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January 28, 2004

RECEIVED
JAN 2004

Mr. David Cobrain
State of New Mexico Environment Department
Hazardous Waste Bureau
2905 Rodeo Park Drive East
Building One
Santa Fe, New Mexico 87505-6303

Reference: Work Assignment No. 06110.210.0002; State of New Mexico Environment Department, Santa Fe, New Mexico; Litigation Support; Reference Lists for Risk Analysis (Section VII.C), Task 2 Deliverable.

Dear Mr. Cobrain:

Enclosed please find the deliverable for the above-referenced work assignment. The deliverable consists of references for the risk analysis Section VII.C of the Corrective Action Order (Order). The text from the Order was broken out by sentence or paragraph, and two or more references, where possible, for the requirements were provided. In addition, a copy of each reference has also been provided.

TechLaw does not have a final copy of the newly revised NMED Soil Screening Guidance. As such, copies of the version we sent as a deliverable to NMED were provided. It is suggested that an entire copy of this document be included as a reference. Also, TechLaw does not have the latest version of Los Alamos's screening documents. As noted in an email from you dated January 9, 2004, a copy of this new document will be sent to TechLaw. It is suggested that in the mean time, this document be added as a reference to Section VIIC.

The document is formatted in Word. The deliverable was emailed to you on January 28, 2004 at David_Cobrain@nmenv.state.nm.us. A formalized hard (paper) copy of this deliverable will be sent via mail. If you have any questions, please call me at (303) 763-7188 or Ms. Paige Walton at (801) 451-2978.

Sincerely,

June K Dreith

June K. Dreith
Program Manager

Enclosure
cc: Mr. John Kieling, NMED
Ms. Paige Walton, TechLaw

32611

TASK 2 DELIVERABLE

REFERENCE LISTS FOR RISK ANALYSIS (SECTION VII.C), CORRECTIVE ACTION ORDER LOS ALAMOS NATIONAL LABORATORY

Litigation Support

Submitted by:

TechLaw, Inc.
560 Golden Ridge Road
Suite 130
Golden, CO 80401-9532

Submitted to:

Mr. David Cobrain
State of New Mexico Environment Department
Hazardous Waste Bureau
2905 Rodeo Park Drive East
Building One
Santa Fe, New Mexico 87505

In response to:

Work Assignment No. 06110.210

January 28, 2004

VII.C Risk Analysis

VII.C.1 General

The Respondents shall attain the cleanup goals outlined in Section VIII of this Order for all media at each site for which the Department determines, under Section VII.D.1, that corrective action is necessary to protect human health or the environment. The Respondents may propose to demonstrate to the Department that achievement of a cleanup goal at a particular site is technically infeasible. The Respondents shall have the burden of making such demonstration to the Department's satisfaction. If the Respondents propose to demonstrate the technical infeasibility of achievement of a groundwater cleanup goal that is a WQCC standard, the applicable requirements of the WQCC Regulations, 6.2.4103.E and 4103.F NMAC, shall be followed. If the Department approves the technical infeasibility demonstration, the Respondents shall prepare a site-specific risk assessment for that site to identify alternate cleanup goals or, if the WQCC Regulations apply, alternate abatement standards. The risk assessment shall include both a human health risk assessment and an ecological risk assessment.

References

- NMAC 20.6.2 (Section 4103.E), allows for demonstration of technical infeasibility;
- NMAC 20.6.2 (Section 4103.F), indicates that alternative must be protective of human health and the environment and will not create a present or future danger to public health, which may be supported by a risk assessment;
- USEPA 2000, pages 31 through 34; and
- USEPA 1993, pages 9 through 12.

VII.C.2 Risk Analysis Report

Within ninety (90) days after receiving from the Department a written determination that a technical infeasibility demonstration has been approved, the Respondents shall submit to the Department for approval a Risk Analysis Report for that site. The Respondents shall follow the Risk Analysis Report format outlined in Section XI.E of this Order.

References

- Timeframe based upon Agency discretion.

VII.C.2.a Conceptual Site Model

The risk analysis shall include information on the expected fate and transport of contaminants detected at the site including a list of all sources of contamination at the site. Sources that are no longer considered to be releasing contaminants, but represent the point of origination for contaminants transported to other locations, shall be included. The discussion of fate and transport shall address potential migration of each contaminant in each medium, potential breakdown products and their migration, and anticipated pathways of exposure for human and ecological receptors.

References

- USEPA 1989, pages 4-4 through 4-6; and
- USEPA 1993, pages 14 and 15.

For human health risk assessments, the conceptual site model shall include residential land use as the future land use for all risk assessments. Site-specific future land use may be included,

provided that written approval to consider a site-specific future land use has been obtained from the Department prior to inclusion in the risk assessment.

References

- NMED 2003, page 8 (discuses residential scenario is the most conservative land use, also provides exposure characteristics and parameters associated with residential use); and
- USEPA 2004, pages 32 and 33.

Conceptual site models presented for ecological risk assessments shall identify assessment endpoints and measurement receptors for the site. The discussion of the model shall explain how the measurement receptors for the site are protective of the wildlife receptors.

References

- NMED 2003, Attachment A, pages 4 through 6;
- USEPA 1997, *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*, pages 1-4 through 1-8 and pages 3-10 through 3-15; and
- USEPA 1998, pages 40 and 41.

VII.C.2.b Risk Screening Levels

The risk assessment shall include the actual screening values used for each contaminant for comparison to all human health and ecological risk screening levels. The Department's soil screening levels (SSLs) for residential soil shall be used to screen soil for human health. For those contaminants not appearing on the Department's SSL table, the EPA Region 6 soil screening value adjusted to meet the Department's target risk goal of 10^{-5} for total risk for carcinogens shall be used to screen the site for human health risks. Screening for ecological risk shall be conducted using the LANL Ecological Screening Levels (ESLs) if the LANL ESLs have received written approval from the Department. If the LANL ESLs have not been approved by the Department or the LANL ESL database does not contain a screening value for the receptor or contaminant, the Respondents shall use U.S. EPA ecological soil screening levels (ECO-SSLs), or derive a screening level using the methodology in the Department's "Guidance for Assessing Ecological Risks Posed by Chemicals: Screening–Level Ecological Risk Assessment." If no valid toxicological studies exist for a particular receptor or contaminant, the contaminant/receptor combination shall be addressed using qualitative methods. If an approved site-specific risk scenario is used for the human health risk assessment, the Respondents shall include all toxicity information and exposure assessment equations used for the site-specific scenario as well as the sources for that information. Other regulatory levels applicable to screening the site, such as drinking water MCLs and WQCC standards, shall also be included in the risk analysis.

References

- NMED 2003, Table A-1;
- USEPA 2004, http://www.epa.gov/earth1r6/6pd/rcra_c/pd-n/screen.htm;
- USEPA 2003, www.epa.gov/ecotox (searchable database);
- NMED 2003, Attachment A; and
- LANL 2002 (searchable database).

References for Section VII.C

LANL, 2002. Eco Risk Database, Release 1.5

NMAC 20.6.3.4103, www.nmcpr.state.nm.us/nmac/parts/title20/20.006.0002.html.

NMED, 2003. *Technical Background Document for Development of Soil Screening Levels*, New Mexico Department Hazardous Waste Bureau and Ground Water Quality Bureau Voluntary Remediation Program.

United States Environmental Protection Agency (USEPA) 2004. *EPA Region 6 Human Health Medium-Specific Screening Levels*. http://www.epa.gov/earth1r6/6pd/rcra_c/pd-n/screen.htm.

USEPA 2003, *Guidance for Developing Ecological Soil Screening Levels*, OSWER 9285.7-55, www.epa.gov/ecotox/ecossl/.

USEPA 2000. *Handbook of Groundwater Policies for RCRA Corrective Action (updated 4/20/2000)*, Office of Solid Waste, EPA/530-D-00-001, April.

USEPA 1998. *Guidelines for Ecological Risk Assessment*, Federal Register 63(93):26846-26924, EPA/630/R-95/002F, April.

USEPA 1997, *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*, Solid Waste and Emergency Response, EPA/540/R-97/006, June.

USEPA 1993. *Guidance for Evaluating the Technical Impracticability of Groundwater Restoration*, Office of Solid Waste and Emergency Response, Directive 9234.2-25, September.

USEPA 1989. *Risk Assessment Guidance for Superfund, Volume I Human Health Evaluation Model (Part A)*, Office of Emergency and Remedial Response, EPA/540/1-89/002, December.

REFERENCES FOR SECTION VII.C – RISK ANALYSIS

Welcome to the ECORISK DATABASE. This database contains the LOS ALAMOS NATIONAL LABORATORY's (LANL's) Environmental Restoration (ER) Project ECOLOGICAL SCREENING LEVELS (ESLs) along with details to support their derivation.

Press the "Menu" button to gain access to LANL ESLs and their supporting information.

Press the "What's New in this Release" button to see highlights of what has changed since the last release.

Press the "Exit" button to exit the database application.

ECORISK DATABASE (Release 1.5) *

September 2002

Prepared for the Los Alamos National Laboratory Environmental Restoration Project by:

Environmental Health Associates, Inc.

Database Manager: Patricia G. Newell

ph: 505-661-4047/ fax: 505-661-7468/ e-mail: pgnewell@cybermesa.com

Menu **What's New in this Releas**

Exit

For comments or questions regarding this database contact:

Rich Mirenda, Los Alamos National Laboratory

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IMPORTANT - If you would like to be notified of data quality control or interface usability issues between official database releases or if you would like to be notified of when a new release of the database is due, please send an email to rmirenda@lanl.gov with "Add to Ecorisk Db Distribution List" in the Subject field of the email and you will be added to the database distribution list.

* Los Alamos National Laboratory (LANL), 2002 (Sep). ECORISK Database (Release 1.5), ER package #186. Environmental Restoration Project, Los Alamos, NM.

20.6.2.4103 ABATEMENT STANDARDS AND REQUIREMENTS:

A. The vadose zone shall be abated so that water contaminants in the vadose zone shall not be capable of contaminating ground water or surface water, in excess of the standards in Subsections B and C below, through leaching, percolation or as the water table elevation fluctuates.

B. Ground-water pollution at any place of withdrawal for present or reasonably foreseeable future use, where the TDS concentration is 10,000 mg/L or less, shall be abated to conform to the following standards:

(1) toxic pollutant(s) as defined in Section 20.6.2.1101 NMAC shall not be present; and

(2) the standards of Section 20.6.2.3103 NMAC shall be met.

C. Surface-water pollution shall be abated to conform to the Water Quality Standards for Interstate and Intrastate Streams in New Mexico (20.6.4 NMAC).

D. Subsurface-water and surface-water abatement shall not be considered complete until a minimum of eight (8) consecutive quarterly samples from all compliance sampling stations approved by the secretary meet the abatement standards of Subsections A, B and C of this section. Abatement of water contaminants measured in solid-matrix samples of the vadose zone shall be considered complete after one-time sampling from compliance stations approved by the secretary.

E. Technical Infeasibility.

(1) If any responsible person is unable to fully meet the abatement standards set forth in Subsections A and B of this section using commercially accepted abatement technology pursuant to an approved abatement plan, he may propose that abatement standards compliance is technically infeasible. Technical infeasibility proposals involving the use of experimental abatement technology shall be considered at the discretion of the secretary. Technical infeasibility may be demonstrated by a statistically valid extrapolation of the decrease in concentration(s) of any water contaminant(s) over the remainder of a twenty (20) year period, such that projected future reductions during that time would be less than 20 percent of the concentration(s) at the time technical infeasibility is proposed. A statistically valid decrease cannot be demonstrated by fewer than eight (8) consecutive quarters. The technical infeasibility proposal shall include a substitute abatement standard(s) for those contaminants that is/are technically feasible. Abatement standards for all other water contaminants not demonstrated to be technically infeasible shall be met.

(2) In no event shall a proposed technical infeasibility demonstration be approved by the secretary for any water contaminant if its concentration is greater than 200 percent of the abatement standard for that contaminant.

(3) If the secretary cannot approve any or all portions of a proposed technical infeasibility demonstration because the water contaminant concentration(s) is/are greater than 200 percent of the abatement standard(s) for each contaminant, the responsible person may further pursue the issue of technical infeasibility by filing a petition with the commission seeking:

(a) approval of alternate abatement standard(s) pursuant to Subsection F of this section; or

(b) granting of a variance pursuant to Section 20.6.2.1210 NMAC.

F. Alternative Abatement Standards.

(1) At any time during or after the submission of a Stage 2 abatement plan, the responsible person may file a petition seeking approval of alternative abatement standard(s) for the standards set forth in Subsections A and B of this section. The commission may approve alternative abatement standard(s) if the petitioner demonstrates that:

(a) compliance with the abatement standard(s) is/are not feasible, by the maximum use of technology within the economic capability of the responsible person; OR there is no reasonable relationship between the economic and social costs and benefits (including attainment of the standard(s) set forth in Section 20.6.2.4103 NMAC) to be obtained;

(b) the proposed alternative abatement standard(s) is/are technically achievable and cost-benefit justifiable; and

(c) compliance with the proposed alternative abatement standard(s) will not create a present or future hazard to public health or undue damage to property.

(2) The petition shall be in writing, filed with the secretary. The petition shall specify, in addition to the information required by Subsection A of Section 20.6.2.1210 NMAC, the water contaminant(s) for which alternative standard(s) is/are proposed, the alternative standard(s) proposed, the three-dimensional body of water pollution for which approval is sought, and the extent to which the abatement standard(s) set forth in Section 20.6.2.4103 NMAC is/are now, and will in the future be, violated. The petition may include a transport, fate and risk assessment in accordance with accepted methods, and other information as the petitioner deems necessary to support the petition.

(3) The commission shall review a petition for alternative abatement standards in accordance with the procedures for review of a variance petition provided in the commission's adjudicatory procedures, 20.1.3 NMAC.

[12-1-95, 11-15-96; 20.6.2.4103 NMAC - Rn, 20 NMAC 6.2.IV.4103, 1-15-01]

NEW MEXICO ENVIRONMENT DEPARTMENT

Hazardous Waste Bureau
and
Ground Water Quality Bureau
Voluntary Remediation Program

TECHNICAL BACKGROUND DOCUMENT FOR DEVELOPMENT OF SOIL SCREENING LEVELS

October 15, 2003

In addition to observations of ecological features, the assessor should note any evidence of chemical releases (including visual and olfactory clues), drainage patterns, areas with apparent erosion, signs of groundwater discharge at the surface (such as seeps or springs), and any natural or anthropogenic site disturbances.

2.3 IDENTIFY CONTAMINANTS OF POTENTIAL ECOLOGICAL CONCERN

Contaminants of Potential Ecological Concern (COPECs) are chemicals which may pose a threat to individual species or biological communities. For the purposes of the Scoping Assessment, all chemicals known or suspected of being released at the site are considered COPECs. The identification of COPECs is usually accomplished by the review of historical information in which previous site activities and releases are identified, or by sampling data which confirm the presence of contaminants in environmental media at the site. If any non-chemical stressors such as mechanical disturbances or extreme temperature conditions are known to be present at the site, they too are to be considered in the assessment.

After the COPECs have been identified, they should be summarized and organized (such as in table or chart form) for presentation in the Scoping Assessment Report.

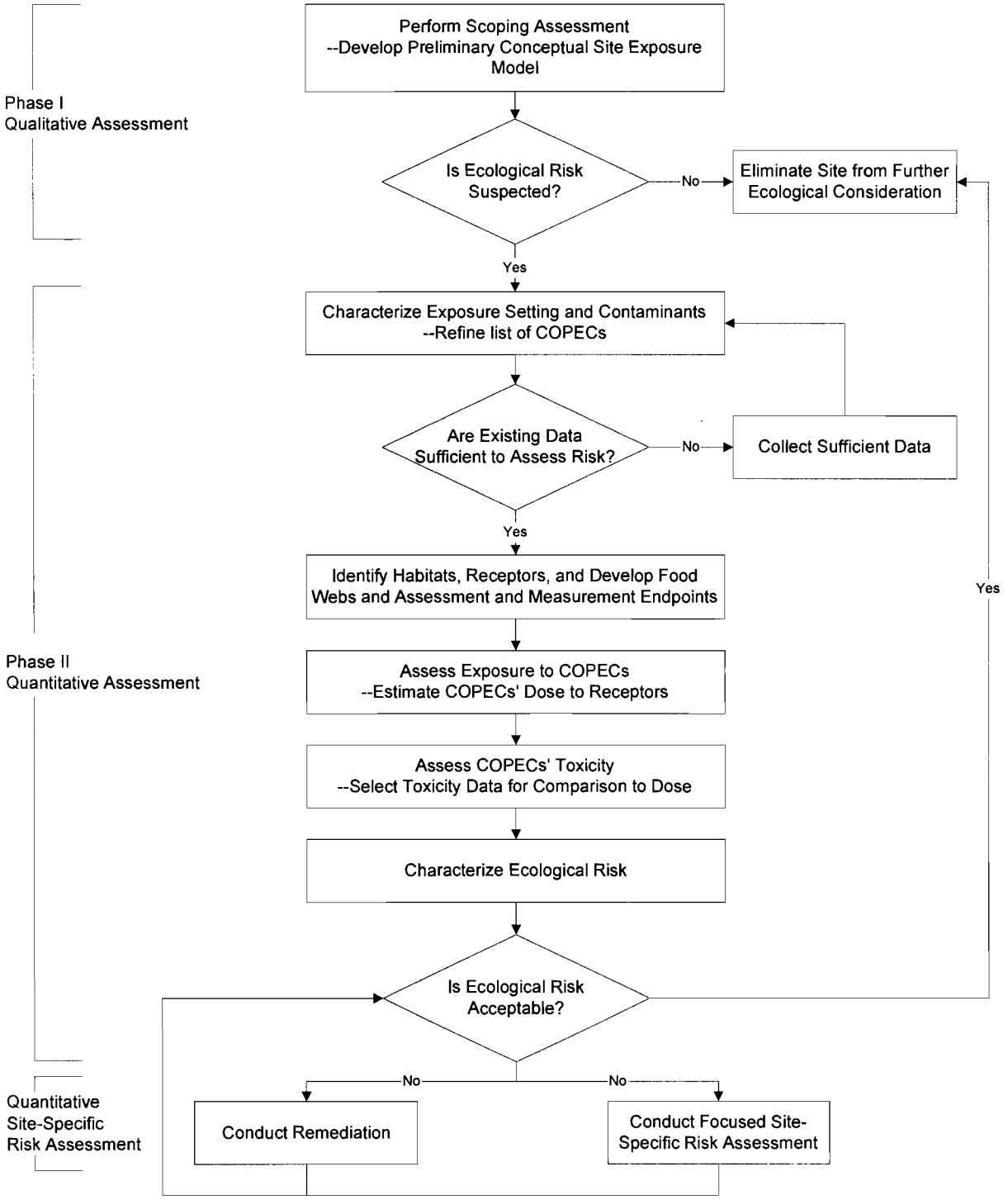
2.4 DEVELOPING THE PRELIMINARY CONCEPTUAL SITE EXPOSURE MODEL

A PCSEM provides a summary of potentially complete exposure pathways, along with potentially exposed receptor types. The PCSEM, in conjunction with the scoping report, is used to determine whether further ecological assessment (i.e., Screening-Level Assessment, Site-Specific Assessment) and/or interim measures are required.

A complete exposure pathway is defined as a pathway having all of the following attributes (US EPA, 1998; NMED, 2000):

- A source and mechanism for hazardous waste/constituent release to the environment
- An environmental transport medium or mechanism by which a receptor can come into contact with the hazardous waste/constituent
- A point of receptor contact with the contaminated media or via the food web, and
- An exposure route to the receptor.

If any of the above components are missing from the exposure pathway, it is not a complete pathway for the site. A discussion regarding all possible exposure pathways and the rationale/justification for eliminating any pathways should be included in the PCSEM narrative and in the Scoping Assessment Report.



Adapted from GAERPC (NMED 2000).

Figure 1. NMED Ecological Risk Assessment Process

The PCSEM is presented as both a narrative discussion and a diagram illustrating potential contaminant migration and exposure pathways to ecological receptors. A sample PCSEM diagram is presented in Figure 2. On the PCSEM diagram, the components of a complete exposure pathway are grouped into three main categories: sources, release mechanisms, and potential receptors. As a contaminant migrates and/or is transformed in the environment, sources and release mechanisms can be defined as primary, secondary, and tertiary.

For example, Figure 2 depicts releases from a landfill that migrate into soils, and reach nearby surface water and sediment via storm water runoff. In this situation, the release from the landfill is considered the primary release, with infiltration as the primary release mechanism. Soil becomes the secondary source, and storm water runoff is the secondary release mechanism to surface water and sediments, the tertiary source.

Subsequent ecological exposures to terrestrial and aquatic receptors will result from this release. The primary exposure routes to ecological receptors are direct contact, ingestion, and possibly inhalation. For example, plant roots will be in direct contact with contaminated sediments, and burrowing mammals will be exposed via dermal contact with soil and incidental ingestion of contaminated soil. In addition, exposures for birds and mammals will occur as they ingest prey items through the food web.

Although completing the Site Assessment Checklist will not provide the user with a ready made PCSEM, a majority of the components of the PCSEM can be found in the information provided by the Site Assessment Checklist. The information gathered for the completion of Section II of the Site Assessment Checklist, can be used to identify sources of releases. The results of Section III, Habitat Evaluation, can be used to both identify secondary and tertiary sources and to identify the types of receptors which may be exposed. The information gathered for completion of Section IV, Exposure Pathway Evaluation, will assist users in tracing the migration pathways of releases in the environment, thus helping to identify release mechanisms and sources.

Once all of the components of the conceptual model have been identified, complete exposure pathways and receptors that have the potential for exposure to site releases can be identified.

For further guidance on constructing a PCSEM, consult the GAERPC (NMED, 2000), and EPA's Office of Solid Waste and Emergency Response's *Soil Screening Guidance: User's Guide* (1996).

2.5 Assembling the Scoping Assessment Report

After completion of the previously described activities of the scoping assessment, the Scoping Assessment Report should be assembled to summarize the site information and present an evaluation of receptors and pathways at the site. The Scoping Assessment Report should be designed to support the decision made regarding the first Technical Decision Point (Is Ecological Risk Suspected?). The Scoping Assessment Report should, at a minimum, contain the following information:

- Existing Data Summary

atm-m^3/mole-°K and a molecular weight less than 200 g/mole.

Inhalation of contaminants via inhalation of fugitive dusts is assessed using a PEF that relates the contaminant concentration in soil/sediment with the concentration of respirable particles in the air due to fugitive dust emissions. It is important to note that the PEF used to address residential and commercial/industrial exposures evaluates only windborne dust emissions and does not consider emissions from traffic or other forms of mechanical disturbance which could lead to a greater level of exposure. The PEF used to address construction worker exposures evaluates windborne dust emissions and emissions from vehicle traffic associated with construction activities. Therefore, the fugitive dust pathway should be considered carefully when developing the CSM at sites where receptors may be exposed to fugitive dusts by other mechanisms. The development of the PEF for both residential and non-residential land uses is discussed further in Section 3.3.

2.2 RESIDENTIAL LAND USES

Residential exposures are assessed based on child and adult receptors. As discussed below, the child forms the basis for evaluation of noncarcinogenic effects incurred under residential exposures, while carcinogenic responses are modeled based upon age-adjusted values to account for exposures averaged over a lifetime. Under most circumstances, onsite residential receptors are expected to be the most conservative receptor basis for risk assessment purposes due to the assumption that exposure occurs 24 hours a day, 350 days per year, extending over a 30-year exposure duration. Table 2-1 provides a summary of the exposure characteristics and parameters associated with a residential land use receptor.

Table 2-1

Summary of the Residential Land Use Receptors	
Exposure Characteristics	Substantial soil exposure (esp. children) High soil ingestion rate (esp. children) Significant time spent indoors Long-term exposure
Default Exposure Parameters	
Exposure frequency (d/yr)	350
Exposure duration (yr)	6 (child) 24 (adult)
Soil ingestion rate (mg/day)	200 (child) 100 (adult)
Body Weight (kg)	15 (child) 70 (adult)
Skin surface area exposed (cm^2)	2,800 (child) 5,700 (adult)
Skin-soil adherence factor	0.2 (child) 0.07 (adult)
Air inhalation rate (m^3/d)	10 (child) 20 (adult)

2.2.1 Residential Receptors

A residential receptor is assumed to be a long-term receptor occupying a dwelling within the site

EPA Region 6

Human Health

Medium-Specific Screening Levels

U.S. Environmental Protection Agency
Region 6
1445 Ross Avenue
Dallas, Texas 75202

January 2004

BACKGROUND ON REGION 6 SCREENING VALUES

EPA Region 6's internet version of Risk-Based Human Health Screening Values can be found at the internet address http://www.epa.gov/earth1r6/6pd/rcra_c/pd-n/screen.htm.
The table was not generated to represent action levels or cleanup levels but rather as a technical tool. The responsibility of its use and relevance to site-specific circumstances becomes the responsibility of the person recommending the values to be used and the user of the table.

Disclaimer

The USEPA Region 6 Human Health Medium-Specific Screening Levels address common human health exposure pathways. They do not consider all potential human health exposure pathways nor address ecological concerns. The comparison of preliminary investigation data against risk-based media concentrations provides for an initial evaluation for the relative environmental concern for a site or set of environmental data. The values are not regulatory, but are derived using equations from EPA guidance and commonly used defaults. The table cannot be guaranteed to be error-free, but if you find an error please let us know.

The screening level tables are not required to be used. The tables are, however, a useful tool in that they are derived using existing equations and models from EPA guidance and are updated yearly.

Organization of Web Site

Changes Made From Previous Table

Background on Region 6 Screening Values

Medium-Specific Human Health Screening Table

Self- extracting Excel Spreadsheet

General

Table 1: STANDARD DEFAULT FACTORS

Symbol	Definition (units)	Default	Reference
SFo	Cancer slope factor oral (mg/kg-d)-1	–	IRIS, NCEA, or HEAST
SFi	Cancer slope factor inhaled (mg/kg-d)-1	–	IRIS, NCEA, or HEAST
RfDo	Reference dose oral (mg/kg-d)	–	IRIS, NCEA, or HEAST
RfDi	Reference dose inhaled (mg/kg-d)	–	IRIS, NCEA, or HEAST
RfC	Reference concentration (mg/m3)	–	IRIS, NCEA, or HEAST
TR	Target cancer risk	10^{-6}	–
THQ	Target hazard quotient	1	–
BWa	Body weight, adult (kg)	70	RAGS (Part a), EPA 1989 (EPA/540/1-89/002)
BWc	Body weight, child (kg)	15	Exposure Factors , EPA 1991 (OSWER No. 9285.6-03)
ATc	Averaging time - carcinogens (days)	25550	RAGS(Part a), EPA 1989 (EPA/540/1-89/002)
ATn	Averaging time - noncarcinogens (days)	ED*365	
SAa	Exposed surface area, adult (cm^2/day)	5700	Supplemental Soil Screening Guidance, EPA 2002
SAc	Exposed surface area, child (cm^2/day)	2800	Supplemental Soil Screening Guidance, EPA 2002
SAao	Exposed surface area, outdoor worker (cm^2/day)	3300	Supplemental Soil Screening Guidance, EPA 2002
AFa	Adherence factor, adult (mg/cm^2)	0.07	Supplemental Soil Screening Guidance, EPA 2002
AFw	Adherence factor, adult-work (mg/cm^2)	0.2	Supplemental Soil Screening Guidance, EPA 2002
AFc	Adherence factor, child (mg/cm^2)	0.2	Supplemental Soil Screening Guidance, EPA 2002
ABS	Skin absorption (unitless):		
	– volatile organics	none	Dermal Assessment, RAGS (Part E)
	– semi-volatile organics	0.1	Dermal Assessment, RAGS (Part E)
	–Inorganics	none	Dermal Assessment, RAGS (Part E)
IRAa	Inhalation rate - adult (m^3/day)	20	Exposure Factors , EPA 1991 (OSWER No. 9285.6-03)
IRAc	Inhalation rate - child (m^3/day)	10	RAGS (Part A), EPA 1989 (EPA/540/1-89/002)
IRWa	Drinking water ingestion - adult (L/day	2	RAGS(Part A), EPA 1989 (EPA/540/1-89/002)
IRWc	Drinking water ingestion - child (L/day)	1	
IRSa	Soil ingestion - adult(resident and outdoor worker) (mg/day)	100	Exposure Factors , EPA 1991 (OSWER No. 9285.6-03)
IRSc	Soil ingestion - child (mg/day),	200	Exposure Factors , EPA 1991 (OSWER No. 9285.6-03)
IRSo	Soil ingestion - indoor worker (mg/day)	50	Exposure Factors , EPA 1991 (OSWER No. 9285.6-03)
EFr	Exposure frequency - residential (d/y)	350	Exposure Factors , EPA 1991 (OSWER No. 9285.6-03)
EFo	Exposure frequency - occupational (d/y)	250	Exposure Factors , EPA 1991 (OSWER No. 9285.6-03)
EFout	Exposure frequency- outdoor worker (d/y)	225	Supplemental Soil Screening Guidance, EPA 2001
EDr	Exposure duration - residential (years)	30[a]	Exposure Factors , EPA 1991 (OSWER No. 9285.6-03)
EDc	Exposure duration - child (years)	6	Exposure Factors , EPA 1991 (OSWER No. 9285.6-03)
EDo	Exposure duration - occupational (years)	25	Exposure Factors , EPA 1991 (OSWER No. 9285.6-03)
	Age-adjusted factors for carcinogens:		
IFSadj	Ingestion factor, soils ([mg●yr]/[kg●d])	114	RAGS(Part B) , EPA 1991 (OSWER No. 9285.7-01B)
SFSadj	Skin contact factor, soils ([mg●yr]/[kg●d])	340	By analogy to RAGS (Part B)
InhFadj	Inhalation factor ([m^3●yr]/[kg●d])	11	By analogy to RAGS (Part B)
IFWadj	Ingestion factor, water ([l●yr]/[kg●d])	1.1	By analogy to RAGS (Part B)
VFw	Volatilization factor for water (L/m^3)	0.5	RAGS(Part B) , EPA 1991 (OSWER No. 9285.7-01B)
PEF	Particulate emission factor (m^3/kg)	in text	Soil Screening Guidance (EPA 1996a,b)
VFs	Volatilization factor for soil (m^3/kg)	in spreadsheet	Soil Screening Guidance (EPA 1996a,b)
sat	Soil saturation concentration (mg/kg)	in spreadsheet	Soil Screening Guidance (EPA 1996a,b)

Footnote:

[a]Exposure duration for lifetime residents is assumed to be 30 years total. For carcinogens, exposures are combined for children (6 years) and adults (24 years).

Biokinetic slope factor (BKSF) (ug/dL per ug/day)	0.3-0.5	0.4
Soil Ingestion Rate (IRs)	0.05 g/day	0.05 g/day
Dust ingestion rate (IRd) (mg/day)	10-25	
Ratio of concentration in dust to that in soil (Ksd)	0.2-1.0	0.7
Soil ingestion frequency (EFs) (days/year)	100-350	219
Dust ingestion frequency (EFd) (days/year)	100-350	219
Absolute absorption fraction of lead in soil (AFs)	0.06-0.2	0.12
Absolute absorption fraction of lead in dust (AFd)	0.06-0.2	
Resulting soil concentration (mg/kg)		780-1,235

APPLICATION OF THE SCREENING VALUES TABLE

The decision to use the screening levels at a site will be driven by the potential benefits of having generic risk-based concentrations in the absence of site-specific risk assessments.

Potential Benefits:

- Screening sites to determine further evaluation
- Prioritizing multiple sites within a facility
- Focusing future risk assessment efforts

Developing a Conceptual Site Model

The primary condition for use of the screening levels is that exposure pathways of concern and conditions at the site match those taken into account by the screening levels. Thus, it is always necessary to develop a conceptual site model (CSM) to identify likely contaminant source areas, exposure pathways, and potential receptors. This information can be used to determine the applicability of screening levels at the site and the need for additional information.

The final CSM diagram represents linkages among contaminant sources, release mechanisms, exposure pathways and routes and receptors based on historical information. It summarizes the understanding of the contamination problem.

As a final check, the CSM should answer the following questions:

- Are there potential ecological concerns?
- Is there potential for land use other than those covered by the screening levels (i.e., residential and industrial)?
- Are there other likely human exposure pathways that were not considered in development of the screening levels (e.g. raising beef, dairy, or other livestock)?
- Are there unusual site conditions (e.g. large areas of contamination, high fugitive dust levels, potential for indoor air contamination)?

Inorganic Background

Naturally-occurring inorganic background levels may be considered in the screening of environmental data. Background values are important in making risk-based decisions. Elevated naturally-occurring background, relative to risk-based screening levels, and/or widespread contaminant concentrations can complicate the extent of the evaluation effort. The issues are complex and present a challenge for regulators nationwide. Typical values of inorganic concentrations found in soils within Region 6 are described in the table below. The values have been compiled from technical sources and from Region 6 approved background study reports. This table has not been updated since 1997.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
SOLID WASTE AND EMERGENCY
RESPONSE

OSWER 9285.7-55

December 29, 2003

MEMORANDUM

SUBJECT: Release of *Guidance for Developing Ecological Soil Screening Levels* (Eco-SSLs) and Eco-SSLs for Nine Contaminants

FROM: Marianne Lamont Horinko /s by Barry Breen for/
Assistant Administrator

TO: Superfund National Policy Managers, Regions 1 - 10
RCRA Senior Policy Advisors, Regions 1 - 10

Purpose

The purpose of this memorandum is to transmit for immediate use the *Guidance for Developing Ecological Soil Screening Levels* (OSWER 9285.7-55) and the Ecological Soil Screening Levels (Eco-SSLs) for the following list of nine contaminants frequently found in soil at hazardous waste sites. These nine contaminant-specific documents and all the supporting attachments for the Guidance are available at: http://www.epa.gov/ecotox/ecossl/. A link to this site is also on the Superfund Risk Homepage. As Eco-SSLs are developed for more contaminants during the next several months, they will also be placed on this web site.

Eco-SSL	OSWER No.
Aluminum	9285.7-60
Antimony	9285.7-61
Barium	9285.7-63
Beryllium	9285.7-64
Cadmium	9285.7-65
Cobalt	9285.7-67
Dieldrin	9285.7-56
Iron	9285.7-69
Lead	9285.7-70

Background

This guidance document describes the process a multi-stakeholder team used to derive a set of risk-based Eco-SSLs for many of the soil contaminants that are frequently of ecological concern for plants and animals at hazardous waste sites. The Guidance also describes how these screening values should be used in assessing ecological risks at sites. The Eco-SSLs presented in the contaminant-specific documents are concentrations of contaminants in soil that are protective of ecological receptors that commonly come into contact with soil or ingest biota that live in or on soil. These values can be used to identify those contaminants of potential concern in soils requiring further evaluation in a baseline ecological risk assessment.

EPA prepared a list of twenty-four (24) contaminants to be addressed initially by the Eco-SSL guidance. This list was based on a review of the contaminants of concern reported in recent Record of Decisions at Superfund National Priority List sites. The Eco-SSL contaminant list also includes contaminants nominated by the EPA Regional Biological Technical Assistance Groups. The process for developing Eco-SSLs for additional chemicals is continuing, and more Eco-SSL documents will be issued within the next 12 months.

Implementation

Although these screening levels were developed specifically to be used during Step 2 of the Superfund ecological risk assessment process (Screening-Level Exposure Estimate and Risk Calculation), EPA envisions that any federal, state, tribal or private environmental assessment or cleanup program can use these values to screen soil contaminants in order to determine if additional ecological site study is warranted. The Eco-SSLs are not designed to be used as cleanup levels and EPA emphasizes that it would be inappropriate to adopt these Eco-SSLs as generic cleanup standards. OSRTI is also preparing an Eco-Update Bulletin to describe how this information can be used in the baseline risk assessment to develop risk-based cleanup *goals*. This Eco-Update will soon be available at: http://www.epa.gov/superfund/programs/ecorisk/ecossl.htm.

EPA initiated this program to derive Eco-SSLs in order to conserve resources by eliminating the need for EPA and other risk assessors to perform duplicative toxicity data literature searches and data evaluations for the same contaminants at every site. These values will also help risk assessors focus their resources on key site-specific studies needed for critical decision-making. EPA expects that the Eco-SSLs will increase consistency among screening level risk analyses and decrease the possibility that potential risks from soil contamination to ecological receptors will be overlooked.

For contaminants for which there is no current Eco-SSL, RPMs should consult with their regional ecological risk assessor(s) for other screening values that are appropriate.

If you have any questions on these documents you may contact:
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Walter Kovalick, TIP/OSRTI
Debbie Dietrich, OEPPR
Cliff Rothenstein, OUST
Linda Garczynski, OBCR
Sandra Connors, FFEO
Susan Bromm, OSRE
Charles Openchowski, OGC
OSRTI Center Directors and Senior Process Managers

United States
Environmental Protection Agency

Office of
Solid Waste

EPA530-D-00-001
April 2000 Draft
http://www.epa.gov/correctiveaction

HANDBOOK OF GROUNDWATER POLICIES FOR RCRA CORRECTIVE ACTION (updated 4/20/2000)

for Facilities Subject to Corrective Action Under Subtitle C of the Resource Conservation and Recovery Act

Issued by

Office of Solid Waste
Corrective Action Programs Branch

Note: This document provides guidance to EPA and states regarding groundwater at facilities subject to RCRA Corrective Action. It also provides guidance to the public and the regulated community on how EPA intends to exercise its discretion in implementing its statutory authorities and regulations. The document does not, however, substitute for EPA's statutes or regulations, nor is it regulation itself. Thus, it cannot impose legally-binding requirements on EPA, States or the regulated community, and may not apply to a particular situation based upon the circumstances. EPA may change this guidance in the future as appropriate.

Technical Impracticability

(Updated 4/20/00)

What does technical impracticability mean?

Technical impracticability (TI) refers to a situation where achieving groundwater cleanup objectives is not possible from an "engineering perspective." The phrase "engineering perspective" refers to how factors such as feasibility, reliability, scale and safety influence the ability to achieve groundwater cleanup objectives. For example, a certain cleanup approach might be technically possible, but the scale of the operation might be of such magnitude, that it was not technically practicable.

What are the primary causes that might lead to a technical impracticability determination?

Reasons for technical impracticability generally fall into one of two categories:

(1) Hydrogeologic factors
(2) Contaminant-related factors

Examples of limiting hydrogeologic factors could include very low-permeable or highly heterogeneous soils, or complex fractures or solution cavities in bedrock. An example of a contaminant-related factor could be presence of residual non-aqueous phase liquids (NAPLs), although there have been many advancements in NAPL remediation in recent years.

Rationale
for Technical Impracticability

Technical impracticability determinations offer a realistic approach to address those situations where currently there are limitations to groundwater restoration. EPA believes that it is appropriate to openly discuss technology limitations rather than establishing unrealistic goals. By recognizing technical impracticability where scientifically justified, we can focus resources on an alternative remedial strategy that is practicable.

Poor cleanup performance due to inadequate remedial design is not sufficient justification for a technical impracticability determination. Design inadequacies could stem from, for example, inadequate characterization, insufficient pumping rates, improper well placement, or selecting inappropriate technologies.

Is the mere presence of non-aqueous phase liquids (NAPLs) sufficient to justify a technical impracticability determination?

No. The presence of NAPL is just one of many factors you should consider when evaluating technical impracticability. Other factors to consider are the type, amount, and location of NAPL, as well as the technologies that are available to clean up the NAPL. Facilities should avoid basing their technical impracticability demonstration on just the presence of NAPL or the apparent inability of any one technology (e.g., pump-and-treat). A technical impracticability determination should be based on a good understanding of hydrogeologic factors, chemical characteristics, and conventional as well as innovative technologies.

When should a facility recommend Technical Impracticability?

Considering technical impracticability early in corrective action (e.g., during facility characterization) is a good idea if you believe a facility has hydrogeologic or chemical-related cleanup limitations. The facility should submit a technical impracticability demonstration along with a recommendation for a final remedy. However, we suggest you do not devote resources on a technical impracticability demonstration until you've achieved the short-term protectiveness goals (e.g., environmental indicators).

Who decides whether cleanup of the groundwater is technically impracticable?

The facility should develop and submit a technical report demonstrating that achieving the groundwater cleanup objectives is technically impracticable. The regulator makes the technical impracticability determination when selecting a final remedy.

What should facilities include in a technical impracticability demonstration?

EPA's guidance (EPA, 1993) on technical impracticability suggests the following:

- Spatial area (the TI zone) over which the TI decision would apply;
- Specific groundwater cleanup objectives that are considered technically impracticable to to achieve;
- Conceptual site model that describes geology, hydrology, groundwater contamination sources, transport and fate;
- Evaluation of the "restoration potential" of the TI zone;
- Cost estimates;
- Any additional information EPA or the State program deems necessary; and
- Description of an alternative remedial strategy.

If I get a technical impracticability determination, have I completed corrective action for groundwater?

No. When the regulator determines that achieving groundwater objectives is technically impracticable, the facility should implement an "alternative remedial strategy." That strategy must protect human health and the environment and should:

- be technically practicable;
- control the sources of contamination and prevent migration of contamination beyond the zone associated with the technical impracticability determination;
- achieve the groundwater cleanup objectives outside the zone associated with the technical impracticability determination; and,
- be consistent with the overall cleanup goals for the facility.

How much facility investigation do I have to conduct within the technical impracticability zone?

You should characterize your facility within the TI zone to: (1) support the technical impracticability demonstration; (2) identify sources that you should control, even within the TI zone; (3) evaluate the potential for cross-media transfer of contamination that may need to be managed (e.g., from groundwater to air) as part of an alternative remedial strategy; and (4) support the development of an alternative remedial strategy as discussed above. The circumstances of the facility will govern the amount of characterization needed to accomplish these objectives.

Why should I control sources within the technical impracticability zone?

Source control is generally an important part of an acceptable alternative remedial strategy and is one of the three recommended threshold criteria for final remedies. Source control prevents the continued input of contamination into surrounding environmental media and can help improve the likelihood that the alternative remedial strategy will be effective in the long-term. Controlling sources within the technical impracticability zone will help to limit the amount of contamination you will need to address if and when achieving the groundwater cleanup objectives becomes technically practicable in the future.

How does a technical impracticability determination affect the point of compliance?

The "throughout-the-plume/unit boundary" point of compliance for groundwater would generally apply even in the context of a TI. However, the goal of achieving groundwater cleanup levels should apply outside the spatial area (TI zone) identified by the facility and approved by the regulator in a TI determination. This TI zone is similar to a waste management area described in this Handbook (see point of compliance). Where a regulator has made a TI determination, the point of compliance for groundwater water should be throughout the plume beyond the limit of the TI zone. The facility in this context would generally not be responsible for achieving groundwater cleanup levels within the TI zone as long as the regulator agrees that the TI determination remains valid. It is important to remember that even if a remedy achieves cleanup levels outside the TI zone, a facility's corrective action obligations for implementing, maintaining and monitoring the containment within the TI zone should continue (1) as long as these obligations are necessary to protect human health and the environment, or (2) until such time that cleanup within the TI zone becomes technically practicable and the cleanup levels are achieved throughout the entire plume (i.e., even within the formerly identified TI zone).

How long should a technical impracticability determination last?

Under EPA's technical impracticability guidance (EPA, 1993), for RCRA Corrective Action, technical impracticability determinations at RCRA facilities, and the responsibility of the facility to manage their facility under the alternative remedial strategy, typically should remain in effect until subsequent advances in technology make achievement of the groundwater cleanup objectives technically practicable. Under this guidance, regulators may require facilities to revisit technical impracticability determinations in the future. Revisiting the technical impracticability determination may be appropriate when new information concerning facility conditions or new technologies indicate that the facility can achieve the groundwater cleanup

objectives. Sometimes, a facility might want to revisit the technical impracticability determination on its own. For example, the facility might want try a new technology that has the ability to achieve the cleanup objectives rather than indefinitely paying for operating and maintenance costs associated with the alternative remedial strategy. Technical impracticability determinations are based on current understanding of capabilities and limitations of cleanup technologies. Stakeholders should consider that future advancements in technologies could overcome today's limitations.

How does groundwater use affect a Technical Impracticability determination?

The groundwater use designation affects a technical impracticability determination because:

- You should use the current groundwater use and the groundwater use designation to develop groundwater cleanup objectives; and,
- A successful technical impracticability demonstration should show that facility conditions prevent the facility from achieving groundwater cleanup objectives.

Therefore, regulators should establish groundwater cleanup objectives prior to considering technical impracticability. For example, if the groundwater use designation is not drinking water, then restoring the contaminated groundwater to drinking water standards might not apply. In a situation where drinking water standards do not apply, the technical impracticability determination would then be based on the inability to achieve groundwater cleanup objectives developed to protect non-drinking water use, such as protection of surface water.

You should also account for current and reasonably expected groundwater use when developing a protective alternative remedial strategy. For example, the long-term reliability of containment technologies and the extent of monitoring, operation and maintenance are critical when groundwater near the facility is currently used for drinking.

Key References:

EPA, 1996a. Advance Notice of Proposed Rulemaking (61 FR 19432, May 1). Available at http://www.epa.gov/docs/fedrgstr/EPA-WASTE/1996/May/Day-01/pr-547.pdf. Particularly relevant page: 19451.

EPA, 1993. Guidance for Evaluating the Technical Impracticability of Groundwater Restoration EPA/540-R-93-080, (September). Available at http://www.epa.gov/oerrpage/superfund/resources/gwdocs/techimp.htm.

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HANDBOOK OF GROUNDWATER POLICIES FOR RCRA CORRECTIVE ACTION (updated 4/20/2000)

for Facilities Subject to Corrective Action Under Subtitle C of the Resource Conservation and Recovery Act

Issued by

Office of Solid Waste
Corrective Action Programs Branch

Note: This document provides guidance to EPA and states regarding groundwater at facilities subject to RCRA Corrective Action. It also provides guidance to the public and the regulated community on how EPA intends to exercise its discretion in implementing its statutory authorities and regulations. The document does not, however, substitute for EPA's statutes or regulations, nor is it regulation itself. Thus, it cannot impose legally-binding requirements on EPA, States or the regulated community, and may not apply to a particular situation based upon the circumstances. EPA may change this guidance in the future as appropriate.

Short-Term Protectiveness Goals

(Updated 4/20/00)

What are EPA's short-term protectiveness goals for groundwater?

Short-term goals associated with groundwater include preventing, minimizing, or eliminating: (1) current or near-future unacceptable exposures to humans or ecologic receptors from contaminated groundwater; (2) sources of groundwater contamination; and, (3) the spread of contaminated groundwater above levels of concern[1]. EPA has been emphasizing these short term goals in guidance and training since 1991 when EPA implemented the RCRA "Stabilization Initiative."

How do facilities achieve these goals?

Facilities should, as appropriate, use interim actions, sometimes referred to as stabilization actions, to achieve these goals while pursuing final remedies. Facilities can implement stabilization activities at individual source areas, or parts of a facility.

How does EPA know when facilities achieve these goals?

EPA tracks the implementation of stabilization activities at facilities in a computer database known as RCRIS (RCRA Information System).
EPA also developed two facility-wide Environmental Indicators to track short-term goals on a national basis. While EPA continues to track stabilization activities on a unit or area-specific basis, EPA believes that facility-wide measures are important to convey an overall sense of environmental conditions at a RCRA facility. The two Environmental Indicators are called "Current Human Exposures Under Control" and "Migration of Contaminated Groundwater Under Control."

Rationale for Short-Term Protectiveness Goals

The highest priority of the RCRA Corrective Action Program is to make sure that people are not being exposed to risky levels of contaminants. Another high priority is to protect our nation's groundwater resources. While final remedies remain the RCRA Corrective Action program's long-term objective, EPA developed two environmental indicators to focus resources on early risk reduction and risk communication. EPA is also currently using these indicators as program measures for the Government Performance and Results Act. These indicators track the progress being made nationwide on reducing near terms risks at RCRA facilities.

The RCRA Cleanup Reforms focus on achieving these two environmental indicators at 1,714 RCRA Corrective Action Facilities. The program's specific goals, which are also established under the Government Performance and Results Act, are as follows: by 2005, the States and EPA will verify and document that 95% of the 1,714 facilities (baseline established in 1997) have "Current Human Exposures Under Control" and 70% will have "Migration of Contaminated Groundwater Under Control." You can see the progress toward achieving these goals at http://www.epa.gov/oswfiles/rcraweb/web_reporting/caindicators.htm .

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[1] Levels of concern are generally concentrations of each contaminant in groundwater appropriate for the protection of the groundwater resource and its maximum beneficial use.

How does a facility achieve an Environmental Indicator?

For Current Human Exposures Under Control, facilities should be able to demonstrate that there are no current unacceptable human exposures to contamination from the facility. For "Migration of Contaminated Groundwater Under Control," a facility should be able to demonstrate that groundwater contamination above levels of concern is not moving beyond the furthest three-dimensional extent to which a contaminant or contaminants occurring in groundwater have migrated. These two indicators reflect facility-wide conditions for contamination that RCRA Corrective Action can address.

Who determines when a facility achieves an Environmental Indicator goal?

EPA or the State determines when a facility achieves an Environmental Indicator goal. However, facilities or their consultants may assist EPA in the evaluation by providing information on the current environmental conditions.

Does a facility need to perform additional investigation or cleanup, once the facility achieves the environmental indicators?

Achieving the Environmental Indicators is an important interim milestone and does not relieve a facility from meeting investigation objectives or from achieving EPA's final remediation goals. The facility will often need to conduct further investigation to support evaluation and selection of final remedies. Furthermore, the facility may need to conduct remedial actions that might be outside the scope of these two Environmental Indicators to achieve other short-term (e.g., source control) and final remediation goals for groundwater (e.g., restoring contaminated groundwater).

How do I consider groundwater use in evaluating "Current Human Exposures Under Control?"

You should consider whether there is any current human exposure to contaminated groundwater. This determination relies on actual facility conditions rather than on an aquifer's groundwater use designation. In making this environmental indicator determination, the regulator considers all reasonably expected direct and indirect ways humans could be exposed to contaminated groundwater. Some examples of direct routes of exposure include drinking contaminated groundwater or having skin come into contact with contaminated groundwater from bathing. Examples of indirect exposure include breathing contaminated vapors entering buildings from underlying contaminated groundwater, and ingestion of sediments, surface water or fish that are contaminated from groundwater discharged to surface water.

How do I consider groundwater use in evaluating the "Migration of Contaminated Groundwater Under Control?"

Regulators should consider the groundwater use designation when establishing the "levels of concern" in groundwater. Levels of concern are concentrations of each contaminant in groundwater that are appropriate for the protection of the groundwater resource and its maximum beneficial use. The level of concern will define the boundary of a contaminant plume which should not be expanding to meet this indicator. Monitoring locations proximate to the outer perimeter of the plume should demonstrate that the plume is not migrating above levels of

concern. EPA determines levels of concern on a facility-specific basis, but these would commonly be the groundwater clean-up levels developed to be consistent with the groundwater use designation and considering other current routes of exposure from contaminated groundwater. However, a regulator may choose to define the boundary using more conservative levels of concern, because conservative screening levels may be more readily available. For example, early in an investigation, the regulator may choose to use drinking water standards to define the level of concern, because sufficient information is not yet available to develop appropriate facility-specific concentrations. Generally drinking water standards will be acceptable to define the boundary of a plume when evaluating this Environmental Indicator unless more stringent levels are needed based on other actual exposures to contaminated groundwater (e.g., inhalation).

According to EPA's guidance on Environmental Indicators, the Migration of Contaminated Groundwater Under Control Environmental Indicator could be achieved even when the plume is off-site. This position is consistent with the previously stated short-term goal of preventing further migration of contaminated groundwater. However, remediation of the off-site plume will often be a high priority for regulators because facilities typically have less ability to control exposures outside the boundary of the facility.

Can a facility achieve the "Migration of Contaminated Groundwater Under Control" when groundwater discharges to surface water?

Yes. A facility can achieve this indicator once the regulator determines that the current discharge of contaminated groundwater into surface water does not cause unacceptable impacts to surface water, sediments, or eco-systems.

Key References:

EPA, 1999f. Interim Final Guidance for RCRA Corrective Action Environmental Indicators (February 5). Available at http://www.epa.gov/epaoswer/osw/ei_guida.pdf .

EPA, 1996a. Advance Notice of Proposed Rulemaking (61 FR 19432, May 1). Available at http://www.epa.gov/docs/fedrgstr/EPA-WASTE/1996/May/Day-01/pr-547.pdf . Particularly relevant pages describing the stabilization initiative and environmental indicators on 19436-37, and discussion of interim measures on page 19446-47.

EPA, 1991a. Managing the Corrective Action Program for Environmental Results: The RCRA Stabilization Effort (October 25). Available at http://yosemite.epa.gov/osw/rcra.nsf/d8382df2d09b64668525652800519745/27d1baa5c1dbb8f38525670f006be76d?OpenDocument

Final Remediation Goals

(Updated 4/20/00)

What are EPA's final remediation goals for groundwater?

EPA believes that you should use the following threshold criteria[1] as general goals for cleanup and screening tools for potential final remedies, including final groundwater remedies:

(1) Protect human health and the environment.

(2) Achieve media cleanup objectives appropriate to the assumptions regarding current and reasonably expected land use(s) and current and potential beneficial uses of water resources.

(3) Remediate the sources of releases so as to eliminate or reduce further releases of hazardous wastes or hazardous constituents that may pose a threat to human health and the environment.

Rationale for Final Remediation Goals

EPA's policy on final remediation goals recognizes that groundwater is a resource that should be protected and restored. This policy is important to ensure the short- and long-term availability of our Nation's groundwater resources and to preserve and protect hydraulically connected surface water and their ecosystems.

Protecting human health and the environment is the mandate from the RCRA statute and regulations; therefore, it is appropriate to include this goal as the first threshold criteria for final RCRA corrective action remedies. This threshold criterion also serves to ensure that remedies include protective activities (e.g., providing an alternative drinking water supply) that would not necessarily be needed to achieve the other criteria. However, EPA also believes that remedies should meet the second and third criteria as a means to demonstrate progress toward achieving the overall mandate to protect human health and the environment.

For groundwater remedies, EPA's goal is to protect human health and the environment, which includes protection of our nation's groundwater resources. In determining appropriate protection and remediation strategies, EPA will consider the use, value and vulnerability of the resource. In support of these overall groundwater goals, EPA expects that final remedies, for facilities subject to RCRA Corrective Action, will return usable groundwaters to their maximum beneficial use, wherever practicable, within a time frame that is reasonable given the particular circumstances of the facility. Where restoration of groundwater to appropriate cleanup levels is not practicable, EPA expects facilities to prevent or minimize the further migration of a plume, prevent exposure to the contaminated groundwater, and evaluate further risk reduction. EPA also expects facilities to control or eliminate surface and subsurface sources of groundwater contamination. In controlling sources, EPA prefers approaches that lead to permanent reductions in toxicity, mobility, or volume. Additionally, EPA typically expects that treatment will be used to address source materials considered to be "principal threats," i.e., materials that are highly toxic or highly mobile that

[1] The 1996 ANPR lists four remedy threshold criteria. EPA no longer believes that the criterion "complying with applicable standards for waste management" is necessary since complying with applicable waste management standards is automatically required under existing RCRA Subtitle C and D regulations.

generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur. For a complete list of EPA's expectations for final remedies, you should refer to page 19448 of the May 1, 1996 ANPR. (http://www.epa.gov/docs/fedrgstr/EPA-WASTE/1996/May/Day-01/pr-547.pdf).

How does groundwater use affect the final remediation goal?

Current and reasonably expected groundwater use is a critical factor in determining the final groundwater remediation goal because EPA's expectation is to "return usable groundwaters to their maximum beneficial uses." The groundwater use designation should serve as a starting point for determining the maximum beneficial use of the groundwater. You should refer to the groundwater use designation policy in this Handbook to help you determine whether the use at a facility will be based on a State designation or the Federal guidelines. To identify other important aspects of how groundwater use affects final remedies, you should refer to other topics in this Handbook such as groundwater cleanup objectives (which includes groundwater cleanup levels, point of compliance and remediation time frames), source control, technical impracticability, performance monitoring, and completing groundwater remedies.

Key Reference:

EPA, 1996a. Advance Notice of Proposed Rulemaking (61 FR 19432, May 1). Available at www.epa.gov/docs/fedrgstr/EPA-WASTE/1996/May/Day-01/pr-547.pdf . Particularly relevant pages: 19448-52.

EPA, 1991b. Protecting the Nation's Groundwater: EPA's Strategy for the 1990's. Office of the Administrator. Washington, D.C. For more information, refer to http://www.epa.gov/OGWDW/Pubs/11ground.html .

EPA, 1991c. A Guide to Principal Threats an Low Level Threat Wastes. Superfund Publication 9380.3-06FS (November). Available at http://www.epa.gov/oerrpage/superfund/resources/gwdocs/threat.pdf .

Groundwater Cleanup Objectives

(updated 4/20/00)

What are groundwater cleanup objectives?

EPA's general expectation for groundwater remediation is to "return usable groundwaters to their maximum beneficial uses." EPA recommends that you use clear and concise groundwater cleanup objectives to help focus evaluation, selection and implementation of remedies aimed at meeting this expectation. Groundwater cleanup objectives are best expressed in terms of three components: groundwater cleanup levels, point of compliance, and remediation time frames. Groundwater cleanup levels represent specific concentrations of chemicals designed to be protective of the groundwater use and other possible routes of exposure. Point of compliance represents the locations where the groundwater cleanup levels should be achieved at the conclusion of the groundwater remedy. Remediation time frames typically include both the time it would take to implement the remedy and the estimated time to achieve the groundwater cleanup levels at the point of compliance.

Rationale for Groundwater Cleanup Objectives

Groundwater cleanup objectives should quantify the scope of cleanup required and create performance measures to determine whether a remedy is working. EPA defines groundwater cleanup levels, point of compliance, and remediation time frames as the three specific and measurable components of generic groundwater cleanup objectives. For each component, EPA recommends the specific approaches in this Handbook to ensure protection of human health and the environment, now and in the future.

Who specifies groundwater cleanup objectives?

Facilities should recommend groundwater cleanup objectives, including all three components. Regulators should consider a facility's recommendation when developing groundwater cleanup objectives to be included in a final remedial decision.

How do groundwater use designations affect groundwater cleanup objectives?

Groundwater use designations generally should influence groundwater cleanup levels and might affect remediation time frames, but generally should not affect the point of compliance. You should consider the groundwater use designation when identifying groundwater cleanup objectives, because those objectives will focus the cleanup on achieving the final remediation goal of returning contaminated groundwater to its maximum beneficial use(s). The relationship between the three components of groundwater cleanup objectives and groundwater use is more fully described in the next three policy discussions in this Handbook.

What is the role of groundwater use in developing facility-specific groundwater cleanup objectives?

First, you should verify that the groundwater use designation is valid. For example, even if the State designation defines the aquifer as a non-drinking water resource, regulators and facilities should verify that no one is drinking the groundwater and that no other unacceptable exposure to contaminants from groundwater is occurring.

Second, once verified, the groundwater use designation may serve as a starting point for establishing facility-specific groundwater cleanup objectives. The facility-specific cleanup objectives should at least be consistent with the groundwater use designation, but should also consider all known or reasonably expected groundwater uses and potential exposures through cross-media transfer, such as volatilization into buildings and hydraulic connections to surface waters and other aquifers. For example, a designation may identify groundwater in a particular area as not a source of drinking water, but the groundwater discharges into an adjacent surface water body. In this example, the regulator should establish groundwater cleanup objectives designed to protect the surface water body.

At a facility-specific level, there may be uses of groundwater or exposures to contaminants from groundwater which may not be considered in a State groundwater use designation. For example, other uses of and exposures to groundwater could include: industrial uses, cooling water, car washes, livestock watering, land irrigation. For example, where groundwater is used for lawn irrigation, sprinklers could cause unacceptable exposure to children through contact of contaminated groundwater to their skin or from breathing contaminants that have volatilized from the groundwater. Furthermore, exposures to contaminants from groundwater could occur even when there is no direct use of the groundwater. For example, groundwater may recharge to adjacent or underlying aquifers that are used for drinking water, or discharge to surface water to support aquatic life, recreation, drinking water, etc. Additionally, exposure to contaminants in indoor air could result from underlying groundwater contaminated with volatile chemicals.

After determining all of the current and reasonably expected uses of groundwater at and around the facility, regulators should make cleanup decisions based on the maximum beneficial use. Within the range of reasonably expected uses, the maximum beneficial groundwater use is the one which that warrants the most stringent groundwater cleanup levels.

Key Reference:

EPA, 1996a. Advance Notice of Proposed Rulemaking (61 FR 19432, May 1). Available at http://www.epa.gov/docs/fedrgstr/EPA-WASTE/1996/May/Day-01/pr-547.pdf . Particularly relevant pages: 19449-52.

Groundwater Cleanup Levels

(updated 4/20/00)

What are groundwater cleanup levels?

Groundwater cleanup levels are facility-specific chemical concentrations in groundwater that a final remedy should achieve for the remedy to be considered complete. Groundwater cleanup levels should consider groundwater use designations and protect human health and the environment. Additionally, groundwater cleanup levels often serve as the basis for identifying the "level of concern" used for the Migration of Contaminated Groundwater Under Control environmental indicator.

How should groundwater cleanup levels be developed?

Groundwater cleanup levels for human health should typically either be developed by using existing cleanup standards (e.g. drinking water standards) or developed based on the degree of actual or potential exposure to a groundwater contaminant (resulting in an estimate of dose) and the toxicity of the contaminant resulting in an estimate of risk. Once an appropriate exposure scenario is determined, groundwater cleanup levels are calculated to fall within generally acceptable levels of risk. EPA recommends that regulators choose risk-based cleanup levels as follows:

Rationale
for Groundwater Cleanup Levels

Groundwater cleanup levels provide clear numerical targets. These targets are important to measure both progress and completion of a groundwater cleanup. The selection of groundwater cleanup levels based on the current use as well as the groundwater use designation allows stakeholders to recognize various uses of the groundwater. This approach ensures current as well as future protection of human health and the environment.

1. For known or suspected carcinogens, regulators should establish groundwater cleanup levels at concentrations which represent an excess upper bound lifetime risk[2] to an individual of between $1x10^{-4}$ and $1x10^{-6}$ (commonly referred to as EPA's risk range). Note that EPA prefers cleanup levels at the more protective end of the risk range. For facilities with multiple contaminants or exposure pathways, cleanup levels should generally be set so that cumulative (total) excess upper bound lifetime risk from all contaminants still falls within the risk range.

2. For toxicants associated with adverse effects other than cancer, groundwater cleanup levels should be established at concentrations to which human populations, including sensitive subgroups could be exposed on a daily basis without appreciable risk of negative effect during a lifetime. Such levels are generally interpreted as equal to or

[2] EPA expresses cancer risk in terms of the likelihood that a person might develop cancer from exposure to contaminants from a facility. For example, a risk assessment might say that a receptor has an upper bound excess cancer risk of $1x10^{-4}$. The numerical estimate means that if 10,000 people received this level of exposure averaged over a 70-year lifetime, no more than one would have a probability of developing cancer. Depending on facility-specific factors, EPA's threshold of acceptable cancer risk ranges from 1×10^{-6} to 1×10^{-4}, or from one in one million to one in ten thousand. Screening values are generally set at a cancer risk of $1x10^{-6}$.

below a hazard quotient of one[3]. For facilities with multiple contaminants or exposure pathways, groundwater cleanup levels should generally be equal to or below a hazard index of one[4].

In addition to protecting human health, groundwater cleanup levels should protect unacceptable cross-media transfer and unacceptable risks to ecologic receptors. For additional guidance on ecologic risk issues, you should refer to numerous resources developed by EPA's Superfund Program avalable at http://www.epa.gov/oerrpage/superfund/programs/risk/ecolgc.htm .

What is the role of groundwater use in setting cleanup levels?

The groundwater use designation is typically the starting point for determining the appropriate exposure scenarios to evaluate risks and identify cleanup levels. For groundwater that is currently used or designated as a current or reasonably expected source of drinking water, regulators should select cleanup levels protective for residential use. For constituents with maximum contaminant levels (MCLs) promulgated under the Safe Drinking Water Act, regulators generally establish groundwater cleanup levels as MCLs. For constituents for which no MCLs have been promulgated, regulators may rely on other established drinking water standards or a risk assessment incorporating standard residential exposure assumptions (for example, ingestion rate of 2 liters/day, exposure frequency of 350 days/year, etc.) to estimate contaminant dose, derive risk estimates, and determine groundwater cleanup levels.

What is the cleanup level if no one is drinking the groundwater?

Even if no one is currently drinking the groundwater, the cleanup level may still be based on drinking water use if the aquifer is considered by EPA or the State to be a reasonably expected future source of drinking water. Stakeholders should consider State groundwater use designations when deciding whether an aquifer is a reasonably expected future source of drinking water.

What is the cleanup level if the groundwater use is designated as non-drinking water?

For a non drinking water groundwater use designation, the cleanup level might not be based on drinking water, but should be protective for other uses and exposures that could occur under its designation. Such uses and exposures could include: sanitary purposes at an industrial facility (including showering), industrial cooling water, car washing, agricultural uses and irrigation. Furthermore, exposures to contaminants from groundwater could occur even when there is no direct use of the groundwater. For example, groundwater may recharge adjacent or underlying aquifers that are used for drinking water or may discharge to surface

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[3] EPA expresses non-cancer health risk as a ratio, known as the Hazard Quotient (HQ), which is defined as the calculated exposure from a single contaminant in a single medium divided by a reference dose. The reference dose is the level of exposure that EPA believes will be without adverse effect in human populations, including sensitive individuals. Note that some chemicals may be associated with both carcinogenic as well as non-carcinogenic effects (such as liver or kidney disease); both should be considered when setting the cleanup level.

[4] The hazard index (HI) assesses potential for toxicity following exposure to multiple contaminants. It is equal to the sum of the hazard quotients. However, where information is available to identify the critical toxic effect for non-carcinogens, only hazard quotients with associated with similar critical effects (target organs) are combined.

water to support aquatic life, recreation, or drinking water, etc. Additionally, exposure to contaminants in indoor air could result from underlying groundwater contaminated with volatile chemicals. Facilities should identify the various uses and exposures (i.e. pathways) to contaminants from groundwater to develop protective groundwater cleanup levels for the facility. To estimate dose, you should evaluate all current and potential routes of exposure within each pathway, such as inhalation, dermal contact, and inadvertent ingestion. EPA does not currently have standard exposure assumptions for most non-residential uses of groundwater. Facilities, in consultation with the regulators, generally should quantify facility-specific exposure assumptions for all expected pathways by collecting facility-specific or other relevant data to develop an appropriate numerical value for those exposures. These exposure values along with toxicity values for each contaminant are then used to calculate contaminant-specific concentrations (groundwater cleanup levels) to achieve protective risk levels (i.e. an excess upper bound lifetime cancer risk of $1x10^{-4}$ to $1x10^{-6}$ or a hazard index of one).

Some States have established generic cleanup levels for groundwater in non-drinking water aquifers. In those states, facilities and regulators should consider these levels when appropriate.

Are there any situations where the levels described above might not be appropriate?

Yes. For example, groundwater cleanup levels that are higher or lower than the levels described above, might be appropriate in the two following circumstances, provided such cleanup levels protect human health and the environment:

(1) Higher cleanup levels may be appropriate, for a given facility, when groundwater is also contaminated by hazardous constituents that are naturally occurring[5], or have originated from a source not associated with the subject facility, <u>and</u> those hazardous constituents are present in concentrations such that remediation of the release would not provide significant reduction in risks to actual or potential receptors.

(2) Lower groundwater cleanup levels may be necessary because of unacceptable risks to human receptors from combined effects of hazardous wastes or hazardous constituents, or to protect potential receptors exposed through cross media transfer, or to protect ecologic receptors.

Are there any situations where I don't need to set a groundwater cleanup level?

Yes. In some cases, the groundwater will already be at acceptable levels for its designated use(s). In other situations, regulators might not establish specific groundwater cleanup levels if: the contaminated groundwater is within a designated non-drinking water aquifer; has no current or foreseeable beneficial use; does not discharge to surface water or to a drinking water aquifer at levels that could cause concern; and does not cause other exposures through media transfer (e.g., indoor air). However, the regulator may still require you to conduct monitoring to ensure continued protection of human health and the environment. Other EPA policies dealing with issues, such as <u>source control</u>, would still likely apply in this situation.

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[5] Naturally occurring substance in its unaltered form, or altered solely through naturally occurring processes or phenomena, [in] a location where it is naturally found (Superfund, Section 104(a)(3)(A)).

Do alternate concentration limits apply to setting groundwater cleanup levels for facility-wide corrective action?

Alternate Concentration Limits (ACLs) apply to corrective action at RCRA regulated units[6], and, therefore, would not typically apply to facility-wide corrective action. ACLs are levels that can be used, as appropriate, to establish groundwater protection standards[7] for RCRA regulated land based units (i.e., all surface impoundments, waste piles, land treatment units, and landfills that received hazardous waste after July 26, 1982). These units are subject to groundwater monitoring and corrective action requirements contained in 40 CFR Part 264, Subpart F. ACLs, which are established in 40 CFR 264.94(b), allow for groundwater protection standards developed based on risk rather than background, and allow decision makers to consider natural attenuation processes in remediating groundwater contamination from RCRA regulated units, where appropriate. Both of these concepts (i.e., risk-based standards and natural attenuation approaches) are available for facility-wide corrective action as explained in other policies discussed in this Handbook. If you have a regulated unit and want to use ACLs, you should read the Alternate Concentration Limit Guidance, July 1987 and call the overseeing regulator.

Under limited circumstances specified in CERCLA 121(d)(2)(B)(ii), ACLs may also be used at Superfund sites. Guidance for using Superfund ACLs is found in the "Rules of Thumb for Superfund Remedy Selection" (EPA, 1997).

What are my cleanup levels for groundwater if I am clean closing a RCRA regulated unit?

To achieve "clean closure," facilities should remove or decontaminate all hazardous waste, liners and environmental media contaminated by releases from the unit. However, hazardous constituents may remain at some level in environmental media, such as groundwater, after clean closure provided the constituents are below levels that may pose a risk to human health or the environment. In 1998, EPA issued a memorandum broadening the interpretation of acceptable levels of residual constituents. This expanded interpretation allows the use of non-residential exposure assumptions to be incorporated into the development of closure standards (i.e. the concentrations that each medium should achieve for the unit to be clean closed.) When the groundwater protection standards are based on a groundwater use designation other than drinking water standards, EPA or the State should be confident that the exposure assumed remains valid (e.g., periodic evaluations of actual use, zoning and/or easements to third parties) since no further regulatory control will be required under subtitle C. For more information on risk based closure, you should read the *Risk-Based Clean Closure* Memorandum and call your overseeing regulator.

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[6] Regulated units are defined in 40 CFR 264.90 as surface impoundments, waste piles, land treatment units, and landfills that received hazardous waste after July 26, 1982.

[7] Groundwater protection standards are constituent concentrations established in permits which trigger corrective action and demonstrate satisfaction of closure requirements.

References:

EPA, 1998c. Memorandum from Elizabeth Cotsworth to RCRA Senior Policy Advisors titled, Risk-Based Clean Closure (March 16). Available at http://www.epa.gov/epaoswer/hazwaste/ca/ .

EPA, 1997b. Rules of Thumb for Superfund Remedy Selection (EPA 540-R-97-013). Available at http://www.epa.gov/superfund/resources/rules/rulesthm.pdf

EPA, 1996a. Advance Notice of Proposed Rulemaking (61 FR 19432, May 1). Available at http://www.epa.gov/docs/fedrgstr/EPA-WASTE/1996/May/Day-01/pr-547.pdf . Particularly relevant pages: 19448-52.

EPA, 1987. Alternate Concentration Limit Guidance (EPA/530-SW-87017).

EPA/630/R-95/002F
April 1998

Guidelines for Ecological Risk Assessment

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Risk Assessment Forum

stressors. Exposure to multiple stressors may lead to effects at different levels of biological organization, for a cascade of adverse effects that should be considered.

Professional judgment and an understanding of the characteristics and function of an ecosystem are important for translating general goals into usable assessment endpoints. The less information available, the more critical it is to have informed professionals help in the selection. Common problems encountered in selecting assessment endpoints are summarized in text box 3-10.

Final assessment endpoint selection is an important risk manager-risk assessor checkpoint during problem formulation. Risk assessors and risk managers should agree that selected assessment endpoints effectively represent the management goals. In addition, the scientific rationale for their selection should be made explicit in the risk assessment.

Text Box 3-10. Common Problems in Selecting Assessment Endpoints

- Endpoint is a goal (e.g., maintain and restore endemic populations)
- Endpoint is vague (e.g., estuarine integrity instead of eelgrass abundance and distribution)
- Ecological entity is better as a measure (e.g., emergence of midges can be used to evaluate an assessment endpoint for fish feeding behavior)
- Ecological entity may not be as sensitive to the stressor (e.g., catfish versus salmon for sedimentation)
- Ecological entity is not exposed to the stressor (e.g., using insectivorous birds for avian risk of pesticide application to seeds)
- Ecological entities are irrelevant to the assessment (e.g., lake fish in salmon stream)
- Importance of a species or attributes of an ecosystem are not fully considered (e.g., mussel-fish connection, see Text Box 3-8).
- Attribute is not sufficiently sensitive for detecting important effects (e.g., survival compared with recruitment for endangered species)

3.4. CONCEPTUAL MODELS

A conceptual model in problem formulation is a written description and visual representation of predicted relationships between ecological entities and the stressors to which they may be exposed. Conceptual models represent many relationships. They may include ecosystem processes that influence receptor responses or exposure scenarios that qualitatively link land-use activities to stressors. They may describe primary, secondary, and tertiary exposure pathways (see section 4.2) or co-occurrence among exposure pathways, ecological effects, and ecological receptors. Multiple conceptual models may be generated to address several issues in a given risk

assessment. Some of the benefits gained by developing conceptual models are featured in text box 3-11.

Text Box 3-11. What Are the Benefits of Developing Conceptual Models?

- The process of creating a conceptual model is a powerful learning tool.
- Conceptual models are easily modified as knowledge increases.
- Conceptual models highlight what is known and not known and can be used to plan future work.
- Conceptual models can be a powerful communication tool. They provide an explicit expression of the assumptions and understanding of a system for others to evaluate.
- Conceptual models provide a framework for prediction and are the template for generating more risk hypotheses.

Conceptual models for ecological risk assessments are developed from information about stressors, potential exposure, and predicted effects on an ecological entity (the assessment endpoint). Depending on why a risk assessment is initiated, one or more of these categories of information are known at the outset (refer to section 3.2 and text box 3-3). The process of creating conceptual models helps identify the unknown elements.

The complexity of the conceptual model depends on the complexity of the problem: the number of stressors, number of assessment endpoints, nature of effects, and characteristics of the ecosystem. For single stressors and single assessment endpoints, conceptual models may be simple. In some cases, the same basic conceptual model may be used repeatedly (e.g., in EPA's new chemical risk assessments). However, when conceptual models are used to describe pathways of individual stressors and assessment endpoints and the interaction of multiple and diverse stressors and assessment endpoints (e.g., assessments initiated to protect ecological values), more complex models and several submodels will often be needed. In this case, it can be helpful to create models that also represent expected ecosystem characteristics and function when stressors are not present.

Conceptual models consist of two principal components:

- A set of risk hypotheses that describe predicted relationships among stressor, exposure, and assessment endpoint response, along with the rationale for their selection
- A diagram that illustrates the relationships presented in the risk hypotheses.

also could need special consideration in the risk assessment (see Section 1.2.3).

1.2.2 Contaminant Fate and Transport

During problem formulation, pathways for migration of a contaminant (e.g., windblown dust, surface water runoff, erosion) should be identified. These pathways can exhibit a decreasing gradient of contamination with increasing distance from a site. There are exceptions, however, because physical and chemical characteristics of the media also influence contaminant distribution (e.g., the pattern of sediment deposition in streams varies depending on stream flow and bottom characteristics). For the screening-level risk assessment, the highest contaminant concentrations measured on the site should be documented for each medium.

HIGHLIGHT 1-2
Industrial or Urban Settings

Many hazardous waste sites exist in currently or historically industrialized or urbanized areas. In these instances, it can be difficult to distinguish between impacts related to contaminants from a particular site and impacts related to non-contaminant stressors or to contaminants from other sites. However, even in these cases, it could be appropriate to take some remedial actions based on ecological risks. These actions might be limited to source removal or might be more extensive. An ecological risk assessment can assist the risk manager in determining what action, if any, is appropriate.

1.2.3 Ecotoxicity and Potential Receptors

Understanding the toxic mechanism of a contaminant helps to evaluate the importance of potential exposure pathways (see Section 1.2.4) and to focus the selection of assessment endpoints (see Section 1.2.5). Some contaminants, for example, affect primarily vertebrate animals by interfering with organ systems not found in invertebrates or plants (e.g., distal tubules of vertebrate kidneys, vertebrate hormone systems). Other substances might affect primarily certain insect groups (e.g., by interfering with hormones needed for metamorphosis), plants (e.g., herbicides), or other groups of organisms. For substances that affect, for example, reproduction of mammals at much lower environmental exposure levels than they affect other groups of organisms, the screening-level risk assessment can initially focus on exposure pathways and risks to mammals. Example 1-1 illustrates this point using the PCB site example provided in Appendix A. A review of some of the more recent ecological risk and toxicity assessment literature can help identify likely effects of the more common contaminants at Superfund sites.

An experienced biologist or ecologist can determine what plants, animals, and habitats exist or can be expected to exist in the area of the Superfund site. Exhibit 1-1, adapted from the Superfund Hazard Ranking System, is a partial list of types of sensitive environments that could require protection or special consideration. Information obtained for the environmental checklist (Section 1.2.1), existing information and maps, and aerial photographs should be used to identify the presence of sensitive environments on or near a site that might be threatened by contaminants from the site.

United States
Environmental Protection
Agency

Solid Waste and
Emergency Response

EPA 540-R-97-006
OSWER 9285.7-25
PB97-963211
June 1997

Superfund

EPA

Ecological Risk Assessment Guidance for Superfund:

Process for Designing and Conducting Ecological Risk Assessments

Interim Final

EXAMPLE 1-1
Ecotoxicity–PCB Site

Some PCBs are reproductive toxins in mammals (Ringer et al., 1972; Aulerich et al., 1985; Wren et al., 1991; Kamrin and Ringer, 1996). When ingested, they induce (i.e., increase concentrations and activity of) enzymes in the liver, which might affect the metabolism of some steroid hormones (Rice and O'Keefe, 1995). Whatever the mechanism of action, several physiological functions that are controlled by steroid hormones can be altered by the exposure of mammals to certain PCBs, and reproduction appears to be the most sensitive endpoint for PCB toxicity in mammals (Rice and O'Keefe, 1995). Given this information, the screening ecological risk assessment should include potential exposure pathways for mammals to PCBs that are reproductive toxins (see Example 1-2).

1.2.4 Complete Exposure Pathways

Evaluating potential exposure pathways is one of the primary tasks of the screening-level ecological characterization of the site. For an exposure pathway to be complete, a contaminant must be able to travel from the source to ecological receptors and to be taken up by the receptors via one or more exposure routes. (Highlight 1-3 defines exposure pathway and exposure route.) Identifying complete exposure pathways prior to a quantitative evaluation of toxicity allows the assessment to focus on only those contaminants that can reach ecological receptors.

Different exposure routes are important for different groups of organisms. For terrestrial animals, three basic exposure routes need to be evaluated: inhalation, ingestion, and dermal absorption. For terrestrial plants, root absorption of contaminants in soils and leaf absorption of contaminants evaporating from the soil or deposited on the leaves are of concern at Superfund sites. For aquatic animals, direct contact (of water or sediment with the gills or integument) and ingestion of food (and sometimes sediments) should be considered. For aquatic plants, direct contact with water, and sometimes with air or sediments, is of primary concern.

The most likely exposure pathways and exposure routes also are related to the physical and chemical properties of the contaminant (e.g., whether or not the contaminant is bound to a matrix, such as organic carbon). Of the basic exposure routes identified above, more information generally is available to quantify exposure levels for ingestion by terrestrial animals and for direct contact with water or sediments by aquatic organisms than for other exposure routes and receptors. Although other exposure routes can be important, more

EXHIBIT 1-1
List of Sensitive Environments in the Hazard Ranking System[a]

Critical habitat for Federal designated endangered or threatened species
Marine Sanctuary
National Park
Designated Federal Wilderness Area
Areas identified under the Coastal Zone Management Act
Sensitive areas identified under the National Estuary Program or Near Coastal Waters Program
Critical areas identified under the Clean Lakes Program
National Monument
National Seashore Recreational Area
National Lakeshore Recreational Area
Habitat known to be used by Federal designated or proposed endangered or threatened species
National Preserve
National or State Wildlife Refuge
Unit of Coastal Barrier Resources System
Coastal Barrier (undeveloped)
Federal land designated for protection of natural ecosystems
Administratively Proposed Federal Wilderness Area
Spawning areas critical for the maintenance of fish/shellfish species within river, lake, or coastal tidal waters
Migratory pathways and feeding areas critical for maintenance of anadromous fish species within river reaches or areas in lakes or coastal tidal waters in which the fish spend extended periods of time
Terrestrial areas utilized for breeding by large or dense aggregations of animals
National river reach designated as Recreational
Habitat known to be used by state designated endangered or threatened species
Habitat known to be used by species under review as to its Federal endangered or threatened status
Coastal Barrier (partially developed)
Federally-designated Scenic or Wild River
State land designated for wildlife or game management
State-designated Scenic or Wild River
State-designated Natural Areas
Particular areas, relatively small in size, important to maintenance of unique biotic communities
State-designated areas for protection or maintenance of aquatic life
Wetlands[b]

[a] The categories are listed in groups from those assigned higher factor values to those assigned lower factor values in the Hazard Ranking System (HRS) for listing hazardous waste sites on the National Priorities List (U.S. EPA, 1990b). See *Federal Register*, Vol. 55, pp. 51624 and 51648 for additional information regarding definitions.

[b] Under the HRS, wetlands are rated on the basis of size. See *Federal Register*, Vol. 55, pp. 51625 and 51662 for additional information.

assumptions are needed to estimate exposure levels for those routes, and the results are less certain. Professional judgment is needed to determine if evaluating those routes sufficiently improves a risk assessment to warrant the effort.

HIGHLIGHT 1-3
Exposure Pathway and Exposure Route

Exposure Pathway: The pathway by which a contaminant travels from a source (e.g., drums, contaminated soils) to receptors. A pathway can involve multiple media (e.g., soil runoff to surface waters and sedimentation, or volatilization to the atmosphere).

Exposure Route: A point of contact/entry of a contaminant from the environment into an organism (e.g., inhalation, ingestion, dermal absorption).

If an exposure pathway is not complete for a specific contaminant (i.e., ecological receptors cannot be exposed to the contaminant), that exposure pathway does not need to be evaluated further. For example, suppose a contaminant that impairs reproduction in mammals occurs only in soils that are well below the root zone of plants that occur or are expected to occur on a site. Herbivorous mammals would not be exposed to the contaminant through their diets because plants would not be contaminated. Assuming that most soil macroinvertebrates available for ingestion live in the root zone, insectivorous mammals also would be unlikely to be exposed. In this case, a complete exposure pathway for this contaminant for ground-dwelling mammals would not exist, and the contaminant would not pose a significant risk to this group of organisms. Secondary questions might include whether the contaminant is leaching from the soil to ground water that discharges to surface water, thereby posing a risk to the aquatic environment or to terrestrial mammals that drink the water or consume aquatic prey. Example 1-2 illustrates the process of identifying complete exposure pathways based on the hypothetical PCB site described in Appendix A.

1.2.5 Assessment and Measurement Endpoints

For the screening-level ecological risk assessment, assessment endpoints are any adverse effects on ecological receptors, where receptors are plant and animal populations and communities, habitats, and sensitive environments. Adverse effects on populations can be inferred from measures related to impaired reproduction, growth, and survival. Adverse effects on communities can be inferred from changes in community structure or function. Adverse effects on habitats can be inferred from changes in composition and characteristics that reduce the habitats' ability to support plant and animal populations and communities.

Many of the screening ecotoxicity values now available or likely to be available in the future for the Superfund program (see Section 1.3) are based on generic assessment endpoints (e.g., protection of aquatic communities from changes in structure or function) and are assumed to be widely applicable to sites around the United States.

EXAMPLE 1-2
Complete Exposure Pathways for Mammals–PCB Site

Three possible exposure pathways for mammals were evaluated at the PCB Site: inhalation, ingestion through the food chain, and incidental soil/sediment ingestion.

Inhalation. PCBs are not highly volatile, so the inhalation of PCB vapors by mammals would be an essentially incomplete exposure pathway. Inhalation of PCBs adsorbed to soil particles might need consideration in areas with exposed soils, but this site is well vegetated.

Ingestion through the food chain. PCBs tend to bioaccumulate and biomagnify in food chains. PCBs in soils are not taken up by most plants, but are accumulated by soil macroinvertebrates. Thus, in areas without significant soil deposition on the surfaces of plants, mammalian herbivores would not be exposed to PCBs in most of their diet. In contrast, mammalian insectivores, such as shrews, could be exposed to PCBs in most of their diet. For PCBs, the ingestion route for mammals would be essentially incomplete for herbivores but complete for insectivores. For the PCB site, therefore, the ingestion exposure route for a mammalian insectivore (e.g., shrew) would be a complete exposure pathway that should be evaluated.

Incidental soil/sediment ingestion. Mammals can ingest some quantity of soils or sediments incidentally, as they groom their fur or consume plants or animals from the soil. Burrowing mammals are likely to ingest greater quantities of soils during grooming than non-burrowing mammals, and mammals that consume plant roots or soil-dwelling macroinvertebrates are likely to ingest greater quantities of soils attached to the surface of their foods than mammals that consume other foods. The intake of PCBs from incidental ingestion of PCB-contaminated soils is difficult to estimate, but for insectivores that forage at ground level, it is likely to be far less than the intake of PCBs in the diet. For herbivores, the incidental intake of PCBs in soils might be higher than the intake of PCBs in their diet, but still less than the intake of PCBs by mammals feeding on soil macroinvertebrates. Thus, the exposure pathway for ground-dwelling mammalian insectivores remains the exposure pathway that should be evaluated.

1.3 SCREENING-LEVEL ECOLOGICAL EFFECTS EVALUATION

The next step in the screening-level risk assessment is the preliminary ecological effects evaluation and the establishment of contaminant exposure levels that represent conservative thresholds for adverse ecological effects. In this guidance, those conservative thresholds are called screening ecotoxicity values. Physical stresses unrelated to contaminants at the site are not the focus of the risk assessment (see Highlight 1-4), although they can be considered later when evaluating effects of remedial alternatives.

Directive 9234.2-25
September 1993

Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration

Interim Final

Office of Solid Waste and Emergency Response
U.S. Environmental Protection Agency
Washington, DC 20460

Monitoring and assessing the performance of DNAPL zone containment and aquifer restoration systems, therefore, are critical to maintaining remedy protectiveness and evaluating the need for remedy enhancements or application of new technologies.

EPA recognizes, however, that there are technical limitations to ground-water remediation technologies unrelated to the presence of a DNAPL source zone. These limitations, which include contaminant-related factors (e.g., slow desorption of contaminants from aquifer materials) and hydrogeologic factors (e.g., heterogeneity of soil or rock properties), should be considered when evaluating the technical practicability of restoring the aqueous plume.

EPA encourages consideration of innovative technologies at DNAPL sites, particularly where containment of a DNAPL zone may require costly periodic maintenance (and perhaps replacement). Innovative technologies, therefore, should be considered where DNAPL zone containment could be enhanced or where such a technology could clean up the DNAPL zone.

4.0 TI Decisions and Supporting Information

4.1 Regulatory Framework for TI Decisions

The bases for TI decisions discussed in this guidance are provided in CERCLA and the NCP for the Superfund program and in the Proposed Subpart S rule for the RCRA program. While the processes the two programs use to establish cleanup levels differ (e.g., the ARAR concept is not used in RCRA), the primary considerations for determining the technical impracticability of achieving those levels are identical:

- **Engineering feasibility; and**
- **Reliability.**

A brief summary of the regulatory basis for establishing cleanup levels and making TI determinations at Superfund and RCRA sites is provided below.

4.1.1 Superfund

Remedial alternatives at Superfund sites must satisfy two "threshold" criteria specified in the NCP to be eligible for selection: 1) the remedy must be protective of human health and the environment; and 2) the remedy must meet (or provide the basis for waiving) the ARARs identified for the action.[8] There generally are several different types of ARARs associated with ground-water remedies at Superfund sites, such as requirements for discharge of treated water to surface water bodies or other receptors, limitations on reinjection of treated water into the subsurface, and cleanup levels for contaminants in the ground water. ARARs used to establish cleanup levels for current or potentially drinkable ground water typically are MCLs or non-zero MCLGs established under the Federal Safe Drinking Water Act, or in some cases, more stringent State requirements. For compounds for which there are no ARARs, cleanup levels generally are chosen to protect users or receptors from unacceptable cancer and non-cancer health risks or adverse environmental effects. Such levels generally are established to fall within the range of 10^{-4} to 10^{-6} lifetime cancer risk or below a hazard index of one for non-carcinogens, as appropriate.

ARARs may be waived by EPA for any of the six reasons specified by CERCLA and the NCP (Highlight 1), including **technical impracticability from an engineering perspective.** TI waivers generally will be applicable only for ARARs that are used to establish cleanup performance standards or levels, such as chemical-specific MCLs or State ground-water quality criteria.

Highlight 1.
CERCLA ARAR Waivers

The six ARAR waivers provided by CERCLA §121(d)(4) are:

1. Interim Action Waiver;
2. Equivalent Standard of Performance Waiver;
3. Greater Risk to Health and the Environment Waiver;
4. Technical Impracticability Waiver;
5. Inconsistent Application of State Standard Waiver; and
6. Fund Balancing Waiver.

8 NCP §300.430(f)(1)(i). For a detailed discussion of the Superfund remedy selection process, see also EPA 1988a and 1988b.

Use of the term "engineering perspective" implies that a TI determination should primarily focus on the technical capability of achieving the cleanup level, with cost playing a subordinate role. The NCP Preamble states that TI determinations should be based on:

> "...engineering feasibility and reliability, with cost generally not a major factor unless compliance would be inordinately costly."[9]

4.1.2 RCRA

The Proposed Subpart S rule specifies that the corrective action for contaminated ground water include attainment of "media cleanup standards," which generally are Federal or State MCLs, contaminant levels within the range of 10^{-4} to 10^{-6} lifetime cancer risk, or hazard index of less than one for non-carcinogens, as appropriate. The proposed rule also specifies three conditions under which attainment of media cleanup standards may not be required: 1) remediation of the release would provide no significant reduction in risks to actual or potential receptors; 2) the release does not occur in, or threaten, ground waters that are current or potential sources of drinking water; and 3) **remediation of the release to media cleanup standards is technically impracticable.**[10]

Further clarification of TI determinations is provided in the preamble to the proposed rule. The determination involves a consideration of the **"engineering feasibility and reliability"** of attaining media cleanup standards, as well as situations where remediation may be "technically possible," but the "scale of the operations required might be of such a **magnitude and complexity** that the alternative would be impracticable" (emphasis added).[11]

The basis for a RCRA Subpart S TI decision (engineering feasibility, reliability, and the magnitude and complexity of the action) therefore is consistent with that provided for the Superfund program in the NCP. In the context of remedy selection, both programs consider the notion of technical feasibility along with reliability and economic considerations; however, **the role of cost (or scale) of the action is subordinate to the goal of remedy protectiveness.**

4.2 Timing of TI Decisions

TI decisions may be made either when a final site decision document is being developed (e.g., RCRA Statement of Basis and Response to Comments or Superfund ROD) or after the remedy has been implemented and monitored for a period of time. EPA believes that, in many cases, TI decisions should be made only after interim or full-scale aquifer remediation systems are implemented because often it is difficult to predict the effectiveness of remedies based on limited site characterization data alone. However, in some cases, TI decisions may be made prior to remedy implementation. These pre-implementation or "front-end" TI decisions must be supported adequately by detailed site characterization and data analysis. Front-end TI evaluations should focus on those data and analyses that define the most critical limitations to ground-water restoration.

Data and analysis requirements for front-end decisions should be considered carefully. Generally, information regarding the nature and extent of contamination sources is more critical to assessing restoration potential than are other types of characterization data. This often is the case, as currently available technologies generally are more effective for remediating and restoring contaminated aquifers affected only by dissolved, or aqueous, contamination. However, certain types of source contamination are resistant to extraction by these technologies and can continue to dissolve slowly into ground water for indefinite periods of time. Examples of this type of source constraint include certain occurrences of NAPLs, such as where the quantity, distribution, or properties of the NAPL render its removal from, or destruction within, the subsurface infeasible or inordinately costly (See Section 3.0).

Geologic constraints, such as aquifer heterogeneity (e.g., interlayering of coarse and fine-grained strata), also may critically limit the ability to restore an aquifer. However, it generally is more difficult to accurately determine the impact of such constraints prior to implementation and monitoring of partial or full-scale aquifer remediation efforts. Some geologic constraints, however, may be defined sufficiently during site characterization so that their impacts on restoration potential are known with a relatively high degree of certainty. An example of this type of constraint includes complex fracturing of bedrock aquifers, which makes recovery of contaminated ground water or DNAPLs extremely difficult.

It should be noted, however, that the presence of known remediation constraints, such as DNAPL,

9 See NCP Preamble, 55 FR 8748, March 8, 1990.
10 Technical impracticability is discussed in Sections 264.525(d)(2) and 264.531 of the Proposed Subpart S rule.
11 Proposed Subpart S; 55 FR 30830, July 27, 1990.

fractured bedrock, or other condition, are not by themselves sufficient to justify a TI determination. Adequate site characterization data must be presented to demonstrate, not only that the constraint exists, but that the effect of the constraint on contaminant distribution and recovery potential poses a critical limitation to the effectiveness of available technologies.

4.3 TI Evaluation Components[12]

Determinations of technical impracticability will be made by EPA based on site-specific characterization and, where appropriate, remedy performance data. These data should be collected, analyzed, and presented so that the engineering feasibility and reliability of ground-water restoration are fully addressed in a concise and logical manner.

The TI evaluation may be prepared by the owner/operator of a RCRA facility, by a PRP at an enforcement-lead Superfund site, or by EPA or the State at Fund- or State-lead sites, as appropriate. **The evaluation generally should include the following components, based on site-specific information and analyses:**

1. Specific ARARs or media cleanup standards for which TI determinations are sought (See Section 4.4.1).

2. Spatial area over which the TI decision will apply (See Section 4.4.2).

3. Conceptual model that describes site geology, hydrology, ground-water contamination sources, transport, and fate (See Section 4.4.3).

4. An evaluation of the restoration potential of the site, including data and analyses that support any assertion that attainment of ARARs or media cleanup standards is technically impracticable from an engineering perspective (See Section 4.4.4). At a minimum, this generally should include:

   a. A demonstration that contamination sources have been identified and have been, or will be, removed and contained to the extent practicable;
   b. An analysis of the performance of any ongoing or completed remedial actions;
   c. Predictive analyses of the timeframes to attain required cleanup levels using available technologies; and
   d. A demonstration that no other remedial technologies (conventional or innovative) could reliably, logically, or feasibly attain the cleanup levels at the site within a reasonable timeframe.

5. Estimates of the cost of the existing or proposed remedy options, including construction, operation, and maintenance costs (See Section 4.4.5).

6. Any additional information or analyses that EPA deems necessary for the TI evaluation.

The data and analyses needed to address each of these components of a TI evaluation should be determined on a site-specific basis. Where outside parties are preparing the TI evaluation, its contents generally should be identified and discussed prior to submittal of the evaluation to EPA. Early agreement between EPA and PRPs or owner/operators on the type and quantity of data and analyses required for TI decisions will promote efficient review of TI evaluations.

References to other documents in the administrative record, such as the RI/FS and RFI, likely will be necessary to produce a concise evaluation; however, these references should be as explicit as possible (e.g., cite specific page or table numbers). Technical discussions and conclusions should be supported by data compilations, statistical analyses, or other types of data reduction included in the evaluation.

4.4 Supporting Information for TI Evaluations

Most, if not all, of the information needed to evaluate TI could be obtained during a thorough site investigation and, where appropriate, remedy performance monitoring efforts. At some sites, however, additional analysis of existing data or new information may be required before EPA can determine accurately the technical practicability of the restoration goals. Not all of the data or analyses outlined in this guidance will be required at all sites; specific information needs will depend on site conditions and any ongoing remediation efforts.

12 For this guidance a "TI evaluation" comprises the data and analyses necessary to make a TI determination. The TI evaluation may be performed by PRPs at enforcement-lead Superfund sites, or by State or other Federal agencies, where appropriate. Similarly, owner/operators at RCRA facilities may perform TI evaluations. However, the actual TI "determination," or "decision," will be made by EPA (or other lead agency, as appropriate).

The data and analyses identified and discussed below address the TI evaluation components provided in Section 4.3.

4.4.1. Specific ARARs or Media Cleanup Standards

The TI evaluation should identify the specific ARARs or media cleanup standards (i.e., the specific contaminants) for which the determination is sought. Such contaminants generally should include only those for which attainment of the required cleanup levels is technically impracticable. Factors EPA will consider when evaluating contaminants that may be included in the TI decision include: 1) the technical feasibility of restoring some of the contaminants present in the ground water; and 2) the potential advantages of attaining cleanup levels for some of the contaminants.

For example, consider a Superfund site with a DNAPL contamination problem (e.g., TCE), including a widespread subsurface DNAPL source area for which containment or restoration are technically impracticable. The aqueous plume also contains inorganic contamination (e.g., chromium) from on-site sources. Although it would be feasible to reduce chromium concentrations to the required cleanup level within a reasonable timeframe, TCE concentrations would remain above cleanup levels much longer due to the continued presence of the DNAPL or slow desorption of TCE from aquifer materials. However, in such cases, EPA may choose to limit the TI ARAR waiver to TCE alone, while requiring cleanup of the chromium.[13]

Two situations would favor use of this approach. The first would be where attaining chromium cleanup levels in the ground water will make future *ex situ* treatment of the (TCE-contaminated) ground water less complex and less expensive. This may be advantageous where a community wishes to extract the TCE-contaminated water, perform *ex situ* treatment, and put the treated water to beneficial use. A related consideration is whether removal of the chromium will facilitate future subsurface remediation using a newly developed technology. The second situation favoring this approach is where one of the contaminants (e.g., TCE) is being naturally biodegraded and the other (e.g., chromium) is not. Therefore, cleanup of the chromium may result in more rapid attainment of the long-term cleanup goals at the site.

Where the balance of conditions at such a site do not indicate that it is practicable to attain the cleanup levels for only some of the contaminants present, EPA may conclude that cleanup levels for the remaining contaminants need not be attained, depending on the circumstances of the site. As discussed further in Section 5.0, however, this decision does not preclude EPA from selecting (or continuing operation of) a remedy that includes active measures (e.g., pump-and-treat) along with measures to prevent exposure (e.g., institutional controls) needed to address site risks.

4.4.2 Spatial Extent of TI Decisions

The TI evaluation should specify the horizontal and vertical extent of the area for which the TI determination is sought. Where EPA determines that groundwater restoration is technically impracticable, the area over which the decision applies (the "TI zone") generally will include all portions of the contaminated ground water that do not meet the required cleanup levels (contaminated ground-water zone), unless the TI zone is otherwise defined by EPA.

In certain cases, EPA may restrict the extent of the TI zone to a portion or subarea within the contaminated ground-water zone. For example, consider a DNAPL site where it is technically impracticable to remove the residual DNAPLs from the subsurface but it is feasible and practicable to: 1) limit further migration of contaminated ground-water using a containment system; and 2) restore that portion of the aqueous plume outside of the containment area. The TI zone in this case should be restricted to that portion of the site that lies within the containment area. Outside of the TI zone, ARARs or media cleanup standards still would apply. The potential to spatially restrict the TI zone, therefore, will depend on the ability to delineate and contain non-removable subsurface contamination sources and restore those portions of the aqueous plume outside of the containment area. The spatial extent of the TI zone should be limited to as small an area as possible, given the circumstances of the site.

A TI zone should be delineated spatially, both in area and depth. Depth of a TI zone may be defined in absolute terms (e.g., feet above mean sea level) or in relative terms (e.g., with respect to various aquifers within multi-aquifer systems), as appropriate. Where

13 The extracted ground water would likely need to be treated for both TCE and chromium to satisfy treatment and waste disposal ARARs.

the TI zone will be restricted to a portion of the contaminated ground-water zone, the limits of the TI zone should be delineated clearly on site maps and geologic cross-sections. Delineation of the TI zone based on the location of a particular mapped contaminant concentration contour interval (e.g., the 200 part per billion isoconcentration line) generally should be avoided. This is because the location of such mapped contours often is highly interpretive, and their position may change with time. While concentration data may be appropriate to consider when determining the size of a containment area or the extent of a TI zone, the limits of that TI zone should be fixed in space, both horizontally and vertically.

4.4.3 Development and Purpose of the Site Conceptual Model

Decisions regarding the technical practicability of ground-water restoration must be based on a thorough characterization of the physical and chemical aspects of the site. Characterization data should describe site geology and hydrology; contamination sources, properties, and distribution; release mechanisms and rates; fate and transport processes; current or potential receptors; and other elements that define the contamination problem and facilitate analysis of site restoration potential. While the elements of such a model may vary from site to site, some generalizations can be made about what such a model would contain. Examples of these elements are provided in Figure 4. The site conceptual model synthesizes data acquired from historical research, site characterization, and remediation system operation.

The site conceptual model typically is presented as a summary or specific component of a site investigation report. The model is based on, and should be supported by, interpretive graphics, reduced and analyzed data, subsurface investigation logs, and other pertinent characterization information. The site conceptual model is not a mathematical or computer model, although these may be used to assist in developing and testing the validity of a conceptual model or evaluating the restoration potential of the site. The conceptual model, like any theory or hypothesis, is a dynamic tool that should be tested and refined throughout the life of the project. As illustrated in Figure 5, the model should evolve in stages as information is gathered during the various phases of site remediation. This iterative process allows data collection efforts to be designed so that key model hypotheses may be tested and revised to reflect new information.

The conceptual model serves as the foundation for evaluating the restoration potential of the site and, thereby, technical impracticability as well. The TI determination must consider how site conditions impact the potential for achieving remediation goals and whether remediation performance, cost-effectiveness, and timeframe meet EPA requirements or expectations. As these determinations rely on professional judgment, the clarity of the conceptual model (and supporting information) is critical to the decision-making process.

4.4.4 Evaluation of Restoration Potential

4.4.4.1 Source Control Measures. Remediation of contamination sources is critical to the success of aquifer restoration efforts. Continued releases of contamination from source materials to ground water can greatly reduce the effectiveness of aquifer restoration technologies, such as pump-and-treat, which generally are effective only for removing dissolved contaminants (EPA 1989b; 1992d). EPA considers subsurface NAPLs to be source materials because they are capable of releasing significant quantities of dissolved contamination to ground water over long periods of time.

A demonstration that ground-water restoration is technically impracticable generally should be accompanied by a demonstration that contamination sources have been, or will be, identified and removed or treated to the extent practicable. EPA recognizes that locating and remediating subsurface sources can be difficult. For example, locating DNAPLs in certain complex geologic environments may be impracticable. EPA expects, however, that all reasonable efforts will be made to identify the location of source areas through historical information searches and site characterization efforts.

Source removal and remediation may be difficult, even where source locations are known. The appropriate level of effort for source removal and remediation must be evaluated on a site-specific basis, considering the degree of risk reduction and any other potential benefits that would result from such an action. Even partial removal of contamination sources can greatly reduce the long-term reliance on both active and passive ground-water remediation.

Where complete source removal or treatment is impracticable, use of migration control or containment measures should be considered. Physical and hydraulic barriers are proven technologies that are capable of limiting or preventing further contaminant

Figure 4. Elements of Site Conceptual Model

The data and analysis required for TI evaluations will be determined by EPA on a site-specific basis. This information should be presented in formats conducive to analysis and in sufficient detail to define the key site conditions and mechanisms that limit restoration potential. Types of information and analysis that may be needed for conceptual model development are illustrated below.

Background Information

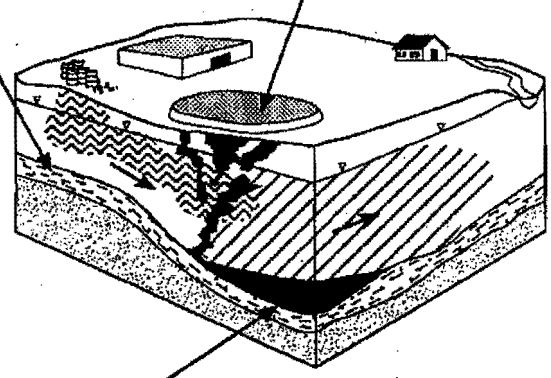
- Location of water supply wells.
- Ground-water Classification.
- Nearby wellhead protection areas or sole-source aquifers.
- Location of potential environmental receptors.

Geologic and Hydrologic Information

- Description of regional and site geology.
- Physical properties of subsurface materials (e.g., texture, porosity, bulk density).
- Stratigraphy, including thickness, lateral extent, continuity of units, and presence of depositional features, such as channel deposits, that may provide preferential pathways for, or barriers to, contaminant transport.
- Geologic structures that may form preferential pathways for NAPL migration or zones of accumulation.
- Depth to ground water.
- Hydraulic gradients (horizontal and vertical).
- Hydraulic properties of subsurface materials (e.g., hydraulic conductivity, storage coefficient, effective porosity) and their directional variability (anisotropy).
- Spatial distribution of soil or bedrock physical/hydraulic properties (degree of heterogeneity).
- Characterization of secondary porosity features (e.g., fractures, karst features) to the extent practicable.
- Temporal variability in hydrologic conditions.
- Ground-water recharge and discharge information.
- Ground-water/surface water interactions.

Contaminant Source and Release Information

- Location, nature, and history of previous contaminant releases or sources.
- Locations and characterizations of continuing releases or sources.
- Locations of subsurface sources (e.g., NAPLs).

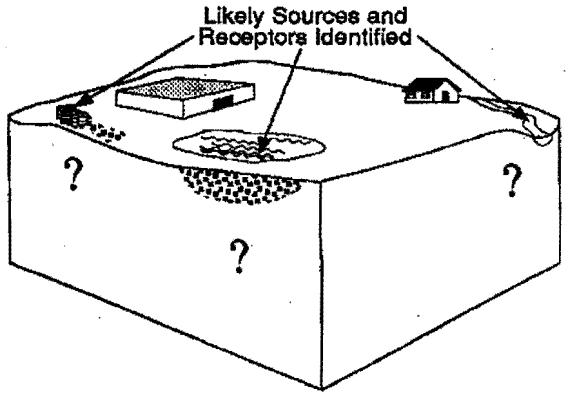


Contaminant Distribution, Transport, and Fate Parameters

- Phase distribution of each contaminant (gaseous, aqueous, sorbed, free-phase NAPL, or residual NAPL) in the unsaturated and saturated zones.
- Spatial distribution of subsurface contaminants in each phase in the unsaturated and saturated zones.
- Estimates of subsurface contaminant mass.
- Temporal trends in contaminant concentrations in each phase.
- Sorption information, including contaminant retardation factors.
- Contaminant transformation processes and rate estimates.
- Contaminant migration rates.
- Assessment of facilitated transport mechanisms (e.g., colloidal transport).
- Properties of NAPLs that affect transport (e.g., composition, effective constituent solubilities, density, viscosity).
- Geochemical characteristics of subsurface media that affect contaminant transport and fate.
- Other characteristics that affect distribution, transport, and fate (e.g., vapor transport properties).

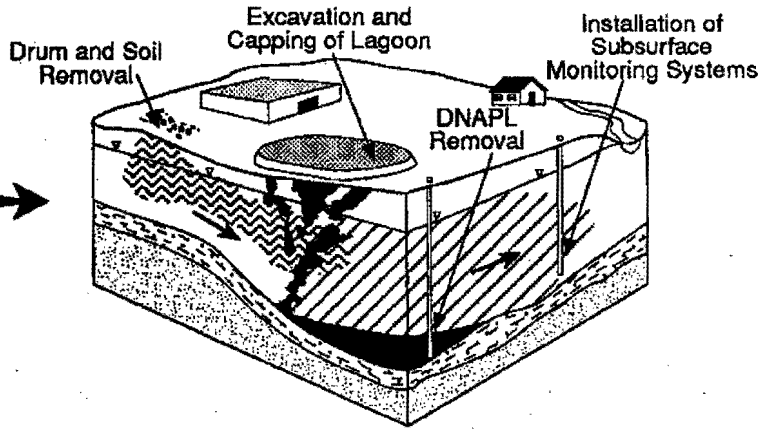
Figure 5. Evolution of the Site Conceptual Model

- Site Background and History
- Preliminary Site Investigations



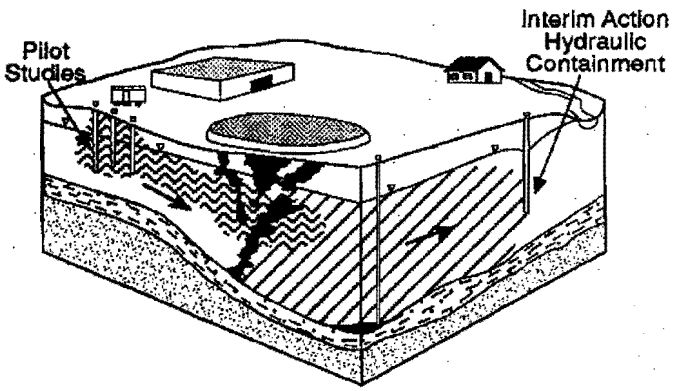
Conceptual Model Provides Basis for:

- Early Action/Removal of Near-Surface Materials
- Site Characterization Studies (RI/FS, RFI)
- Removal of Subsurface Sources (e.g., free-phase NAPLs)



Conceptual Model Provides Basis for:

- Pilot Studies
- Interim Ground-Water Actions



Conceptual Model Provides Basis for:

- Evaluation of Restoration Potential (or TI)
- Full-Scale Treatment System Design and Implementation
- Performance Monitoring and Evaluations
- Enhancement or Augmentation of Remediation System, if Required
- Future Evaluation of TI , if Required (See Figure 6)

migration from a source area under the right circumstances. While these containment measures are not capable of restoring source areas to required cleanup levels (i.e., a TI decision may be necessary for the source area), they may enable restoration of portions of the aquifer outside the containment zone.

4.4.4.2 Remedial Action Performance Analysis. The suitability and performance of any completed or ongoing ground-water remedial actions should be evaluated with respect to the objectives of those actions. Examples of remedy performance data are provided in Figure 6. The performance analysis should:

1. Demonstrate that the ground-water monitoring program within and outside of the aqueous contaminant plume is of sufficient quality and detail to fully evaluate remedial action performance (e.g., to analyze plume migration or containment and identify concentration trends within the remediation zone).[14]

2. Demonstrate that the existing remedy has been effectively operated and adequately maintained.

3. Describe and evaluate the effectiveness of any remedy modifications (whether variations in operation, physical changes, or augmentations to the system) designed to enhance its performance.

4. Evaluate trends in subsurface contaminant concentrations. Consider such factors as whether the aqueous plume has been contained, whether the areal extent of the plume is being reduced, and the rates of contaminant concentration decline and contaminant mass removal. Further considerations include whether aqueous-phase concentrations rebound when the system is shut down, whether dilution or other natural attenuation processes are responsible for observed trends, and whether contaminated soils on site are contaminating the ground water.

Analysis of aqueous-phase concentration data should be performed with caution. Contaminant concentrations plotted as a function of time, pore volumes of flushed fluids, or other appropriate variables may be useful in evaluating dominant contaminant fate and transport processes, evaluating remedial system design, and predicting future remedial system performance. Sampling methodologies, locations, and strategies, however, should be analyzed to determine the impact they may have had on observed concentration trends. For example, studies of ground-water extraction systems indicate that some systems show rapid initial decreases in aquifer concentration, followed by less dramatic decreases that eventually approach an asymptotic concentration level (EPA 1989b, 1992d). This "leveling off" effect may represent either a physical limitation to further remediation (e.g., contaminant diffusion from low permeability units) or an artifact of the system design or monitoring program. Professional judgment must be applied carefully when drawing conclusions concerning restoration potential from this information.

In certain cases, EPA may determine that lack of progress in achieving the required cleanup levels has resulted from system design inadequacies, poor system operation, or unsuitability of the technology for site conditions. Such system-related constraints are not sufficient grounds for determining that ground-water restoration is technically impracticable. In such instances, EPA generally will require that the existing remedy be enhanced, augmented, or replaced by a different technology. Furthermore, EPA may require modification or replacement of an existing remedy to ensure protectiveness, regardless of whether or not attainment of required cleanup levels is technically impracticable.

4.4.4.3 Restoration Timeframe Analysis. Estimates of the timeframe required to achieve ground-water restoration may be considered in TI evaluations. While restoration timeframes may be an important consideration in remedy selection, no single timeframe can be specified during which restoration must be achieved to be considered technically practicable. However, very long restoration timeframes (e.g., longer than 100 years) may be indicative of hydrogeologic or contaminant-related constraints to remediation. While predictions of restoration timeframes may be useful in illustrating the effects of such constraints, EPA will base TI decisions on an overall demonstration of the extent of such physical constraints at a site, not on restoration timeframe analyses alone. Such demonstrations should be based on detailed and accurate site conceptual models that also can provide the bases for meaningful predictions of restoration timeframes.

14 Further guidance on design of performance monitoring for remedial actions at ground-water sites is provided in "General Methods for Remedial Operations Performance Evaluations," EPA Office of Research and Development Publication EPA/600/R-92/002, January 1992 (EPA 1992e).

Figure 6. Remedy Performance Analysis

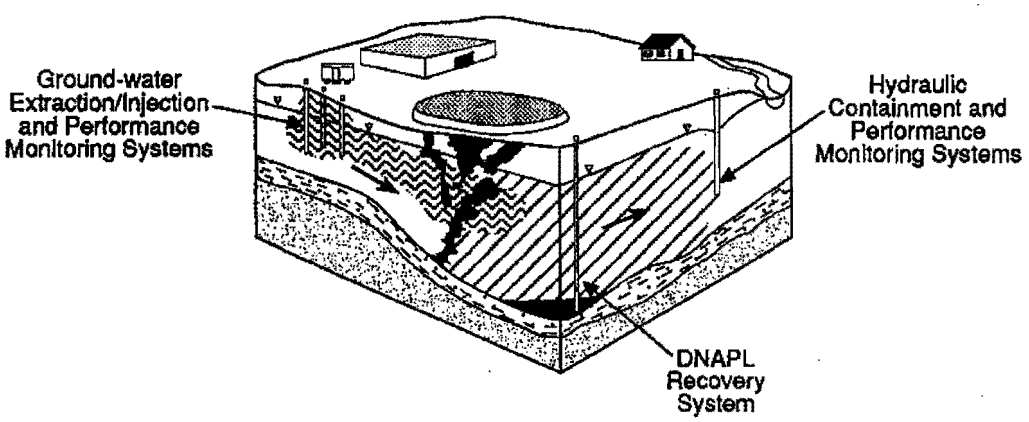
Remedy design and performance data requirements should be specific to technologies employed and site conditions. The categories of required information normally necessary to evaluate performance are provided below with some examples of specific data elements. These data should be reported to EPA in formats conducive to analysis and interpretation. Simple data compilations are insufficient for this purpose.

Remedy Design and Operational Information

- Design and as-built construction information, including locations of extraction or *in situ* treatment points with respect to the contamination.
- Supporting design calculations (e.g., calculation of well spacing).
- Operating information pertinent to remedy (e.g., records of the quantity and quality of extracted or injected fluids).
- Percent downtime and other maintenance problems.

Enhancements to Original Remedial Design

- Information concerning operational modifications, such as variations in pumping, injection rates, or locations.
- Rationale, design, and as-built construction information for system enhancements.
- Monitoring data and analyses that illustrate the effect these modifications have had on system performance.



Source Removal or Control

- Source removal information (e.g., results of soil excavations, removal of lagoon sediments, NAPL removal activities).
- Source control information (e.g., results of NAPL containment, capping of former waste management units).

Performance Monitoring Information

- Design and as-built construction information for performance monitoring systems.
- Hydraulic gradients and other information demonstrating plume containment or changes in areal extent or volume.
- Trends in subsurface contaminant concentrations determined at several/many appropriate locations in the subsurface. Trends should be displayed as a function of time, a function of pore volumes of flushed fluids, or other appropriate measures.
- Information on types and quantities of contaminant mass removed and removal rates.

A further consideration regarding the usefulness of restoration timeframe predictions in TI evaluations is the uncertainty inherent in such analyses. Restoration timeframes generally are estimated using mathematical models that simulate the behavior of subsurface hydrologic processes. Models range from those with relatively limited input data requirements that perform basic simulations of ground-water flow only, to those with extensive data requirements that are capable of simulating multi-phase flow (e.g., water, NAPL, vapor) or other processes such as contaminant adsorption to, and desorption from, aquifer materials. Model input parameters generally are a combination of values measured during site characterization studies and values assumed based on scientific literature or professional judgment. The input parameter selection process, as well as the simplifying assumptions of the mathematical model itself, result in uncertainty of the accuracy of the output. Restoration timeframes predicted using even the most sophisticated modeling tools and data, therefore, will have some degree of uncertainty associated with them.

Restoration timeframe analyses, therefore, generally are well suited for comparing two or more remediation design alternatives to determine the most appropriate strategy for a particular site. Where employed for such purposes, restoration timeframe analyses should be accompanied by a thorough discussion of all assumptions, including a list of measured or assumed parameters and a quantitative analysis, where appropriate, of the degree of uncertainty in those parameters and in the resulting timeframe predictions. The uncertainty in the predictions should be factored into the weight they are given in the remedy decision process.

4.4.4.4 Other Applicable Technologies. The TI evaluation should include a demonstration that no other remedial technologies or strategies would be capable of achieving ground-water restoration at the site.[15] The type of demonstration required will depend on the circumstances of the site and the state of ground-water remediation science at the time such an evaluation is made. In general, EPA expects that such a demonstration should consist of: 1) a review of the technical literature to identify candidate technologies; 2) a screening of the candidate technologies based on general site conditions to identify potentially applicable technologies; and 3) an analysis, using site hydrogeologic and chemical data, of the capability of any of the applicable technologies to achieve the required cleanup standards. Analysis of the potentially applicable technologies generally can be performed as a "paper study." EPA, however, may reserve the right to require treatability or pilot testing demonstrations to determine the actual effectiveness of a technology at a particular site.

Treatability and pilot testing should be conducted with rigorous controls and mass balance constraints. Information required by EPA for evaluation of pilot tests will be similar to that required for evaluation of existing remediation systems (e.g., detailed design and performance data).

4.4.4.5 Additional Considerations. Techniques used for evaluation of ground-water restoration potential are still evolving. The results of such evaluations generally will have some level of uncertainty associated with them. Interpretation of the results of restoration potential evaluations, therefore, will require the use of professional judgment. The use of mathematical models and calculations of mass removal rates are two examples of techniques that require particular caution.

Ground-water Flow and Contaminant Transport/Fate Modeling. Simulation of subsurface systems through mathematical modeling can be useful for designing remediation systems or predicting design performance. However, the limitations of predictive modeling must be considered when evaluating site restoration potential. As discussed in Section 4.4.4.3, ground-water models are sensitive to initial assumptions and the choice of parameters, such as contaminant source locations, leachability, and hydraulic conductivity. Predictions such as the magnitude and distribution of subsurface contaminant concentrations, therefore, will involve uncertainty. The source and degree of this uncertainty should be described, quantified, and evaluated wherever possible so the reviewer understands the level of confidence that should be placed in the predicted concentration values or other outputs. Predictive modeling may be most valuable in providing insight into processes that dominate contaminant transport and fate at the site and evaluating the relative effectiveness of different remedial alternatives. Further guidance and information on the use of ground-water models is provided in Anderson and Woessner (1992), EPA (1992f), and EPA (1992g).

Contaminant Mass Removal Estimates. Evaluation of contaminant mass removal may be useful at some sites

15 See discussions in the NCP (55 FR 8748, March 8, 1990) and Subpart S (55 FR 30838, July 27, 1990).

with existing remediation systems. These measures may include evaluation of mass removal rates, comparison of removal rates to *in situ* mass estimates, changes in the size of the contaminated area, comparison of mass removal rates with pumping rates, and comparison of such measures with associated costs. Mass removal and balance estimates should be used with caution, as there often is a high degree of uncertainty associated with estimates of the initial mass released and the mass remaining *in situ*. This uncertainty results from inaccuracy of historical site waste-management records, subsurface heterogeneities, and the difficulty in delineating the severity and extent of subsurface contamination.

4.4.5 Cost Estimate

Estimates of the cost of remedy alternatives should be provided in the TI evaluation. The estimates should include the present worth of construction, operation, and maintenance costs. Estimates should be provided for the continued operation of the existing remedy (if the evaluation is conducted following implementation of the remedy) or for any proposed alternative remedial strategies.

As discussed in Section 4.4.1, a Superfund remedy alternative may be determined to be technically impracticable if the cost of attaining ARARs would be inordinately high. The role of cost, however, is subordinate to that of ensuring protectiveness. The point at which the cost of ARAR compliance becomes inordinate must be determined based on the particular circumstances of the site. As with long restoration timeframes, relatively high restoration costs may be appropriate in certain cases, depending on the nature of the contamination problem and considerations such as the current and likely future use of the ground water. Compliance with ARARs is not subject to a cost-benefit analysis, however.[16]

5.0 Alternative Remedial Strategies

5.1 Options and Objectives for Alternative Strategies[17]

EPA's goal of restoring contaminated ground water within a reasonable timeframe at Superfund or RCRA sites will be modified where complete restoration is found to be technically impracticable. In such cases, EPA will select an alternative remedial strategy that is technically practicable, protective of human health and the environment, and satisfies the statutory and regulatory requirements of the Superfund or RCRA programs, as appropriate.[18]

Where a TI decision is made at the "front end" of the site remediation process (before a final remedy has been identified and implemented), the alternative strategy should be incorporated into a final remedy decision document, such as a Superfund ROD or RCRA permit or enforcement order. Where the TI decision is made after the final decision document has been signed (i.e., after a remedy has been implemented and its performance evaluated), the alternative remedial strategy should be incorporated in a modified final remedy decision document, such as a ROD amendment or RCRA permit/order modification (see Section 6.0).

Alternative remedial strategies typically will address three types of problems at contaminated ground-water sites: prevention of exposure to contaminated ground water; remediation of contamination sources; and remediation of aqueous contaminant plumes. Recommended objectives and options for addressing these three problems are discussed below. Note that combinations of two or more options may be appropriate at any given site, depending on the size and complexity of the contamination problem or other site circumstances.

5.1.1 Exposure Control

Since the primary objective of any remedial strategy is overall protectiveness, exposure prevention may play a significant role in an alternative remedial strategy. Exposure control may be provided using institutional controls, such as deed notifications and restrictions on water-supply well construction and use. The remedy should provide assurance that these measures are enforceable and consistent with State or local laws and ordinances.

5.1.2 Source Control

Source remediation and control should be considered when developing an alternative remedial strategy.

16 A Fund-Balancing ARAR waiver may be invoked at Fund-lead Superfund sites where meeting an ARAR would entail such cost in relation to the added degree of protection or reduction of risk that remedial actions at other sites would be jeopardized (EPA 1989c).

17 These recommendations are consistent with those made in Section 3.0 concerning DNAPL sites, but are applicable for any site where restoration is technically impracticable.

18 PRPs or owner/operators may propose and analyze alternative remedial strategies. However, only EPA (or designated lead agency, where appropriate) has remedy selection authority.

Sources should be located and treated or removed where feasible and where significant risk reduction will result, regardless of whether EPA has determined that ground-water restoration is technically impracticable.

In some cases, however, the inability to remove or treat sources will be a major factor in a TI decision. Where sources cannot be completely treated or removed, effective source containment may be critical to the long-term effectiveness and reliability of an alternative ground-water remedy. Options currently available for source containment usually involve either a physical barrier system (such as a slurry wall) or a hydraulic containment system (typically a pump-and-treat system) (EPA 1992b).

Applicability and effectiveness of containment systems are influenced by several hydrogeologic factors, however. For example, the effectiveness of a slurry wall generally depends on whether a continuous, low permeability layer exists at a relatively shallow depth beneath the site.

Source containment has several benefits. First, source containment will contribute to the long-term management of contaminant migration by limiting the further contamination of ground water and spread of potentially mobile sources, such as NAPLs. Second, effective source containment may permit restoration of that portion of the aqueous plume that lies outside of the containment area. Third, effective containment may facilitate the future use of new source removal technologies, as some of these technologies (e.g., surfactants, steam injection, radio frequency heating) may increase the mobility of residual and free-phase NAPLs. Remobilization of NAPLs, particularly DNAPLs, often presents a significant risk unless the source area can be reliably contained.

5.1.3 Aqueous Plume Remediation

Remediation of the aqueous plume is the third major technical concern of an alternative remedial strategy. Where the technical constraints to restoration include the inability to remove contamination sources, the ability to effectively contain those sources will be critical to establishing the objectives of plume remediation. Where sources can be effectively contained, the portion of the aqueous plume outside of the containment area generally should be restored to the required cleanup levels.

Inability to contain the sources, or other technical constraints, may render plume restoration technically impracticable. There are several options for alternative remedial strategies in such cases. These include hydraulic containment of the leading edge of the aqueous plume, establishing a less-stringent cleanup level that would be actively sought throughout the plume (at Superfund sites), and natural attenuation or natural gradient flushing of the plume.

Containment of the aqueous plume usually requires the pumping and treating of contaminated ground water, but usually involves fewer wells and smaller quantities of water than does a full plume restoration effort. Plume containment offers the potential advantages of preventing further spreading of the contaminated ground water, thereby limiting the size of the plume, and preventing the plume from encroaching on water-supply wells or discharging to ecologically sensitive areas.

At certain Superfund sites, it may be feasible to restore the contaminated plume (outside of any source containment area) to a site-specific cleanup level that is less stringent than that originally identified. EPA may establish such a level as the cleanup level within the TI zone, where appropriate. The site-specific level may consider the targeted risk level for site cleanup and other factors. Site-specific cleanup levels offer the advantage of providing a clear goal against which to measure the progress of the alternative remedial strategy. However, where site-specific cleanup levels exceed the acceptable risk range for human or environmental exposure, the remedy generally must include other measures (e.g., institutional controls) to ensure protectiveness.

At some Superfund sites, a less-stringent ARAR than the one determined to be unattainable may have to be complied with. For example, it may be technically impracticable to attain the most stringent ARAR at a site (e.g., a State requirement to restore ground water to background concentration levels). However, the next most stringent ARAR (e.g., Federal MCL) for the same compound may be attainable. In such cases, the next most stringent ARAR generally must be attained.

In certain situations where restoration is technically impracticable, EPA may choose natural attenuation as a component of the remedy for the aqueous plume.[19] Natural attenuation generally will result in

19 Technical impracticability of restoration is not a precondition for the use of natural attenuation in a ground-water remedy, however.

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4.1.4 USE OF THE DATA QUALITY OBJECTIVES (DQO) GUIDANCE

The DQO guidance (EPA 1987a,b) provides information on the review of site data and the determination of data quality needs for sampling (see the box below).

OVERVIEW OF DQO GUIDANCE

According to the DQO guidance (EPA 1987a and b), DQO are qualitative and quantitative statements established prior to data collection, which specify the quality of the data required to support Agency decisions during remedial response activities. The DQO for a particular site vary according to the end use of the data (i.e., whether the data are collected to support preliminary assessments/site inspections, remedial investigations/feasibility studies, remedial designs, or remedial actions).

The DQO process consists of three stages. In Stage 1 (Identify Decision Types), all available site information is compiled and analyzed in order to develop a conceptual model of the site that describes suspected sources, contaminant pathways, and potential receptors. The outcome of Stage 1 is a definition of the objectives of the site investigation and an identification of data gaps. Stage 2 (Identify Data Uses/Needs) involves specifying the data necessary to meet the objectives set in Stage 1, selecting the sampling approaches and the analytical options for the site, and evaluating multiple-option approaches to allow more timely or cost-effective data collection and evaluation. In Stage 3 (Design Data Collection Program), the methods to be used to obtain data of acceptable quality are specified in such products as the SAP or the workplan.

Use of this guidance will help ensure that all environmental data collected in support of RI/FS activities are of known and documented quality.

4.1.5 OTHER DATA CONCERNS

The simple existence of a data collection plan does not guarantee usable data. The risk assessor should plan an active role in oversight of data collection to ensure that relevant data have been obtained. (See Section 4.9 for more information on the active role that the risk assessor must play.)

After data have been collected, they should be carefully reviewed to identify reliable, accurate, and verifiable numbers that can be used to quantify risks. All analytical data must be evaluated to identify the chemicals of potential concern (i.e., those to be carried through the risk assessment). Chapter 5 discusses the criteria to be considered in selecting the subset of chemical data appropriate for baseline risk assessment. Data that do not meet the criteria are not included in the quantitative risk assessment; they can be discussed qualitatively in the risk assessment report, however, or may be the basis for further investigation.

4.2 REVIEW OF AVAILABLE SITE INFORMATION

Available site information must be reviewed to (1) determine basic site characteristics, (2) initially identify potential exposure pathways and exposure points, and (3) help determine data needs (including modeling needs). All available site information (i.e., information existing at the start of the RI/FS) should be reviewed in accordance with Stage 1 of the DQO process. Sources of available site information include:

- RI/FS scoping information;
- PA/SI data and Hazard Ranking System (HRS) documentation;
- listing site inspection (LSI) data (formally referred to as expanded site inspection, or ESI);
- photographs (e.g., EPA's Environmental Photographic Interpretation Center [EPIC]);
- records on removal actions taken at the site; and
- information on amounts of hazardous substances disposed (e.g., from site records).

If available, LSI (or ESI) data are especially useful because they represent fairly extensive site studies.

Based on a review of the existing data, the risk assessor should formulate a conceptual model of the site that identifies all potential or suspected sources of contamination, types and concentrations of contaminants detected at the site, potentially contaminated media, and potential exposure pathways, including receptors (see Exhibit 4-1). As

discussed previously, identification of potential exposure pathways, especially the exposure points, is a key element in the determination of data needs for the risk assessment. Details concerning development of a conceptual model for a site are provided in the DQO guidance (EPA 1987a,b) and the RI/FS guidance (EPA 1988a).

In most cases, site information available at the start of the RI/FS is insufficient to fully characterize the site and the potential exposure pathways. The conceptual model developed at this stage should be adequate to determine the remaining data needs. The remainder of this chapter addresses risk assessment data needs in detail.

4.3 ADDRESSING MODELING PARAMETER NEEDS

As discussed in detail in Chapter 6, contaminant release, transport, and fate models are often needed to supplement monitoring data when estimating exposure concentrations. Therefore, a preliminary site modeling strategy should be developed during RI/FS scoping to allow model input data requirements to be incorporated into the data collection requirements. This preliminary identification of models and other related data requirements will ensure that data for model calibration and validation are collected along with other physical and chemical data at the site. Exhibit 4-2 lists (by medium) several site-specific parameters often needed to incorporate fate and transport models in risk assessments.

Although default values for some modeling parameters are available, it is preferable to obtain site-specific values for as many input parameters as is feasible. If the model is not sensitive to a particular parameter for which a default value is available, then a default value may be used. Similarly, default values may be used if obtaining the site-specific model parameter would be too time consuming or expensive. For example, certain airborne dust emission models use a default value for the average wind speed at the site; this is done because representative measurements of wind speed at the site would involve significant amounts of time (i.e., samples would have to be collected over a large part of the year).

Some model parameters are needed only if the sampling conducted at a site is sufficient to support complex models. Such model parameters may not be necessary if only simple fate and transport models are used in the risk assessment.

4.4 DEFINING BACKGROUND SAMPLING NEEDS

Background sampling is conducted to distinguish site-related contamination from naturally occurring or other non-site-related levels of chemicals. The following subsections define the types of background contamination and provide guidance on the appropriate location and number of background samples.

4.4.1 TYPES OF BACKGROUND

There are two different types of background levels of chemicals:

(1) naturally occurring levels, which are ambient concentrations of chemicals present in the environment that have not been influenced by humans (e.g., aluminum, manganese); and

(2) anthropogenic levels, which are concentrations of chemicals that are present in the environment due to human-made, non-site sources (e.g., industry, automobiles).

Background can range from localized to ubiquitous. For example, pesticides -- most of which are not naturally occurring (anthropogenic) -- may be ubiquitous in certain areas (e.g., agricultural areas); salt runoff from roads during periods of snow may contribute high ubiquitous levels of sodium. Polycyclic aromatic hydrocarbons (PAHs) and lead are other examples of anthropogenic, ubiquitous chemicals, although these chemicals also may be present at naturally occurring levels in the environment due to natural sources (e.g., forest fires may be a source of PAHs, and lead is a natural component of soils in some areas).

EXHIBIT 4-1
ELEMENTS OF A CONCEPTUAL EVALUATION MODEL

	VARIABLES	HYPOTHESES TO BE TESTED
SOURCES	• CONTAMINANTS • CONCENTRATIONS • TIME • LOCATIONS	• SOURCE EXISTS • SOURCE CAN BE CONTAINED • SOURCE CAN BE REMOVED AND DISPOSED • SOURCE CAN BE TREATED
PATHWAYS	• MEDIA • RATES OF MIGRATION • TIME • LOSS AND GAIN FUNCTIONS	• PATHWAY EXISTS • PATHWAY CAN BE INTERRUPTED • PATHWAY CAN BE ELIMINATED
RECEPTORS	• TYPES • SENSITIVITIES • TIME • CONCENTRATIONS • NUMBERS	• RECEPTOR IS NOT IMPACTED BY MIGRATION OF CONTAMINANTS • RECEPTOR CAN BE RELOCATED • INSTITUTIONAL CONTROLS CAN BE APPLIED • RECEPTOR CAN BE PROTECTED