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ABSTRACT

The U.S. Department of Energy (DOE) has established a policy whereby, for remedial actions, the procedural and documentational requirements of the National Environmental Policy Act (NEPA) are integrated with those of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended. However, the objectives of risk assessment under NEPA and CERCLA differ somewhat. Until its recent application at contaminated sites, NEPA analysis has typically been applied to impacts from taking actions at clean sites (e.g., for construction activities), and a somewhat loosely structured process has historically been used to estimate relative risks for NEPA analyses. Decisions such as cleanup levels were not made on the basis of the risk estimates, and they therefore tended to be conservative and were not discussed in detail. In contrast, risks estimated for Superfund (CERCLA) sites are used to focus the decision-making process for those sites and support national prioritization for cleanup, and the U.S. Environmental Protection Agency (EPA) has developed a detailed framework for preparing baseline health risk assessments for these sites.

The purpose of this paper is to discuss issues related to integrating the CERCLA and NEPA approaches into the risk assessments that have been prepared for a DOE remedial action project at the Weldon Spring site near St. Charles, Missouri. These issues are grouped into three basic categories: general assumptions for the impact evaluation, data management, and presentation of the methodology and results. This paper is not intended to represent DOE policy and guidance, nor does it represent the only approach that can be used for integrated risk assessments. It merely discusses the process that was used for the Weldon Spring project, articulating the issues that were encountered and how they were addressed.

INTRODUCTION

Prior to the somewhat recent application of NEPA to cleanup actions at contaminated sites, the evaluation of impacts from federal actions under NEPA had historically been applied to proposed construction and operation activities at uncontaminated sites, e.g., construction and operation of highways or power plants. No direct impacts or risks are typically associated with the no-action alternative for such projects, and the objective of estimating risks for the various action alternatives is to support the determination of the environmentally preferable option. To meet this objective, only relative risk estimates were required. Hence, risks estimated for NEPA analyses tended to be conservative (often bounding-case) and the presentations limited (highlighting key results).

In contrast, risks estimated for remedial action projects are generally highest for the long-term assessment of the no-action alternative, e.g., under an assumed loss of institutional control resulting in unrestricted public access. The objective of estimating risks for these projects is not only to indicate the potential risks associated with the no-action alternative and support a relative comparison of alternatives but also to directly support the development of quantitative cleanup decisions. To meet this objective, the risk assessment process has been standardized under CERCLA. This process involves the stepwise quantification of potential impacts associated with contaminated sites and the presentation of results for all reasonable pathways.

Baseline risk assessments developed for Superfund sites play a direct role in cleanup decisions for those sites, including their recent use to support DOE site prioritization efforts. Therefore, such assessments must be prepared with considerable deliberation using reasonable assumptions. The approaches for assessing impacts or risks in accordance with CERCLA and NEPA are currently being integrated at sites across the country -- including the Weldon Spring site -- in order to facilitate completion of the compliance process, optimize resources, and ensure document and decision consistency. Our challenge is to integrate the general assessment process that has been used under NEPA into the standardized process that EPA has developed for CERCLA sites, recognizing the differences between the two and the reasons for those differences.

SITE BACKGROUND AND DOCUMENTATION OVERVIEW

The Weldon Spring site is located about 48 km (30 mi) west of St. Louis, Missouri, and is surrounded by federal- and state-owned land, much of which is wildlife management area. The site consists of two noncontiguous areas: an 88-ha (217-acre) chemical plant area and a 3.6-ha (9-acre) limestone quarry. Both areas are radioactively and chemically contaminated as a result of processing and disposal activities that took place over 20 years ago. The quarry was listed on EPA's National Priorities List in 1987, and the chemical plant area was added to the listing in 1989. These areas are fenced and closed to the public.

Several interim response actions have been conducted at the site, both removal actions and an interim remedial action. These actions have been taken to respond to ongoing releases and to existing health and safety threats on-site. Potential health and environmental impacts have been evaluated at a scope and level of detail appropriate for each specific action, considering both the CERCLA and NEPA processes. The CERCLA analyses for various removal actions have been documented in engineering evaluation/cost analysis (EE/CA) reports that were written to meet the requirements of NEPA, typically at a level appropriate for an environmental assessment (EA). The CERCLA analyses for the interim remedial action at the quarry were documented in a focused remedial investigation/feasibility study (RI/FS), also written to meet NEPA requirements consistent with an EA-level analysis.

Risks estimated for the removal actions emphasized impacts during the action period, and baseline risks were addressed qualitatively as part of the justification for the action in accordance with the CERCLA process. For the interim remedial action at the quarry, health risks were quantified for both baseline conditions and the remedial action period. Although the available EPA guidance addresses baseline risk assessments, i.e., no-action conditions, the process was also applied to the estimation of health risks for the remedial action period.

For removal actions with no off-site releases -- such as decontaminating and dismantling the existing chemical plant buildings and storing the debris on-site pending upcoming disposal decisions -- no significant public health impacts were expected. Therefore, workers were identified as the likely human receptors. This assessment included a population dose, which has typically been presented in NEPA analyses. The primary exposure pathways addressed in the assessment were those considered most likely to contribute to potential worker exposures -- i.e., inhalation and external gamma irradiation. Available characterization data (screening-level data for most buildings) were used because no additional information was needed to justify the action on the basis of a potential health and safety threat under current conditions. In addition, the data were sufficient to assess the nature and general magnitude of risks that could result from taking the action. A commitment was made in the EE/CA to conduct additional testing during the action to provide more detailed information for refining the worker protection program and to support subsequent treatment and disposal decisions for the building material.

For removal actions with off-site releases -- such as constructing and operating water treatment plants at the quarry and the chemical plant area to treat impounded surface water, with effluent discharges to a nearby river -- workers were not considered the primary human receptors because they were not expected to be exposed to contaminated water. Rather, the local population was considered the primary potential receptors because drinking-water supply facilities with intakes on the river are located downstream. Therefore, the assessments focused on the general public and addressed ingestion as the primary exposure pathway, considering both water and fish. Available data were used because no additional information was needed to justify the actions on the basis of a potential health threat under current conditions. A commitment was made to operate the effluent ponds in a batch mode to ensure that discharge limits established in coordination with the state of Missouri were met prior to each release; hence, these limits were used for the calculations. Worker doses were also estimated for potential exposures via external gamma irradiation due to temporary storage on-site of containerized process sludge from the treatment plants, pending disposal decisions for the project.

The interim remedial action for the project involved the removal of bulk solid wastes that had been disposed of in the quarry, with transportation to the chemical plant area for temporary storage pending comprehensive disposal decisions for the project. This action represented one of the major steps toward quarry remediation, and a baseline risk evaluation (BRE) was prepared as part of the focused RI/FS. The evaluation presented an integrated analysis of the no-action alternative. That is, the BRE addressed potential health and environmental impacts associated with no further action beyond the water treatment action previously documented in the EE/CA. Impacts to workers and the general public associated with waste excavation, transport, and storage were addressed in the FS.

The quarry action addressed the removal of bulk wastes that could be readily excavated; it was scoped to respond to an immediate problem: the release of radon from these wastes into the air at levels exceeding state limits, and the release of radioactive and chemical contaminants into the underlying groundwater with potential transport to a nearby county well field. Because the action constituted an early stage of overall quarry remediation, cleanup criteria were not developed in the RI/FS. These criteria will be developed during the next stage of quarry remediation, which will be documented in a separate RI/FS within the next few years. An updated baseline (or "rebaseline") assessment will be presented in this upcoming documentation to address changed conditions at the quarry after the solid wastes have been removed; an evaluation of potential health risks combined across multiple pathways will be included in this assessment. The BRE was tailored to the stage of quarry cleanup being addressed. Therefore, the time period assumed for the duration of potential exposures was 10 years due to (1) the intermediate stage of the response, (2) the expectation of continuing cleanup activities at the quarry, and (3) the more appropriate inclusion of long-term considerations at the next stage of cleanup -- i.e., in the future RI/FS from which cleanup criteria and final decisions will be developed.

A hypothetical trespasser and a hypothetical passerby were identified as the human receptors to be evaluated in the BRE. The exposure pathways considered for the trespasser were those associated with surface soil, including incidental ingestion, inhalation, dermal contact, and external gamma irradiation. For the passerby, inhalation and external gamma irradiation were evaluated. Although the available characterization data were somewhat limited, no additional data were collected because (1) no more information was needed to justify the action on the basis of risk, (2) cleanup criteria were not being established, and (3) a commitment was made for further characterization of the quarry material at the storage area to support subsequent treatment and disposal decisions. This approach is consistent with EPA's strategy for streamlining the RI/FS process.

To support risk estimates in the FS for the quarry action, limited additional data were collected to confirm information from previous studies on the relative activity concentrations of radionuclides in the uranium and thorium decay series. This information was used to estimate potential risks associated with waste excavation and transportation during the remedial action period for both workers and local public receptors within an estimated radius of potential impact. A hypothetical passerby and nearby resident were evaluated for the quarry area, as were an on-site office worker at the chemical plant area and a student at a nearby high school. Inhalation was addressed as the primary exposure pathway for general public receptors; external gamma irradiation was also addressed for the passerby at the quarry. Exposure pathways considered for workers in the area of cleanup activities included external gamma irradiation, inhalation, and incidental soil ingestion.

The environmental analyses included in the compliance documents for these interim actions addressed the nature and duration of disturbance, areas and types of habitat disturbed, transportation impacts, and potential impacts and associated mitigative measures for various environmental resources. These evaluations were primarily qualitative and included discussion of threatened and endangered species, critical habitats, and other ecological resources; archeological and cultural resources; and soil, air, and water resources. A floodplain assessment was prepared for the quarry water treatment plant action. Consultation with other agencies was also addressed.

An integrated remedial investigation/feasibility study-environmental impact statement (RI/FS-EIS) is currently being prepared to address comprehensive cleanup decisions for the

Weldon Spring project. As for the quarry interim remedial action, the risk assessment prepared for this component of site cleanup represents an integrated analysis of the no-action alternative. That is, an integrated health and environmental baseline assessment (BA) is being prepared to assess potential health and environmental impacts for existing site conditions under both short-term and long-term scenarios, considering both the CERCLA and NEPA approaches.

Similar to the quarry action, groundwater is outside the scope of the current decision-making process for the chemical plant area. This has been defined as a separate operable unit, and a separate RI/FS will be prepared within the next several years to address groundwater at the chemical plant area. A BA will be prepared for this RI/FS that will evaluate updated conditions for the site, reflecting cleanup decisions that will be made from the RI/FS-EIS and including a comprehensive risk assessment for multiple pathways.

DISCUSSION

A number of specific issues have been raised in the process of incorporating into the CERCLA risk assessment process those elements that have historically been associated with risk analyses under NEPA. Because EPA is continuing to develop guidance for baseline ecological assessments to include quantitative evaluations, this paper focuses on integrating the human health assessment in accordance with the guidance provided by EPA for baseline risk assessments. (Note that EPA is also in the process of developing guidance for assessing impacts of remedial action alternatives.) The specific issues can be grouped into three categories: general assumptions, data management, and presentation. The issues within each of these categories and their proposed resolutions are identified in the following discussion.

General Assumptions

Issues related to the general assumptions used to evaluate potential impacts include: definition of baseline conditions, determination of the time period assumed for future scenarios, identification of assumptions for maintenance of institutional controls and future land use, selection of appropriate receptors, and identification of reasonable exposure scenarios. These issues are discussed individually below.

Baseline Conditions. The baseline for a site should be defined by existing conditions. Under NEPA, the baseline (no-action) conditions for a site have typically been fixed. However, due to the increasing use of interim actions at CERCLA sites, the "existing conditions" can change considerably as these actions are finalized and implemented prior to completion of a comprehensive RI/FS for the site. (This also raises the issue of segmenting decisions under NEPA, and it is very important to scope the interim actions to avoid such segmentation. For more discussion of this issue, see the related conference paper on interim actions at the Weldon Spring site.) Because one of the basic purposes of a risk assessment is to support the decision for cleanup actions by indicating potential risks in the absence of action, it is important to define the site baseline for the risk assessment in a manner consistent with this purpose. It would be inappropriate to "revisit and repeat" this decision-making effort by including in the baseline definition of a site those features for which cleanup decisions have already been made via interim actions (unless this inclusion serves some useful purpose). Therefore, flexibility and staged updating should be considered in reconciling the "moving baseline" problem.

As an example of how this issue was addressed for the Weldon Spring project, the baseline definition of the quarry on which the BRE was based did not include the quarry pond because the environmental compliance process for the removal and treatment of this surface water had already been completed and design and implementation activities were under way. Similarly, groundwater at the quarry was not included in the BRE because (1) decisions for this medium were beyond the scope of the interim action for the bulk wastes (groundwater will be addressed in the upcoming RI/FS), (2) conditions are expected to change as a result of source (bulk waste) removal, and (3) additional characterization data will be collected at the quarry to support upcoming cleanup decisions. Text and figures were included in the documents to explain the staged approach for the risk assessments and remediation decisions. In keeping with the staged responses, the upcoming RI/FS for the quarry will contain an updated baseline (or "rebaseline") no-*further*-action assessment that presents information for both groundwater and the residual solid material in the quarry as support for cleanup decisions related to the final stage of quarry remediation.

As a second example, certain site conditions evaluated in the BA being prepared for the chemical plant area are changing due to interim actions. Part of the problem is that the BA is a component of a very complex RI/FS-EIS for which the planning and preparation has spanned several years. This RI/FS-EIS addresses final alternatives from which subsequent decisions will be made for a number of contaminated media; therefore, it must include detailed risk estimates to support the final cleanup criteria that will be generated from the analyses. During the time it has taken to approach completion of the RI/FS-EIS, decisions have been finalized for a number of interim actions. Because the chemical plant area consists of a variety of contaminated areas and media, it was determined that the BA should present a comprehensive initial snapshot of the area so that the interrelationships between different media could be understood and the focus of remaining decisions for site remediation could be explained.

Therefore, the BA includes certain features such as buildings and surface water impoundments that currently exist but are soon expected to change as a result of interim actions. In a sense, this approach provides confirmation of interim actions such as dismantling contaminated buildings; therefore, only screening-level calculations are presented for these features in the BA. Calculations associated with media for which cleanup decisions have yet to be made -- i.e., soil and sediment -- are presented in much greater detail. To provide the link between the BA and these changed site conditions, an updated "rebaseline" risk assessment is presented in the FS component of the RI/FS-EIS; this rebaseline assessment excludes those features for which decisions have been made. By this staged approach, the short-term and long-term future scenarios can focus on remaining decisions for the site. To limit redundancy and streamline the preparation of the rebaseline assessment, liberal reference has been made to the detailed data and methodology discussions in the BA, with callouts of specific sections and tables to facilitate cross-referencing. Figures were also included to highlight the changed site conditions.

Time Period. The time period of a risk evaluation under NEPA has not typically been a standard assumption, although 1,000 years has often been used for the long-term analysis of radioactively contaminated sites. Under CERCLA, the time period can be selected to focus cleanup decisions being made at each stage of the project. The time periods used for the various risk assessments prepared for the Weldon Spring project have been determined specifically for each action. For example, to estimate risks associated with the water treatment actions in the EE/CAs, a time period of 10 years was used to correspond to a reasonable estimate of the discharge duration, i.e., the 10-year operational period of the plants.

For the quarry BRE, the time period for the duration of future trespasser or passerby exposure was conservatively assumed to be 10 years because cleanup activities were already under way and quarry conditions are very likely to change within the next few years. For the chemical plant area BA and the rebaseline assessment in the FS, the duration of potential short-term (current) exposures was 10 years for reasons similar to those identified for the BRE, i.e., DOE's commitment to a timely response and demonstrated progress with its staged response strategy.

The time period for the future hypothetical scenarios in the BA was conservatively assumed to be 30 years. Although a longer time would typically be selected for the future scenario of a comprehensive baseline risk assessment under CERCLA, the chemical plant BA was tailored to evaluate the area under the first major phase of staged response actions. The time period assumed for the scenario in the FS rebaseline assessment extends to at least 100 years, and that for the groundwater operable unit RI/FS will extend to 200 years and beyond (e.g., to 1,000 years). An explanation of the staged assessments is included in the documents.

Institutional Controls and Land Use. Under NEPA, DOE has typically assumed that institutional controls can be maintained at a site for no longer than 100 years. Under CERCLA, the site is evaluated assuming that controls are lost, even in the near term. The DOE currently maintains institutional controls at the Weldon Spring site, and a perception problem for the local public is possible if hypothetical risks are estimated that would not actually occur because such exposures would be precluded by access restrictions. However, DOE does not maintain such controls at all sites at which it is undertaking remedial action. Therefore, this assumption may be realistic rather than hypothetical for certain assessments. In addition, an assumed loss of such controls is essential to the determination of the major problems at a site, which is very important to the development of site cleanup decisions. That is, by assuming a loss of institutional control, the areas and media that could pose risks in the absence of cleanup can be emphasized. This information is very useful for site prioritization efforts.

Loss of institutional control has been assumed for each of the baseline and rebaseline assessments prepared for the Weldon Spring project so that the assessments can serve their decision-making purpose. To limit the possible misinterpretation of estimates (e.g., public health concerns) under this hypothetical loss of control scenario, an explanation has been included in the documents to indicate that the scenario is highly unlikely and to clarify the reason for the assumption. Reasonable projections of future land use should be identified in the documents to support the selection of receptors and exposure scenarios for evaluation. These projections should consider the time period of the evaluation as well as current ownership of surrounding land and possible development plans.

In the BA prepared for the chemical plant area, existing land use was assumed for the future because the time period was 30 years. Combining the fact that the surrounding land use is primarily recreational with an assumed hypothetical loss of institutional control at the site, recreational use of the site was evaluated for the future scenario. In the rebaseline assessment of the FS, it was assumed that with hypothetical loss of institutional control over the next 100 years, the site might be used for a residence and/or for a wildlife area ranger station.

Receptors. In addition to estimating individual risks for the general public from radioactively contaminated sites, population doses have generally been estimated under NEPA for exposure to radionuclides (but not chemicals) over a given radius, e.g., 80 km (50 mi), without explicitly evaluating contaminant fate and transport. Such explicit evaluation could be used to identify a site-specific radius of impact in order to evaluate potentially affected individuals and populations. Under CERCLA, contaminant fate and transport are explicitly addressed and risks are estimated for individual receptors that could be exposed. Risks are not generally estimated for populations. Because the estimates presented in CERCLA documents are not conservative or "worst-case," site-specific information should be used in place of generic assumptions to determine areas of potential impact and reasonable receptors.

In integrating the risk assessments prepared for the Weldon Spring project, a discussion of the rationale for selecting specific receptors has been included in the documents. A conceptual model is presented in the baseline assessments, and site-specific information was used to determine potentially affected members of the general public during the action period. For example, to support the risk estimates for the air pathway, two computer models were used to determine the area that could be affected by the bulk waste action for the quarry; this information was presented in the quarry FS. To estimate population doses, additional modeling was used to estimate a reasonable radius of impact during the cleanup period. Population doses and risks are presented for both the reasonable radius of impact and the 80-km (50-mi) radius in the FS for the chemical plant area.

For the water treatment actions, information was obtained from the state of Missouri to determine the population served by the water treatment facilities and the amount of fish ingested from the affected stretch of river; this information was used to estimate risks from drinking water and eating fish. Radiological risks were estimated for both an individual and a conservatively estimated population. (The discussion included a comparison with risks estimated for background levels of the contaminant evaluated to limit possible misinterpretation.) Fishing information for local lakes was also obtained from the state of Missouri to support the evaluation of potential impacts from fish ingestion that was presented in the BA. The BA also included a related discussion of contaminant fate and transport to explain the rationale for this evaluation.

Past NEPA analyses for long-term storage or disposal sites have also differed from the CERCLA approach in assuming that a "resident intruder" would live on the waste containment cell. This assumption has been used to estimate bounding-case health risks under the long-term future scenario. Under CERCLA, risk estimates are to be reasonable rather than bounding; and, although residents are commonly addressed (as appropriate to projected land use conditions), they are not assumed to live on top of a disposal cell. To resolve this issue, the resident intruder has been addressed qualitatively in the FS prepared for the chemical plant area. The rebaseline assessment in the FS quantitatively evaluates an on-site resident not living on the disposal cell in order to support the development of soil cleanup criteria, including a determination of residual levels that would be most protective and reasonably achievable (i.e., "as low as reasonably achievable" or ALARA).

For workers, radiological impacts have typically been quantified as part of NEPA analyses for contaminated sites, and individual and population doses are commonly estimated. However, impacts from nonradiological contaminants have not historically been evaluated for each pathway because awareness of the need to address chemical exposures has only recently developed. Such exposures are evaluated as part of CERCLA assessments, but population estimates have not yet been associated with these assessments. To integrate these factors, exposure to both radiological and chemical contaminants via various pathways has been addressed in worker risk assessments for the Weldon Spring project, as appropriate to the focus of the action. For example, the EE/CA for decontaminating and dismantling the buildings addressed inhalation exposure to asbestos, radon, and suspended radioactive particulates as well as external gamma exposure. A range of pathways is addressed for the remedial action worker in the chemical plant area FS, including inhalation, incidental ingestion, dermal absorption, and external gamma exposure. Risks to an on-site office worker (i.e., nonremedial action worker) have also been evaluated. Radiological population risks for the cleanup workers have been presented as part of the analyses.

A second issue for the worker assessment is that the available EPA guidance addresses baseline risk assessments. This guidance is not explicitly geared to address remedial action workers, although standardized guidance for the action period assessment is in preparation. To address this issue for the Weldon Spring project documents, basic elements of the baseline assessment process have been applied to the evaluation of workers during the remedial action period. In addition, an outdoor worker was addressed in the BA prepared for the chemical plant area because this receptor is present under existing conditions. That is, baseline risks were estimated for an on-site worker involved in routine maintenance activities.

Exposure Scenarios. The exposure scenarios that have been evaluated in the past under NEPA have typically highlighted the primary pathways and have often used conservative assumptions. Under CERCLA, reasonable maximum exposures are evaluated across multiple pathways (sometimes including quantification for pathways that do not contribute significantly to estimated risks); these pathways are defined by considering a range of possible scenarios. To resolve this issue, a broad range of exposure scenarios has been evaluated in the baseline assessments prepared for the Weldon Spring project, consistent with the stage of cleanup being addressed. The logic for these scenarios has been explained in the documents, and assumptions have been tabulated to highlight specific components of the exposure assessment.

For example, the BA evaluates a variety of scenarios and includes tabulated receptors, locations, and exposure pathways as well as intake parameters used for the exposure assessment. A matrix is also included for different receptors (e.g., a current trespasser and a future recreational visitor) to permit combinations across pathways to estimate reasonable maximum exposures. Assessments of the action period for removal actions have focused on the major pathways of concern, as appropriate to each limited scope. (The various exposure scenarios considered for these documents were highlighted in the overview discussion of compliance documentation.)

Data Management

Appropriate contaminant characterization data are critical to CERCLA risk assessments. A number of contractors have been involved over the years in data collection at the Weldon Spring site, and the reporting of sampling and analytical results has not always been consistent or complete. In addition, the site was listed on the NPL long after characterization began. Therefore, data management for the risk assessments was not as straightforward as it would have been had the standard EPA process for characterizing Superfund sites been followed from the start. For example, data quality objectives were not established by earlier contractors to specifically support risk analyses, and standard qualifiers did not accompany the laboratory results. A number of the data management issues for the Weldon Spring project reflect these site-specific factors. However, because these factors may be true for other DOE facilities and other basic problems were also involved, the approach used to resolve issues for the Weldon Spring project may be useful as "lessons learned" for other projects at which comprehensive characterization and data interpretation is just getting under way.

Issues associated with the management and interpretation of characterization data used in the calculations include: data availability and need, verification and validation, outliers and nondetects, comparison with background concentrations, and surface versus subsurface contamination. These issues are discussed individually below.

Availability and Need. Relative to comprehensive data collection, NEPA documents have typically been prepared earlier in the decision-making and response process than are CERCLA documents. In addition, the purpose of past NEPA risk assessments differed from that of CERCLA assessments. Hence, available data have generally been compiled for use in the risk assessments; that is, a staged data collection effort and formal data review have not typically been conducted to support the assessments for past NEPA analyses. In contrast, the data are rigorously reviewed to identify gaps that should be filled to support the risk assessment under the CERCLA process. This rigor is important because the resultant risk estimates are used to develop quantitative cleanup criteria and identify areas for potential remediation. In integrating the two processes, data used in the baseline assessments for the Weldon Spring site have been evaluated in accordance with the CERCLA process. Additional data collection to address data gaps has been determined by the level of assessment required, considering the scope of the action and the decision to be made.

For example, the screening-level data available for the chemical plant buildings were considered adequate for the level of assessment in the BA because the buildings were to be dismantled under a removal action and were not part of residual risk estimates for the site. In contrast, data for media that are being evaluated in terms of the need for and appropriate extent of cleanup as well as the magnitude of residual risk must be comprehensive enough to support cleanup decisions. This is especially important when "no action" may be the ultimate remedial action decision, e.g., for certain areas of sitewide soil. For the BA and rebaseline assessment in the FS, additional data were needed for a radiological source term analysis to assess the presence of specific isotopes in site soil and sludge. This information was needed to support the risk calculations and to determine the need for mitigative measures during the cleanup period, e.g., for remedial action workers, as well as to support the development of final cleanup criteria for the site.

Verification and Validation. A formal data verification and validation effort has not typically been conducted for past NEPA analyses, although general data management activities have been followed. Under CERCLA, site data are subjected to a formal verification/validation review to ensure the quality of data used in the risk assessment. In integrating the two processes, data used for the baseline assessments for the chemical plant area were subjected to a formal verification and validation review. Although EPA's standard Contract Laboratory Program qualifiers did not accompany the site data, the intent of the process was followed, using similar information from sampling, analysis, and recording activities. The database was computerized in a form that facilitated this and subsequent data management efforts. It is highly recommended that the data for all projects be computerized so discrepancies can be easily identified and corrected.

Outliers and Nondetects. In past NEPA analyses, a formal data evaluation process has not typically been applied to address outliers (such as unusually high values) or nondetects (samples where the parameter tested was not measured at the detection limit). Under CERCLA, outliers and nondetects in the database are identified and then reviewed to determine how they should be addressed in the risk assessment. In integrating the two processes, the soil data used for the BA and rebaseline assessment were sorted to identify outliers and nondetects. Then, two different approaches were used in the risk assessment. For the first, a location-specific (borehole-by-borehole) analysis was conducted to specifically highlight hot spots. For the second approach, a sitewide analysis was conducted using average values to provide more realistic "random use" risk estimates.

To address nondetects, the likelihood that the contaminant was present was estimated using historical data and other available characterization data (e.g., whether the contaminant had been found elsewhere and with what frequency it was detected at the site). In reviewing historical data for the Weldon Spring site, operational records were examined to determine whether the use of certain chemicals was ever indicated for the site. Then, to obtain averages for the sitewide analysis, nondetects for contaminants such as organic compounds that were not reasonably expected on the basis of site history and other information (e.g., detection frequency) were replaced with zero. For contaminants that could reasonably be expected to be present (e.g., naturally occurring radionuclides and metals) nondetects were replaced with either half the value or the full value of the detection limit, as appropriate to the specific parameter and limit.

Comparison with Background. Site characterization data have not typically been compared with information for local background, notably for nonradiological parameters, as part of past NEPA analyses. Under CERCLA, this comparison can be used to focus the selection of contaminants of concern for the risk assessment. In integrating the two processes for preparation of the chemical plant area BA, site data considered to represent background were compiled for various media (soil, surface water, and groundwater) in the general vicinity of the site. In addition, data from other locations in the state of Missouri and literature data for the United States and other areas were reviewed. This information was presented together with the characterization data to support screening decisions used to identify the contaminants of concern. This information was also useful in determining incremental risks (e.g., risks above those that could result from exposure to natural background concentrations of metals and radionuclides), which supported the development of cleanup criteria.

Surface and Subsurface Contamination. In past NEPA analyses, subsurface contamination has not typically been addressed in detail as part of cleanup criteria development, i.e., by hypothesizing specific scenarios under which the material could be brought to the surface. Under CERCLA, an evaluation such as an "excavation and surface redistribution" of subsurface soil may be included in the future scenario of a baseline assessment to support cleanup decisions. In integrating the two processes for the rebaseline assessment of the chemical plant area, locations with potential subsurface contamination were identified by reviewing the characterization data and site history (e.g., to evaluate burial areas and underground piping). To support the site characterization effort, blueprints were examined to determine locations of pipes and process lines or storage areas at which spills might have occurred; disposal records and cut-and-fill maps were also reviewed, as were operational records. This information was used to evaluate the data for subsurface contamination. The potential for future exposures at these locations was then evaluated by estimating health effects associated with excavating soil for the basement of a residence and redistributing this soil on the surface, e.g., to represent the new yard. This evaluation was presented in the future resident discussion of the rebaseline assessment in the FS. Leaching of buried contaminants to groundwater was also evaluated to support the cleanup determination of "action" or "no action" for subsurface contamination.

Presentation

Issues associated with presentation of the impact evaluation include: level of detail, combining radiological and chemical risk results, contribution of background levels to risk estimates, specific pathway and contaminant contributions to total risks, summary of results, and cumulative impacts. These issues are discussed individually below.

Level of Detail. For past NEPA analyses, risk results have typically been presented without indicating intermediate calculations or extensive explanations of the methodology. Under CERCLA, the methodology and assumptions are presented in a stepwise manner and in considerable detail. In integrating the two processes, the objective of a risk assessment at a remedial action site must be emphasized, and considerable detail should be presented to support subsequent decisions. For example, intake equations and background information on the methodology and toxicity assessment were presented in the BA. In addition, assumptions used for the calculations were tabulated. This level of detail facilitates understanding not only by the reviewers but also by the public, demystifying the risk assessment process and allowing the interested lay person to repeat the calculations.

Combining Radiological and Chemical Results. Past NEPA analyses for radioactively contaminated sites have typically focused on radiological risks. Recent awareness of chemical contaminants at such sites has resulted in the inclusion of associated impacts in the assessments. Under CERCLA, both carcinogenic risks and noncarcinogenic health effects from exposure to chemicals are explicitly assessed. At issue is whether the results of these two analyses should be combined or presented separately in the documents. Because the assumptions, methodologies, and target endpoints used to assess radiological and chemical carcinogenic risks differ, the two results have been presented side by side in the assessments prepared for the Weldon Spring project. This helps keep radiological risks in perspective relative to background risks and the target incremental risk range for Superfund sites (which was developed without specific consideration of radiological risks). To reduce confusion between the carcinogenic and noncarcinogenic effects, the results for noncarcinogenic chemical effects were presented in decimal notation (e.g., hazard index of 0.1 or 1) rather than in scientific notation, which was used to indicate carcinogenic risks (e.g., 10^{-5}).

One instance where it may be appropriate to present the radiological and chemical results together is in the FS discussion that addresses cleanup criteria. For example, risk contours for the two different calculations can be combined to identify potential areas for cleanup. However, in general, it may be most appropriate to summarize results of the baseline radiological and chemical risk calculations separately but together (e.g., in separate columns of a single table).

Background Contribution. Under NEPA, incremental risks have not always been separated out for individual contaminants and pathways at contaminated sites. However, risks from natural radiation have been included in the assessments to place the site problem in perspective. Under CERCLA, excess risk is the target endpoint of the risk calculations, and contaminant and pathway contributions are commonly indicated. In integrating the two processes, the analyses for the Weldon Spring site have indicated the risk contribution from background concentrations of the specific contaminants evaluated.

For example, the risks presented in the water treatment EE/CAs for ingesting uranium from the affected river were assessed for both the naturally occurring concentration in the river and for the concentration assumed to result from the treatment plant discharge. For the rebaseline assessment in the FS, total risks are presented along with risks associated with a nearby background location. To support the development of cleanup criteria, risks are presented first as total risks and then as incremental risks (e.g., determined by subtracting an average background value from the measured contaminant concentration). The first approach satisfies requirements for presenting baseline information. The latter supports subsequent cleanup decisions. This also helps put in perspective the EPA target range for incremental lifetime carcinogenic risk of 10^{-4} to 10^{-6} relative to naturally occurring radionuclides (e.g., in the uranium and thorium decay series) and metals. The EPA has estimated that the lifetime risk from background radiation is about 10^{-2}; using the standard EPA process, the risks estimated for exposure to certain metals (such as arsenic and beryllium) at background levels in environmental media can be at the upper limit of the target range (e.g., for a residential scenario).

Pathway and Contaminant Contribution. Contributions from individual contaminants and exposure pathways to estimated risks have not typically been isolated in the documentation for NEPA analyses at contaminated sites. Under CERCLA, results are typically presented as individual pathway-specific and contaminant-specific calculations. In integrating the two processes, the baseline assessments prepared for the Weldon Spring site have presented the analyses in accordance with the CERCLA approach. This allows the assessment to focus on the contaminants and pathways that drive the cleanup decision while presenting supporting information for other contaminants and pathways, e.g., at the contaminant selection stage and in the fate and transport discussion. This approach also permits various combinations across multiple pathways so that reasonable maximum exposures can be identified for the different receptors.

Summary of Results. Risk results of past NEPA analyses have typically been presented in summary tables with generally limited discussion in the text. Under CERCLA, emphasis is placed on indicating the results of the health assessment in considerable detail. In integrating the two processes, the baseline assessments prepared for the Weldon Spring site have used figures and tables extensively so that the reader can quickly identify the media, pathways, exposure points, and receptors that are evaluated in detail and see the key results. Specific site locations with elevated risks or hazard indexes can be clearly indicated on figures. Tables can be used to indicate the range of estimated health effects for different hypothetical receptors and for various combinations of exposures.

Cumulative Impacts. Under NEPA, cumulative impacts must be specifically identified as part of the impact evaluation. Historically, this evaluation has related to the actions that might alter or increase existing environmental impacts on a resource such as a river because of the construction and operation of an additional facility such as a dam or power plant. As Superfund cleanups have progressed and the advantages of a phased cleanup strategy using interim actions and separate operable units for certain projects have become apparent, so has the relevance of cumulative impacts to the CERCLA assessments. In fact, EPA has recently raised this issue in risk assessment discussions. In each of the documentation packages prepared for the Weldon Spring project, cumulative health and environmental impacts have been determined by rolling forward the risks estimated for previously proposed actions and considering overlaps of location, impact type, time period, receptors, and exposure pathways.

Potential future actions should also be considered during each stage of the cleanup response in order to address reasonably foreseeable potential impacts. For example, the interim action for a water treatment plant at the quarry preceded the similar action at the chemical plant area. For the earlier action, use of a single system to treat water from both areas was considered, but this was ruled out for various reasons. Although it was addressed as part of the scoping process for the action, the issue was not explicitly discussed in the first EE/CA. Hence, the discussion was incorporated in the second EE/CA to document its earlier consideration regarding reasonably foreseeable impacts. This discussion explained that a single plant was determined to involve additional risks, questionable effectiveness, and higher overall costs and was therefore eliminated as a viable option, precluding such potential impacts. Looking to the future when planning and documenting a phased cleanup strategy can help ensure that all relevant factors are considered at each decision stage, thereby strengthening the overall remediation approach.

CONCLUSIONS

The CERCLA risk assessment process was developed specifically for remedial action sites, and it should therefore serve as the driver in preparing integrated CERCLA/NEPA assessments for DOE sites. This approach is indicated in DOE policy, in which the RI/FS process is identified as the primary instrument for integration. Specific elements of NEPA that have not yet been explicitly identified in EPA guidance for CERCLA assessments should be folded into the integrated assessments in accordance with the DOE policy. For example, impacts during the cleanup period should be quantified in some detail (including worker impacts) and impacts to environmental resources other than biota should be clearly addressed.

The risk assessments prepared for a project should be scoped to reflect the major phases of site cleanup. By this approach, site conditions that have changed markedly as a result of interim actions can be addressed in a manner that will limit the redundancy of documentation and decisions. Those assessments that are part of interim actions for which cleanup criteria are not being established do not require the same level of detail as baseline assessments that are used to develop final cleanup decisions.

Exposure scenarios should be defined on the basis of "likely" and "reasonable" land use and receptor assumptions rather than "bounding-case" assumptions because the assessment must support quantitative cleanup decisions. To do otherwise could result in an inappropriate allocation of cleanup funds.

Data review for a project should begin early and should be rigorously pursued for all media for which the decision to remediate must be determined and for which cleanup criteria must be developed. Immediate focus on this data management task can help ensure that appropriate information is available for the risk assessment, i.e., that critical data gaps are filled. A delay in initiating this effort can significantly delay not only preparation of the risk assessment but also the entire decision-making process for a project.

Finally, the overall strategy and critical assumptions used in the risk assessment should be clearly presented in the document. More importantly, they should be presented to all review groups for discussion as they are developed, with regular updates as the document evolves. Because each site has unique problems and surrounding conditions, no single set of assumptions can be standardized. Therefore, to streamline the integration process for risk assessments at DOE sites, the importance of a sound strategy and early interagency involvement cannot be overemphasized.

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