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Environmental Guidance

Risk-Based Corrective Action

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RISK-BASED CORRECTIVE ACTION GUIDE

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BACKGROUND AND SUMMARY

The Department of Energy (DOE) supports and is implementing many efforts to reduce the costs, increase effectiveness, improve efficiency, and accelerate the schedules of environmental restoration projects. Risk-based decision making is one approach available for streamlining and accelerating the environmental restoration process. In OSWER Directive 9610.17 (Reference #1), EPA defines risk-based decision making as "a process that uses risk assessment and exposure methodology to make determinations about the extent and urgency of remedial actions."

The American Society of Testing and Materials (ASTM) has developed and issued risk-based corrective action (RBCA) standards for addressing petroleum (Reference #2) and chemical releases (Reference #3). Although EPA has recognized RBCA as one approach to risk-based corrective action at petroleum release sites, the Agency has not formally recognized the applicability of the RBCA process to chemical release sites. However, the Agency did review and comment on the draft standard and ASTM has adopted many of EPA's comments in the provisional standard for chemical releases (version 9.0).

RBCA is defined by the ASTM as an iterative streamlining process that uses a tiered approach and site classifications to screen and address sites based on their relative risk. The ASTM standards provide a logical process for implementing the RBCA approach at petroleum and chemical release sites. These standards also provide appendices that contain calculations and potential resources that may be used as examples when establishing risk-based screening levels and initial response actions at contaminated sites.

The purpose of this guide is to explain risk-based decision making and the RBCA process for environmental restoration of chemically contaminated sites. It presents an introductory guide to using risk-based decision making at DOE facilities and discusses how risk-based decision making can be used in conjunction with other DOE streamlining initiatives to reduce environmental restoration costs and schedules.

As is true in all environmental restoration projects, risk-based decision making or RBCA, will be most effective when it enables core decision making teams (e.g., DOE, EPA, state regulators, key stakeholders) to use scientifically defensible analyses to come to agreement on issues such as:

- ❒ What site problems potentially require remediation;
- ❒ What are appropriate remediation levels;
- ❒ What response actions are the most likely to meet these levels; and
- ❒ What data are necessary to make these decisions.

The RBCA process provides "tools" and concepts that may assist decision-making teams to better come to agreement on these issues. A major strength of the RBCA process is its emphasis on determining the data required for technical decision making rather than on following specific process steps. RBCA is intended to ensure that key issues are addressed and decisions made rather than focusing on following a rote process.

USE OF RISK-BASED CORRECTIVE ACTION AT DOE SITES

RBCA is a risk-based streamlining tool that helps determine remedial objectives and priorities and is appropriate for many types of remedial problems. DOE managers may wish to consider using the concepts of risk-based corrective action to accelerate their projects in at least two circumstances.

1) At less complex or lower hazard sites, where DOE and regulators have determined that a risk-based decision-making approach may be appropriate, RBCA can be used as a stand alone process; or

2) RBCA concepts can also be used as part of an environmental restoration process at more complex sites where a risk-based approach is needed to make decisions on a particular portion of a site-wide remediation project. For example, a variety of contaminants and contamination scenarios may occur at different locations, with vastly differing soil and hydrogeologic conditions. These situations provide good opportunities for DOE to use risk-based decision making to identify contaminated areas and prioritize

response actions based on real or anticipated impacts to human health and the environment.

Despite its streamlining advantages, RBCA may have some limits to its usefulness at DOE sites. For example, RBCA is currently limited to addressing remediation of chemical releases and does not provide specific tools to establish risk-based goals for releases of radionuclides. However, in cases where both chemical and radionuclide contamination exist, combining RBCA with radionuclide risk screening approaches may still allow DOE to realize many of the benefits of the RBCA approach. Additionally, RBCA incorporates only a limited, qualitative ecological risk assessment discussion that may need to be supplemented by other approaches to address ecological issues to the appropriate extent during the remediation process (see Reference #7). *[Note: ASTM is also in the process of planning and outlining a future standard for conducting ecological risk assessments.]*

KEY CONCEPTS OF ASTM'S RBCA APPROACH

A major emphasis of the ASTM standard is that the focus of environmental restoration is on gathering data that is necessary to make sound technical decisions. The RBCA emphasis is built on five concepts that could allow DOE to reduce time and lower costs compared with those incurred under more traditional environmental restoration approaches. Each concept is explained in this section and illustrated with an example in the next section of this guide. Specifically, RBCA

❒ outlines a tailored approach to data collection that is based on the explicit identification of decision making needs;

❒ introduces a logical process that helps project managers incorporate risk goals and risk planning early into the remedial action process;

❒ uses a tiered approach that starts simple and only becomes more complex as needed;

❒ provides core decision-makers with tools (e.g., tiered risk levels for comparison with site constituent concentrations) that can be used to determine whether remediation is required or what cleanup levels should be sought through remediation; and

❒ focuses on early identification of response actions that can meet risk-based goals as early on in the decision making process as possible.

KEY STEPS OF ASTM'S RBCA PROCESS

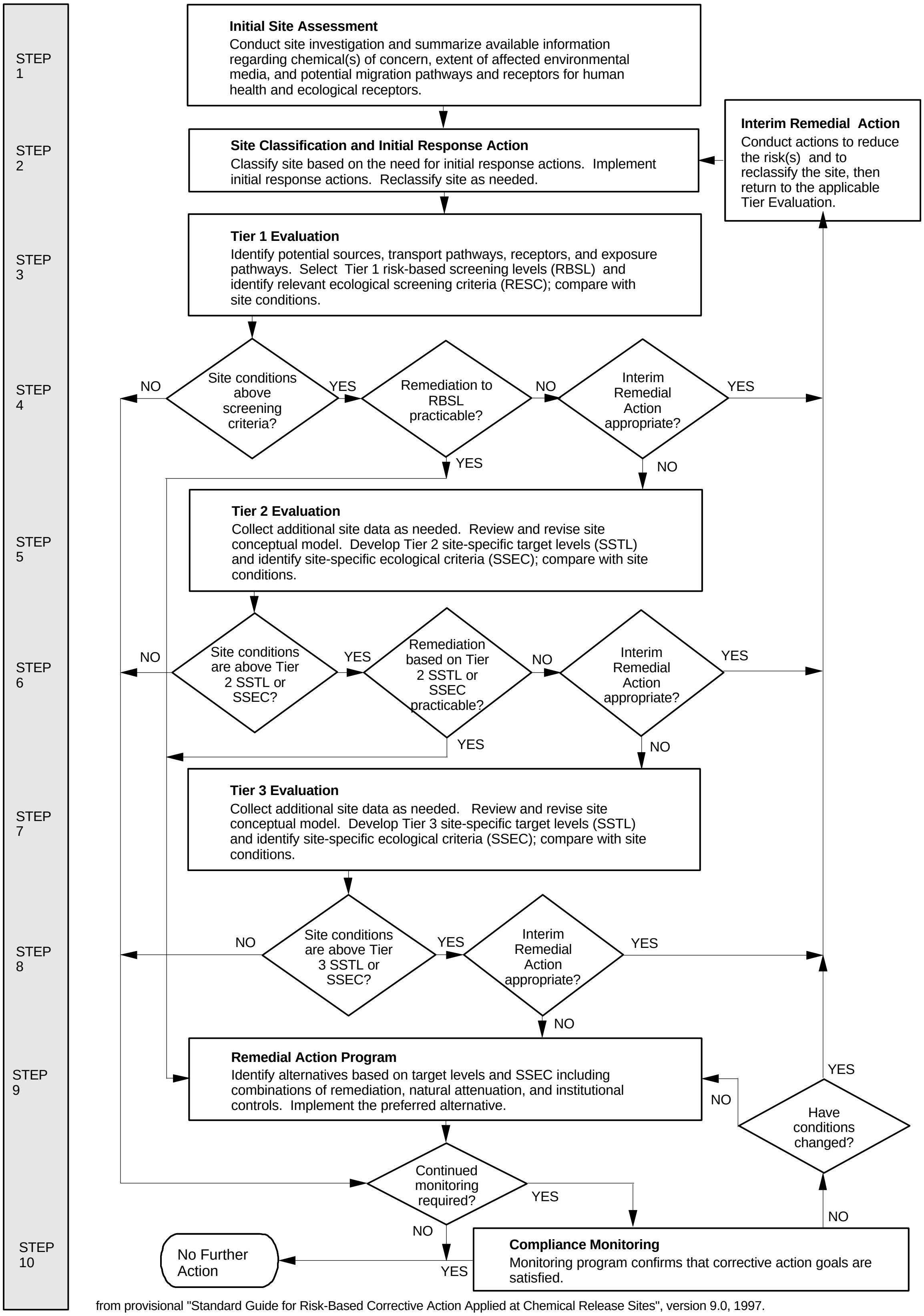
Prior to initiating the RBCA process, DOE users should identify the stakeholders interested in the corrective action process, identify methods of communicating with stakeholders, and establish a mechanism for receiving input on technical policy decisions identified throughout the process (or involving stakeholders as part of a core project team). Successful implementation of the RBCA framework will depend on the user obtaining early agreement with stakeholders and regulators on the technical policy decisions and data quality objectives.

ASTM's RBCA process encourages use of the flow diagram shown in Figure 1. DOE users and stakeholders can follow this process to achieve better environmental restoration planning and results. Key elements of this flow diagram are listed below and are discussed in greater detail later in this guide:

❒ Developing a conceptual site model (or conducting an "initial site assessment") and creating a site-specific look-up table of risk-based chemical concentrations to assist in making remediation decisions;

❒ Using a simple classification system to determine what, if any, early remedial actions are appropriate given the existing risks and site conditions. Classifications are based on the urgency of need for a response, as determined by the current and projected degree of hazard posed to human and environmental receptors;

Figure 1
Risk Based Corrective Action Process Flowchart



from provisional "Standard Guide for Risk-Based Corrective Action Applied at Chemical Release Sites", version 9.0, 1997.

- ❒ Collecting data using three step-wise tiers, each of which reflects a different degree of complexity of the analysis, as dictated by the site conditions (e.g., higher tiers and more complex analysis are usually required for more complex conditions and conceptual models). RBCA relies on project managers to make remediation decisions at the tier that provides them with the information, which may entail extensive data collection at even at the Tier I level, necessary to make the appropriate remedial decisions; and

- ❒ Using basic risk equations to develop Risk-Based Screening Levels (RBSLs), Site-specific Target Levels (SSTLs), Relevant Ecological Screening Criteria (RESC), and Site-Specific Ecological Criteria (SSEC).

When compared against site concentrations, these risk-based standards allow project managers to decide whether risks exist and to what degree remediation must occur to reduce those risks to levels protective of human health and the environment.

Conceptual Site Model. Successful use of the RBCA process is dependent upon developing an effective conceptual model of site conditions. The conceptual site model, or RBCA initial site assessment (Step 1), is the foundation of the process and involves identifying:

- ❒ known and possible exposure pathways, transport mechanisms, potential receptors; and reasonably anticipated land use;

- ❒ principal chemicals of concern; and

- ❒ potential immediate risks.

The conceptual site model identifies the chemicals of concern, the complete or potential exposure pathways, transport mechanisms, and the likely dispersion of the chemicals of concern. The exposure pathways are then used to determine which risk equations should be used to calculate the RBSLs and which ecological criteria should be used in calculating the RESC. Only when the reasonable exposure pathways and chemicals of concern are identified can the risk-based look-up table be developed for the site.

If appropriate, RBSLs at a site may be based on aesthetic or other performance criteria. The appropriateness of using non risk-based criteria should be determined by consultations with federal, state, and local regulators, and stakeholders. Such a determination would be made when the initial policy and clean-up level decisions are made during the development of the site conceptual model.

Classification. RBCA uses classifications of known conditions to determine if early responses are needed and to identify interim response measures that could be implemented until a final remedy can be selected. This classification provides an opportunity for early risk reduction while additional site investigations are ongoing. Classifying site conditions involves prioritizing the site (or release at a site) based on the relative risk and the corresponding urgency of initial response actions. As a site moves through the RBCA process, site conditions can be evaluated and compared to a menu of pre-determined initial response options. As new data indicate a change in conditions, the classification is updated accordingly.

The RBCA process identifies four site classifications. Class 1 sites are those associated with immediate threats to human health and the environment. Class 2 sites are those with short-term threats (0-2 years), class 3 sites pose long-term threats (> 2 years), and class 4 sites pose no potential threats to human health and the environment. Class 1 sites almost always warrant strong consideration of early initial actions; class 4 sites may be candidates for no further action and initial response actions are much less likely to be required.

Tiers and Risk-Based Screening Levels. The RBCA standard guide (Reference #3) provides example fate and transport assumptions and risk equations based on the chemical types (e.g., VOCs, metals, etc.) and exposure pathways identified in the conceptual site model. The RBCA process encourages project managers to use site-specific equations based on existing site conditions.

Once the project manager identifies the appropriate equations for the chemicals and pathways of concern, RBSLs can be calculated using the human health and toxicological information available from the EPA-approved sources identified in the following paragraph. The RBSLs for each chemical and exposure pathway identified at the site combine to form the look-up table. The calculated risk-based concentrations in the look-up table are compared to the concentrations of contaminants at the site to determine the need for and extent of remediation.

The look-up table is developed by using exposure and dose-response models to estimate how the chemicals of concern will migrate through the identified media over time, and what the resulting chemical uptake will be. In developing the look-up table, current generic human health parameters such as US EPA reasonable maximum exposure (RME) assumptions, reference doses, and no observed adverse effects levels (NOAEL) are often used as values in the risk equations. Current human toxicological information should be obtained from standard sources such as the US EPA Integrated Risk Information System (IRIS) Database, Health Effects Assessment Summary Tables (HEAST), State sources, additional peer-reviewed sources, or other agency-approved toxicity data.

Figure 2 shows in detail how the tiered approach and risk -based screening levels can be used throughout the RBCA process. It should be noted that extensive site characterization may be necessary prior to conducting a Tier 1 analysis. Investigations conducted during the development of the conceptual site model need to be sufficiently detailed to ensure that all major sources, pathways, potential receptors, and areas of contamination have been identified within acceptable limits of uncertainty. Project managers should also note that the RBCA standard does not fully incorporate consideration of site-specific indirect exposures until a site has progressed to a Tier 3 analysis. *In its comments on RBCA, however, EPA cautions users to consult the appropriate regulatory officials if intending to "screen out" a site from considering further remediation prior to evaluating the potential for indirect exposures.*

RELATIONSHIP OF RBCA TO OTHER ENVIRONMENTAL RESTORATION APPROACHES

Figure 3 compares the RBCA process to the steps in a traditional CERCLA or RCRA remediation process and identifies potential constraints on using this method of streamlining. The extent to which these constraints exist in a given project or at a site will help project managers to determine if RBCA offers a feasible remedial approach.
Many other DOE techniques for accelerating environmental restoration, including the Streamlined Approach for Environmental Restoration (SAFER), which has evolved into the Principles of Environmental Restoration, and EPA approaches such as the Superfund Accelerated Cleanup Model (SACM), and the RCRA Stabilization Initiative share several common features and objectives with the RBCA process:

❒ Heavy reliance on early site characterization through the iterative development of a conceptual site model;

❒ Use of an iterative site assessment and data collection process;

❒ Use of early actions to mitigate problems and to prevent exposures and/or the spread of contamination while a final remedy is being selected; and

❒ Addressing sites that pose the greatest risks first (e.g., immediate, high-risk problems such as contaminated drinking water wells.)

RBCA fits particularly well with DOE's Principles of Environmental Restoration. The Principles of Environmental Restoration are based on four key concepts. These concepts or "principles" are:

❒ Building an effective project team is essential;

❒ Clear, concise, and accurate problem identification and definition are critical;

Figure 2
Application of RBCA Tiers and Screening Levels

Tier	Screening Level	Purpose and Key Elements	Example of Use and Impact
1	Risk-Based Screening Level (generic and comparative)	RBSLs are risk-based screening levels that are used to determine if remediation is required. RBSLs are non site-specific values based on conservative exposure factors for complete and potentially complete human exposures and qualitative ecological receptors. Direct and indirect exposures are evaluated as if the receptor and the source of contamination are at the same location regardless of the actual or potential future location of the receptor (i.e., RBSLs assume that the concentration at the point of contamination is the concentration at the point of exposure).	Develop RBSLs in the site look-up table. Compare existing monitoring/sampling concentrations to the RBSLs in the look-up table. If site concentrations are less than RBSLs and the generic assumptions used for calculating RBSLs match the conceptual site model, no further action is required. If concentrations are greater than RBSLs or the generic assumptions need revision to more accurately reflect conditions identified in the conceptual site model, project managers may need to advance to Tier 2, collect additional data, calculate SSTLs, and refine the exposure analysis. If concentrations are less than RBSLs but the conceptual site model indicates the potential for indirect exposures, the analysis should advance to Tier 2. Additionally, if evidence suggest cumulative risks from multiple chemicals is a concern at the site, then the analysis should proceed to Tier 2.
2	Site-Specific Target Level	SSTLs are used to determine if remediation is needed and to what levels concentrations of contaminants must be reduced to. SSTLs use receptors for site-specific human exposures and ecological criteria. SSTLs are similar to RBSLs, except direct exposure values at site-specific points of exposure replace the generic exposure assumptions used in the RBSLs. If applicable, SSECs are developed for relevant ecological receptors. For Tiers 2 and 3, the non site-specific assumptions are replaced by site-specific assumptions, but are aimed at achieving the same levels of protection.	Collect additional site data and update the site classification, as needed. Compare site data to the SSTLs and SSECs (which will replace the RBSLs in the look-up table). If concentrations exceed SSTLs at the identified exposure points and remediation is practicable, implement a remedial action. If site concentrations are greater than SSTLs, or the conceptual site model indicates SSTLs for indirect exposures need to be developed, project managers may need to implement interim measures and collect additional data or utilize more complex models for a Tier 3 evaluation.
3	Site-Specific Target Level	Tier 3 provides the user with an option to determine SSTLs for both direct and indirect human exposure pathways using site-specific parameters, points of exposure, and points of compliance. For SSECs a Tier 3 evaluation becomes more quantitative and may involve more extensive site-specific analysis.	Tier 3 invokes the maximum amount of flexibility in applying site-specific values. More advanced exposure and toxicity assessments are often required due to the complexity of the site/contamination reflected in the conceptual site model. Indirect exposure scenarios and ecological receptors are fully incorporated into the equations, and the point of exposure is further refined to fit site-specific conditions. Cumulative risks are fully addressed in Tier 3. Compare sampled concentrations to refined SSTLs in the look-up table and make remediation decisions.

Figure 3
Comparison of RBCA to Traditional CERCLA Remedial Action/ RCRA Corrective Action Steps

CERCLA Remedial Action/ RCRA Corrective Action Step	Primary Purpose of Step	Applicable RBCA streamlining Step	Potential Regulatory Constraints to Only Using RBCA Process
Remedial Investigation/ RCRA Facility Assessment	Identify/characterize (i.e. Define nature and extent of releases) sites or areas requiring further investigation based on preliminary evaluations.	Site Investigation: Delineate risks using Tier 1 Levels to determine if any risks exist under conservative assumptions. May proceed to using generic exposure conditions or evaluate site-specific exposure points for Tier 2.	Regulations may require investigations to identify non-risk related issues.
Baseline Risk Assessment	Conduct baseline risk assessment to quantify human health and environmental hazards and establish preliminary remediation goals.	Identify exposure pathways for the conceptual site model and establish target risk levels to determine if remediation is warranted.	Must comply with ARARs that could require remediation even if baseline risks do not warrant it.
Interim Measures Study	Evaluate and implement interim response actions to control immediate threats and/or support the overall response action.	Interim Response Actions: Use RBCA exposure flowcharts to classify site and evaluate applicable interim measures	None.
Feasibility Study/ RCRA Facility Investigation and Corrective Measures Study	Define nature and extent of releases. Collect data. Identify and evaluate potential remedial technologies and alternatives, considering various measures of effective implementability and cost.	Delineate affected media exceeding RBSL. Use exposure control flowchart with site-specific exposure points. If necessary, calculate SSTLs for Tier 2 and apply more sophisticated Tier 3 modeling methods.	Iterative CERCLA comment and review process can be extensive. Action levels and MCLs are not always risk-based. Some treatment standards are technology rather than risk-based and may require remediation beyond accepted human health or risk levels. Remedy selection criteria have a preference for “permanent” removal or treatment options.

❒ Early identification of likely response actions is possible, prudent, and necessary; and

❒ Uncertainties are inherent and will always need to be managed.

These four principles are the basis for effective problem solving under any regulatory authority and can be applied throughout the restoration process - from scoping to implementation.

RBCA has many similarities to this DOE streamlining technique. Both focus on early identification of remedial cleanup targets and technologies; have techniques for focusing decision making on less complex sites; and use more complex models and tools only where data are not readily available or substantial uncertainties exist.

Because of the complexity of many DOE sites, the DOE processes place greater emphasis on active involvement of regulators and other stakeholders. This is not precluded in RBCA, but RBCA is largely designed as a self-implementing process. The Principles of Environmental Restoration incorporates more explicit recognition of non-risk based factors in determining when remediation is necessary, such as site-specific drivers, agreements with stakeholders or treaties with Indian Nations, and the effects of multiple release sites or delayed risk profiles. Additionally, the RBCA approach advocates a specific series of steps; DOE streamlining processes tailor their steps to the site-specific circumstances.

EXAMPLES OF HOW TO APPLY RBCA AND RISK-BASED DECISION MAKING CONCEPTS

Example 1: Using RBCA to Determine if Remediation is Necessary

Site Background. The site consists of several acres located near a university. The site is surrounded by campus research facilities. For more than 30 years the laboratory was used by the university to conduct chemical properties research. As a result of this research, soil was contaminated by the onsite burial of wastes in shallow trenches and in a one-half acre landfill. Initial sampling shows that the chemicals of concern are methylene chloride, cadmium, and mercury. It is uncertain whether some chemical contaminants have reached the groundwater.

Soil samples from previous investigations were collected from monitoring well borings installed adjacent to the disposal unit. Down-gradient groundwater monitoring was also conducted as part of the previous investigations. A shallow water-bearing zone and a deeper aquifer are beneath the site. The shallow zone is located approximately 50 - 60 feet below the surface and flows southwest to northeast, the deeper aquifer is approximately 80-110 feet below the surface.

Problem Identification. The primary remediation concerns at the site are the occurrence and migration of methylene chloride as a dense non-aqueous phase liquid (DNAPL), the leaching of contamination from surficial soils to groundwater, and the threat of direct contact with contamination in the trenches and landfill.

Use of RBCA. RBCA can be used to determine what, if any, remedial response is required. In applying RBCA at this site, an initial site assessment was conducted (using previously collected data) and potential exposure pathways were identified using a conceptual site model. The conceptual site model presented as Figure 4, showed three possible exposure routes:

1) Soil, through dermal contact or ingestion;

2) Air, from the inhalation of particulate; and

3) Groundwater.

The data from the conceptual site model were used to classify the site. Based on the available data the site was classified as a 3 or 4, with a possible long-term threat to human health depending on how the contaminant concentrations detected in the groundwater compare to the RBSLs. Initial response actions would be to notify the proper authorities and continue monitoring the groundwater. Likely final response actions to be evaluated are:

❒ no further action;

❒ long-term pumping or monitoring of groundwater if DNAPLs are present;

❒ capping of wastes in place; and

❒ excavation of hot spot material followed by capping of residual waste in place.

Results from Using the RBCA Process. The results of conducting a Tier 1 evaluation and comparing the conceptual site model exposure pathways to the RBSLs in the look-up table are presented in Figure 5. Sampled soil concentrations (column A) were compared to RBSL values in columns E and F, and groundwater concentrations were compared to values in column C. As shown, when the sampling data were compared to the RBSLs in Figure 5, none of the contaminants of concern

Figure 4
Conceptual Site Model for Example 1

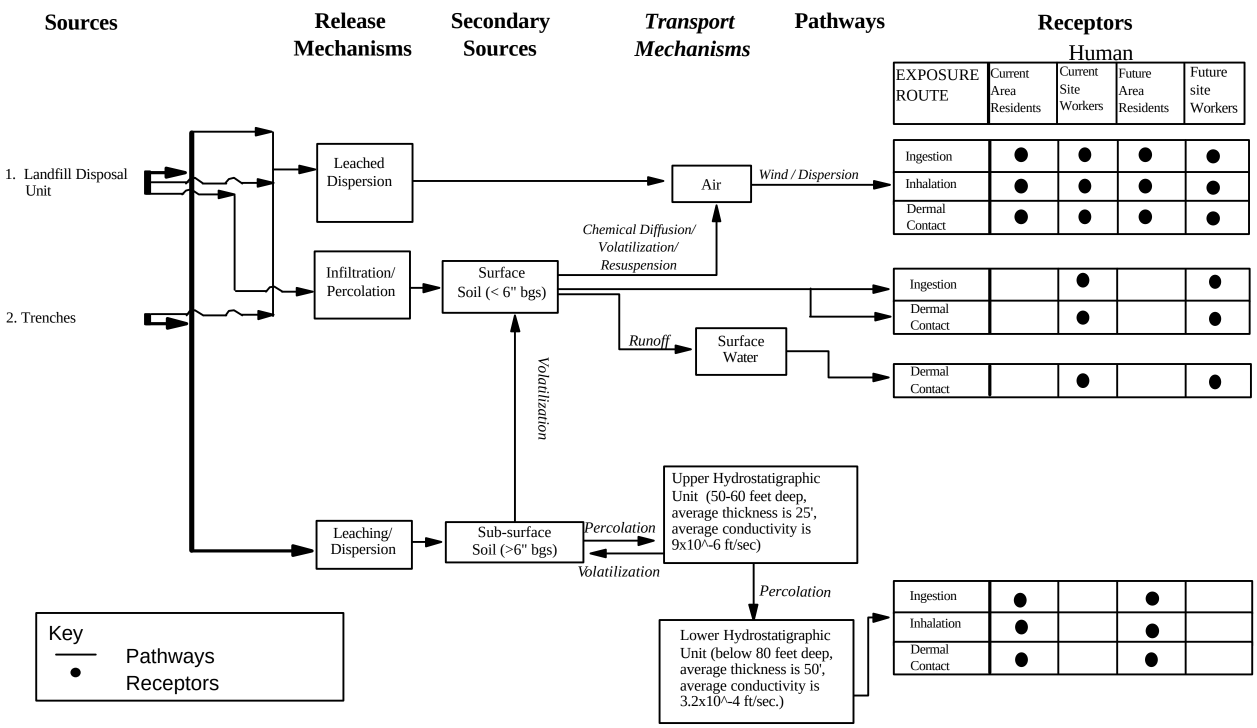


Figure 5
Initial Site Assessment Findings For Example 1

Contaminant Found at Site	(A) Highest Detected Value in Soil (mg/kg)	(B) Highest Detected Value in Groundwater (mg/L)	Residential Use RBSLs				(G) Conclusion
			© Risk Or Hazard Criteria	(D) GW Ingestion (mg/L)	(E) Soil Leaching to GW (mg/kg)	(F) Surficial Soil Exposure (mg/kg)	
Methylene chloride	0.9	.001	THQ=1 TR=10^{-6} MCL	2.19 .011 .005	1.94 .01 .004	4,790 23.5 NA	Because B<D, A< F, and A > E ∴ may want to monitor GW
Cadmium	<3.0	.002	THQ=1 MCL	.018 .005	6.52 1.79	365 NA	Because B<D, and A< E and F ∴ No further action
Mercury	0.5	.002	THQ=1 MCL	.011 .002	2.71 .494	16.1 NA	Because B<D, and A≤ E and F ∴ may want to monitor GW

KEY: THQ = Target Hazard Quotient TR = Target Risk Level MCL = Maximum Contaminant Level

[*Note: In Figure 5, target risk levels were developed for compounds that have been classified as carcinogens, based on the general equation: risk = average lifetime intake [mg/kg-day] x slope factor [mg/kg-day]$^{-1}$. For compounds that have not been classified as carcinogens, target hazard quotients were used for the RBSLs based on the equation: hazard quotient = average intake [mg/kg-day]/ reference dose [mg/kg-day].*]

exceeded the RBSLs (based on the target hazard quotients and a risk level of 10^{-6}). Because the concentrations detected at the site are assumed to be conservative values (based on sampling at locations expected to yield the highest concentrations) a finding of no further action may be possible. Nevertheless, some further investigation or groundwater compliance monitoring may be warranted to ensure that methylene chloride and other contaminants do not become contaminants of concern with respect to soil leaching to groundwater, but active remediation or capping should not be required according to the risk-based evaluation. However, as always, the appropriate regulatory authorities should be consulted early in the process and made a party to any final remedial decisions.

Example 2: USING RBCA AS PART OF A MORE COMPLEX REMEDIATION PROJECT

Site Background. An area at this facility has a history of receiving debris and fill materials. The northern portion of the site was used as a general disposal area for contaminated debris. The location of the general disposal area is believed to be primarily in the original ravine between two buildings. A septic tank was installed below grade in the northern portion of the site for use during construction of the plant. The exact size, location, contents, and composition of the tank is unknown. When in service, the septic tank received only sanitary waste from the administrative buildings. No records are available that indicate when the tank was taken out of service. In 1984, an asphalt parking lot was built on the southeastern side of Building A, paving over part of the backfilled area and the septic tank location.

Plant staff interviews and limited written records indicate that an unknown number of dump truck loads (but likely less than five) of mercury and benzene contaminated soil were deposited in 1959 in or around the septic tank.

During the Site Survey Project, several core samples were taken around the septic tank. Two samples taken from boreholes near and possibly through the tank, indicated the presence mercury and benzene. A ground-penetrating radar (GPR) survey was performed at the site. The survey indicated anomalies 18 feet below ground surface that appear to be within 50 feet of the same two borehole locations and the reported location of the tank.

Portions of the site are expected to be released for residential use with the remaining portions retained under federal control.

Restoration Approach. The first activity of the remediation process is often to develop a core project team with all stakeholders adequately represented. At this site, the project team would need to include DOE and EPA officials, local citizens groups, and state regulators. The project team would then develop the problem statement to help determine data collection goals. The conceptual site model for this site is presented in Figure 6. The problem posed by this situation is to identify the extent, location, and remediation needed for the contaminated soils. Given the available information, the likely response actions are excavate the soils; use soil vapor extraction (SVE) to treat the benzene and then cap the mercury contaminated areas; or leave the materials in place and monitor (no action).

Use of RBCA. An effective use of RBCA concepts at this site would be to classify release sites and determine whether response actions for the contamination are required. For example, RBCA could be used to develop RBSLs and SSTLs for the benzene and mercury contaminated areas. For these constituents, the RBCA process could be applied, the release sites could be classified and the remediation could proceed.

Results from Using the RBCA Process. The core team in this case decided to use RBCA to determine whether remediation (e.g. excavation) was warranted if the contaminated soil and debris could be located. The existing site data collected as part of the conceptual site model and the residential use RBSLs are presented in Figure 7. The data show that at 10^{-6} (and even 10^{-4}) risk levels the sampled concentrations exceed the RBSLs for soils leaching to groundwater and exceed or are equal to the RBSLs for surficial soil exposure. Therefore, the Tier 1 evaluation, where the risks at the source are assumed to equal the risks at the point of exposure, indicates that this site may need to advance to Tier 2 or more likely, Tier 3 (since indirect exposures are likely, such as the ingestion of contaminated fish in down gradient surface waters).

Figure 6
Conceptual Site Model for Example 2

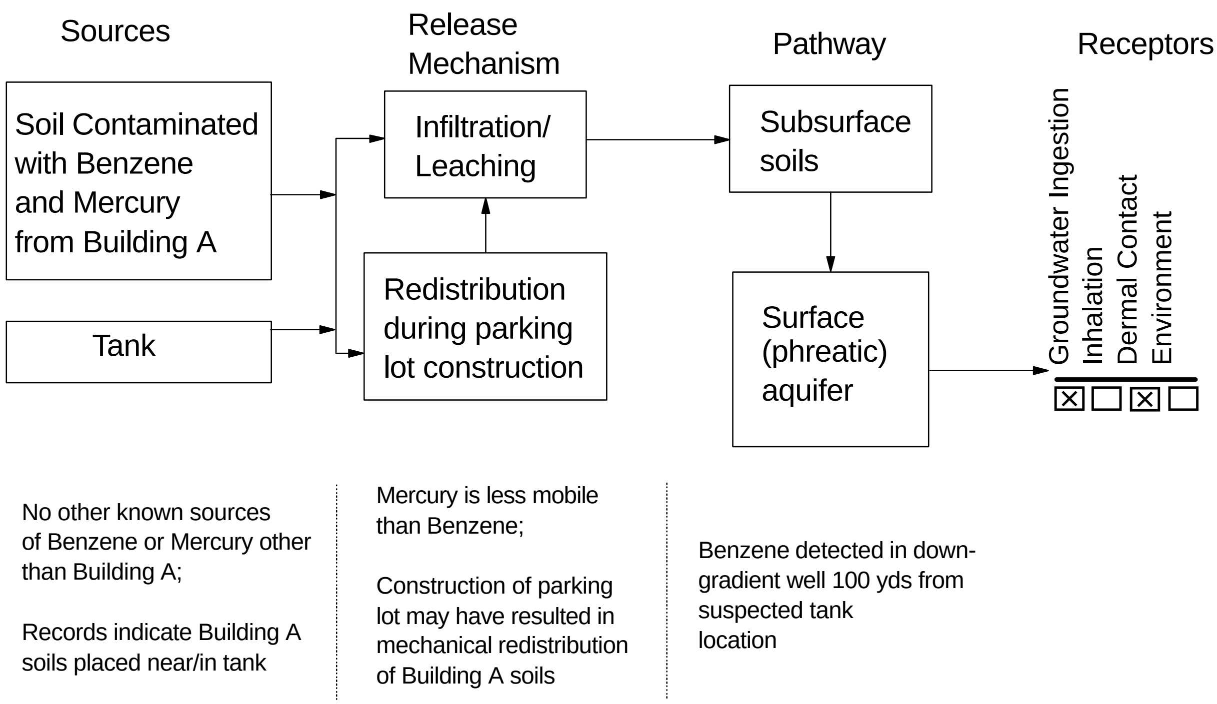


Figure 7
Initial Site Assessment Findings For Example 2

Contaminant	(A) Range of Value Detected in Soil	Residential Use RBSLs				Conclusion
		(B) Risk Or Hazard Criteria	© GW Ingestion	(D) Soil Leaching to GW	(E) Surficial Soil Exposure	
Benzene	60 - 800 (mg/kg)	$TR=10^{-4}$ $TR=10^{-6}$	.294 (mg/L) .003 (mg/L)	.912 (mg/kg) .009 (mg/kg)	470 (mg/kg) 4.70 (mg/kg)	A > D ∴ Continue to Tier 2, refine SSTL equations and decide on appropriate remedial response.
Mercury	4.0 - 12 (mg/kg)	THQ=1 MCL	.011 (mg/L) .002 (mg/L)	2.71 (mg/kg) .494 (mg/kg)	16.1 (mg/kg) NA	A > D ∴ Need to continue to Tier 2

KEY: THQ = Target Hazard Quotient TR = Target Risk Level MCL = Maximum Contaminant Level

[*Note: In Figure 7, target risk levels were developed for compounds that have been classified as carcinogens, based on the general equation: risk = average lifetime intake [mg/kg-day] x slope factor* $[mg/kg\text{-}day]^{-1}$*. For compounds that have not been classified as carcinogens, target hazard quotients were used for the RBSLs based on the equation: hazard quotient = average intake [mg/kg-day]/ reference dose [mg/kg-day].*]

Site-specific points of exposure and risk levels also need to be incorporated into the SSTL development process to evaluate the risks posed to users of the down gradient well. If ecological risks exist, this site may need to incorporate more advanced SSECs or may need to incorporate methods from other remedial approaches.

Reasons for Not Relying Solely on RBCA. Because portions of this site are expected to be available for residential use, stakeholders may be hesitant to use RBCA methods due to a desire to remediate the site beyond risk-based levels. For example, this may occur when a site future use is anticipated to be residential, recreational, or the land will be released to another entity. What the Tier 1 analysis has shown in this case, is that unacceptable risks would exist if direct exposures occur. This may even lead to an early core team decision to remediate without further risk evaluation, or lead the team to conduct the Tier 2 and 3 analysis, which may lead to an alternate conclusion under an RME scenario.

Additionally, business decisions or stakeholder concerns may be the primary drivers for remedial decisions. For example, aesthetics, public perception, or property transfer/reuse issues may motivate project managers to remediate a site or release beyond risk-based levels.

Although RBCA allows SSTLs to be based on non-risk criteria, the RBCA standard does not provide guidance on reaching agreement on non-risk based levels.

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8. "Site Conceptual Exposure Model Builder", US DOE, Office of Environmental Policy and Assistance, RCRA/CERCLA Division (EH-413),July, 1997.

* Available on the EH-41 World Wide Web site at **http://tis-nt.eh.doe.gov/oepa** under the "tools" button.

Please refer any questions concerning the subject material covered in this guidance document to Jerry Coalgate, RCRA/CERCLA Division, EH-413, at (202) 586-6075, or jerry.coalgate@eh.doe.gov