards per ton, whereas the upper bound reflects EPA's later use of 1.6 cubic yards per ton. We based our analysis on EPA documents and did not independently verify the soil quantities reported by EPA.

[a]EPA revised its original quantity estimate for OU1 soils as a result of its investigation of OU2 contamination. Based on our analysis of site documents, the revised quantity is approximately 152,600 to 162,700 tons.

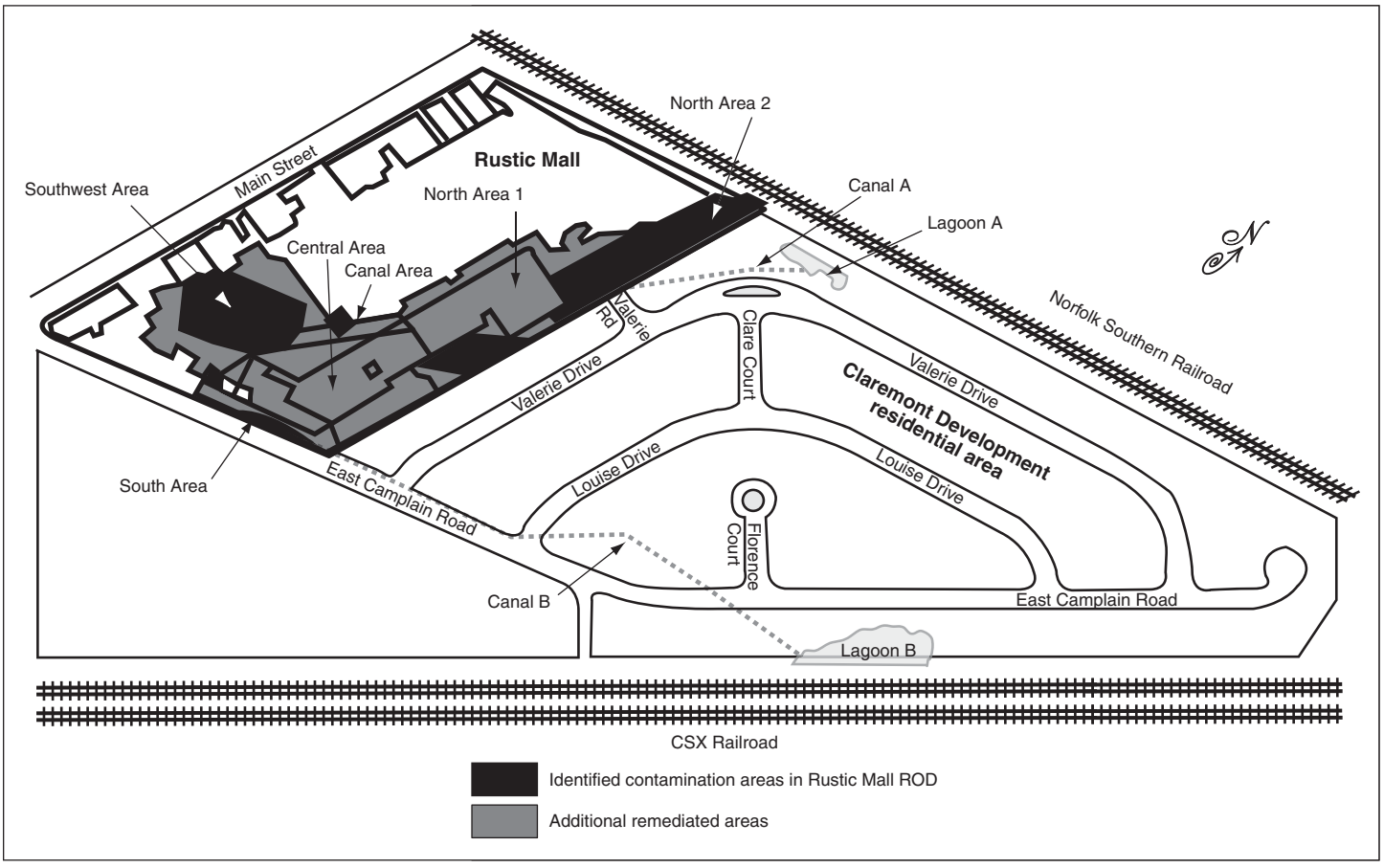
[b]Totals may not add due to rounding.

According to EPA officials, it is common for EPA to remove more soil than originally estimated at Superfund sites because of the uncertainty inherent in using soil samples to estimate the extent of underground contamination. For example, EPA guidance indicates that the scope of a remedial action is expected to be continuously refined as the project progresses into the design stage and as additional site characterization data and information become available.[56] However, both Corps and EPA officials stated that the Federal Creosote site posed a particular challenge for estimating soil quantities prior to excavation because of the way in which the waste moved at the site and, in some cases, because of access restrictions during sampling. According to EPA's Remedial Project Manager (RPM) for the site, soil contaminants generally either stay in place or migrate straight down; however, while some of the creosote waste at the site stayed in place, some of the waste migrated both horizontally and vertically. The RPM said that this migration made it difficult to predict the waste's location through sampling. For example, during excavation, contractors found seams of contaminated material, some of which led to additional pockets of creosote waste, while others did not. Given the diameter of the sampling boreholes (which were generally 2 to 4 inches wide) and the width of the seams of creosote waste (which in some cases were only 6 inches wide), the sampling process could not detect all of the creosote seams at the site, despite what EPA officials considered to be the extensive sampling during the early site investigations that formed the basis for the initial cost estimates. Additionally, sampling during the site investigations for the residential area as well as the Rustic Mall was limited by the location of buildings and access restrictions, according to EPA's RPM. For example, site documents indicate that no samples could

[56]Our analysis of site documents found that additional sampling during the design stage was generally successful in refining the estimated quantity of material requiring excavation across all OUs. Specifically, final excavation amounts increased by only about 28 percent over estimates at the design stage as compared with at least 178 percent over ROD estimates.

be taken from under the mall during the OU3 soil investigation because the buildings were being used. It was not until the mall owners decided to demolish the existing structures as part of a town revitalization plan that mall tenants left and EPA was able to take samples in the areas covered by the buildings. These areas were found to contain additional areas of creosote waste, as shown in figure 4.[57]

Figure 4: Rustic Mall Areas Remediated at the Federal Creosote Site



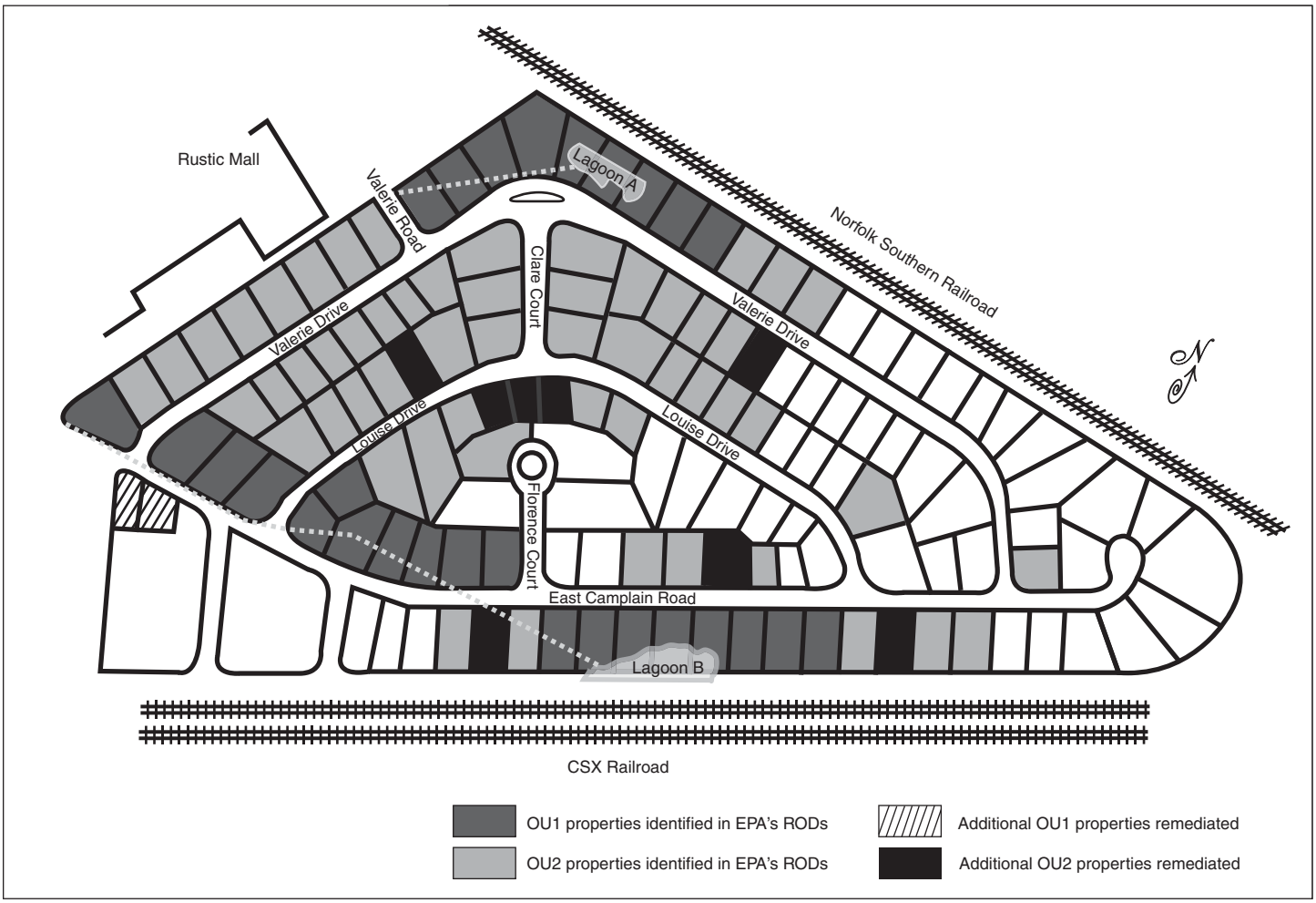
Source: GAO analysis of EPA site documents.

[57]According to site documents, EPA suspected there was contamination underneath the Rustic Mall buildings on the basis of sampling in the areas surrounding the mall. However, because EPA did not have access beneath the mall buildings for sampling and EPA's original quantity estimates presumed the buildings would remain standing, contamination under the buildings was not included in the original estimates.

Although the mobility of the waste in the subsurface soil and sampling limitations hindered EPA's ability to determine the total quantity of material requiring excavation during the pre-ROD site investigation when the initial cost estimates were prepared, soil sampling during this stage was generally successful at identifying which residential properties contained contamination, according to our analysis of site documents. For example, pre-ROD soil sampling allowed EPA to correctly identify 83 of the 93 residential properties that would eventually require remediation, as shown in figure 5.[58]

[58]According to EPA, residents at 3 properties refused EPA access to conduct sampling during the pre-ROD site investigation. EPA later gained access to the properties and found that 2 of the 3 properties required soil remediation.

Figure 5: Residential Area Properties Remediated at the Federal Creosote Site



Source: GAO analysis of EPA site documents.

Note: In addition to the properties highlighted in this figure, other areas, such as sections of streets and railroad rights of way, were also excavated.

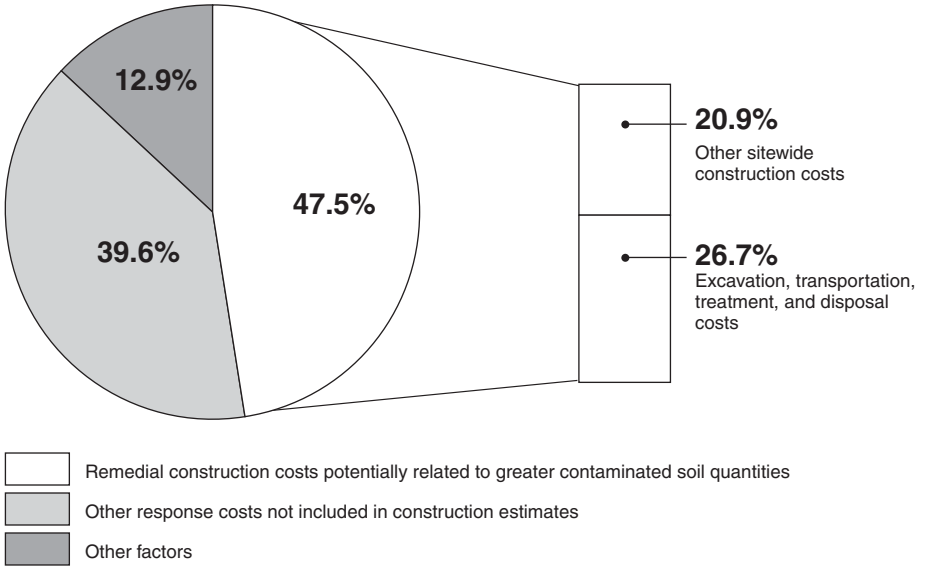
According to EPA guidance, because of the inherent uncertainty in estimating the extent of site contamination from early investigation data, cost estimates prepared during the RI/FS stage are based on a conceptual rather than a detailed idea of the remedial action under consideration. The guidance states that these estimates, therefore, are expected to provide sufficient information for EPA to compare alternatives on an "order of magnitude" basis, rather than to provide an exact estimate of a particular remedy's costs. For example, the guidance also states that preliminary

cost estimates prepared to compare remedial alternatives during the detailed analysis phase of the RI/FS process are expected to range from 30 percent below to 50 percent above actual costs.

However, at the Federal Creosote site, actual construction costs were more than twice what EPA estimated. Specifically, we found that sitewide remedial construction costs increased by $141 million over EPA's estimated amounts. According to site documents, increases in the quantity of material requiring excavation, transportation, treatment, or disposal resulted in higher construction costs across all OUs. Our analysis of site cost data indicated that construction costs potentially associated with the additional quantity of contaminated material accounted for most of this increase ($111 million, or about 78.7 percent).[59] In particular, soil excavation, transportation, treatment, and disposal costs constituted approximately 56.1 percent ($62 million) of the increased construction costs potentially related to additional quantities of material, and 26.7 percent of the overall $233 million difference between estimated construction and total site costs, as shown in figure 6.

[59]In 2006, EPA issued an Explanation of Significant Differences for the site, which documented quantity increases and their associated cost increases to date across all three OUs. According to EPA officials, they waited to issue this document until after the completion of the OU3 design phase so that they could understand the differences across the entire site. Generally, EPA does not revisit its remedy selection decision unless new information indicates that the selected remedy is technically infeasible or is not sufficiently protective to meet cleanup goals, or that an alternative approach would be equally protective and more cost-effective. According to EPA officials, they did not find anything to indicate the agency should change the overall cleanup approach at the site.

Figure 6: Actual Remedial Construction Costs as a Portion of the Difference between Estimated Construction and Total Site Costs at the Federal Creosote Site



Source: GAO analysis of data obtained from EPA, the Corps, and court documents.

Note: Site costs were drawn from several sources, including Corps data on construction contractor costs updated through February 15, 2009, as well as Corps and EPA sources updated through various dates from April to early May, 2009. Due to several reasons, including our methodology for adjusting costs to fiscal year 2009 dollars, the percentages in this figure are considered to be approximate.

According to EPA's RPM, both the need to excavate greater amounts of material and the reclassification of excavated material from nonhazardous waste to hazardous waste affected excavation, transportation, treatment, and disposal costs. For example, the discovery of additional pockets of creosote waste increased the overall amount of material requiring excavation and treatment or disposal because, in addition to removing the waste itself, any soil overlying the contamination needed to be removed and disposed of to access the creosote waste. Additionally, if a pocket of creosote waste was unexpectedly discovered in an area of soil that had already been designated for excavation and disposal in a landfill without treatment because prior sampling indicated it was less contaminated, the overall amount of soil to be excavated would not be affected, but costs

would increase because treatment is more expensive than landfill disposal.[60]

In addition, EPA and Corps officials said that the need to remediate greater quantities of material contributed to increases in other sitewide construction costs, such as general construction requirements and site restoration costs. Our analysis showed that such costs accounted for another 20.9 percent of the difference between estimated construction costs and total site costs—although the exact extent to which additional amounts of material contributed to the difference in costs is not clear. EPA's RPM stated that the effect of increased quantities varied, depending on the OU. However, EPA and Corps officials said that in general, more extensive excavation would increase design engineering, inspection, and other costs as well as costs for general construction requirements and for site restoration, as shown in table 4. For example, the decision to remediate additional contaminated material under the Rustic Mall buildings led to increased design engineering costs because the original excavation plans were created under the assumption that the mall would remain standing, and further rounds of design sampling were needed to identify the extent and location of contamination once the buildings were demolished. Additionally, our analysis of site documents indicated that the increased time required to excavate additional material could have led to greater project costs for general construction requirements, such as temporary facility rental, site security, and health and safety costs. Similarly, site restoration costs, such as costs for backfill soil, could have increased because more backfill would be required to restore the site after excavation.

[60]Although the quantities of soil and contaminated material increased above EPA's estimates, our analysis found that the average unit costs that EPA paid for thermal treatment and disposal of contaminated material—the most expensive remediation option—were lower than originally estimated and decreased over time. For example, the estimated unit cost for these services ranged from $510 for OU1 to $650 for OU2 and OU3; however, actual average unit costs were $448 per ton for OU1, $426 per ton for OU2, and $354 per ton for OU3. We did not adjust these costs to 2009 dollars to more accurately reflect the actual bid prices at the time of construction.

Table 4: Estimated and Actual Remedial Construction Costs at the Federal Creosote Site

Cost description[a]	ROD estimates (FY 2009 dollars)[b]	Actual cost (FY 2009 dollars)[b,c]
Excavation, transportation, treatment, and disposal	$76,110,500	$159,643,400
Design-engineering, inspection, and other costs[d]	12,027,400	34,133,500
Resident relocation and home demolition	5,874,000	9,405,500
General construction requirements	5,495,500	26,613,900
Site restoration	4,298,300	15,101,000
Site preparation	1,183,700	926,500
Total	**$104,989,400**	**$245,823,800**

Source: GAO analysis of data obtained from EPA and the Corps.

Note: Site costs were drawn from several sources, including Corps data on construction contractor costs updated through February 15, 2009, as well as Corps and EPA sources updated through various dates from April to early May, 2009. Due to several reasons, including our methodology for adjusting costs to fiscal year 2009 dollars, the amounts in this table are considered to be approximate.

[a]Some actual costs were not listed as line items in the ROD estimates. In these cases, we included related actual costs in the same category. For example, water removal costs for soil excavation areas below the water table and odor control were not line items in the estimates, but we included them in the "excavation" category because they are part of the process.

[b]These amounts do not match EPA-published data as a result of our methodology for adjusting the data to fiscal year 2009 dollars, among other reasons.

[c]This amount includes approximately $2.1 million in inflated prices due to contractor fraud, as we discuss later in this section of the report.

[d]Some groundwater remediation costs incurred as part of the Corps' contract for design activities were included under the engineering, inspection, and other costs category. This total also includes the Corps' management and support fee, which according to EPA's RPM, was not charged to individual sites at the time the ROD estimates were prepared.

According to the RPM, EPA and the Corps instituted certain controls at the site to minimize costs. In particular, the RPM stated that the Corps took steps to ensure that material was not unnecessarily excavated and sent for treatment and disposal. For example, if contractors found an unexpected pocket of creosote waste during excavation, they were required to notify the Corps official on-site, who would decide whether additional excavation was required depending upon visual inspection and additional testing, as needed. The contractor was not allowed to excavate beyond the original excavation limits without Corps approval. According to the RPM, the Corps' approach of reevaluating the original excavation depth on the basis of additional sampling results and a visual inspection of the soil led to cost savings because in some areas less material needed to be excavated than originally planned. Furthermore, EPA and Corp officials

stated that this process minimized unnecessary treatment and disposal costs that might be incurred if "clean" soil was sent for treatment or hazardous waste disposal. Additionally, EPA's decision in November 2002 to allow treated soil to be disposed of in a nonhazardous waste facility if it met the facility's criteria for contamination levels helped reduce unit costs for treatment and disposal because disposing of soil at a hazardous waste facility is more expensive. For example, in a bid for a contract to treat and dispose of soil following EPA's decision, the selected subcontractor submitted a unit price for treatment and disposal at a nonhazardous waste facility that was $80 (or 16 percent) less than its unit price for treatment and disposal at a hazardous waste facility—which for that particular contract saved $800,000.[61]

Furthermore, on the basis of information gathered from site documents and from statements made by EPA and Corps officials, EPA and the Corps took other steps intended to minimize costs. For example, a Corps official said that reducing the duration of the project could help minimize certain site costs. Specifically, according to our analysis of site documents, to reduce the amount of time spent waiting for sampling results prior to backfilling an excavated area, EPA and the Corps incorporated state postexcavation sampling requirements into their design sampling plans for earlier investigations. Accordingly, unless additional excavation was required to meet the cleanup goals, these samples could be used to confirm that the boundaries of the excavation areas had been tested for contamination. Additionally, our analysis of site documents showed that the Corps tested various odor control measures before beginning excavation at certain areas of the site, which allowed it to use less expensive odor control alternatives than originally planned and saved approximately $1.1 million in implementation costs. These measures also helped to speed up the construction work. Finally, according to the RPM, the Corps was able to minimize costs by managing the work to avoid costly contractor demobilization and remobilization expenses. For example, the Corps dissuaded the contractors from removing idle equipment and worked with the RPM to resolve administrative or funding

[61]Additionally, according to site documents, EPA did not excavate contaminated soil at the site if EPA determined that it did not pose a direct threat of human exposure. Specifically, although EPA removed source material that could pose a threat of groundwater contamination, EPA allowed residually contaminated soil to be left in some areas of the site at levels deeper than approximately 14 feet below the ground surface. According to site documents, EPA and NJDEP used deed notices for properties in these areas to document the remaining contamination and restrict excavation.

issues or questions about the work as they arose to prevent an expensive work stoppage.[62]

Contrasting Cost-Estimating Methodologies and Contractor Fraud Explain a Smaller Portion of the Difference between Estimated Construction and Total Site Costs

Other factors, including different cost-estimating methodologies and contractor fraud, explain a smaller portion of the difference between estimated construction and total site costs at the Federal Creosote site. In developing its estimates, EPA followed agency guidance, which states that as a simplifying assumption, most early cost estimates assume that all construction costs will be incurred in a single year.[63] According to EPA, since the estimated implementation periods for EPA's remedial actions were relatively short periods of time, EPA did not discount future construction costs in its estimates, and, therefore, these estimates were higher than they would have been otherwise.[64] In accordance with our best practices regarding the use of discounting, we adjusted the initial cost estimates to reflect that costs were projected to accrue over several years and that, therefore, future costs should be discounted.[65] However, by discounting future construction costs prior to adjusting for inflation, our discounted values were lower than EPA's original estimates in site documents. According to our analysis, discounting estimated costs accounted for approximately 12 percent of the $233 million difference between estimated construction and total site costs (see fig. 7).

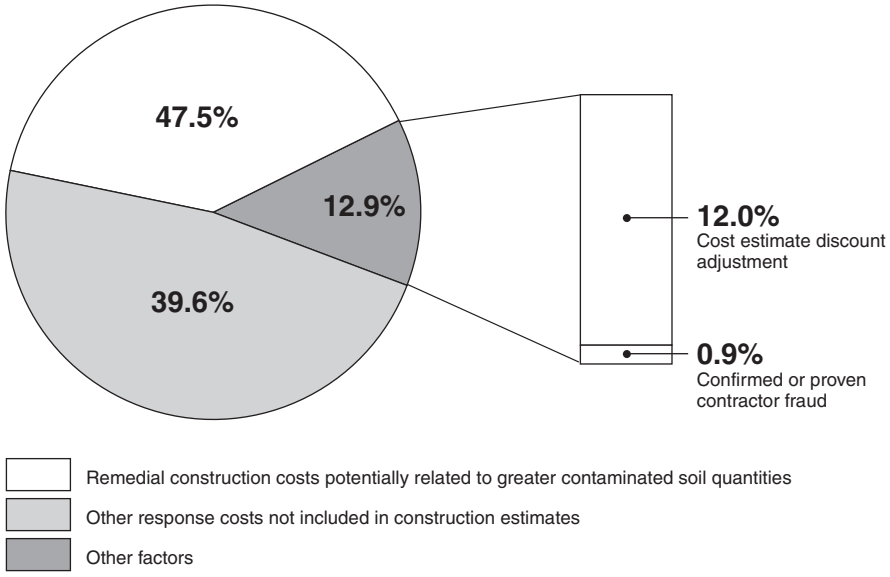
[62]Region 2 officials said it was important to prevent a work stoppage because it would lead to additional contractor demobilization and remobilization costs and would negatively impact community relations.

[63]This assumption can be modified if construction is projected to last over a longer period of time.

[64]Discounting future costs to their present value accounts for the time value of money. In particular, having one dollar today is worth more than having one dollar a year from now because if it were invested, it could earn a return from interest. EPA's estimated implementation periods for site construction at the ROD stage ranged from 21 months to 3.5 years. However, EPA did not expect to begin implementing remedial actions until at least 1 year after it selected its remedies because of, for example, design activities or resident relocations. Therefore, while EPA's estimated construction periods were relatively short, EPA did not plan to incur construction costs until further into the future than is indicated simply by its estimated time frames. Consequently, discounting these future implementation costs had a relatively greater effect on our analysis of EPA's estimated site costs than if the costs were projected to occur immediately after EPA selected its remedies.

[65]GAO, *Discount Rate Policy*, GAO/OCE 17.1.1 (Washington, D.C.: May 1991).

Figure 7: Contrasting Methodologies and Contractor Fraud as a Portion of the Difference between Estimated Construction and Total Site Costs at the Federal Creosote Site



Source: GAO analysis of data obtained from EPA, the Corps, and court documents.

Note: Site costs were drawn from several sources, including Corps data on construction contractor costs updated through February 15, 2009, as well as Corps and EPA sources updated through various dates from April to early May, 2009. Due to several reasons, including our methodology for adjusting costs to fiscal year 2009 dollars, the percentages in this figure are considered to be approximate.

Contractor fraud also contributed to the difference between estimated construction and total site costs, but to a small degree. However, while some parties have pled guilty to fraud, the full extent of the effect of fraud on site costs will not be known until all investigations are complete. Court documents alleged that employees of the prime contractor at the site, as well as some subcontractors, were engaged in various kickback and fraud schemes, which resulted in inflated prices for certain subcontractor services. For example, a subcontractor for soil treatment and disposal agreed to pay approximately $1.7 million in restitution to EPA for fraud in inflating its bid prices. In addition, court documents alleged that fraudulent price inflation also affected other site costs, including certain subcontracts for items such as wastewater treatment, backfill, landscaping services, and utilities. To date, our analysis of available court documents indicated that at least approximately $2.1 million in inflated payments may be directly attributable to fraud at the Federal Creosote site. On the basis of currently available information, this figure represents less than 1

percent of the difference between estimated construction and total site costs. However, since the fraud investigations are ongoing and additional charges may be filed, the full extent of contractor fraud is not currently known. See appendix I for more information about site-related fraud investigations.

EPA Provided Overall Project Management and Communicated with Residents, while the Corps Oversaw Contractor Implementation of the Remedy

EPA managed the overall cleanup and communicated with residents through a dedicated on-site staff presence, among other actions. The Corps implemented the cleanup work by hiring and overseeing contractors; the Corps was less involved in selecting and overseeing subcontractors at the site.

EPA Managed the Cleanup and Communicated with Residents

According to a 1984 interagency agreement between EPA and the Corps for the cleanup of Superfund sites, EPA maintains statutory responsibility for implementing the Superfund program. In addition to selecting the remedy at a site, EPA provides overall management of the cleanup, ensures that adequate funding is available, and manages relationships with other interested parties, such as residents. If EPA decides that Corps assistance is needed to conduct cleanup work, EPA establishes site-specific interagency agreements. These agreements outline the specific tasks and responsibilities of the Corps at the site and provide a proposed budget for the activities listed. Once the site-specific agreements are established, EPA's primary responsibilities are to make sure that the work continues without interruption and that adequate funding is available, according to EPA officials. EPA officials also noted that the agency does not have the authority to direct Corps contractors at the site; rather, all instruction and direction to contractors goes through the Corps.

To fulfill its project management and community outreach responsibilities, EPA dedicated a full-time RPM to the Federal Creosote site, according to Region 2 officials. Although RPMs generally have two or more sites for which they are responsible at any given time, Region 2 officials stated that the size and complexity of the site required a higher level of EPA involvement. For example, the officials said that the relatively large size of

the site and stringent cleanup goals meant that a large area was excavated, and the complexity of the cleanup process led to a greater number of questions from the Corps and its contractors that required EPA's attention. According to the officials, the RPM was on-site at least two to three times per week; however, during some segments of the work, he was on-site almost every day. They noted that the design phase in particular required close coordination with the Corps because design activities for different areas of the site occurred simultaneously and were often concurrent with construction.[66] Consequently, the RPM said he was on-site working with the Corps and its design contractor to design new phases of the work; revise existing designs; and answer any questions regarding ongoing construction activity, such as whether to excavate additional pockets of waste found during the construction phase. According to the RPM, although the Corps was required to ask EPA for approval only to expand excavation to properties that were not included in the RODs, in practice, Corps officials kept him informed whenever additional excavation was required, and, in many cases, he made the decision regarding whether to broaden or deepen the excavated area.

To monitor project progress and funding, the RPM had weekly on-site meetings with the Corps and received weekly and monthly reports on progress and site expenditures, according to EPA officials.[67] At the weekly meetings, the RPM would answer Corps questions regarding the work and be informed of any contracting or subcontracting issues that might delay or stop work at the site. Moreover, as part of EPA's oversight of site progress, the RPM said he reviewed Corps documents regarding any changes in the scope of the work. Because EPA provided funding to the Corps on an incremental basis, the RPM also closely monitored the rate of Corps expenditures to ensure sufficient funding to continue the work, according to EPA officials. The RPM explained that he also reviewed

[66]Design specifications provide detailed instructions to the contractor about how to perform the work. See appendix III for a timeline of key remedial design and action events at the Federal Creosote site.

[67]Although concerns were identified by a 2007 EPA Office of Inspector General report that evaluated EPA's management of Superfund interagency agreements at the Federal Creosote site and certain other sites, officials with EPA's Office of Inspector General indicated that key findings did not necessarily involve EPA's oversight at the Federal Creosote site. According to these officials, the only issue related to the Federal Creosote site was a lack of detail in the monthly progress reports that the Corps submitted to EPA. However, the officials stated that, because of the RPM's on-site presence and level of involvement at the Federal Creosote site, they believed that the RPM had a good understanding of the work that was occurring at the site.

Corps cost information for unusual charges and, with the exception of a few instances of labor charge discrepancies, most of the time the Corps reports did not contain anything surprising. In the few instances where the RPM found a discrepancy, he contacted Corps officials, and they were able to explain the reason for the discrepancy—for example, a problem with the Corps' billing software. The RPM stated that, under the interagency agreement with the Corps, he did not review contractor invoices or expenditures because the Corps had both the responsibility and the expertise necessary to determine whether the contractor charges were appropriate, given the assigned work.

Additionally, EPA officials stated that the residential nature of the site necessitated a substantial investment in community relations to manage residents' concerns about the contaminated material under their homes and the Rustic Mall. As part of these efforts, EPA used such tools as flyers, newsletters, resident meetings, and media interviews to communicate with concerned citizens.[68] According to the RPM, managing community relations required the second largest commitment of his time, after designing the work. He said that he spent a great deal of time working with residents to help them understand the situation during the early site investigation stage, when it was not clear who was going to need to move out of their homes and residents were concerned about their health and property. The RPM said that he also worked personally with residents during the design and implementation of the remedy to minimize the impact to the community and to inform it of any additional actions needed, such as excavating contamination across a property line or closing roads.

According to site documents and a local official, EPA's community relations efforts were successful at reducing residents' anxieties. For example, in a summary of lessons learned from the cleanup effort, site documents indicate that EPA's policy of promptly responding to community inquiries and the regular presence of EPA personnel at the site helped to establish and preserve a high level of public acceptance and trust with the community. Also, a Borough of Manville official noted that the continuity provided by having one RPM dedicated to the site for the duration of the project was particularly helpful in maintaining good communication because it allowed EPA officials to know almost all of the residents on a first-name basis and encouraged their participation in the cleanup process. For example, the RPM stated that he worked closely with

[68]In addition to the RPM, EPA also assigned a community relations specialist to the site.

residents to address their concerns and minimize impacts to the community during the excavation of contaminated material and the restoration of affected areas of the neighborhood. Similarly, according to the Borough of Manville official, EPA and the contractors effectively coordinated with town officials to ensure that the cleanup effort went smoothly. For example, to minimize disruption, EPA consulted with town officials about which roads would be best to use, considering the routes and weight limitations of trucks leaving the site. In the official's view, EPA's outreach efforts ensured that residents and the community as a whole had sufficient information to feel comfortable about the cleanup. Consequently, despite the size and scope of the cleanup effort, the official could recall very few complaints from residents.

The Corps Selected and Oversaw Contractors' Design and Implementation of the Remedy but Had a Limited Role in the Subcontracting Process

At the Federal Creosote site, the Corps selected and oversaw private contractors' design and implementation of the remedial action; however, the Corps was less involved in the subcontracting process. Under the 1984 interagency agreement with EPA, the Corps selects and oversees private contractors for all design, construction, and other related tasks at Superfund sites, in accordance with Corps procedures and procurement regulations.[69] According to Corps officials, the Corps selected a contractor to perform the design for the three OUs at the Federal Creosote site from a list of qualified vendors and then negotiated a price for the contracts. For construction, the Corps selected a prime contractor from a pool of eligible contractors under a cost-reimbursement, indefinite-delivery/indefinite-quantity (IDIQ) contract.[70] According to EPA and Corps guidance, this system provides more flexible and responsive contracting capabilities for Superfund sites, which may require a quick response and often lack a sufficiently defined scope of work for price negotiation.

[69]Under the 1984 interagency agreement, the Corps is also responsible for providing (1) technical assistance to EPA during the RI/FS phase and (2) site-specific cost documentation to support EPA's cost recovery efforts.

[70]A cost-reimbursement contract is one in which the contractor receives payments for the amount of allowable costs incurred to the extent prescribed in the contract rather than a prenegotiated fixed amount, while an IDIQ contract is one in which orders for goods or services are placed against an established contract. The IDIQ contracts used at the Federal Creosote site were "pre-placed remedial action contracts" (PRAC). According to Corps officials, the construction at the site was performed under four PRACs—three for the prime contractor and one for the demolition contractor.

The Corps' prime contractor performed some of the work and subcontracted some tasks to other companies. For example, the prime contractor excavated contaminated material but awarded subcontracts for transportation, treatment, and disposal of the excavated material. Other subcontracted services included providing backfill soil and landscaping for site restoration, and treating wastewater. To subcontract, the prime contractor solicited bids from potential vendors and, for smaller subcontracts, provided the Corps with advance notification of the award. To award larger subcontracts, the prime contractor requested Corps approval.

To carry out its oversight responsibilities, the Corps monitored changes in the scope of the work, contractor progress and costs, and work quality. For example, Corps officials stated the following:

- The Corps had to approve any changes in project scope, such as excavating greater quantities of material, or any increases in other construction services or materials beyond the amounts originally negotiated between the Corps and the prime contractor. According to EPA officials, this chain of command helped prevent any unauthorized expansion of work at the site.[71]

- To monitor project progress and contractor costs during construction, the Corps reviewed prime contractor cost summary reports for each phase of the work. These reports contained detailed information on contractor costs and work progress, and, according to Corps officials, they were updated, reviewed, and corrected if necessary on a daily, weekly, and monthly basis.[72] For example, Corps officials explained that they reviewed the daily reports primarily for accuracy and unallowable costs. For weekly and monthly reports, the Corps also examined whether the contractor was incurring costs more quickly than expected, which could indicate that a cost was incorrectly attributed or that a change in project scope was necessary (i.e., because particular aspects of the work were more costly than anticipated, and, therefore, a scope revision was needed to complete

[71]Although the Corps directed the prime contractor, Corps officials also noted that the RPM was heavily involved at the beginning of each work phase and established a precedent for when decisions regarding additional excavation could be made by the Corps, and for when the RPM needed to be consulted first.

[72]Corps officials said that EPA specifically requested that the Corps track contractor charges daily because of the large scale of the project and of EPA's concern about maintaining forward progress due to the residential nature of the site.

planned activities). However, Corps officials commented that the contractor data were generally accurate, and that errors were infrequent. The officials also said that, during the most active periods of the work, they discussed the cost reports and project progress, including any potential changes in unit costs, during the weekly meetings with the contractor.

- The Corps also monitored work quality at the site. According to site documents, the Corps was required to implement a quality assurance plan as part of its oversight responsibilities and had a quality assurance representative at the site during construction. For example, in a July 2002 notice to the prime contractor, the Corps identified several workmanship deficiencies that the contractor had to address to retain its contract for that portion of the work.[73]

According to Corps guidance and officials, the Corps had a limited role in the subcontracting process at the Federal Creosote site. For example, the prime contractor was responsible for selecting and overseeing subcontractors. In particular, Corps guidance states that since subcontracts are agreements solely between the prime contractor and the subcontractor, the Corps does not have the authority to enforce the subcontract provisions.[74] Rather, the guidance indicates that the Corps oversees the prime contractor's management systems for awarding and administering subcontracts through periodic reviews of the contractor's subcontracting processes and ongoing reviews of subcontract awards. According to Corps officials, the Corps' main responsibility in the subcontracting process at the Federal Creosote site was to review subcontract decisions and approve subcontracts above a certain dollar threshold. As Corps officials explained, subcontracts between $25,000 and $100,000 did not need to be approved by the Corps; rather, the prime contractor sent the Corps an "advance notification" package, which documented that the contractor had competitively solicited the work and

[73]In addition to overseeing the prime contractor charged with construction, site documents showed that the Corps was also required to oversee the design contractor and provide written reports to EPA on a monthly basis on changes in the scope of work, project progress, and costs. Additionally, the Corps was responsible for ensuring that the prime contractor's work was in accordance with EPA guidance and policies.

[74]Although the Corps is not a party to the contract between the prime contractor and the subcontractor, the Corps requires that the prime contractor include certain contract clauses in its subcontracts to ensure that the subcontract follows the intent of federal acquisition regulations and policies.

why the contractor selected a particular subcontractor over others. However, for subcontracts greater than $100,000, the prime contractor had to submit a "request for consent" package to the Corps, which contained similar documentation as an advance notification but required Corps approval prior to awarding a subcontract.

According to federal acquisition regulations and policies, when evaluating request for consent packages, Corps contracting officers should consider whether there was sufficient price competition, adequate cost or price comparison, and a sound basis for selecting a particular subcontractor over others, among other factors. Early in the project, the Corps identified several issues with the prime contractor's performance at the site, including the award of subcontracts. According to a letter the Corps sent to the prime contractor, the Corps noted that after repeated unsuccessful attempts to address these issues, the Corps would initiate proceedings to terminate the contract for site work unless the contractor took corrective action. However, Corps officials said the contractor demonstrated sufficient improvement in its documentation practices. Then, in 2003, the Corps raised the request for consent threshold from $100,000 to $500,000 because of the high volume of these packages that the Corps was receiving.[75] A Corps official noted that while the Corps reviews and consents to the subcontracting decisions of its contractors as appropriate, it avoids becoming too involved in the subcontracting process because of bid protest rules regarding agency involvement in that process. According to the official, under these rules, a subcontract bidder cannot protest a subcontract award unless it can show that the overseeing agency was overly involved in the subcontracting process.

Concerning contractors at the Federal Creosote site, the Department of Justice and EPA's Office of Inspector General have ongoing investigations, some of which have resulted in allegations of fraud committed by employees of the prime contractor and several subcontracting firms. For example, court documents alleged bid-rigging, kickbacks, and other fraudulent activity related to the award of several subcontracts for a variety of services and materials. According to Corps officials, the Corps did not suspect issues of fraud in the subcontracting process until 2004 when, in one instance, a subcontract bidder objected to the award of a soil

[75]The advance notification threshold was also increased from $25,000 to $100,000 at this time, according to Corps officials. Corps officials said that raising the notification and consent thresholds is not unusual, and it had been done before at other sites.

transportation, treatment, and disposal subcontract to another firm whose bid was substantially higher. Upon further review of the documents, Corps officials found that the prime contractor had not conducted a proper evaluation of the bid proposals, and the Corps withdrew its consent to the subcontract—ultimately requesting that the prime contractor solicit bids under a different process.[76] In the revised bidding process, the firm that had won the earlier subcontract reduced its price from $482.50 to $401.00 per ton of contaminated material—only 70 cents below the competing bid submitted by the firm that had protested the original subcontract. On this basis, the prime contractor again requested consent to subcontract with the firm to which it had awarded the earlier subcontract. According to a Corps official, the Corps was suspicious of illegal activity given how close the two bids were, and Corps officials discussed whether to take formal action against the prime contractor. However, Corps officials decided they did not have sufficient evidence of wrongdoing to support a serious action but did cooperate with others' investigations of fraud at the site. For more information on site-related fraud, see appendix I.

Agency Comments and Our Evaluation

We provided a draft of this report to the Secretary of the Army and the Administrator of the Environmental Protection Agency for review and comment. The Secretary, on behalf of the Corps of Engineers, had no comments on the draft report. EPA generally agreed with our findings regarding the agency's actions and costs to clean up the Federal Creosote site, and provided a number of technical comments, which we incorporated as appropriate. EPA's written comments are presented in appendix IV.

In its comments, EPA noted that the draft report accurately described the cleanup of the site and correctly compared the site's estimated and final remedial construction costs. However, EPA stated that comparing estimated remedial construction costs to total site costs is not an "apples to apples" comparison because some costs, such as amounts spent on removal actions or EPA personnel salaries (referred to as "other response

[76]The prime contractor had solicited bids under a "Request for Proposals" process, which, according to a site document, allowed it to select the subcontractor that provided the "best value," even if it involved paying a higher price. However, the Corps found that the prime contractor did not adequately justify why a higher price should be paid for the subcontractor's services and requested that the prime contractor solicit bids using a sealed bid process, in which only a price per ton and a determination of a subcontractor's ability to perform the work were considered in the selection process.

costs" in this report), are purposely excluded from EPA's early estimates of remedial construction costs. We agree that to identify the extent to which site costs increased over agency estimates, one should only compare estimated and actual remedial construction costs, as we do in table 4 of this report. However, our objective was, more broadly, to identify what factors contributed to the difference between the estimated remedial construction costs ($105 million) and the actual total site costs ($338 million). We found that the difference between these two amounts was $141 million in remedial construction cost increases—which were largely due to increases in the amount of contaminated material requiring remediation—and $92 million in other response costs that were not included in EPA's original estimates. We believe it was necessary to provide information on these other response costs to more fully answer our objective and to provide a more informative accounting of the total costs that EPA incurred in cleaning up the Federal Creosote site.

As agreed with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution of it until 30 days from the date of this report. At that time, we will send copies of this report to the appropriate congressional committees, the Secretary of the Army, the Administrator of the Environmental Protection Agency, and other interested parties. In addition, the report will be available at no charge on GAO's Web site at http://www.gao.gov.

If you or your staffs have any questions about this report, please contact me at (202) 512-3841 or stephensonj@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Key contributors to this report are listed in appendix V.

John B. Stephenson
Director, Natural Resources
and Environment

Appendix I: Summary of Criminal and Civil Litigation Related to the Federal Creosote Site

Court records show that several cases have been brought concerning the Federal Creosote site cleanup. First, the Department of Justice (Justice) and the state of New Jersey have filed claims to recover cleanup costs. Second, Justice has brought criminal charges in a series of cases against one employee of the prime contractor, three subcontractor companies, and eight associated individuals involved in the cleanup, alleging fraud, among other things. Third, the prime contractor has brought a civil suit against a former employee alleged to have committed fraud and other offenses during his employment as well as against associated subcontractors. The information in this appendix provides a brief summary of known actions related to the Federal Creosote site cleanup.

Cost Recovery and Natural Resources Damages Claims

United States v. Tronox, LLC: The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) provides that parties incurring costs to respond to a release or threatened release of a hazardous substance may recover such costs from legally responsible parties, including persons who owned or operated a site, among others. In this regard, the Environmental Protection Agency (EPA) identified Tronox, LLC, the successor to the companies that owned and operated the Federal Creosote site, and, for 2 years, EPA and Tronox participated in alternative dispute resolution concerning EPA's cost recovery claims. In August 2008, Justice, on behalf of EPA, filed a civil action in the United States District Court for the District of New Jersey against Tronox, seeking recovery of costs that the government incurred for the Federal Creosote site cleanup. The complaint asserted that the government had incurred at least $280 million in response costs and would incur additional costs. In October 2008, the New Jersey Department of Environmental Protection and the Administrator of the New Jersey Spill Compensation Fund filed suit in the same court against Tronox, seeking recovery of costs incurred for the site, as well as damages for injury to natural resources—under both CERCLA and the New Jersey Spill Compensation Act—and public nuisance and trespass claims.[1] In December 2008, the federal and state cases were consolidated. Tronox has stated its intent to vigorously defend against these claims. In early 2009, Tronox filed for voluntary Chapter 11 bankruptcy in federal bankruptcy court and initiated an adversary proceeding in that court, seeking a declaratory judgment on the status of the EPA and New Jersey claims with respect to the bankruptcy.

[1]New Jersey's related claims in state court, originally filed in 2007, were dismissed subsequent to the filing in federal court.

Subsequently, both courts entered a stipulation filed by both the government plaintiffs and Tronox to stay the cost recovery case as well as the adversary proceeding to allow the parties to resolve the claims. As of the date of this report, the stays remain in effect.

Criminal Cases Involving Alleged Contractor Fraud at the Site

United States v. Stoerr: Norman Stoerr, a former employee of the prime contractor at the Federal Creosote site, pled guilty to three counts related to his activities as a contracts administrator at the site. Court documents alleged that over a 1-year period, the employee conspired with others to rig bids for one subcontractor at the site, resulting in EPA being charged inflated prices. In addition, the documents alleged that over several years, the employee solicited and accepted kickbacks from certain subcontractors at the Federal Creosote site and another site, and allowed the kickbacks to be fraudulently included in subcontract prices that were charged to EPA. To date, Stoerr has not been sentenced.

United States v. McDonald et al: In August 2009, the United States indicted Gordon McDonald—a former employee of the prime contractor at the Federal Creosote site—as well as representatives of two subcontractors who worked at the site, for various counts, including kickbacks and fraud. The indictment charged that the prime contractor's employee, a project manager, solicited and accepted kickbacks from certain subcontractors in exchange for the award of site work, and that these kickbacks resulted in EPA being charged an inflated price for the subcontractors' work. The indictment also charged that the project manager disclosed the bid prices of other vendors during the subcontracting process, which resulted in the government paying a higher price for services than it would have otherwise paid.[2] One of the indicted employees (James Haas)—representing a subcontractor who provided backfill material to the site—has pled guilty of providing kickbacks and submitting a bid that was fraudulently inflated by at least $0.50 per ton of material. Haas agreed to pay more than $53,000 in restitution to EPA as part of his guilty plea, and has been sentenced to serve 33 months in jail and to pay a $30,000 criminal fine. McDonald's case is proceeding, and charges against a third defendant are still pending.

[2]The indictment alleged that these acts took place on several occasions and at more than one Superfund site.

United States v. Bennett Environmental, Inc.: Bennett Environmental, Inc. (BEI), a subcontractor providing soil treatment and disposal services to the Federal Creosote site cleanup, entered a plea agreement admitting to one count of fraud conspiracy. Court documents alleged that over 2 years, the company paid kickbacks to an employee or employees of the prime contractor, in return for receiving favorable treatment in the award of subcontracts, and inflated its prices charged to EPA. BEI was sentenced to 5 years' probation and ordered to pay $1.662 million in restitution to EPA, plus a $1 million fine.[3]

United States v. Tejpar: Zul Tejpar, a former employee of BEI, entered a plea of guilty to one count of fraud conspiracy. Court documents alleged that Tejpar, along with coconspirators, provided kickbacks to employees of the prime contractor to influence the award of subcontracts at the site and fraudulently inflated the company's bid price after an employee of the prime contractor revealed the other bid prices. To date, Tejpar is awaiting sentencing.

United States v. Griffiths: Robert P. Griffiths entered a plea of guilty to three counts related to fraudulent activity at the Federal Creosote site when he was an officer of BEI. Griffiths, along with coconspirators, provided kickbacks to employees of the prime contractor to influence the award of subcontracts at the site, fraudulently inflated the company's invoices that the prime contractor charged to EPA, and fraudulently received the bid prices of other bidders prior to award of a subcontract. To date, Griffiths is awaiting sentencing.

United States v. JMJ Environmental, Inc.: JMJ Environmental, Inc., a subcontractor providing wastewater treatment supplies and services, and John Drimak, Jr., its president, entered guilty pleas related to fraudulent activity at the Federal Creosote site and another site. At the Federal Creosote site, JMJ Environmental and Drimak, along with coconspirators, provided kickbacks to employees of the prime contractor to influence the award of subcontracts at the site, fraudulently inflated the company's prices that the prime contractor charged to EPA, and arranged for intentionally high, noncompetitive bids from other vendors. To date, JMJ Environmental and Drimak are awaiting sentencing.

[3]Courts may impose probation on a corporation. This probation may involve various activities intended to prevent future wrongdoing and often involves court-appointed oversight.

United States v. Tranchina: Christopher Tranchina, an employee of subcontractor Ray Angelini, Inc., which provided electrical services and supplies, entered a plea of guilty to fraud conspiracy for activities at the Federal Creosote site. Tranchina, along with coconspirators, provided kickbacks to employees of the prime contractor to influence the award of subcontracts at the site and fraudulently inflated the company's prices that the prime contractor charged to EPA. Tranchina was sentenced to imprisonment of 20 months and ordered to pay $154,597 in restitution to EPA.

United States v. Landgraber: Frederick Landgraber, president of subcontractor Elite Landscaping, Inc., entered a plea of guilty to fraud conspiracy for activities at the Federal Creosote site. Landgraber, along with coconspirators, provided kickbacks to employees of the prime contractor to influence the award of subcontracts at the site and submitted fraudulent bids from fictitious vendors to give the appearance of a competitive process, resulting in EPA paying higher prices than if procurement regulations were followed. Landgraber was sentenced to imprisonment of 5 months and ordered to pay $35,000 in restitution to EPA and a $5,000 fine.

United States v. Boski: National Industrial Supply, LLC, a pipe supply company, and coowner Victor Boski entered guilty pleas for fraud conspiracy at the Federal Creosote site and another site. At the Federal Creosote site, National Industrial Supply and Boski, along with coconspirators, provided kickbacks to employees of the prime contractor to influence the award of subcontracts at the site and fraudulently inflated the company's prices that the prime contractor charged to EPA. The terms of the plea agreement require National Industrial Supply and Boski to have available $60,000 to satisfy any restitution or fine imposed by the court, among other items. To date, they are awaiting sentencing.

Prime Contractor Civil Suit

Sevenson Environmental Services, Inc. v. McDonald: In 2008, Sevenson Environmental Services, Inc., the prime contractor at the Federal Creosote site, sued former employee Gordon McDonald for fraud, breach of fiduciary duty, breach of contract, and other claims. The suit also asserted various claims against other defendants, including McDonald's relatives and companies allegedly owned by him,[4] and six subcontractors and

[4]These defendants include GMEC, Inc.; Patricia McDonald; Flowers By Sweetens, Inc.; Matthew McDonald; Kevin McDonald; and Thomas McDonald.

associated individuals.[5] The allegations related to the Federal Creosote site and another site. With respect to the Federal Creosote site, the suit alleged that the subcontractors provided unauthorized kickbacks to McDonald, his companies, or affiliates. Sevenson also alleged, among other things, that the company suffered substantial damage from the fraud perpetrated by McDonald and employees of BEI, for example, in the company's reliance on fraudulent change orders prepared and recommended by McDonald and fraudulent invoices submitted by BEI. Sevenson asserted similar allegations of kickbacks and fraudulent invoices with respect to other subcontractors. Sevenson sought judgment against the defendants, including punitive damages. To date, the parties have stipulated to a stay of the case while criminal charges against McDonald and others are pending (see the previously mentioned cases).

[5]These defendants include BEI; John Bennett; Robert Griffiths; DCP Technical Services; JMJ Environmental, Inc.; John Drimak, Jr.; Elite Landscaping, Inc.; Frederick A. Landgraber; Ray Angelini, Inc.; Ray Angelini; Christopher Tranchina; National Industrial Supply, LLC; and Victor Boski.

Appendix II: Objectives, Scope, and Methodology

This appendix provides information on the scope of work and methodology used to examine (1) how EPA assessed the risks and selected remedies for the Federal Creosote site, and what priority EPA assigned to site cleanup; (2) what factors contributed to the difference between the estimated and actual remediation costs of the site; and (3) how responsibilities for implementing and overseeing the site work were divided between EPA and the U.S. Army Corps of Engineers (the Corps). It also discusses our methodology for summarizing criminal and civil litigation related to the Federal Creosote site.

To examine how EPA assessed the risks and selected remedies for the Federal Creosote site, as well as what priority it assigned to the cleanup, we reviewed EPA's Superfund site investigation and cleanup processes, including applicable statutes, regulations, and agency guidance. We also reviewed documentation from the site's administrative record, which detailed the agency's activities and decisions at the site.[1] As part of this review, we analyzed public comments that were documented in site records of decision to identify key issues with the cleanup effort. To obtain additional information on these and other site cleanup issues, we interviewed EPA Region 2 officials involved with the site, including officials from the Emergency and Remedial Response Division, the Public Affairs Division, and the Office of Regional Counsel. Furthermore, we interviewed and reviewed documentation obtained from officials with the Agency for Toxic Substances and Disease Registry regarding its determination of site risks. We also consulted with New Jersey and Borough of Manville officials to obtain their views on the cleanup effort. Finally, we interviewed representatives of the potentially responsible party for the site to obtain the party's views on EPA's risk assessment, remedy selection, and site prioritization.

To determine what factors contributed to the differences between the estimated and actual costs of site cleanup, we obtained and analyzed data on estimated and actual site costs from several sources.[2] For estimated site costs, we combined EPA's estimates for selected remedies from site records of decision and remedial alternative evaluations. In developing

[1]We did not independently verify the accuracy of the information contained in these documents.

[2]We focused on the estimated and actual costs of activities that had already been performed as of the spring of 2009, and excluded the costs of future activities at the site, such as groundwater monitoring.

these estimates, EPA applied a simplifying assumption that all construction costs would be incurred in a single year, and, therefore, EPA did not discount future construction costs, even though work was projected to occur several years into the future as a result of design activities and resident relocations as well as EPA's estimated construction time frames.[3] However, our discount rate policy guidance recommends that we apply a discount factor to future costs.[4] Consequently, to convert EPA's estimated costs into fiscal year 2009 dollars, we (1) conducted a present value analysis to discount future site costs to the dollar year of the original estimate (base year) for each remedy, using EPA's recommended discount rate of 7 percent, and (2) converted the present value of each estimate into fiscal year 2009 dollars. To calculate the present value of estimated costs, we identified the projected construction time frames for each remedy from site documents. Because the documents did not provide information on how construction costs would be distributed over the projected time frame, we calculated the midpoint of a range of values, assuming that all costs for particular activities comprising EPA's selected remedies would either be incurred at the beginning of the projected time frame (the maximum value of these costs) or at the end of the projected time frame (the minimum value). To adjust the present values from the base year to fiscal year 2009 constant dollars, we divided the present values by the inflation index for the base year and weighted the calculation to convert the base year from calendar years to fiscal years.

To identify actual sitewide costs, we compiled data from multiple sources, including EPA's Superfund Cost Recovery Package Imaging and On-Line System (SCORPIOS) for data on site costs through April 30, 2009;[5] the Corps of Engineers Financial Management System (CEFMS) for data on Corps and contractor costs through various dates in April and early May, 2009; and contractor-generated project cost summary reports for data on

[3]Because EPA did not discount future construction costs when calculating its estimates, EPA's estimated costs were actually higher than they would have been otherwise.

[4]GAO, *Discount Rate Policy*, GAO/OCE 17.1.1 (Washington, D.C.: May 1991).

[5]The SCORPIOS data collected from EPA included all costs that the agency identified as specifically related to the Federal Creosote site. According to an EPA official, some early investigation work was performed by a contractor that was working at multiple sites, and EPA was unable to identify how much of the contractor's costs were attributable to the Federal Creosote site. As a result, costs for this work were not included in the SCORPIOS data that EPA provided.

contractor costs for each phase of the cleanup through February 15, 2009.[6] We relied on multiple data sources for our analysis because none of the sources provided a sufficient level of specificity for us to comprehensively determine when and for what purpose costs were incurred. In particular, the SCORPIOS data provided specific dates of when EPA incurred costs but for some costs, especially those related to site construction work, the data did not generally provide detailed information on why the costs were incurred. Therefore, to obtain more detailed information on the reason for incurring certain costs, we used the data from CEFMS and the contractor's project cost summary reports. However, the CEFMS and contractor project cost summary report data did not generally provide specific information on when costs were incurred. Consequently, to determine actual site costs in fiscal year 2009 dollars, we used two approaches. For costs taken from the SCORPIOS data or when detailed information on the date of a particular cost was available, we applied the inflation index for the particular fiscal year in which EPA incurred the cost. For costs taken from the other data sources, we used the midpoint of the range of inflation-adjusted values for the construction start and end dates for individual work phases, as recorded in site documents.

We worked with EPA Region 2 officials to categorize site costs, including those that were part of EPA's original construction estimates as well as those that were not part of EPA's estimates. After identifying the costs that were not included in EPA's original estimates, we took the difference between estimated and actual construction costs, according to categories that we discussed with EPA, to identify where actual costs changed the most from EPA's estimates. Then, to identify the factors that contributed the most to the difference in these cost categories, we analyzed the types of costs in each category and interviewed EPA Region 2 and Corps officials responsible for the cleanup. In addition, we analyzed data from site documents on the estimated and actual amounts of contaminated material at various stages of the cleanup process to obtain further information on the extent to which increased amounts of contaminated material affected site costs.[7] To examine the impact of alternative methodologies on the disparity between estimated and actual costs, we

[6]According to site documents, remedial construction concluded in February 2008; however, EPA and Corps officials noted that costs for some site maintenance and administrative activities continued to accrue.

[7]We did not independently verify the information on soil quantities within the site documents.

reviewed EPA cost-estimating guidance and calculated the effect of discounting future estimated costs within our analysis. To determine how fraud impacted site costs, we reviewed civil and criminal litigation documents describing the monetary values exchanged in various schemes.[8]

To ensure the reliability of the actual cost data we used for this report, we reviewed the data obtained from the SCORPIOS and CEFMS databases as well as the contractor-generated cost summary reports that the Corps provided. For each of these data sources, we reviewed agency documents and interviewed EPA and Corps officials to obtain information on their data reliability controls. We also electronically reviewed the data and compared them across all sources as well as with other information on site costs as available. For example, we compared contractor cost data provided by the Corps with similar data from the contractor-generated cost summary reports. Similarly, we compared Corps cost data from CEFMS with analogous data from EPA's SCORPIOS database. Generally, we found that discrepancies among comparable data from different sources were most likely attributable to the potential delay between when a cost is incurred by a contractor and when it is invoiced and processed, first by the Corps and later by EPA. On the basis of our evaluation of these sources, we concluded that the data we collected and analyzed were sufficiently reliable for our purposes. However, because some costs incurred prior to early May 2009 may not have been processed through the Corps and EPA's cost-tracking systems at the time of data collection, site cost data in this report are considered to be approximate. Moreover, because our methodology relied on calculating the midpoint of a range of costs for both the present value calculations and adjusting data for inflation, we consider the data we present in this report on estimated and actual costs and the difference between these costs also to be approximate.

To describe how responsibilities for implementing and overseeing the site work were divided between EPA and the Corps, we reviewed the interagency agreement between EPA and the Corps for Superfund sites in general as well as site-specific agreements for the design and implementation of the cleanup at the Federal Creosote site. We also

[8]Because some cases involved fraud at multiple sites and investigations are ongoing, we could not determine the exact extent to which fraud affected cleanup costs at the Federal Creosote site.

reviewed agency guidance regarding EPA's responsibilities at Superfund sites. To obtain information on EPA's oversight actions, we interviewed EPA and Corps officials responsible for site cleanup and contracting work. We also reviewed site meeting minutes, monthly progress reports, EPA correspondence to the Corps, and relevant EPA Office of Inspector General reports. To further describe the Corps' responsibilities at the Federal Creosote site, we reviewed Corps guidance for the cleanup of hazardous waste projects, Corps contract management best practices, and relevant procurement regulations. To obtain information on actions that the Corps took to implement its site responsibilities, we reviewed Corps correspondence to the contractor and contractor requests for approval of soil treatment and disposal subcontracts. We also interviewed Corps officials responsible for site cleanup and contracting work as well as EPA Region 2 officials. However, we did not assess the adequacy of the Corps' efforts or its compliance with Corps guidance and federal procurement regulations.

To examine issues regarding civil and criminal litigation related to the Federal Creosote site, we collected case data from the Public Access to Court Electronic Records system.[9] We then qualitatively analyzed documents obtained from this system to identify the issues involved and the status of each case as well as the outcomes, if any, of the cases. However, because criminal investigations are ongoing and confidential, we could not determine whether any additional criminal charges were under consideration, but relied solely on the publicly available information for charges that had been filed as of November 2009.[10]

We conducted our work from May 2008 through February 2010 in accordance with all sections of GAO's Quality Assurance Framework that are relevant to our objectives. The framework requires that we plan and perform the engagement to obtain sufficient and appropriate evidence to meet our stated objectives and to discuss any limitations in our work. We believe that the information and data obtained, and the analyses conducted, provide a reasonable basis for any findings and conclusions in this product.

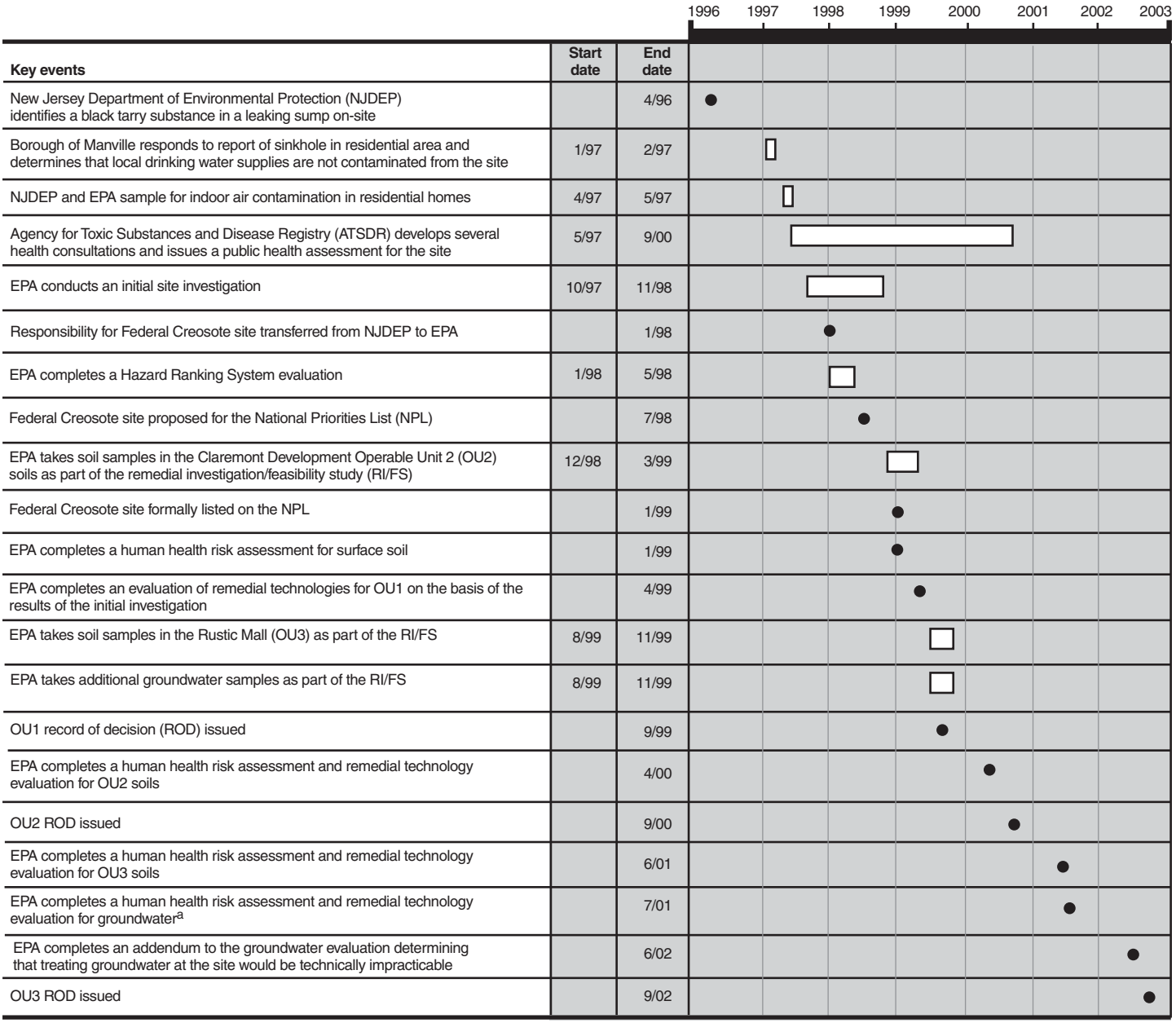
[9]This system provides access to documents related to cases filed in federal courts and is operated by the Administrative Office of the U.S. Courts, which is the central support agency for the Judicial Branch.

[10]We did not evaluate the accuracy of the information obtained from court documents.

Appendix III: Timeline of EPA Actions at the Federal Creosote Site

Figures 8 and 9 provide additional information on the timing of EPA's actions at the Federal Creosote site. Specifically, figure 8 shows the timing of key EPA actions related to its risk assessment and remedy selection at the site, while figure 9 provides additional information on the timing of key remedial design and action activities. Both figures demonstrate the extent to which EPA's efforts to assess risks and select, design, and construct remedies took place concurrently.

Figure 8: Key Events Related to Risk Assessment and Remedy Selection at the Federal Creosote Site

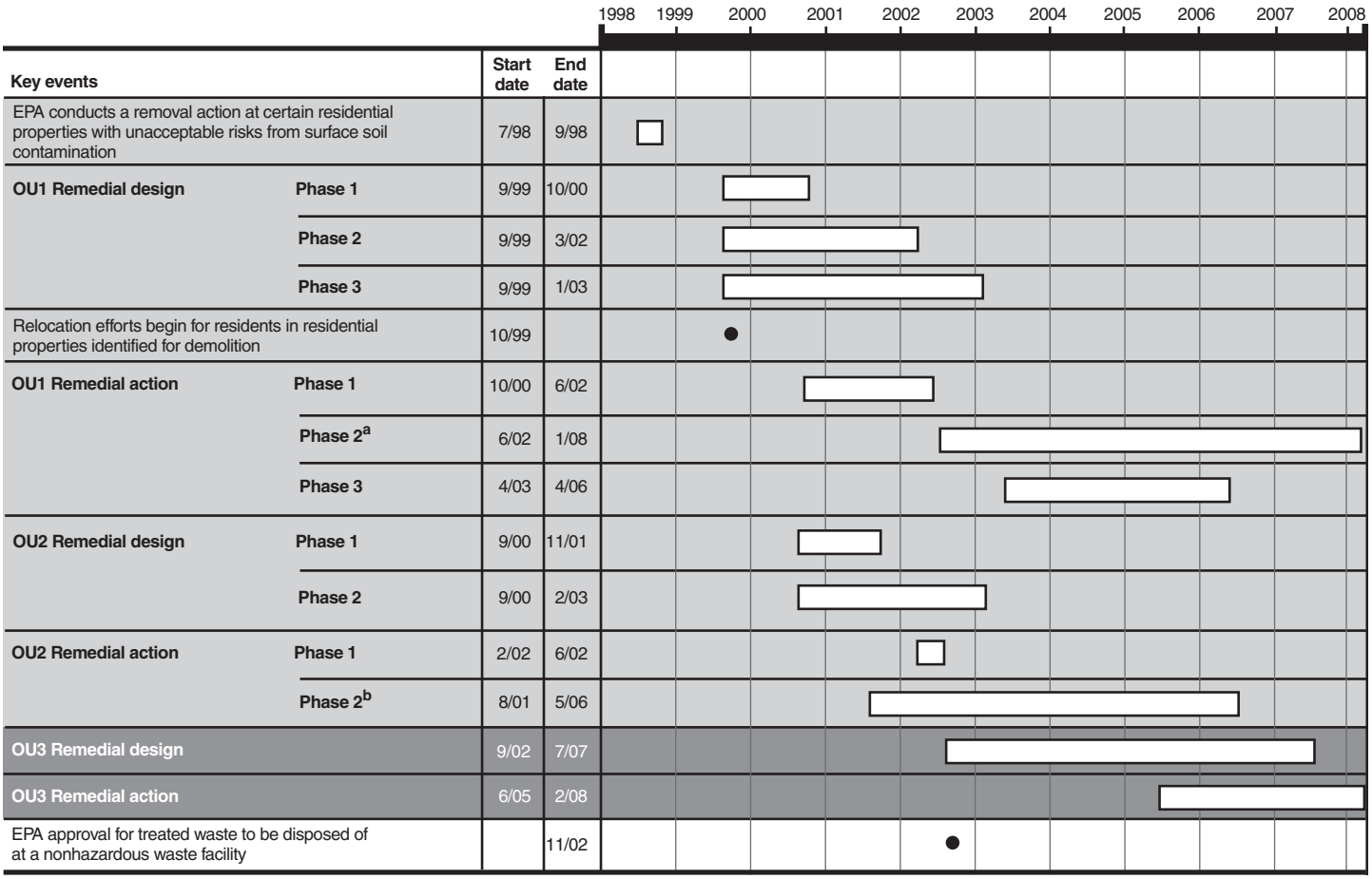


Key events	Start date	End date
New Jersey Department of Environmental Protection (NJDEP) identifies a black tarry substance in a leaking sump on-site		4/96
Borough of Manville responds to report of sinkhole in residential area and determines that local drinking water supplies are not contaminated from the site	1/97	2/97
NJDEP and EPA sample for indoor air contamination in residential homes	4/97	5/97
Agency for Toxic Substances and Disease Registry (ATSDR) develops several health consultations and issues a public health assessment for the site	5/97	9/00
EPA conducts an initial site investigation	10/97	11/98
Responsibility for Federal Creosote site transferred from NJDEP to EPA		1/98
EPA completes a Hazard Ranking System evaluation	1/98	5/98
Federal Creosote site proposed for the National Priorities List (NPL)		7/98
EPA takes soil samples in the Claremont Development Operable Unit 2 (OU2) soils as part of the remedial investigation/feasibility study (RI/FS)	12/98	3/99
Federal Creosote site formally listed on the NPL		1/99
EPA completes a human health risk assessment for surface soil		1/99
EPA completes an evaluation of remedial technologies for OU1 on the basis of the results of the initial investigation		4/99
EPA takes soil samples in the Rustic Mall (OU3) as part of the RI/FS	8/99	11/99
EPA takes additional groundwater samples as part of the RI/FS	8/99	11/99
OU1 record of decision (ROD) issued		9/99
EPA completes a human health risk assessment and remedial technology evaluation for OU2 soils		4/00
OU2 ROD issued		9/00
EPA completes a human health risk assessment and remedial technology evaluation for OU3 soils		6/01
EPA completes a human health risk assessment and remedial technology evaluation for groundwater[a]		7/01
EPA completes an addendum to the groundwater evaluation determining that treating groundwater at the site would be technically impracticable		6/02
OU3 ROD issued		9/02

Source: GAO analysis of EPA documents.

[a]The groundwater human health risk assessment and remedial technology evaluation was completed in two parts. First, in July 2001, EPA issued a remedial investigation report for groundwater that contained the human health risk assessment. Second, in August 2001, EPA issued a feasibility study report that included the remedial technology evaluation for groundwater.

Figure 9: Key Events Related to Remedial Design and Action at the Federal Creosote Site



Key events		Start date	End date
EPA conducts a removal action at certain residential properties with unacceptable risks from surface soil contamination		7/98	9/98
OU1 Remedial design	**Phase 1**	9/99	10/00
	Phase 2	9/99	3/02
	Phase 3	9/99	1/03
Relocation efforts begin for residents in residential properties identified for demolition		10/99	
OU1 Remedial action	**Phase 1**	10/00	6/02
	Phase 2[a]	6/02	1/08
	Phase 3	4/03	4/06
OU2 Remedial design	**Phase 1**	9/00	11/01
	Phase 2	9/00	2/03
OU2 Remedial action	**Phase 1**	2/02	6/02
	Phase 2[b]	8/01	5/06
OU3 Remedial design		9/02	7/07
OU3 Remedial action		6/05	2/08
EPA approval for treated waste to be disposed of at a nonhazardous waste facility			11/02

Indicates activities for the Claremont Development

Indicates activities for the Rustic Mall

Source: GAO analysis of EPA documents.

[a]According to EPA, the OU1 Phase 2 remedial action was completed in April 2004. However, this area was used as a staging area for waste from OU1 Phase 3, OU2 Phase 2, and OU3 properties. As a result, restoration of the OU1 Phase 2 area could not be completed until all excavation and shipping of OU3 waste was complete (since OU3 was the last completed area for which the OU1 Phase 2 area was used to stage waste).

[b]According to EPA, the OU2 Phase 2 remedial action occurred on an episodic basis. The initial remedial action that was part of OU2 Phase 2 was a remedial action at the day-care center playground that began and ended in August 2001. Remedial action on OU2 Phase 2 residential properties was not begun until almost 2 years later and was completed in June 2005. Also, because the day-care center parking lot was connected to the Rustic Mall, the remedial action at the parking lot was completed, together with the OU3 remedial action, between November 2005 and May 2006.

Appendix IV: Comments from the Environmental Protection Agency

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 2
290 BROADWAY
NEW YORK, NY 10007-1866

JAN 29 2010

John B. Stephenson
Director
Natural Resource & Environment
United States Government Accountability Office
441 G Street, NW, Room 2075
Washington, D.C. 20548

Dear Mr. Stephenson,

Thank you for the opportunity to review and comment on the draft report of the Government Accountability Office (GAO) entitled *Information on Cost and Other Issues Related to the Cleanup of the Federal Creosote Site*. Consistent with our comments on the Statement of Facts, the Environmental Protection Agency (EPA) agrees that the GAO report accurately reflects the events that describe the cleanup of the Federal Creosote site, located in Manville, New Jersey, from early removal activities and placement on the National Priorities List (NPL), through the selection and implementation of a series of remedial actions to address the nature and extent of contamination at the site. In the Federal Creosote cleanup, EPA addressed the remnants of a long-abandoned industrial complex found beneath a residential community of 137 single-family homes. Meeting a residential threshold for cleanup, and doing so while limiting the disruption to the fabric of the neighborhood, were two of the principal challenges for EPA while implementing this action, which is now completed and the site is nearing deletion from the NPL.

EPA is constantly striving to improve the Superfund program, and welcomed GAO's review as an opportunity for an independent check of our methods. EPA is pleased to find that, after GAO's thorough evaluation of this project, it has no major recommendations on how we might have improved this cleanup effort.

The GAO was asked to look into the difference between the total construction cost estimates EPA made prior to 2002, $105 million, and the final total cost of 2009, $338 million, a sum EPA is seeking to recover from the parties that are responsible for the contamination at the Federal Creosote site. The vast bulk of the difference between these figures results from two factors.

First, the amount of highly contaminated soil which was actually found as EPA worked at the site was nearly three times the amount used when EPA made its original construction cost estimates. In fact, we found 456,600 tons of contaminated soil that we had to excavate, remove, treat and/or dispose of, and replace, rather than the 164,400 tons on which the early estimates were based. This increase in quantity of contaminated material itself accounts for $112 million in added costs. When that amount is added to the original construction cost estimate, one gets a final total construction cost of $217 million. Another $29 million in increased construction costs came from the added time that was needed to complete the cleanup, increases for commodities like fuel oil, and additional costs for residential relocation. This total, $246 million, is the figure which should be used to make an apples-to-apples comparison of estimated and final costs. The

difference is largely explained by the sheer increase in volume of material we dealt with and the costs of inflation. We are pleased to note that your draft report makes exactly this comparison, the correct one, in Table 4 on page 33.

Second, a very large portion of the $338 million final total cost figure is composed of categories of costs which were not – and never are – included in early cost estimates. Specifically, while early cost estimates, which are made solely for the purpose of comparing the costs of different potential remedies, include only projected construction costs, the final total includes the money EPA spent on a removal action at the site, on investigative work, on personnel salaries, on indirect (or overhead) costs, and interest, as provided by law, on the money the government advanced for the cleanup. These other nonconstruction costs total $92 million. GAO was asked to add them to the final total construction costs and to compare the total with initial construction cost estimates. Unfortunately, that comparison is not particularly useful as it is a comparison of apples to oranges, not, as explained above, an apples-to-apples comparison.

Thank you again for the opportunity to comment on this draft report. EPA reiterates its commitment to improving the implementation of the Superfund program. If you have any questions relating to this response, please call Region 2's GAO liaison, John Svec, at (212) 637-3699.

Sincerely,

Judith A. Enck

Judith A. Enck
Regional Administrator

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Appendix V: GAO Contact and Staff Acknowledgments

GAO Contact

John B. Stephenson, (202) 512-3841 or stephensonj@gao.gov

Staff Acknowledgments

In addition to the individual named above, Vincent P. Price, Assistant Director; Carmen Donohue; Maura Hardy; Christopher Murray; Ira Nichols-Barrer; and Lisa Van Arsdale made key contributions to this report. Elizabeth Beardsley, Nancy Crothers, Alexandra Dew, Richard Johnson, and Anne Stevens also made important contributions.

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