Superfund
Residential Lead Sites Handbook

Office of Superfund Remediation and Technology Innovation

U.S. Environmental Protection Agency

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Disclaimer

The document provides technical guidance to U.S. Environmental Protection Agency (EPA) staff for sites contaminated with lead (Pb). The document is designed to implement national policy regarding the characterization and cleanups of lead contaminated sites. This document does not substitute for EPA's statutes or regulations, nor is it a regulation. Thus, it cannot impose legally binding requirements on EPA, states, or the regulated community, and may not apply to a specific situation based upon the circumstances. EPA recognizes that there may be certain cases where site information and professional judgment may provide sufficient rationale to deviate from the recommendations described herein. EPA may change this document in the future, as appropriate. Any decisions regarding a specific situation are expected to be made based on site-specific factors considering EPA guidance, applicable statutes, and the regulations.

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Table of Contents

List of Tables

List of Figures

List of Acronyms

AALM	All Ages Lead Model
ABA	Absolute Bioavailability
ACCLPP	Advisory Committee on Childhood Lead Poisoning Prevention
ALM	Adult Lead Methodology
ARAR	Applicable or Relevant and Appropriate Requirement
ASAOC	Administrative Settlement Agreement and Order on Consent
ATSDR	Agency for Toxic Substances and Disease Registry
AWA	Area Weighted Average
bgs	Below Ground Surface
BLL	Blood Lead Level
BMP	Best Management Practice
BRAC	Base Realignment and Closure
BTV	Background Threshold Value
CAA	Clean Air Act
CAG	Community Advisory Group
CD	Consent Decree
CDC	U.S. Centers for Disease Control and Prevention
CEC	Cation Exchange Capacity
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CIC	Community Involvement Coordinator
CIP	Community Involvement Plan
cm	Centimeters
COPC	Contaminant of Potential Concern
CSM	Conceptual Site Model
CWA	Clean Water Act
dL	Deciliter
DOD	U.S. Department of Defense
DQO	Data Quality Objective
DU	Decision Unit
EC	Engineering Control
EDX	Energy Dispersive X-Ray
EJ	Environmental Justice
EJCPS	Environmental Justice Collaborative Problem Solving

EJSCREEN	Environmental Justice Screening
EMPA	Electron Micro Probe Analysis
EO	Executive Order
EPA	U.S. Environmental Protection Agency
EPC	Exposure Point Concentration
ESD	Explanation of Significant Differences
EU	Exposure Unit
FDA	U.S. Food and Drug Administration
FLAA	Flame Atomic Absorption
FOSET	Finding of Suitability to Early Transfer
FOST	Finding of Suitability to Transfer
FP-XRF	Field-Portable X-Ray Fluorescence
FYR	Five-Year Review
g/day	Grams per Day
GFAA	Graphite Furnace Atomic Absorption
GIS	Geographic Information System
GSD	Geometric Standard Deviation
HASP	Health and Safety Plan
HDOH	Hawaii Department of Health
HEPA	High-Efficiency Particulate Air
HHRA	Human Health Risk Assessment
HIPAA	Health Insurance Portability and Accountability Act
HRS	Hazard Ranking System
HUD	U.S. Department of Housing and Urban Development
IC	Institutional Control
ICIAP	Institutional Control Implementation and Assurance Plan
ICP-AES	Inductively Coupled Plasma-Atomic Emission Spectrometry
ICP-MS	Inductively Coupled Plasma-Mass Spectrometry
ICP-QMS	Inductively Coupled Plasma-Quadrupole Mass Spectrometry
ICP-SFMS	Inductively Coupled Plasma-Sector-Field-Mass Spectrometry
ICP-TOF-MS	Inductively Coupled Plasma-Time-of-Flight-Mass Spectrometry
ICS	Incremental Composite Sampling
IEUBK	Integrated Exposure Uptake Biokinetic Model
IQ	Intelligence Quotient
ISM	Incremental Sampling Methodology
ITRC	Interstate Technology and Regulatory Council

IVBA	*In Vitro* Bioaccessibility
kg	Kilogram
LBP	Lead-Based Paint
LCF	Linear Combination Fitting
LCR	Lead and Copper Rule
LEP	Limited English Proficiency
MCS	Media Cleanup Standard
mg/g	Milligram per Gram
mg/kg	Milligram per Kilogram
µg	Microgram
µg PB/g	Micrograms of Lead per Gram
µm	Micrometer
mm	Millimeter
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NDAA	National Defense Authorization Act
NEJAC	National Environmental Justice Advisory Council
NFRAP	No Further Remedial Action Planned
NHANES	National Health and Nutrition Examination Survey
NIST	National Institute of standards and Technology
NPL	National Priorities List
NTCRA	Non-Time-Critical Removal Action
NTE	Not to Exceed
O&M	Operation and Maintenance
OLEM	Office of Land and Emergency Management
ORC	Office of Regional Counsel
ORD	Office of Research and Development
OSC	On-Scene Coordinator
OSRTI	Office of Superfund Remediation and Technology Innovation
OSWER	Office of Solid Waste and Emergency Response (Now OLEM)
PAH	Polycyclic Aromatic Hydrocarbon
Pb	Lead
PbB	Blood Lead Concentration
PCB	Polychlorinated Biphenyl
PEHSU	Pediatric Environmental Health Specialty Unit
PIME	Planning, Implementing, Maintaining, and Enforcing
POLREP	Pollution Report

ppm	Parts per Million
PRG	Preliminary Remediation Goal
PRP	Potentially Responsible Party
PRSC	Post Removal Site Control
QAPP	Quality Assurance Project Plan
RA	Remedial Action
RAL	Remedial Action Level
RAO	Remedial Action Objective
RBA	Relative Bioavailability
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
RI/FS	Remedial Investigation/Feasibility Study
RML	Removal Management Level
ROD	Record of Decision
RPM	Remedial Project Manager
RRP	Renovation, Repair, and Painting
RSL	Regional Screening Level
SALT	Strategy, Action, and Learning, and Supported by Tools
SAM	Site Assessment Manager
SAP	Sampling and Analysis Plan
SAR	Sodium Absorption Ratio
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SEM	Scanning Electron Microscopy
soilSHOP	Soil Screening, Health, Outreach, and Partnership
SOP	Standard Operating Procedure
SRM	Standard Reference Material
SRP	Superfund Redevelopment Program
STL	Superfund Technical Liaison
SU	Sampling Unit
SVOC	Semi-Volatile Organic Compound
TAG	Technical Assistance Grant
TANA	Technical Assistance Needs Assessment
TAP	Technical Assistance Plan
TASC	Technical Assistance Services for Communities
TBC	To Be Considered

TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TCRA	Time-Critical Removal Action
TEM	Transmission Electron Microscopy
TI-MS	Thermal Ionization-Mass Spectrometry
TKN	Total Kjeldahl Nitrogen
TRW	Technical Review Workgroup
TSCA	Toxic Substances Control Act
UAO	Unilateral Administrative Order
UCL	Upper Confidence Limit
UECA	Uniform Environmental Covenants Act
U.S.	United States
USGS	United States Geological Survey
UU/UE	Unlimited Use/Unrestricted Exposure
VOC	Volatile Organic Compound
WDX	Wavelength Dispersive X-ray Analysis
WIC	Women, Infants, and Children
WIIN	Water Infrastructure Improvements for the Nation
XANES	Fitting X-Ray Absorption Near Edge Structure
XAS	X-Ray Absorption Spectroscopy
XRF	X-Ray Fluorescence
<	Less Than
>	Greater Than

CHAPTER 1
Introduction

1.1 Purpose

The United States (U.S.) Environmental Protection Agency (EPA) developed this Handbook to promote national consistency when assessing and managing risks associated with lead-contaminated residential sites under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as Superfund. This is an update to the *Superfund Lead-Contaminated Residential Sites Handbook*, August 2003 (U.S. EPA 2003a), reflecting best practices, guidance, and policy for lead site characterizations, risk assessments, and risk management.[1]

The primary audiences for this Handbook are Superfund Remedial Project Managers (RPMs), On-Scene Coordinators (OSCs), risk assessors, and Community Involvement Coordinators (CICs) working on site characterization, cleanup of lead-contaminated residential sites, and communication with communities. However, it may also be applicable to Resource Conservation and Recovery Act (RCRA) project managers, state and local governments, other federal agencies, tribes, public interest groups, private industry, or anyone evaluating and addressing lead-contaminated residential sites.

The purpose of this Handbook is to:

- Provide insight on site assessment, characterization, community involvement, and health education;
- Describe approaches used in risk assessment and risk management at lead-contaminated residential Superfund sites; and
- Discuss approaches for reducing human health risks related to exposure to site contamination.

This Handbook encourages best practices in the characterization and cleanup of lead-contaminated residential sites, while retaining the flexibility needed to address community

[1] Although this Handbook supersedes the 2003 *Superfund Lead-Contaminated Residential Sites Handbook*, it does not supersede or modify any other existing EPA guidance or policy, nor does it suggest that CERCLA authorities are to be applied at all lead-contaminated residential sites. Rather, these references are provided to the reader as resources to be considered in developing site characterization and cleanup strategies under whatever regulatory or non-regulatory approach is appropriate at a site. However, the National Oil and Hazardous Substances Pollution Contingency Plan (National Contingency Plan or NCP) should be followed, and other applicable guidance should be consulted when addressing lead-contaminated residential sites under CERCLA.

needs and site-specific variables. In all cases, reviewing and understanding the site history (*e.g.*, type of lead site, mode of lead deposition, fill activities, previous disease surveillance) is necessary when characterizing a site.

Generally, CERCLA response[2] actions are undertaken to address a release, or the threat of a release, of a hazardous substance, pollutant, or contaminant, such as lead, into the environment that presents, or may present, an unacceptable risk to human health or the environment. EPA notes: “When the PRG *(preliminary remediation goal)* or MCS *(media cleanup standard for RCRA)* is exceeded, remedial action (RA) is generally recommended” (U.S. EPA 1994a).

Lead contamination found inside homes may be caused by deteriorating lead-based paint (LBP), plumbing, or other sources not resulting from a release into the environment, and may therefore be more appropriately addressed by authorities and programs other than CERCLA.[3] In some situations, it may be appropriate to use CERCLA authorities to conduct sampling and site characterization activities to determine the source of the lead contamination, differentiate between various site-related sources, and help determine if action under CERCLA may be the appropriate authority to use to address unacceptable risk.

Lead-contaminated sites may also contain other metals such as zinc, cadmium, and arsenic. This Handbook, while primarily focused on addressing lead contamination, may also be appropriate for use in the characterization and assessment of risk at sites contaminated with other metals. Typically, this Handbook addresses sites where lead contamination has resulted predominantly from primary or secondary lead smelting, battery cracking, mining and milling operations, and other industrial/commercial releases of lead to the environment. Lead and other potentially toxic metals originating from paint and dust, along with other sources of lead and other toxic metals, may also be present in various media at these sites; however, these additional sources may be excluded from response actions under CERCLA by regulatory or policy exclusions. Refer to Chapter 2 for additional information on CERCLA response limitations.

Residential properties are defined in this Handbook as any area with high or unrestricted accessibility to sensitive populations (*e.g.*, young children less than [<] 7 years old), and includes, but is not limited to, properties containing single- and multi-family dwellings,

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[2] CERCLA response actions encompass removal and remedial response activities; see 42 U.S.C. § 9601(25) for more information.

[3] Lead contamination found outside of homes and throughout communities may also be from a variety of sources, including historic deposition from burning of lead-containing fuels or industrial sources such as mining, manufacturing, and poor waste management practices.

apartment complexes, vacant lots in residential areas, schools, daycare centers, community centers, playgrounds, parks and other recreational areas, green ways, and any other areas where young children may be exposed to site-related contaminated media (U.S. EPA 1998, 1997a, 1996a). This Handbook defines sensitive populations as young children under 7 years of age because they are the most sensitive receptor for residential land use areas. That is, children <7 years of age are the most vulnerable to lead poisoning and have the greatest exposure because of their relatively small body mass (U.S. EPA 2024, CDC 2012, 2005, U.S. EPA 1990a, 1986) and the sensitivity of the developing nervous system to the effects of lead (U.S. EPA 2024, CDC 2012). Lead response efforts for residential sites under CERCLA are based on protecting the most sensitive receptor and thereby protect all other residents in the process (including older children, pregnant women, and other adults). For other sites, the most sensitive receptor is the fetus of pregnant women (U.S. EPA 2003b). Other EPA guidance (U.S. EPA 2001a, 1995a) and local zoning regulations should also be consulted to determine which properties may be considered as potential or future residential properties or present other unique exposure risks.

1.2 Scope

The scope of this Handbook is limited to addressing soil lead contamination at residential sites that may result in unacceptable blood lead levels (BLLs) in sensitive populations. This Handbook describes some of the key considerations for assessing and addressing soil lead contamination at residential CERCLA and RCRA corrective action sites and encourages users to refer to supplemental guidance and/or policies to consider site-specific factors as warranted.

This Handbook does not address:

- Carcinogenic risk;
- Risks associated with the inhalation of lead in ambient air;
- Ecological risks from lead and lead sites;
- Non-residential Superfund site scenarios; or
- Preliminary assessment/site inspection activities.[4]

[4] EPA recommends consideration of this Technical Guide when undertaking removal actions, remedial actions, pre-remedial investigations, remedial investigations*, and five-year reviews (FYRs) and selecting remedies under CERCLA. *CERCLA authorizes the EPA to identify and prioritize which sites warrant further investigation to ascertain whether remedial action is needed. The Hazard Ranking System (HRS) is the statutorily required method for evaluating and identifying sites for placement on the National Priorities List (NPL).

This Handbook does not, outside of the scope of the CERCLA response, apply to lead-contaminated residential sites addressed under Title 24, Part 35 (HUD 2004). References are provided to the reader as resources to be considered in developing site characterization and cleanup strategies under whatever regulatory or non-regulatory approach is appropriate at a particular site.

Although this Handbook does not specifically address non-residential areas (*e.g.*, lead-contaminated commercial or industrial properties) or sites where ecological risks are the primary concern, general concepts and practices outlined in this Handbook may be useful when assessing exposure to lead at such properties or if redevelopment could result in residential land use. This Handbook also provides information applicable to assessing risk for non-residential land use areas where children spend time (*e.g.*, parks, playgrounds, schools, beaches, water bodies).

For clarification of terms used throughout this Handbook, refer to Appendix A.

1.3 Overview of Document

Chapter	Overview of Contents
Chapter 1 – Introduction	Provides the purpose and scope of this Handbook
Chapter 2 – Background and Authorities	Provides background information on lead and CERCLA's authority and limitations when dealing with lead contamination at a Superfund site
Chapter 3 – Superfund Site Team and Collaboration	Provides information on the EPA Site Team and collaboration to address multiple sources of lead contamination and facilitate health education
Chapter 4 – Overview of Community Involvement	Provides information on community involvement activities and resources available to the project team
Chapter 5 – Health Education	Provides information on public health education and the Agency for Toxic Substances and Disease Registry (ATSDR)
Chapter 6 – Site Characterization	Provides information on sampling access, methods, units, preparation, and analysis
Chapter 7 – Source Attribution for Lead Contamination at Superfund Sites	Provides information on source attribution techniques that may be used at sites
Chapter 8 – Residential Lead Risk Assessments	Provides information on data evaluation, exposure assessments, calculating an exposure point soil lead concentration, the Integrated Exposure Uptake Biokinetic (IEUBK) Model and its limitations, toxicity assessment, and risk characterization

Chapter	Overview of Contents
Chapter 9– Implementation of Cleanup Level Selection	Provides information on selecting cleanup levels, PRGs, prioritizing response actions, yard cleanup specifics, application of cleanup numbers and remediation, and other cleanup considerations including background lead concentrations and prevention of recontamination
Chapter 10 – Institutional Controls and Reuse	Provides information on land use controls including engineering controls (ECs) and institutional controls (ICs), such as types of ICs and returning sites to safe reuse
Chapter 11 – Five-Year Reviews for Superfund Sites	Provides information on the Five-Year Review (FYR) process to determine if the remedy is, or will be, protective of human health and the environment
Chapter 12 – Federal Facilities	Provides information on assessing lead risk at federal facility sites
Chapter 13 – Cleanup Documentation	Provides information on providing a 'clean' letter to the property owner
Chapter 14 – Access and Enforcement Considerations	Provides information on gaining access and response actions
Chapter 15 – References	Provides full citations for references cited throughout this Handbook

CHAPTER 2
Background and Authorities

2.1 Lead in the Environment

Lead is present in the environment from both naturally occurring sources and anthropogenic activities and can present an unacceptable risk to human health primarily via ingestion. Young children (<7 years of age) are particularly susceptible to health impacts from lead exposures.

Throughout human history, lead has been mined, smelted, refined, and used in many products (*e.g.*, as an additive in paint, gasoline, pottery, water pipes, solder, crystal, and ceramics). These activities have resulted in substantial increases in lead levels in individuals and in the environment, especially near mining and smelting sites (Patterson et al. 1991, Chaney et al. 1984, Shacklette and Boerngen 1984).

Lead in the environment does not decompose. Lead compounds may be transformed in the environment to other lead compounds; however, lead is an element and cannot be destroyed. Because lead does not decompose, these former uses leave their legacy as higher concentrations of lead in the environment.

Lead particles in the environment can be a substantial constituent of dust and can travel long distances in the air. These lead-containing dust particles may also be removed from the air by rain and then deposited on surface soil, where they may remain for many years and where they can further migrate to surface water. In addition, heavy rains may cause lead in surface soil to migrate into groundwater and eventually into water systems.

Since the 1970s, lead concentrations in exposure media and national BLLs have decreased as a result of efforts to reduce the use of lead in fuel, reduced emissions associated with smelters, reduced mining, banned use of LBP in households, and decreased use of lead-based printing inks in food packaging materials[5] (Egan et al. 2021).

Residential lead site characterization and cleanup procedures are unique from a risk assessment standpoint as the principal effect of lead exposure is neurologic impairment of young children (including impacts to intelligence quotient [IQ]). There is no known threshold level of lead exposure that is not harmful to the neurological system (U.S. EPA 2024, CDC 2012). See Section 8.7 for more information.

[5] https://www.cdc.gov/nchs/nhanes/index.htm.

In general, lead risks to young children are characterized by predicting blood lead concentrations with computer models and are also based on guidance developed by EPA that is available at http://www.epa.gov/superfund/lead-superfund-sites-guidance. See Sections 8.5 and 8.6 for more information.

2.2 Overview of Policies, Laws, and Regulations

This section is designed to provide EPA RPMs and OSCs with a description of important authorities to help better understand EPA directives, policies, and regulations related to lead risk assessment and remediation. Additional information regarding federal laws is available online at http://www.epa.gov/lead/lead-laws-and-regulations. For state and tribal considerations, OSCs and RPMs are encouraged to refer to appropriate state and tribal sources of information related to site-specific exposure assumptions, regulations, and guidance that may inform the response decision.

2.2.1 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

Enacted in 1980, CERCLA has provided response authority for site assessments and cleanups at numerous releases across the United States.[6] CERCLA authorities have been used for responses ranging from the removal of drums of hazardous substances, pollutants, and/or contaminants at long-abandoned sites to large-scale responses at sites on the National Priorities List (NPL) (NRC 2005, SARA 1986,[7] CERCLA 1980[8]). Depending on site-specific circumstances, CERCLA response authority allows EPA to address a wide variety of releases to air, surface water, sediment, groundwater, and soil.

CERCLA authorities address a release or threatened release of a hazardous substance or pollutant or contaminant into the environment (U.S. EPA 2000a, SARA 1986, CERCLA 1980). "Release" may include spilling, discharging, emitting, or leaking into the environment, and may also include the abandonment of closed containers containing hazardous substances, pollutants, or contaminants.[9] "Hazardous substance" and "pollutant or contaminant" are defined at CERCLA Section 101(14) and 101(33), respectively.[10] CERCLA's broad response

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[6] http://www.epa.gov/superfund/superfund-cercla-overview.

[7] Superfund Amendments and Reauthorization Act of 1986, Pub. L. No. 99-499, 100 Stat. 1613-1782 (1986).

[8] Comprehensive Environmental Response, Compensation and Liability Act of 1980, Pub. L. No. 96-510, 94 Stat. 2767 (1980).

[9] See CERCLA 101(22) for full definition of "release."

[10] http://www.epa.gov/laws-regulations/summary-comprehensive-environmental-response-compensation-and-liability-act.

authorities make it possible to conduct environmental assessments and site cleanups utilizing CERCLA response authorities.

CERCLA provides EPA with the authority to perform “removal” and “remedial” actions. Removal Site Evaluations evaluate risk for contaminants of concern, exposure pathways, and potential receptors. If a site meets the criteria in 40 Code of Federal Regulations (CFR) 300.415(b)(2), a removal action may be appropriate. Removal actions can be performed on mining and mineral processing (primary lead and other metal smelters) sites, and other sites with lead releases to the environment, of any size. Removal actions, both time-critical and non-time critical, can be performed on lead releases to the environment.[11] Once a determination is made to conduct a removal action, there are two types of removal actions that are commonly performed at residential lead properties/sites: Time Critical Removal Actions (TCRA) or Non-Time Critical Removal Actions (NTCRA). The primary difference is the time sensitivity of the action and the associated evaluation and community relations requirements. All fund-lead removals, TCRAs and NTCRAs alike, are subject to $2 million or 12-month statutory limitations, though the National Oil and Hazardous Substances Pollution Contingency Plan (National Contingency Plan or NCP) outlines two exemptions to the $2 million/12-month limitations.[12] Both TCRA and NTCRA authorities may be utilized regardless of the NPL site status.[13] Additionally, both TCRAs and NTCRAs can be used in conjunction with remedial action. For example, removal authority may be appropriately used to address areas that pose significant risks or act as contamination sources while remedial authority would be used to select a final, comprehensive response.

Remedial actions are typically long-term responses performed at those sites placed on the NPL or being addressed through remedial authorities on non-NPL sites (such as Superfund Alternative Approach sites). Remedial actions are not subject to the time or dollar limitations imposed on removal actions but require a more detailed and formal decision process. Under these conditions, EPA’s cleanup decisions are generally based upon a risk assessment, risk management decisions, and consideration of Applicable or Relevant and Appropriate Requirements (ARARs). CERCLA response actions can be conducted by EPA, states, tribes, or other federal agencies (Section 104), or federal agencies may enter into agreements with private parties (Section 122) or require private parties (Section 106) to perform such cleanup activities. CERCLA provides the flexibility to assess and clean up releases based upon site-

[11] NCP 300.415.
[12] NCP 300.415(b)(5).
[13] NCP 300.425(b)(1).

specific circumstances. There are also limitations to CERCLA response actions as discussed in the next section.

2.2.1.1 CERCLA Limitations

There are potential limitations in CERCLA that may be relevant to lead-contaminated sites. For example, Section 104(a)(3) limits EPA's ability to respond to releases within residential structures as follows:

> "Limitations on Response. The President shall not provide for removal or remedial action under this section in response to a release or threat of release from products which are part of the structure of, and result in exposure within, residential buildings or business or community structures..."

The above cited section of CERCLA generally limits the authority of EPA/Office of Land and Emergency Management (OLEM) to respond to LBP inside a structure or house. However, as noted in Chapter 6, EPA may have the authority to conduct response actions addressing soils contaminated by a release of lead-contaminated paint chips from the exterior of homes to prevent recontamination of soils that have been remediated. In addition, Section 104(a)(4) provides an exception to the limitations in Section 104(a)(3) and states, "notwithstanding 104(a)(3)…, to the extent authorized by this section, the President may respond to any release or threat of release if in the President's discretion, it constitutes a public health or environmental emergency and no other person with the authority and capability to respond to the emergency will do so in a timely manner." Refer to to EPA's guidance, *Response Actions at Sites with Contamination Inside Buildings*,[14] for additional information (U.S. EPA 1993).

2.2.2 Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Criteria

Under Section 121(d) of CERCLA, remedial actions must comply with substantive provisions of federal environmental laws and more stringent, timely-identified, state environmental or facility siting laws. Removal actions should comply with ARARs to the extent practicable considering the exigencies of the situation, while remedial actions must comply with ARARs unless waived. "Applicable" requirements are those federal or state laws or regulations that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA release. "Relevant and appropriate" requirements are not "applicable," but address problems or situations similar enough to those at the CERCLA

[14] https://semspub.epa.gov/work/HQ/123627.pdf.

release that their use is well suited at the release (refer to EPA's guidance on ARAR requirements).[15] Whether a law or regulation is an ARAR for a particular site is a site-specific decision.

The Toxic Substances Control Act (TSCA) Section 403 Soil-Lead Hazard Rule from 2001 establishes a soil-lead hazard of 400 parts per million (ppm) for bare soil in play areas and 1,200 ppm for bare soil in non-play areas of the yard. Section 403 standards provide generic levels that can be used at thousands of widely varying sites across the nation. The site-specific characterization of releases that are conducted at CERCLA and RCRA sites allow for development of action levels that are tailored to the individual release, exposure, and risk. Therefore, while TSCA Section 403 may be identified as an ARAR for some CERCLA response actions where it would help inform a CERCLA acceptable risk level, for protectiveness purposes on a site-specific basis, response actions may go further than the Section 403 rule.

State requirements may be ARARs if they meet several criteria including that they be health based, applied consistently, promulgated and enforceable, identified in a timely manner, and more stringent than federal requirements.[16] See also 40 CFR 300.5 and CERCLA 121(d)(2) for the NCP definitions of "applicable" and "relevant and appropriate." States may have carcinogenic and toxicity values for lead that could be considered when assessing lead sites. Such values may constitute a to-be-considered (TBC) guidance under 40 CFR 300.400(g)(3). A state might also have laws or promulgated regulations that establish a protective value for lead that could constitute an ARAR that under CERCLA would either need to be met or waived in accordance with the NCP. This information is evaluated on a site-specific basis.

More information on ARARs is provided in the *CERCLA Compliance with Other Laws Manual*, Part I, August 1988, and Part II, August 1989 (U.S. EPA 1989a, 1988a) and in U.S. EPA (2023a). Consultations with appropriate program offices and the Office of Regional Counsel (ORC) will help ensure that the most current regulations are considered.

In addition to ARARs, the lead and support agencies involved in assessing and addressing Superfund sites may identify other advisories, criteria, or guidance that were developed by EPA, other federal agencies, or states to be considered relevant for a particular release. These

[15] https://www.epa.gov/superfund/applicable-or-relevant-and-appropriate-requirements-arars.

[16] See U.S. EPA (2023a), OLEM Directive 9234.0-07 *Documenting Applicable, or Relevant and Appropriate Requirements in Comprehensive Environmental Response, Compensation, and Liability Act Response Action Decisions* at https://semspub.epa.gov/work/HQ/100003232.pdf.

comprise the TBC category, which may be used to inform remedy selection (U.S. EPA 2017a). For more information, see 40 CFR § 300.400(g)(3).

2.2.3 Superfund Lead Directives

EPA has developed the following lead directives for addressing lead contamination in soils at CERCLA and RCRA sites.

EPA Directive 9355.4-12, *Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities* (Office of Solid Waste and Emergency Response [OSWER]) (U.S. EPA 1994a), established EPA's approach for addressing lead in soil at CERCLA and RCRA sites. The 1994 Directive states that, "OSWER (OLEM) will attempt to limit exposure to soil lead levels such that a typical (or hypothetical) child or group of similarly exposed young children would have an estimated risk of no more than 5% probability of exceeding a 10 microgram per deciliter (µg/dL) blood-lead level" (U.S. EPA 1994a). Refer to Appendix B for the 1994 Directive.

In 1998, EPA clarified the 1994 Directive through Directive 9200.4-27P ("Clarification") (U.S. EPA 1998), recommending that the Integrated Exposure Uptake Biokinetic (IEUBK) model be used as the primary tool to generate risk-based soil cleanup levels at lead sites for current and future residential use. Additionally, the 1998 clarification states that response actions can be taken using the IEUBK predictions alone, and that blood lead studies, while providing useful information, should not be used <u>alone</u> either to assess risk from lead exposure or to develop soil lead cleanup levels (U.S. EPA 1998). EPA recommends that risk assessments conducted at lead-contaminated residential sites use the individual residence as the primary exposure unit (EU) of concern. Refer to Appendix C for the 1998 Directive.

In 2024, EPA updated the residential soil screening levels and EPA's approach for reducing lead exposures at CERCLA sites and RCRA Corrective Action Facilities in a manner consistent with the best available science (Breen 2024).

2.3 Other Acts, Rules, and Regulations Regarding Lead Contamination

The substantive portions of federal statutes that may constitute ARARs on a site-specific basis include, but are not limited to:

- Resource Conservation and Recovery Act (RCRA);[17]
- Clean Air Act (CAA);[18]
- Clean Water Act (CWA);[19]
- Safe Drinking Water Act (SDWA);[20]
- Reduction of Lead in Drinking Water Act;[21]
- Lead and Copper Rule;[22] and
- TSCA Subchapter IV Lead Program.[23]

2.4 Other Superfund Resources on Lead

In addition, supplemental guidance and technical support are available through the Technical Review Workgroup (TRW) Lead Committee website at: https://www.epa.gov/superfund/lead-superfund-sites.

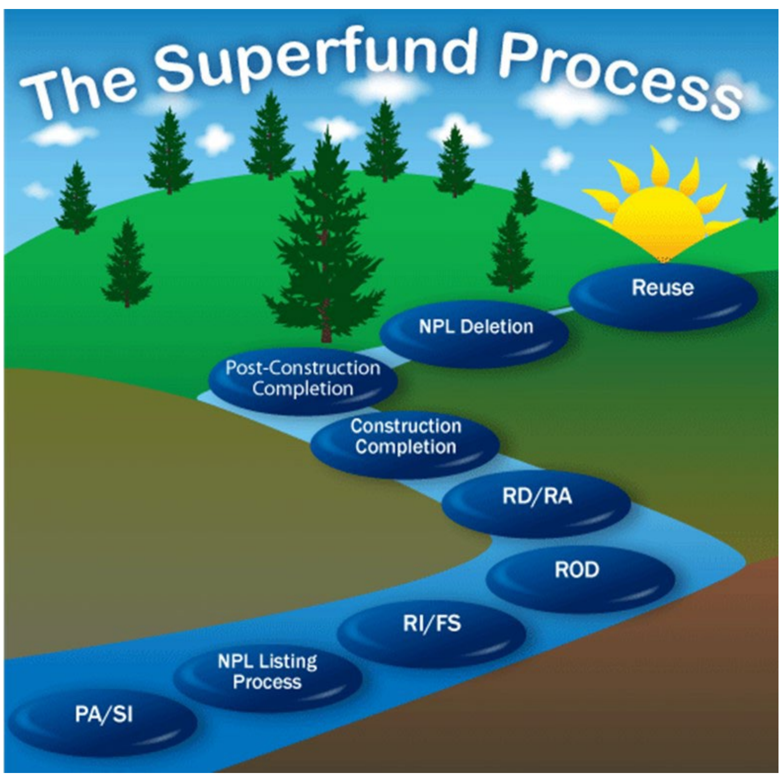
[17] http://www.epa.gov/rcra.
[18] http://www.epa.gov/air/caa/.
[19] http://www.epa.gov/laws-regulations/summary-clean-water-act.
[20] http://www.epa.gov/laws-regulations/summary-safe-drinking-water-act.
[21] https://www.gpo.gov/fdsys/pkg/BILLS-111s3874enr/pdf/BILLS-111s3874enr.pdf.
[22] http://water.epa.gov/lawsregs/rulesregs/sdwa/lcr/.
[23] http://www.epa.gov/enforcement/toxic-substances-control-act-tsca-and-federal-facilities.

CHAPTER 3
Superfund Site Team and Collaboration

3.1 Superfund Site Team

The composition of the Superfund site team varies depending on the type of response and the complexity of the site. Site team members may include (but are not limited to) RPMs, OSCs, site assessment managers (SAM), geologists, toxicologists/risk assessors, CICs, environmental justice coordinators, public affairs staff (including press officers), site attorneys and other enforcement staff, and relevant state, territorial or tribal representatives. The composition of a Superfund site team may vary over time due to the specific needs of each phase of the cleanup process[24] (Figure 3-1). For example, the initial CERCLA process involves identifying and assessing sites that would require SAM expertise, and a site undergoing remedial investigation may require various technical experts to design and implement sampling programs such as quality assurance specialists and sampling design experts. As that same site moves into construction, it may be important to add team members with construction oversight and construction health and safety expertise to the team.

Figure 3-1. The Superfund Process



[24] https://www.epa.gov/superfund/superfund-cleanup-process.

When the site is large and cleanup is expected to last years, the program may want to consider having multiple CICs or locating a full-time CIC at the site, if feasible. The roles of the CIC are to plan, coordinate, and conduct community involvement activities and to be accessible to the public to provide information and answer questions concerning site activities. Community involvement activities include working with internal team members and external partners to vet consistent messaging, developing written and online materials, establishing a social media presence, regularly updating the project webpage, designing public meetings and workshops, and more. The CIC should be intimately familiar with all activities at the site and should advise the rest of the site team on community information and local knowledge that may impact decisions, as well as on appropriate communications and outreach to the community.

Additionally, at residential Superfund sites where lead is a risk driver and there may be multiple sources of lead, it is important that Superfund site teams work in a collaborative manner with communities. This can be achieved by ensuring that there is a regional EPA employee (or employees) who acts as a Convener. The Convener ensures that the site team is coordinating with other EPA programs and other agencies (*e.g.*, federal, state, etc.) to identify and address sources of lead beyond releases being addressed under CERCLA authority and communicating consistent community goals and messages. Close coordination among EPA programs and other agencies is critically important at these complex sites and EPA staff can oftentimes act in a convener role to help communities at Superfund sites to leverage all available resources that might benefit them (U.S. EPA 2020a). Community Involvement is discussed further in Chapter 4.

There may be many site- and Region-specific factors to consider when determining whether EPA should fill a convener role. Due to the nature of the convenor role, it may be helpful to take advantage of regional employees already in cross-cutting positions in the Region to draw on their skillsets, established network of connections, and extensive coordination responsibilities already built into their role (such as a Children's Health Coordinator or Lead Policy Coordinator, if available). This would allow those conveners in this type of position to draw upon and leverage those relationships to reach across programmatic siloes. In other cases, the RPM, OSC, or CIC may have already established collaborative relationships and may comprehensively understand Superfund site needs, as well as other programmatic capabilities, and would therefore be best suited for the role of convener. Assigning more than one convener, or co-conveners, may enable them to draw on their expertise. Multiple conveners or co-conveners could be comprised of different variations of expertise such as the following:

- Multiple RPMs/OSCs/CICs

- RPM or OSC or CIC and Children's Health Coordinator
- Management-level staff and RPM

The variation would depend on site- and Region-specific resources and circumstances. The work of collaborating across EPA offices and across federal, tribal, state, and local lines may benefit from the assignment of co-conveners to help mix knowledge bases, skillsets, and networks of contacts to help balance the work of conveners and the Superfund site team. In some cases, a Region may find that capitalizing on the experience of a convener (or co-conveners) to work on multiple residential lead Superfund sites in the Region allows them to streamline coordination efforts, establish relationships more consistently, and make quicker connections with partners for newly identified collaboration efforts and new Superfund sites. Regardless of an individual's or group's capacity or experience, acknowledgement of the workload involved in convening as well as management and team support is integral to developing meaningful outcomes of the convener role.

3.2 Collaborative Approach to Addressing Lead at Superfund Sites

There may be Superfund sites where children may be at increased risk due to cumulative impacts from lead, such as the aggregate exposure to multiple sources of lead contamination present in their community. However, as discussed previously, there are limitations under CERCLA to address some of these sources, such as LBP or corrosion of lead plumbing, because CERCLA responses are generally limited to releases or threatened releases to the environment from products that are part of the structure of, and result in exposure within, residential buildings or business or community structures (U.S. EPA 1993). Superfund, however, can promote addressing these non-CERCLA sources through actions by others as a component of an overall site management strategy, particularly at urban sites. Success is dependent on effective and structured coordination and collaboration at the federal, state, tribal, and local level to address lead holistically at Superfund sites.

As recommended in the *Clarification to the 1994 Revised Interim Soil Lead (Pb) Guidance for CERCLA Sites and RCRA Corrective Action Facilities* (U.S. EPA 1998) and *Updated Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities* (Breen 2024), EPA Regions should coordinate with these other authorities to design a comprehensive, cost-effective response strategy that addresses as many sources of lead as practicable. These strategies should include actions to respond to LBP, interior dust, and lead plumbing, as well as groundwater sources and lead-contaminated soil (see Sections 6.7.1 and 6.8.1) (U.S. EPA 1998). Coordination should also involve incorporating information on best practices to reduce lead exposure to residents at lead-contaminated sites at a federal, tribal, and/or state or local government level.

Regional Lead Coordination Committee

Within each Region, there is a Staff Lead Coordinating Committee or Regional Lead Action Plan work group (the title may differ across regions) coordinating efforts to protect children from lead exposure by working with other federal, state, and local government agencies, tribes, and community groups by combining Federal authorities, programs, projects, and resources. The Staff Lead Committee consists of representatives from all divisions who coordinate to provide updates on lead programs, share opportunities for collaboration, and monitor regional progress, and can be an important avenue for collaboration.

As identified above, assigning a regional EPA employee (or employees) to act as a convener to bring the necessary parties together for collaboration across authorities with other EPA programs, other federal agencies, and/or state, local, and tribal entities can support this collaborative approach. Later sections of this Handbook identify actions that the Superfund RPM, OSC, and/or Superfund site team can take within CERCLA authority to identify and address sources of lead beyond the CERCLA release, and situations when collaboration and integration of partners with other authorities into the project team may be beneficial or necessary.

3.2.1 Collaboration for Health Education

There are numerous tools and resources available through other EPA Programs, other agencies, and organizations at the federal, tribal, state, and local levels. By collaborating with these entities, Superfund site teams may be able to help local stakeholders identify non-Superfund opportunities for addressing other sources of lead (*e.g.*, grants from other EPA programs and/or federal agencies).

Other steps to take to support health education may include (not an exhaustive list):

- Coordinate with community members, Community Advisory Groups (CAGs), and other agencies, including local and state health departments, to determine the best way to support health education at your site.
- Develop outreach materials that inform residents about both Superfund-related and non-Superfund-related efforts to reduce and prevent lead exposure. Outreach materials can include information about EPA sampling and cleanup efforts, how to get blood lead

testing, and/or steps for preventing exposure to lead from sources beyond the scope of the site (*e.g.*, lead paint, lead in drinking water from service lines and/or residential plumbing).

- Consider developing joint presentations at community meetings to inform residents about both Superfund-related and non-Superfund-related efforts to reduce and prevent lead exposure.

- Collaborate with EPA's lead paint program to provide Renovation, Repair, and Painting (RRP) training in the community and/or additional education and outreach on lead paint safety.[25]

- Coordinate with the Agency for Toxic Substances and Disease Registry (ATSDR) or a local or state health department to host a Soil Screening, Health, Outreach, and Partnership (soilSHOP; see more information on working with ATSDR in Section 5.3 and more information about hosting a soilSHOP in Section 4.4). ATSDR has used soilSHOPs co-hosted with EPA to identify potential areas needing further assessment outside the Superfund boundaries. Community members are offered free soil lead screenings to raise awareness of potential lead in their soil, information on safe gardening practices, ways to protect children from lead exposure, and one-on-one health education about the hazards of lead.[26] The health education piece of a soilSHOP provides valuable information. Participants may wish to seek further laboratory testing to confirm their soil screening results. If a resident is within the Superfund cleanup area, they are directed to the Superfund site team for a full assessment.

Additionally, when lands in Indian country are impacted, the Superfund site team may refer to *Tribal Lead Curriculum: Lead Awareness in Indian Country: Keeping our Children Healthy!* for curriculum and outreach materials[27] (U.S. EPA 2023b). Additionally, where tribal interests may be affected, EPA must follow the Agency's *Tribal Consultation Policy*,[28] *Guidance for Discussing Tribal Treaty or Similar Rights*,[29] and any Region-specific tribal consultation guidance. The Superfund site team should work with the regional Superfund tribal coordinator to ensure appropriate tribal consultation and coordination.[30]

3.2.2 Collaboration for Sharing Blood Lead Monitoring Results

In addition to collaboration for health education, collaboration between state Departments of Health and EPA is also important. State Departments of Health can provide EPA with annual

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[25] https://www.epa.gov/lead/lead-renovation-repair-and-painting-program.
[26] https://www.atsdr.cdc.gov/soilshop/index.html.
[27] https://www.epa.gov/lead/tribal-lead-curriculum.
[28] https://www.epa.gov/tribal/epa-policy-consultation-indian-tribes.
[29] https://www.epa.gov/system/files/documents/2023-12/revisions-to-the-consultation-policy-and-tribal-treaty-or-similar-rights-guidance-fact-sheet_0.pdf.
[30] https://www.epa.gov/superfund/remedial-program-indian-country#contacts.

statistics on blood concentrations of young children in the community from opportunistic monitoring without violating Health Insurance Portability and Accountability Act (HIPAA) Privacy Rules. Children with BLLs above U.S. Centers for Disease Control and Prevention (CDC) reference values should follow CDC guidance (*e.g.*, to identify and reduce or eliminate the source of contamination leading to elevated blood lead concentrations). Once the source of elevated blood lead has been identified, EPA can work collaboratively with other state and federal partners to address the source of lead contamination.

CHAPTER 4
Overview of Community Involvement

4.1 Introduction to Community Involvement

Superfund community involvement is the term that EPA uses to describe the process of engaging with communities affected by Superfund sites (U.S. EPA 2020a). Requirements for involving the public in the Superfund cleanup decision-making process were established under CERCLA and further strengthened in the Superfund Amendments and Reauthorization Act (SARA) of 1986. Furthermore, the NCP describes EPA's process for conducting Superfund community involvement activities (see 40 CFR 300.430).

Superfund community involvement should raise awareness of EPA's activities early in the process, provide meaningful and timely opportunities to influence site cleanup and reuse decisions, and provide information about how the Agency considers their concerns in the site decision-making process.[31] Providing information and engaging communities in the Superfund process can improve upon the success of the overall response. Additionally, community acceptance is one of the nine criteria identified in the NCP that EPA must evaluate before selecting a final cleanup plan for Superfund sites (U.S. EPA 2020a).

Key decision points for engaging community involvement are the following:

- Anticipated timing and level of community involvement;
- Acknowledgement that the EPA will consider all public input; and
- EPA must meet the legal requirements of the Superfund law (U.S. EPA 1999a).

EPA's 2020 *Superfund Community Involvement Handbook* (U.S. EPA 2020a) addresses the community involvement activities (both required and suggested additional activities) that should take place throughout the Superfund process. Additional community involvement activities may be appropriate at a site depending on the complexity of the site, the level of community interest and concern regarding the release, and the level of media interest at the site. Other considerations may include whether environmental justice or tribal concerns are present at the site.[32] In keeping with Superfund program community involvement policy objectives, this Handbook supports, on a site-specific basis:

[31] https://www.epa.gov/system/files/documents/2023-11/achieving-health-and-environmental-protection-through-epas-meaningful-involvement-policy.pdf.
[32] https://www.epa.gov/superfund/supporting-environmental-justice-superfund-sites.

- Conducting early, frequent, and meaningful community involvement;
- Keeping the public well-informed of ongoing and planned activities;
- Setting clear expectations with the community about how they can influence site activities and what limitations may be;
- Encouraging and enabling the public to get involved;
- Listening carefully to what the public is saying;
- Considering public comments in the decision-making process; and
- Explaining to community members how EPA considered their comments, what the Agency plans to do, and why this decision was made.

A firm foundation for successful community involvement is built on trust, transparency, responsiveness, professionalism, regular engagement, and a commitment to addressing community concerns and facilitating the community's participation in the decision-making process at Superfund sites. Although stakeholders may disagree with specific Agency decisions, they are more likely to understand and accept decisions if they trust EPA and think that the decision-making process is fair and that their input is considered, and if EPA communicates effectively about why the decision was made.

A successful approach to community involvement at Superfund sites usually involves:

- Interacting with the community in ways that promote trust and constructive dialogue;
- Modeling exceptional teamwork;
- Knowing the audience and carefully planning community involvement activities based on knowledge of the site and the needs of the affected community; and
- Addressing several overarching issues and considerations such as:

  (1) communicating risk effectively so that the community may understand risk exposures;

  (2) providing timely and accurate information in plain language;

  (3) assessing and addressing environmental justice concerns;

  (4) assessing and responding to technical assistance needs;

  (5) coordinating and collaborating with other EPA programs and federal, state, tribal, and local agencies to address non-CERCLA sources of lead;

(6) involving the community in considering reasonably anticipated future land use options;

(7) using media effectively;

(8) planning for community involvement when resources are limited; and

(9) evaluating community involvement efforts.

Specific community involvement practices that inspire public participation include:

- Listening to valuable information the public might provide that could help with site characterization and the risk assessment, including pathways of exposure, historical activity, and potential future use of each site;
- Identifying and dealing responsibly and in a timely fashion with public concerns;
- Creating a mailing list, email list, or listserv of concerned community members and using it to distribute site information;
- Establishing a toll-free telephone hotline and publicizing its availability;
- Modifying proposed actions based on public comments;
- Being responsive to community members by explaining EPA's review of comments and modifications to the plan, and why EPA reached its decision;
- Identifying communication and information needs and providing materials in formats that are accessible to individuals with disabilities and individuals with limited English proficiency (LEP), as appropriate;
- Offering technical assistance so communities can better understand the science and comment on EPA's work;
- Identifying environmental justice concerns;
- Identifying health issues, high risk subpopulations, exposure factors, and high soil levels;
- Developing educational programs;
- Coordinating sustainable education with local health organizations, schools, community organizations and health care providers; and
- Holding "hybrid" public meetings, listening sessions, open houses, and workshops that are accessible to all (in-person and virtual participation), including individuals with disabilities and individuals with LEP.

The following links provide overviews of required activities and additional community involvement activities that may become part of a site-specific Community Involvement Plan (CIP; see Section 4.3 for additional information about CIPs):

- https://www.epa.gov/superfund/superfund-community-involvement
- https://semspub.epa.gov/src/document/HQ/100002223
- https://semspub.epa.gov/src/document/HQ/100002222

4.2 Environmental Justice

Environmental Justice (EJ) is an integral component of the Superfund program. EPA defines environmental justice as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.[33] **Fair treatment** means no group of people should bear a disproportionate share of the negative environmental consequences resulting from industrial, governmental, and commercial operations or policies.

[33] Environmental justice is defined in Executive Order 14096 Section 2(b) as, "the just treatment and meaningful involvement of all people, regardless of income, race, color, national origin, Tribal affiliation, or disability, in agency decision-making and other Federal activities that affect human health and the environment so that people: (i) are fully protected from disproportionate and adverse human health and environmental effects (including risks) and hazards, including those related to climate change, the cumulative impacts of environmental and other burdens, and the legacy of racism or other structural or systemic barriers; and (ii) have equitable access to a healthy, sustainable, and resilient environment in which to live, play, work, learn, grow, worship, and engage in cultural and subsistence practices."

Despite substantial progress in reducing lead exposures nationwide, significant disparities remain along racial, ethnic, and socioeconomic lines (Laidlaw et al. 2023, Egan et al. 2021, Aelion and Davis 2019). Children living in communities overburdened by pollution and other health and social stressors, which are often communities of color and lower socioeconomic status, are at greater risk. For example, LBP, lead service lines, and plumbing fixtures containing lead are more likely to be found in older houses in lower-income areas. Communities of color can also face greater risk due to redlining, historic racial segregation in housing, and reduced access to environmentally safe and affordable housing.[34] Industrial sources of lead are more likely to be closer to lower income neighborhoods and communities of color where soils in residential and public places can be contaminated (U.S. EPA 2022a). There are limitations on the actions EPA can take under CERCLA to address different sources of lead contamination. While the risks associated with anthropogenic or background lead sources may be documented in the risk assessment, cleanup levels are generally not set at concentrations below natural or anthropogenic background levels (U.S. EPA 2002a).

Environmental Justice Collaborative Problem-Solving (EJCPS) Cooperative Agreement Program

The Environmental Justice Collaborative Problem-Solving (EJCPS) Cooperative Agreement Program provides financial assistance to eligible organizations and assists recipients in building collaborative partnerships with other stakeholders (*e.g.*, local businesses and industry, local government, medical service providers, academia, etc.) to develop solutions that will significantly address environmental and/or public health issue(s) at the local level.

More information on the program including requirements and eligibility is available at: https://www.epa.gov/environmentaljustice/environmental-justice-collaborative-problem-solving-cooperative-agreement-5.

The Superfund program's approach to engaging communities with environmental justice concerns is primarily done through its robust community involvement program. The community involvement program enables EPA to understand, elevate, and address the concerns of affected community members. Approximately 21 million people live within 1 mile of a Superfund site. Compared to the general public, communities located near Superfund sites are more likely to

[34] https://www.epa.gov/newsreleases/biden-harris-administration-proposes-strengthen-lead-paint-standards-protect-against.

have people and populations within those communities that are communities of color, lower income, linguistically isolated, and less likely to have a high school education.[35]

Communities with environmental justice concerns commonly face challenges and barriers to meaningful participation in the Superfund process. The National Environmental Justice Advisory Council (NEJAC) model plan for public participation outlines some of the common issues faced by these communities. The model plan identifies the following issues:

- Lack of availability and access to resources (specifically funding and staff) to conduct meaningful participation over the long term;
- Poor or little coordination among and between various federal, state, tribal, local government agencies, and other entities;
- Language and cultural differences;
- Identification of and coalition-building among local leadership within a community;
- Lack of cultural competency among agencies trying to cultivate community involvement;
- Lack of recognition among communities and individuals of their stakeholder status in environmental justice concerns; and
- Lack of trust between community members, regulatory agencies, and regulated industries.

Tribes affected by a Superfund site may identify environmental justice concerns, and EPA's policy is to seek to be responsive to the environmental justice concerns of federally recognized tribes, Indigenous peoples throughout the United States, and others living in Indian country.[36] In addition to community involvement, working to address tribal environmental justice concerns may require additional actions such as consultation and coordination with the tribe (see discussion in Section 3.2.1).

4.3 Community Involvement Plan (CIP)

The CIP is a required site-specific strategy that outlines how EPA plans to engage the community throughout the Superfund process. The NCP (see Section 2.2) requires the lead agency to prepare a CIP "based on the community interviews and other relevant information, specifying the community relations activities that the lead agency expects to undertake during

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[35] For more information, see https://journalistsresource.org/environment/superfund-toxic-waste-race-research/ and https://www.epa.gov/superfund/superfund-community-involvement-tools-and-resources.
[36] https://www.epa.gov/sites/default/files/2017-10/documents/ej-indigenous-policy.pdf.

the remedial response."[37] The CIP generally provides a road map for the site team's use throughout the cleanup process by describing the outreach activities EPA plans to undertake to address community needs and concerns during the cleanup process. A well-written CIP should enable community members affected by a Superfund site to understand the ways in which they can participate in decision-making throughout the process. A CIP is a living document and may be updated as new information becomes available. CIPs should:

- Describe the site;
- Describe the community and, as part of this, describe any environmental justice issues that exist in the community;
- Identify key community needs, questions, and concerns as a result of interviews with community members;
- Discuss the need for technical assistance services;
- Include an Action Plan that specifies EPA's planned outreach activities and community involvement mechanisms;
- Identify any additional special services or approaches that EPA may use to address unique needs of the community;
- List site contacts and their areas of expertise; and
- Discuss plans to evaluate accomplishments.

A communication strategy may be one component of a CIP that addresses a specific event, issue, or concern, such as a health education campaign to prevent children from being exposed to lead in their yards. Communication strategies outline the objectives/goals of the communication, identify stakeholders, define key messages, pinpoint potential methods and vehicles for communicating information for a specific purpose taking into account languages spoken/LEP, lay out a timeline for communications and points of contact/roles, and specify the mechanism that will be used to obtain feedback. Communications should inform residents of the risks associated with lead, exposure reduction activities, and the status of EPA's activities. Social media tools and distribution of materials, such as fact sheets and mailings, are examples of vehicles for communicating information. The site team is encouraged to obtain feedback on communications from community members and CAGs and to adjust the communication strategy to suit the community needs.

[37] 40 CFR 400.430(c)(2)(ii); Note: The Community Relations Plan referenced in 40 CFR 400.430 is now commonly referred to as the Community Involvement Plan.

For more information on this topic, please reference the *Community Involvement Plans* tool and the *Communication Strategies* tool in the online *Superfund Community Involvement Toolkit*.[38]

4.4 Community Advisory Group (CAG)

The site team may consider helping the community form a CAG if there is enough interest. A CAG is the term that EPA uses to define a committee, task force, or board composed of community members and the other stakeholders affected by a hazardous waste site (U.S. EPA 2020a). These community-based groups serve as a public forum for representatives of diverse community interests to present and discuss their needs and concerns related to the Superfund decision-making process (U.S. EPA 2020a, 1995b). CAGs can also help EPA's work at a site by facilitating community understanding, trust, and acceptance of the cleanup plan. CAG membership should represent the diverse segments of the community such as: residents; workers; business owners; planning, community, or economic development representatives; real estate and lending professionals; minority leaders; educators; health officials; elected officials; city public works staff; faith-based groups; and local environmental groups. The site team should coordinate with, and encourage, other federal, state, and tribal agencies to attend CAG meetings. Relevant agencies may include ATSDR, U.S. Department of Housing and Urban Development (HUD), and state health and environmental departments, including Pediatric Environmental Health Specialty Units (PEHSUs).

Generally, the earlier in the process a CAG is formed, the more the community will be able to help inform the decision-making for the site. Therefore, communities interested in organizing should be encouraged to form CAGs prior to the beginning of the remedial investigation/ feasibility study (RI/FS), if possible. However, not every community will desire or support a CAG, and a CAG may not be suitable at every Superfund site. As such, the site team should assess whether formation of the CAG is appropriate. For example, CAGs have been most beneficial at remedial and removal sites that are not time-critical. Work at time-critical removal sites often occurs too fast to form a CAG but outreach to the community as outlined in the CIP is important.

[38] https://www.epa.gov/superfund/community-involvement-tools-and-resources.

CAGs can help facilitate the long-term success of the remedy. Examples of successful programs and activities accomplished by community groups at different sites have included: facilitating general education and awareness among the segments of the community that they individually represent; creating site-specific education material such as coloring/story books; hosting health fairs; supporting Soil Screening, Health, Outreach, and Partnership (SoilSHOP);[39] creating health education programs for local school districts; establishing lead poisoning prevention merit badges for girl and boy scout organizations; developing instructional videos; and establishing pre- and post-natal education programs at local hospitals.[40]

How to Host a SoilSHOP

Hosting a soilSHOP is a positive, interactive, and informative activity. The name soilSHOP stands for Soil Screening, Health, Outreach, and Partnership. ATSDR developed a toolkit to help communities and other groups plan their own soilSHOP events.

At soilSHOP events, people can receive:

- Free soil screening for lead;
- Information on safe gardening practices;
- Ways to protect children from lead exposure; and
- One-on-one health education about the hazards of lead.

For more information about how to plan and host a soilSHOP, visit: https://www.atsdr.cdc.gov/soilshop/index.html

4.5 Technical Assistance

Technical assistance refers to the provision of funding (EPA grant) and/or services (EPA contract) focused on increasing a community's understanding of the science, regulations, and policy related to environmental issues and EPA actions at Superfund sites. To support healthy communities and strengthen environmental protection, EPA staff can work closely with communities and provide technical assistance to make sure they have the technical help to fully understand local environmental issues and participate in a meaningful way in decision-making at Superfund sites. Additional information on technical assistance can be found on EPA's

[39] Disclaimer: The soilSHOP is a health education event where community members are offered free lead screenings to raise awareness of potential lead in their soil sample, and information about how to avoid exposure to lead while gardening or playing in yards. SoilSHOP staff will help explain soil screening results and share information on ways to reduce potential exposures to lead in soils. If the residents are within the Superfund cleanup area, they are directed to the Superfund site team for a full assessment.

[40] For more information about CAGs, see: https://www.epa.gov/superfund/superfund-community-advisory-groups.

Superfund community involvement webpage under *Technical Assistance* and *Tools and Resources*.[41]

Depending on the community and site circumstances, a Technical Assistance Needs Assessment (TANA) may be helpful in identifying community assistance needs and ways in which those needs can be met. A TANA is a site-specific process that identifies how the community is receiving site-related information; what types of information are being received; whether the community needs additional assistance; what types of assistance would benefit the community; and whether there are local organizations interested or involved in site-related issues and capable of acting as an appropriate conduit for technical assistance services. The TANA process produces a blueprint for a coordinated effort to meet a community's needs for additional technical assistance while minimizing the overlap of services provided by EPA site staff, external partners, and EPA grants and contracts.[42]

4.5.1 Technical Assistance Grants (TAGs)

EPA provides technical assistance grants (TAGs) to communities to help community members understand site-related information (U.S. EPA 2003d). The NCP (40 CFR §300.430(c)(2)(iv)) requires EPA to inform communities about the availability of TAGs. TAGs are only available for sites on the NPL or proposed for the NPL where a response action under CERCLA is underway.[43]

Under the TAG program, initial grants of up to $50,000 are available to qualified groups affected by a response action. Additional funding may be available if the initial award was effectively managed, if the site meets 3 out of 10 factors listed in the TAG regulations (40 CFR §34.4065(a)(2)), and if the group can identify a need for additional funding. Only one TAG at a time may be awarded per NPL site, so EPA encourages competing groups to form coalitions. Applicant groups must be willing to incorporate as a state non-profit organization for the purpose of participating in the decision-making at the site. If awarded a TAG, the group must provide proof of state non-profit status before receiving any TAG funds. A 20% match of the total project costs is required, unless fully or partially waived by EPA. This requirement can be met with cash, donated supplies, and/or volunteered services.

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[41] https://www.epa.gov/superfund/superfund-community-involvement.

[42] For more information on TANAs, see https://www.epa.gov/superfund/technical-assistance-needs-assessments-tanas.

[43] A technical assistance plan (TAP) may be available at non-NPL sites if negotiated with the potentially responsible party (PRP) to fund. TAPs are also available at NPL sites if the PRPs agree in the enforcement document. For Superfund Alternative Approach sites, PRPs are required to agree to fund a TAP if the community requests one.

In their TAG application, groups must prepare a project budget and work plan showing how they will use their TAG funds and meet the matching share. A small portion of TAG funds may be used for administrative costs (*e.g.*, developing newsletters, general supplies). All or most of the TAG funds must be used to procure and pay a technical advisor. The technical advisor is an independent expert who can review and interpret site-related documents and explain technical or health-related information to community members. A TAG advisor may make site visits to gain a better understanding of the cleanup activities, and can also assist the community in communicating their concerns to EPA. A portion of the TAG funds may also be used to procure a grant administrator to assist with grant management. However, TAG funds may not be used for group members' travel or training, political activities or lobbying, social activities, fundraising, lawsuits or other legal actions, or to generate new data (*e.g.*, to conduct sampling or testing).[44]

4.5.2 Technical Assistance Services for Communities (TASC)

EPA's national technical assistance services for communities (TASC) program provides non-advocacy technical assistance services through an EPA contract to help communities better understand the science, regulations, and policies of environmental issues and EPA actions. Through the TASC contract, a contractor provides scientists, engineers, and other professionals who can review and explain technical information to communities. EPA's Conflict Prevention and Resolution Center (CPRC) is available to provide facilitators and mediators as needed.[45] The services are determined on a project-specific basis and are provided at no cost to communities. This assistance supports community efforts to get more involved and work productively with EPA to address environmental issues.

TASC services can include information assistance and expertise, community education, information assistance needs evaluation and plan development, and assistance to help community members work together to participate effectively in environmental decision-making. The TASC program benefits communities by providing contractors who explain technical findings and answer community questions, help community members understand complex environmental issues, and support active roles in protecting healthy communities and advancing environmental protection. The TASC program can also provide opportunities for

[44] For further information on TAGs, see: https://www.epa.gov/superfund/technical-assistance-grant-tag-program.
[45] For further information, see: https://www.epa.gov/system/files/documents/2023-03/FY%202022%20EPA%20ECCR%20Annual%20Report%20-%20Final.pdf.

environmental education, bring diverse groups together and help them get more involved, and offer environmental training.[46]

4.6 Risk Communication: Engaging Stakeholders and Organizing Informational Meetings

Risk communication is a dialogue between the site team and the community to characterize the risks at a site and the actions that people can take to reduce their exposure to the risks, if necessary. An effective risk communication strategy considers the level of understanding people have about the site, what their perceptions are about health and safety, and what they can do to have some level of control in the situation. Communicating site risks early and often also helps build trust and promotes transparency. The Superfund program has developed a 40-minute video, *Superfund Risk Assessment and How You Can Help,* to explain, in plain terms, the Superfund Human Health Risk Assessment (HHRA) process and how communities can be involved.[47]

In addition, to promote public involvement, EPA developed the *Seven Cardinal Rules of Risk Communication* (see text box) (U.S. EPA 1988b).

[46] For more information, see: https://www.epa.gov/superfund/technical-assistance-services-communities-tasc-program.
[47] See http://www.clu-in.org/search/t.focus/id/948/.

Risk communication (1) provides an opportunity for EPA and the community to exchange information regarding the site and activities, (2) facilitates community participation in the decision-making process, (3) helps the site team understand and appreciate the community's perception of risk, and (4) helps establish mutual trust and a productive relationship between EPA and the community. Trust between the community and EPA helps prevent conflicts and facilitates resolution of conflicts that may arise. If the staff follow the Seven Cardinal Rules and the **S**trategy, **A**ction, and **L**earning and supported by **T**ools (SALT framework) guidelines in the *Risk Communication* tool of the online *Superfund Community Involvement Toolkit*, it is anticipated that trust and credibility in the community have a better chance to develop.[48]

Seven Cardinal Rules of Risk Communication

1. **Accept and involve the public as a legitimate partner** through early involvement of the community and all other parties that have an interest in the issue.
2. **Plan carefully and evaluate your efforts.** Successful risk communication planning involves having clear objectives, being attentive to the needs and interests of various groups, training staff in communication skills, rehearsing and testing your message, and assessing efforts and lessons learned.
3. **Listen to the public's concerns** by taking the time to find out what people know, think, or want, and recognizing their feelings.
4. **Be honest, frank, and open.** Try to share more information with the community, not less; otherwise, people may think you are hiding something.
5. **Coordinate and collaborate with other credible sources.** Take the time to coordinate with other organizations and credible sources, and jointly communicate the issue.
6. **Meet the needs of the media** by being open with, and accessible to, reporters. Establish long-term relationships of trust with specific editors and reporters.
7. **Speak clearly and with compassion.** Communicate on a personal level by using vivid, concrete images or examples and anecdotes that make technical risk data come alive. Acknowledge and respond with the words and emotions that people express—anxiety, fear, anger, outrage, and helplessness.

Covello and Allen (1988)

The public should be involved as early as possible in decisions affecting a Superfund site. The site team should consider holding frequent community involvement events to inform the community of current and planned EPA activities and to hear the community's concerns and suggestions about the Agency's approach. If a CAG has been formed at the site, meetings with the group should be frequent and open to the public. In addition to

[48] https://www.epa.gov/risk-communication/salt-framework.

CAG meetings, site teams should consider holding availability sessions, open houses, and other types of meetings on a regular basis to share progress and promote understanding of potential risks. Having frequent meetings can help the public stay informed of site progress and can also permit their timely input to the process.

In addition to public meetings held pursuant to CERCLA (*e.g.*, Proposed Plan public meeting), site teams should also consider having availability sessions or open houses at the following points in the process:

(1) Before sampling is conducted—to explain why lead contamination is suspected; describe the overall goals of the project; obtain community input on sampling plans; discuss consent to access; explain how EPA or contractors will conduct sampling; describe protection of privacy and results; and describe how residents can reduce exposure while awaiting sampling results.

(2) After sampling is conducted—to explain results and the risk assessment process; describe whether the results require remedial action or not and how this decision was made; reiterate how residents can reduce exposure; and explain plans and the schedule for conducting remediation.

(3) After remediation is completed—to explain what was done; provide documentation of the results of the remediation; and discuss any landscaping concerns with the resident and plans for care and maintenance of the area to reduce potential exposures.

More information about this topic can be found in the *Risk Communication* tool in the online *Superfund Community Involvement Toolkit*.[49]

[49] https://www.epa.gov/risk-communication.

CHAPTER 5
Health Education

5.1 Introduction to Health Education

Exposure to lead contamination in the environment may cause adverse health effects, particularly in young children and the fetuses of pregnant women (ATSDR 2020, Harrington et al. 2014, NTP 2012). The goal for addressing lead contamination is to reduce overall exposures and associated adverse health outcomes. Remediating residential lead sites is a complex multiphase process that can take decades to complete (von Lindern et al. 2016). The CDC recommends primary prevention to remove lead hazards from the environment before exposure can occur as the most effective way to ensure that vulnerable and/or overburdened populations do not experience the harmful health effects of lead.[50] Health education and other secondary prevention strategies may mitigate lead exposure in combination with exposure reduction measures. In the recent EPA publication, *Superfund Cleanups and Children's Lead Exposure* (Klemick et al. 2020), EPA recommends supplementing engineering approaches that remove or stabilize contaminants with community outreach and health education, particularly at sites with lead-contaminated residential areas. Education by itself has not been shown to lower BLLs (Nussbaumer-Streit et al. 2020, Yeoh et al. 2012, 2008). This chapter will discuss the benefits and limitations of health education at Superfund lead sites.

5.2 Benefits of Health Education

Elevated soil lead levels can be predictive of elevated BLLs in populations, which can be reduced through effective remediation of lead contamination in soil (Ye et al. 2022). As noted in other chapters of this Handbook, soil excavation and/or alternative cleanup methods are the prominent health-protective strategies for addressing lead-contaminated soil at residential sites. However, there may be circumstances where this option is not feasible or timely. For example, due to the extent of the contamination, there may be a need to leave residual lead at depth and implement ICs to prevent or limit exposures, or there may be a situation where exposure to lead is from multiple sources, not all of which may be addressed under CERCLA authorities. At sites with an extensive history of lead mining, milling, and smelting operations, evaluation and cleanup have multiple steps that can result in a lengthy process to address the various lead-contaminated media (U.S. EPA 2020b). In these situations, health education may be the primary interim health-protective approach.

[50] https://www.cdc.gov/nceh/lead/prevention/default.htm.

The objectives of health education are to provide information to impacted communities about the risks associated with lead contamination, ways to reduce exposure to lead, and ways to alleviate health outcomes associated with lead exposures. Education can be targeted to residents, communities, and local health officials who may or may not be familiar with EPA's Superfund risk assessment and risk management processes. There are several tools and resources that families can use to address both Superfund and non-Superfund sources of lead (see Sections 3.2, 4.4, and 4.5).

Community education conducted in association with site cleanup activities can contribute to the decline of blood lead concentrations, although health education alone may not be sufficient to achieve major health benefits (Table 5-1 and Appendix E). Remedial activities may be performed in conjunction with health education and/or blood lead monitoring, as appropriate, and can contribute to the success of the project (ATSDR 2002). Once the public and local health officials are made aware of the potential risks present at the site, cleanup and other health-protective activities may be more effective, more widely understood by the community, and easier to implement when the citizens understand the hazards and believe that the community is at risk (ATSDR 2022).

Table 5-1. Review of Sites where Community Education Supported Reductions in Blood Lead Levels

Site	Agency/ Organization	Education/Outreach Program	Comments	Reference
Milwaukee, Wisconsin (effort to lower BLLs in a specific neighborhood)	Milwaukee Health Department	• Enrollment in an intervention program of prevention education and environmental cleanup. • Identification of children 6 months to 6 years old with BLLs 10-19 µg/dL. • Education home visits over a 4-year period.	Comparisons of BLLs from the targeted community versus the city-wide averages showed a 1.6-fold decrease. For those children starting with BLL 10-19 µg/dL, average BLLs were 12.9, 10.8, 10.3, and 9.8 µg/dL each year of the study, indicating a steady decrease.	Schlenker et al. (2001)
Oronogo-Duenweg Mining Belt, Missouri (Jasper County)	ATSDR	Lead poisoning awareness in school curricula, site-specific coloring/story books, merit badge for local Girl Scouts chapter, presentations at grand rounds in area hospitals, fliers, magnets, and other awareness materials.	Programs were associated with a mean BLL decline of 2.42 µg/dL; while the significant reductions were attributed to soil remediation, health education was provided as a compliment to remedial actions at the site.	ATSDR (2002)

Table 5-1. Review of Sites where Community Education Supported Reductions in Blood Lead Levels

Site	Agency/ Organization	Education/Outreach Program	Comments	Reference
Bunker Hill Superfund site, Idaho	U.S. EPA	• Intervention and education program implemented by the Panhandle Health District, utilizing lead screening and health education materials. • Annual door-to-door blood survey and nursing follow-up. • Public education modules aimed at local schools, parent and service groups, and health care providers.	A reduction in blood lead (3.9 µg/dL average) in 2-year-old children was found at non-remediated yards; this reduction was associated with the implemented intervention and education program. Lead soil replacement at the neighborhood scale was twice as effective at reducing blood lead concentrations as cleaning up a single yard.	Sheldrake and Stifelman (2003)
Minneapolis, Minnesota (pregnant women and mothers of infants; inner-city, economically disadvantaged, ethnically diverse subpopulation)	University of Minnesota	• Blood samples drawn regularly from all children and homes were assessed for lead contamination. • Participants received state health department brochures about lead in their own language. • Knowledge of lead risks and prevention techniques was assessed periodically throughout study. • Intensive educational intervention was delivered to intervention groups only. Teachers met individually with intervention group participants in their homes to improve their knowledge and increase their capacity to reduce lead exposure in their children.	Higher education level in the mother promoted lower blood lead concentrations in children (<10 µg/dL on average and reduced the risk of a BLL greater than or equal to 10 µg/dL by about 34%). Education as primary prevention may not be sufficient to prevent lead burden in high-risk, low-income subpopulations (intervention not 100% effective). Certain factors can make an educational approach more effective: • intensity/duration of educational process • focus on a range of prevention strategies beyond housecleaning, tailoring the educational curriculum and delivery approach to specific ethnicities • facilitating a rapport between a consistent and dedicated peer teacher	Jordan et al. (2003)

Table 5-1. Review of Sites where Community Education Supported Reductions in Blood Lead Levels

Site	Agency/ Organization	Education/Outreach Program	Comments	Reference
St. Francois and Jasper Counties Missouri	Multiple authors/ Missouri Department of Health and Senior Services	Combined tailored education, lead dust removal by trained cleaners, and family follow-up visits were compared to conventional health education programs.	BLLs decreased overall 1.54 μg/dL (12.1%) during the study.	Sterling et al. (2004)
East Helena Superfund site, Montana	ATSDR	Community outreach: Lead Education and Abatement Program.	Program's effectiveness was reviewed in 1999 and 2005.	ATSDR (2008a)

5.3 ATSDR Involvement and Other Health Education Partners

Additional benefits can be achieved through partnerships with local health districts that are better equipped to provide health education to benefit exposed community members. Local health districts will be knowledgeable about outreach methodologies that are best utilized in the area and other lead-related concerns that may be present in the community. Through collaboration with these local health districts (*e.g.*, county and state health departments), EPA can focus on cleanup activities while local health departments address health education at the site. The community can benefit from working with health agencies on further follow-up and understanding of other health concerns.

The EPA Superfund program does not conduct most health education activities. The project manager/site team (*e.g.*, RPM or OSC) often coordinates with the ATSDR and other various health agencies to establish health education programs on the risks of lead exposure and ways to prevent it (ATSDR 2022, 2008a, 2008b, Sheldrake and Stifelman 2003, ATSDR 2002). Health education programs are often implemented by local health districts that, in turn, may coordinate with schools and other community groups working with families and children. These education programs can be specific to affected residences or can be more community-wide around the site and may be part of a broader IC program. Initial tasks typically include educating the community regarding their lead exposure and associated health risks. The ATSDR ToxFAQ Fact Sheet on lead can be useful.[51] This work can take the form of risk communication, where the technical aspects of EPA's lead education program can be explained to the public. This can include explanations for the need to sample soil and indoor dust, characterize soil lead

[51] https://semspub.epa.gov/work/05/950630.pdf.

bioavailability, discuss specific risks with residents based on results, and generally describe hygiene in the home to reduce risks (ATSDR 2022).[52]

ATSDR, administered by the CDC, is the main federal agency that EPA Superfund collaborates with for health activities, including health education. ATSDR has a statutory role for evaluating health at Superfund sites through CERCLA and should be consulted for health education activities. ATSDR has developed relationships with many state and local health departments that may have blood lead screening and health education programs. In addition, ATSDR partners with academic institutions, non-profit agencies, and community groups. Increased collaboration among the involved agencies and engagement of local partners is critical to properly implement a health education program. ATSDR also has fact sheets to help educate the community on reducing risks from yards, gardening, home, etc., and has developed several fact sheets specifically for use at lead sites.[53]

5.4 Health Education Lessons Learned

The Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP) released its report to CDC in 2007 (ACCLPP 2007). The report was targeted to clinicians to help identify gaps in knowledge concerning blood lead levels <10 µg/dL. The report concluded that providing low-income parents with lead-related education was effective in increasing knowledge of lead in homes and helping families comply with lead preventative activities. The report concluded that education alone will not reduce BLLs. In another paper (Wasserman 2002), educational interventions via caregivers were examined to determine if BLLs could be lowered. The findings showed a significant difference in the BLLs between the first and second visit to the clinic. This helped to show that not only was lead education beneficial, but that clinician knowledge of lead poisoning prevention was additionally effective.

Centers for Medicare and Medicaid Service recommend that officials use a blood lead test to screen children when they reside in an older home, when they receive services through Medicaid or the Supplemental Food Program for Women, Infants, and Children (WIC), or when parents or guardians self-identify potential hazards through the administration of a risk questionnaire (Aoki and Brody 2018). Ideally, CERCLA risks are included in risk questionnaires, but experience shows that this is not always the case. Incorporating health provider education as part of the remedial process prevents potential oversight of CERCLA risks and helps ensure improved screening, surveillance, and risk identification.

[52] See also https://panhandlehealthdistrict.org/institutional-controls-program and https://thep.ca.
[53] https://www.cdc.gov/nceh/lead/prevention/sources.htm.

As discussed in this Handbook, LBP hazards, while generally not considered CERCLA releases, contribute significant risk to childhood lead poisoning. Discussion of LBP hazards can also be addressed in health education materials. Partnerships with federal and state partners like HUD and state health departments can augment health education by identifying the appropriate resources needed in the impacted community. Health disparities and inequities impact a community's ability to address comprehensive health risks (*CDC Environmental Justice Demonstration Index factsheet*[54]). For example, HUD's *Lead-Based Paint* and *Lead Hazard Reduction Grant Programs* are the country's largest programs that address LBP hazards. However, both programs require grantees to match funds at 10% and 25%, respectively. The minimum award is $1,000,000, which would require a community to match $100,000.[55] This can be a barrier in economically distressed or rural communities. Health education, combined with remediation activities, can be a useful tool in helping to reduce risk at lead sites in these communities.

5.5 Resources/Tools

- ATSDR's *Community Engagement Playbook* is a useful resource and tool that can be used throughout the community engagement process.[56] The Playbook describes various phases of the process and engagement activities that build community capacity by facilitating environmental health learning and community connections with other organizations.

- ATSDR's *Environmental Health and Medicine* education and training resources provide training for medical providers and other public health and environmental professionals. ATSDR's environmental medicine education products are accredited and free.[57]

- ATSDR also provides community environmental health presentations developed for general use and designed for health educators to use in face-to-face sessions with community members to increase environmental health literacy. Chemical-specific resources are available for lead and other environmental health topics.[58]

- ATSDR's *Environmental Health Resources Self Learning Modules* provide educational resources on a variety of topics including risk communication, risk assessment, toxicology, and land reuse.[59]

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54 https://www.atsdr.cdc.gov/placeandhealth/eji/fact_sheet.html.
55 See HUD Office of Lead Hazard Control and Healthy Homes website, https://www.hud.gov/lead.
56 https://www.atsdr.cdc.gov/ceplaybook/index.html.
57 https://www.atsdr.cdc.gov/emes/index.html.
58 https://www.atsdr.cdc.gov/emes/public/health_presentations.html.
59 https://www.atsdr.cdc.gov/environmentaleducation.html.

- ATSDR's *Community Stress Resource Center* provides a framework and resources for reducing stress and building resilience as part of the public health response to environmental contamination.[60]

- ATSDR ToxFAQs, ToxZine, and Public Health Statements are useful tools that provide easy to understand information on the health effects of hazardous substances.[61]

- CDC's *Blood Lead Levels in Children* provides information on blood lead testing in children.[62]

- CDC's *Recommended Actions Based on Blood Lead Level* provides recommendations for follow-up and case management of children based on confirmed BLLs.[63]

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[60] https://www.atsdr.cdc.gov/stress/index.html.
[61] https://wwwn.cdc.gov/TSP/ToxFAQs/ToxFAQsLanding.aspx, https://www.atsdr.cdc.gov/sites/toxzine/index.html, and https://wwwn.cdc.gov/TSP/PHS/PHSLanding.aspx.
[62] https://www.cdc.gov/nceh/lead/prevention/blood-lead-levels.htm.
[63] https://www.cdc.gov/nceh/lead/advisory/acclpp/actions-blls.htm.

CHAPTER 6
Site Characterization

6.1 Introduction to Site Characterization

This chapter describes special considerations for residential lead sites, regardless of whether they are on the NPL or being addressed under removal authorities. During the site characterization phase of a remedial investigation or during a removal site evaluation, the sampling and analysis plan (SAP) developed during project scoping is implemented and field data are collected and analyzed to determine the nature and extent of threats to human health and the environment posed by a site (U.S. EPA 2018a, 1989b).

EPA has reviewed various sampling designs historically employed at lead-contaminated residential sites. EPA has assessed the ability of these sampling designs to meet the needs of site characterization, including providing data for a site-specific risk assessment, delineating the nature and spatial extent of contamination, and supporting the development of cleanup levels for removal and remedial actions.

While this Handbook was developed to promote consistent investigation and cleanup activities at Superfund lead-contaminated residential sites, flexibility is needed to best respond to local conditions and uncertainties.

The sampling approach for each site will be documented in the site-specific Quality Assurance Project Plan (QAPP), consistent with the EPA *Quality Assurance Project Plan Standard* (U.S. EPA 2023c). The plan documented in the QAPP should include, as part of the requirements of the Standard, the site-specific conceptual site model (CSM[64]), field sampling plan, and data quality objectives (DQOs).[65] Historical data are important when establishing a CSM. Development of an exposure CSM is a vital step because the exposure CSM establishes the lead-specific exposure pathways that will be quantified in the risk assessment. For example, for sites with a receptor accessing a non-residential site,[66] track-in of offsite soil or dust into the home should always be

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[64] A CSM is a comprehensive graphical and written summary of what is known or hypothesized about environmental contamination at a site and the relationships among key site characteristics that are pertinent to decision-making (see U.S. EPA 2020g, 1988c).

[65] Additional information on the DQO process can be found online at: http://www.epa.gov/quality/guidance-systematic-planning-using-data-quality-objectives-process-epa-qag-4.

[66] A residential recreator is an exposure scenario involving a receptor who both resides in a residential exposure unit (EU) and recreates at a different location (e.g., park, beach, or water body) EU that is part of the site. Their exposure includes both locations and is time-weighted according to U.S. EPA (2003c).

considered (that transport pathway may or may not be complete depending on site-specific conditions). The CSM can inform the collection of representative and high-quality data.

Additionally, Chapter 3 of this Handbook identifies opportunities to collaborate with other agencies and organizations to identify sources of lead exposure beyond the Superfund release. The sections in that chapter identify what the Superfund site team can do within CERCLA authority as well as when there are opportunities to collaborate and integrate with other programs. While it is recognized that collaborative partners will be able to better understand and implement required actions under their authorities, including those authorities delegated to states, tribes, and/or community members, broad descriptions of authorities and entities are included with footnotes and links to additional information (see Chapter 3 for more information).

6.2 Determining the Nature and Extent of Contamination

Historical information regarding facility operations and use is crucial for the design of SAPs to delineate contamination from a specific source. In addition to gathering data on the source of the release of contamination and historical operations documents, descriptive information should include both current and historical aerial imagery to identify areas where soil may have been moved, where fill or topsoil may have been placed, where soil was displaced because of natural processes, and historic use and development of all properties within the area to be characterized. EPA's Office of Technology Operations and Planning, Office of Environmental Information, Office of Mission Support High-End Scientific Computing, and Remote Sensing Information Gateway are sources of such aerial imagery. Sanborn fire insurance or other historical maps or photos, historic city directories, and historic news articles obtained through address or company searches may also be useful resources. Guidance is available from EPA concerning use of historical site data (NAS 2017, U.S. EPA 2001b, 2001c).

6.2.1 Background (Natural and Anthropogenic)

Delineating the extent of contamination generally distinguishes soil with *background* lead concentrations from soil contaminated by site-related activities. EPA guidance defines background as the following (U.S. EPA 2002a):

> Background refers to constituents or locations that are not influenced by the releases from a site, and is usually described as naturally occurring or anthropogenic (U.S. EPA 1995a, 1989b):

1) Anthropogenic – natural and human-made substances present in the environment as a result of human activities (not specifically related to the CERCLA release in question); and,

2) Naturally occurring – substances present in the environment in forms that have not been influenced by human activity (U.S. EPA 2002a).

Natural background concentrations of lead vary widely with local geology. Background reference areas should include natural and non-site-related anthropogenic sources (*e.g.*, historic automobile emissions, LBP), because these background concentrations estimate likely levels of lead unrelated to the CERCLA release and are indicative of recontamination levels post response action. Background samples should be collected from reference areas near the site that are not influenced by the site release, but that have the same basic characteristics (*e.g.*, zoning and land use, traffic density, population and building density, distance from traffic, housing age, lot size, building material, exterior paint, soil type). The OSC/RPM should collect background reference samples using the same methods used to collect onsite samples to support defensible site-versus-background comparisons.

Residential lead sites typically contain many small decision units (DUs), each with limited sampling density or data, which may pose a challenge to performing a statistical analysis as described in Superfund guidance. To address that challenge, RPMs and OSCs may use the Incremental Sampling Methodology (ISM) to assess background concentrations and compare them to concentrations of lead in onsite residential EUs where data have been collected using ISM. ISM is a structured composite sampling and processing protocol that reduces data variability and provides an unbiased, representative, and reproducible estimate of the mean concentration of a contaminant in a soil or sediment sample. This approach can demonstrably improve data quality and usability without increasing analytical costs, though it can require more up-front planning than discrete sampling. To compare background and onsite concentrations using ISM, all sampling should be done using the same ISM sample design and background areas should be of similar size to onsite areas. Further information on ISM can be found in Section 6.6, Appendix I, and Appendix J. Guidance on how to use ISM sampling can be found on the Interstate Technology and Regulatory Council (ITRC) website (ITRC 2020) and on the State of Hawaii Department of Health website (HDOH 2023).

Because OLEM programs generally do not clean up sites to concentrations below background concentrations and lead contamination is ubiquitous, characterization of background is important for risk management decisions (U.S. EPA 2002a). Background concentrations may be presented and discussed at the end of the risk characterization discussion of the risk assessment (*e.g.,* as an uncertainty or in an appendix), separately from site risks. Background concentrations are not subtracted from site samples. CERCLA releases are co-mingled with background contamination and PRGs are calculated based on the combined risk from the CERCLA release and background. If the risk-based PRG is less than the background concentrations, then the cleanup level should be based on background concentrations. *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites* (U.S. EPA 2002b) and *Statistical Methods for Evaluating the Attainment of Cleanup Standards, Volume 3: Reference-based Standards for Soil and Solid Media* (U.S. EPA 1992) provide additional information on background concentrations in CERCLA response actions. Note that the approaches recommended in these two guidance documents differ substantially from the ProUCL Background Threshold Value (BTV) approach, which calculates an estimate of the upper tail of the background distribution (Technical Support Center for Monitoring and Site Characterization 2022). The ProUCL BTV approach is commonly used throughout EPA programs, including Superfund, to determine an upper bound estimate of the background concentrations, but it is not the recommended approach in Superfund background guidance. While the BTV approach assigns a certain confidence level to describing the upper tail of the background concentrations, the 2002 Background Guidance assigns a minimum acceptable confidence and power in comparing background concentrations to onsite concentrations (U.S. EPA 2002a).

EPA has discretion in how to determine background concentrations; OLEM's preferred approach at residential soil lead sites is described in the 2002 Background Guidance. As noted in the front material of the 2022 ProUCL technical manual (U.S. EPA 2022b), it is not Agency guidance or policy. It is a user's manual for statistical software. OLEM prefers to use the directly applicable Agency guidance, which in this case is the 2002 Background Guidance (U.S. EPA 2002a).[67] The approaches discussed in the 2002 Background Guidance provide a robust approach to determine whether a contaminated location has concentrations elevated above those at a background location, with appropriate estimates of the confidence and power levels. These methods directly support the use of background data at a Superfund site. The Background Threshold Module that is available in the ProUCL software provides a robust approach for calculating an estimate of the upper tail of a background data set, with an appropriate estimate of the confidence level. *Frequently Asked Questions About the Development and Use of Background Concentrations at Superfund Sites: Part One, General Concepts* (U.S. EPA 2018b) and *Role of Background in the CERCLA Cleanup Program* (U.S. EPA

[67] Note that to meet project-specific DQOs, a sufficient number of onsite samples will be needed to perform the recommended statistical hypothesis testing.

2002a) provide information and supplemental guidance on background. In cases where ARARs regarding cleanup to background levels apply to a CERCLA action, the response action generally should be carried out in the manner prescribed by the ARAR. When a law or regulation is determined to be an ARAR and it requires cleanup to background levels, then the ARAR will normally apply and be incorporated into the decision document (*e.g.*, Record of Decision [ROD]), unless the ARAR is waived.

Background data should meet site DQOs. In general, CERCLA response actions should use site-specific background levels (including both naturally occurring and anthropogenic sources). The *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites* (U.S. EPA 2002b) provides a decision tree to aid in determining whether existing background data are of sufficient quality to use for CERCLA decisions. The TRW Lead Committee provides information on state-specific soil lead geogenic background levels from the 2013 United States Geological Survey (USGS) study.[68] If the USGS background information does not meet site DQOs, then other background information or data should be sought or collected.[69]

Determining background concentrations for use in risk assessment or remedial decision-making can be challenging, particularly in urban areas or other areas with many sources of lead. The Office of Superfund Remediation and Technology Innovation (OSRTI) regional coordinator can facilitate assistance with support for study design, data analysis, and application of the data to Superfund decision-making. Statistical support can be obtained through the Site Characterization and Monitoring Technical Support Center.[70]

6.2.2 Delineation of Contaminated Areas

Statistical approaches for delineating contaminated areas are often useful. OSRTI technical experts are available to consult with RPMs and OSCs, including the Technology Integration and Information Branch, the Technical Review Workgroup for Lead,[71] and the Environmental Response Team. The collection of samples from all potentially contaminated media is critical to accurately determine the nature and extent of contamination and ensure that the sampling is adequate and complete. The CSM should address whether or not aerial deposition of the lead contamination is a probability or whether the contamination migrated in other ways (*e.g.*, use of lead-contaminated material as fill material or for driveways). If the contamination was

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[68] https://www.epa.gov/superfund/lead-superfund-sites-united-states-geological-survey-usgs-background-soil-lead-survey.
[69] For example, https://www.epa.gov/risk/regional-urban-background-study.
[70] https://www.epa.gov/land-research/site-characterization-and-monitoring-technical-support-center-scmtsc
[71] https://www.epa.gov/superfund/lead-superfund-sites-technical-assistance.

released by aerial deposition, there is a potential for contamination inside homes. Fence lines, property lines, and landscaping should never be used to delineate the extent of contamination. The effectiveness of geostatistical analyses for delineating the spatial extent of contaminant zones has been widely demonstrated (Goovaerts 1997, Englund and Heravi 1994, Flatman and Yfantis 1984, Journel 1984, Gilbert and Simpson 1983). See U.S. EPA (1995c) for more information.

6.3 Sampling Environmental Media for Risk Assessment

The risk assessment sampling approach should be informed by the sampling objectives in the DQO and the exposure CSM (described in Section 6.1). The exposure and other information in the CSM should be updated throughout the investigation and cleanup process as data are collected and evaluated. EPA recommends that sampling at lead-contaminated residential sites focus on an individual residential property as the primary EU of concern[72] while recognizing that exposure does not end at the property line (U.S. EPA 1998), especially in light of potential access, cleanup, and eventual property transfer considerations (see Sections 6.5 and 6.9 for additional information). This information is beneficial to the risk manager when considering appropriate risk reduction strategies for those areas.

The overarching goals of sampling are the following:

- Collect data and information to support current or future risk-based decisions.
    - Considerations include identifying EUs or DUs (see Section 6.5 for more information) as well as media and receptors for complete exposure pathways (current and potential future).
    - Determine mean lead concentrations in media to generate exposure point concentrations (EPCs) for likely exposures for receptors (U.S. EPA 2007a): appropriate sample depth for soil media that represents the site-specific exposure such as, but not limited to, direct contact for incidental ingestion and gardening, disturbed or undisturbed sampling of surface water from an appropriate depth depending on exposure, and sieving of solid media (soil should be sieved to achieve a 150-µm particle size fraction because it is most likely to adhere to hands for incidental ingestion exposures; see Section 6.11 [U.S. EPA 2016]).
- Collect data and information to support nature and extent characterization.
    - Determine the geographic extent of site-attributable contamination to support potential cleanup planning.

[72] The primary EU of concern could include several sampling DUs.

- Identify sources of contamination and the fate and transport of the contaminants through the study area.

With input from the site team, RPMs/OSCs should design sampling to meet the data needs and DQOs to support defensible site decisions (U.S. EPA 2006). An important criterion for defensible data is demonstrated reproducibility. The sampling designs discussed in this section support decision-making during all phases of the project to avoid repeat sampling and mobilizations. Representative site-specific data are used to calculate EPCs for risk assessment, develop remedial action objectives (RAOs), and determine cleanup levels under CERCLA.

The DQO process documented in the SAP QAPP provides a structured approach to problem formulation to guide collection of environmental data that are of sufficient quality and quantity and relevant to support the site investigation, risk assessment, and risk management decisions (U.S. EPA 2006). Systematic planning provides a framework for documenting site information: sample number, sample size, sample locations and media type, bioavailability analysis, laboratory analyses, temporal and meteorological factors, sieving, sampling depth, and sampling costs (see the *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Part A* [U.S. EPA 1989b] and the *Guidance for Sample Collection for In Vitro Bioaccessibility Assay for Arsenic and Lead in Soil and Applications of Relative Bioavailability Data in Human Health Risk Assessment* [U.S. EPA 2020c]). See Section 6.13 for information on how to sample for bioavailability and apply those data to the HHRA.

A site-specific SAP QAPP includes a field sampling plan to ensure that the samples collected meet the DQOs for the site and therefore will support site decisions. This includes making sure that the number and type of samples collected are adequate to characterize the concentration of the contaminant with sufficient statistical power, and that the area sampled spatially represents the anticipated variability of concentration within the exposure area. Samples represent the media that receptors contact (*e.g.*, soil depth likely to be contacted and subsequently incidentally ingested). A risk assessor should be involved in developing the SAP QAPP to ensure that the field sampling plan and subsequent analytical results will provide defensible and fit-for-purpose data for the risk assessment.

Collecting reproducible data of known and documented quality is necessary to support risk management decisions. The type and quantity of sampling needed at a given location will be site-specific and based on factors such as the sampling objectives and the current understanding of the CSM, discussed in further detail in Table 6-1.

Exposure information needed to quantify risks at sites includes media-specific concentration data (*e.g.*, residential soil lead concentration) and may include site-specific exposure data. Site-specific environmental lead concentration data from the media of interest (*e.g.*, air, water, soil, or sediment) should be sampled to determine the concentration of lead at a scale relevant to the receptor's EU. If soil or sediment are media of interest, site-specific bioavailability data should generally also be collected (U.S. EPA 2020c).

For most exposure factors used in risk calculations (*e.g.*, age, body weight, breathing rate, or soil ingestion rate), the Superfund program has standard default parameters that are built into the EPA IEUBK Lead Model.[73] Information for some site-specific exposures (*e.g.*, the number of days per week that young children visit a recreational area away from their home) may also be needed. Consultation with a risk assessor ensures that the sampling plan is designed to collect the information needed to support the site-specific baseline risk assessment.

Typical reasons for sampling various media at residential properties are provided in Table 6-1. The collection of other types of media (*e.g.*, residential water, soil, or sediment lead concentrations at a nearby recreation area) may help to determine overall risk as well. The site team should consider which of these apply to their site, since not all are necessarily applicable.

Table 6-1. Reasons for Sampling Environmental Media at Residential Properties

Sample Location	Rationale for Sample Collection
Residential property soil	Surface soil is a direct incidental exposure pathway for residents. Soil samples should be collected and analyzed to estimate average lead concentrations as well as site-specific *in vitro* bioaccessibility (IVBA) (U.S. EPA 2020c). Depending on the size and uses of the property, it may be sampled as an entire yard, or it may be divided into smaller DUs. Residential soil may also be part of an indirect exposure pathway via house dust exposure. Biased samples should never be used to estimate average concentrations. DUs should reflect potential exposure patterns, play areas, gardens, etc. and EUs should be designed such that the receptor has an equal probability of being exposed anywhere within the EU.
Soil in play areas	Soil in play areas is part of a direct exposure pathway to children of all ages, but especially to younger children. Samples should be collected both inside and outside sandboxes, play areas, or similar structures. Depending on the property size and layout, play areas should be separate DUs because they are likely contacted frequently. Soil samples should be collected and analyzed to estimate lead concentrations as well as site-specific IVBA.

[73] See https://www.epa.gov/superfund/lead-superfund-sites-software-and-users-manuals.

Table 6-1. Reasons for Sampling Environmental Media at Residential Properties

Sample Location	Rationale for Sample Collection
Gravel driveways	Fine-grained driveway material may be part of a direct exposure pathway and an indirect pathway when contamination is tracked into the home and contaminates indoor dust (both because the gravel may be contaminated with lead and because the soil below the gravel driveway may be contaminated and gravel is not an effective barrier). Samples may be collected from the driveway and from beneath the gravel layer to estimate lead concentrations as well as site-specific IVBA.
Rooftops, drip zones, and soil areas below roof gutter downspouts	Rooftops, downspouts, and drip zones may concentrate lead from aerial deposition or LBP. Drip zone areas (commonly approximately 4-6 feet from the base of the structure) on structures with LBP may also contain LBP residue. Characterizing the lead concentration in the drip zone may be important at some sites, but the drip zone is not representative of the overall exposure for a residential lot. Site teams may choose to evaluate drip zones as a separate DU or as part of the yard DU, depending on the DQO.
Garden soil	Garden soil may be part of a direct exposure pathway to persons who actively maintain a garden (U.S. EPA 2013). Soil samples should be collected and analyzed to estimate lead concentrations as well as site-specific IVBA. The TRW Lead Committee has developed supplemental guidance for garden areas[74].
Interior lead dust	Lead in household dust may represent an important exposure pathway, but it may also include LBP or other sources not addressed under CERCLA authority. Dust exhibits temporal variability relative to soil and presents significant logistical challenges. If soil contamination is controlled, then it will no longer contaminate house dust (von Lindern et al. 2003). Dust samples may be collected and analyzed to estimate lead concentrations as well as site-specific IVBA. Because lead-contaminated interior dust can be derived from multiple sources (U.S. EPA 2008), please refer to CERCLA guidance/limitations on sampling and response actions indoors (U.S. EPA 2009, 1993). The IEUBK model includes a module that predicts house dust lead concentration from outdoor soil concentration, so interior dust sampling is generally not needed to assess risk for residential areas. Consultation with the TRW Lead Committee is recommended when designing sampling plans to collect indoor dust lead samples.
Lead-based paint (LBP)	Deteriorating LBP may contribute lead to household dust or soil. If elevated concentrations of lead are found in interior dust, then samples of interior paint should be collected and analyzed to estimate lead concentrations. Deteriorating LBP or a history of exterior LBP may contribute to the contamination of yard soil in the dripline and recontamination of remediated properties. Samples of exterior LBP should be collected and analyzed to estimate lead concentrations. A Field-Portable X-Ray Fluorescence (FP-XRF) spectrometer to measure for interior and exterior LBP is recommended for paint sampling. Reference CERCLA guidance/limitations on sampling indoors (U.S. EPA 2009, 1993).

[74] https://www.epa.gov/superfund/lead-superfund-sites-guidance#gardening.

Table 6-1. Reasons for Sampling Environmental Media at Residential Properties

Sample Location	Rationale for Sample Collection
Residential drinking water and public water supply	Groundwater and surface water containing elevated lead concentrations provide an exposure route for ingestion. Some residences located within the site may use local groundwater or nearby surface water as a source of drinking, cooking, and/or irrigation water. Residential water lead information may be derived from the municipal water supply (*e.g.*, SDWA reporting data) or by collecting samples of residential tap water. Residential tap water may be collected from standing water in the pipes (first-run sample) and water discharged after the home plumbing system has been flushed (flushed sample); both kinds of samples should be collected and analyzed to estimate lead concentrations. Consideration should be given to the potential source of lead contamination in the drinking water (either site-specific wells, residential plumbing, or distribution service lines, or contamination from the municipality).
Crawl spaces and attics	Crawl spaces and attics should be sampled if they are accessible to, and regularly used by, children and/or pets. At some sites (*e.g.*, Bunker Hill Superfund Site, Idaho), this has been found to be a significant exposure pathway (IDHW 2000, TerraGraphics 2000). Pets can transport fine dust containing elevated lead levels into the residence (*e.g.*, where a pet may sleep on the child's bed at night) from crawl spaces (TerraGraphics 2000). Information on concentrations of lead in attics or crawl spaces of the residence may be used to document the need to preclude access or take other response actions to reduce exposure. Consultation with EPA's TRW Lead Committee is recommended when designing sampling plans to collect indoor dust lead (attic) samples.
Other areas within the site	Because exposure is likely to occur throughout the site, other properties should also be sampled, including residences of extended family, day care facilities, schools, and parks within the site. These exposures could be assessed quantitatively in the risk assessment using the Intermittent Exposure Guidance (U.S. EPA 2003c) or be remediated by applying residential cleanup levels to other site-related locations frequented by residents.
Air	Outdoor air samples may be collected to replace the default air lead concentration in the IEUBK model. Additionally, consideration can be given to whether the site is near a lead non-attainment zone.[75] PM10 data monitoring data (from at least 4 quarters or an annual average) may be used in the IEUBK model. The IEUBK model converts outdoor air lead concentrations to indoor air lead concentrations.

6.4 Residential Soil Sampling

6.4.1 Sampling Consent for Access

Prior to conducting any sampling or CERCLA response activities at a residential property, access must be obtained from the property owner, either on consent or through an enforcement instrument; access obtained from tenants or renters is not sufficient. RPMs/OSCs should coordinate closely with the ORC to obtain access for sampling. Coordination with ORC is

[75] Lead non-attainment zone: https://epa.maps.arcgis.com/apps/MapSeries/index.html?appid=8fbf9bde204944eeb422eb3ae9fde765.

important as renters' rights vary by locality and while generally not sufficient for access, having renters' consent does help if other enforcement instruments, such as warrants, might be considered for access. It is essential to begin obtaining access as early as possible in the response process to avoid potentially lengthy delays. Access consent can be obtained through door-to-door interactions, community meetings, and/or direct mailings. It may be more cost-effective to use direct mailings followed by door-to-door outreach in areas with poor responses. In areas occupied by renters, this may not be sufficient. Examples of access consent forms are presented in Appendix F. If possible, access for remediation should be obtained at the same time as access for sampling is sought. Examples of combined sampling/remediation access consent forms are included in Appendix F. Combining sampling and cleanup access will avoid delays. Where applicable, access should be obtained for any interior dust sampling and/or cleaning that may be performed at the residence. Additionally, the OSC/RPM can provide questionnaires requesting information on indoor lead sources. These could be provided in combination with a property access request. For an example of a sample questionnaire, see Appendix O and Section 6.7.1.

6.5 Sampling Units, Exposure Units, and Decision Units

The primary objective of sampling residential soil at lead sites is to accurately determine the representative soil lead concentrations for decision-making. EUs, sampling units (SUs), and DUs are terms used when discussing sampling areas of solid media. For the purposes of this Handbook, these terms are defined as:

- <u>Exposure unit (EU)</u>: The EU is generally determined by the receptor and exposure scenario in the geographic area in which individuals are randomly exposed to a contaminated medium for some relevant exposure duration (*i.e.*, receptors have an equal probability of being anywhere in an EU over the exposure duration). Environmental sampling provides information about the contamination within and around an EU. Multiple EUs may be defined at a site based on the population(s) of interest, exposure medium, and nature of contact with that medium. For example, residential exposures for children may involve exposures via incidental soil ingestion in a yard with a drip zone impacted by LBP (the yard is the EU comprising separate SUs and/or DUs for the yard and drip zone) (U.S. EPA 2001b, 2001c). An EU can contain one or more SUs or DUs.

- <u>Sampling unit (SU)</u>: The SU is defined as an area of soil selected for sampling that will be represented by the sample data collected within it. The SU is generally determined by the known or anticipated concentration of contaminants over a geographic area. It is defined as the area of soil selected for sampling to derive an estimate of the mean lead concentration for that area. EUs and DUs may be composed of one or more SUs. The purpose of having smaller SUs is to gather information about contaminant patterns or trends within specific areas of EUs or DUs to refine the location of contamination for more precise removal of the contamination. SUs are specific to the study objectives and should be determined by the site team during DQO and SAP QAPP development. An example of an SU is a drip zone around a home with suspected LBP on the exterior of the home.

- Decision unit (DU): The DU is defined by the risk management team. The DU is the smallest geographic area of soil that will be subject to a risk-based decision. A DU may consist of one or more SUs and be the same as, or smaller than, an EU. A DU can contain one or more SUs.

Sampling at residential properties that are one-tenth of an acre (a typical urban lot) would be approached differently than a greater-than-10-acre property (which may be encountered in a rural setting). Portions of some large properties may not be utilized regularly by the residents (*e.g.*, forested land). Sampling should be focused where residents are most likely to come in contact with soil, such as gardens and play areas. Discussing land use with residents prior to sampling is essential to support a sampling plan based on known or likely exposure and may differ at individual properties. This is particularly important in cases where the entire property cannot be sampled. Consultation with risk assessors early in the sampling design process is recommended to develop a site-specific strategy for sampling areas.

6.6 Soil Sampling Methods

Table 6-2 highlights three soil sampling methods (incremental composite sampling [ICS], composite sampling, and discrete sampling) that can be used to provide an unbiased estimate of the mean concentration and may be appropriate for collecting soil lead concentration data for use in the risk assessment and/or characterizing nature and extent. In addition to sampling and analysis approaches that rely on destructive analytical techniques, x-ray fluorescence (XRF) analysis may be used at sites depending on the DQOs for sampling and analysis. The heterogeneous composition of soil combined with complex contaminant distribution patterns can result in highly variable concentrations over both short and long distances at a site. Because ICS approaches are better at incorporating the variability of soil concentrations with a smaller number of chemical analyses, this sampling design is generally preferred over other sampling approaches (ITRC 2020, 2012, Brewer et al. 2016a, 2016b).[76] The appropriate and optimal sampling design will depend on site-specific conditions (*e.g.*, SU area), study objectives, data requirements for the risk assessment (*e.g.*, number of replicates), resources available, the CSM, and DQOs (see Appendices J and K for additional information).[77]

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[76] https://www.clu-in.org/conf/itrc/ISM_051514/ISM-hotspot-FAQ-Final.docx.
[77] https://health.hawaii.gov/heer/guidance/specific-topics/decision-unit-and-multi-increment-sampling-methods/.

Table 6-2. Typical Soil Sample Methods Used at Lead-Contaminated Sites

Incremental composite sampling (ICS)	ICS, also known as multi-increment sampling, can provide an unbiased and reproducible estimate of the mean concentration within an SU. An ICS is assembled from a large number (*e.g.*, 30-100) of samples (*i.e.*, increments) of equivalent size/mass collected from simple random or systematic random locations across the SU. The process typically yields a large sample mass (*e.g.*, 1-3 kilograms). Typically, incremental samples are carefully processed and subsampled in the laboratory to increase the likelihood that the analytical result is "representative" of the mean concentration within the SU. The large number of increments, large sample mass, and carefully planned processing/subsampling procedures work together to reduce both small- and large-scale variability and produce a defensible estimate of the mean contaminant concentration within the SU.
Composite sampling	A typical composite sample is assembled from a small number (*e.g.*, fewer than 10) of discrete samples that are combined in the field. The discrete component samples may be collected in a clustered pattern (*e.g.*, a 5-point composite) or from simple random or systematic locations across the SU. Careful consideration of the mass of each discrete component sample is necessary to ensure that an unbiased and "representative" composite sample is achieved of sufficient mass to achieve the analytical goals. Composite samples can reduce small-scale variability by physically combining samples from a small area. Composite samples may be appropriate for small areas such as drip zones and play areas that are too small to support triplicate ICS. Composite samples are typically combined and homogenized in the field and a subsample of the composite is placed into sample containers specified by the analytical method. The sample volume and additional sample processing can vary based on site-specific DQOs.
Discrete sampling	Discrete samples can be collected from biased or random sample locations. The samples are collected from a single location and placed into sample containers specified by the analytical method. The sample volume and additional sample processing can vary based on site-specific DQOs. Individual discrete samples tend to exhibit highly variable concentrations at both small and large spatial scales and generally require a large sample size to achieve a "representative" sample for risk assessment. Biased discrete samples are not recommended because they do not efficiently or reproducibly estimate the mean concentration of lead in a DU. Discrete samples may be used to characterize the concentration of contaminants in material known to be homogeneous (*e.g.*, a waste rock pile at a mining site).
XRF analysis	Sampling information from XRF analysis may be used to support characterization of nature and extent of contamination. Because of their speed, low cost, and ease of use, FP-XRF instruments are often used for screening to quantify metal concentrations in solid media at hazardous waste sites. XRF is a non-destructive screening-level analytical technique used to determine the elemental composition of materials. XRF analyzers determine the chemistry of a sample by measuring the fluorescent (or secondary) x-rays emitted from a sample when it is excited by a primary x-ray source. Each of the elements present in a sample produces a set of fluorescent x-rays having a characteristic wavelength spectrum ("a fingerprint") that is unique for that specific element, allowing for qualitative and semi-quantitative analysis of material composition. U.S. EPA (2007b) notes that XRF is a screening method to be used with confirmatory analysis using other

Table 6-2. Typical Soil Sample Methods Used at Lead-Contaminated Sites

	techniques (*e.g.*, flame atomic absorption [FLAA] spectrometry, graphite furnace atomic absorption [GFAA] spectrometry, inductively coupled plasma-atomic emission spectrometry [ICP-AES], or ICP-mass spectrometry [ICP-MS]). Final remedial decisions around the decision point should be confirmed with definitive information derived from confirmatory analytical techniques (including IVBA). See the *Superfund X-Ray Fluorescence XRF Field Operations Guide* (U.S. EPA 2017b) for more information. Notes: 1. XRF measurement does not inform site-specific bioavailability. 2. XRF samples are expected to be *ex situ* and sieved to the relevant particle size for risk assessment.

Sampling designs should include collection of a sufficient number of samples to adequately control Type I and Type II statistical error (*i.e.,* false positive and false negative error rates) to achieve reproducible and defensible data required for decision-making (U.S. EPA 2006).[78] Collection of biased discrete samples from known or supsected areas of contamination may be appropriate for screening on a presence/absence basis; however, biased discrete samples should not be used to calculate the mean contaminant concentration for an SU for risk assessment, limiting the use of biased sampling for risk assessment or cleanup decisions. Biased data are usually of unknown quality and may lead to an unreliable estimate of contamination.

Composite samples combine discrete, mass-defined samples from multiple locations to arrive at an estimate of the mean contaminant concentration with relatively fewer samples and, therefore, lower analytical costs than discrete sampling (that are often combined mathematically) (U.S. EPA 1995d). For example, a common approach for small SUs (*e.g.*, <100 square feet) is to collect five equivalent mass samples in a geometric pattern (*e.g.*, five points arranged in a cross, with four of them forming a square or rectangle and a fifth at its center), which are then combined, homogenized, and submitted as a single composite sample for analysis. Composite samples with fewer than 10 samples generally cannot be used to approximate spatial variance of lead concentration within the SU from which the composite sample was collected and are not recommended (U.S. EPA 1995d). An adequate number of composite samples must still be collected in order to obtain an estimate of the population variance and control for large scale heterogeneity (U.S. EPA 1995d). In general, if incremental or other composite-type sampling is determined to be the most effective sampling method at a site, triplicate sampling within an SU can be used in which the entire pattern of increments/

[78] ProUCL and related guidance is available to inform the number of samples necessary to support decision-making.

composites is performed three times to provide a measure of reproducibility of the estimated mean and the global variance.[79]

6.7 Lead-Based Paint (LBP) and Interior Dust Sampling

Deteriorating LBP may contribute lead to household dust. If elevated concentrations of lead are found in interior dust in the absence of outdoor soil sources, the source of lead may be interior LBP. Lead in household dust may be a significant contributor to elevated blood lead in younger children. Lead-contaminated interior dust can be derived from multiple sources; dust mat samples (in concert with speciation of lead) can be used to identify lead sources. Indoor dust samples may be collected and analyzed to estimate its potential contribution to lead exposure.[80] Wipe samples measure lead loading (mass of lead per area), not concentrations (mass of lead per mass of dust). As such, wipe sample results are not appropriate for use in the IEUBK model (because the IEUBK model requires concentration data). Guidance on LBP and dust sampling is available from HUD (2012). More information on interior dust sampling for use in lead risk assessment at Superfund sites is available (see U.S. EPA 2008).

6.7.1 Collaboration to Identify and Address Lead-based Paint Hazards[81]

Collaboration with other EPA programs, other federal agencies, states, tribes and/or local governments may be required to ensure that exposures to lead from lead paint are identified and addressed. There may be situations that warrant additional collaboration, such as where the site team suspects that an LBP hazard could pose an exposure risk to residents within the boundaries of the Superfund site, in addition to the CERCLA release. Lines of evidence suggesting an LBP hazard that would require additional collaboration may include screening or analytical data, available geospatial census level data, construction date (pre-1978), and/or condition of the structure. When evidence at a site suggests that an LBP hazard exists, it is recommended that the RPM, OSC, and/or CIC (or other identified convener) coordinate with the regional and/or state, tribal, or territory LBP program.

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[79] Note that triplicate samples for a DU or EU at a relatively small residence may constrain the ability to make robust statistical comparisons to background due to limited statistical power.

[80] CERCLA authority to address these sources may be limited; refer to Chapter 2 for additional information on CERCLA limitations.

[81] Under Toxic Substances Control Act (TSCA) Section 401 (15 U.S.C. 2681), LBP hazards are defined as conditions of LBP and lead-contaminated dust and soil that would result in adverse human health effects. As defined in TSCA section 401 (15 U.S.C. 2681(9)), LBP means paint or other surface coatings that contain lead in excess of 1.0 milligrams per centimeter squared or 0.5 percent by weight or (1) in the case of paint or other surface coatings on target housing, such lower level as may be established by HUD, as defined in 42 U.S.C. 4822(c), or (2) in the case of any other paint or surface coatings, such other level as may be established by EPA.

6.8 Residential Drinking Water and Public Water Supply

Groundwater and surface water may contain elevated lead concentrations impacting drinking water used for consumption. Some residences located within the site may use local groundwater or nearby surface water as a source of drinking, cooking, and/or irrigation water. As noted in Section 6.3, Table 6-1, consideration should be given to the potential source of lead contamination in the drinking water (either site-specific wells, residential or distribution water lines, or contamination from the municipality).

If lead is present in drinking water due to the site release, Superfund has authority to address the issue and the EPA regional Drinking Water program may be informed for situational awareness. If it is determined that lead is present in drinking water because of lead plumbing or fixtures, then the Superfund site team (or other identified convener) should inform the regional Drinking Water program to coordinate activities to reduce exposure to lead (because these sources are generally excluded from Superfund authority). If it is determined that a drinking water supply is impacted by corrosion of lead plumbing, the Superfund site team (or other identified convener) can also determine if federal partnerships have already been established that would help address the problem, such as EPA's free Water Technical Assistance (Water TA) services and programs,[82] and EPA's Urban Waters program.[83]

6.8.1 Collaboration to Identify and Reduce Exposure to Lead in Drinking Water

If lead is found in groundwater as part of the release and/or due to migration from site-related sources of lead in soil to groundwater, the Superfund site team, after briefing the appropriate Section and/or Branch management (as needed), should inform the EPA regional Drinking Water program as well as the impacted public water system for situational awareness.[84] The lead in groundwater and drinking water (if impacted) would be addressed under Superfund authority if it is determined to be related to a site release.

[82] https://www.epa.gov/water-infrastructure/water-technical-assistance-waterta

[83] Urban Waters Federal Partnership: The EPA urban waters regional contacts can be found by navigating to each individual partnership page: https://www.epa.gov/urbanwaterspartners. Urban Waters program fact sheet: https://www.epa.gov/sites/production/files/2015-09/documents/uwfp_factsheet-final.pdf.

[84] In accordance with the 1996 amendment to the SDWA, every state exercising primacy enforcement responsibility for public water systems must assess its sources of drinking water to identify significant potential sources of contamination and to determine how susceptible the sources are to these threats. While there is no federal requirement to update these assessments, some states do require updates. Any impact to groundwater due to migration from site-related sources of lead in soil should be shared with the regional drinking water program so that the information can be communicated to the states. For more information, see: https://www.epa.gov/sites/production/files/2015-04/documents/epa816f04030.pdf.

If the public water supply and/or tap water data indicate that lead is present because of corrosion and/or leaching of lead from pipes or fixtures within the boundaries of the Superfund Site, the Superfund site team should collaborate with, and direct the issue to, the regional Drinking Water program since Superfund does not have the authority to address this source of lead.

The following bullets describe the recommended steps for identification and coordination when lead is or may be in drinking water:

- If private drinking water wells are in the footprint of, or near, the impacted groundwater, Superfund would conduct an investigation that may include sampling the private wells to determine if lead is present in the drinking water and related to the site release (Section 6.3). Additionally, the Superfund site team, including the site human health risk assessor, can coordinate with ATSDR to ensure that the public is receiving appropriate outreach and educational materials.

- If the public water system[85] is drawing groundwater or surface water from within the boundaries and/or vicinity of the Superfund site, the site team should take steps to determine if the drinking water supply is impacted by the site release.

- The Superfund site team may review publicly available information reported by the public water system, if this information is readily available, but it is recommended that the Superfund site team connect with the EPA regional Drinking Water program through the Drinking Water Branch Chief, especially if data indicate that the public water supply may be impacted by the site release. The primacy agency (*i.e.*, state, tribal government, or EPA region) would work with the public water system to pursue data collection to determine if influent and effluent treatment system data indicate that lead from the Superfund release is impacting the public water supply.

- There may be instances[86] where the RPM or OSC (or contractor) may collect a subset of residential tap water data such as for use as an input to the IEUBK[87] model. The site human health risk assessor should be consulted regarding tap water sampling for use in the IEUBK model. The RPM should also consult with the regional Drinking Water program, which can provide a reference to a current list of approved sampling methods

[85] A public water system may be publicly or privately owned. EPA has defined three types of public water systems according to the number of people they serve, the source of their water, and whether they serve the same customers year-round or on an occasional basis. For more information, see https://www.epa.gov/dwreginfo/information-about-public-water-systems.

[86] These decisions will be made based on site-specific information, such as past industrial practices or processes that may result in mobilizing lead in soil.

[87] Current versions of the IEUBK model and relevant guides and guidance can be found at: https://www.epa.gov/superfund/lead-superfund-sites-software-and-users-manuals.

for drinking water compliance under the Lead and Copper Rule (LCR; 40 CFR 141.86(b)).[88]

- If residential tap water data show that lead is present in drinking water, then the Superfund site team should inform the EPA regional Drinking Water program and share information such as the tap water sampling methods and protocol as well as analytical data.

- The EPA regional Drinking Water program contact, the state contact, or the local public water system may be able to inform the Superfund site team of the presence or absence of lead service lines, if that information is known, and may assist in evaluating public water supply data to determine if there have been lead action level exceedances and health-based violations of the effective LCR or future revisions of this rule.

- The Superfund site team may also want to work with the regional geographic information system (GIS) team to determine if geospatial data layers exist with respect to public lead indices based on old housing (including the Environmental Justice Screening and Mapping Tool [EJSCREEN] and other EPA tools).

- The Water Infrastructure Improvements for the Nation (WIIN) Act that was enacted on December 16, 2016, explains the notification and coordination requirements that EPA must follow when EPA develops or receives data (other than from a primacy agency or a public water system) indicating that household water testing results exceed the lead action level. *The Strategic Plan for Targeted Outreach to Populations Affected by the Lead WIIN Act* outlines the statutory requirements and process for distributing sampling data to the public water system or state, and notification requirements. It is important that if the Superfund site team is sampling from residential taps and analytical data indicate an action level exceedance, the Superfund site team is prepared to implement the Strategic Plan. The first step is to immediately notify the Drinking Water program and provide the associated data so the manager responsible for the regional Drinking Water program can orchestrate the required data sharing and notification within a timeframe consistent with the Strategic plan[89] and per the requirements of the WIIN Act (U.S. EPA 2017c).

6.9 Sampling for Exposures at Secondary Areas and Community-Wide Exposures

Exposure does not end at the property line (Laidlaw et al. 2014, Zahran et al. 2013a, Laidlaw and Filippelli 2008, Sheldrake and Stifelman 2003). Lead-contaminated soil-dust moves at various scales via wind, vehicular tracking, or transport on clothes, shoes, tools, equipment, or pets (Zahran et al. 2013b). It is important to consider whether there are other areas of lead

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[88] See 40 CFR 141.86(b) for guidance on collecting tap water samples for lead: https://www.law.cornell.edu/cfr/text/40/141.86.

[89] See Figure 1 in the *Strategic Plan for Targeted Outreach to Populations Affected by Lead Water Infrastructure Improvements for the Nation (WIIN) Act*. Accessing the file at https://www.epa.gov/sites/default/files/2017-07/documents/wiin_strategic_plan_july_18_finalv5.pdf provides an interactive version of the figure.

contamination that represent an additional, distinct exposure area (*e.g.*, neighboring parks or play areas; schools and daycare locations; or areas where trespassing may occur). Because releases and possible corresponding exposures can extend beyond property lines, and both children and soil-dust are mobile, properties in the vicinity of a residence may be considered as part of the exposure area (Zahran et al. 2013a, 2013b, Sheldrake and Stifelman 2003). In such cases, these areas should be evaluated on a case-by-case basis to determine the extent of the exposure duration and frequency; sampling may also be recommended to determine how concentrations at these locations differ from the residential scenario. Sampling at these locations/properties should generally be consistent with the DQOs for residential properties. EPA's *Assessing Intermittent or Variable Exposures at Lead Sites* guidance document presents a methodology for the assessment of lead risks when exposures may occur at secondary locations (U.S. EPA 2003c).

6.10 Soil Sampling Depth

Sampling depth depends upon the CSM and the exposure scenario(s) for the site, but in most instances, the recommended soil sampling depth is the top 0-1 inches (0-2.5 centimeters [cm]) for direct contact with surface soil, where typical exposures for children are most likely to occur. However, there may be more than one exposure scenario for the site. For example, one exposure scenario at a site may be children playing at a residential property with exposure to contaminated surface soil; the same site might also include a deeper horizon for a sandbox (*e.g.*, 0-6 inches) or garden area (*e.g.*, 0-12 inches). The sampling depth should match the exposure pathways and contaminant transport routes of concern.

Sampling depth also varies depending upon site-specific conditions. The *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Part A* (U.S. EPA 1989b) states that the assessment of surface exposures will be more certain if samples are collected from the shallowest depth that can be practically obtained to avoid dilution if the transport mechanism is aerial deposition or fugitive dust. Keeping in mind the broader considerations mentioned above, to assess risk from current exposure to lead-contaminated surface soil, EPA generally recommends the collection of the top inch (0-1 inches or 0-2.5 cm) of the soil layer for determining direct contact exposure to surface soil (U.S. EPA 1996b). In some cases, grass, organic litter, sod, wood chips, or sand will be encountered and soil below the cover material should be collected (U.S. EPA 1996b). If aerial deposition is the dominant source of contamination, the soil is undisturbed, and surface soil concentrations are below screening levels, it may not be necessary to collect samples at depths greater than (>) 1 inch.

If contamination is found at depths below 1 inch, or 2.5 cm, then the risk assessment for the current exposure scenario should consider the likelihood of whether children (or other receptors) may be exposed to soil at that depth and select the sampling depth accordingly. Samples collected at depths >1 inch below ground surface (bgs; *i.e.*, subsurface) may also be appropriate for risk management purposes, such as future use scenarios (*e.g.*, play areas, gardening, construction or utility work, yard maintenance). To assess risks from exposure to contaminated subsurface soil, samples should be collected from the depth interval that is consistent with the applicable exposure scenario as determined by the site team based on site-specific information (*e.g.*, several depth intervals down to 24 inches bgs; 0-1, 1-6, 6-12, 12-18, and 18-24 inches). The EPC for each exposure scenario should be estimated with data from the depth interval(s) relevant to each scenario. Regions or states may have specific guidance on sampling depths.

Soil samples below 1 inch may also be useful for determining where ICs may be needed; response actions may warrant ICs or post-removal site controls if subsurface contamination remains following a response action. Please refer to Chapter 10 for additional information on ICs.

6.11 Sample Preparation (Sieving)

Samples should represent current or potential future exposure to young children. Children inadvertently ingest lead from fine particles of contaminated soil and dust that adhere to their hands, toys, and other objects they put in their mouths. Additionally, smaller particles migrate more easily into the home. Therefore, sieving of soil samples is recommended to better represent the soil-dust fraction that is incidentally ingested by children. Accordingly, lead concentrations in soil samples should be measured in the fine particle fraction of <150 µm (#100 sieve), or at a particle size fraction of <250 µm (#60 sieve) for sediment samples.[90] In rare cases (such as where bullet fragments are present), it may be that the coarse fraction (*i.e.,* the fraction that does not pass through the selected sieve) or the total unsieved sample (*i.e.*, the fraction that is <2 mm) must also be analyzed for at least a portion of samples at sites where the CSM suggests that significant lead may be present in the coarser fraction (*e.g.*, shooting ranges[91], artisanal lead recovery/reuse operations) because these larger lead particles may weather over time to increase the concentration of lead in the finer fraction. Consultation with

[90] OLEM Directive 9200.1 128 (U.S. EPA 2016) *Recommendations for Sieving Soil and Dust Samples at Lead Sites for Assessment of Incidental Ingestion.*

[91] See U.S. EPA (2003e)

a risk assessor is recommended when the lead concentration is higher in the <2 mm fraction than in the finer fractions of a sample.

6.12 Holding Times

EPA evaluated sample holding times for lead in soil and found that no significant changes in concentration occurred within a year of sample collection (U.S. EPA 2005a). EPA generally recommends holding times of no more than 6 months for inorganic contaminants (U.S. EPA 2005a); however, site-specific SAP QAPPs may specify different holding times.

6.13 Assessment of Relative Bioavailability (RBA) of Lead in Soil

Depending on the chemical and physical characteristics of the environmental media matrix and the type of lead present, <100% of lead entering the body through ingestion may be absorbed into systemic circulation (U.S. EPA 2024). This is referred to as the bioavailability of lead—a characteristic critical for both understanding how the body absorbs and reacts to lead exposure, and for determining the risk of detrimental health effects associated with lead exposure (U.S. EPA 2020d). Once absorbed into the body, lead is widely distributed and interacts with the body's chemistry, affecting soft tissues (*e.g.*, kidneys, liver, heart), the brain, and eventually accumulating in the teeth and bones over time (U.S. EPA 2024). Though relatively stable when stored in the bones, it is in equilibrium with blood and its release into the bloodstream is enhanced due to osteoporosis and during pregnancy and lactation (ATSDR 2020). RBA of a contaminant in soil is how much of that contaminant is absorbed into the body from soil compared to how much of that contaminant is absorbed from a reference exposure medium (*e.g.*, food, water) that relates back to the toxicity value of that contaminant. The default RBA of lead for both the IEUBK and the Adult Lead Methodology (ALM) is 60%, based on the mean RBA of a large number of soils (U.S. EPA 2021a). However, the RBA of lead in soils can range from <10% up to 100%. The use of site-specific RBA information greatly improves the accuracy of the HHRA and can result in a PRG that differs substantially from the regional screening level (RSL) or removal management level (RML).

RBA of lead in soil and sediment can be estimated from *in vitro* assays that measure lead bioaccessibility (an *in vitro* measure of the physiological solubility of the lead that may be available for absorption into the body) (U.S. EPA 2020c).[92] EPA SW-846 Method 1340 has been validated as an *in vitro* bioaccessibility (IVBA) assay method to predict the RBA of both lead and arsenic in soil or sediment (U.S. EPA 2012b). EPA SW-846 Method 1340 is a substantially less

[92] https://semspub.epa.gov/src/document/HQ/100002712.

expensive alternative to an animal bioassay for assessing RBA. The relatively low cost of the IVBA assay compared to an animal bioassay, availability of standard operating procedures (SOPs), and availability of public and commercial laboratories where it can be performed allows larger numbers of soil samples to be processed more rapidly for the same cost as a single animal bioassay while reducing animal testing. Using the IVBA assay to evaluate multiple soil or sediment samples at a site can provide a more thorough assessment of site RBA. When using novel media that were not represented in the data used to validate the IVBA assay, however, it is prudent to conduct confirmatory animal RBA bioassays before using an IVBA assay. These may include soils with chemical and physical characteristics outside the domain of soils used to develop and validate the IVBA assay (which included residential soils, mining soils, smelter soils, slag, National Institute of Standards and Technology [NIST] paint, and galena enriched soil). For a list of the validation samples and their characteristics, see U.S. EPA (2007b). EPA is working on assessing the relationship between *in vivo* animal assays and the Method 1340 IVBA and will publish that update at https://www.epa.gov/superfund/soil-bioavailability-superfund-sites. It may also include soils that have received treatments with amending agents that alter mobility or solubility of arsenic or lead. At this time, IVBA methods have not been validated for soil that has received amendments for chemical alteration of soil lead (*e.g.*, phosphate amended soils).

EPA generally recommends that site-specific RBA data be collected at lead-contaminated Superfund removal and remedial sites and RCRA Corrective Action sites using validated *in vitro* (or less commonly, *in vivo*) methods (U.S. EPA 2020c, 2017d). It may also be useful to collect bioavailability data for other purposes, such as pre-NPL listing decision-making. Note that sediment IVBA is for swimming and wading scenarios where young children are exposed to sediments in shallow water, not exposure through fish consumption. EPA provides guidance (U.S. EPA 2020c) on major topics related to collection of information on, and application of, RBA data in HHRA, including: (1) rationale for collecting RBA data to support HHRA; (2) application of IVBA and RBA data in HHRA; (3) evaluation and analysis of IVBA and RBA data for use in HHRA; (4) systematic planning for collection of RBA data; and (5) collection and processing of soil samples for measurement of arsenic and lead IVBA at sites. In the absence of RBA assessments from a validated assay, EPA recommends that the default RBA of 0.6 (60%) be assumed for soil lead at all sites other than firing ranges, where an RBA of 1.0 (100%) should be used (U.S. EPA 2020d). See the Bioavailability Committee website[93] for more information on using bioavailability information in risk assessments.

[93] https://www.epa.gov/superfund/soil-bioavailability-superfund-sites-guidance.

6.14 Evaluating Soil Data and Soil Screening Levels

Data obtained from soil sampling efforts may be used to determine whether mean lead concentrations present in soil pose a potential unacceptable risk to residents, and can further inform risk management decisions. See Section 8.4 for a discussion of sampling for and calculating EPCs. See Section 9.4.1.2 for a discussion of how the EPC is compared to the PRG or cleanup level as a not-to-exceed (NTE) level and Section 9.4.1.3 for a discussion of how the EPC is compared to the PRG or cleanup level as an area-wide average.

OLEM recommends using an RSL[94] for lead in soil at residential sites (Breen 2024, U.S. EPA 2016, 1994a). RSLs, along with RMLs for the Removal Action, are not cleanup levels, but rather guidelines to determine which sites or portions of sites may warrant further study. While residential areas with soil lead concentrations below an RSL/RML generally warrant no further action, some actions may be appropriate in certain situations because the screening level does not generally consider site-specific information, such as soil lead bioavailability information. For example, metallic lead in soils weathers quickly to lead oxide, lead carbonate, and other lead salts that are highly bioavailable. Firing ranges and other locations with metallic lead in soils may benefit from further investigation even where the soil lead concentration is below the RSL/RML.

EPCs are compared to RMLs and RSLs to determine if:

- Removal action may be warranted if media concentrations exceed RMLs[95];
- Further site characterization of risk if media concentrations exceed RSLs; and
- No further action if media concentrations do not exceed RSLs and high bioavailability of lead is not expected.

EPA developed the *Residential Lead Screening Level Checklist* to assist site teams in selection and documentation of the RSL for lead in soil at residential sites (see supporting information at https://www.epa.gov/superfund/updated-soil-lead-guidance-cercla-sites-and-rcra-corrective-action-facilities).

[94] For more information on RSLs, see https://www.epa.gov/risk/regional-screening-levels-rsls-users-guide#lead.

[95] RMLs are only one component evaluated by OSCs in determining whether a removal action is warranted. For instance, OSCs are also required to evaluate the eight factors at 40 CFR 300.415(b)(2). Also, the exceedance of an RML does not always justify a removal action (see RML User's Guide: https://www.epa.gov/risk/regional-removal-management-levels-rmls-users-guide). Conversely, when site concentrations don't exceed RMLs, then a removal action is unlikely to be justified. Except in limited circumstances, sites with soil concentrations above the RSL but below the RML would be referred to another Program (*e.g.*, Remedial, State, Brownfields, etc.) for follow up.

6.15 Dietary Sources of Lead Exposure

The default dietary inputs in EPA's lead risk assessment model (the IEUBK, see Chapter 8) represent national estimates of lead exposure from food. The default estimates are based on lead concentration information from market basket studies conducted by the U.S. Food and Drug Administration (FDA) and food consumption information from the National Health and Nutrition Examination Survey (NHANES).[96] The alternate dietary intake menu includes ingestion of game animals from hunting, fish from fishing, and home-grown fruits and vegetables. This exposure pathway is an alternative approach to substituting for dietary exposure to lead in store-bought food based on information from the FDA. This feature can be used when site-specific data are available to estimate both the concentration of lead in these food sources and the contributions of these food sources to the diet of a typical child resident at the site. Alternatively, the Alternate Source Pathway of the IEUBK model may be used to assess risk for these dietary sources. While this alternative may result in double-counting of lead exposure from dietary sources, it benefits from not requiring professional judgment to determine how much of the diet is replaced by local sources. Consultation with the TRW Lead Committee[97] is available if RPMs or risk assessors have questions about assessing site-specific dietary exposures.

6.15.1 Fish (Fish from Surface Waters Impacted by the Release) and Game (from Hunting within the Site)

When the alternate dietary intake menu mode of data entry is used, the IEUBK model substitutes fish or game for other store-bought meat dishes, so users must estimate fish or game meals as a proportion of total meat meals. For example, in estimating child lead exposure from recreational fishing, appropriate inputs for percent of food class would be 10% for recreational fishing or as much as 50% for high-end cases; note that these may vary depending on site-specific information. Fish collected from the site, or impacted by the site, should represent the types and size class of fish that local people catch and eat. The average concentration of lead in fish as consumed (either fillets or whole fish depending on site-specific information) is entered as micrograms of lead per gram (µg Pb/g) of fish tissue. The analysis should consider the fish consumption habits of residents, since the lead concentration may differ in fish fillets versus whole fish.

[96] https://www.epa.gov/superfund/lead-superfund-sites-guidance.
[97] https://www.epa.gov/superfund/lead-superfund-sites-technical-assistance#:~:text=The%20TRW's%20Lead%20Committee%20reviews,methodologies%20at%20hazardous%20waste%20sites.

In addition, EPA's *Guidance for Assessing Chemical Contaminant Data for use in Fish Advisories Vol. 2* (U.S. EPA 2000b) recommends three-ounces of fish per day (85 grams/day [g/day]) for children as an average. Therefore, consumption of fish meals between the average 3 ounces and an upper bound estimate of 8 ounces (85 and 227 grams, respectively) may also be used in the analysis. Note that fish consumption may differ from the national estimates on a site-specific basis (*e.g*., Native American populations). The RPM/OSC may want to work with the risk assessor to evaluate available studies of similar water bodies and populations to identify ingestion rates based on similarities in fish species, type of water body (*e.g.*, fresh versus salt water, stream versus river, fish advisory present or not), population demographics, potential for response bias, and other characteristics.

Similarly, site-specific information on consumption of hunted game would be used to replace meat intake in the IEUBK model.

6.15.2 Garden Produce

The uptake of metals into plant tissue for most common garden vegetables is not very high and does not contribute significantly to exposure; however, exposures typically come from ingesting soil adhered to produce, garden soil exposure, and handling and tracking contaminated soil into the residence (U.S. EPA 2014a). Vegetables should be scrubbed or peeled before consumption, and hands, clothing, and tools should be cleaned before being brought indoors. See Table 6-3 for recommended Best Management Practices (BMPs) for gardening in lead-contaminated areas to reduce lead exposure in contaminated soil (Brown et al. 2015, U.S. EPA 2014a). Additional information on collecting and utilizing garden data in the IEUBK model can be found in the Guidance Manual for the IEUBK model (U.S. EPA 1994b).[98]

[98] For additional information, refer to: https://www.epa.gov/superfund/lead-superfund-sites-frequent-questions-risk-assessors-integrated-exposure-uptake#garden; https://www.epa.gov/superfund/lead-superfund-sites-guidance#gardening.

Table 6-3. Approaches to Reduce Exposure to Lead in Garden Soil

Techniques	Approaches
Behavioral	• Discard outer leaves of leafy vegetables • Wash produce to remove soil • Peel root crops • Discourage eating soil • Wash hands, toys, pacifiers • Wear gloves • Keep children from entering the garden if contaminant levels are unknown • Minimize soil track-in • Take off shoes, use doormats, and clean floors • Provide alternative safe areas, like a sandbox, for children's play • Locate gardens away from older painted structures, fences, or sheds
Soil remediation	• Request a soil sample test for metals and agronomic parameters before beginning gardening • Adjust soil pH to near neutral (~6.5-7.5), based on findings • Incorporate clean materials (*e.g.*, compost, manure) • Apply mulch to reduce dust and soil splash-back onto crops and reduce exposures • Add phosphate amendments where appropriate • Excavate contaminated soil and place geotextile barriers
Alternate remediation	• Build raised beds with safe materials (*i.e.*, do not use treated lumber, salvaged painted wood, or railroad ties) with a barrier (*e.g.*, landscape fabric) and fill with clean soil • Use containers to grow in clean soil (*e.g.*, 5-gallon buckets that do not leach metals) • Consider other land/location options

CHAPTER 7
Source Attribution for Lead Contamination at Superfund Sites

7.1 Introduction

7.1.1 Purpose

This chapter provides information for assessments at lead sites where source attribution techniques may be needed to better inform site management decisions. It is relevant to a variety of lead sites where multiple sources of lead in the environment complicate site decisions under Superfund authorities. This chapter will provide information to support site decisions at lead-contaminated sites using a consistent analytical or scientific framework, acknowledging that a flexible, site-specific approach may be needed for characterization, risk assessment, and risk management. The source attribution techniques in this Handbook promote best practices for assessing and managing risks associated with lead-contaminated residential sites being addressed under Superfund authority.

7.1.2 Sources of Lead and Environmental Distribution

Lead is a widespread, naturally occurring element that occurs in the Earth's crust and geological formations (*e.g.*, rocks, sediment, etc.). Lead is the 38th most abundant element with an average crustal abundance of 14 milligrams per kilogram (mg/kg) (Krauskopf and Bird 1995). Lead can be dispersed by natural processes such as wind and soil erosion, or by intentional transport such as human activities like mining and the inclusion of lead in consumer products (*e.g.*, LBP). In some situations, mine waste has been used as construction fill, roadbed materials, and building materials. Furthermore, sediment-associated lead can be reintroduced into river sediment from a contaminated riverbank or dispersed via airborne transport. In many urban environments, soil mixed with other materials from the as-built environment is used to modify site elevation to facilitate property development. Urban fill material is a soil matrix that can include brick, cement, wood, wood ash, coal, coal ash, boiler ash, clinkers, asphalt, glass, plastics, metal, ceramics, demolition debris, roadside ditch materials, slag, and other waste materials. Many of these fill components can be sources of lead.

7.1.3 Urban Environments

The distribution and anthropogenic concentrations of lead in the environment is the most widely studied legacy metal in industrial cities (Maxim et al. 2022). The sources of lead are predominantly from historical use of leaded gasoline, LBP, coal burning, and industry. These widespread anthropogenic sources make determining the background levels of lead more complicated. Knowing the background level of lead is an important part of the process necessary to accurately attribute lead to specific sources. This information is also useful in determining if the release of lead can be addressed using Superfund authority.

7.1.4 Source Attribution Overview

A wide array of techniques has been used to determine the relative contributions of lead from natural and anthropogenic sources in soils, sediments, water, and air. The EPA has used several methods in Superfund site investigations, including site history, spatial deposition, elemental concentrations and ratios, isotopic analysis, and other soil-metal characterization (NAS 2017). Also, combinations of these methods may be used in a weight-of-evidence approach.

7.1.4.1 What is Source Attribution?

Source attribution involves identifying unique physical or chemical characteristics associated with suspected sources of lead in the environment, and comparing those characteristics with lead in samples of soil, sediment, water, and air collected from a site to determine its origin (NAS 2017). Various physical and geochemical fingerprinting strategies are available for each of the different environmental media at a site; selection of the appropriate one(s) to implement depends on site-specific variables uncovered during site characterization and researching site history. The general assumption behind fingerprinting is that the physical or chemical composition of a sample is a function of the characteristics or composition of the lead sources and the relative amount of each source that contributes to it. The characterization tools that are most used for lead source attribution include lead concentrations with spatial analysis, lead isotope ratio analysis, solid-phase speciation analysis using spectroscopy, microscopy, and sequential extraction techniques, and element correlation using multi-variate statistical methods.

7.1.4.2 Why is Source Attribution Important?

As part of the Superfund program, the EPA conducts site investigations, determines whether a site needs to be remediated, and identifies the parties that may be responsible for the contamination. Given that lead is a naturally-occurring metal and has been used in a variety of consumer products known to cause environmental contamination, parsing out the source of lead contamination at a site is critical to identifying potentially responsible parties (PRPs). If lead is discovered to be a result of nonpoint anthropogenic background sources, federal and local stakeholders may collaborate as appropriate to evaluate whether lead is present at concentrations above risk thresholds. If lead is found to be a result of one or more CERCLA sources of concern, EPA will first look to PRPs to clean up the lead that is present above risk thresholds in site-impacted media.

Similarly, EPA will look first to PRPs to bear the costs for investigation and remediation at Superfund sites. At Superfund sites associated with lead-mining districts, cleanup costs can range from hundreds of millions to billions of dollars. As such, source attribution is a useful tool to establish PRP liability for the cleanup costs.

7.1.4.3 When to Consider Using Attribution Techniques

Urban sites and mining sites can be complex and problematic when identifying contaminant sources. This is due to the multiple possible natural and anthropogenic sources of contamination, and is further complicated at mining sites due to their sheer size, and at urban sites which may have multiple potential point sources of contamination (*e.g.*, manufacturing plants, processing facilities, and landfills) within a relatively small geographic area.

Source attribution is typically more successful for sites with concentrated waste materials. It can be more challenging at sites with large amounts of low-concentration wastes, such as landfills and mining sites. Source attribution can also be more diffcult in areas with high concentrations of lead that are due to either local geology, anthropogenic background, or multiple nonpoint sources.

7.2 Issues for Consideration

The Superfund program was primarily established to address human health and environmental risks posed by hazardous waste sites. CERCLA gives the EPA the resources and authority to remediate sites and seek reimbursement from PRPs. Sites may be addressed using removal authorities to mitigate immediate threats. For complex sites, the first phase of the Superfund process is the Site Assessment; from there, steps in the Superfund assessment process may include NPL listing, site characterization (the RI/FS), the ROD, remedial design and remedial action, construction and post-construction completion, NPL deletion, and reuse (U.S. EPA 2023d). While source attribution may be used during the removal process, two of these steps (Site Assessment and Risk Assessment, which occurs as part of the RI/FS) are discussed below in relation to source attribution of lead at Superfund sites.

7.2.1 CERCLA Authority

CERCLA gives EPA the authority to clean up sites and seek reimbursement from PRPs. Given that lead is both a naturally occurring element and widespread in the environment due to its legacy use in gasoline and paint, determining both natural and anthropogenic background is important. This allows the EPA to separate lead due to the contaminated site (evaluated under Superfund) from lead present at background levels that would not generally be addressed under CERCLA.

7.2.2 Geologic Confounding

A variety of geologic processes can cause natural lead enrichment; natural processes that occur at or near the earth's surface, such as volcanic emissions, forest fires, and erosion, can concentrate lead or disperse it into the environment. In most rock, lead occurs at low concentrations; when present at high concentrations, lead forms discrete lead-rich minerals, the most common of which are lead sulfide (galena), lead carbonate (cerussite), and lead sulfate (anglesite). Four categories of mineral deposits might be encountered at a mining Superfund site:

1. Primary lead deposits in which lead is the primary or sole commodity motivating mining;
2. Mineral deposits in which lead minerals are part of the ore body and an essential part of the economics, but production of other metals is also essential;
3. Mineral deposits in which lead is recovered as a byproduct because it is economically profitable to do so, but not necessary for profitability; and
4. Mineral deposits where lead at lower concentrations (*e.g.*, <0.5%) is mined with the ore but is not recovered.

Distinguishing lead from natural (background) sources and lead from local mining materials or waste is much more challenging in contaminated soil. Natural or mined materials from the same region will typically contain lead with similar lead isotopic composition, making fingerprinting a less useful source attribution technique. The same is true for non-mining sites that have high naturally-occurring lead in soils.

7.2.2.1 Potential Past Impacts

Historical review of public records at a site can be used, along with onsite observations, to determine whether a predominant source of lead contamination exists, even when other nearby sources may be present, or whether there are several point sources of lead at the site. Examples of past site use that may affect site characterization and source attribution techniques include whether there are or were buildings onsite constructed before the 1980s that could have been painted with LBP; whether there are obvious atmospheric point sources of lead nearby, such as a smelter or mine; whether mine-waste material containing lead has been deposited onsite as backfill or used as roadway material; and whether lead-acid batteries were stored or disposed of onsite.

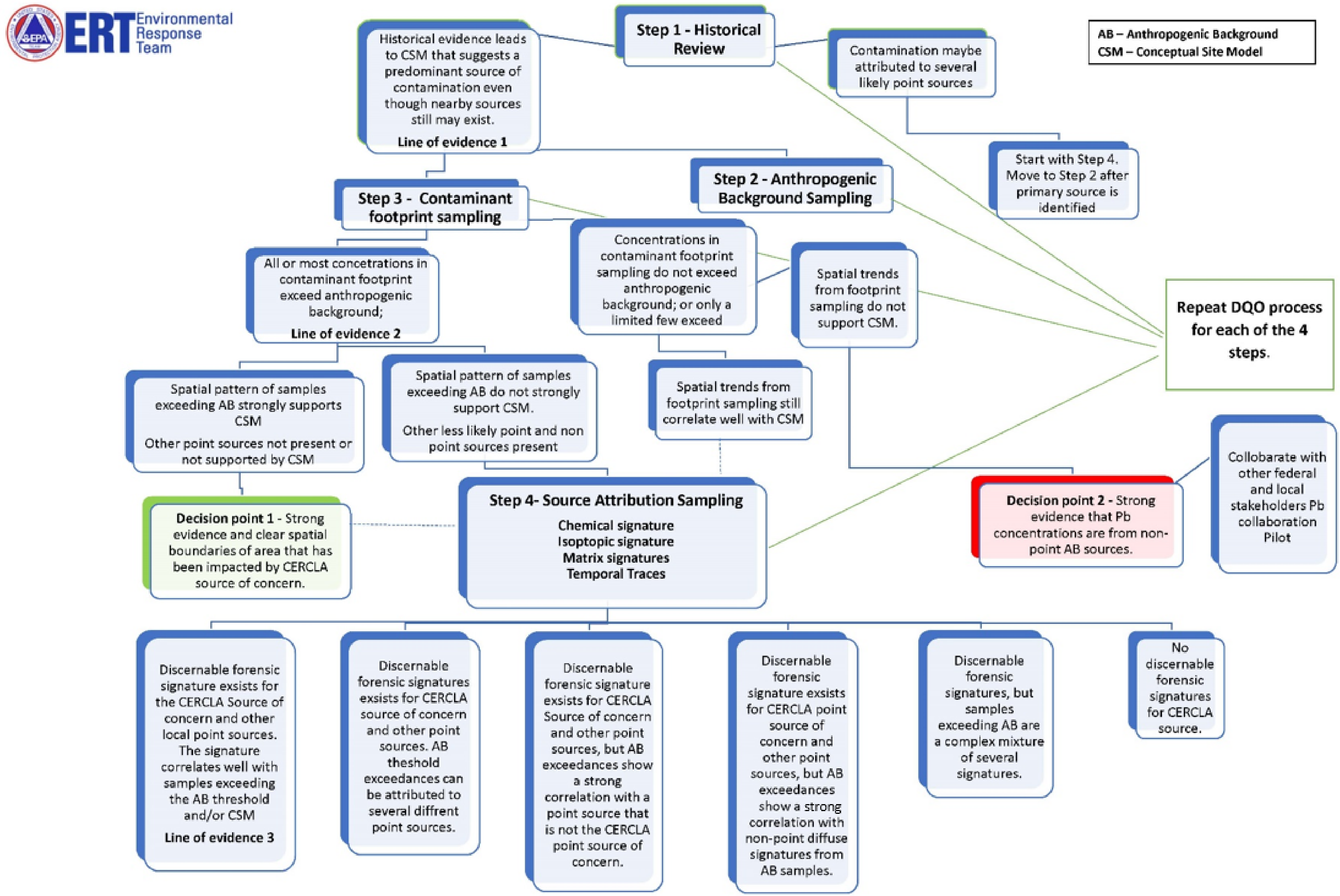
7.2.2.1.1 *Transport Mechanisms*

Lead can be dispersed in the environment by natural processes and through intentional (human-caused) transport. Lead attached to suspended sediment particles or to riverbank soils, or from commercial sources such as paint and other consumer products, can be transported in natural waters and by overland runoff. Airborne transport of lead in surface soils or dust, or attached to particulate emissions, can disperse lead great distances depending on prevailing weather patterns. Intentional transport of mining materials and waste (*e.g.*, rock, tailings, slag, chat) or other consumer products can be an important mechanism of lead dispersal in the environment. These transport mechanisms should be considered when tracking lead from sources to affected areas.

7.2.2.2 Anthropogenic Background

Anthropogenic background sampling and contaminant footprint sampling can be used at a site to determine lead concentrations within the site boundary and lead concentrations attributable to anthropogenic background. If lead concentrations in the contaminant footprint do not exceed anthropogenic background, and spatial analysis of trends in site lead concentrations do not appear to support the current CSM, then the CSM may require updating, or lead concentrations are from nonpoint anthropogenic background sources. If lead concentrations in the contaminant footprint exceed anthropogenic background and the spatial pattern of concentrations appears to support the current CSM, there is strong evidence and clear spatial boundaries of an area that has been impacted by the CERCLA source of concern. This is shown as a decision tree in Figure 7-1.

Figure 7-1. Lead Source Attribution Decision Tree (from OSC Readiness [U.S. EPA 2022c])



The primary goal of CERCLA is to protect human health and the environment from current and potential threats posed by uncontrolled releases of hazardous substances. Contamination at Superfund sites may originate from releases attributable to the site itself, as well as contamination from other sources, including natural and/or anthropogenic sources. In some cases, the same contaminant associated with the hazardous release at the site is also a constituent of background. Contaminants of potential concern (COPCs) with both site release-related and background-related sources should be included in the risk assessment (U.S. EPA 2002a).

In cases where background soils naturally contain high levels of lead, or where there are nonpoint sources contributing to anthropogenic background, concentrations of lead in soil outside the site boundary may be above screening levels. In these cases, lead should be included in the risk assessment and discussed qualitatively in the risk characterization for areas outside the site boundary. Background information is important to risk managers because the CERCLA program generally does not clean up to concentrations below natural or anthropogenic background levels (U.S. EPA 2002a, 2002c).

7.2.2.3 EPA Authority for Cleanup

Under Superfund, EPA can only address media where it has the authority to perform the cleanup. The Superfund program includes community involvement, the goal of which is to advocate and strengthen community participation during Superfund cleanups. Many Superfund sites, particularly those that are more complex, have CAGs associated with them (see Section 4.4). CAGs are made up of representatives of diverse community interest and are designed to serve as the focal point for exchanging information among the local community and EPA, the State regulatory agency, and other pertinent federal agencies involved at the site. The CAG provides a public forum for community members to present and discuss their needs and concerns, and can assist EPA in making better decisions on how to clean up a site by offering EPA an opportunity to hear and consider community preferences for site cleanup and remediation. CAGs are most useful at Superfund sites in communities where there is a high level of interest and concern about site activities.

In situations where lead concentrations do not exceed anthropogenic background, and spatial trends from contaminant footprint sampling do not appear to support the current CSM, it may be necessary to collaborate with other federal, state, and local stakeholders and partners to address lead concentrations present above screening levels.

7.3 Methods for Lead Source Attribution

Numerous methods have been proposed for use to determine the specific sources of lead that contribute to the contamination of a site (Table 7-1). A more detailed description of the methods, examples of their application (see Appendix D), and a more detailed discussion of the strengths and weaknesses are provided in the following sections.

Table 7-1. Available Methods for Use for Determining Lead Source Attribution at Superfund Sites

Source Attribution Method	Strengths	Weaknesses
Site characterization and history	Used to build CSM; can guide investigations towards likely lead sources; collects information on previous land use and likely presence of LBP and other anthropogenic sources.	Not quantitative in nature; if multiple potential sources are found, additional attribution techniques will be needed.
Lead concentrations – spatial and depth sampling analysis (chemical signature)	Spatial distribution of lead at a site is often a clue to its source; sampling and analysis laterally and at depth may help identify the lead concentration both in soil parent material and in layers that have been enriched by human activities. Often used in combination with an analysis of prevailing wind diagrams and land use patterns.	Natural, alluvial, or aerially deposited material may show similar spatial patterns of lead that require further analysis; interpreting lead concentrations as a function of depth can be complicated by weathering (lead can be more concentrated near the surface as more soluble materials are removed).
Lead-isotope ratios (isotopic signature)	If the isotopic signature is unique, lead isotopic composition can potentially identify a lead source: stable lead isotopes can be measured with a high degree of precision and accuracy; lead is unreactive and immobile over a wide range of environmental conditions; fractionation of lead isotopes by physical, chemical, and biologic processes is minimal. The isotopic concentration of lead does not change appreciably as it is dispersed through the environment.	If lead isotopic compositions of the source and non-source materials are similar, or overlap, this method cannot be used on its own to assess lead sources. Available data for non-CERCLA sources (*e.g.*, paint, gasoline, coal) can be quite limited and can also vary greatly causing a fair amount of overlap. The expertise and mass spectrometry instrumentation required for measurement of lead isotope ratios are not widely available at commercial laboratories and may be challenging or expensive to access.

Table 7-1. Available Methods for Use for Determining Lead Source Attribution at Superfund Sites

Source Attribution Method	Strengths	Weaknesses
Mineralogic analysis and particle morphology of bulk sample or separated fractions	Minerals unique to specific sources (*e.g.*, galena) can help with source attribution. Lead concentrations tend to depend on particle size in material deposited as dust, with larger particles deposited closer to the source; particle-size analyses can help to determine source.	As lead disperses through the environment, soil concentrations typically decrease with increased distance from the source, and lead is more likely to be adsorbed to other soil minerals, rendering this technique inconclusive on its own.
Lead chemical speciation	Can provide additional means for understanding sources, contaminant distribution, and associations with other metals.	Lead can be dispersed or poorly crystallized, or be associated with small particles, making speciation difficult; weathering, alteration, and dissolution of primary lead compounds can change lead speciation.
Source-associated tracers, including ratios of lead concentrations to concentrations of other metals (matrix signature), and looking at stable isotopes other than lead	Can be used to determine the contribution of lead from multiple sources on the basis of the composition of the geologic materials with which lead is associated, or the ratios of lead to other metals specific to a certain process (*e.g.*, smelter emissions).	Methods have not been extensively applied to the specific problem of lead-source attribution.

7.3.1 Elemental Concentration Ratios

Spatial distribution of lead at a site is often a clue to its source. Lead is well-suited for tracing of its source by spatial distribution; its low chemical mobility means that lead typically remains where it is deposited and most movement would be associated with mass movement physical processes (*e.g.*, erosion). Spatial deposition analysis can be used in combination with an analysis of prevailing wind diagrams and land use patterns. Sampling and analysis laterally and at depth may help identify the lead concentration both in soil parent material and in layers that have been enriched by human activities (Nazarpour et al. 2019). A study of surface soil lead concentrations in the urban center of Durham, North Carolina used spatial lead distribution to great effect for attributing lead paint and gasoline sources (Wade et al. 2021). The highest lead concentrations were found within 1 mile of pre-1978 residential foundations and inversely correlated with building age. The streetside soil concentrations were correlated with traffic flow. Spatial distribution of lead along the Big River, Missouri gave contributing evidence for source attribution of lead from a waste chat pile adjacent to the riverbank (Noerpel et al. 2020). Upstream of the pile, lead concentrations in stream sediments are near background, increase significantly near the waste pile, and steadily decrease with downstream distance from the pile, indicating fluvial transport and dilution effects.

There are, however, a few limitations to using spatial distribution of lead for attribution. Natural, alluvial, or aerially deposited material may show similar spatial patterns of lead that require further analysis. Interpreting lead concentrations as a function of depth can be complicated by weathering or pedogenic processes, which can lower surface lead concentration over time via burial (Wade et al. 2021). Additionally, lateral translocation of lead by erosion, runoff, or active land use can also complicate interpretation.

Elemental ratio analysis has been utilized in some cases but methods have not been extensively applied specifically to lead source attribution and are typically used as a complementary analysis. Utilizing elemental ratios involves trace metal co-contaminants present in the lead source(s), which could be used as a source-associated tracer, including ratios of lead concentrations to the co-contaminants. Gathering total concentration data on soils from a contaminated site is a common and routine method for baseline site characterization, so additional utility may be gained by this additional elemental ratio analysis. In one study, the zinc/cadmium and lead/cadmium ratios in soils and plants were used to distinguish between top and bottom ash from a smelting operation source (Bi et al. 2009). More commonly, total elemental ratios have been employed to support more established and validated methods (*e.g.*, lead isotopic ratio analysis) (Wang et al. 2015, Graney and Landis 2013). However, the limitations of utilizing elemental ratios for source attribution are similar to those of the lead isotope ratio method; it depends on knowledge of all potential sources to the site, having total elemental concentrations of all sources, and unique ratios of elements between sources.

7.3.1.1 Lead Speciation

The chemical speciation of lead in soils can provide additional information on source attribution. Positively identifying a chemical form of lead present in soils that originated from a previous release would provide evidence that the source contributed to the soil contamination. For example, if galena (lead sulfide) is associated with mining activities, and galena is present in a soil sample, that would provide a line of evidence that the soil lead may have originated from the mining activity. However, several challenges may arise as many primary lead compounds are not stable in soil environments. Weathering, alteration, and dissolution of primary lead compounds can alter lead chemical speciation and may result in adsorption of lead on mineral or organic-matter surfaces or its substitution as a minor element in newly precipitated phases obscuring the results.

Selective extractions have been used to assess the chemical speciation of lead.[99] Most series of selective extractions are based on a method developed by Tessier (Tessier et al. 1979). Various methods are reviewed and summarized by Ure (Ure et al. 1993). One potential issue is that while the extracting medium may target lead associated with specific materials (*e.g.*, organic matter, carbonates, or iron or manganese oxide), it might also capture other materials, resulting in a partial separation. Combined with the problem with changes in the lead species, this leads to imprecision in the method. However, despite the limitations, selective extractions are useful for assessing relative reactivity of lead in different soil fractions that can then be compared with other soil layers or other sources and should be confirmed by other methods.

For example, at the Klondyke State Superfund site, a six-step sequential chemical extraction was coupled with x-ray absorption spectroscopy (XAS) and XRF to study lead speciation in mine tailings to correlate lead-containing particle size that may dominate the dispersion in arid or semi-arid landscapes (Hayes et al. 2012). This information may be useful in site characterization to inform the potential risk to surrounding communities that lends to remedy selection (*e.g.*, capping or phytostabilization) of mine tailings.

7.3.2 Isotopic Analysis

Stable lead isotope data are useful for source attribution studies because isotopic compositions are conserved as lead moves through the environment (*i.e.*, lead does not change its isotopic composition or fractionate through typical weathering and transport processes). Four stable lead isotopes occur in geologic materials (*i.e.*, ore bodies, coals, and uncontaminated background rocks and soils). ^{204}Pb is "primordial," or original, in geologic materials, ^{206}Pb and ^{207}Pb are the endpoints in the decay chains of ^{238}Uranium (^{238}U) and ^{235}U, respectively, and ^{208}Pb is the end of the decay chain for ^{232}Thorium (^{232}Th) (Komárek et al. 2008, Cheng and Hu 2010, Tuccillo et al. 2023). Therefore, lead isotope ratios within the uranium decay chain are a function of the concentrations of uranium (U) and thorium (Th) present in a system. There are also >40 unstable isotopes of lead. For example, ^{210}Pb is a short-lived naturally occurring isotope with a half-life of 22.6 years; ^{210}Pb is commonly used for dating recent sediments and peat deposits but is not typically used for source attribution.

A graphical approach is often used to examine isotopic data and draw inferences about potential sources of lead. The isotopic ratios of samples may be plotted against the inverse lead concentration (*e.g.*, ^{206}Pb/^{204}Pb vs. 1/Pb). This approach can reveal high-concentration "source"

[99] Selective extraction is an analytical process where lead is leached from a sample with a solution to recover only a specific form of lead.

material and low-concentration background samples, as well as samples that fall along the mixing continuum. Three-isotope graphs that plot two ratios (*e.g.*, $^{206}Pb/^{207}Pb$ vs. $^{206}Pb/^{204}Pb$) often produce a more useful data representation when lead concentrations are heterogeneous. In a simple binary system, samples will plot along a mixing line connecting two sources with known isotopic signatures (Brugam et al. 2012, Ellam 2010).

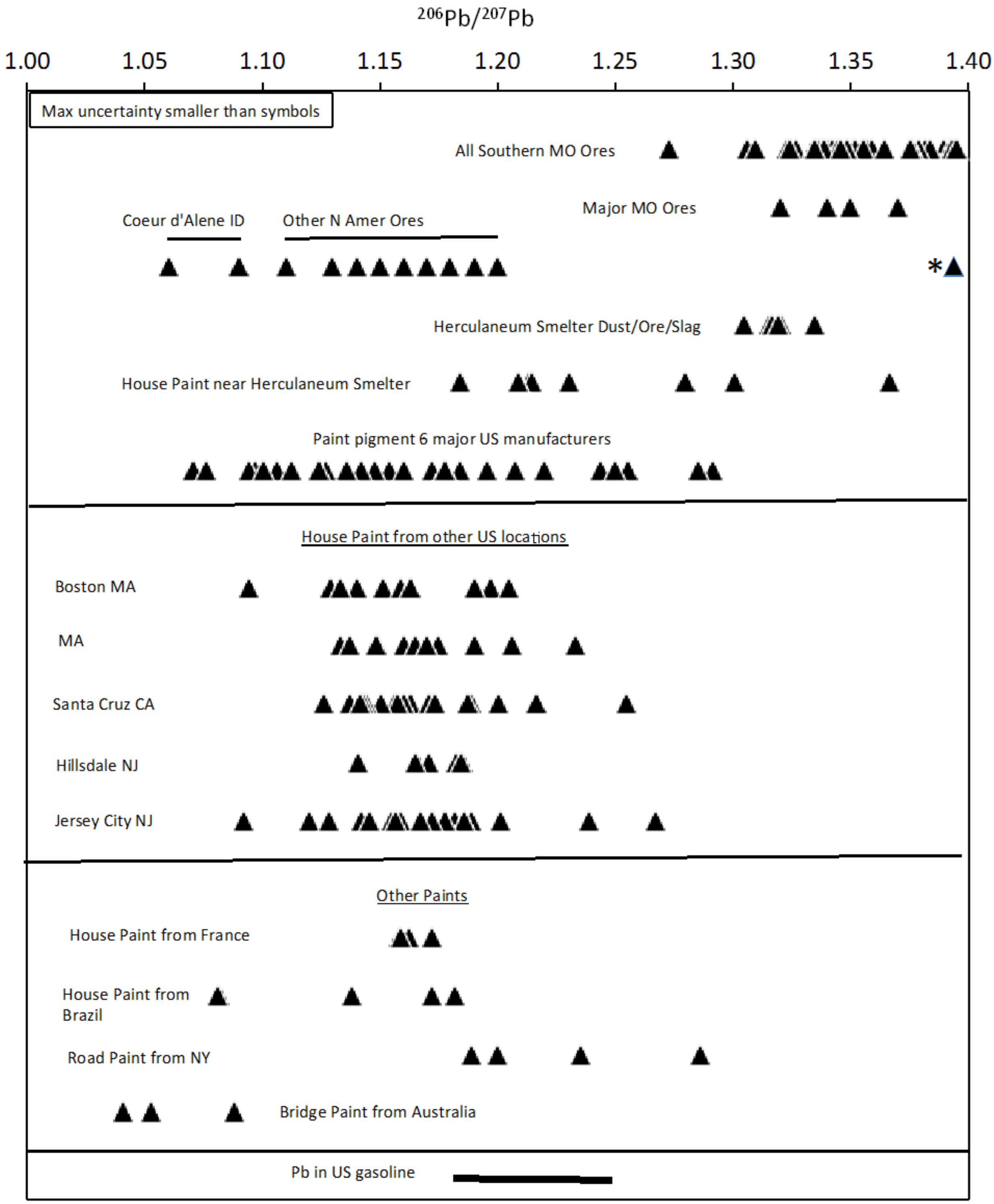
Isotopic data provide an additional level of sample information that supplements lead concentration data and spatial analysis. The isotopic composition can potentially identify a lead source if the isotopic signature is unique. The effectiveness of isotopic fingerprinting is related to several factors: uniqueness of the stable isotope signature of lead source(s), the fact that lead is generally immobile and unreactive over a range of geochemical conditions, and because fractionation of lead isotopes by physical, chemical, and biological processes is minimal. Thus, the lead isotopic composition of natural and anthropogenic sources (including ore deposits) does not change appreciably as it is dispersed through the environment. Observed differences in isotopic composition of soil lead can be attributed to mixing of multiple sources (Cheng and Hu 2010). Lead isotopic composition of ore deposits on a global scale is highly variable (Bird 2011, Miller et al. 2007) and lead derived from ore deposits can differ from lead found in non-ore rocks and soils (Hopper et al. 1991 as cited by NAS 2017).

Lead isotopes can be effective in determining lead sources if the isotopic values of the source materials are unique (*e.g.*, Pribil et al. 2014, Ma et al. 2014, MacKinnon et al. 2011, Prapaipong et al. 2008, Clark et al. 2006, Steinnes et al. 2005, Gulson et al. 1981, Rabinowitz and Wetherill 1972). Analyzing the depth distribution and isotopic signatures of lead in soil may allow source determination (Wang et al. 2022, MacKinnon et al. 2011, Prapaipong et al. 2008, Steinnes et al. 2005). If the isotopic character of the lead in soil is different from the parent rock/material, then it is likely that the lead originated from a different source. Numerous studies have used lead-isotope ratios to distinguish between potential sources of lead in soils and atmospheric and household dust (*e.g.*, Wang et al. 2022, Kelepertzis et al. 2020, Graney et al. 1995, Gulson et al. 1981; see Figure 7-2). Changing lead concentration isotope patterns with depth in a soil profile can reveal aerial deposition of lead in shallow horizons and geogenic lead in deeper horizons. This approach has been used to identify lead deposition from coal burning (Ma et al. 2014), lead smelters (Prapaipong et al. 2008), and leaded gasoline (MacKinnon et al. 2011, Graney et al. 1995). Studies have shown that if the lead isotopic compositions of potential sources are unique and known, and if the lead isotopic values in samples of concern fall within the range of the source materials, then the contribution of each source of lead contamination can be determined. However, if the lead isotope compositions of potential source materials overlap or if there is uncertainty about potential source materials, then the isotopic method cannot be completely determinative of the source of lead and additional techniques should be used (Tuccillo et al. 2023).

Lead isotope ratios in geological materials vary because lead isotopes are produced by the radioactive decay of uranium and thorium over geologic timescales. Lead-isotope ratios are often reported as $^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$, and $^{208}Pb/^{204}Pb$, and plots of these ratios give the most complete differentiation between ore deposits and between sources of environmental lead. Other isotope ratios such as $^{206}Pb/^{207}Pb$ and $^{208}Pb/^{206}Pb$ are commonly reported and can be calculated from the ^{204}Pb-normalized values. Lead isotope ratios are measured using mass spectrometry, either with thermal ionization (TI-MS) or with ICP-MS as the ion source. The ICP-MS instruments include those with quadrupole-based (ICP-QMS), time-of-flight-based (ICP-TOF-MS), and sector-based (or sector field) (ICP-SFMS) mass analyzers, equipped with single or multiple collector detection. These techniques all have their unique advantages and limitations in analyzing lead isotope ratios in environmental samples (Gulson et al. 2018, Bird 2011, Komárek et al. 2008). A single method or a combination of these methods can be used to optimize the data acquisition process, depending on the required analytical precision, sample load, and instrument availability (Komárek et al. 2008). A standard reference material (*e.g.*, NIST Standard Reference Material [SRM]-981) is necessary to calibrate analytical instruments and to correct for mass bias (Yuan et al. 2016).

Other metals that are co-contaminants with lead also have isotopic variability that can be used in source apportionment studies (for example, cadmium [$^{114}Cd/^{110}Cd$; Zhang et al. 2020], mercury [$^{202}Hg/^{198}Hg$; Estrade et al. 2010], copper [$^{65}Cu/^{63}Cu$; Gonzalez et al. 2016], and zinc [$^{66}Zn/^{64}Zn$; Gonzalez et al. 2016]). These other non-traditional isotopes are increasingly being studied and, in some cases, combined with lead isotope compositions (*e.g.*, Schleicher et al. 2020). These isotope systems require the multi-collector ICP-MS technique for high resolution discrimination of isotope ratios. It is anticipated that source apportionment studies using isotope tracers at impacted sites will increasingly take advantage of multiple isotopic elements.

Figure 7-2. Compilation of $^{206}Pb/^{207}Pb$ Ratios in North America Ore Deposits, Gasoline, and Paint Samples



Note: the asterisked triangle represents the average $^{206}Pb/^{207}Pb$ ratios in ores from the Upper Mississippi Valley District (source: NAS 2017).

7.3.3 Additional Soil-Metal Characterization

7.3.3.1 X-ray Absorption Spectroscopy (Spectroscopic Speciation)

XAS is an element-specific technique that may be used to chemically speciate elements (*e.g.*, lead) in soils and other environmental samples. Advantages of XAS include the ability to conduct *in situ* measurements with little to no pretreatment of a soil/environmental sample. XAS is suitable for distinguishing multiple phases that may be present in a sample enabling the identification of both primary and secondary phases. Determining lead chemical speciation is also possible at lower concentrations in soils (<20 mg/kg) depending upon sample matrix. Crystallinity is not a requisite for sample analysis as XAS spectra is independent of the chemical phase and may be used to identify amorphous phases, organo-metallic complexes, adsorbed phases, and species in solution. Disadvantages of XAS sample anaysis are related to instrument access. At this time, XAS is primarily a synchrotron-based technique. Beamtime at these facilities is usually awarded through a competitive proposal process. The most commonly used XAS analysis technique with environmental samples is Linear Combination Fitting (LCF) of the energy region near the x-ray absorption near edge structure (XANES). In this process, the pattern created by the unknown sample is compared algebraically against a library of known standards to determine the major species composition.

Other lab-based methods exist for determining speciation, though they have significant limitations. The accuracy of a series of selective extractions has been assessed by comparing them with direct spectroscopic analyses, such as XAS, x-ray fluorescence, Raman spectroscopy, and other advanced methods (Hayes et al. 2012, 2009, Scheckel et al. 2005), that provide information on chemical bonding. For example, in a study of mine tailings from Leadville, Colorado, coupling of direct characterization of lead speciation that used XAS with a series of selective extractions revealed discrepancies between lead fractions targeted in extractions and lead speciation determined spectroscopically, and demonstrated substantial redistribution of lead after extraction treatment (Ostergren et al. 1999).

Generally, XAS can be used only as a secondary line of evidence when determining source attribution. This is because in most cases, the species of lead can change in the environment. These changes often take place in a predictable manner which can non-conclusively point to a potential source. This was the case in the Big River in Missouri where the lead from tailings piles near the river had a substantial amount of primary lead ore species (galena) present in the piles and the relative abundance of galena decreased with distance from the river as secondary oxidation products (Cerussite, Anglesite, and adsorbed lead) became more prevalent. Direct access to a potential source, however, led to isotopic analysis being the main line of evidence in that study (Noerpel et al. 2020). XAS speciation could be used as a main line of evidence only if the suspected source produced an environmentally stable and uncommon lead species (*e.g.*, leaded glass).

7.3.3.2 Scanning Electron Microscopy (SEM)-Energy Dispersive X-Ray (EDX)/Wave-Length Dispersive X-Ray (WDX)

The mineralogy and particle structure determined with optical microscopy and scanning electron microscopy (SEM) of sand particles has been used extensively on alluvial and dust deposits to track sediment sources (Cardona et al. 2005, Abu-Zeid et al. 2001, Arribas et al. 2000) and might serve to attribute lead sources in soil.

SEM coupled with elemental analysis, conducted with energy dispersive x-ray (EDX) spectroscopy or wave-length dispersive x-ray (WDX) spectroscopy, is an additional way of obtaining chemical information and information on particle structure. A description of the attributes and limitations of SEM and elemental analysis for identifying particle sources is provided in Pye (2004). SEM analysis of soils and sediments has been used extensively in attempt to speciate metals based on particle size, shape, and chemical composition (D'Amore et al. 2005 and references therein).

Specific elemental ratios and morphologic characteristics of particles can be used to infer mineral identity and combining mineralogy, particle size, and elemental composition has proved successful in source attribution (Sterling et al. 1998, de Boer and Crosby 1995). Linton et al. (1980) used specific particle structure and chemical composition to distinguish lead sources between automotive exhaust and paint chips. Sobanska et al. (1999) used spherical structure and elemental composition to identify lead originating from smelters. Demonstrative features such as spherical structure are indictive of high-temperature processing, such as smelting, whereas subtle etching of sand grains might provide important clues to particle source.

Transmission electron microscopy (TEM) coupled with EDX and electron diffraction may also be useful for determining source attribution. Examination of individual particles will provide insights into mineralogy and surface morphology for well crystalline materials (Buseck and Posfai 1999).

7.3.3.3 Electron Micro Probe Analysis (EMPA)

Electron Micro Probe Analysis (EMPA) has the same capabilities as SEM without the optical imaging optics (D'Amore et al. 2005). Coupling EMPA with WDX analysis, along with high beam current and long dwell times, provides increased elemental sensitivity compared to SEM/EDX analysis (D'Amore et al. 2005). The application and use of EMPA for determining chemical speciation was a common technique during the 1980s and 1990s. However, advancement in other chemical speciation techniques have minimized use of the technique (D'Amore et al. 2005). A recent example of where EMPA has been used for assessing source attribution and chemical speciation was published by Taylor and Robertson (2009). EMPA was used to investigate road-deposited sediment where results demonstrated that lead was associated with two distinct phases: iron oxides and iron-rich glass slag grains. The identification of the glass slag phase had not been previously reported and was not included in the current extraction schemes.

7.3.1 Lines of Evidence Approach

Lead concentrations also tend to depend on particle size. Dividing particles into fine and course fractions can help to determine their source (*e.g.*, larger particles deposit closer to the source [NEPC 1998]).

Wire-mesh sieves are typically used for separating particles larger than 0.05 mm. Finer particles are measured by sediment rate separation, suspension density, or laser light scattering. For example, lead concentrations closer to a source such as a mining and smelting may be higher than in more distant soils (Taylor et al. 2010). Such geographic concentration data may be combined with dispersion models that predict downwind deposition and surface concentrations of atmospheric lead from known sources (Small et al. 1995).

The attribution of airborne lead and other metals to mining and smelting operations by using heavy minerals has generally been based on spatial variations in the quantity with which they are found in soils relative to the source and the area's predominant wind directions.

Source-associated tracers such as multi-elemental analysis and methods that involve stable isotopes other than lead have been used to determine the contribution of lead from multiple sources on the basis of the composition of the geologic materials with which lead is associated. For example, cadmium and zinc are commonly associated with and recovered during the processing of lead ores. As the ore is smelted, light isotopes of zinc and cadmium exit with the exhaust and the heavier isotopes are retained in the smelting residue. Therefore, the differences may be used to examine the deposition patterns of smelter products over a region by identifying zinc and cadmium isotopic composition of soils. In another example (Eckel et al. 2002), antimony/lead ratios were used to correlate soil lead contributions from smelting operations. Antimony was used in alloying processes at specific smelters.

Zinc, cadmium, and arsenic ratios have been used to identify lead sources from chat, whereas manganese has been used to identify uncontaminated soil. In another case, arsenic/lead ratios in soil were used to identify lead contaminated soils from pesticide application and lead/barium/zinc ratios were used to identify particles from paint sources.

Concerning attribution, OLEM supports using tools for source attribution where appropriate and when sufficient resources are available. In the past, there was much interest in attribution through speciation of lead in soil. Speciation can help only at sites where the forms of lead are distinctly different and the level of uncertainty often does not allow for confidence in source attribution. Once lead gets into soil, it will begin to transform to the equilibrium status of the soil. For example, if lead carbonate or hydroxycarbonate from LBP falls on an acidic soil, over time, it will convert to lead sulfate and be much different than the source material. This is very similar for lead in gasoline emissions, which change over time as well. In that situation, the key to identifying the source of lead would be finding mining ore still remaining in the soil. A better option for identifying the source is finding other element markers such as barium in LBP or using isotope techniques (if the original source material is still available and differs from other lead sources in the area).

At some sites, the use of multiple analytical tools can assist in identifying the source. As lead can weather and mix with the background over time, it is difficult for a single analytical method to constrain a source. However, the combination of two or more analytical methods has proven useful in complex source receptor studies.

CHAPTER 8
Residential Lead Risk Assessments

8.1 Introduction to Residential Lead Risk Assessments

The OLEM risk assessment process includes analytical data collection and evaluation of lead concentrations in all affected media, exposure assessment, toxicity assessment, and risk characterization, which includes the uncertainties, quantification, and qualification associated with the potential current and future risks to human health.

Verify that you are using the most recent version of EPA's residential lead modeling software as well as the latest guidance and training, available on the TRW Lead Committee's website at http://www.epa.gov/superfund/lead-superfund-sites.

This chapter describes how to conduct risk assessments for residential land use scenarios where lead is a contaminant of concern. The IEUBK model for lead in children[100] is the risk assessment tool that predicts blood lead concentrations (and associated probability of exceeding a target BLL) in areas where there is a current or potential future exposure scenario (U.S. EPA 1998, 1994a). The results of the IEUBK model with site-specific information support removal and remedial response actions at contaminated residential sites to ensure that the most sensitive population (children <7 years of age) will be protected[101] (Breen 2024, U.S. EPA 2020e, 2020f, 1998, 1994a).

Users of this Handbook, including RPMs and OSCs, are encouraged to work with the regional risk assessors early in the site characterization process to ensure adequate data collection that supports an assessment to ensure removal or remedial decisions are defensible. For more information on EPA risk assessments, visit EPA's Waste and Cleanup Risk Assessment webpage.[102]

8.2 Data Evaluation

It is important to understand the available data for the site in terms of the CSM, DQOs, and QAPP for sampling and analysis (these are described in Chapter 6). This will allow the site team to identify and understand the data gaps, assumptions, uncertainties, and limitations

[100] The IEUBK model can be found at: https://www.epa.gov/superfund/lead-superfund-sites-software-and-users-manuals.
[101] In a residential setting, evaluation of the child is protective of an adult exposure scenario.
[102] https://www.epa.gov/risk/superfund-risk-assessment.

associated with the risk assessment to reach a well-informed risk management decision. Data evaluation and data gap analysis may result in a recommendation to conduct additional data collection that could further inform the risk management decision. This is especially true for model parameters that are particularly influential in the IEUBK model (*e.g.*, soil lead concentration and bioavailability). When conducting a risk assessment, it is important to identify the key site-related variables and assumptions that contribute most to uncertainty. Data uncertainty should be assessed for each data set.

8.3 Exposure Assessment

Exposure is contact between a person and a chemical in one or more media (*e.g.*, soil, groundwater, air, etc.). Exposure assessment measures (or estimates) the magnitude, frequency, duration, and route of exposure. Children can be exposed to lead by multiple exposure pathways (ingestion, inhalation, dermal) from lead-contaminated media (*e.g.*, dust, soil, water, air, food, etc.) (U.S. EPA 2024, ATSDR 2007, U.S. EPA 2000c) and are generally considered the most sensitive receptor for residential land use areas. Refer to the TRW Lead Committee website[103] for additional information.

Exposure assessments should consider both current and potential future land use scenarios. EPA currently uses the IEUBK model for residential scenarios (the receptor is young children <7 years of age, which is the most sensitive population).[104] For more information, see: https://www.epa.gov/superfund/lead-superfund-sites-software-and-users-manuals.[105]

The IEUBK model accounts for intake and uptake components of lead exposure and allows the user to input site-specific exposure information (*e.g.*, concentration of lead in environmental media and media intakes) to predict blood lead concentrations. Predicted blood lead concentrations provide one indication of the associated lead risk for both current and potential future land use assumptions. The predictive accuracy of the IEUBK model output is dependent

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[103] http://www.epa.gov/superfund/lead-superfund-sites.

[104] For non-residential exposures where young children are not frequent receptors, the ALM is used to estimate maternal and fetal BLLs.

[105] EPA is currently developing the All Ages Lead Model (AALM) to improve predictive accuracy for lead dosimetry following a wide range of exposure conditions and populations. It is anticipated that the AALM will predict blood and tissue lead concentrations resulting from exposures to lead in air, drinking water, surface dust, food, or other exposure pathways, allowing users to simulate multi-pathway exposures that are constant or that vary in time increments as small as 1 day, and that occur at any age from birth to 90 years. As of the release of this Handbook, the AALM is for use as a research tool only and has not been approved for Superfund site risk assessment. **The IEUBK is the only model approved for Superfund HHRAs for young children.**

on the representativeness of the input data (Brown et al. 2023, U.S. EPA 2021b,d, 2003b, 1994a).

8.4 Exposure Point Soil Lead Concentration

The average, or arithmetic mean, of soil lead concentration from an EU (e.g., the yard) is the EPC and is recommended as the soil lead concentration data entry for the IEUBK model.

The soil and dust lead concentrations are important input values for the IEUBK model. A site-specific arithmetic mean soil lead concentration is recommended. Indoor dust lead concentration may be derived from indoor dust sampling or from outdoor soil data using multiple source analysis in the IEUBK model (White et al. 1998). Please refer to EPA's IEUBK guidance manual and user's guide for additional information on the multiple source analysis (U.S. EPA 2021b, 1994b). The soil lead concentration parameter is the only input parameter of the IEUBK model for which a site-specific value is required (although soil lead bioavailability is highly recommended) to generate a meaningful site-specific risk estimate (the default values may be used for all other inputs assuming they represent site conditions). Alternatively, the *Find Soil Pb Concentration* function of the IEUBK model can be used to calculate a site-specific soil PRG, but soil and dust lead bioavailability are highly influential, and that information should be included in the PRG calculation on a site-specific basis.

An EPC is the contaminant concentration within an EU to which receptors are exposed (see Sections 6.5 and Appendix A). Estimates of the EPC represent the concentration term used in an exposure assessment. For additional information, refer to OSWER 9200.1-78 (U.S. EPA 2007a), *Short Sheet: Estimating the Soil Lead Concentration Term for the Integrated Exposure Uptake Biokinetic (IEUBK) Model*.[106]

The EPC used in the IEUBK model should be the average, or arithmetic mean, of soil lead concentration from a representative exposure area in the yard (generally, this is ¼ to 1 acre area around the residence). This approach is generally recommended; however, it may not be appropriate for some sites. Without detailed exposure information, the average concentration is usually the most appropriate for predicting current and future exposure risks.

For example, spatially weighted averages may be used when the location (*i.e.,* coordinates) of each sample is available and the relative size of the areas is known and small (<0.5 acre). The spatially weighted average assumes that exposure is proportional to the size of the various

[106] https://www.epa.gov/superfund/lead-superfund-sites-guidance#estim.

areas of the yard being sampled (*e.g.,* garden, play areas). This assumes that contact with soil in all areas of the EU is equally likely (U.S. EPA 1989b).

Alternatively, time-weighted averages can be used when both geographical information and behavior patterns are known. In this case, consideration is given to how much time a child spends in various areas of the yard, and the most-frequented areas are weighted more heavily.

The appropriate method for estimating the EPC depends on the DQOs and sampling plan designed to support the baseline risk assessment (see U.S. EPA 2007a). It is recommended that the risk assessor (and perhaps a statistician) be involved in the SAP and QAPP as early as possible. This can prevent unexpected errors and low-confidence data results for the inputs to the IEUBK.

The soil lead concentration is generally used to predict current risk. The soil concentrations obtained by the previously described averaging are central tendency estimates for use in estimating blood lead concentrations for young children (<7 years of age). However, these central tendency estimates are subject to uncertainty, and if a risk assessor seeks to provide a protectively high estimate of the average concentration of lead present in yard soil, then an upper confidence limit (UCL) of the mean may be appropriate. The issue is whether there is confidence in the arithmetic mean value as the most representative EPC for lead risk calculations. The geometric standard deviation (GSD) in the IEUBK model is intended to address variability in blood lead concentrations in a population of similarly exposed individuals, not in the EPC. If the EPC varies substantially within an EU, then the population may not be "similarly exposed." The IEUBK model can use a UCL as a soil lead EPC; however, results may be biased high if the sampling plan is inadequate. Alternatively, the site team may also consider dividing the EU into smaller EUs. A well-designed sampling plan, including ICS, would be expected to provide narrower confidence limits around the mean.

Additional information, equations, and examples on calculating soil lead EPCs for use in the IEUBK model can be found in EPA's guidance documents (U.S. EPA 2020f, 1994b) and OSWER 9200.1-78 *Short Sheet: Estimating the Soil Lead Concentration Term for the Integrated Exposure Uptake Biokinetic (IEUBK) Model* (U.S. EPA 2007a).

8.5 Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children

The IEUBK model was developed to evaluate exposure, estimate risk, and determine remedial or removal PRGs or cleanup goals. Lead is assessed differently from other contaminants in risk assessments because there is no reference dose (RfD) or slope factor available to estimate the probability of adverse health effects. Since 1994, OLEM has used the IEUBK model as the risk assessment tool to support environmental cleanup decisions at residential sites for children <7 years of age (U.S. EPA 1994a, 1994b).

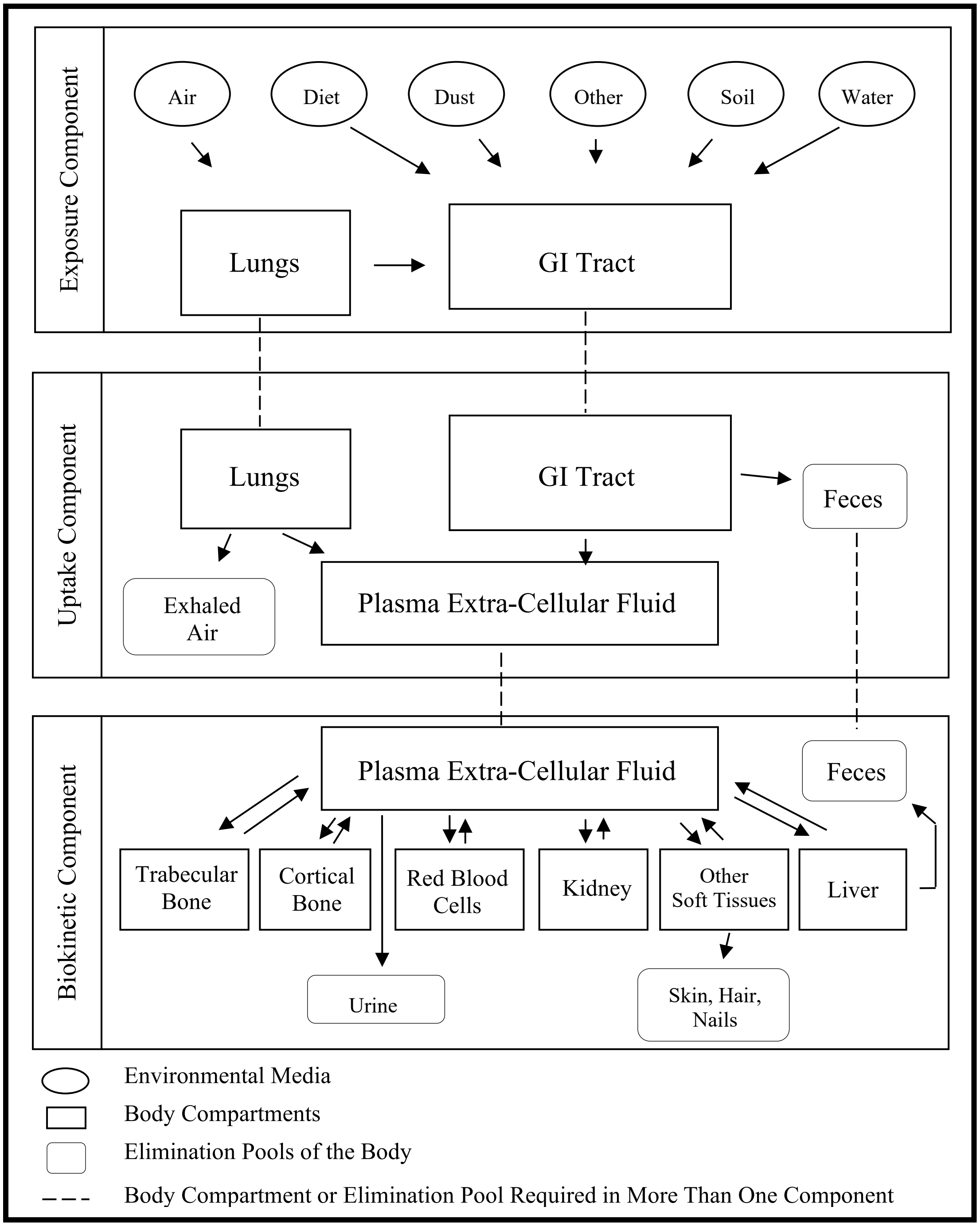
The IEUBK model uses more than 100 input parameters that are initially set to default values (U.S. EPA 2021b, 2021c).[107] Default values represent national averages or other central tendency values derived from: (a) empirical data in the open literature that included lead concentrations in exposure media (*e.g.,* diets representative of national food sources); (b) intake rates based on ambient air, water, food, and soil/dust; and (c) exposure durations (White et al. 1998). As previously stated, while site-specific environmental data improve the reliability of the IEUBK model for risk assessment, the concentration of lead in soil at the site is the only required site-specific input parameter for a lead risk assessment. More information on the IEUBK model and training can be found online at http://www.epa.gov/superfund/lead-superfund-sites.

The IEUBK model is a tool for making rapid calculations of a complex set of equations, which include many exposure, uptake, and biokinetic parameters, as shown in Figure 8-1 (U.S. EPA 2021b). The representativeness of the model output is dependent upon the representativeness of the input data, which are often assessed in terms of completeness, comparability, reproducibility, and accuracy (U.S. EPA 2021b, 1994b, 1994c).

The IEUBK model should be used to support environmental cleanup decisions for residential scenarios at CERCLA and RCRA Corrective Action sites (Breen 2024, U.S. EPA 2020f, 1994a, 1994c).

[107] The Technical Support Document for the IEUBK model provides a detailed explanation of the equations, parameter values, and the sources of data considered for the IEUBK model.

Figure 8-1. Structure of the IEUBK Model



8.6 Limitations of the IEUBK Model

The IEUBK model cannot be used to assess short-term, infrequent, or acute exposures, or the deliberate ingestion of soil when the ingestion rate is excessive (soil pica). Infrequent and non-continuous exposures (*i.e.*, <1 day/week over a minimum duration of 90 days) produce oscillations in blood lead concentrations associated with the absorption and subsequent clearance of lead from the blood between each exposure event that cannot be simulated using the IEUBK model (Lorenzana et al. 2005). The IEUBK model can only provide an approximation of quasi-steady-state blood lead concentrations during non-continuous exposure scenarios of at least 1 day per week lasting for at least 90 consecutive days. That is, the model predicts a geometric mean blood lead concentration (this is also the median concentration) associated with continuous exposures of sufficient duration to reach equilibrium (U.S. EPA 2003c).[108] The reliability of the IEUBK model predictions for exposures of <3 months has not been assessed, and the IEUBK model generally should not be used to evaluate exposure scenarios shorter than 90 consecutive days. In such cases where infrequent and non-continuous exposures occur, options should be discussed with the regional risk assessor (consultation with the TRW Lead Committee is also available for EPA site teams).

The IEUBK model does not aim to reproduce the observed blood lead concentration (PbB) for any specific child or community since there can be diverse lead exposures to varied environmental lead concentrations within the community, because of the practical limitations of default exposure characterizations, uncertainty in site-specific exposure, housekeeping differences, variability in behavior, and variability in uptake and biokinetics (White et al. 1998). In the simplest scenario, the model uses environmental lead concentrations and bioavailability at a residence to predict the plausible distribution of PbBs of children who might reside at the residence either currently or in the future. Most importantly, the IEUBK model is not a substitute for medical evaluation of an individual child when a known or suspected lead exposure is identified.

The initial placeholder soil lead concentration in the IEUBK model of 200 ppm is a reasonable and representative initial value for the IEUBK model for soil lead concentration for the conterminous United States (White et al. 1998, U.S. EPA 1994b). Neither this initial value nor the values identified by the USGS in their nationwide background study represent soil lead concentrations at a specific lead-contaminated site and may not be relevant for characterizing soil lead concentrations for Superfund sites. A site-specific soil lead EPC is required, and soil lead bioavailability information is highly recommended, to use the IEUBK model to assess risk to young children.

Because the IEUBK model assesses risk from exposure to multiple media, the *Find Soil Pb Concentration* function of the IEUBK model (whereby the model identifies a soil lead concentration that meets criteria specified by the user) may not find a solution when the

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[108] Based on estimates of the first-order elimination half-time for lead in blood—approximately 30 days for adults (Chamberlain et al. 1978, Rabinowitz et al. 1976) — a constant lead intake rate of at least 1 day per week over a duration of 90 days would be expected to achieve a blood lead concentration that is sufficiently close to the quasi-steady state (Lorenzana et al. 2005, U.S. EPA 2003c).

exposures from non-soil sources exceed the risk benchmark specified by the user. This situation indicates that there is no level of soil lead that will achieve the target BLL, and background concentrations may be used to define the cleanup level.

8.7 Toxicity Assessment

Young children are adversely impacted by lead exposure and lead has a range of adverse health effects (*e.g.*, neurological, developmental, etc.). Epidemiological studies have evaluated the health effects of lead in all organ systems. For the most studied endpoints (neurological, hematological, immunological, reproductive, and developmental), effects occur at the lowest lead blood levels studied (see Table 8-1). A threshold for adverse health effects for lead has not been established (ATSDR 2020, U.S. EPA 2024, CDC 2012). Depending on the chemical and physical characteristics of lead, however, <100% of lead entering the body is readily absorbed into systemic circulation (U.S. EPA 2024). The relative amount of lead absorbed is referred to as bioavailability, a characteristic critical to understanding how the body absorbs and reacts to lead exposure, as well as determining the risk of detrimental health effects associated with lead exposure (U.S. EPA 2007c).[109] See Section 6.13 for more information on soil lead bioavailability.

In recognition of there being no known threshold for adverse health effects of lead exposure in children, the CDC adopted the ACCLPP (2007) recommendations to eliminate the term "level of concern" and instead use a blood lead "reference value" for recommending public health actions based on elevated PbB. The CDC has recommended using the 97.5th percentile of blood lead distribution in children from 1 to 5 years of age, as determined by NHANES (CDC 2012). The age range of the IEUBK was changed to match CDC's age range. The reference value is not a health-based value; it is a statistic representing the upper tail (*i.e.*, 2.5%) of the U.S. population. The CDC blood lead reference value is used to identify children with PbB that are higher than most (97.5%) children in the United States; in other words, a high estimate of background PbBs. A lower CDC blood lead reference value means that more children will be identified as having excessive lead exposure prompting parents, doctors, public health officials, and communities to more aggressively prevent lead exposure. Using the 2007-2010 NHANES data, the BLL reference value associated with the 97.5th percentile is 5 µg/dL (CDC 2012). In May 2021, CDC used NHANES data from 2015-2016 and 2017-2018 data collection cycles to update the BLL reference value to 3.5 µg/dL and it has been steadily decreasing for decades (Egan et al. 2021).

[109] See https://www.epa.gov/superfund/soil-bioavailability-superfund-sites.

Table 8-1. Summary of Health Effects of Lead Exposure, Evidence from the 2024 Integrated Science Assessment for Lead (U.S. EPA 2024)

Health Outcome Group	Lifestage	Causality Determination[1]	Health Outcome	Blood Pb Evidence[2]	Bone/Tooth Pb Evidence
Nervous System Effects	Children	Causal	Cognitive effects: IQ decrements; impaired memory, learning, and executive function; academic achievement	Prenatal, early childhood, and adolescence: <5 µg/dL	No data
		Causal	Externalizing behaviors: attention, impulsivity, and hyperactivity; ADHD-related behaviors and Clinically Diagnosed ADHD	Prenatal and early childhood: <5 µg/dL	Tooth Pb levels associated with attention, impulsivity, and hyperactivity; ADHD-related behaviors
		Likely to be Causal	Externalizing behaviors: conduct disorders, aggression, and criminal behavior	Prenatal, early childhood, adolescence, and young adulthood[3]: <10 µg/dL	Limited evidence demonstrating an association between tibia Pb levels and aggression scores
		Likely to be Causal	Internalizing behaviors: anxiety and depression	Prenatal and early childhood: <7 µg/dL	Limited evidence demonstrating an association between tooth Pb levels and anxiety and depression
		Likely to be Causal	Motor function	Prenatal and early childhood (infancy through 3 years) : <15 µg/dL	No data
		Suggestive	Sensory Function	Early childhood through adolescence: <5 µg/dL	No data
		Suggestive	Social cognition and behavior: increased autism risk and autistic behavior; reduced social cognition	Prenatal, early childhood, and early adolescence: <5 µg/dL	Limited evidence demonstrating an association between tooth Pb levels and ASD
	Adults	Causal	Cognitive effects: decrements in IQ and global cognitive function	Childhood: ≤10 µg/dL Adulthood: <5 µg/dL	Tibia and patella Pb levels associated with cognitive function decrements
		Likely to be Causal	Psychopathological effects: anxiety and depression	Childhood: ≤20 µg/dL	Tibia Pb levels associated with depressive symptoms
		Suggestive	Sensory function: auditory effects	Adulthood: <5 µg/dL	Limited evidence demonstrating an association between tibia Pb levels and hearing threshold
		Suggestive	Neurodegenerative disease: ALS and Parkinson's Disease	Adulthood: <5 µg/dL	Limited evidence demonstrating an association between tibia Pb levels and Parkinson's Disease

Health Outcome Group	Lifestage	Causality Determination[1]	Health Outcome	Blood Pb Evidence[2]	Bone/Tooth Pb Evidence
Cardiovascular Effects	Adults	Causal	CV effects and CV-related mortality: increased blood pressure, hypertension, and CVD mortality	<5 µg/dL	Tibia and patella Pb levels consistently associated with hypertension and CVD mortality
Renal Effects	Adults	Causal	Renal effects: Decreased kidney function (kidney disease and decreased eGFR)	<5 µg/dL	Limited evidence demonstrating tibia and patella Pb level associations with reduced kidney function
Immune System Effects	Children	Likely to be causal	Immunosuppression: higher susceptibility to viral and bacterial infection, reduced antibiotic resistance, and reduced vaccine antibodies	<5 µg/dL	No data
	Children	Suggestive	Sensitization and allergic responses: Asthma incidence	≥5 µg/dL	No data
Hematological Effects	Children and Adults	Causal	Altered heme synthesis and decreased RBC survival and function	<10 µg/dL	No data
Reproductive and Developmental Effects	Children	Causal	Development: Delayed pubertal onset	<5 µg/dL	No data
		Likely to be Causal	Pregnancy and birth outcomes: preterm birth, low birthweight	<5 µg/dL	No Data
	Adults	Causal	Male reproductive function: effects on sperm/semen production, quality, and function	<5 µg/dL	No data
		Likely to be Causal	Female reproductive function: effects on hormone levels and menstrual/estrous cyclicity	<5 µg/dL	Limited evidence demonstrating tibia and patella Pb levels associations with early menopause
Hepatic Effects	Adults	Suggestive	Higher serum biomarkers of liver function (e.g., AST, ALT, and ALP)	<5 µg/dL	No data
Musculoskeletal Effects	Children	Likely to be Causal	Higher prevalence of dental caries and tooth loss	<5 µg/dL	No data
	Adults	Likely to be Causal	Higher prevalence of osteoporosis, dental caries, and tooth loss	<5 µg/dL	No data
Mortality	Adults	Causal	Total (nonaccidental) mortality	<5 µg/dL	Patella Pb levels associated with total mortality
Cancer	Adults	Likely to be Causal	Evidence of tumor development in animal studies; human evidence inconsistent	Human evidence inconsistent	No data

Abbreviations: ADHD, Attention-Deficit/Hyperactivity Disorder; ALP, Alkaline Phosphatase; ALT, Alanine Transaminase; ASD, Autism Spectrum Disorder; AST, Aspartate Aminotransferase; ALS, Amyotrophic Lateral Sclerosis; CV, Cardiovascular; CVD, Cardiovascular Disease IQ, Intelligence Quotient; Pb, Lead

[1]The 2024 Pb ISA evaluates the weight of the available evidence to reach causality determinations on the health effects of Pb. Conclusions on the overall strength of evidence are described using a five-level hierarchy that classifies the weight of evidence for causation. These causality determinations are made for broad health and welfare effect categories and are informed by evaluating evidence across scientific disciplines for consistency, coherence, and biological plausibility, as well as for uncertainties. This table summarizes health outcomes for which the evidence indicates a causal relationship ("causal") or likely to be causal relationship ("likely to be causal"), or is suggestive of, but not sufficient to infer a causal relationship ("suggestive"). The ISA's approach to evaluating the weight of evidence and reaching causality determinations is described in more detail in the Preamble to the Integrated Science Assessments (U.S. EPA 2015a).

[2]The blood Pb levels reported in this table represent the lowest group or population mean blood Pb levels associated with the specified health outcome(s). Blood Pb may reflect both recent as well as past exposures because Pb is both taken up by and released from the bone. The relative proportion of BLLs resulting from recent versus past exposure is uncertain in the absence of specific information about the pattern of exposure contributing to observed BLLs, which is generally not ascertainable in epidemiologic studies. This uncertainty is greater in adults who have lengthy exposure histories and were likely exposed to high levels of Pb prior to the phaseout of leaded gasoline. Thus, the extent to which adult BLLs reported in this table reflect potentially higher exposure histories is undiscernible, as is the extent to which these past Pb exposures (magnitude, duration, frequency) may or may not elicit effects.
[3]Includes overlap with adult populations (7 to 33 years old)

8.8 Uncertainty

The uncertainty section of a lead risk assessment should discuss and, where possible, estimate the direction and magnitude of uncertainty associated with influential parameters used to estimate risk. Areas of uncertainty that may make an appreciable difference in the risk assessment results or conclusions are appropriate topics for an uncertainty discussion (U.S. EPA 2014b). The primary sources of uncertainty relative to assumptions, results, and conclusions are:

- Uncertainty in site characterization and data quality;
- Uncertainty in the representation of the EPCs;
- Uncertainty in the exposure assessment; and
- Uncertainty in the IEUBK estimation of the risk.

Influential parameters that contribute to exposure estimates that exceed risk benchmarks are a particularly important focus for uncertainty discussion because consideration of uncertainty in these parameters can inform risk management decisions. Influential parameters are also those that have the largest effect on the risk estimate when varied across a plausible range, as determined by site-specific information that informs that range of possible values.

The IEUBK model has been evaluated at a target PbB level of 5 µg/dL and shown to accurately predict the geometric mean PbB level, the probability of the PbB levels exceeding 5 µg/dL, and the distribution of observed individual PbB levels for children living at the Bunker Hill Superfund Site (Brown et al. 2022). Application of the IEUBK at lower soil lead levels has not been evaluated and may create additional uncertainty in the estimate of risk. The increased relative influence of other sources of lead on predicted PbB levels, most notably exposure through diet, is a key uncertainty in the model’s estimate of risk at a target PbB level below 5 µg/dL. At a target PbB level of 5 µg/dL and above, more than half of the predicted PbB comes from soil and dust lead levels. Below a target PbB level of 5 µg/dL, diet becomes a major contributer to the predicted PbB levels. The effect of variability in dietary exposure on the model predictions is unknown, but likely to be large where diet is a major contributor to the predicted PbB levels. Another key uncertainty is that the relationship between PbB levels and soil lead levels at low PbB levels (*e.g.*, <200 mg/kg) is not well characterized and may not be linear as it is where there are higher soil lead levels and PbB levels (Mielke et al. 2019, Zahran et al. 2011). If this relationship is non-linear at levels below the target PbB level of 5 µg/dL, the IEUBK may tend to predict lower PbB levels than what may be observed in a population. Where the IEUBK model is used with a target PbB level <5 µg/dL, the uncertainty section of the risk assessment should discuss these additional uncertainties in the model predictions.

8.9 Risk Characterization

Risk characterization is the bridge between risk assessment and risk management. Risk characterization integrates and summarizes information gathered during the three phases of risk assessment (data collection and evaluation, exposure assessment, and toxicity assessment) relating toxicity and exposure assessments. This may include the development of PRGs.

It is important to identify and understand the assumptions, uncertainties, and limitations associated with the risk assessment to reach a fully informed risk management decision. Moreover, uncertainty analysis may identify areas at a site where additional data collection could aid in the selection of a cleanup response. This is especially true for model parameters that require site-specific input (*i.e.*, soil lead EPC and bioavailability). When conducting a risk assessment, it is more important to identify and prioritize the key site-related variables and assumptions that contribute most to uncertainty than it is to precisely quantify the degree of uncertainty in the entire risk assessment. Data uncertainty needs to be assessed for each data set.

CHAPTER 9
Implementation of Cleanup Level Selection

9.1 Introduction to Selecting Cleanup Levels at EPA Removal and Remedial Residential Lead Sites

Due to significant site-specific variability, EPA's Superfund program does not set a national cleanup standard for lead in residential soil. Once EPA has determined that a removal or remedial action at a site is warranted under CERCLA, the Superfund program uses a consistent risk-based process by which residential soil lead removal and remedial cleanup levels are based on utilizing the IEUBK model with a target BLL (see Chapter 8).

At sites where lead in soil is a contaminant of concern, EPA Regions will determine whether actions to reduce lead exposure may be warranted under CERCLA. Once the determination has been made to address the lead contamination under CERCLA at a site, Regions should consider taking early actions to mitigate site risks by addressing the immediate risk posed to the current population, followed by longer-term actions to achieve site-wide protectiveness. Regions should also consider whether removal authority is appropriate at the site if current or potential elevated blood lead concentrations for children at specific residences, or elevated soil lead levels at or above the RML[110], may warrant a time critical removal.

When elevated BLLs are the basis for concern at either a home or site, occupational contributions of lead, elevated lead levels in drinking water, lead from nearby air emissions, and LBP dust in the homes should be assessed in addition to contaminated soil. These sources of lead can be significant and, in some cases, may be a greater contributor to elevated BLLs than contaminated soil. The IEUBK model can help determine if contributions by these other sources are significant. When this happens, consultation with regional risk assessors and public health officials (such as those at ATSDR and state/local health departments who can lead individual interviews and investigations) is recommended to better understand potential health impacts and identify alternative (non-CERCLA) resources to reduce exposure. While CERCLA may address many of the exposure pathways, there may be situations where other authorities should be considered.

[110] https://www.epa.gov/risk/regional-removal-management-levels-chemicals-rmls.

Please note that unless all removal/remedial responses achieve unlimited use/unrestricted exposure (UU/UE) status, protectiveness is often achieved through some level of ICs as a component of the remedy (see Chapter 10 for more information).

The following sections describe some of the different strategies available should a CERCLA response action be warranted.

9.2 Applying Removal Management Levels (RMLs) and Establishing Preliminary Remediation Goals (PRGs)

9.2.1 Applying Removal Management Levels (RMLs) at Sites

The Emergency Response and Removal Program (Removal Program) has addressed lead contamination in the outdoor environment for decades and believes a consistent, scientifically defensible, and attainable lead contamination level could help streamline lead cleanups and provide clarity amongst EPA's suite of cleanup programs (*i.e.*, removal, remedial, and RCRA). The Removal Program encourages Regions, where appropriate, to use site-specific considerations, modeling (IEUBK), and analytical testing (IVBA assays) when developing their removal actions involving lead in soils. As lead contamination is ubiquitous in the United States, the Removal Program is sensitive to focusing EPA's limited resources on lead contamination that poses substantial danger to public health.

RMLs were developed to help the Agency identify sites where a removal action under CERCLA may be warranted. Although not necessarily protective for long-term exposures, RMLs are risk-based values commonly used to help define areas, contaminants, and conditions that may warrant a removal action at a site. RMLs do not account for site-specific information. Furthermore, RMLs are not *de facto* cleanup standards and sites where contaminant concentrations fall below RMLs are not necessarily "clean" and could warrant further action under the Remedial Program.

9.2.2 Establishing Preliminary Remediation Goals (PRGs) at Remedial Sites

CERCLA's remediation goal is to achieve protectiveness either through actions such as, but not limited to, excavation of lead-contaminated soil to meet protective media levels or the use of ICs/ECs to prevent exposure. The CERCLA remedial cleanup process includes developing PRGs as described in the preamble of the NCP as: "The preliminary remediation goals are concentrations of contaminants for each exposure route that are believed to provide adequate protection of human health and the environment based on preliminary site information" (55 FR 8712, March 8, 1990). In general, PRGs are based on risk or ARARs and TBC criteria.

As noted in the NCP:

(i) Establish a remedial action objective specifying contaminants and media concern, potential exposure pathways, and remediation goals. Initially, preliminary remediation goals (PRGs) are developed based on readily available information such as chemical-specific ARARs or other chemical information. Preliminary remediation goals should be modified as necessary, as more information becomes available during the RI/FS. Final remediation goals will be determined when the remedy is selected. Remediation goals shall establish acceptable exposure levels that are protective of human health and the environment (See 40 CFR 300.430(e)(2)(i)).

A key concept is that a PRG is the average concentration of a chemical in an exposure area that will yield the specified "target risk" in an individual who is exposed at random within the exposure area (U.S. EPA 1991). For lead sites, the PRG is the average or arithmetic mean value. Site-specific factors such as current and reasonably anticipated future land use need to be considered to develop a protective level. Thus, if an exposure area has an average above the PRG, some level of response action may be warranted. (In some cases, the value set may be an NTE value.) However, in general, it may not be necessary to remediate all EUs with concentrations that exceed the PRG to ensure that the larger exposure area meets the protective level. Rather, in some situations, it may be appropriate to reduce the contaminant level such that the average concentration for a given EU be reduced to a protective level. Therefore, some concentration values in SUs within a larger exposure area may remain that are above the PRG, so long as the average PRG for the exposure area meets the protective level. The concentration value that is to be removed to reduce the mean to the protective cleanup level may be from a subset of SUs that comprise the larger exposure area.[111] In the case of lead, the risk assessor may determine a PRG by running the IEUBK model to recommend the concentration of soil lead that corresponds to the specified "target risk" set at a target BLL where the goal is to be below 5% probability of exceeding the target BLL (see Chapter 8 for more information). Whichever approach is taken – remediating all values above the PRG or remediating so that the average concentration in an EU meets the PRG – should be clearly explained in the decision documents for the cleanup.

For residential sites with lead contamination, risk-based PRGs should be calculated with the IEUBK model using existing, pre-remedial response action, site-specific data. PRGs for residential lead sites should be established to protect children from excess exposures to soil and house dust attributable to outdoor soil and are not necessarily applicable to exposures

[111] Decisions about whether to use an NTE or average approach depends on the quantity and quality of site characterization data and the CSM.

attributable to other sources, such as interior LBP, which should be managed on a residence-specific basis (see Chapter 3 for information on collaboration). Any consideration to take a CERCLA response action at a residence that factors in the increased risk from sources other than outdoor soil needs to be a site-specific risk management determination taking into consideration CERCLA statutory limitations on response (see Chapters 2 and 3 for more information). Additional information on using the IEUBK model to calculate PRGs can be found in the Guidance Manual for the IEUBK model (U.S. EPA 2021b, 1994b).

The next step is to get assistance from regional risk assessor(s) to run the IEUBK model with applicable site-specific input to support the selection of a site-specific PRG corresponding to a user-specified target BLL. For lead soil contamination in residential areas, PRGs are generally associated with a target risk based on IEUBK model runs using site-specific exposure information (see Chapter 8 for more information). The PRGs are important in beginning to design an effective risk reduction strategy and are used to inform soil cleanup levels when action is warranted under CERCLA.

Remedial or removal actions to address outdoor soil contamination reduce the contribution of lead from soil in indoor dust over time (von Lindern et al. 2003). The IEUBK model-derived PRGs, however, are not the only factor in determining cleanup levels. For remedial actions, cleanup levels can be based on a variety of information inputs, including state and federal regulations that may constitute an ARAR, TBC criteria, IEUBK model results, and site-specific information such as area-wide background concentrations (U.S. EPA 1990b).

EPA recommends that a soil lead concentration for residential land use areas (residential EUs) be determined so that a typical child or group of similarly exposed children exposed to lead at this level would have no more than a 5% probability of exceeding the target BLL (note: the 5% risk acceptance value <u>does not equate to</u> five children out of every 100 exceeding the target BLL in the community. It is an estimate of risk based on a predicted distribution of BLLs). Selecting a soil lead PRG in this manner is not a guarantee that a given individual child will be below the target BLL. Many factors other than elevated soil lead concentration may contribute to elevated BLLs, including pica behavior and exposure to other sources of lead beyond the exposure scenario. Scenarios include LBP, diet (including supplements and spices), soil at a daycare facility, camping sites, or other areas frequented by the child.[112]

[112] In addition to the individual residence, accessible lead sources outside the residential property, such as tailings piles, should also be evaluated to understand how these potential exposures contribute to the overall risk to children. When the evaluation indicates a significant contribution to risk, response measures should be evaluated for those areas.

9.3 Prioritizing Response Actions at EPA Lead Sites

> Priority should be to take immediate action at properties with greatest risk.
>
> Residential properties can move into a different priority scheme if conditions change (*e.g.,* young children or pregnant women move into a house).

At lead sites with many properties above the RML, RSL, and/or PRG, Regions should prioritize properties so those with the greatest risks are addressed first. The need for the Regions to take early action and prioritize response actions at residential properties may be based on the levels of lead detected, current exposure potential, presence of a susceptible receptor such as young children and pregnant women, or known elevated BLLs.

While having a consistent national approach to prioritizing properties is important, every site is different, and Regions may adjust the approach as appropriate on a site-specific basis. Further, because the size and complexity of many lead sites often warrants implementation of response actions over many years, early and interim response actions may be needed to manage short-term exposure and source area concerns. If removal actions are taken at remedial residential lead sites, consistent with the NCP, they should align with the planned objectives of remedial actions.

The soil lead concentration and receptors inform the prioritization process; however, other considerations (*e.g.*, environmental justice considerations, other non-soil sources of lead exposure from lead pipes, LBP, and/or lead air emissions, as well as data on background soil lead concentration) may also inform prioritization. The RPM or OSC should determine whether immediate action is needed. A removal action may be justified if soil concentrations are above EPA's lead RML. Properties at remedial sites with soil lead concentrations less than the PRG generally do not require further investigation.

9.3.1 Early Actions to Address Short-Term Exposures

Early response actions to protect young children can be an essential aspect of reducing risk at a site, as discussed above. This approach focuses on starting early risk reduction strategies for all portions of the community. These risk reduction strategies may be implemented through removal (TCRA or NTCRA) or remedial (*e.g.*, early action ROD) authorities. The specific strategy will vary, depending on the susceptibility of the receptor at risk, soil concentrations, stage of the project, and planning period necessary prior to initiating action. These actions should be coordinated with source controls to avoid recontamination. The following list includes, but is not limited to, examples of measures that may be used to reduce the potential for recontamination when scoping an early action:

- Evaluate the feasibility of conducting the cleanup of residential areas in their entirety during an early removal phase if contamination is widespread. If this is not possible, limit early removal actions to immediate risks (*e.g.*, residences with elevated BLLs) to minimize the potential for recontamination.
- Seek permanence in selecting the cleanup alternative(s), if possible, such as at properties where there is an acute risk (*e.g.,* complete removal to depth of soil contamination).
- Consider simultaneous cleanup of adjacent properties when not doing so might threaten the permanence or effectiveness of the early action.
- Use engineering controls (ECs) such as monitoring, water trucks, vehicle washing, etc. to control fugitive dust sources, access, tracking, and erosion of contaminants to the extent possible.
- Perform high-efficiency particulate air (HEPA) street sweeping to minimize tracking of contaminants throughout a community.
- Provide informational fact sheets to homeowners on how to minimize recontamination of their property.
- Establish ICs to manage cleaned areas with contamination present at the site (at depth) after the early action is taken. This could involve local and state government agencies, and PRPs that are available to recommend BMPs for homeowner projects and provide education to the homeowner, as well as utility districts and companies that may excavate contaminated material.
- Provide site plans or other documentation of areas that have been cleaned up, as well as information on areas that are still contaminated, to the local governmental entity responsible for the maintenance of the remedy (*i.e.*, for monitoring ICs and tracking properties over time and informing residents, including new or prospective residents, of contamination and associated ICs).
- Establish a GIS for monitoring ICs and properties for remedial actions.

See EPA's *Policy on Management of Post-Removal Site Control* (40 CFR 300.415[l]) for additional information (U.S. EPA 1990c).

9.4 Application of Cleanup Levels

This section presents approaches on how to apply cleanup levels at a site and delineate which soil areas to remediate. In addition, this section provides remedial options to achieve the cleanup goal or RAO. The recommended approaches in this section provide information to inform and support risk management decisions towards achieving a risk reduction remedial goal.

9.4.1 Recommended Options for Implementing Cleanup Levels

This section discusses options for risk managers to implement cleanup levels. A key factor driving the choice between these options is the soil sampling design and basis for the cleanup level. The method used in implementing the cleanup should be compatible with the method used in establishing the cleanup level (including the DQOs for sampling and analysis). Another important factor is the nature and extent site assessment data. Therefore, consideration of the cleanup implementation should inform the sampling design and risk assessment. Further, the decision about which approach to take should be clearly explained in the decision documents for the cleanup. This section describes advantages and disadvantages as well as the appropriate use for the two options.

9.4.1.1 Key Factors

Exposure: The exposure assumptions made in determining which approach to use should be consistent with the exposure assumptions used in risk assessment and the determination of the EPC.

Size of EU: If the size of the EU is different pre- and post-remediation due to changes in the land use, the sampling may not be appropriate to support implementation of either approach. The change in land use could be from overgrowth being allowed (covering up previously sampled areas), trees and/or overgrowth being cleared (creating more area that was not previously sampled to potentially be exposed to), or a previously sampled area being paved over for parking, a pool installation, or a patio area.

Confidence in the Cleanup Level: If the cleanup level is the risk-based PRG and the EUs are well defined, then an area-wide average may be an acceptable approach. However, if the cleanup level is less "conservative" based on practical and technical considerations (*e.g.*, cost, implementability), then an area-wide average may not be an acceptable approach and a not-to-exceed approach is recommended.

Quality and Quantity of Site-Characterization Data: Confidence in the accuracy of the lead soil concentration data to represent soils that a receptor contacts over time may influence the decision on which approach to use.

9.4.1.2 Not-To-Exceed (NTE)

The NTE option typically entails treating or removing all soil DUs with contaminant concentrations that exceed the cleanup level. Implementing the cleanup level as an NTE value normally means that soil removal or treatment will continue until the analysis of soil samples (including step-out samples) indicates that the EPC from a DU will have soil contaminant concentrations below the cleanup level. After remediation is complete, the highest remaining concentration within any DU within an EU should be at or below the cleanup level, and the post-remediation EPC (average or UCL) within the EU should be lower than the cleanup level. If the risk-based PRG chosen by the risk manager is the cleanup level, then applying it as an NTE level should result in a post-remediation EPC that is below this protective level (see U.S. EPA 2005b for more information).

9.4.1.3 Area-Wide Average

The area-wide average approach assumes random exposure within the EU; all areas (including clean areas) within the EU should be included in the calculation. This approach is specifically intended for situations where adequate site characterization data are available. Implementing an area wide averaging cleanup approach requires more sampling information (*e.g.*, smaller SUs and DUs within an EU).

Where multiple exposure scenarios over different spatial scales are being assessed, it is generally recommended to use the smallest EU or DU relevant to the risk assessment or remedial decision. EUs evaluated are no larger than an individual property. For example, a residential property may be one potential EU, which includes a garden and a play area where receptor behaviors may be focused. Sampling to assess the average of a larger EU may not be adequate to achieve DQOs for smaller EUs. However, there are robust statistical methods to calculate an area-weighted average for a large EU based on the average, variance, and skewness of data from smaller EUs. In the example above, small EUs for the play area, garden, and the remainder of the yard could be sampled, and area-weighted statistics for stratified sample designs could be used to assess exposure across the yard as a single large EU.

The area-wide average approach involves remediating the areas of the EU with the highest lead concentrations until the post-remediation EPC for the EU is at or below the cleanup level. In some cases, such as when EPA would like to control both false compliance and false exceedance error rates or control the uncertainty in making multiple statistical decisions, it may be appropriate to use statistical comparison. A statistician should be consulted at both the sample planning and data analysis stages to ensure that an appropriate sample design and statistical methodology is used.[113] These approaches normally require establishing a cleanup level that is the post-remedial EPC and making a statistical determination of a remedial action level (RAL). The RAL is the level to which lead soil concentration within an EU is reduced to ensure that the post-remediation EPC for the EU does not exceed the cleanup level. The method to determine the RAL should be compatible with the method used to determine the EPC. Because the area-wide average approach may result in some high concentrations being left in place, risk managers should work with risk assessors to ensure that the remediation plan is compatible with long-term protectiveness (including consideration of potential land use changes [*e.g.*, a future resident placing a garden or swing set on the high DU], future occupants, and the potential for contamination of adjacent DUs through the movement of fine particles on the surface).

Classical statistical and geostatistical methods are generally available for calculating RALs when implementing cleanup levels as area-wide averages. The study design and spatial bias of the sample locations are a critical consideration in selecting an appropriate statistical method. Sample designs with no spatial bias (either random sampling or sampling on a grid of equal sample density across the EU or DU) greatly simplify the data analysis. Classical statistical approaches should only be selected if there is no spatial bias in the sample locations. If there is no spatial bias in the sample locations, these methods are generally appropriate regardless of the presence of spatial patterns or spatial autocorrelation. If there is spatial bias in the sample locations, a spatially weighted approach should be used. This requires an interpolation method to generate spatial weights and to appropriately account for spatial relationships and spatial autocorrelation, in addition to accounting for the variance and skewness of the data. Such methods are referred to as geostatistical methods and are generally more rigorous. Geostatistical methods may be used to account for the relationship between the contaminant concentrations and the size, receptor behavior, location, and geography of the EU. An alternative to area weighting is to apply time weighting to the DUs within an EU based on known or reported behavior of receptors.

[113] pbhelp@epa.gov.

Three statistical methods that have been suggested for use in implementing an area-wide average approach to cleanup sites:

1. **Iterative Truncation Method**

    - Order sampling data from lowest to highest concentration.
    - Starting with the highest concentration, remove a sample and replace it with the post-remediation concentration, usually defined by the expected concentration in fill material.
    - Recalculate the UCL of the post-remediation EPC for the new data set and compare the EPC to the cleanup level
    - If the UCL of the post-remediation EPC is higher than the cleanup level, repeat the process until the UCL is less than or equal to the cleanup level.
    - When the UCL of the post-remediation EPC in the data set is less than or equal to the cleanup level, the highest sample concentration remaining in the data set is designated as the RAL.

2. **Confidence Response Goal Method**

    - Function of the mean (average) and standard deviation of contaminant compared to the cleanup level.
    - The UCL of the post-remediation distribution is calculated from the average and variance of the unremediated portion with the pre-remediation data distribution and the assumed clean fill concentrations throughout the remediated portion (spatially weighted as appropriate when sample locations are spatially biased).
    - Based on the assumption of lognormality of contaminant concentration.
    - Requires statistical expertise.

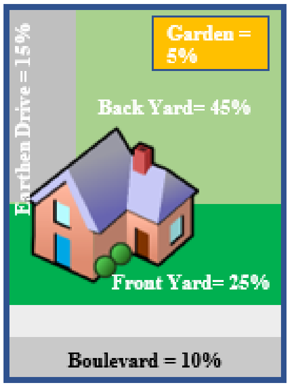
3. **Geostatistical Method**

    - Requires geostatistical expertise.
    - Estimates means, variances, and skewness within areas (*e.g.*, gridded surface, or polygons) designated by the user.
    - In most cases, can accommodate biased data. Note: step-out samples are an extreme form of spatial bias. While they are useful for characterizing the extent of contamination, they create a bias in average and UCL calculations that cannot be corrected by geospatial methods

- Requires initial analysis to determine whether a transformation of data is warranted.
- Produces variograms.
- The EPC for each EU is determined by superimposing an interpolated data grid on the site map.
- Calculating the UCL cannot be done using the interpolated data because interpolation smooths the variance of the data and produces an artificially low UCL. The UCL calculation should be done using the spatial weights created by the interpolation method and applying them to each data point to calculate the weighted UCL. Note: ArcGIS software will calculate a weighted average and a UCL. However, a statistician should be consulted to ensure that the UCL was calculated appropriately and did not use the interpolated data grid.
- An iso-concentration map is used to identify EUs that must be remediated to reduce UCLs of the EPC to less than or equal to cleanup levels and is repeated until the RAL is achieved.
- The original iso-concentration map is used to define zones with concentrations greater than the RALs.

See Figure 9-1 for an example of implementing the area-wide average approach to implementing cleanup goals.

Figure 9-1. Example of an Approach for Area Weighted Average (AWA) for Lead

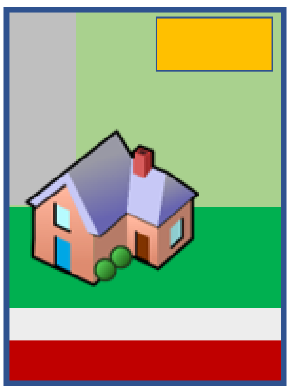


Exposure is related to concentration and to how often contact is made with that concentration. **Areas with discrete direct surface soil contact with elevated lead (hot spots) in a property may be of concern. However, if the *overall* average lead concentration to the surface soil (what is known as the AWA) is below the cleanup level, this may be acceptable.**

To calculate the AWA, the concentration for each yard component is multiplied by the percentage of the yard covered by that component. The results of all components are added to get the **AWA** for the property.

Let's look at some examples of what areas would and wouldn't be recommended for clean-up using the **AWA** and **a lead cleanup level of 250 ppm**. We'll track what happens when different yard components are given a value of 450 ppm lead. In these examples, red indicates areas of elevated lead. Although some yard components exceed the lead cleanup level in each example, cleanup is only recommended in two cases. Example #3 illustrates that the AWA is greater than the lead cleanup level of 250 ppm. Example #4 illustrates that when there is a scenario where there are high contact rates and high intensity activity such as a gardening scenario, a risk management decision may warrant cleanup. **Please note: the example cleanup level and other concentrations are for illustrative purposes only.**

Example #1



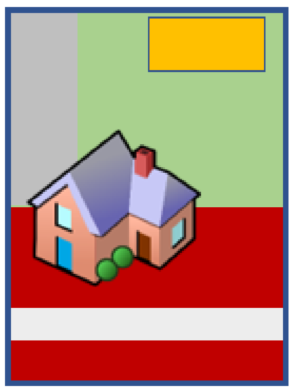
Boulevard = 10% x **450** ppm
Front yard = 25% x 100 ppm
Back yard = 45% x 150 ppm
Drive = 15% x 90 ppm
Garden = 5% x 110 ppm

AWA = 158* ppm

Lead in this boulevard is greater than the cleanup level, *but the AWA does not exceed the cleanup level.*

Cleanup NOT Required
Overall risk does not exceed acceptable limits

Example #2



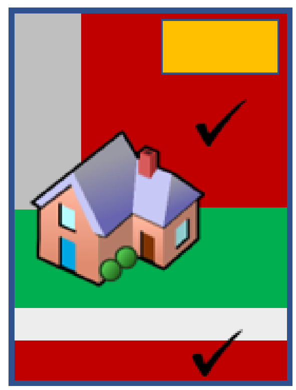
Boulevard = 10% x **300** ppm
Front yard = 25% x **450** ppm
Back yard = 45% x 150 ppm
Drive = 15% x 90 ppm
Garden = 5% x 110 ppm

AWA = 231* ppm

Lead in this boulevard *and* front yard is greater than the cleanup level, *but the AWA does not exceed the cleanup level.*

Cleanup NOT Required
Overall risk does not exceed acceptable limits

Example #3



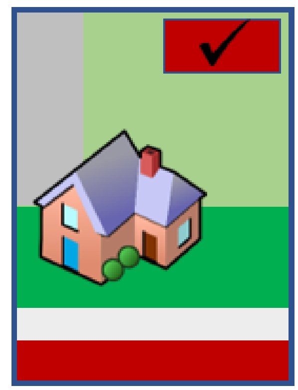
Boulevard = 10% x **300** ppm
Front yard = 25% x 100 ppm
Back yard = 45% x **450** ppm
Drive = 15% x 90 ppm
Garden = 5% x 110 ppm

AWA = 278* ppm

The AWA here exceeds the lead cleanup level. The boulevard and back yard *also exceed the cleanup level.*

Cleanup Recommended Back yard and boulevard

Example #4



Boulevard = 10% x **300** ppm
Front yard = 25% x 100 ppm
Back yard = 45% x 150 ppm
Drive = 15% x 90 ppm
Garden = 5% x **450** ppm

AWA = 160* ppm

All garden soil that exceeds 250 ppm lead will be removed. However, *the AWA does not exceed the cleanup level.*

Cleanup Recommended Garden

*The math, for those who want to check: Ex. 1 (45+25+68+14+6=158), Ex. 2 (30+113+68+14+6=231), Ex. 3 (30+25+203+14+6=278), and Ex. 4 (30+25+68+14+23=160)

9.4.2 Evaluating Soil Cleanup Technologies

EPA's Office of Research and Development (ORD) Superfund Technical Liaisons (STLs) may be contacted for accessing resources for your site.[114] Historically, the most commonly selected response actions for lead contamination in a residential area are: (1) excavation of contaminated soil from 0 to 12 inches bgs or to 24 inches bgs[115] followed by covering the excavated area with clean soil and/or other material to return yard to grade; and (2) placement of a material that provides a direct exposure barrier (*i.e.*, cover) without any excavation of contaminated soil. Excavation followed by the replacement of clean soil or other material may leave contamination at depth that exceeds residential cleanup levels. In those cases, a visible marker or barrier (*e.g.*, orange snow/construction fencing) is generally recommended to be placed below the clean fill to signify contamination at depth and/or prevent upward migration of contaminated soil.[116]

The evaluation of the application of fill or cover materials should consider the route of exposure (direct contact only or infiltration concerns), operation and maintenance (O&M) viability, responsibility and costs, site drainage considerations, and long-term reliability. ICs should be considered for long-term protectiveness if soil contamination remains that exceeds the protectiveness level (see Chapter 10). Any ARARs must be met or waived.

9.4.3 Minimum Excavation Depth/Soil Cover Thickness

A minimum of 1 foot (12 inches) of clean soil is generally recommended for protection of human health for the direct contact of soil.[117] Frost heaving or other routine or potential disturbances to the surface (*i.e.*, gardening or frequent athletic use) may call for greater depths of clean soil. Cover soil can either be placed after excavation as backfill or on top of the contaminated yard soil. However, if backfill is placed on top of the contaminated soil, erosion of the fill should be taken into consideration in the long-term effectiveness of the cover. Except for gardening, typical activities do not disturb soil >12 inches bgs. Mitigation measures for any infrequent activity (*e.g.*, building a structure, planting large trees) that may disturb soil below 12 inches can be addressed by implementing site-specific ICs, such as deed restrictions or a property notice, or environmental covenants.

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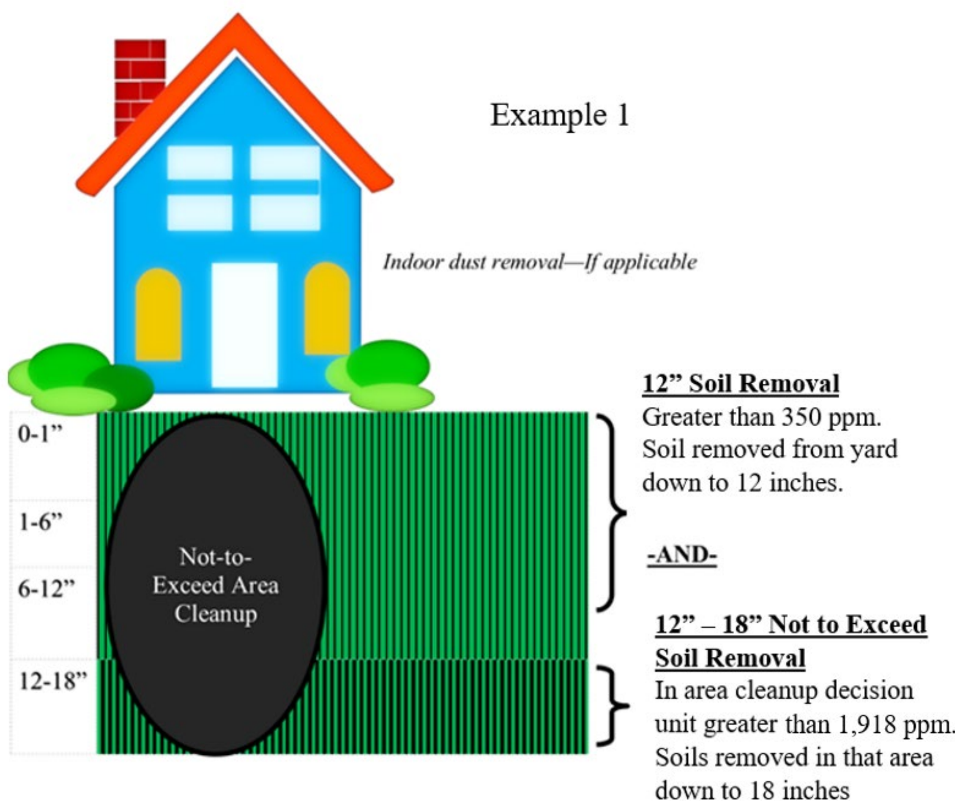
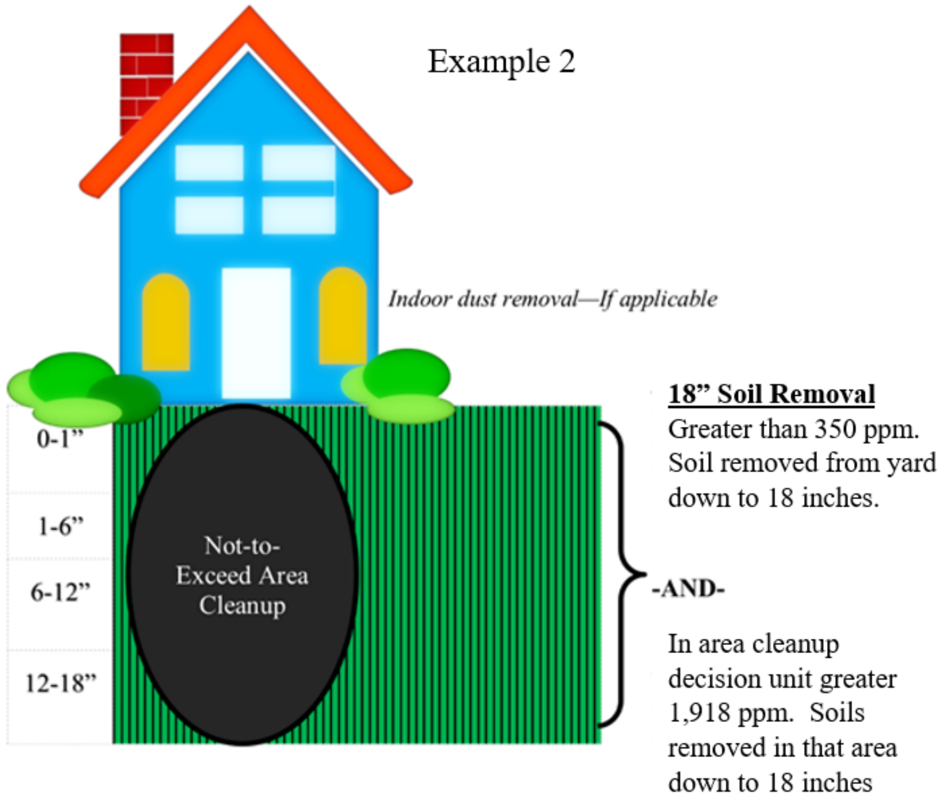
[114] See https://www.epa.gov/land-research/superfund-and-technology-liaison-program.
[115] Considered to be the depth for direct contact human health exposure.
[116] https://semspub.epa.gov/work/06/901287.pdf.
[117] Note: there may be state ARARs for clean fill depth.

The decision to perform soil cleanup to depths greater or less than 12 inches should be considered on a site- or property-specific basis. However, there are many properties at which lead contamination is located at depth. Full vertical soil cleanup may not be cost-effective and/or feasible at such properties. Potential for freeze/thaw upward migration, groundwater contamination, and the cost, extent, and effectiveness of ICs are some of the factors that should be considered. In Figure 9-2[118], Example 1 illustrates a hypothetical site where the receptor contacts the top 12 inches of soil. The first step evaluates contamination levels from 0 to 12 inches and evaluates each average contamination level at each soil horizon: 0-1, 1-6, and 6-12 inches. Soil cleanup is recommended when the average for any of these intervals from 0 to 12 inches exceeds the corresponding cleanup level. The second step addresses remediation of soil hotspot contamination above the NTE cleanup level. Soil hotspots exceeding the NTE at any depth sampled should be removed to a maximum depth of 18 inches.

Figure 9-2. Examples of Potential Alternative Soil Lead Cleanup Scenarios for Subsurface Soil Contamination



[118] The cleanup levels are for illustrative purposes and based on possible site-specific exposure scenarios.



Example 2 illustrates that the first step evaluates contamination levels from 0 to 12 inches and evaluates each average contamination level at 0-1, 1-6, 6-12, and 12-18 inches. Soil cleanup is recommended when the average for any interval from 0 to 18 inches exceeds the corresponding cleanup level. The second step addresses remediation of soil hotspot contamination above the NTE cleanup level at any depth sampled. The recommendation for any such hotspot contamination is removal to a maximum depth of 18 inches.

Full vertical removal of residential soil avoids costs of maintaining the soil cover, placing subsurface barriers and markers, and obtaining environmental easements (*i.e.*, ICs). Full removal also satisfies EPA's preference for permanent remedies and normally allows the remediated yard to return to unrestricted use.

Gardening scenarios normally consider direct contact to contaminated soil down to 2 feet bgs. Therefore, 2 feet of soil cover is generally recommended for vegetable gardens; however, site-specific conditions warranting more or less soil cover (*e.g.*, presence of burrowing animals) should be considered, depending on the difference between the EPC, cleanup level, background, and lead content of the replacement soil. The use of raised gardens may be a cost-effective response, adding 2 feet of clean soil to garden areas (see Chapter 6 on gardening for more information) and may be attractive to the residents.

When considering the use of mulch, sod, or other vegetation as part of the response, the OSC/RPM should determine that such use would not preclude property owners from full utilization of their property (*i.e.*, placement of a garden or swing set). Vegetative options generally may be considered to augment the remedy (*e.g.*, as dust control for areas where there is no direct exposure), but these are generally not considered protective as stand-alone remedial options. Since digging may still occur in these areas or the vegetation may die, potentially resulting in unacceptable exposures, a visible barrier should be placed below the application of the cover materials where utilized.

9.4.4 Examples of Implementing Cleanup Options

This section describes the implementation of two cleanup options that should be considered in conjunction with the results of the sampling efforts:

(1) Excavation and backfill (and placement of a visible subsurface barrier if applicable); or

(2) Soil cover placement (and placement of a visible subsurface barrier if applicable).

The options should be performed as described below (see also Figure 9-3). The goal should be to remove all contaminated soil or provide a minimum 12 inches of clean soil cover.

The following describes the implementation of an excavation and backfill remedy:

- If any soil down to 6 inches exceeds the cleanup level, a 6- or 12-inch excavation is recommended, depending on the 6- to 12-inch sample horizon results;
- If the 6- to 12-inch horizon exceeds the cleanup level, a 12-inch excavation is recommended. A visual subsurface barrier should always be used if the 12- to 18-inch horizon exceeds the cleanup level;
- If any soil down to 6 inches exceeds the cleanup level and the 6- to 12-inch horizon does not exceed the cleanup level, a 6-inch excavation is recommended; a visual subsurface barrier is not recommended.

The following describes the implementation of a soil cover remedy:

- If any soil down to 6 inches exceeds the cleanup level, a 12-inch soil cover and visual barrier should be used;
- If the 6- to 12-inch horizon exceeds the cleanup level (but not the 0- to 1-, 1- to 6-, or 0- to 6-inch intervals), a 6-inch soil cover should be used;
- If only the 12- to 18-inch horizon exceeds the cleanup level, capping is not recommended.

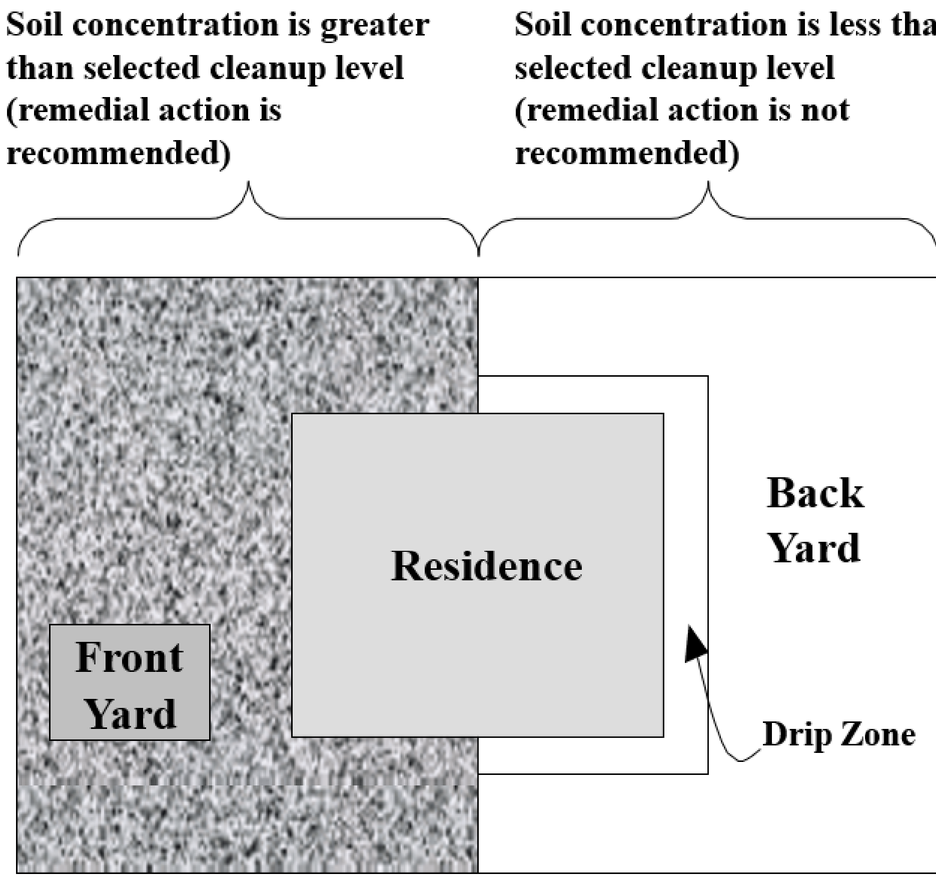
Figure 9-3. Example Interpreting Sampling Results

	Depth	**Soil Concentration Exceed Action Level?**							
	0-1”	Yes	Yes	Yes	Yes	No	No	No	No
	1-6” (or 0-6”)	Yes	Yes	No	No	No	Yes	No	Yes
Remedial Action Options	6-12”	Yes	No	Yes	No	No	No	Yes	Yes
Option 1: Excavation (& Backfill)	Depth of excavation	12”	6”	12”	6”	No action	6”	12”	12”
Option 2: Capping	Soil cover thickness	12”	12”	12”	12”	No action	12”	6”	12”

The figure shows remedial action recommendations based on the results of composite soil samples collected for each of the depth intervals shown. The figure includes two remedial action options: (1) excavation followed by backfilling, and (2) placement of a clean soil cover without removal of soil that exceeds the action level. To use the figure, find the column of the table that agrees with the soil sample results for your site, then read down the table to determine the recommended depth of soil to remove (option 1: excavation remedies) or the thickness of the recommended soil cover (option 2: capping remedies). For example, the heavy border around the third column of the table corresponds to a situation where the lead concentration in the 0- to 1- and 1- to 6-inch depth intervals exceed the action level, but the 6- to 12-inch interval does not. In this example, it is recommended to remove the top 6 inches of contaminated soil and replace it with clean soil, or to place a 12-inch clean soil cover (cap). The goal is to provide a minimum 12-inch barrier of clean soil when the underlying soil exceeds the action level.

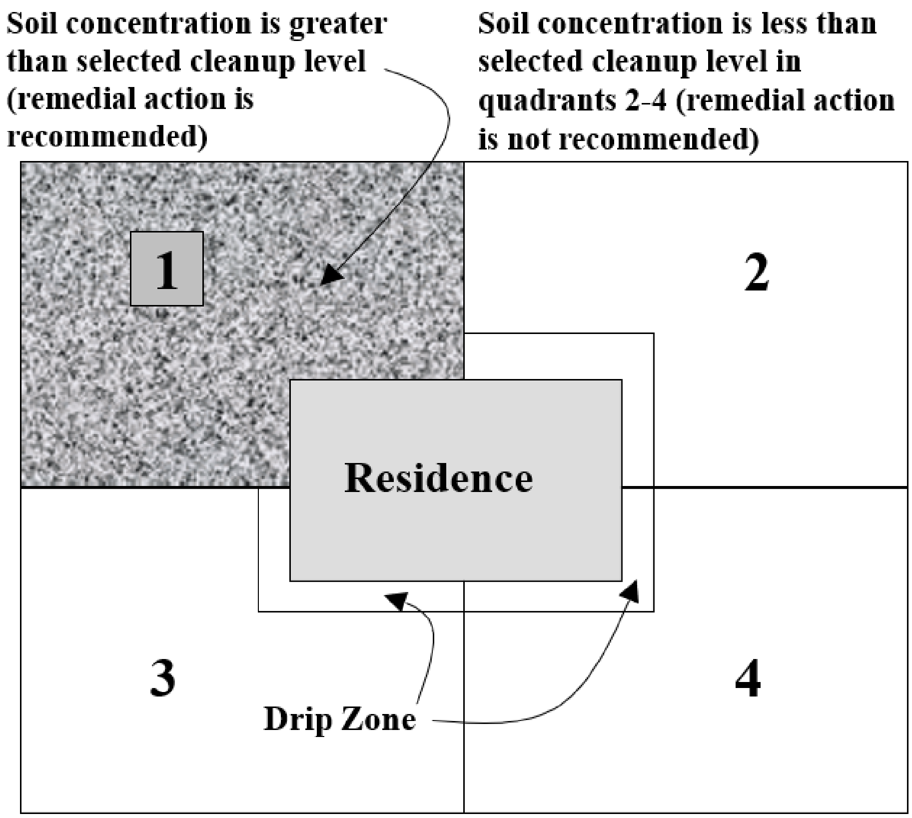
Sampling results obtained for residential lots may indicate that only a portion of the lot contains soil that exceeds the selected cleanup level. Although it will depend on relevant site-specific factors such as the actual square footage of the residence, properties could be divided into multiple SUs and DUs for remedial decisions. For example, for properties <5,000 square feet, the recommended spatial scale for the remedial decision should be one-half of the yard. For properties >5,000 square feet, the property may be divided into four quadrants and a remedial decision should be made for each quadrant. It is usually protective to excavate only the portion(s) of the lot that exceed the cleanup level (Figures 9-4 and 9-5). However, in such a scenario, removal of the sod layer and re-sodding/reseeding the unexcavated portion(s) of the lot is strongly recommended to promote consistency in the vegetative cover of the yard to help address homeowner satisfaction and community acceptance.

Figure 9-4. Partial Cleanup of Residential Lot Less than or Equal to 5,000 Square Feet in Size



In this hypothetical example, the lead concentration measured in the front yard exceeds the selected cleanup level while the concentration measured in the backyard does not. The entire drip zone should be cleaned up if the average lead concentration exceeds the cleanup level. The drip zone in the back yard (as well as the front yard) should be cleaned up if the average concentration in the drip zone exceeds the cleanup level.

Figure 9-5. Partial Cleanup of Residential Lot Greater than 5,000 Square Feet in Size



In this hypothetical example, the lead concentration measured in quadrant 1 exceeds the selected cleanup level while the concentration measured in quadrants 2-4 do not. Cleanup may be limited to quadrant 1, although it is recommended that the sod layer in the entire lot be removed to promote consistency in the vegetative cover on the property for homeowner satisfaction and community acceptance. The entire drip zone should be cleaned up if the average lead concentration exceeds the cleanup level. For example, in the above figure, the drip zone in quadrants 2-4 (as well as quadrant 1) should be cleaned up if the average concentration in the drip zone exceeds the cleanup level.

If the only portion of the yard that exceeds the selected cleanup level is the drip zone, the exterior paint should be checked for lead content (see Section 6.7). If the drip zone contamination does not appear to be paint-related, the drip zone should generally be cleaned up if action is taken under CERCLA. If the drip zone contamination appears to be solely paint-related, EPA should promote the remediation of the exterior LBP by local health agencies, other local government agencies, state health agencies, and/or the homeowner. At a minimum, the resident should be notified and informed of relevant disclosure requirements (Appendix M). The Superfund site team (or other identified convener) should notify and collaborate with the relevant EPA programs, and state, territorial, tribal, and local government agencies, as appropriate. For this reason, separate sampling or avoidance of drip zone soils should be addressed by the QAPP and associated field sampling plan.

9.5 Yard Excavation Cleanup Specifics

The steps of a typical soil cleanup are shown in the text box below.

<u>Steps of a Typical Soil Response Action</u>

Step 1 (Consent to Access) - Collect access consent form(s) from each owner (or tenant, if necessary) before any work is conducted (see Appendices F and G). Access from the tenant or renter is likely not sufficient. If questionnaires requesting information on indoor lead sources have not yet been provided, need to be updated, or are otherwise incomplete, these may also be provided with the access agreement.

Step 2 (Initial Survey) - Interview the owner/resident(s) to determine if there are any specific problems that need attention, and if there are any structures or property the owner wants left untouched. The contractor will conduct a thorough documentation of the property using drawings, digital photographs, and digital video. Once documented, the owner should sign a property agreement that documents any special requests or considerations in cleaning up the yard, any contaminated yard areas that will not be cleaned up, provisions for structural concrete and fence restoration, and deviations from strict soil excavation and capping.

Step 3 (Excavation) - Each tract is excavated by the contractor(s), who will also complete documentation and provide depth confirmations. Ensure that documentation meets any technical requirements needed for the particular site-specific situation.

Step 4 (Backfill) - After excavation of properties where full excavation to depth has been performed, the excavated area is backfilled and compacted. After excavation of properties with a vertical excavation limit, a permanent, permeable barrier/marker may be placed in the excavated area. After placement of any barrier/marker, the excavation area is backfilled and compacted (see Section 13.1).

Step 5 (Restoration) - Restoration of the property, including landscaping, sod/seeding, fencing, stone, and concrete (as needed) is conducted.

Step 6 (Final Inspection) - After restoration activities are complete, EPA or its agent (*e.g.*, Army Corps of Engineers) will conduct a final inspection.

Step 7 (Closeout Form) - A property closeout form should be signed by the property owner, which documents that the owner is satisfied with the remediation of the property. Any outstanding issues between the EPA and the homeowner that have not been fully resolved should be documented in the closeout form.

Step 8 (Cleanup Documentation Letter) - After the property owner signs a property closeout form, EPA documents its actions by issuing a letter to the owner, which documents that the property has been remediated. Any areas that are not cleaned up via the owner's request, such as gardens, should be noted in the letter. Additionally, a map and photos of areas left and/or where marker layers/ barriers were placed should be included. For properties where contamination is not completely removed, the cleanup letter should also document, if applicable, the presence of contamination at depth, and should describe any protective measures (including ECs or ICs) that were taken to prevent exposure to the remaining contamination (*i.e.*, barriers/markers).

It is important to define the properties that will be remediated during a response. The use of property boundaries rather than temporary features, such as a fence, to delineate boundaries is recommended. The use of temporary features may confuse remediation contractors and result in the partial cleanup of some properties and increases the chance of trespassing on adjacent properties.

It is the responsibility of the RPM or OSC to make site-specific recommendations regarding yard size limitations, and whether to clean up empty lots and other sources of lead (*e.g.*, alleyways). The remedial approach should be based on the reasonably anticipated land use as discussed in the May 25, 1995, memorandum entitled, *Land Use in CERCLA Remedy Selection Process* (Directive 9355.7-04 [U.S. EPA 1995a] and the March 17, 2010, memorandum entitled, *Considering Reasonably Anticipated Land Use and Reducing Barriers to Reuse at EPA Lead-Superfund Remedial Sites* (Directive 9355.7-19). In general, "remedial [action] objectives should be developed in order to develop alternatives that would achieve cleanup levels associated with the reasonably anticipated future land use over as much of the site as possible" (see page 6, U.S. EPA 1995a).

9.5.1 Yard Cleanup: Development and Screening of Alternatives

Whether remediation consists of placement of a soil cover, excavation and placement of a soil cover, or another technology, consultation with the property owners is important to the development and implementation of response actions and may necessitate property-specific deviations to the guidelines listed in this section. Table 9-1 illustrates an example of an evaluation of various remedial options. The evaluation criteria in development and screening of remedial alternatives are as follows:

- Effectiveness – The effectiveness evaluation focuses on the potential effectiveness of the process options in handling volume of soils or areas of concern and meeting the RAOs, the potential risk to human health and the environment during implementation, and how proven or reliable the technology and process is for handling contaminants at the site;
- Implementability – The implementability evaluation examines the technical and administrative feasibility of implementing a technology and process option; and
- Cost – The cost evaluation looks at relative capital costs rather than detailed estimates. Engineering judgement is used to determine whether the costs associated with each process option are high, medium or low relative to other process options under that technology type.

Table 9-1. Development and Screening of Remedial Alternatives: Example of Site-Specific Evaluation of Remedy Components and Process Options for Residential Soil

General Remedy Components for Residential Soil	Remedial Technology Types	Process Options	Short- and Long-Term Effectiveness	Implementability	Relative Cost	Option Retained?
Containment controls	Engineered cover	Soil cover	Moderate	Low	Moderate	No
		Soil-clay cover	Moderate	Low	Moderate	No
		Asphalt cover	High	Low	High	No
		Concrete cover	High	Low	High	No
		Synthetic membrane	High	Low	High	No
Migration controls	Surface controls	Grading, revegetation, erosion controls	Low	Moderate	Moderate	Retained for use in conjunction with other process options
Soil removal/ replacement	Excavation	Conventional earth moving	High	High	Moderate	Yes
	Onsite disposal	Construct onsite waste repository	Moderate	Low	Low	No
	Offsite disposal	Dispose at appropriate landfill	High	High	Moderate	Yes
Soil treatment	Chemical treatment	Soil amendments	Low	Moderate	Low	No
	Physical treatment	Soil tilling	Moderate	Moderate	Low	No

Containment controls are engineered barriers that limit exposure to, and the potential mobility of, soil or waste. Typical process options for containment include engineered soil cover, soil-clay cover, asphalt cover, concrete cover, and synthetic membrane cover. Soil and soil-clay covers are somewhat effective provided they are appropriately maintained. Asphalt, concrete, and synthetic membrane covers may be highly effective when long-term maintenance is applied. Covers are difficult to install and maintain over small, non-contiguous areas such as residential properties or portions of yards, making the implementability of these options low for this example site. Cost to construct and maintain soil covers is relatively low, costs for soil - clay covers are medium, and costs to install and maintain asphalt, concrete, or synthetic covers are relatively high. Although there are advantages and disadvantages to each of these containment process options, all require significant long-term maintenance to be effective. Because of this, covers are not retained for further consideration in this example site.

Migration controls reduce the movement of contamination from source areas into the surrounding soils. Surface controls are the only migration control technology considered in this site example. Process options for surface controls include grading, revegetation, and erosion protection. These options are generally employed in concert at larger sites to reduce the amount of precipitation coming in contact with contaminated soils or wastes. Grading, erosion control, and revegetation can be effective in reducing the migration of contaminants away from source areas; however, the soil disturbance associated with grading and establishing new vegetation could expose workers or neighbors to airborne dust containing unacceptable levels of lead. Stormwater flow is considered when grading would be employed both to protect the replaced soil from erosion and to ensure that there are not negative impacts to neighboring properties. Stormwater drainage controls may be required as part of this response action in this example site. Surface controls require ongoing maintenance to remain effective in the long term. O&M considerations make the effectiveness of surface controls low when considered as a stand-alone option. Ultimately, grading, revegetation and erosion control are retained to be used in conjunction with soil removal and replacement options for residential areas in this example site.

Soil removal and replacement is a three-stage process involving excavation of contaminated soils, disposal of excavated materials, and replacement with clean soils. In some cases, where contamination is left in place below the depth of the excavation, a visible barrier material will be placed, such as snow fence or geotextile. Conventional earth moving refers to the variety of excavation techniques that may be employed for moving soil utilizing hand tools and/or heavy equipment as space allows. Removal and replacement are highly effective at preventing or reducing long-term exposures to soils containing unacceptable levels of lead, even though excavation activities may result in short term impacts such as dust generation and disturbance to vegetation. At some properties, exterior painting may be appropriate to encapsulate peeling or chipping LBP, which has the potential to impact the soil remedy. If all site-related contamination above levels that allow for UU/UE is removed, there are generally no ongoing O&M requirements that must be considered for soil removal and replacement. However, if sampling data indicate that some contamination will be left in place at depths greater than the prescribed excavation depth, there may be ongoing O&M requirements and ICs (*i.e.*, placement of snow fence or geotextile barrier) to be considered for soil removal and replacement. Soil removal by excavation is readily implementable and is retained for further consideration in this example.

Process options for disposal of contaminated soils or wastes are onsite and offsite disposal. Onsite disposal involves building a waste repository onsite near the location of original waste generation and moving contaminated soils to that repository. Designing and building a waste repository can be a very long process, which lowers the short-term effectiveness of this option. When construction of an onsite repository is a viable option, it can be highly effective at reducing exposures to waste in the long term and can be less costly than offsite disposal. Whether onsite disposal is a viable option depends on current site ownership, land use, topography, the volume of waste to be disposed of, and the available area(s) onsite appropriate for a waste repository. Significant time and effort may be required to identify an area suitable for a waste repository and to negotiate with landowners for consent for EPA to design and build a repository at a given location. These factors may prevent onsite disposal from being implemented in a timely manner. For purposes of this example, it was determined that significant time and effort would be required to identify a suitable area for a waste repository and to negotiate consent agreements with landowners. For these reasons, onsite disposal of waste was determined not to be implementable from a technical or administrative standpoint at this example site and is not retained for further consideration.

Offsite disposal at a landfill is a protective option for disposing of wastes that pose an unacceptable risk to human health or the environment. Landfills may be RCRA Subtitle C facilities or sanitary landfills depending on the nature of the waste to be disposed. Offsite disposal is an effective, proven, and reliable option for reducing human contact with soils containing unsafe levels of arsenic and/or lead. Offsite disposal is readily implementable and is retained for further consideration when developing and screening remedial alternatives at this example site. Two primary treatment technologies were evaluated for potential use at the example site, including chemical treatment (soil amendment) and physical treatment (soil tilling). The process option considered for chemical treatment is the application of phosphate soil amendments. Phosphate stabilization is a procedure in which phosphate salts or acids are physically mixed into soil. This chemical additive can reduce the bioavailability of lead in soil below levels that are unsafe for human exposure. However, phosphate would not impact the bioavailability of arsenic or other metals in soil. Phosphate addition has the potential to increase the solubility of some metals, most notably arsenic, as discussed in the EPA's June 2015 *Phosphate Amendment Fact Sheet* (U.S. EPA 2015b). Phosphate stabilization is moderately effective and moderately implementable; however, there are challenges and situations where treatment may not be applicable (Kastury et al. 2023).

Another process option evaluated for physical treatment at the example site is soil tilling. Soil tilling involves the physical turning over and mixing of the soil column. Tilling the surficial 12 inches of the soil column may reduce surface concentrations of lead below risk-based cleanup levels. Soil tilling with revegetation is a viable stand-alone alternative when surficial soil concentrations are close to cleanup levels and concentrations of contaminants are much less deep in the soil column. However, soil tilling is not a viable option when contaminant concentrations are similar throughout the soil column or when very high concentrations exist within the depth interval to be tilled. Soil tilling is typically used in large areas such as agricultural fields where heavy equipment can maneuver easily. For small areas, soil tilling may be impractical to implement. Soil tilling overall is a moderately effective process option because it can be highly effective in certain cases, but ineffective in others. Due to the small size of properties within the study area, it may not be a viable option to retain or use in conjunction with other approaches.

Prior to cleanup of a residential property, access to the property should be obtained from the property owner, not just from tenants or renters. It is recommended that access be obtained by going door-to-door. If residents are not home, a blank access consent form with instructions for signature and submission to the EPA, along with relevant contact information, should be left at the residence and not in a mailbox. An example access consent form is presented in Appendix F. Consider, if possible, obtaining access for remediation at the time that access for sampling is being sought.

Prior to initiating cleanup activities, the condition of each property should be documented and recorded in a property inspection form. 'Cleanup activity' includes any disturbance of the property, including the removal of debris and dilapidated structures that may be required prior to initiating the excavation of contaminated soil. An example of a property inspection form is provided in Appendix L. EPA (or other agency or entity performing work) should memorialize in the consent form signed by the owner any special requests or considerations in cleaning up the yard. For example, during a response action, if EPA removes a concrete sidewalk to complete the response action and the homeowner would prefer a brick walkway as a special request, it may be possible to prepare the area for homeowner improvement rather than replace the walkway with another concrete walkway. In this example, EPA would not install the improved walkway, but would prepare the area such that the homeowner could replace the walkway with material of their choice. Additionally, the homeowner can work directly with the remedial contractor to facilitate the special requests and payment, as EPA would not accept payment for these improvements. All additional costs associated with special requests and considerations must be borne by the homeowner. Any contaminated yard areas that will not be addressed through the response, special resident concerns, and any deviations from strict soil excavation or capping should be noted in the consent form.

Temporary relocation of residents during yard soil remediation is rarely needed and is generally not recommended (U.S. EPA 1999b).[119]

The Health and Safety Plan (HASP) should describe safety issues for the remedial team during residential cleanup, including ingress and egress to the residential property. For example, access should be coordinated with the property owner/residents and spelled out in the site-specific HASP before remedial activity.[120]

Removal of contaminated soils is generally preferred, but a barrier may be considered for areas where cleanup is not feasible, to limit exposure. Incomplete barriers made from rock or gravel or minimal use areas such as areas under porches should be cleaned up to the extent practical. For example, for areas underneath porches, a shotcrete barrier may be used in some cases (sprayed concrete that can easily be placed in tight or confined areas). It may be preferable to place a more complete barrier such as asphalt on heavily trafficked roads or driveways, especially those that experience severe erosion, rather than gravel.

In most cases, every attempt should be made to clean up contaminated areas of the entire yard (as well as qualifying areas within 100 feet of the property as appropriate); however, any residential property areas without permanent barriers that the resident requests to leave unremediated, such as gardens or patios, should be sampled separately to determine if a response action is needed. If the cleanup level is exceeded and the owner refuses to allow

[119] Guidance is available online at: https://www.epa.gov/superfund/superfund-relocation-information.
[120] See https://response.epa.gov/main/healthsafety.aspx.

cleanup of that portion of the yard, then the cleanup documentation letter issued to the owner should note the unremediated area and also describe any ICs consistent with the decision document(s).

9.6 Other Cleanup Considerations

The CSM should define the exposure area for a young child, and the area remediated on a single residential property generally should not exceed the 1-acre area around the residence. Remediation should prioritize risk and exposure over lot lines and land ownership.

The recommendation for cleanup of a residential property that exceeds 1 acre is to excavate or cap the portion of the yard that is in frequent use and continue to limit exposure in the unremediated portion of the yard. To this end, it may be appropriate to address the yard such that it is fenced to clearly delineate the remediated and unremediated areas and to limit the potential for offsite tracking of contaminants by humans (*e.g.*, tracking contaminated soil from the unremediated area to the remediated area of the yard). Exceptions to this general approach may include areas outside the 1-acre remediated area that are used for recreation and gardening, high incidence child use areas, areas with the potential for residential development, and residential areas outside but near the 1-acre remediated area.

If contaminated soil is not removed to the full depth of contamination on a property, a permanent barrier/marker that is permeable, visible, and not prone to frost heave should be placed to separate the clean fill from the contamination. This applies to both incomplete vertical excavation with placement of a soil cover and placement of a soil cover without excavating contaminated soil. Selection of an appropriate permanent barrier/marker should be based on the type of contamination left in place, the chemical/physical characteristics of the soil (*e.g.*, pH), the potential for upward migration of the contamination, and/or the types of ICs developed for the site. Examples of suitable barriers/markers include snow fencing (usually orange), a clean, crushed limestone layer, or geotextile fabric.

Empty lots that are zoned residential and contain soils with lead concentrations greater than the cleanup level should be cleaned up when nearby residential lots are remediated because exposure to soil and soil-dust occurs beyond individual lots. Also, unpaved parking areas should be sampled and cleaned up if necessary, or access restrictions put in place, to prevent recontamination (*e.g.*, vehicle tracking of contaminants) even if no current direct exposure exists. The selected remedy needs to be protective for reasonably anticipated future uses although the timing of the response may prioritize specific areas depending on current land use.

While some research to date suggests that treatment of soil may be used to reduce the bioavailability of lead, additional research (Sowers et al. 2022, 2021, Scheckel et al. 2005, Cao et al. 2003) continues to evaluate the long-term effectiveness of the methods. Treatment technologies that have been preliminarily investigated include amending the soil with potassium-jarosite, phosphate compounds (*e.g.*, apatite [calcium phosphate], fish bones), biochar, or compost. If regions are considering these technologies, they should work with the TRW Bioavailability Committee and their STL to perform a site-specific treatability study.

EPA has generally not selected phytoremediation or plant-based covering methods such as phytostabilization, mulching, seeding, and sodding as elements of remedial actions at lead sites. While these approaches may provide short-term protectiveness as part of an interim response action to prevent near-term exposure, minimize contaminated soil transport, and help restore properties to their original condition, they generally rank low on permanence or long-term effectiveness. The following factors related to phytoremediation should be considered in a nine-criteria analysis (the detailed analysis of the alternatives identified in the screening stage): (1) the lead concentrations may not be within the optimal performance range for the plants; (2) the plants may concentrate lower level lead contamination and present an increased disposal cost if the plants fail the toxicity characteristic leaching procedure (TCLP) test (they would then need to be disposed of as a RCRA hazardous waste); (3) the length of time required for meeting cleanup goals; (4) local regulations regarding yard maintenance; and (5) the depth of contaminated soils.

9.6.1 Background Lead Concentrations

Some of the sites on the NPL are in areas with relatively high anthropogenic or natural background lead concentrations that may exceed PRGs. Unacceptable lead levels from the release may be exacerbated by the presence of high background concentrations of lead in various media (such as soil and groundwater) from anthropogenic sources. CERCLA 104 (a)(3)(B) generally limits the Agency from taking response actions to address a "... naturally occurring substance in its unaltered form, or altered solely through naturally occurring processes or phenomena, from a location where it is naturally found" (U.S. EPA 2000a). CERCLA cleanup levels generally are not below natural or anthropogenic background concentrations (U.S. EPA 2018b, 2002a, 2002c, 1997b, 1996b).

Public education about widespread risks should be started early in the process to help the community understand that Superfund actions are designed to address risks from site-specific releases to the environment (U.S. EPA 2002a). In situations where the risk is due solely to natural and anthropogenic background, it is important to inform the public of the risk and any limitations under CERCLA to address that risk. Both remedial and removal site teams should coordinate with health districts, state departments of environmental protection, housing agencies, and private parties to identify other programs or regulations that may have the authority and capability of addressing risks associated with high natural or anthropogenic background (see Section 3.2; U.S. EPA 2002a). Additional guidance is available for developing a risk management-based response strategy that is protective of human health and the environment (U.S. EPA 1988a).

9.6.2 Prevention of Recontamination

RPMs and OSCs should take steps to mitigate recontamination. During site closeout and five-year reviews (FYRs), the project manager may also sample for recontamination to determine whether any recontamination presents an unacceptable risk.

At large sites, cleanup occurs over a long period of time and through multiple phases, throughout which the potential for recontamination exists. During each of these phases, windblown dust sources, vehicle tracking, and flooding can cause recontamination. Initially, cleanup may prioritize the properties with the greatest risk, which could be scattered, before addressing adjacent properties systematically. In addition to dust monitoring, dust control, vehicle washing, and other mitigation, confirmation samples should be collected to identify potential recontamination.

Flooding can pose a serious problem for these areas in that flood waters can erode clean materials, exposing subsurface contamination, and entrained sediments bearing contamination may be left on top of newly remediated properties.

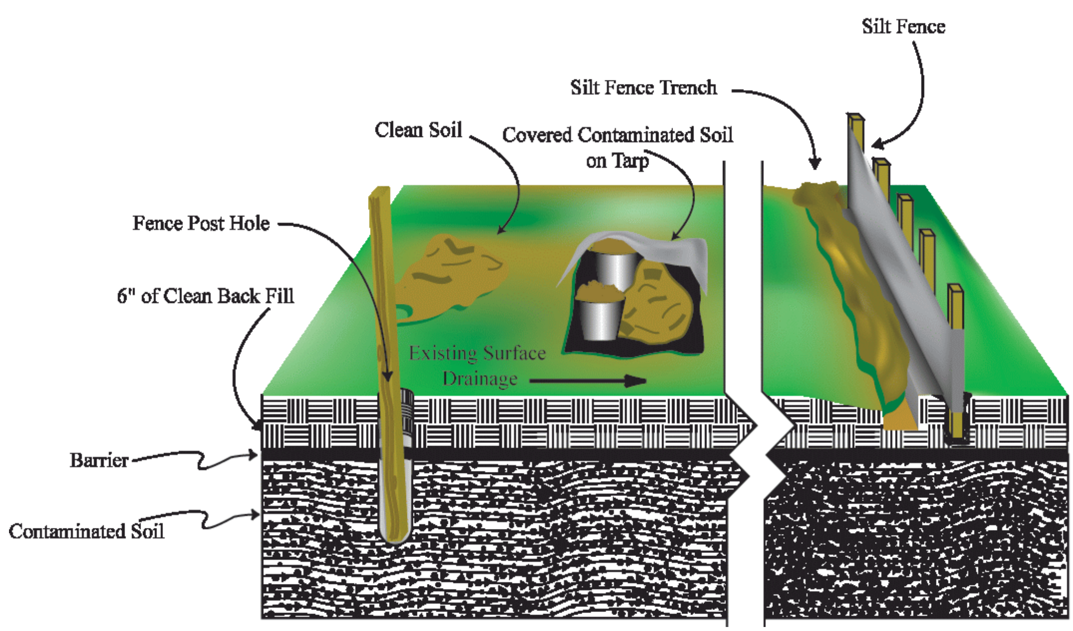
Inadequate drainage can recontaminate previously cleaned areas (*e.g.*, lead particles on a crowned road with no curb and gutter may be rinsed onto adjacent residential properties with normal rainfall). Burrowing animals can bring contaminated soils to the surface.

> Best Management Practices (BMPs) – In general, BMPs are a combination of practices that are determined to be the most effective and practicable means of controlling point and nonpoint pollutants at levels compatible with environmental quality goals.

An Institutional Control Implementation and Assurance Plan (ICIAP) should have procedures in place that can help prevent residents from breaching visual subsurface barriers when installing fence posts, planting a new tree or shrub, or conducting other activities that threaten the integrity of the remedy (see Chapter 10 for more information on ICs). Education and licensing of contractors who work on areas with clean soil cover/visual subsurface barriers should generally be required (*e.g.*, as part of a local ordinance) to ensure the longevity of the remedy. Also, at many sites (*e.g.*, Bunker Hill Superfund Site), ICs have been most effective when linked to the *call before you dig* program typically operated by many counties to avoid disruption of utility service (see, *e.g.*, Panhandle Health District's Institutional Controls Program,[121] which also includes free haul-away of contaminated soil and free replacement clean fill, HEPA vacuum loans, and other services to protect people).

Large-scale residential development projects (*e.g.*, that may raze old housing and replace it with new residential housing) may recontaminate areas by moving lead-contaminated soil that was left at depth, without appropriate BMPs in place. BMPs include silt fences (and other barriers) to limit movement of contamination off a project site and stockpiling of contaminated soil on a tarp to prevent contamination of underlying soil (Figure 9-6). EPA provides guidance on the implementation of BMPs in construction activities at sites where contamination is present (U.S. EPA 1997c) and it has been shown that BMPs typically add about 5% to project cost (TerraGraphics 2000). Periodic inspections of residential areas should be performed by the local government to ensure that projects within the site are conducted in accordance with BMPs.

Figure 9-6. Implementing a Clean Soil Cover During Construction Work



The BMPs shown in the above figure represent one component of the ICs that may be put in place by local ordinance to ensure the long-term protectiveness of the remedy and to prevent recontamination. The staging of contaminated soil on tarps and/or in small buckets, and the installation of silt fences downgradient of the construction area are examples of BMPs intended to prevent the migration of contaminated material from the construction site.

[121] https://panhandlehealthdistrict.org/institutional-controls-program/.

Windblown dust can pose a significant threat to the health of individuals at a site and can cause recontamination. Tailings impoundments that have dried can be large sources of windblown lead dust with potential to recontaminate residential properties downwind. Windblown dust should be addressed to minimize recontamination.

Although mechanisms vary from site to site, the types of response actions put in place and the sequence in which these actions take place can play a significant role in enhancing the permanence and effectiveness of a remedy.

An engineered soil repository may be needed because municipal landfills may not accept contaminated soil. Without free or low-cost disposal for contaminated soil available to each homeowner or renter, improper disposal is more likely, which could result in recontamination. In addition, a disposal area may be needed if certain materials at a site fail TCLP and cannot be commingled with solid waste.

In some cases, the property owner may not provide access to allow sampling or respond to contaminated soil. In these cases, changes in property ownership over time should be monitored and new landowners should be contacted. Local implementation helps ensure that cleanup of these properties occurs as soon as possible, further ensuring the protectiveness of the remedy by minimizing the potential for recontamination to the extent possible.

9.6.2.1 Long-term Remedial Actions

Some or all of the following measures may be useful to address the risk of recontamination during the remedial action and post-design phase:

- Evaluate the permanence and effectiveness of the various remedial actions under consideration. Consider the economic feasibility of complete contaminated soil removal to minimize reliance on ICs.
- Conduct a cost analysis comparing the cost of long-term ICs to those of complete removal (U.S. EPA 2000d).
- Remedial action should strive to remediate the contamination in the community. This decision is, in part, made based on input from the community (community acceptance is one of the nine criteria in the NCP). Each segregable area should be cleaned up as quickly as possible (*e.g.*, within one construction season) to minimize recontamination of cleaned properties and to compound the protection to human health (U.S. EPA 2000a,d).

- Fugitive dust and access to contaminated sources should be controlled. Air monitoring along with depositional modeling may be necessary to determine if windblown dust presents a significant threat of recontamination. Significant sources of windblown dust should be controlled prior to or simultaneously with cleanup of adjacent residential areas. Readers may consider HEPA street sweeping during remediation and immediately following completion of cleanup to minimize tracking of contaminants throughout a community.

- Complete removal of contaminants should be considered in flood prone areas or areas with a high groundwater level due to the inherent difficulty in maintaining a soil cover remedy in these areas. Drainage-ways containing contamination within the floodplain that are not addressed in the remedy could also lead to remedy failure if the contaminants are eroded to other areas.

- Remediation of contaminated rights-of-way should occur within segregable areas simultaneously, if possible, or as close together in time as possible to minimize vehicle tracking and recontamination of driveways from the rights-of-way.

- Infrastructure improvements should also be considered, as appropriate. At the Bunker Hill Superfund Site, EPA has funded street paving, drainage improvements, and other infrastructure needed to protect the remedy.[122]

- Control measures for all remaining sources, such as mining waste piles surrounding the community, should be developed to ensure that the remediated neighborhoods are kept clean. ECs and ICs should be established to ensure the control, or proper use and disposal, of any wastes remaining on site.

- If the residential remedy includes replacement of soils, removal or encapsulation of deteriorating exterior LBP (*e.g.*, by pressure washing, or painting) could be considered to minimize the soil recontamination potential.

- Other sources of residential property recontamination should also be considered. For example, homeowners may unknowingly bring in contaminated soil for fill or other uses on their property.

- Unless all contaminant levels meet risk reduction goals, some level of ICs will be necessary to help effectuate a protective remedy.

[122] See https://semspub.epa.gov/work/10/100363132.pdf.

CHAPTER 10
Institutional Controls and Reuse

10.1 Institutional Controls (ICs)

This chapter lays out considerations for RPMs/OSCs to evaluate before using ECs and ICs when addressing lead contaminated residential soils. ECs are considered engineered or physical barriers that are built or installed to separate people from chemical, biological, or physical hazards, including barriers such as landfill caps, asphalt and concrete driveways and sidewalks, fences, or security guards. EPA defines ICs as administrative and/or legal controls that help to minimize the potential for exposure to contamination and/or protect the integrity of a response action. ICs typically are designed to work by limiting land/or resource use or by providing information that helps modify or guide human behavior at a site. ICs can be implemented on a site at any time, including: (1) when contamination is first discovered (*i.e.*, prohibition of excavation of newly discovered soil contamination); (2) when the remedy is ongoing (*i.e.*, restrictions on property use until cleanup levels are met); and (3) when hazardous substances, pollutants, or contaminants remain at the site above levels that allow for UU/UE. For remedial actions, ICs should be periodically inspected by the party responsible for maintaining them to ensure that they are operating as planned. For removal actions, post-removal site controls should be in place prior to the completion of a cleanup and coordinated with local, state, or tribal authorities where prudent and warranted.

As described in earlier chapters, residual lead contamination is common for many lead sites after response actions. Site managers and site attorneys should consider whether the remedy would achieve UU/UE as one of the factors in deciding when an IC is appropriate at a site. UU/UE generally is the level of cleanup at which all exposure pathways present an acceptable level of risk for all media uses. It is EPA's policy that if a CERCLA response action cannot support UU/UE (U.S. EPA 2000d), ICs are generally required. The UU/UE threshold is a site-specific determination. Note that the term "residential" is often used interchangeably with UU/UE but these are not synonymous terms. For example, a lead cleanup where the top layer of soil has been removed and replaced can support residential use at a site that includes restrictions on use below the top layer (*e.g.*, restrictions on digging, requirements for elevated gardens, an information/outreach program, etc.).

ICs are also used to protect the integrity of a remedy. In the lead cleanup context, this may mean using ICs to prevent penetration of a cap or damage to monitoring equipment. An important consideration in this context is what type of IC will provide the required remedy protection. For example, the primary concern for protecting a remedy in a lead cleanup scenario is typically uncontrolled excavation. For this reason, it is important to include ICs that will be relevant to excavators. Examples of potentially effective ICs are deed restrictions, zoning ordinances, local digging or drilling permits, and “Dig Safe,” “One-Call,” or “Miss Utility” systems.

Where contamination is not fully removed and the cleanup does not achieve UU/UE, O&M and/or Post Removal Site Control (PRSC) may be required by the appropriate party in perpetuity to maintain the effectiveness of the remedy. O&M or PRSC may include activities such as periodic inspections to ensure that soil cover and any barrier/marker remains in place, contaminated soil has not been disturbed, and an evaluation of whether ICs are effective. The required activities should be determined site-specifically and would normally be outlined in an O&M plan or similar document. For additional information on O&M and other post-construction activities in the remedial program, see the *Guidance for the Management of Superfund Remedies in Post Construction* (U.S. EPA 2017e). For more information on PRSC, see the *Policy on Management of Post-Removal Site Control* (U.S. EPA 1990c).

10.2 Types of Institutional Controls

In general, there are four types of ICs commonly used in cleanups: proprietary controls, governmental controls, enforcement and permit tools with IC components, and informational devices. The following definitions are summarized from the current EPA guidance *Institutional Controls: A Guide for Planning, Implementing, Maintaining, and Enforcing Institutional Controls at Contaminated Sites* (PIME Guidance) (U.S. EPA 2012a).

Proprietary controls are land use controls that tend to affect a single parcel of property and are established by a private agreement between the property owner and a second party who, in turn, can enforce the controls. Common examples include easements that restrict use (also known as negative easements) and/or that provide access rights to a property to perform work and restrictive covenants. These types of controls can prohibit activities that may compromise the effectiveness of the response action or restrict activities or future resource use that may result in unacceptable risk to human health or the environment. State and tribal laws typically authorize proprietary controls. In some cases, the authority comes solely from common law. Some states have enacted statutes that directly authorize these types of controls for the purposes of preventing use in conflict with environmental contamination or remedies. These statutes tend to divide into ones modeled after the Uniform Environmental Covenants Act (UECA) and other non-UECA statutes. These UECA and non-UECA state statutes can provide advantages over traditional common law proprietary controls.

A proprietary control may be used to restrict certain activities on the property, such as excavating below a certain depth. These are powerful tools in that they can be made to "run-with-the-land" (*i.e.*, effective if ownership changes), but they may provide significant challenges because property interests are often transferred. As such, they should be acquired consistent with state and local rules and procedures that cover acquisitions of real property. Accordingly, selecting the grantee of the proprietary control property interest normally marks an important step in proprietary control acquisition and later implementation. While the grantee can range among various parties, EPA can act as the grantee at Fund-lead sites. In these cases, the United States must acquire the proprietary control property interest and, in turn, rules governing United States real property acquisition, as well as CERCLA rules relating to property acquisition, apply. EPA's authority to acquire interests in property is found in CERCLA Section 104(j). Among other requirements, CERCLA Section 104(j) specifies that prior to acquiring an interest in real property, the state must provide an assurance that it will accept transfer of that interest at completion of the remedial action (see U.S. EPA 2012a, PIME Guidance).

Governmental controls are usually implemented and enforced by a state, tribal, or local government. Some of the more common examples include zoning restrictions, building/ excavation permits, groundwater drilling and use permits, ordinances, fishing bans, sports/ recreational fishing limits, or other provisions that restrict land or resource use at a site. These types of mechanisms are popular in remedies because the administrative processes are in place and are typically well understood within a particular jurisdiction. This type of control is often implemented, monitored, and enforced by an agency other than EPA or the state.

Enforcement tools with IC components are legal tools, such as administrative orders, federal facility agreements, and Consent Decrees (CDs) that limit certain site activities or require the performance of specific activities (*e.g.*, monitor and report on IC effectiveness). Under CERCLA Sections 104, 106(a), 107, and 122, such legal tools include unilateral administrative orders (UAOs) and administrative

> Unilateral Administrative Order (UAO) – A UAO is an enforcement instrument that EPA can use to require parties to take a response action, provide access, or request information. If settlement negotiations fail, EPA has the authority to compel the PRP to do the cleanup by issuing a UAO. Administrative orders are issued under CERCLA Sections 104 and 106.

settlement agreements and orders on consent (ASAOCs), which can be issued or negotiated to compel the landowner to limit certain site activities at both federal and private sites. When EPA negotiates with a PRP to do cleanup work at a Superfund site, the agreement may be documented in an ASAOC. If the negotiations fail, EPA has the authority to compel the PRP to do the cleanup by issuing a UAO. In addition, CERCLA Section 122(d) authorizes the use of CDs at privately-owned sites. ICs incorporated into enforcement devices are some of the more common ICs. The strength of these types of tools is that EPA or states can directly enforce them (rather than relying on a local agency for governmental controls or using real estate common law for proprietary controls). However, since these enforcement tools only bind the parties named in the enforcement document, it may be necessary to require the parties to implement additional ICs such as proprietary controls that "run with the land" (*i.e.*, applied to the property itself) in order to bind subsequent land owners.

Informational devices are types of devices that only provide information or notification such as recorded notice in property records or advisories to local communities, tourists, recreational users, or other interested persons that residual contamination remains on site. These types of tools are common at lead cleanups to provide both notification of residual contamination and information that may modify behavior to minimize the potential for unacceptable exposure. Examples include placing a property on a state contaminated properties registry, developing deed notices, and providing periodic lead-education advisories to residents. Due to the nature of informational devices and their non-enforceability, it is important to carefully consider the objective of this category of ICs. Informational devices are most likely to be used as a secondary "layer" to help ensure the overall reliability of other ICs.

There is generally an inverse relationship between the amount of cleanup and the degree of reliance on ICs (*i.e.*, the more soil that is removed from the site, the less reliance there would have to be on implementing ICs). Moreover, the greater the reliance on ICs, the greater the expectation that enforceable ICs be employed to provide for a protective remedy. EPA tends to focus on multiple considerations when evaluating the long-term viability and amount of redundancy required for ICs at a site.

EPA guidance strongly advocates the use of ICs in "layers" and/or in "series" (U.S. EPA 2012a, 2000e). Layering ICs means using multiple ICs concurrently (*e.g.*, a CD, deed notice, educational/informational device and a covenant). Using ICs in series is appropriate when IC mechanisms are removed or changed as site circumstances evolve, such as reduction in restrictions during the clean up lifecycle. As illustrated in the descriptions of the different categories of ICs, there are inherent strengths and weaknesses with each type. The goal is to obtain the best mixture of ICs to manage the risk at a site over the long-term.

There are many important factors to consider when determining what types of ICs are most appropriate at a site. The following is not intended to be a comprehensive list, but rather illustrative of the site-specific nature of these types of decisions. A few common considerations include: (1) the type of enforcement mechanism used (*e.g.,* CD, order, permit, ordinance); (2) who will enforce the mechanism (*i.e.*, EPA, the state, local agency, third party, etc.); (3) who the intended IC will effect and how; (4) the level of sophistication of the party implementing the cleanup and those remaining on the property; (5) the expected property use (likelihood of redevelopment and/or resale); and (6) the degree of cooperation exhibited by the parties regarding the cleanup. Since ICs can impact future development at sites, it is important to work cooperatively to determine the appropriate mix of ICs. The objective is not to use as many layers of ICs as possible, but rather to strike a balance that ensures that the site remedy will be protective over time while maximizing the site's future beneficial use. An ICIAP may be particularly helpful at a site where multiple ICs are used either in layers or in series to clearly document all IC activities and the entities responsible for implementation, maintenance and enforcement of the ICs.[123]

For larger lead sites, GIS systems have often been used to track the cleanup status of properties located at the site. The GIS tracking system facilitates the monitoring of ICs and the maintenance of the remedy. While EPA has used GIS systems to track some site activity, more extensive GIS systems are operated by local governments, state governments, and PRPs.

Finally, should contaminant levels drop to levels that no longer warrant ICs, then modification and/or termination of the ICs should be considered. Because lead does not naturally degrade as many anthropogenic compounds do, residual lead waste that is left in place will likely remain in place.

10.3 Reuse

Examples of sites that have been successfully reused have employed many combinations of remedial actions, including complete soil removal to soil removal of a top layer of contamination that is covered by a barrier to show the separation of clean and contaminated soils, to capping contaminated soils with asphalt and or concrete to support structures. In

[123] Additional information can be found at: https://www.epa.gov/sites/default/files/documents/final_pime_guidance_december_2012.pdf and https://www.epa.gov/sites/default/files/documents/iciap_guidance_final_-_12.04.2012.pdf.

selecting remedies, both reuse and the challenges of maintaining ICs and ECs should be considered.

In addition to achieving protectiveness, one of the Superfund program's goals is to return contaminated sites to beneficial reuse. Returning formerly contaminated sites to safe reuse not only supports a safe environment, it can also support the community through economic development, contribute to the tax base, and potentially provide services that community members seek.

Site reuse planning and consideration of future land use go together in planning effective remedies. Site reuse planning engages interested stakeholders to help EPA identify the reasonably anticipated future use for the property and ensure that the intended land use will be appropriate for the remedy selected. The redevelopment and reuse of sites can also help remedial and removal actions remain protective over the long-term. Moreover, should there be any residual contamination, having reliable information about the likely future use of the property is typically helpful in ensuring that ICs and ECs will be effectively monitored and maintained. This is especially important for lead sites because residual contamination with ICs is not unusual. Please see the guidance titled: *Land Use in the CERCLA Remedy Selection Process* (OSWER Directive 9355.7-04, [U.S. EPA 1995a]).[124]

The Superfund Redevelopment Program (SRP) is EPA's national reuse resource for Superfund sites. Since its inception, SRP has developed tools and resources to address evolving community priorities and tackle new Superfund redevelopment challenges. These tools help engage communities in dialogue relating to reuse that informs the cleanup process, addresses barriers to reuse that impact protectiveness, and communicates best practices and lessons learned. Additional information can be found at https://www.epa.gov/superfund-redevelopment.

10.3.1 Reuse Tools Available for Communities Affected by Residential Lead Contamination

The needs of communities are unique from place to place with different communities needing different support. Through the SRP, EPA's Superfund program offers many tools that support current and future use of sites. The full suite of tools is available on the SRP website at https://www.epa.gov/superfund-redevelopment.

The reuse assessment, planning, and gathering of information for the anticipated future use of a site during the remedy selection process allows for the integration of community input goals,

[124] https://www.epa.gov/sites/production/files/documents/landuse.pdf.

land use context, and guides local planning, development, and the remedial process. Understanding the future land use plays important roles in the baseline risk assessment, remedy selection, and remedy design, as well as the phasing of cleanup. Reuse planning can ensure that any new use of the site is consistent with the cleanup remedy, particularly if remedy components remain in place at the site. Reuse planning at this phase can also assist in avoiding unnecessary barriers to reuse.

Examples of how reuse planning could be used related to residential lead cleanup include, but are not limited to:

(1) Engaging in a stakeholder process to understand how residents use their properties, how EPA may need to take steps to ensure their protectiveness, and coming up with a strategy for relaying that information in a reliable and effective manner.

(2) Developing a plan for returning yards to residents after cleanup in a thoughtful manner.

(3) Discussing the likely future use of the former facility that impacted the residential properties in a way that benefits the overall community, taking into account the plans of the owner and the municipality.

(4) Exploring the possibility of future residential use on land contaminated with lead, taking into account the plans of the owner and the municipality.

Superfund Redevelopment Coordinators are assigned in each Region to help determine appropriate regional reuse projects. Their contact information can be found at the SRP web address referenced above.

10.3.2 Residential Use Support

SRP tracks examples of sites in ongoing or new residential use and has provided support to several communities. The following example demonstrates how EPA can help, although the needs of each site and community are different. While there a number of examples of site reuse on the SRP website, the Midvale Slag site below serves as an example lead site that has been part of the SRP program.

Supporting New Residential Development on Lead-Impacted Soils: Midvale Slag – Region 8

From 1871 to 1958, five smelters processed lead and copper ore at the Midvale Slag site, as well as at the adjacent Sharon Steel site. EPA worked together with state agencies, the City of Midvale, local community members, and the site's owner to link the site's cleanup and redevelopment with a cleanup plan and revitalization goals. The SRP worked with the Region to help make this transformation possible, awarding a Pilot grant in 1999 and providing a Ready for Reuse determination in 2008. This led to the groundbreaking creation of the Bingham Junction Reuse Assessment and Master Plan in 2000. Today, the site is home to Bingham Junction, a thriving mixed-use development supporting thousands of jobs. As of 2019, the reported assessed value is about $800 million, which is up from about $4 million in 2004. Builders have completed over 2,300 residential units on the site property. Other case studies are available at https://www.epa.gov/superfund-redevelopment/find-superfund-sites-reuse.

CHAPTER 11
Five-Year Reviews for Superfund Sites

Section 121 of CERCLA, as amended by the 1986 SARA, requires that remedial actions at sites that result in any hazardous substances, pollutants, or contaminants remaining at the site be subject to an FYR. The NCP requires that remedial actions that result in any hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for UU/UE be reviewed no less often than every 5 years to ensure protection of human health and the environment. Consistent with Executive Order (EO) 12580, other federal agencies are responsible for ensuring that FYRs are conducted at federal facility sites where required or appropriate.

The purpose of the FYR is to evaluate the implementation and performance of a remedy to determine if the remedy is, or will be, protective of human health and the environment. *The Comprehensive Five-Year Review Guidance*, OSWER Directive 9355.7-03B-P, dated June 2001, contains further guidance on FYRs and is intended to promote consistent implementation of the FYR process (U.S. EPA 2001d).

The FYR process integrates information taken from decision documents, remedy implementation, operational data, site inspections, and community input to assess the remedy's performance, and ultimately, to determine the protectiveness of that remedy. The FYR will identify RAOs and remedy components selected in decision document(s), including lead cleanup levels for residential lead sites. The technical assessment of an FYR examines three questions to determine the protectiveness of the remedy:

- Question A: Is the remedy functioning as intended by the decision documents?
- Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid?
- Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

When answering Question A, the focus is the technical performance of the remedy and may include a review of implementation status to date, sampling data, O&M activities and ICs required by the decision documents (*i.e.*, RODs, Amended RODs, Explanations of Significant Differences [ESDs], and Action memos). At large lead sites, remedy protectiveness issues may relate to the implementation and management of ICs and recontamination of areas previously remediated.

In answering Question B, the lead agency should review the risk parameters on which the original remedy decision was based. The assessment should test the validity of all assumptions that underlie the original risk calculation. A re-evaluation of lead risk may be initiated at the time an FYR is performed. If there have been any changes to cleanup levels, risk assessment methodologies, toxicity information, exposure assumptions used, or a change in land use at the time of the ROD, then an evaluation of these factors and response actions at the site may need to be completed. This evaluation will determine whether the changes impact the protectiveness of the selected remedy and identify issues and recommendations for additional investigation, evaluation, and/or actions needed to address any impacts to protectiveness. These issues and recommendations may involve additional site investigation and characterization of lead in soil (see Chapter 6 for a discussion of site characterization), additional remedy selection and/or decision document amendments to document any changes, additional response actions, or other actions to address any impacts to remedy protectiveness.

An assessment of the data available at the time of the FYR may determine if the residual risk at the site for impacted populations meets, or is progressing towards, RAOs for the site. Available data may include, but are not limited to, any data collected during remedial investigation, remedy implementation data including post-excavation sampling data, and data related to backfill concentrations. In addition to the remedy investigation and implementation data identified, if there are blood lead concentration data from the community, that information may be reviewed at the time of the FYR. If the data collected show that there are exceedances of blood lead guideline criteria, then further evaluation may need to be performed to determine if lead contamination from site soil is a contributor (see Chapter 8 for a discussion of lead risk assessment) or if additional investigation is needed if the cause is unknown.

To answer Question C, the lead agency should determine if new information is available at the time of the FYR that was not already identified in Questions A or B. This may include impacts such as those from changes in land use, natural disasters, or site changes or vulnerabilities that may be related to climate change impacts not apparent during remedy selection, remedy implementation, or O&M (*e.g.*, changes in precipitation, increasing risk of floods, changes in temperature, etc.) (U.S. EPA 2016).

After examining the information available at the time of the FYR in the technical assessment, the lead agency determines the protectiveness of the remedy, or remedies, and documents the rationale for this determination in the report. The conclusion of the FYR may also include an identification of issues that affect protectiveness and recommendations or follow-up actions needed to address them.

Additional resources can be found online:

- Five-Year Review of Federal Facilities Cleanups webpage (https://www.epa.gov/fedfac/five-year-review-federal-facility-cleanups)
- Comprehensive Five-Year Review Guidance webpage (http://www.epa.gov/superfund/superfund-five-year-reviews)
- Comprehensive Five-Year Review Guidance (http://semspub.epa.gov/src/document/11/128607)
- 2011 Program Priorities (https://www.epa.gov/sites/default/files/documents/program_priorities_federal_facility_five-year_review.pdf)
- Corrections to the 2011 Memo (https://www.epa.gov/sites/default/files/documents/correction_program_priorities_federal_facility_five-year_review.pdf) (U.S. EPA 2018c)
- 2016 FYR Recommended Template (https://www.epa.gov/sites/default/files/2016-01/final_five_year_review_recommended_template_1.20.2016.docx)
- Superfund Today: Focus on Five-Year Reviews and Involving the Community (https://semspub.epa.gov/work/HQ/175190.pdf) and the Community Involvement toolkit: Five Year Review Tool (https://semspub.epa.gov/work/HQ/100001744.pdf)

CHAPTER 12
Federal Facilities

Multiple federal statutes and regulations establish requirements for EPA and other federal agencies to protect human health and the environment through cleanups at federal facilities, including CERCLA, which was amended by SARA in 1986; the NCP; the National Defense Authorization Act (NDAA) amendments; various Base Realignment and Closure (BRAC) Acts; and RCRA. With certain exceptions specified in CERCLA Section 120(a), each federal agency shall be subject to CERCLA to the same extent as a private entity, including liability. Federal agencies shall comply with all guidelines, rules, regulations, and criteria related to removal and remedial actions and shall not adopt guidelines inconsistent with those established by the EPA Administrator.

While existing policy, guidance, and directives on lead contamination are applicable at federal facilities, property transfer issues may present unique requirements. Beginning in 1995, EPA and the U.S. Department of Defense (DOD) began to address policy differences on the cleanup levels for lead in soils from LBP. In March 1999, DOD and EPA formalized the *Principles Memorandum* (DOD/EPA 1999), an agreement on the management of LBP at residential and nonresidential areas at BRAC properties. The *Principles Memorandum* stated that for existing residential areas located on BRAC sites, Residential Lead-Based Paint Hazard Reduction Act of 1992 (also known as Title X[125]) procedures provide an efficient, effective, and legally adequate framework for addressing LBP in residential areas, and that as a matter of policy, CERCLA/RCRA would apply in limited circumstances. For residential areas that were being transferred, EPA and DOD agreed that the Title X regulations would apply. Residential real property is defined by Title X as real property on which there is situated one or more residential dwellings used or occupied, in whole or in part, as the home or residence of one or more persons. It is important to note that Title X defines residential property differently than the Handbook.

For federal property transfers subject to CERCLA where there is a concern about lead contamination to soils from LBP, EPA Regions, where they are involved, will need to decide whether the property meets the requirements of CERCLA Section 120(h)(3). This section of CERCLA outlines deed requirements for transferring federally owned property listed on the NPL and requires covenants indicating that all remedial actions necessary to protect human health and the environment have been taken prior to the date of transfer with respect to any hazardous substances remaining on the property, and that any additional remedial action found

[125] https://www.epa.gov/lead/residential-lead-based-paint-hazard-reduction-act-1992-title-x.

to be necessary after the date of transfer shall be conducted by the United States. Federal property contaminated with lead from LBP should be evaluated based on the property's use, or its intended reuse, before the property has been sold or transferred to a nonfederal or private entity. Generally, EPA concurrence or nonconcurrence with a Finding of Suitability to Transfer (FOST) or Early Transfer (FOSET) is documented and included in the public or administrative record.

LBP is generally considered to be the predominant source of lead in residential soil on federal facilities but it is not the only source. When evaluating potential exposure, it is important to develop a CSM to determine if the lead is a result of paint, industrial processes, already contaminated soil from another location on base (*i.e*., shooting range, etc.), or another scenario.

As science evolves or as EPA policy and/or guidance is updated, it may be appropriate for the federal facility, along with EPA or the state regulatory agency, to reassess sites with lead contamination previously assigned a "No Further Remedial Action Planned" (NFRAP) as part of a CERCLA remedial or removal action at the site for protectiveness and potential need for additional CERCLA response actions or RCRA corrective actions for locations with residential land use. Other federal agencies serving as the lead for these facilities should discuss prioritizing reassessment and other actions with its regulators.

CHAPTER 13
Cleanup Documentation

Upon confirmation that initial yard sampling indicates that a given residential property does not exceed the lead cleanup level for the site, or upon the completion of the cleanup of a residential property, a letter ("clean" letter) should be sent to the property owner documenting that EPA considers the lead level in the yard to be below the level of human health concern. Prior to issuing a "clean" letter, a property closeout form should be signed by the property owner documenting that the owner is satisfied with the remediation of the property. Examples of property closeout forms are in Appendix M. Any areas that are not cleaned up per the owner's request, such as gardens, should be noted in the "clean" letter. If contamination is not cleaned up to depth, this fact, along with protections (*i.e.*, barriers/markers) that are put in place, should be stated in the "clean" letter. The "clean" letter provides official documentation to the property owner for use in future property sales or transactions. Sample "clean" letters are provided in Appendix N.

13.1 Backfill and Waste Soil Sampling

Backfill soil used as part of the response action to fill in excavated areas should be consistent with the respective state's technical requirements for site remediation, and should be sampled to ensure that material being placed on the site does not pose an unacceptable human exposure to lead or any other potential contaminant(s). The list of analytes and the frequency of sampling backfill soil should be based on site-specific factors, including the location of the source of the backfill material relative to potential sources of contamination and the geochemistry of the borrow areas and the heterogeneity of the material, and any ARARs, such as state sampling or residential use criteria. Site-specific cleanup levels and regionally applicable background concentrations should be considered in defining acceptable levels of lead and any other potential contaminant(s) in the backfill source. The sampling program, chemical analyses, and statistical analysis program for establishing the acceptability of candidate fill sources should be consistent with the program described in Section 6.2.1 and should consider the heterogeneity of the material and the geology of the borrow area. In some urban areas, fill may be blended from multiple borrow areas and could change during the course of cleanup. Additionally, these operations generally do not have much space and/or have such high demand that a pile of backfill sampled one week could be gone by the time analytical results are received and therefore not truly be representative of what will be shipped. In short, there are many factors that need to be considered for backfill in many suburban and urban areas.

For early cleanups (removals or early action remedial actions), when site-specific characterization information may be incomplete, 50 ppm lead in backfill serves as a preliminary recommendation to reduce the risk from lead exposure. This reduces the risk of using backfill above the potential final cleanup level, which could result in the need to re-remediate backfill soils that are above final cleanup levels. Acceptable backfill concentrations can be revaluated once the RSL and characterization are completed and there is confidence in what the final cleanup concentrations will be.

For final remedial actions, Regions can elect to use this recommendation (50 ppm lead in backfill) or develop their own backfill numbers using site-specific information. If the evaluation of available backfill material within a reasonable distance from the site is found to contain lead and/or other contaminants at levels above site-specific cleanup levels, then an evaluation of possible alternative fill materials, alternative mitigation actions, and/or interim or permanent ICs is recommended. Where backfill material contains lead >50 ppm, an evaluation should also be conducted to contribute to the efficient performance of any anticipated long-term remedial action to the extent practicable.

For example, at the Bunker Hill Superfund site, four-point composite samples were collected for every 200 cubic yards of backfill soil (TerraGraphics 1997a). Please note that for this site, due to site specific circumstances, it was determined that four-point composite samples were sufficient to control heterogeneity. The number of composite samples to collect to determine the concentration of lead in fill material should be determined on a site-specific basis to ensure that the results are definitive (*i.e.*, sufficiently low to be considered clean fill).

Gravel used for driveway backfill at the Bunker Hill Superfund Site was also sampled every 200 cubic yards (TerraGraphics 1997b). Some states have requirements for backfill sample collection and analyses, and should be consulted when performing this type of sampling.

Samples of excavated soil for disposal should be analyzed for the analytical parameters that are required under the disposal facilities permit to determine if the soil contains a RCRA hazardous waste and requires management as a hazardous waste. The analysis typically includes the full TCLP and analyzes for contaminants such as:

- RCRA toxicity characteristic metals plus copper, manganese, vanadium, and zinc;
- Target Compound List (TCL) semi-volatile organic compounds (SVOCs);
- Low-level polycyclic aromatic hydrocarbons (PAHs);

- TCL chlorinated pesticides;
- Polychlorinated biphenyls (PCBs);
- Chlorinated herbicides;
- Cyanides; and
- Other chemicals that may be specific to the waste, such as TCL volatile organic compounds (VOCs).

In addition, backfill soil samples and duplicates, as needed, may be tested for agronomy parameters such as:

- Soil classification;
- pH;
- Electroconductivity;
- Organic matter: loss on ignition;
- Nutrients such as nitrogen, phosphorus, and potassium;
- Carbon-Nitrogen Ratio: calculated from Total Kjeldahl Nitrogen (TKN) and via combustion byproducts;
- Sodium Absorption Ratio (SAR); and
- Cation Exchange Capacity (CEC).

These are valuable to ensure that the soils being used will support restoration and proper compaction, and where needed, provide proper growth medium. There may be different analyses recommended for topsoil versus common fill.

This information is to be documented in the remedial action report, the removal action report for completed soil cleanups, and/or the pollution report (POLREP).

CHAPTER 14
Access and Enforcement Considerations

The RPM should strive to characterize all residences within the identified zone of contamination and achieve cleanup at all residences where lead concentrations exceed the cleanup level. At all residential cleanup sites, a percentage of homeowners typically will refuse to grant access to EPA for sampling and/or for cleanup. To meet remedial goals of protecting a community, all residences suspected of being located within a zone of contamination should be sampled.

It is important to work with the landowner (and renter/resident, if other than landowner) and be sensitive to a landowner's concerns regarding property access when providing them with the consent for access form. The project manager should educate the landowner of the dangers that lead contamination may pose. If a landowner still refuses to grant access following attempts to negotiate the consent for access form, the Region should consider issuing an access order for sampling (U.S. EPA 1990d) or seeking access using one of EPA's other authorities.

To ensure a clear record, these communications should be documented. If the owner continues to refuse the access necessary to implement the remedy, EPA's program office, in consultation with EPA counsel, should continue taking appropriate steps, such as seeking the assistance of the CIC to obtain consent, or if that fails, issuing a UAO to secure the cooperation of an uncooperative landowner. EPA may also seek a warrant or court order for access.

An owner of residential property on a Superfund site may be potentially liable under CERCLA Section 107(a)(1). However, as an exercise of enforcement discretion, EPA generally will not take CERCLA enforcement actions against an owner of residential property unless the residential homeowner's activities lead to a release, or threat of release, of hazardous substances resulting in the taking of a response action at a site (see *Policy Towards Owners of Residential Property at Superfund Sites* [July 3, 1991]).[126]

Additionally, under CERCLA, a residential property owner may qualify for statutory protection from CERCLA liability as:

- a bona fide prospective purchaser;
- a contiguous property owner; or

[126] https://www.epa.gov/sites/default/files/documents/policy-owner-rpt.pdf.

- an innocent landowner.

Under both the statute and EPA's policy, a residential property owner is expected to cooperate with EPA and the party taking the response action (if other than EPA), and the project team should inform the owner of EPA's expectations for cooperation in connection with the remedy. These obligations include:

- providing access and information as requested;
- agreeing to comply with land use restrictions relied on in connection with the remedy; and
- not impeding the effectiveness or integrity of ICs (see CERCLA Sections 101(40)(B)(vi), 107(q)(1)(a), 101(35)(A)-(B)).

If some properties are not addressed under site response actions (*e.g.*, current homeowners with no young children or women of child-bearing age), then consideration could be given to establishing a trust fund (under state authority or local law) to be administered by a local government for the cleanup of the property at a future date, when the property is transferred (*e.g.*, by sale) to a new owner. Buyers of contaminated properties could make use of the fund to have the property cleaned up at their discretion. For more information, see https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.cleanup&id=1000195#Enforce.

If the situation involves contaminated rental properties, EPA should attempt securing access with the owners of the contaminated rental property using the consent for access form, while also communicating with the occupants appropriately and seeking their access as well. If the rental property owners refuse to agree to access, EPA should consider issuing a UAO for access to those owners of contaminated rental property who refuse to provide access. To ensure the protection of occupants, enforcement of the UAO may be necessary to clean up all rental properties with contamination greater than the cleanup level.

CHAPTER 15
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APPENDIX A
Glossary

Absolute Bioavailability (ABA): The ratio of the amount of lead absorbed compared the amount ingested: ABA = (Absorbed Dose) / (Ingested Dose) (see relative bioavailability).

Absorbed Dose: The amount of a substance that penetrates an exposed organism's absorption barriers (*e.g.*, skin, lung tissue, gastrointestinal tract) through physical or biological processes (synonymous with internal dose).

Absorption Barrier: Any of the exchange barriers of the body that permits uptake of various substances at different rates (*e.g.*, skin, lung tissue, gastrointestinal-tract wall).

Absorption Fraction: Only a fraction of the lead entering the body through the respiratory or gastrointestinal tracts is absorbed into the systemic circulation. This absorption fraction is, by convention, termed bioavailability and provides the most convenient parameterization of the uptake process.

Accuracy: The measure of the correctness of data, as given by the difference between the measured value and the true or standard value.

Adult Lead Methodology (ALM): A mathematical equation used by the U.S. EPA to predict the lead concentration in soil that would be for non-residential areas (*e.g.*, industrial or commercial areas) where children are not likely to live or play.

Arithmetic Mean: The sum of all the measurements in a data set divided by the number of measurements in the data set.

Averaging Time: The default assumption for the averaging time is one year (365 days), which is sufficient time for blood lead to approach quasi-steady state.

Background Level (Environmental): The concentration of substance in a defined control area during a fixed period of time before, during, or after a data gathering operation.

Bias: A systematic error inherent in a method or caused by some feature of the measurement system.

Bioaccessibility: An *in vitro* measure of the physiological solubility of the contaminant that may be available for absorption into the body.

Bioavailability: Degree of ability to be absorbed and ready to interact in organism metabolism. The fraction of intake at a portal of entry into the body (*e.g.*, skin, lung tissue, gastrointestinal tract) that enters the blood. Bioavailability is typically a function of chemical properties, physical state of the material that an organism ingests or inhales, and the ability of the individual organism to physiologically absorb the chemical. The absorption rate varies widely by type of substance and can greatly influence the toxicity of lead over that acute timeframe.

Biokinetics (BK): Processes affecting the movement of molecules from one internal body compartment to another, including elimination from the body.

Biokinetic Slope Factors (BKSF): µg/dL blood lead per mg/day lead uptake; an empirically-based estimate of the slope of the linear relationship between blood lead concentration and lead uptake (µg/dL per µg/day); reflects the biokinetics of absorbed, rather than ingested.

Comparability: The ability to describe likenesses and differences in the quality and relevance of two or more data sets.

Compartment: A distinct organ, tissue, fluid pool, or group of tissues within the body that are "kinetically homogeneous."

Conceptual Site Model (CSM): The CSM, a key element used in facilitating cleanup decisions during a site investigation, is a planning tool that organizes information that already is known about a site and identifies the additional information necessary to support decisions that will achieve the goals of the project. The project team then uses the CSM to direct field work that focuses on the information needed to remove significant unknowns from the model. The CSM serves several purposes: as a planning instrument; as a modeling and data interpretation tool; and as a means of communication among members of a project team, decision makers, stakeholders, and field personnel. From Waste and Cleanup Risk Assessment Glossary.

Decision Unit (DU): The mass of soil in the field for which a decision will be made based on the true concentration for that entire mass of soil. At a minimum, the DU's soil mass must be defined in terms of its location (Where is it?), spatial dimensions (What are its 3-dimensional boundaries?), and the targeted soil particle size (Everything <2 mm? Only the particles passing through a 60-mesh sieve? Or a 100-mesh sieve? etc.). The true concentration of the DU is the same concentration that would be obtained if the entire DU mass could be analyzed as a single giant sample in a single analysis.

Dose: The amount of a substance available for interaction with metabolic processes or biologically significant receptors after crossing the outer boundary of an organism. The potential dose is the amount ingested, inhaled, or applied to the skin. The applied dose is the amount of a substance presented to an absorption barrier and available for absorption (although not necessarily having yet crossed the outer boundary of the organism). The absorbed dose is the amount crossing a specific absorption barrier (*e.g.*, the exchange boundaries of the skin, lung tissue, and gastrointestinal tract) through uptake processes; internal dose is a more general term denoting the amount absorbed, without respect to specific absorption barriers or exchange boundaries. The amount of the chemical available for interaction by any particular organ or cell is termed the delivered dose for that organ or cell.

Dust Loading (LD): The amount of dust per unit area expressed as micrograms per square meter ($\mu g/m^2$) or micrograms per square foot ($\mu g/ft^2$).

Exposure: Contact of a chemical, physical, or biological agent with the outer boundary of an organism. Exposure is quantified as the concentration of the agent in an ambient or environmental medium in contact integrated over the time duration of that contact.

Exposure Duration (ED): Period over which exposure occurs. The modeled ED should be sufficiently long to allow blood lead concentrations to approach quasi-steady state. As discussed in the guidance, the shortest period of time appropriate for an ED is three months (90 days).

Exposure Pathway: The path from sources of pollutants via soil, water, or food to man and other species or settings. The physical course a chemical or pollutant takes from the source to the organism exposed.

Exposure Point Concentration (EPC): The contaminant concentration within an exposure unit to which receptors are exposed. Estimates of the EPC represent the concentration term used in exposure assessment.

Exposure Route: The way a chemical or pollutant enters an organism after contact (*e.g.*, by ingestion, inhalation, or dermal absorption).

Exposure Scenario: A set of facts, assumptions, and inferences about how exposure takes place that aids the exposure assessor in evaluating, estimating, or quantifying exposures.

Exposure Unit (EU): The EU is generally the geographic area within which a receptor comes in contact with a contaminated medium; it should be defined based on the receptor, the exposure medium (*e.g.*, soil, water, sediment), and the nature of the receptor's contact with the medium. If the receptor is a resident exposed to soils in his/her yard, the EU will likely encompass the residential property. Other receptors, such as workers and recreators, may be exposed to contaminants across much larger areas, and a much larger EU may be appropriate.

Ex Situ: Not in the natural or original position or place. Other FP-XRF instruments require that soil samples are collected and placed in a sample cup that is then placed in a covered sample chamber for analysis.

Gastrointestinal (GI): Relating to the GI tract, or affecting the stomach and/or intestine.

Geometric Mean (GM): The central predicted value (*e.g.*, blood lead concentration) in a log-normally distributed population of observations. The IEUBK model calculates a log-normally distributed population of predicted blood lead concentrations. The predicted geometric mean blood lead concentration is the central value in that population.

Geometric Standard Deviation (GSD): The GSD describes the variability (or spread) in a log-normally distributed population of observations. The higher the GSD of the population, the greater the difference between the upper and lower tail of the population around the central value.

Guidelines: Principles and procedures to set basic requirements for general limits of acceptability for assessments.

Intake: The process by which a substance crosses the outer boundary of an organism without passing an absorption barrier (*e.g.*, skin, lung tissue, GI tract) (see potential exposure concentration).

Internal Dose: The amount of a substance penetrating across the absorption barriers (*e.g.*, skin, lung tissue, gastrointestinal tract) or an organism, via either physical or biological processes (see absorbed dose).

In Situ: In the natural or original position or place. Some FP-XRF instruments can be placed directly on the soil surface for *in situ* measurements.

Lead Absorption Factor (ABS_S): Fraction absorption from soil at low saturation (maximum absorption coefficient, active).

Lead Loading: The concentration of lead per unit area measured in micrograms per square meter ($\mu g/m^2$).

Lead Concentration in Air (PbA): The mass concentration of lead per mass of air, typically reported as micrograms per cubic meter ($\mu g/m^3$). However, IEUBK model default values for lead concentration in air can be replaced with site-specific data for indoor air lead concentration as a percentage of outdoor air lead concentration (µg/m^3), outdoor air lead concentration (µg/m^3), time spent outdoors (hours/day), ventilation rate (m^3/day), or lung absorption (%).

Lead Concentration in Dust (PbD): The mass concentration of lead per mass of dust, typically reported as micrograms lead per gram dust (µg Pb/g dust) or in parts Pb per million dust (ppm). The IEUBK model uses lead concentration data as the metric to represent the extent and magnitude of lead in residential dust at a site.

Lead Concentration in Soil (PbS): The mass concentration of lead per mass of soil, typically reported as parts per million (µg Pb/g soil). Soil lead concentration is the only input parameter of the IEUBK model for which a site-specific value is recommended. The arithmetic mean of soil lead concentration for a representative exposure area in the yard should be used for the lead concentration in soil.

Lead Concentration in Water (PbW): The mass concentration of lead per mass of water, typically reported in micrograms lead per liter water (µg Pb/L water). Drinking water data are divided in the IEUBK model into water consumption rates and environmental concentrations based on age dependent, national averages. Consumption rates should only be changed ONLY when valid site-specific monitoring data are available.

Mass Fraction of Soil to Dust (M_{SD}): The mass fraction of soil-derived particles in indoor dust (g soil/g dust). The M_{SD} represents the mass fraction of house dust that is derived from outdoor soil. It is used in Multiple Source Analysis to compute the contribution of outdoor PbS to the indoor PbD concentration. The default value for M_{SD} recommended by the U.S. EPA is 0.70 g soil/g dust.

Median Value: The value in a measurement data set such that half of the measured values are greater and half are less.

Pathway: The physical course a chemical or pollutant takes from the source to the exposed organism.

Pharmacokinetics: The study of the time course of absorption, distribution, metabolism, and excretion of a foreign substance (*e.g.*, a drug or pollutant) in an organism's body.

Pica: Deliberately ingesting soil. Individuals exhibiting pica behaviors may have soil ingestion rates well in excess of the typical ingestion levels used in most U.S. EPA risk assessments. Pica exposure is generally not assessed in Superfund lead risk assessments.

Potential Exposure Concentration: The amount of a chemical contained in material ingested, air breathed, or bulk material applied to the skin (see intake).

Precision: A measure of the reproducibility of a measured value under a given set of conditions.

Preliminary Remediation Goal (PRG): In the process of screening a soil against a certain contaminant, we define the health-risk-based PRG as the contaminant concentration above which some remedial action may be required. Thus, the PRG is the first standard (or guidance) for judging a site.

Probability Samples: Samples selected from a statistical population such that each sample has a known probability of being selected.

Quasi-Steady State: An intake over a sufficient duration for the blood lead concentration to become nearly constant over time. Based on estimates of the first-order elimination half-time for lead in blood of approximately 30 days for adults, a constant lead intake rate of over a duration of 90 days would be expected to achieve a blood lead concentration that is sufficiently close to the quasi-steady state.

Quincunx: a geometric pattern consisting of five points arranged in a cross, with four of them forming a square or rectangle and a fifth at its center.

Random Samples: Samples selected from a statistical population such that each sample has an equal probability of being selected.

Range: The difference between the largest and smallest values in a measurement data set.

Reasonable Worst-Case Exposure or Risk Range: The lower portion of the “high end” of the exposure, dose, or risk distribution. An estimate of the individual dose, exposure, or risk level received by an individual in a defined population that is greater than the 90th percentile but less than that received by anyone in the 98th percentile in the same population (“maximum exposure or risk range”).

RSL: Residential screening level for soil.

Relative Bioavailability (RBA): The ratio of the absolute bioavailability of lead present in some test material compared to the absolute bioavailability of lead in some appropriate reference material: RBA = ABA(test) / ABA(reference).

Representativeness: A measure of how closely the sample (a sub-set of a population) matches the target (entire) population.

Representative Sample: A subset of a statistical population that accurately reflects the members of the entire population. A representative sample should be an unbiased indication of what the population is like. http://www.investopedia.com/terms/r/representative-sample.asp

Reproducible: The coefficient of variation or relative standard deviation (equal to the ratio of sample standard deviation to the mean) is acceptable given site DQOs.

Residential Properties: Residential properties include single- and multi-family dwellings, apartment complexes, vacant lots in residential areas, schools, daycare centers, community centers, playgrounds, parks, green ways, and any other areas where children may be exposed to site-related contaminated media (U.S. EPA, 1996a, 1997a, 1998a).

Risk: A measure of the probability that damage to life, health, property, and/or the environment will occur as a result of a given hazard.

Route: The way a chemical or pollutant enters an organism after contact (*e.g.*, by ingestion, inhalation, or dermal absorption).

Sampling Unit (SU): The mass, volume, or area of soil in the field represented by a single sample and single data result(s) [the sample data can consist of results for many analytes]. Where a DU is represented by a 30-increment incremental sample, the DU is the same physical area as the SU. But the term "SU" is usually reserved for masses of soil that are smaller than DUs. SUs are commonly used to detect concentration trends or boundaries between "clean" and "contaminated" areas. For example, a nine-point composite sample might be used to represent a four-square foot SU area. A line of 10 nine-point-composite 100 square feet ($9.3m^2$) might form a transect looking to pin down a spill boundary. Unlike grab samples, the nine-point composites avoid the risk that results will be biased high or low by short-scale heterogeneity. An SU of one square foot area should be sampled with at least five increments. An even better approach when the targeted surface soil layer is thin (*i.e.*, only a few inches deep) is to collect the entire volume encompassed by the one-square foot by X-inch depth.

Scenario Evaluation: An approach to quantifying exposure by measurement or estimation of both the amount of a substance contracted and the frequency/duration of contact, and subsequently linking these together to estimate exposure or dose.

Structural Equations Model: A statistical model of a process, in which several regression equations are solved simultaneously, and outputs or responses from one equation may be used as inputs or predictors in another equation. Note: Useful in pathway modeling. https://en.wikipedia.org/wiki/Structural_equation_modeling

Surrogate Data: Data from studies of test organisms or a test substance that are used to estimate the characteristics or effects on another organism or substance.

Upper Confidence Level (UCL): The upper limit of a confidence interval for a population parameter, such as the mean, at a specified level of confidence (*e.g.*, 95 percent [%]). For example, the 95% UCL of a mean is defined as a value that, when calculated repeatedly for randomly drawn subsets of site data, equals or exceeds the true mean 95 percent of the time.

Uptake: Entrance into the body; mass of lead absorbed per day from diet or inhalation) into the systemic circulation of blood (µg/day).

APPENDIX B
1994 OSWER Directive 9355.4-12

EPA
OSWER Directive #9355.4-12
August 1994

MEMORANDUM: OSWER DIRECTIVE: REVISED INTERIM SOIL LEAD GUIDANCE FOR CERCLA SITES AND RCRA CORRECTIVE ACTION FACILITIES

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

NOTICE

This document provides guidance to EPA staff. It also provides guidance to the public and to the regulated community on how EPA intends to exercise its discretion in implementing the National Contingency Plan. The guidance is designed to implement national policy on these issues. The document does not, however, substitute for EPA's statutes or regulations, nor is it a 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.

MEMORANDUM

SUBJECT: Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities

FROM: Elliott P. Laws
Assistant Administrator

TO: Regional Administrators I-X

PURPOSE

As part of the Superfund Administrative Improvements Initiative, this interim directive establishes a streamlined approach for determining protective levels for lead in soil at CERCLA sites and RCRA facilities that are subject to corrective action under RCRA section 3004 (u) or 3008 (h) as follows:

- It recommends screening levels for lead in soil for residential land use 400 (ppm);[1]
- It describes how to develop site-specific preliminary remediation goals (PRGs) at CERCLA sites and media cleanup standards (MCSs) at RCRA Corrective Action facilities for residential land use; and,
- It describes a plan for soil lead cleanup at CERCLA sites and RCRA Corrective Action Facilities that have multiple sources of lead.

This interim directive replaces all previous directives on soil lead cleanup for CERCLA and RCRA programs (see the Background section, 1989-1991).

KEY MESSAGES

Screening levels are not cleanup goals. Rather, these screening levels may be used as a tool to determine which sites or portions of sites do not require further study and to encourage voluntary cleanup. Screening levels are defined as a level of contamination above which there may be enough concern to warrant site-specific study of risks. Levels of contamination above the screening level would NOT automatically require a removal action, nor designate a site as "contaminated."

The residential screening level for lead described in this directive has been calculated with the Agency's new Integrated Exposure Uptake Biokinetic Model (IEUBK) model (Pub. # 9285.7-15-2, PB93-963511), using default parameters. As outlined in the Guidance Manual for the IEUBK Model for Lead in Children (Pub. # 9285.7-15-1, PB93-963510, February 1994), this model was developed to: recognize the multimedia nature of lead exposure; incorporate important absorption and pharmacokinetic information; and allow the risk manager to consider the potential distributions of exposure and risk likely to occur at a site (the model goes beyond providing a single point estimate output). For these reasons, this approach is judged to be superior to the more common method for assessing risks of non-cancer health effects which utilizes the reference dose (RfD) methodology. Both the Guidance Manual and the model are available to Superfund staff through the Superfund Document Center (703-603-8917) and to the public through the National Technical Information Service (703-487-4650).

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[1] The residential screening level is the same concept as the action level proposed in the RCRA Corrective Action Subpart S rule (July 27, 1990, 55 *Federal Register* 30798).

Residential preliminary remediation goals (PRGs) for CERCLA remediations and media cleanup standards (MCSs) for RCRA corrective actions can be developed using the IEUBK model on a site-specific basis, where site data support modification of model default parameters. At some Superfund sites, using the IEUBK model with site-specific soil and dust characteristics, PRGs of more than twice the screening level have been identified. However, it is important to note that the model alone does not determine the cleanup levels required at a site. After considering other factors such as costs of remedial options, reliability of institutional controls, technical feasibility, and/or community acceptance, still higher cleanup levels may be selected.

The implementation of this guidance is expected to provide for more consistent decisions across the country and improve the use of site-specific information for RCRA and CERCLA sites contaminated with lead. The implementation of this guidance will aid in determining when evaluation with the IEUBK model is appropriate in assessing the likelihood that environmental lead poses a threat to the public. Use of the IEUBK model in the context of this guidance will allow risk managers to assess the contribution of different environmental sources of lead to overall blood lead levels (e.g., consideration of the importance of soil lead levels relative to lead from drinking water, paint and household dust). It offers a flexible approach to considering risk reduction options (referred to as the "bubble" concept) that allows for remediation of lead sources that contribute significantly to elevated blood lead. This guidance encourages the risk manager to select, on a site-specific basis, the most appropriate combination of remedial measures needed to address site-specific lead exposure threats. These remedial measures may range widely from intervention to abatement. However, RCRA and CERCLA have very limited authority to address interior exposures from interior paint. For detailed discussion of the decision logic for addressing lead-contaminated sites, see the Implementation section and Appendix A.

Relationship to lead paint guidance. In addition, this interim directive clarifies the relationship between guidance on Superfund and RCRA Corrective Action cleanups, and EPA's guidance on lead-based paint hazards (discussed further in Appendix C). The paint hazard guidance will be issued to provide information until the Agency issues regulations identifying lead-based paint hazards as directed by Section 403 of the Toxic Substances Control Act (TSCA).[2] Lead-based paint hazards are those lead levels and conditions of paint, and residential soil and dust that would result in adverse health effects.

The two guidance documents have different purposes and are intended to serve very different audiences. As a result the approaches taken differ to some degree. The lead-based paint hazard guidance is intended for use by any person who may be involved in addressing residential lead exposures (from paint, dust or soil). It thus relates to a potentially huge number of sites, and serves a very broad potential audience, including private property owners or residents in addition to federal or state regulators. Much residential lead abatement may take place outside any governmental program, and may not involve extensive site-specific study.

This OSWER guidance, on the other hand, deals with a much smaller number of sites, being addressed under close federal regulatory scrutiny, at which extensive site characterization will have been performed before cleanup decisions are made. Thus, the RCRA and CERCLA programs will often have the benefit of much site-specific exposure information. This guidance is intended for use by the relatively small number of agency officials who oversee and direct these cleanups.

Both the TSCA Section 403 and OSWER programs use a flexible, tiered approach. The OSWER guidance sets a residential screening level at 400 ppm. As noted above, this is not intended to be a "cleanup level" for CERCLA and RCRA facilities, but only to serve as an indicator that further study is appropriate. The Section 403 guidance indicates that physical exposure-reduction activities may be appropriate at 400 ppm, depending upon site-specific conditions such as use patterns, populations at risk and other factors. Although worded somewhat differently, the guidances are intended to be similar in effect. For neither guidance is 400 ppm to automatically be considered a "cleanup level"; instead, it indicates a need for considering further action, but not necessarily for taking action. Neither is meant to indicate that cleanup is necessarily appropriate at 400 ppm. The greater emphasis in this OSWER guidance on determining the scope of further study reflects the fact that both CERCLA and RCRA cleanups proceed in stages with detailed site characterization preceding response actions in every case.

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[2]Title IV of TSCA (including section 403) was added by the Residential Lead-Based Paint Hazard Reduction Act of 1992 (Title X of the Housing and Community Development Act of 1992).

Above the 400 ppm level, the Section 403 guidance identifies ranges over which various types of responses are appropriate, commensurate with the level of potential risk reduction, and cost incurred to achieve such risk reduction. For example, in the range of 400 to 5000 ppm, limited interim controls are recommended depending, as noted above, on conditions at the site, while above 5000 ppm, soil abatement is recommended. This OSWER guidance does not include comparable numbers above 400 ppm; instead, as discussed above, it recommends the site-specific use of the IEUBK model to set PRGs and MCSs, when necessary. The remedy selection process specified in the National Contingency Plan (NCP) should then be used to decide what type of action is appropriate to achieve those goals.

In general, because the Section 403 guidance was developed for a different purpose and audience, OSWER does not recommend that it be used as a reference in setting PRGs and MCSs or in determining whether action at a particular site is warranted. (To put it another way, it generally should not be treated as a "to be considered" document or "TBC" under CERCLA.) The section 403 guidance is meant to provide generic levels that can be used at thousands of widely varying sites across the nation. The detailed study that goes on at CERCLA or RCRA sites will allow levels to be developed that are more narrowly tailored to the individual site. Nothing in the section 403 guidance discourages setting more site-specific levels for certain situations; in fact, it specifically identifies factors such as bioavailability that may significantly affect the evaluation of risk at some sites.

The IEUBK model. The Agency is further studying both the IEUBK model and analyses of epidemiologic studies in order to better develop the technical basis for rulemaking under TSCA Section 403. The Agency intends to promulgate regulations under Section 403 setting health-based standards for lead in soil and dust. OSWER intends to issue a final soil lead directive once the TSCA Section 403 regulations are finalized. For additional information on TSCA Section 403 developments, call (202) 260-1866.

However, the Agency believes that risk managers (risk assessors, on-scene coordinators, remedial project managers, and other decision-makers at Superfund and RCRA sites) are currently in need of the best guidance available today. The Agency believes that the IEUBK model is the best available tool currently available for assessing blood lead levels in children. Furthermore, use of the IEUBK provides allows the risk manager to consider site-specific information that can be very important in evaluating remediation options. Therefore, using the latest developments in the IEUBK model and the collective experience of the Superfund, RCRA Corrective Action, and TSCA Section 403 programs, the Agency is offering this guidance and is recommending a residential screening level for Superfund and RCRA sites of 400 ppm.

BACKGROUND

Early OSWER guidance (1989-1991). Four guidance documents on the soil lead cleanup were issued by OSWER during the period of 1989 to 1991:

1. September 1989, OSWER Directive #9355.4-02. This guidance recommended a soil lead cleanup level of 500 - 1000 ppm for protection of human health at residential CERCLA sites.

2. May 9, 1990. RCRA Corrective Action program guidance on soil lead cleanup. This guidance described three alternative methods for setting "cleanup levels" (not action levels) for lead in soil at RCRA facilities. One approach was to use levels derived from preliminary results of IEUBK model runs. The other two approaches were to use the range of 500 to 100 provided in the 1989 directive on CERCLA sites, or to use "background" levels at the facility in question.

3. June 1990, OSWER Directive #9355.4-02A. Supplement to Interim Guidance on Establishing Soil Land Cleanup Levels at Superfund Sites. This memorandum reiterated that the September 1989 directive was guidance and should not be interpreted as regulation.

4. August 29, 1991. This supplemental guidance discussed EPA's efforts to develop a new directive that would accomplish two objectives: (1) account for the contribution from multiple media to total lead exposure; and, (2) provide a stronger scientific basis for determining a soil lead cleanup level at a specific site.

Development of the IEUBK Model for OSWER use. During the 1989-91 time period, use of EPA IEUBK model was identified as the best available approach for accomplishing the objectives outlined in the August 1991 guidance. The model integrates exposure from lead in air, water, soil, dust, diet, and paint with pharmacokinetic modeling to predict blood lead levels in children (i.e., Children 6 to 84 months old), a particularly sensitive population.

In the spring of 1991, OSWER organized the Lead Technical Review Workgroup to assist Regional risk assessors and site managers in both using the model and making data collection decisions at CERCLA and RCRA sites. The workgroup was composed of scientists and risk assessors from the Regions and Headquarters, including the Office of Research and Development (ORD), and the Office of Pollution Prevention and Toxic Substances (OPPTS).

In November 1991, the EPA Science Advisory Board (SAB) reviewed the scientific merits of using the IEUBK model for assessing total lead exposure and developing soil lead cleanup levels at CERCLA and RCRA sites. In general, the SAB found the model to be an important advance in assessing potential health risks from environmental contaminants. However, the SAB also recommended additional guidance on the proper use of the model.

In response to SAB concern over the potential for incorrect use of the model and selection of inappropriate input values both for default and site-specific applications, OSWER developed a comprehensive "Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children" (referred to in this interim directive as the "Guidance Manual"). This Guidance Manual assists the user in providing inputs to the model to estimate risks from exposures to lead. It discusses the use of model default values or alternative values, and the application of the model to characterize site risks. Use of the Guidance Manual should facilitate consistent use of the IEUBK model and allow the risk assessor to obtain valid and reliable predictions of lead exposure. The Lead Technical Review Workgroup has been collecting data to further validate the model and to update the Guidance Manual as needed.

Relationship to RCRA Corrective Action "Action" Levels. The approach for calculating a screening level for lead (including exposure assumptions), set forth in this Revised Interim Soil Lead Directive, supersedes the guidance provided for calculating "action" levels set forth in Appendix D of the proposed Subpart S Corrective Action rule. In the July 27, 1990 RCRA proposal (55 *Federal Register* 30798), EPA introduced the concept of "action levels" as trigger levels for further study and subsequent remediation at RCRA facilities. In this respect, the current directive's "screening levels" are analogous to the proposed rule's "action levels." In the proposal, where data were available, action levels were developed for three pathways of human exposure to contaminants: soil ingestion, water ingestion and inhalation of contaminated air. Exposure assumptions used in the calculations were set out in Appendix D of the proposal. For the soil pathway, action levels were calculated two different ways depending on whether the contaminant in the soil was a carcinogen or systemic toxicant. Although lead was listed in Appendix A of the preamble to the rule as a class B2 carcinogen, no action level had been calculated because neither a carcinogenic slope factor (SF) nor a reference dose (RfD) had been developed by the Agency. Although the guidance in Appendix D of the proposed Corrective Action rule remains in effect with respect to other hazardous constituents, this directive now allows for the development of the lead screening ("action") level using the IEUBK model.

Recent developments (1992-Present). Following discussions among senior Regional and OSWER management, the OSWER Soil Lead Directive Workgroup (composed of Headquarters, Regional and other Federal agency representatives) recommended in the spring of 1992 that a "two step" decision framework be developed for establishing cleanup levels at sites with lead-contaminated soils. This framework would identify a single level of lead in soils that could be used as either the PRG for CERCLA site cleanups or the action level for RCRA Corrective Action sites, but would allow site managers to establish site-specific cleanup levels (where appropriate) based on site-specific circumstances. The IEUBK model would be an integral part of this framework. OSWER then developed a draft of this directive which it circulated for review on June 4, 1992. The draft set 500 ppm as a PRG and an action level for RCRA facilities in residential settings.

Following development of this draft, OSWER held a meeting on July 31, 1992 to solicit a broad range of views and expertise. A wide range of interests, including environmental groups, citizens and representatives from the lead industry attended. This meeting encouraged OSWER to think more broadly about how the directive would affect urban areas, how lead paint and dust contribute to overall risk, and blood lead data could be used to assess risk. In subsequent meetings with the Agency for Toxic Substances and Disease Registry (ATSDR) and Centers for Disease Control (CDC), options were discussed on how to use blood lead data and the need to evaluate the contribution of paint. In addition, during these meetings, a "decision tree" approach was suggested that proposed different threshold levels (primary and secondary) for screening decisions, action decisions and land use patterns.

Findings from the three cities (Baltimore, Boston, and Cincinnati) of the Urban Soil Lead Abatement Demonstration Project (peer review scheduled for completion in late 1994) indicate that dust and paint are major contributors to elevated blood lead levels in children. Furthermore, preliminary findings suggest that any strategy to reduce overall lead risk at a site needs to consider not only soil, but these other sources and their potential exposure pathways. (For further information on this demonstration project, contact Dr. Rob Elias, USEPA/ORD, Environmental Criteria And Assessment Office (ECAO), RTP, (919) 541-4167.)

Finally, in its efforts to develop this interim directive, the OSWER Soil Lead Workgroup has met with other EPA workgroups including the TSCA Section 403, Large Area Land Sites, and Urban Lead workgroups, as well as other Federal agencies including the Agency for Toxic Substances and Disease Registry, the Centers for Disease Control, and Department of Housing and Urban Development.

Derivation of Lead Screening Levels. Development of the residential screening level in this interim directive required two important OSWER decisions. 1) OSWER determined that it would seek to achieve a specific level of protectiveness in site cleanups; generally, OSWER will attempt to limit exposure to soil lead levels such that a typical (or hypothetical) child or group of similarly exposed children would have an estimated risk of no more than 5% exceeding the 10 µg lead/dl blood lead level. This 10 µg/dl blood lead level is based upon analyses conducted by the Centers for Disease Control and EPA that associate blood lead levels of 10 µg/dl and higher with health effects in children; however, this blood lead level is below a level that would trigger medical intervention. 2) In developing the residential screening level, OSWER has decided to apply the EPA's IEUBK model on a site-specific basis. This model has been designed specifically to evaluate exposures for children in a residential setting. Current research indicates that young children are particularly sensitive to the effects of lead and require specific attention in the development of a soil screening level for lead. A screening level that is protective for young children is expected to be protective for older population subgroups.

In general, the model generates a probability distribution of blood lead levels for a typical child, or group of children, exposed to a particular soil lead concentration and concurrent lead exposures from other sources. The spread of the distribution reflects the observed variability of blood lead levels in several communities. This variability arises from several sources including behavioral and cultural factors.

The identification of lead exposures from other sources (due to air, water, diet, paint, etc.) is an essential part of characterizing the appropriate blood lead distribution for a specific neighborhood or site. For the purpose of deriving a residential screening level, the background lead exposure inputs to the IEUBK model were determined using national averages, where suitable, or typical values. Thus, the estimated screening level of 400 ppm is associated with an expected "typical" response to these exposures, and should not be taken to indicate that a certain level of risk (e.g., exactly 5% of children exceeding 10 µg/dl blood) will be observed in specific community, e.g., in a blood lead survey.

Because a child's exposure to lead involves a complex array of variables, because there is population sampling variability, and because there is variability in environmental lead measurements and background levels of lead in food and drinking water, results from the model may differ from results of blood lead screening of children in a community. Extensive field validation is in progress. The model will be evaluated further once these efforts are completed.

OBJECTIVE

With this interim directive, OSWER recommends using 400 ppm soil lead (based on application of the IEUBK model) as a screening level for lead in soil for residential scenarios at CERCLA sites and at RCRA Corrective Action sites. Residential areas with soil lead below 400 ppm generally require no further action. However, in some special situations, further study is warranted below the screening level. For example, agricultural areas, wetlands, areas with ecological risk, and areas of higher than expected human exposure are all situations that could require further study. For further guidance on ecological risks, Superfund risk managers are encouraged to consult their Regional Biological Technical Assistance Groups (BTAGs; see Appendix D).

Generally, the ground water pathway will not pose a significant risk since many lead compounds are generally not highly mobile. However, there are situations where, because of the form of lead, hydrogeology, or the presence of other contaminants at the site, lead may pose a threat to the ground water. In these situations, additional analysis is warranted, Superfund Regional Toxics Integration Coordinators (RTICs; seeAppendix B) or RCRA hydrogeologists should be consulted.

While recognizing that urban lead is a significant problem, this interim directive is not designed to be applied in addressing the potential threat of lead in urban areas other than at CERCLA or RCRA Corrective Action sites. Guidance and regulations to be developed under TSCA Section 403 will provide an appropriate tool for addressing urban sites of potential concern.

Generally, where the screening level is exceeded, OSWER recommends using the IEUBK model during the Remedial Investigation or the RCRA Facility Investigation for evaluating potential risks to humans from environmental exposures to lead under residential scenarios. Site-specific data need to be collected to determine PRGs or MCSs. At a minimum, this may involve collecting soil and dust samples in appropriate areas of the site. Further guidance on data collection or modification of the non-residential equation can be obtained by contacting the RTICs or RCRA Regional risk assesors, who in turn may consult the Lead Technical Review Workgroup.

The type of site-specific data that should be collected will obviously depend on a number of factors, including the proximity of residences to the contaminated soil, the presence of site access controls, and other factors that would influence the probability of actual human exposure to the soils. At a minimum, when residences are at or near the site, it is expected that using the model will generally involve taking soil and dust samples from appropriate areas of the site. In many cases, it may not be necessary to gather certain types of data for input into the model. For example, when there are no residences nearby, or where there is otherwise no exposure or very limited exposure to lead contamination, it may not be necessary to collect site-specific data (e.g., dust, water, paint, blood-lead, etc.)

In developing a PRG for CERCLA sites or a MCS for RCRA facilities, EPA recommends that a soil lead concentration be determined so that a typical child or group of children exposed to lead at this level would have an estimated risk of no more than 5% of exceeding a blood lead of 10 µg/dl. In applying the IEUBK model for this purpose, appropriate site-specific data on model input parameters, including background exposures to lead, would be identified.

When the PRG or MCS is exceeded, remedial action is generally recommended. Such action does not, however, necessarily involve excavating soil. A range of possible actions may be considered, as discussed in greater detail under the Implementation section of this directive: Issues for Both Programs.

IMPLEMENTATION

Superfund

This interim directive applies to all future CERCLA Remedial Investigation/Feasibility Study (RI/FS) work; this interim directive should generally not be applied at sites for which risk assessments have been completed. For removal sites, this interim directive recommends that decisions regarding removal actions be considered first by the Regional Decision Team (RDT). The RDT will then refer sites to the removal program for early action, as appropriate.

The approach in this interim directive helps meet the goals set by the Superfund Accelerated Cleanup Model (SACM) for streamlining remedial decision-making. (This streamlined approach is described in Appendix A, Suggested Decision Logic for CERCLA and RCRA Corrective Action.) This interim directive also recognizes that other methods (e.g., slope studies and others) for evaluating risks at lead sites may also be appropriate and may be used in lieu of, or in conjunction with, the IEUBK model. If an alternate approach to lead risk assessment is to be applied, an EPA scientific review should be obtained. For example, expert statisticians would need to review slope factor calculations for statistical biases before their use could be supported. Recognizing that all assessment methods involve some uncertainties, the Agency, at this time, believes the IEUBK model is the most appropriate and widely applicable tool for Superfund and RCRA sites. Alternatively, EPA may require setting cleanup levels below the screening level if site-specific circumstances warrant (e.g., ecological risk). For further information on the use of the IEUBK model at CERCLA sites, contact the Regional Toxics Integration Coordinators identified in Appendix B.

RCRA Corrective Action

It is expected that the RCRA corrective action program will generally follow an approach similar to CERCLA's (as described above) in using the IEUBK model. In the case of RCRA facilities at which lead contaminated soils are of concern, collection and evaluation of data for the purpose of using the model will be primarily the responsibility of the owner/operator.

Issues for Both Programs

Cleanup of soils vs. other lead sources: OSWER's approach to assessing and managing risks from lead is intended to address the multi-media/multi-source nature of environmental lead exposures because it is expected that people at or near CERCLA and RCRA Corrective Action sites will experience lead exposures from sources in addition to contaminated soil. In some instances, these other exposures may be large (e.g., where there are children living in houses with high levels of lead dust form deteriorated paint). The presence of various sources of lead exposure may be very important in both the development of site-specific risk assessments and in the consideration of alternative risk management options.

From an assessment perspective, estimating blood lead levels, that might result from exposures at a site, depends on appropriately integrating exposures from all relevant media. Specifically, it is important to consider direct soil exposures and indoor dust exposures (which can include contributions from both soil and lead-based paint) on a site-specific basis, as well as any contributions from drinking water or other local sources of lead exposure. In using the IEUBK model to estimate blood lead levels, it is important to note that the risk attributable to soil lead exposures is dependent upon the existing level of exposures from other sources. That is, the amount by which the total risk would be lowered if all exposures to lead in soil were removed is not a constant, but varies with the level of existing non-soil exposures. This is because the model derives "distribution" (rather than a simple point estimate) as an output whose shape and size is quite dependent on the predicted variability of exposures from each lead source. As a result, other factors being equal, the risks attributable to soil will generally be higher in the presence of elevated lead exposures from other sources. Therefore, in applying the IEUBK model, the risk attributable to soil lead can be predicted as the difference between the risk estimated when all sources of lead exposure are assessed, and the risk estimated considering only non-soil related exposures. This concept is especially important when evaluating different options for risk reduction at a given site.

From a risk management perspective, achieving a safe environment for populations at CERCLA and RCRA Corrective Action sites may require attention to multiple sources of lead, not all of which may be related to contamination from the source that was the initial concern at the site. Generally, the goal of the Agency, while acting within the constraints of CERCLA and RCRA legal authorities, is to reduce, to the maximum extent feasible, the risk of having significantly elevated blood lead levels. On a site-specific basis this can include remediation approaches that would lead to reduction of exposure from other sources, such as lead-based paint, in conjunction with appropriate soil remediation. Following from the risk assessment discussion in the previous paragraphs, exposures from lead in soils may have a lesser impact in producing high blood lead level if existing exposures from lead in soils may have a lesser impact in producing high blood lead levels if existing exposures from lead-based paint are reduced.

Abatement vs. Intervention: Remedial measures can be divided into those that remove the source of contamination (abatement) and those that leave the contamination in place but block the exposure pathway (intervention). These combinations of measures might include but not be limited to:

Abatement - Soil removal or interior and exterior lead paint abatement.

Intervention - Institutional controls, education/public outreach, gardening restrictions, indoor cleaning and dust removal, or additional cover.

Generally, the most appropriate CERCLA or RCRA response action or combination of actions will be based, in part, on the estimated level of threat posed at a given site. However, as mentioned earlier, key decision criteria also include the overall protectiveness of response options, attainment of Applicable or Relevant and Appropriate Requirements (for CERCLA), a preference for permanent remedies, implementability, cost-effectiveness, and public acceptance. Intervention measures may be more appropriate than abatement (e.g., soil excavation) at many sites, especially in areas where soil lead levels fall at or near the site-specific PRG or MCS.

Addressing exposure from other sources of lead may reduce risk to a greater extent and yet be less expensive than directly remediating soil. In some cases, cleaning up the soil to low levels may, by itself, provide limited risk reduction because other significant lead sources are present (e.g., contaminated drinking water or lead-based paint in residential housing). If it is possible to address the other sources, the most cost-effective approach may be to remediate the other sources as well as, or (if exposures to lead in soil are relatively low) instead of full soil lead abatement.

Lead-based paint can be a significant source of lead exposure and needs to be considered when determining the most appropriate response action. Interior paint can contribute to elevated indoor dust lead levels. In addition, exterior paint can be a significant source of recontamination of soil. Appendix A-3 of this document contains more information on how to evaluate and address the contribution of paint.

Certain legal considerations arise in considering remediation of sources other than soil. In particular, interior exposures from interior paint generally are not within the jurisdiction of RCRA or CERCLA. In addition, where other sources are addressed, issues may arise regarding the recoverability of costs expended by the Agency, or the possibility of claims being asserted against the Fund where other parties are ordered to do the work.

As discussed above, in considering whether to address sources other than soil, it is necessary to consider the risk that would remain from the lead in the soil. In some cases, after risks from other sources have been addressed, unrestricted exposure to soil could be allowed while still being protective (e.g., where the IEUBK model result was heavily affected by the other sources). In other cases, soil risks may still be high enough to require abatement, containment or institutional controls to prevent high levels of exposure. In such cases, before a conclusion is made that the overall remedy will be protective, institutional controls should be carefully studied to make sure that they will be implementable, effective in both the long-term and short-term, and likely to achieve community acceptance.

A potentially useful approach that can be considered in conjunction with other, more active measures in reducing blood lead levels is to develop and promote public education and awareness programs that focus on the causes and prevention of lead poisoning in children. EPA's Office of Pollution Prevention and Toxics (OPPT) provides information on abatement of lead-based paint by the homeowner as well as inexpensive preventive measures the public can take to reduce their exposure to lead. Additional research to evaluate the effectiveness of educational efforts in reducing lead exposures are needed to allow better evaluation of the usefulness of this option. Further, OPPT is assessing the effectiveness of various lead paint abatement options emphasizing low-cost methods. For additional information, contact the National Lead Information Center at 1-800-424-LEAD.

Mining-related sites: Both risk assessors and site managers should be aware that there are a number of factors that affect the relationship between soil lead concentrations and blood lead levels. These factors include the variability in soil lead contribution to house dust levels, or differences in the bioavailability of lead. See discussion in next section, Use of blood lead data, for assessing differences between measured and predicted blood lead levels.

Thus, for mining-related sites without significant past smelting/mill activity, this interim directive encourages further research for characterizing the potential impact of particle size and speciation on soil bioavailability.

Site managers and risk assessors are cautioned that most areas impacted by mining activities are also associated with present or historical smelting or milling operations. Generalizations regarding distinct differences between mining and smelting or milling sites should be avoided until adequate site history and characterization are complete.

Use of blood lead data: In conducting Remedial Investigations (RIs) for CERCLA or RCRA Facility Investigations (RFIs) for RCRA Corrective Action, the interim directive recommends evaluating available blood lead data. In some cases, it may be appropriate to collect new or additional blood lead samples. In general, data from well-conducted blood lead studies of children on or near a site can provide useful information to both the risk assessor and site manager. However, the design and conduct of such studies, as well as the interpretation of results, are often difficult because of confounding factors such as a small population sample size. Therefore, any available blood lead data should be carefully evaluated by EPA Regional risk assessors to determine their usefulness. The Guidance Manual discusses how to evaluate observed blood lead survey data and blood lead data predicted by the IEUBK model.

The Guidance Manual recommends that blood lead data not be used alone either to assess risk from lead exposure or to develop soil lead cleanup levels. During its review of the IEUBK model, the SAB supported this position by asserting that site residents may temporarily modify their behavior (e.g., wash their children's hands more frequently) whenever public attention is drawn to a site. In such cases, this behavior could mask the true magnitude of potential risk at a site and lead to only temporary reductions in the blood lead levels of children. Thus, blood lead levels below 10 µg/dl are not necessarily evidence that a potential for significant lead exposure does not exist, or that such potential could not occur in the future.

Non-residential (adult) screening level. EPA also believes there is a strong need to develop a non-residential (adult) screening level. The IEUBK model is, however, not appropriate for calculating this screening level since it is designed specifically for evaluating lead exposures in children. At this time, EPA is considering a few options for developing this screening level. Several adult models have recently become available. Developing a screening level by using any of them is likely to require significant additional work by the Agency. This work might include testing, validation, and selection of one of the existing models or development of its own model, both of which would require a considerable amount of time. Consequently this would probably be a long-term option. A short-term option would be to develop a screening level based on a simple approach that approximates the more complicated biokinetics in humans. This can serve in the interim while more sophisticated adult lead exposure assessment tools can be identified or developed.

NOTICE: Users of this directive should bear in mind that the recommendations in this document are intended solely as guidance, and that EPA risk managers may act at variance with any of these recommendations where site-specific conditions warrant, as has been noted above. These recommendations are not intended, and cannot be relied upon, to create any rights, substantive or procedural, enforceable by any party in litigation with the United States, and may change at any time without public notice.

Because this document and the related Guidance Manual are not legally binding either upon EPA or other parties, Agency personnel should keep in mind if they are questioned or challenged in comments on a proposed remedial plan, such comments must be considered and a substantive explanation must be provided for whatever approach is ultimately selected. For example, while the IEUBK model is recommended here, its use is not a regulatory requirement and comments on the model or its use should be fully considered.

APPENDICES

Appendix A-1

Suggested Decision Logic for Residential Scenarios for CERCLA and RCRA Corrective Action

Step 1: Determine soil lead concentration at the site.

If soil lead is less than 400 ppm:
STOP, no further action is required, UNLESS special circumstances (such as the presence of wetlands, other areas of ecological risk, agricultural areas, shallow aquifers, or other areas of potentially high exposure) warrant further study.

If soil lead is greater than 400 ppm:
PROCEED to Step 2, UNLESS 400 ppm is selected as a cleanup goal based on consideration of all relevant risk management factors.

Step 2: Evaluate probable land use and develop exposure scenarios.

Step 3: Collect appropriate site-specific data based on selected scenarios.

For example, sampling data may include:

- Soil and dust (at a minimum), paint, water, and air,
- For unique site situations, data on speciation and particle size, and behavioral activities may be required.

Available blood lead data:

- If blood lead data are available, consult the Guidance Manual and Regional Risk Assessor.
- If blood lead data are not available, Regional Risk Assessors and site managers should consider the appropriateness of consulting a blood lead study to supplement available data.

Step 4: Run the IEUBK model with site-specific data to estimate risk and evaluate key exposure pathways at the site.

- If blood lead data are available, compare the data to the model results.

Step 5: Where risks are significant, evaluate remedial options.

If lead-based exterior or interior paint is the only major contributor to exposure, no Superfund action or RCRA corrective action is warranted.

If soil is the only major contributor to elevated blood lead, a response to soil contamination is warranted, but paint abatement is not.

If both exterior lead-based paint and soil are major contributors to exposure, consider remediating both sources, using alternative options as described in Appendix A-2.

If indoor dust levels are greater than soil levels, consider evaluating the contribution of interior lead-based paint to the dust levels. If interior lead-based paint is a major contributor, consider remediating indoor paint to achieve a greater overall risk reduction at a lower cost. (See Appendix A-2.)

NOTE: Available authority to remediate lead-based paint under CERCLA and RCRA is extremely limited.)

Step 6: If the IEUBK model predicts elevated blood leads, rerun the model using the site-specific parameters selected to reflect remedial options in Step 5 to determine site-specific PRGs or MCSs for soil.

Appendix A-2

Suggested Decision Logic for Lead-based Paint for CERCLA and RCRA Corrective Action

(If soil lead levels are below screening levels, lead-based paint could be addressed by authorities other than RCRA or CERCLA.)

If soil lead levels are above screening levels:

Step 1: Examine condition of exterior paint and determine its lead content, if any.

- If the paint is deteriorated, assess contribution or potential contribution of paint to elevated soil lead levels through speciation studies, structural equation modeling, or other statistical methods.

Step 2: Evaluate potential for recontamination of soil by exterior paint.

Step 3: Remediate exterior paint only in conjunction with soil.

- Determine appropriate remediation based on risk management factors (e.g., applying the nine criteria), remediating the major contributor first.

Step 4: Examine condition of indoor paint and determine its lead content, if any.

- If indoor dust lead concentration is greater than outdoor soil lead concentration (because of contamination from both interior paint and outdoor soil), remediate indoor dust (e.g., through a removal action, or making HEPA-VACS available to community).

Step 5: Once the risk from indoor paint has been assessed, examine options to abate indoor paint (e.g., PRP, State, local, HUD) and consult TSCA Section 403 program for additional information and/or guidance.

Step 6: While RCRA and CERCLA have very limited authority regarding the cleanup of interior paint, the remedy may take into account the reduction of total risk that may occur if interior paint is addressed by other means. Thus, for example, a Record of Decision (ROD) or Statement of Basis (SB) may recognize that interior lead-based paint is being addressed by other means, and narrow the response accordingly (possibly making this contingent on completion of the interior lead-based paint abatement effort).

Appendix B

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Appendix C

Relationship between the OSWER Soil Lead Directive and TSCA Section 403 Guidance

Since lead exposures occur through all media, a variety of Agency programs address lead under a number of statutes. Lead in soil is addressed under TSCA Section 403, the RCRA Corrective Action program, and CERCLA, each of which differs somewhat in the types of sites that apply and the types of standards that are used. These differences are primarily due to differences in the purposes of the programs and the authority granted by the statutes under which they are developed. Section 403 soil standards will apply only to residential soil and the current TSCA guidance is generic in nature, with the same standards applying on a nationwide basis. Given the wide applicability of Section 403, generic standards are used in the current guidance in order to reduce resource requirements, as compared to site-specific decisions which can involve expensive and time-consuming analyses. Required RCRA and CERCLA activities are determined on a site-specific basis. The agency's recommendations for evaluating RCRA Corrective Action and CERCLA sites are contained in the OSWER Interim Soil Lead Directive.

In all three of these programs, the Agency's approach is to consider soil lead in the context of other lead sources that may be present and contribute to the total risk. For example, TSCA Section 403 specifically requires the Agency to consider the hazards posed by lead-based paint and lead-contaminated interior dust, as well as lead-contaminated soil. Likewise, the OSWER Soil Directive includes evaluation of other lead sources at a site as part of site assessment / investigation procedures. In addition, the primary focus of the three programs is primary prevention -- the prevention of future exposures from the source(s) being remediated.

The fundamental difference between the relatively new TSCA Section 403 program and the RCRA Corrective Action and CERCLA cleanup programs is that, under current guidance the Section 403 program seeks to establish national standards to prioritize responses to lead hazards whereas the other two programs usually develop site-specific cleanup requirements. This is because TSCA Section 403 deals with a potentially huge number of sites, and resources for the investigation needed to accurately identify their risks are typically very limited. Therefore most decisions under Section 403 will be made with little or no regulatory oversight and clear generic guidelines will be more effective. The more established RCRA and CERCLA programs, on the other hand, deal with a much smaller number of sites, at which extensive site characterization will have been performed before cleanup decisions are made. In addition, these programs have well-established funding mechanisms.

Appendix D

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APPENDIX C
1998 OSWER Directive 9200.4-27P (‘Clarification’)

EPA/540/F-98/030
PB98-963244
OSWER Directive #9200.4-27P
August 1998

MEMORANDUM:
OSWER DIRECTIVE:
CLARIFICATION TO THE 1994 REVISED INTERIM SOIL LEAD (Pb) GUIDANCE FOR CERCLA SITES AND RCRA CORRECTIVE ACTION FACILITIES

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

NOTICE

This document provides guidance to EPA staff. It also provides guidance to the public and to the regulated community on how EPA intends to exercise its discretion in implementing the National Contingency Plan. The guidance is designed to implement national policy on these issues. The document does not, however, substitute for EPA's statutes or regulations, nor is it a 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.

MEMORANDUM

SUBJECT: Clarification to the 1994 Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities

FROM: Timothy Fields, Jr.
Acting Assistant Administrator

TO: Regional Administrators I-X

PURPOSE

This directive clarifies the existing 1994 Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities, OSWER Directive 9355.4-12. Specifically, this directive clarifies OSWER's policy on (1) using EPA's Science Advisory Board (SAB) reviewed Integrated Exposure Uptake Biokinetic Model (IEUBK) and blood lead studies, (2) determining the geographic area to use in evaluating human exposure to lead contamination ("exposure units"), (3) addressing multimedia lead contamination and (4) determining appropriate response actions at lead sites. The purpose for clarifying the existing 1994 directive is to promote national consistency in decision-making at CERCLA and RCRA lead sites across the country.

BACKGROUND

OSWER Directive 9355.4-12, issued on July 14, 1994 established OSWER's current approach to addressing lead in soil at CERCLA and RCRA sites. The existing directive established a streamlined approach for determining protective levels for lead in soil at CERCLA sites and RCRA facilities as follows:

- It recommends a 400 ppm screening level for lead in soil at residential properties;
- It describes how to develop site-specific preliminary remediation goals (PRGs) at CERCLA sites and media cleanup standards at RCRA Corrective Action facilities for residential land use; and,
- It describes a strategy for management of lead contamination at CERCLA sites and RCRA Corrective Action facilities that have multiple sources of lead.

The existing interim directive provides direction regarding risk assessment and risk management approaches for addressing soil lead contaminated sites. The OSWER directive states that, " ... implementation of this guidance is expected to provide more consistent decisions across the country ..." However, since that directive was released, OSWER determined that clarification of the guidance is needed. Key areas being clarified by issuance of this directive include: (1) using the IEUBK model and blood lead studies, (2) determining exposure units to be considered in evaluating risk and developing risk management strategies, (3) addressing multimedia lead contamination and (4) determining appropriate response actions at residential lead sites. The existing directive provides the following guidance on these areas:

1. The OSWER directive recommends using the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children (Pub. # 9285.7-15-1, PB93-963510) for setting site-specific residential preliminary risk-based remediation goals (PRGs) at CERCLA sites and media cleanup standards (MCSs) at RCRA corrective actions Facilities. The directive states that the IEUBK model is the best tool currently available for predicting the potential blood lead levels of children exposed to lead in the environment. OSWER's directive also recommends the evaluation of blood lead data, where available, and states that well-conducted blood lead studies provide useful information to site managers. The directive however recommends that "... blood lead data not be used <u>alone</u> to assess risk from lead exposure or to develop soil lead cleanup levels."

2. The directive describes OSWER's risk reduction goal as "...generally, OSWER will attempt to limit exposure to soil lead levels such that a typical (or hypothetical) child or group of similarly exposed children would have an estimated risk of no more than 5% of exceeding a 10 ug/dl blood lead level." The directive also states that "... EPA recommends that a soil lead concentration be determined so that a typical child or group of children exposed to lead at this level would have an estimated risk of no more than 5% of exceeding a blood lead of 10 ug/dl." OSWER generally defines an exposure unit as a geographic area where exposures occur to the receptor of concern during the time of interest and believes that for a child or group of similarly exposed children, this is typically the individual residence and other areas where routine exposures are occurring.

3. The directive recommends that risk managers assess the contribution of multiple environmental sources of lead to overall lead exposure (e.g., consideration of the importance of soil lead levels relative to lead from drinking water, paint, and household dust) which promotes development of risk reduction strategies that address all sources that contribute significantly to exposure.

4. The OSWER directive states that the IEUBK model is not the only factor to be considered in establishing lead cleanup goals. Rather, the IEUBK model is the primary risk assessment tool available for evaluating lead risk and the results of the model are used to guide selection of appropriate risk management strategies for each site.

Since the OSWER directive was issued in 1994, there has been a trend toward a more consistent approach to managing risk at residential lead sites, however, OSWER was interested in identifying areas requiring additional clarification to facilitate more effective implementation of the directive. As a first step in the process, meetings were held with various EPA Regions, States and local governments to discuss how the directive has been implemented nationally at lead sites since 1994. By participating in these meetings and by reviewing the decisions that are being made across the country, OSWER believed that clarification of certain aspects of the 1994 directive would be useful.

All of the documents and guidance referenced in this directive are available through the National Technical Information Service (NTIS) at 703-605-6000 or could be downloaded electronically from: http//epa.gov/superfund/oerr/ini_prod/lead/prods.htm.

OBJECTIVE

At lead contaminated residential sites, OSWER seeks assurance that the health of the most susceptible population (children and women of child bearing age) is protected and promotes a program that proactively assesses and addresses risk. OSWER believes that predictive tools should be used to evaluate the risk of lead exposure, and that cleanup actions should be designed to address both current and potential future risk.

While health studies, surveys, and monitoring can be valuable in identifying current exposures and promoting improved public health, they are not definitive tools in evaluating potential risk from exposure to environmental contaminants. In the case of lead exposure, blood lead monitoring programs can be of critical importance in identifying individuals experiencing potential negative health outcomes and directing education and intervention resources to address those risks. However, CERCLA §121(b) requires EPA to select cleanup approaches that are protective of human health and the environment and that utilize permanent solutions to the maximum extent practicable. To comply with the requirements set forth in CERCLA § 121(b), OSWER will generally require selection of cleanup programs that are proactive in mitigating risk and that do not simply rely on biological monitoring programs to determine if an exposure has already occurred.

To meet these objectives, OSWER will seek actions that limit exposure to soil lead levels such that a typical child or group of similarly exposed children would have an estimated risk of no more than 5% of exceeding a 10 µg/dl blood lead level. If lead is predicted to pose a risk to the susceptible population, OSWER recommends that actions be taken to significantly minimize or eliminate this exposure to lead.

The principles laid out in the **four attached fact sheets** (Appendix) support OSWER's goals by encouraging appropriate assessment and response actions at CERCLA and RCRA lead sites across the country.

This clarification directive emphasizes the following key messages regarding the four areas and encourages the users of this directive, be they EPA Regions, States, or other stakeholders, to adopt these principles in assessing and managing CERCLA and RCRA lead sites across the country. The critical elements of the attached papers are as follows:

I. Using Blood Lead Studies and IEUBK Model at Lead Sites:

OSWER emphasizes the use of the IEUBK Model for estimating risks for childhood lead exposure from a number of sources, such as soils, dust, air, water, and other sources to predict blood lead levels in children 6 months to 84 (7 years) months old. The 1994 directive also recommended evaluation of available blood lead data and stated that data from a well-conducted blood lead study of children could provide useful information to site managers. In summary, OSWER's clarification policy on the appropriate use of the IEUBK and blood lead studies is that:

- OSWER recommends that the IEUBK model be used as the primary tool to generate risk-based soil cleanup levels at lead sites for current or future residential land use. If Regions propose an alternative method for generating cleanup levels, they are required to submit their approach to the national Lead Sites Consultation Group (LSCG)[1] for review and comment ;

- Response actions can be taken using IEUBK predictions alone; blood lead studies are not required; and

- Blood lead studies and surveys are useful tools at lead sites and can be used to identify key site-specific exposure pathways and to direct health professionals to individuals needing immediate assistance in minimizing lead exposure; however, OSWER recommends that blood lead studies not be used for establishing long-term remedial or non-time-critical removal cleanup levels at lead sites.

II. Determining Exposure and Remediation Units at Lead Sites

OSWER recommends that cleanup levels at lead sites be designed to reduce risk to a typical or individual child receiving exposures at the residence to meet Agency guidelines (*i.e.*, no greaterthan a 5% chance of exceeding a 10 ug/dl blood-lead level for a full-time child resident). Therefore, it is recommended that risk assessments conducted at lead-contaminated residential sites use the individual residence as the primary exposure unit of concern. This does not mean that a risk assessment should be conducted for every yard, rather that the soil lead contamination

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[1]The Lead Sites Consultation Group (LSCG) is comprised of senior management representatives from the Waste Management Divisions in all 10 EPA regions along with senior representatives from the Office of Emergency and Remedial Response in EPA headquarters. The LSCG is supported by EPA's Technical Review Workgroup (TRW) for lead and the national Lead Sites Workgroup (LSW). The TRW consists of key scientific experts in lead risk assessment from various EPA Regions, labs and headquarters. The LSW is comprised of senior Regional Project Managers from various Regions and key representatives from headquarters who are experienced in addressing lead threats at Superfund sites.

data from yards and other residential media (for example, interior dust and drinking water) should be input into the IEUBK model to provide a preliminary remediation goal (PRG) for the residential setting. When applicable, potential exposure to accessible site-related lead sources outside the residential setting should also be evaluated to understand how these other potential exposures contribute to the overall risk to children, and to suggest appropriate cleanup measures for those areas.

III. Addressing Multimedia Contamination at Lead Sites

EPA generally has limited legal authority to use Superfund to address exposure from **interior lead-based paint**. As a policy matter, OSWER recommends that such exposures not be addressed through actual abatement activities. However, EPA Regions should promote addressing interior paint risks through actions by others (e.g., potentially responsible parties (PRPs), other government programs, etc.) as a component of an overall site management strategy. Because of other competing demands on the Superfund Trust Fund, OSWER recommends that EPA Regions avoid using the Superfund Trust Fund for removing **exterior lead-based paint** and soil contaminated from lead-based paint. Superfund dollars *may* however be used in limited circumstances to remediate exterior lead-based paint in order to protect the overall site remedy (i.e., to avoid re-contamination of soils that have been remediated) but generally only after determining that other funding sources are unavailable. As with interior lead-based paint abatement, EPA Regions should promote remediation of exterior lead-based paint by others, such as PRPs, local governments or individual homeowners.

IV. Determining Appropriate Response Actions at Lead Sites

In selecting site management strategies, it is OSWER's preference to seek early risk reduction with a combination of engineering controls (actions which permanently remove or treat contaminants, or create reliable barriers to mitigate the risk of exposure) and non-engineering response actions. All potential lead sources should be identified in site assessment activities. Non-engineering response actions, such as education and health intervention programs, should be considered an integral part of early risk reduction efforts because of their potential to provide immediate health benefits. In addition, engineering controls should be implemented early at sites presenting the greatest risk to children and other susceptible subpopulations.

As a given project progresses, OSWER's goal should be to reduce the reliance on education and intervention programs to mitigate risk. The goal should be cleanup strategies that move away from reliance on long-term changes in community behavior to be protective since behavioral changes may be difficult to maintain over time. The actual remedy selected at each CERCLA site must be determined by application of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (55 FR 8666- 8865, March 8, 1990) remedy selection criteria to site-specific circumstances. This approach also recognizes the NCP preference for permanent remedies and emphasizes selection of engineering over non-engineering remedies for long-term response actions.

This directive clarifies OSWER's policy on four key issue areas addressed in the 1994 OSWER soil lead directive in order to promote a nationally consistent decision-making process for assessing and managing risks associated with lead contaminated sites across the country. The policy presented in these specific issue areas supersedes all existing OSWER policy and directives on these subjects. No other aspects of the existing 1994 directive are affected.

IMPLEMENTATION

The principles laid out in this directive (which includes the four attached factsheets) are meant to apply to all residential lead sites currently being evaluated through the CERCLA Remedial Investigation/Feasibility Study process and all future CERCLA Sites and RCRA Corrective Action Facilities contaminated with lead. The Regions will be required to submit their rationale for deviating from the policies laid out in this directive to the Lead Sites Consultation Group. This directive does not apply to previous remedy selection decisions.

Attachments

cc: Waste Management Policy Managers (Regions I-X)
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Elizabeth Cotsworth, OSW
James Woolford, FFRRO
Barry Breen, OSRE
Larry Reed, OERR
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Murray Newton, OERR
Betsy Shaw, OERR
John Cunningham, OERR
Paul Nadeau, OERR
Bruce Means, OERR
Earl Salo, OGC

NOTICE: This document provides guidance to EPA staff. The document does not, however, substitute for EPA's statutes or regulations, nor is it a 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.

Appendix
OSWER Directive # 9200.4-27P
August 1998

Factsheet: Using the IEUBK Model and Blood Lead Studies at Residential Lead Sites

Question: What is OSWER's policy on using the IEUBK model and blood-lead studies in conducting risk assessments and setting cleanup standards at residential lead contamination sites?

Answer: OSWER's policy on using the IEUBK model and blood-lead studies in conducting risk assessment and setting cleanup standards is as follows:

A. <u>Use of the IEUBK Model:</u>

1. The IEUBK model is a good predictor of potential long-term blood-lead levels for children in residential settings. OSWER recommends that the IEUBK model be used as the primary tool to generate risk-based soil cleanup levels at lead sites for current or future residential land use. If Regions propose an alternative method for generating cleanup levels, they are required to submit their approach to the National Lead Sites Consultation Group (LSCG) for review and comment.

2. Blood-lead distributions predicted by the IEUBK model illustrate a plausible range of variability in children's physiology, behavior, and household conditions.

3. Response actions can be taken, and remedial goals developed, using IEUBK predictions alone.

B. <u>Use of Blood-Lead Studies/Data:</u>

1. Blood-lead studies, surveys, and monitoring are useful tools at lead sites and can be used to help identify key site-specific exposure pathways and direct health professionals to individuals needing immediate assistance in minimizing lead exposure.

2. The utility of blood lead testing results and studies depends on how representative the information is of the population being evaluated, the design of the data collection, and the quality of the laboratory analysis. To this end, OSWER recommends that EPA Regions consult with ATSDR or CDC to assess or design studies according to their intended use.

3. Many blood-lead screening, monitoring, or testing programs differ from blood lead studies in that they do not attempt to identify risk factors for childhood exposure to lead sources. Although these programs may be extremely beneficial in identifying children with elevated blood lead levels and identifying candidates for referral to medical professionals for evaluation, they may not provide an accurate representation of community-wide exposure.

4. Well-designed blood lead studies may be used to identify site specific factors and pathways to be considered in applying the IEUBK model at residential lead sites. However, OSWER recommends that blood-lead studies not be used to determine future long-term risk where exposure conditions are expected to change over time; rather, they should be considered a snapshot of ongoing exposure under a specific set of circumstances (including community awareness and education) at a specific time. Long-term studies may be helpful in understanding exposure trends within a community and evaluating the effectiveness of cleanup strategies over time.

C. IEUBK and Blood-Lead Studies/Data:

1. Blood-lead data and IEUBK model predictions are expected to show a general concordance for most sites. However, some deviations between measured and predicted levels are expected. On some occasions, declines in blood-lead levels have been observed in association with lead exposure-reduction and health education. However, long-term cleanup goals should be protective in the absence of changes in community behavior as there is little evidence of the sustained effectiveness of these education/intervention programs over long periods of time.

2. Where actual blood-lead data varies significantly from IEUBK Model predictions, the model parameters should not automatically be changed. In such a case, the issue should be raised to the Lead Technical Review Workgroup (TRW) to further identify the source of those differences. Site work need not be put on hold while the issue is being reviewed by the TRW; the site manager should review other elements of the lead directive and the "Removal Actions at Lead Sites" guidance to determine appropriate interim actions to be taken at the site.

The Regions will be required to submit their rationale for deviating from the policies laid out in this factsheet to the Lead Sites Consultation Group.

Factsheet: Determining Exposure and Remediation Units at Residential Lead Sites

Question: How does OSWER define an exposure unit, and subsequently apply this definition in conducting risk assessment and risk management activities at residential lead sites?

Answer: OSWER recognizes that defining and characterizing exposure unit(s) for a site is critically important in undertaking risk assessment activities and in designing protective cleanup strategies. An **exposure unit** is defined as a geographic area where exposures occur to the receptor of concern during the time of interest and that for a child, or group of similarly exposed children, this is typically the individual residence and other areas where chronic or ongoing exposures are occurring.

Various approaches to characterizing and managing risks by exposure units have been examined by OSWER. OSWER recognizes that lead ingestion can also cause adverse health effects in adults and fetuses but believes that by adequately limiting lead exposures to young children at residential sites, these other receptors will generally be likewise protected from adverse health impacts.

EPA's goal is to protect human health and the environment under current and future exposure scenarios. At lead sites, OSWER wants to assure that children's health is protected and promotes a program that proactively assesses risks rather than relying on biological monitoring to determine if an exposure has already occurred. OSWER emphasizes actions be taken at lead sites that will minimize or eliminate exposure of children to environmental lead contamination.

To achieve the above stated goal, OSWER recommends characterizing **exposure units as exposure potential at the individual residence as the primary unit of concern for evaluating potential risk at lead contaminated residential sites**. This recognizes that there are children whose domain and activities occur principally within the confines of a particular residential property. For determining exposure potential (and ultimately developing protective cleanup levels) at the individual home, OSWER recommends the scenario to be evaluated (through use of the IEUBK Model) would be a young child in full-time residence. This approach helps achieve OSWER's recommended health protection goal that an individual child or group of similarly exposed children would have <5% chance of exceeding a blood-lead concentration of 10 ug/dl. In designing community wide cleanup strategies, it is essential that non-residential areas (e.g., parks, day care facilities, playgrounds, etc.), where lead exposure may occur, also be characterized with respect to their contribution to soil-lead exposure, and appropriate cleanup actions implemented.

OSWER recommends that risk management decisions for response to residential lead contamination sites focus on reducing risk at residences, but also recommends that response strategies be developed for other site locations (exposure units) where children receive exposure. Flexibility in determining appropriate response actions that provide protection at the individual residence should be considered in context of the NCP remedy selection criteria. The lead exposure issues are complex and OSWER recommends that EPA Regions try to communicate clearly the risk characterization and risk management decisions to the site residents. Affected communities must clearly understand the context of risk management decisions, how these decisions affect the health of their children, and how cleanup actions will influence the future growth and development of the community.

The Regions will be required to submit their rationale for deviating from the policies laid out in this factsheet to the Lead Sites Consultation Group.

Factsheet: Addressing Multimedia Contamination at Residential Lead Sites

Question: What is OSWER's policy on addressing multimedia contamination at residential lead sites?

Answer: OSWER recognizes that several sources of lead-contamination, including soil, ground water, airborne particulates, lead plumbing, interior dust, and interior and exterior lead-based paint may be present at Superfund sites where children are at risk or have documented lead exposure. These lead sources may contribute to elevated blood-lead levels and may need to be evaluated in determining risks and cleanup actions at residential lead sites. However, there are limitations on the Agency's statutory authority under CERCLA to abate some of these sources, such as indoor lead-based paint and lead plumbing because CERCLA responses may be taken only to releases or threatened releases into the environment (CERCLA §104 (a)(3) and (4)).

When EPA's resources, or authority to respond or to expend monies under Superfund is limited, OSWER recommends that EPA Regions identify and coordinate to the greatest extent possible with other authorities and funding sources (e.g., other federal agencies and state or local programs). EPA Regions should coordinate with these other authorities to design a comprehensive, cost-effective response strategy that addresses as many sources of lead as practicable. These strategies should include actions to respond to lead-based paint, interior dust, and lead plumbing, as well as ground water sources and lead-contaminated soil.

Although OSWER will encourage that EPA Regions fully cooperate in the development of a comprehensive site management strategy, OSWER realizes that complete active cleanup of these other sources may be difficult to complete due to limited funding available to other authorities. Since complete cleanups of these sources is not guaranteed, and at most sites may be unlikely, OSWER recommends that the soil cleanup levels not be compromised. In other words, the soil cleanup levels should be calculated with the IEUBK model using existing pre-response action site specific data. This is due to the fact that soil cleanup levels at residential lead sites are generally established to protect individuals, from excess exposures to soils, and house dust attributable to those soils, and are not attributable to exposure to other sources such as interior lead paint which should be managed on a residence specific basis. Remediation of non-soil lead sources to mitigate overall lead exposure at individual residences should therefore not be used to modify sitewide soil lead cleanup levels.

The recommendations provided below represent OSWER's policy on addressing lead-contaminated media and/or sources for which EPA has limited or no authority to remediate.

Interior Paint: EPA has limited legal authority to use Superfund to address exposure from interior lead-based paint. As a policy matter, OSWER recommends that such exposures not be addressed through actual abatement activities. However, EPA Regions should promote addressing interior paint risks through actions by others, such as HUD, local governments, or individual home owners as a component of an overall site management strategy. Any activities to clean up interior lead-based paint by PRPs or other parties should not result in an increase of the risk-based soil cleanup levels.

Exterior Paint: Because of other competing demands on the Superfund Trust Fund, OSWER recommends that EPA Regions avoid using the Superfund Trust Fund for removing exterior lead-based paint and soil contaminated from lead-based paint. Superfund dollars *may* be used to respond to exterior lead-based paint for protecting the overall site remedy (i.e., to prevent re-contamination of soils that have been remediated) but only after determining that other funding sources are unavailable. Where other sources of funding are not available, EPA may utilize the CERCLA monies to remediate exterior lead-based paint on homes/buildings, around which soil contaminated by other sources has been cleaned up to prevent recontamination of the soil. The Superfund should not be used to remediate exterior lead-based paint where no soil cleanup has occurred. As with interior lead-based paint abatement, EPA Regions should promote remediation of exterior lead-based paint by others, such as PRPs, local governments or individual homeowners. Cleanup activities of exterior paint conducted by PRPs or other parties should not result in an increase of the risk-based soil cleanup levels.

Interior Dust: Lead contaminated interior dust can be derived from several sources, including interior paint, home owner hobbies, exterior soil, and other exterior sources. In many cases, it may be difficult to differentiate the source(s) for the lead contamination in the dust. In general, EPA Regions should refrain from using the Superfund Trust Fund to remediate interior dust. Because of the multi-source aspects of interior dust contamination, potential for recontamination, and the need for a continuing effort to manage interior dust exposure, OSWER recommends the use of an aggressive health education program to address interior dust exposure. Such programs, administered through the local health department (or other local agency), should be implemented in conjunction with actions to control the dust source. At a minimum, the program should include blood-lead monitoring, and personal hygiene and good housekeeping education for the residents. OSWER believes that EPA Regions can also support the program by providing HEPA vacuums to the health agency for use in thoroughly cleaning home interiors.

Lead Plumbing: Generally CERCLA does not provide for legal authority to respond to risks posed by lead plumbing within residential dwellings. It should be noted that the water purveyor is responsible for providing clean water to the residences. As with interior dust, OSWER recommends that EPA Regions coordinate with local agencies to establish a health education program to inform residents of the hazards associated with lead plumbing and how to protect themselves by regularly flushing, or preferably, replacing lead pipes. Soil cleanup levels should not be adjusted to account for possible remediation of lead plumbing.

Factsheet: Determining Appropriate Response Actions at Residential Lead Sites

Question: What is OSWER's position on the appropriate use of engineering and non-engineering response actions in developing risk management strategies for lead sites?

Answer: One goal emphasized in the recent third round of Superfund Reforms is for EPA to take a consistent approach in selecting and implementing both long- and short-term response actions at lead sites in all regions. One obstacle to achieving this consistency has been differing degrees of reliance on non-engineering response actions in reducing risk.

Site management strategies at lead sites typically include a range of response actions. Alternatives range from engineering controls that permanently remove or treat the contaminant source to non-engineering response actions, such as educational programs and land use restrictions. This continuum represents the range of response options available to risk managers. This position paper clarifies the relationship between engineering and non-engineering response actions in developing site management strategies.

In selecting site management strategies, OSWER's policy will be to seek early risk reduction with a combination of engineering controls (actions which permanently remove or treat contaminants, or which create reliable barriers to mitigate the risk of exposure) and non-engineering response actions. All potential lead sources should be identified in site assessment activities. Non-engineering response actions, such as education and health intervention programs, should be considered an integral part of early risk reduction efforts due to their potential to provide immediate health benefits.[2] In addition, engineering controls should be implemented early at sites presenting the greatest risk to children and other susceptible subpopulations. Community concerns should receive a high priority in site decision-making; local support is vital to the success of health intervention and education programs.

As the project progresses, OSWER's goal should be to reduce reliance on education and intervention programs to mitigate risk. The goal should be cleanup strategies that move away from reliance on long-term changes in community behavior to be protective; behavioral changes

[2]The actual effectiveness of health intervention and educational programs in reducing risk continues to be a subject of discussion. Anecdotal information suggests that such programs can provide short-term benefits in some populations. Rigorous statistical studies demonstrating the benefits of educational programs in preventing lead exposure are lacking. It is generally recognized that not all segments of the population will be influenced by such programs, and that long-term benefits are less certain. Local support for such programs is critical. The active (and long-term) participation of local and state public health agencies is needed in implementing institutional controls, including health intervention and education programs; without local implementation of such programs their success is uncertain. Additional research on the effectiveness of these programs is critical to consideration of their use in future cleanups.

may be difficult to maintain over time. The actual remedy selected at each site must be determined by application of the NCP remedy selection criteria to site-specific circumstances. However, this approach recognizes the NCP preference for permanent remedies and emphasizes the use of engineering controls for long-term response actions. This approach also recognizes that well-designed health intervention and education programs, when combined with deed restrictions and/or other institutional controls, may be appropriate for reducing future exposure potential and may supplement engineering controls.

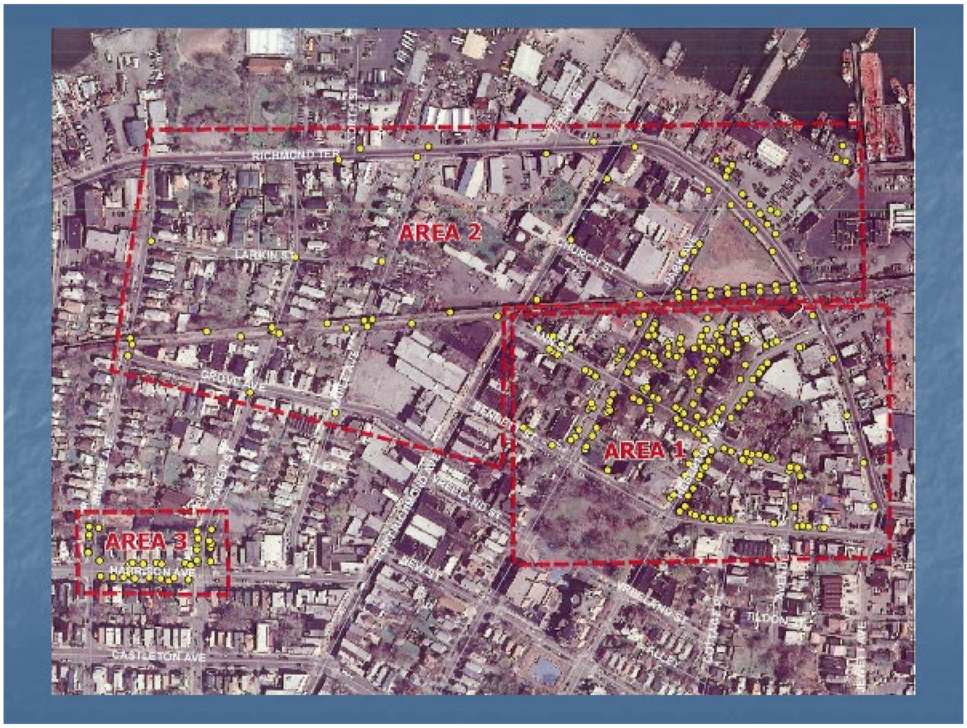
In instances where Regions believe that the use of engineering controls is impracticable, and education, health intervention, or institutional controls are proposed as the sole remedy, Regions will be required to consult with the LSCG.

APPENDIX D
Lead Source Attribution Case Study

APPENDIX D

Lead Source Attribution Case Study

JEWETT WHITE LEAD–SITE - STATEN ISLAND, NY



Area 1 = Residential; Area 2 = Jewett White Lead Facility/Mixed Use; Area 3 = Background

Site History: Lead substrates were stored and converted onsite into a product known as white-lead for paint pigments. The Jewett White Lead site consists of the historic footprint of the former Jewett White Lead Company facility and extent of contamination that includes a 1.07-acre parcel of land (2000-2012 Richmond Terrace) and 4.41-acre parcel of land (2015 Richmond Terrace). In 2009, EPA selected Port Richmond and adjoining neighborhoods as a nationally-designated Environmental Justice Showcase Community. This effort seeks to bring together governmental and non-governmental organizations and pools their collective resources and expertise on the best ways to achieve real results in communities.

Removal/Remedial Decision: A non-time-critical removal action of excavating lead-contaminated soil of a portion of the 2000-2012 Richmond Terrace parcel of the Jewett White former facility. Key lines of evidence including isotopic analysis concluded that the lead in soils in the surrounding community was predominantly from other sources than the Jewett White Lead site.

Sampling Results:

Background samples were collected ¼ mile upwind along the road and grass patches. The background levels are higher on average than the samples collected closer to the site. However, statistically the lead content of the soils samples are the same at all depths.

Residential soil lead concentrations ranged from 11.4 ppm to 3,510 ppm.

Sampling Depth	Average Lead Concentration	Location
0 – 2”	778 ppm	Background
2 – 6”	792 ppm	Background
6 – 12”	352 ppm	Background
0 – 2”	549 ppm	Residential
0 – 2”	666 ppm	Near Area 2 (grass)
2 – 6”	663 ppm	Near Area 2 (grass)
6 – 12”	546 ppm	Near Area 2 (grass)
0 – 2 “	171 ppm	Road Grit
0 – 2”	1,039 ppm	Train Trestle

Soil samples were collected from the drip-line if lead-based paint was present on homes. The soil lead concentrations ranged from **2,340 ppm** to **3,510 ppm**.

Key Evidence Supporting EPA’s Decision:

Spatial Distribution

The geographic distribution of lead across the area. The concentration of lead would be elevated near the source of the release and decline as you move further from the source. There was no spatial distribution in the residential properties. Elevated lead levels were associated with lead-based paint.

Background Results

The average background concentrations and the concentrations detected in a six block area surrounding the site are similar.

Lead-Based Paint on Homes

Highest levels detected were found in the drip line of the homes. Lead-based paint was detected at most of homes.

Urban Soil Studies

Studies in several urban areas have similar lead concentrations as the Jewett White Lead Site.

Elemental Correlation

Strong relationship observed between lead and other metals in on-site samples. Different relationships observed in off-site samples. Barium/lead ratio for on-site samples is considerably higher than in off-site samples. Manganese/lead ratio exists in on-site samples and not in off-site samples.

Lead Isotope Ratios ("fingerprinting")

The lead in the background and residential property samples are different from the lead on the Jewett White samples. The results appear that the lead in the background and community is predominantly from other environmental sources and not the site. The off-site lead fingerprint is similar to urban lead fingerprinting typically seen in the industrialized North East US.

APPENDIX E
Blood Lead Concentrations

BLOOD LEAD MONITORING

The IEUBK model was designed to predict typical blood lead concentrations representative of a population of young children exposed to environmental concentrations of lead. Representative site-specific data that are predictive of the entire exposed population are essential to accurately reflect the current or potential future conditions. The most common site-specific data collected during site characterization are media-specific lead concentration (*e.g.*, air, water, soil, dust) and soil or dust lead bioavailability of lead in soil.

EPA recommends collection of representative environmental data to support remedial decisions (U.S. EPA, 2003a, 1998a, 1994a), but EPA does not require blood lead information to list a site on the NPL or to take action at a lead site under the Superfund program. Blood lead information at Superfund sites may supplement the environmental data and can be useful in prioritizing response actions.

The IEUBK model predicts likely blood lead levels from current or potential exposure and helps to prevent elevated blood lead now or in the future. Because opportunistic monitoring typically associated with childhood lead poisoning prevention screening is not typically designed as a statistical sample of blood lead in a community, blood lead data from opportunistic monitoring are not typically included quantitatively in the Superfund site characterization. Information regarding blood lead is more appropriately used for public health monitoring, identifying children at risk, and public health interventions (*e.g.*, medical follow up, education and outreach efforts), than for site assessment or risk assessment. Blood lead level information may be acquired from state or local health departments. Such data are often collected for public health monitoring. Blood lead information complements EPA's risk assessment process (see Yeoh et al., 2012) when paired with representative, site-specific environmental data, and can be effectively used at Superfund sites by:

- **Identifying individual children with elevated blood lead concentrations for public health intervention.** Blood lead data that can be paired with environmental sampling information from site-specific investigations may be useful in identifying individual children at risk (U.S. EPA, 1998a). This is most effective when blood lead data are collected at the time when blood lead levels peak for the population of interest, which may be in the late summer months, when blood lead concentrations in children are highest in many communities with lead-contaminated soil (Zahran et al., 2013a; Laidlaw et al., 2012; U.S. EPA, 1995a,b). It may be possible to acquire this information from state or local health departments.

- **Prioritizing cleanup actions at lead contaminated sites.** Blood lead data can be helpful in prioritizing Time-Critical Removal Actions (TCRA) at those residences with children or women of child-bearing age (U.S. EPA, 1998a) and in identifying specific residential areas that do not warrant immediate action.

- **Identifying site-specific demographic and exposure variables, sources of lead exposure and pathways of exposure, and informing decisions for additional sampling of environmental media.** Blood lead information can potentially identify other sources of lead exposure. These other sources of lead exposure may include occupational "take home" exposures such as crafts or lead-based paint.

- **Identifying trends in exposure from longitudinal studies, and support community education needs to mitigate exposures.** Longitudinal blood lead studies that are implemented over time may help identify exposure trends within a community and can assess the effectiveness of the cleanup and other intervention strategies (U.S. EPA, 2003a, 1998a). If there is interest in assessing the effectiveness of the remedy, a study designed to meet this objective is necessary and consultation with CDC and ATSDR, and Pediatric Environmental Health Specialty Units (PEHSUs), as well as the state or local health districts with respect to planning and funding such a program, is strongly recommended.[1] When designing such studies, it is important to ensure that EPA will have access to the blood lead sampling results so that the results can be paired with environmental sampling results.

Blood lead monitoring is temporal and can be expected to vary with the season and current exposure conditions. In general, on-going blood lead testing would generally be done under other authorities and no part of the CERCLA response.

SAMPLE COLLECTION AND ANALYTICAL CONSIDERATIONS

Blood lead monitoring/screening programs are generally not implemented by EPA, but specific EPA Regions have provided funding in the past through a grant to the state or local health department. Blood lead surveillance programs are more typically operated and overseen by the CDC, state or local health departments.[2] CDC has issued screening and case management guidelines for increasing intensity of health intervention activities based on blood lead results (see http://www.cdc.gov/nceh/lead/publications/#screening). EPA (2003a) recommends close collaboration among the involved agencies and with ATSDR to properly implement monitoring at Superfund sites. Additionally, CDC's National Center for Environmental Health (NCEH) and

[1] The project team should consult with their regional human subjects research point of contact or the EPA's Human Subjects Research Review Official (HSRRO) prior to designing a blood lead study at a Superfund site. The regional human subjects research point of contact and the HSRRO can ensure EPA's responsibilities pertaining to Human Subjects Research as specified in the Common Rule (40 CFR 26) and the Policy and Procedures on Protection of Human Subjects in EPA Conducted or Supported Research (EPA Order 1000.17 Change A1) are met.

[2] U.S. Department of Health and Human Services, through CDC, provides grants to support childhood lead poisoning prevention programs. These grants, mainly to support secondary prevention efforts, are provided to state and local health departments. The NCEH also oversees CDC's Healthy Homes and Lead Poisoning Program by providing grants and technical assistance for states to develop laboratory-based monitoring systems to determine blood lead concentrations in children (see http://www.cdc.gov/nceh/information/about.htm for more information.

many state and local health departments have ongoing blood lead screening, as well as health education programs. Information from site-specific or targeted blood lead monitoring at contaminated sites is valuable for targeting follow-up health education to individual families with children identified as having elevated blood lead levels and determining the area and demographic extent of elevated blood lead levels under other authorities from CERCLA.

Where local or state screening programs are not anticipated, working with state health and social service agencies and local health care providers may support additional targeted blood lead screening. In identified high risk areas, targeted blood lead screening of children may also be recommended and funded as part of Early and Periodic Screening Diagnostic and Testing Service under Medicaid (Wengrovitz and Brown, 2009). Further information is available at https://www.medicaid.gov/medicaid/benefits/epsdt/index.html.

The World Health Organization (WHO) has developed collection and analysis protocols for blood lead surveys (WHO, 2011). In 2012, CDC adopted ACCLPP's recommendations to eliminate the term "level of concern" and use a blood lead reference value (BLRV) that is based on the 97.5th percentile of the NHANES blood lead distributions in children from one to five years of age (CDC, 2012).[3] In 2012, the BLRV was established using the 2007–2010 NHANES data and the 97.5th percentile was equal to 5 µg/dL. In 2021, the evaluation of 2015-2016 and 2017-2018 NHANES data established an updated BLRV of 3.5 µg/dL.

UNCERTAINTIES AND LIMITATIONS

Blood lead data from public health surveys or opportunistic monitoring are generally inappropriate for risk assessment, and such data generally should not be used to predict blood lead concentrations in future populations,[4] for estimating IEUBK model parameters (including GSD), for evaluating IEUBK model predictions,[5] or for empirical comparison with the IEUBK model predictions because of the following characteristics of blood lead surveys:

[3] NHANES is a continuous program that is designed to assess the health and nutritional status of children and adults in the United States (http://www.cdc.gov/nchs/nhanes.htm). NHANES is the only source of periodic nationally-representative data on blood lead concentrations in the U.S. population. Data from the NHANES are used to track trends in blood lead concentrations, identify high-risk populations, and support regulatory and policy decisions. In the context of childhood blood lead concentrations in the United States, NHANES data provides an appropriate source for characterizing a reference value for in children 1–5 years old (CDC, 2012).

[4] Blood lead survey data represent a snapshot in time and may not necessarily represent future risks (which are a component of remedial decision making for Superfund); it is not recommended that blood lead concentration data be used to establish long-term remedial or non-time-critical removal cleanup goals (U.S. EPA, 1998a).

[5] It is generally not recommended that the results of a community blood lead surveys be used to evaluate or adjust specific IEUBK model parameters. Statistical models relating community blood lead concentrations data to community media exposures are highly complex (*e.g.,* Lanphear et al., 1998; Succop et al., 1998) and, as a result, attributing differences between predicted and observed blood lead concentrations to specific IEUBK model parameters will be accompanied with large uncertainties.

(5) Blood lead surveys are typically cross-sectional and single events, and provide a snapshot of current exposures that may not necessarily represent past or future site conditions or risks.[6] Results do not represent temporal variability (*e.g.*, seasonality) in individual or population blood lead concentration (Zahran et al., 2013a; Laidlaw et al., 2012; U.S. EPA, 1995a,b; David et al., 1982; Rabinowitz et al., 1974). In this regard, it is recommended that blood lead data not be used to establish long-term remedial or non-time-critical removal cleanup goals (U.S. EPA, 1998a). Blood lead studies are more representative if they are repeated for several years.

(6) Blood lead surveys typically lack paired environmental exposure data (*i.e.*, dust and soil lead concentrations collected at the same time and from the residences of those individuals in the blood lead survey). In most cases, health agencies do not include EPA in their consent forms so that blood lead information can be paired with environmental sampling information that is needed to evaluate the association between environmental and blood lead. Moreover, because of the interpersonal variability in exposure frequency for various media, it is expected that blood lead will differ among and between individuals, even under the same environmental conditions.

(7) Blood lead surveys are voluntary rather than based on a statistically random selection study design and may not represent the entire population of children at the site.[7] Typically, voluntary blood lead surveys do not achieve sufficient participation for detecting the occurrence of occasional sub-locations where risk may be elevated, even if average risks are not above a target blood lead level.

Well-designed blood lead studies that attempt to pair environmental and blood lead data and use statistically proven techniques may be initiated and funded by EPA if the project team believes that the data will inform site decisions. However, due to the difficulties in designing and interpreting blood lead studies, consultation and collaboration with CDC, ATSDR and PEHSUs is recommended.

In the event that EPA contributes to funding blood lead studies, the project team should consult with their regional human subject's research point of contact or the Agency's Human Subjects Research Review Official (HSRRO) prior to designing a blood lead study at a Superfund site. The regional human subjects research point of contact and the HSRRO can ensure EPA's responsibilities pertaining to Human Subjects Research as specified in the Common Rule (40 CFR 26) and the Policy and Procedures on Protection of Human Subjects in U.S. EPA Conducted or Supported Research (U.S. EPA Order 1000.17 A) are met. In addition, Institutional

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[6] By contrast, IEUBK modeling can be used to predict future blood lead concentrations (White et al., 1998).

[7] Blood lead surveys do not accurately reflect the impact of education and awareness of lead exposure on blood lead concentrations in a community. However, there are exceptions, such as states where blood lead sampling is required by state law for young children.

Review Board approval and survey approval by the Office of Management and Budget (OMB, 2006) may be necessary.

APPENDIX F
Access Consent Forms

Prior to conducting any sampling or cleanup activities at a residential property, written consent is generally needed from the property owner; access obtained from tenants or renters is not sufficient. It is essential to begin access procurement as early as possible in the response process to avoid potentially lengthy delays. It is recommended that access be obtained by going door-to-door. If residents are not home, a blank access consent form with instructions and posted-paid return envelope for signature and submission to EPA, along with relevant contact information, should be left at the residence. If possible, access for remediation should be obtained at the same time access for sampling is sought. Combining sampling and cleanup access will avoid potentially lengthy delays. Additionally, access should be obtained for any interior dust sampling and/or cleaning that is expected to be performed at the residence. If the property owner denies access to a property, EPA may issue unilateral administrative orders[1]. An alternative to issuing orders is to consider obtaining public sampling easements/rights of way in the residential area to begin characterization efforts. EPA also has the authority to seek judicial action against property owners who ignore administrative orders. Example access consent forms used at a Superfund site are provided in Appendix H.

[1] Note that the sampling results may require the homeowner to provide the results to a prospective purchaser per the Lead Disclosure Rule. In the event that a cleanup action is taken, then the cleanup level could serve as evidence that there is no unacceptable risk at the property, depending on the cleanup levels achieved.

APPENDIX G
Examples of Property Access Consent Forms

CONSENT FOR ACCESS TO PROPERTY FOR SAMPLING

Name: ______________________________ Daytime Phone Number: ____________________________

Address(es) of Property(ies): ____

____

I consent to officers, employees, and authorized representatives of the United States Environmental Protection Agency (EPA) entering and having access to my property for the purpose of taking [DESCRIBE NUMBER OF SAMPLING LOCATIONS AND DEPTHS] which are necessary to implement the cleanup of lead contamination in the soil.

This written permission is given by me voluntarily with knowledge of my right to refuse and without threats or promises of any kind. I understand that EPA or authorized representatives of EPA will contact me at least one week in advance before the soil samples are collected. This agreement is only for the purpose of soil sampling and no other work.

____
Date

☐ I grant access to my property

☐ I do not grant access to my property

____
Signature

____
Signature

☐ I would also like EPA to have a lead expert contact me to schedule a free inspection to identify potential lead hazards in my home and provide safety tips.

United States Environmental Protection Agency Region 6 1445 Ross Avenue, Suite 1200 Dallas, Texas 75202-2733

CONSENT FOR ENTRY AND ACCESS TO PROPERTY FOR SAMPLING

Description of property (including address) for which consent to access is granted:

Example: XXXX Street, Texarkana, Arkansas, more particularly described as a lot measuring approximately 3,000 square feet, including a two-room wood structure of approximately 300 square feet

Name of Signatory: ______________________________

Address: ________________________
____
________________________ Phone: (_____)______________

Relationship to property (*e.g.*, owner, lessee, agent or employee of owner, etc.):

I HEREBY CONSENT to officers, employees and parties authorized by the U.S. Environmental Protection Agency (EPA), entering and having continued access to the property described above at reasonable times for the following purposes (List the activities to be undertaken on the property): Example:

- Sample collection including: (1) the gathering of soil from the outside area of the property; (2) drawing water from the tap; and (3) vacuuming the inside area of any inhabitable structure in order to collect dust.

- Taking photographs to record the sampling process.

I realize that these actions are undertaken pursuant to EPA's response and enforcement responsibilities under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42

U.S.C. Sections 9601-9675. This written permission is given by me voluntarily with the knowledge of my right to refuse and without threats or promises of any kind.

This agreement expires on: ____________________
(Date)

I HEREBY WARRANT that I have authority to make this access agreement.

________________________ ________________________
Date Signature

____
Print name

CONSENT FOR ACCESS TO PROPERTY
FOR SAMPLING AND TO TAKE RESPONSE ACTION

Name: ______________________ Daytime Phone Number: ______________________

Address(es) of Property(ies): ______________________

____

I consent to officers, employees, and authorized representatives of the United States Environmental Protection Agency (EPA) entering and having access to my property for the purpose of sampling and taking a response action including: (1) preparing for and excavation of soil from my property; (2) backfilling the excavated area(s) with clean soil and/or backfill; and (3) restoring any grass or other vegetation or structures to their pre-excavation state. These activities are necessary to implement the cleanup of lead contamination in the soil.

This written permission is given by me voluntarily with knowledge of my right to refuse and without threats or promises of any kind. I understand that EPA or authorized representatives of EPA will contact me approximately two weeks in advance before the removal of soil begins, to discuss the steps involved in the excavation and removal program and all measures EPA will take to restore my yard. I also understand that if there is any damage to structures such as sidewalks that is caused by the work conducted by EPA or authorized representatives of EPA, then EPA or authorized representatives of EPA shall repair such damage.

____
Date

☐ I grant access to my property

☐ I do not grant access to my property

____
Signature

____
Signature

XXXX TRIBE OF OKLAHOMA

PROPERTY ACCESS CONSENT AGREEMENT
FOR SAMPLING AND TO TAKE RESPONSE ACTION

The Property which is the subject of this agreement is described as follows:

NE 1/4 SE 1/4, Section 6, Township 28 North, Range 24 East, Xxxx County, Oklahoma otherwise described as Beaver Springs Park and Tribal Office which includes the Pow Wow grounds (hereinafter the Property).

THIS______DAY OF___________________, 1999, by authority of the Xxxx Tribal Business Committee, permission is hereby granted to officers, employees and parties authorized by the United States Environmental Protection Agency (EPA) entering and having continued access to the Property until 4:30 pm (CST) on _________________, to conduct the following work (hereinafter the work):

(1) To perform necessary response actions (*e.g.*, excavation of contaminated soil, backfilling with clean soil or gravel, and sodding or seeding) to address lead and other metals from mining waste contamination on the above-described lands in accordance with the EPA Record of Decision issued August 27, 1997;

(2) To take necessary samples of environmental media to identify lead and other metals that may be a threat to public health or welfare or the environment.

Nothing contained in this permit shall operate to delay or prevent a termination of Federal trust responsibilities with respect to the Property by the issuance of a fee patent or otherwise during the term of the work; however, such termination shall not serve to terminate the work. The Xxxx Tribal Business Committee shall notify EPA of any change in status or ownership of the Property.

The Xxxx Tribal Business Committee realizes that the work will be undertaken pursuant to EPA's Superfund authority under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. Sections 9601-9675.

This written permission is given by the Xxxx Tribal Business Committee voluntarily with the knowledge of its right to refuse and without threats or promises of any kind.

The Xxxx Tribal Business Committee is the property owner or a responsible representative of the property owner and I, Xx Xxxx, as Chairman of that Committee, warrant that I have authority to make this access agreement.

____________________________ Xx Xxxx Xxxx Tribal Chairman Xxxx Tribe of Oklahoma	____________________________ Date
____________________________ U.S. Environmental Protection Agency	____________________________ Date

CONSENT FOR ACCESS TO PROPERTY TO TAKE RESPONSE ACTION

Name: ______________________________ Daytime Phone Number: ____________________________

Address(es) of Property(ies): ____

____

I consent to officers, employees, and authorized representatives of the United States Environmental Protection Agency (EPA) entering and having access to my property for the purpose of taking a response action including: (1) preparing for and excavation of soil from my property; (2) backfilling the excavated area(s) with clean soil and/or backfill; and (3) restoring any grass or other vegetation or structures to their pre-excavation state. These activities are necessary to implement the cleanup of lead contamination in the soil.

This written permission is given by me voluntarily with knowledge of my right to refuse and without threats or promises of any kind. I understand that EPA or authorized representatives of EPA will contact me approximately two weeks in advance before the removal of soil begins, to discuss the steps involved in the excavation and removal program and all measures EPA will take to restore my yard. I also understand that if there is any damage to structures such as sidewalks that is caused by the work conducted by EPA or authorized representatives of EPA, then EPA or authorized representatives of EPA shall repair such damage.

____
Date

☐ I grant access to my property

☐ I do not grant access to my property

____
Signature

____
Signature

APPENDIX H
Example of Dust Abatement Access Consent Form

CONSENT FOR ACCESS TO PROPERTY

Name: ______________________ Daytime Phone Number: ______________________

Address(es) of Property(ies): ______________________

____

I hereby consent to grant officers, employees, contractors, sub-contractors and authorized representatives of the United States Environmental Protection Agency (EPA) access to the interior of my home and/or property for the purpose of interior dust abatement. The home dust abatement program being offered at this time consists of vacuuming floors and walls with a special vacuuming system. This system is portable and compact and easy to use. A team of bonded representatives will be providing the service at no charge to the homeowner.

Videotaping of the interior of the residence will be necessary to provide backup documentation in the event of any claims. It will be necessary that someone remain at the residence for one or two days while it is being vacuumed. This lead abatement program is offered only to homeowners who have or will grant access to their property for the remediation of in their yards. These activities are necessary to interrupt the movement of lead through soil dust, house dust, and paint dust.

If you want the process completed in your home and prefer to do it yourself, please note in the appropriate space and arrangements will be made to schedule the loan of a HEPA-VAC unit to you.

This written permission is given voluntarily with the knowledge of its right to refuse and without threats or promises of any kind. I understand that, if any damage to my property results from these activities or any work conducted by the USEPA or its authorized representatives, then the USEPA or its authorized representatives shall repair or replace such damage.

____
Date

- ❑ I grant access to my property for Representatives of the EPA to video and vacuum.
- ❑ I wish to make arrangements to vacuum myself.
- ❑ I do not grant access to my property.

____
Signature

Please return as soon as possible for scheduling of work. If you should have any questions please contact [LOCAL CONTACT NAME] at [PHONE NUMBER].

APPENDIX I
Comparison of Discrete (Grab) Sampling with Incremental Composite Sampling

Table I-1. Comparison of Discrete (Grab) Sampling with Incremental Composite Sampling

Parameter	Discrete Sampling	Incremental Composite Sampling
Assumptions about soil contamination relevant to sampling and analysis		
Soil homogeneity	Constituents of interest are homogeneously distributed within a soil matrix (like salt dissolved in water) whether at background concentrations or anthropogenic release. **Corollary: The concentration at two soil locations 0.1, 0.5, 1, 2, 5, 10 meters apart are approximately the same.**	Because constituents preferentially bind to certain soil particles, contaminants behave as solid particles (concentrated "nuggets") that are unevenly dispersed (heterogeneous) at spatial scales relevant to contaminant sampling and analysis. **Corollary: Concentrations may differ greatly even for grab samples taken near each other.**
Subsampling	Contaminant concentrations within a sample jar are the same at the top, middle, and bottom of the jar, so that any grab subsample represents the jar's average concentration. Stirring, cone-and-quartering, etc. are acceptable ways to "mix" samples.	Since contaminants are borne on particles, and particles segregate by size during sample transport and manipulation (such as stirring and weighing), a grab subsample can be strongly biased high or low as compared to the jar's average concentration. Appropriate sample processing and subsampling procedures are required to counter this bias.
Analytical mass	A concentration result will be the same no matter how much or how little soil from the jar is used to perform the analysis. The mass of subsamples is determined by laboratory convenience, the needs of instrumentation, and the desire for waste-reduction.	Smaller analytical samples are less precise than larger samples. Larger analytical subsamples are more likely to represent the true concentration within the jar than smaller subsamples. The size of the largest particle in the sample determines the appropriate analytical mass.
Grab sample reliability	Grab samples are the most appropriate way to collect field samples and subsample soil samples for analysis. Only one grab sample or subsample gives sufficiently accurate information on which to base a decision.	Grab samples can be trusted to provide accurate information <u>only</u> if there are enough of them to accurately measure variability and to provide an estimate of statistical confidence around the average calculated from the data.
Number of samples	The number of grab samples is determined by the available budget, and by non-scientific negotiations among the regulator, responsible party, and perhaps stakeholders, so that regulator and stakeholder "comfort" is achieved.	The number of increments is determined by: (a) using a conservative default shown to be sufficient for most situations (^{3}30 per an area of ½ acre or less), or (b) by calculation from the actual variability observed for those increments within the defined soil mass (the DU).

Table I-1. Comparison of Discrete (Grab) Sampling with Incremental Composite Sampling

Parameter	Discrete Sampling	Incremental Composite Sampling
Statistical data distribution of results	Usually not normal (lognormal, gamma, or nonparametric distributions), although too few discrete samples may be collected to reliably determine the distribution. High variability and non-detects are usually present in the data set. Non-normality and many non-detects can make statistical analysis of the data complex. Selection of an appropriate UCL calculation method can be unclear and controversial. UCLs can be unrealistically high. Conclusions may be uncertain because of the combination of too few samples and high variability.	Since each IS result is an estimate of the DU mean, assuming a normal distribution is justified unless the underlying variability is very high. Since there are usually only three replicates from which to calculate the DU mean and UCL, the options for calculating a UCL are limited to the Student’s t and the Chebyshev. The UCL calculation is balanced by a high precision among the replicates against the penalty for only having three results. There are fewer (or no) non-detect results. Statistical analysis of the data can be easier and less subject to controversy. Unless the three replicates are exactly the same, the UCL will be higher than the highest replicate result, but the UCL (not the highest result) should be used as a conservative estimate of the DU mean.
Spatial resolution	Grab sample results are assumed to represent the actual spatial resolution present in the field. Grab sample results are often used to draw “contour lines” to delineate areas with different concentrations. Contour lines generated from high variability; low sample-density data sets uncertain.	No spatial resolution within the DU is possible unless a more complicated incremental design (involving SUs) is used. Alternatively, DUs could be made smaller. For “point” data purposes such as transects, very small SUs (1–4 square feet) can be represented by composite samples (^{3}5 increments) to reduce the biasing effect of short-scale field heterogeneity. A composite sample needs to be processed and subsampled in the same way as an incremental sample.

Table I-1. Comparison of Discrete (Grab) Sampling with Incremental Composite Sampling

Parameter	Discrete Sampling	Incremental Composite Sampling
Sample representativeness	The concentration result from a 1-g analytical sample grabbed from a 100-g sample jar can be assumed to represent the concentration for hundreds to thousands of kg of surrounding soil without a need for corroborating evidence. The volume and distance over which a single soil result will be extrapolated is determined by professional judgment, regulatory comfort, or whatever the grid size happened to be to accommodate the number of samples allowed by the budget. **Corollary: A SINGLE sample result provides actionable information for an undefined volume of soil.**	The true concentration for any large mass of soil is the same concentration that would be obtained by mathematically averaging the results of all potential analytical samples within that mass. The chance that any single analytical sample would be the same as (*i.e.*, represent) that true concentration is very small. **Corollary: The only way to estimate the true concentration of a soil mass is to mathematical or physically (via incremental sampling) obtain an average from an adequately large set of samples (or increments) taken from a pre-defined soil mass (the DU).**

Table I-1. Comparison of Discrete (Grab) Sampling with Incremental Composite Sampling

Parameter	Discrete Sampling	Incremental Composite Sampling
QC Results	The results of collocated field samples and laboratory duplicates can be ignored when using the associated analytical results for decision-making. This type of QC information is not used to improve sample collection and handling procedures or determine sample numbers when designing future sample collection efforts. **Corollary: A decision can be based on a single sample result without consideration of the result's uncertainty. Despite the high degree of sampling variability frequently measured by QC data, sample results are used "as is" and considered reproducible because that is what we've always done.**	The results of collocated field samples and laboratory duplicates provide valuable information about how much confidence can be placed in any single analytical result. These QC results are used to evaluate (and improve if necessary) the adequacy of current and future sample collection and processing procedures. **Corollary: Decisions should not be based on a single discrete sample unless the uncertainty in that result is estimated using QC data.** QC for Incremental Samples: Even decisions based on a single incremental sample may be uncertain unless there are sufficient QC data to measure sources of variability: (a) At least three independent replicate incremental samples from the same DU are collected to quantify precision over the entire measurement system. (b) At least three subsampling replicates are performed to quantify the precision of sample processing, subsampling, and analysis. (c) Laboratory control samples are used to measure analytical error. (d) From (a) and (b), the overall degree of field variability can be calculated to determine whether sufficient increments are being used. (e) From (b) and (c), the degree of sample processing and subsampling variability can be calculated to determine whether those procedures are sufficiently effective.

Table I-1. Comparison of Discrete (Grab) Sampling with Incremental Composite Sampling

Parameter	Discrete Sampling	Incremental Composite Sampling
Sample plans	It is sufficient for sampling plans to simply claim that "representative samples" will be collected. A description of what the data are supposed to represent or how the data will be used to make project decisions is not required for the sampling plan to be approved. After data are collected, "data review/data validation" does not include either a qualitative or quantitative determination of what the data represent.	Sampling plans must explain the intended project decisions that the data are to support. DUs are constructed so that the DU data are representative for the decision-making scenario(s). It can be concluded that incremental sample results represent the true DU concentration if: (a) sufficient increment density was used (default is less than or equal to 30 per an area of ½ acre or less) AND (b) less than or equal to three independent replicate incremental samples (from the same DU) agree.
Hot spots	A "hot spot" can be defined ("I'll know a hot spot when I see the data"), detected ("some unknown mass of soil is dirty"), or ruled out ("some unknown mass of soil is clean") using the result from a single grab sample. **Corollary: No forethought about defining hot spots is required before collecting the data.**	All concentration results represent an average concentration for some soil mass. The question is "What volume of soil is <u>known</u> to be represented by that result?" Without corroborating information, the only thing known for sure is that the analytical results represent the average concentration for a 0.5-, 1-, 10-, or 30-g subsample mass that is actually analyzed. The result cannot be assumed to represent the concentration for the sample jar, much less the concentration of some larger soil mass in the field. **Corollary: Reproducible detection of hot spots requires that project planning first define the volume and concentration of the soil mass that qualifies as a hot spot.**
Contaminant concentration data management and storage		

Table I-1. Comparison of Discrete (Grab) Sampling with Incremental Composite Sampling

<table>
<tr><th>Parameter</th><th>Discrete Sampling</th><th>Incremental Composite Sampling</th></tr>
<tr><td>Soil data documentation</td><td>Details about the procedures used to collect, handle, and analyze samples do not need to be stored in the database with the actual data. Sample ID, sample location, sample concentration, and the concentration units are enough for any future secondary uses of the data.</td><td>The following information should be stored in a database:
the spatial dimensions of the DU;
the number of increments making up the DU incremental sample; the sample support of the increments; the total mass of the incremental sample; the type of soil (sandy, clayey, etc.); how the sample was processed;
the particle size actually analyzed and what percentage of the total sample mass that particle size comprised;
the mass of the analytical sample and how it was prepared (grab or incremental subsampling);
and the QC data from which can be determined the magnitude of field variability, subsampling variability, and analytical variability.
This will likely require attaching reports to the database.</td></tr>
</table>

APPENDIX J
Comparison of Discrete, Five-Point Composite, and Incremental Sampling

Table J-1. Comparison of discrete, Five-Point Composite, and Incremental Sampling

Sampling Design	Overview	Assumptions about Sampling Error	Pros	Cons
Discrete	A set of grab samples collected and analyzed individually. A mean and UCL may be calculated for the set, but if any single sample exceeds a decision threshold, a "hot spot" is assumed to exist for some poorly defined region around the sample's location.	• Sampling error due to soil heterogeneity is a negligible source of data error (misleading sample results). • In other words, <u>short-scale field heterogeneity</u> is assumed NOT to cause collocated samples to have significantly different results, and <u>micro-scale heterogeneity</u> is assumed NOT to cause lab duplicate QC samples to have significantly different results.	• Since the amount of variability in the data set contains sampling variability, it is possible to use that variability to statistically calculate the number of grab samples needed to compensate for sampling error. • If sufficient sampling-related QC data (collocated samples and lab duplicates) are gathered and evaluated, it is possible to calculate the amount of data error contributed by field and subsampling variability for discrete sampling designs. This information can be used to improve critical aspects of the sampling and analysis design. • Sampling can be used to pinpoint source of contamination and inform cleanup efforts.	• The high number of samples required to manage sampling error for most lead-contaminated sites is cost-prohibitive. • Since sampling-related QC data are seldom sufficiently evaluated, the amount of sampling error, the likelihood that it may cause decision error, and what aspects of the design need improvement are usually unknown. • Unless subsampling error is controlled, and short-scale field heterogeneity is measured, there is no scientific basis for assuming a single high discrete sample result represents a meaningful "hot spot." • The small mass and area of a discreet sample does not represent the scale of human exposure. • "Surgical" removals are not effective in reducing mean lead concentration over large exposure areas.

Table J-1. Comparison of discrete, Five-Point Composite, and Incremental Sampling

Sampling Design	Overview	Assumptions about Sampling Error	Pros	Cons
Five-point composite	Five individual samples (increments) are combined to create a single composite sample. Typically, during composite sampling, an investigator will grid off an area and collect a number of samples within the grid.	• Sampling error due to soil heterogeneity is a minor source of data error (misleading sample results). • Short-scale field heterogeneity is assumed to be mild enough that five increments can control that source of variability enough for a reproducible estimate of the mean over the area covered by the five increments. • Micro-scale (within-sample) heterogeneity is usually ignored.	• Five-point composites can be useful for reducing the noise caused by short-scale heterogeneity when trying to detect a concentration trend or boundaries. At each point location along a transect, the composite is collected over a very small area, such as 1–4 square feet. • Triplicate five-point composites (independent composites from the same area) are used as QC to estimate the reproducibility (*e.g.*, coefficient of variance or relative standard deviation) of the five-point composite result.	• Over the spatial scale of DUs, five increments are insufficient to reliably estimate mean concentrations for yard-sized areas with lead contamination. This concern can be tested by taking triplicate five-point composites and examining their precision. • Five-point composites have insufficient increments to invoke the Central Limit Theorem, which is the statistical basis of incremental sampling. • If the five-point composite sample is not sufficiently processed and correctly subsampled, micro-scale heterogeneity will produce high subsampling imprecision in the composite results.

Table J-1. Comparison of discrete, Five-Point Composite, and Incremental Sampling

Sampling Design	Overview	Assumptions about Sampling Error	Pros	Cons
Incremental composite	Sampling consists of a minimum of 30 increments of equal volume (called increments) of soil from a target area (SU or DU) that are composited and subsampled using the sampling pattern in Figure 6.	• Two spatial scales of sampling error are assumed to exist for all contaminated soils, causing decision errors if they are not measured and controlled (Gy, 1992). • Short-scale field heterogeneity is managed by taking 30 or more increments per sample. • Micro-scale heterogeneity in the same jar is managed by sample processing and incremental subsampling.	• Data of known and documented quality when the objective is to estimate the mean concentration for SU or DU (Hathaway et al., 2008). • Lower variability and higher reproducibility (HDOH, 2023)[a]. • More likely to capture a heterogeneous contamination. • Spatial dimensions of DUs or SUs are defined early on, taking into account hot spots (*i.e.*, very small areas within a SU that are highly contaminated). • Incremental composite sampling requires sufficient QC so that the contributions of field variability and subsampling error to total data variability are measured. • Variability information is used to quantify decision errors to ensure decisions are scientifically defensible. • Often assumed to cost more, but experienced practitioners claim better data quality for same or less cost.	• The technique requires training in the details of planning, implementation, and data calculations. Note that training is widely available online[b]. • The specialized sample processing and subsampling techniques are unfamiliar to some labs. • The basic incremental design loses spatial information within a SU/DU. This is why SU/DU must be delineated with care; they should be the largest area where spatial resolution is not needed.

[a]https://health.hawaii.gov/heer/guidance/specific-topics/decision-unit-and-multi-increment-sampling-methods.

[b]Refer to ITRC (2012) for additional information (available online at https://itrcweb.org/teams/training/incremental-sampling-methodology-ism-update); training for incremental composite sampling: www.itrcweb.org; www.clu-in.org/conf/itrc/ISM and http://www.clu-in.org/conf/itrc/ism/.

APPENDIX K
Contacts and Software for Sampling Design

Table K-1. Contacts and Software for Sample Planning Design

Topic		Contact(s)
Sampling plan design/ Systematic Planning	General support	EPA HQ Quality Staff Phone: (202) 564-6830 E-mail: quality@epa.gov
	Dynamic Field QA Activities	https://www.epa.gov/irmpoli8/epa-qa-field-activities-procedures
Software	DEFT: Data Quality Objectives Decision Error Feasibility Trials	https://www.epa.gov/quality
	VSP: Visual Sample Plan	http://vsp.pnnl.gov/

APPENDIX L
Example of Property Inspection Checklist

TAR CREEK PROJECT
PROPERTY HOME INSPECTION CHECKLIST

______________________________ ______________
Address Date

____
Property Group Number

Home Interior Access (check one, see comments):
☐ Approved by Property Owner ☐ Denied by Property Owner

Property (Yard) Access (check one, see comments):
☐ Approved by Property Owner ☐ Denied by Property Owner

	OK	NA	PROBLEM/CONDITION
YARD AREA			
1. Lawn Area			
A. Location of Flower/Plant Boxes			
B. Soil (grade) next to house			
C. Shrubbery			
D. Trees			
E. Low areas near house (that could cause ponding of			
F. Other: ____________________			
2. Utility			
A. Water Meter			
B. Gas Meter			
C. Sewer Lines			
D. Other: ____________________			
3. Driveway			
A. Concrete cracked, damaged			
B. Blacktop cracked, damaged			
C. Uneven Settling			
D. Other: ____________________			

	OK	NA	PROBLEM/CONDITION
YARD AREA (cont.)			
4. Streetwalk & Walkways			
A. Concrete cracked, eroded			
B. Tripping hazards			
C. Tree roots cracking, lifting slab			
D. Sections missing			
E. Other ______________________			
5. Garage			
A. Settlement cracks in walls			
B. Concrete floor slab cracked, damaged			
C. Door jambs damaged, rotted			
D. Door hard to open, close			
E. Other: ______________________			
6. Swimming Pool (Above Ground)			
A. Leakage			
B. Visible damage			
C. Other: ______________________			
7. Swimming Pool (Below Ground)			
A. Leakage			
B. Visible damage			
C. Other ______________________			
8. Storm Cellar			
A. Damaged			
B. Indication of Flooding			
C. Other: ______________________			

	OK	NA	PROBLEM/CONDITION
YARD AREA (cont.)			
9. Electrical Service			
A. Damaged circuit breaker panel box			
B. Wiring hanging outside			
C. Damaged electric meter			
D. Other:______________________			
EXTERIOR AREA			
10. 9 **Brick** 9 **Siding**			
A. Brick bulging, spalling, cracking			
B. Mortar loose, needs repointing			
C. Lintel needs repair			
D. Stucco bulging, cracking			
E. Siding dented, damaged			
F. Finish wearing off siding			
G. Siding loose, not level, missing			
H. Siding rotted, termites			
I. Composite shingles worn, broken, missing			
J. Windows damaged			
K. Other:______________________			
11. Roofing			
A. Age of covering			
B. Shingles worn, damaged, patched			
C. Brick chimney broken, leaning			
D. Joint open between chimney & exterior wall			
E. Need flashing at chimney, vents, walls			

	OK	NA	PROBLEM/CONDITION
EXTERIOR AREA (cont.)			
F. Parapet wall leaning			
G. Roof sagging			
H. Metal flashing damaged, missing			
I. Other: ______________________			
12. Gutters & Leaders 9 **Yes** 9 **No**			
A. Copper discolored, greenish, damaged			
B. Galvanized rusted, patched			
C. Fascia board rotted, damaged, patched			
D. Drain onto foundation wall			
E. Need to divert water from wall			
F. Soffit venting 9 Yes 9 No			
G. Concrete slab cracked, deteriorated			
H. Concrete slab/splash block need			
I. Other: ______________________			
13. Entrance Steps			
A. Concrete cracked			
B. Brick cracked, mortar loose			
C. Structurally sound			
D. Handrail			
E. Other: ______________________			
14. Exterior Doors			
A. Damaged			
B. Opens/closes freely			
C. Weatherstripping			
D. Trim rotted, missing			

	OK	NA	PROBLEM/CONDITION
EXTERIOR AREA (cont.)			
E. Jambs rotted, damaged			
F. Frame separation from walls			
G. Other:______________________			
INTERIOR AREA			
15. Windows			
A. Trim/sills rotted			
B. Broken glass			
C. Open freely			
E. Frame separation from walls			
F. Other: ______________________			
16. Kitchen			
A. Cracked walls, ceiling			
B. Loose nails, tape on drywall			
C. Soft, springy floors			
D. Wood, tiles on floor damaged			
E. Faucet leaks			
F. Doors don't close			
G. Cabinets don't close			
H. Moisture in cabinets			
I. Walls have moisture damage			
J. Other: ______________________			
17. Interior Rooms			
A. Cracked walls, ceiling			
B. Loose nails, tape on drywall			
C. Soft, springy floor			
D. Carpeting water damaged			
E. Water stains near windows			

	OK	NA	PROBLEM/CONDITION
INTERIOR AREA (cont.)			
F. Mold/mildew on walls			
G. Other:______________________			
18. Toilet Facility			
A. Cracked tile, plaster on walls			
B. Cracked plaster on ceilings			
C. Loose tiles on walls, floors			
D. Loose nails, tape on drywall			
E. Toilet cracked			
F. Water leaks at closet flange			
G. Grout missing around tub			
H. Shower pan damaged, missing			
I. Shower door damaged, missing			
J. Need new shower door			
K. Water stains on ceiling below bathroom			
L. Hot water heater tank corroded			
M. Water stains on floor around hot water heater			
N. Moisture present around hot water heater			
O. Other:______________________			
19. Interior Doors			
A. Open freely			
B. Frame separation from walls			
C. Other:______________________			
20. Attic			
A. Only if visual indicator			
B. Other:______________________			

	OK	NA	PROBLEM/CONDITION
INTERIOR AREA (cont.)			
21. Foundation			
A. Minor cracks			
B. Settlement cracks at corners, walls			
C. Wall bulging inward			
D. Seepage into basement/cellar			
E. Mortar deteriorating			
F. Other: ______________________			
22. Basement or Cellar			
A. Seepage, water stains on floor/wall			
B. Sump pump installed			
C. Water pipe leaks			
D. Sewer pipe leaks			
E. Other: ______________________			
FOUNDATION AREA			
23. Foundation (Slab on Grade)			
A. Settlement cracks			
B. Joint separation			
C. Spalding			
D. Other:______________________			
24. Foundation (Elevated Slab w/Crawl Space)			
A. Concrete support integrity			
B. Evidence of moisture or visible moisture in crawl space			
C. Evidence of water accumulation (*e.g.*, water stains)			

	OK	NA	PROBLEM/CONDITION
FOUNDATION AREA (cont.)			
D. Sagging joist/support girders			
E. Fungus growth evident			
F. Sump pump evident			
G. Vents present			
H. Vapor barriers			
I. Pier settlement			
J. Uneven subgrade			
K. Insect damage			
L. Sill plate damaged			
M. Subfloor damaged, loose			
N. Need subfloor			
O. Other:________________________			
25. Plumbing (Raised Floors Only)			
A. Pipe insulation crumbling, missing			
B. Need to insulate pipes			
C. Water pipes leaking			
D. Sewer pipes leaking			
E. Water pipe condition			
F. Other: ________________________			
26. Plumbing			
A. Water pipe conditions			
B. Sewage pipe conditions			
C. Pipes leaking			
D. Pipe insulation			
E. Corrosion on drain lines			
F. Other: ________________________			

	OK	NA	PROBLEM/CONDITION
FOUNDATION AREA (cont.)			
27. Other Area			
A. ______________________			
B. ______________________			
C. ______________________			
D. ______________________			

COMMENTS: ____

____

____

Topo Survey Requested ☐ Yes ☐ No

____ ______________________

Inspector Signature Date

APPENDIX M
Examples of Property Closeout Forms

USEPA REMEDIATION AGREEMENT FORM

Name: Sam's Restaurant

Address: 5000 Main St

Madison, IL 62060

Phone: 000-123-4567

This form documents the completion of remedial activity performed on my property. My signature will designate that I am satisfied with the restoration of my property, and that no items are in question, now, or at any time in the future, except those items listed below, if any.

Comments: 100% satisfied

Restoration items in question:

1. NONE
2.
3.
4.
5.
6.
7.

Chloe Irish	Chloe Irish	01/24/98
Resident Signature	Printed Name	Date
Brad W. Bradley	Brad W. Bradley	04/13/98
USEPA Representative Signature	Printed Name	Date

RESIDENTIAL REMEDIATION INSPECTION/AGREEMENT FORM

Name Sara O'Mara

Address 777 East Ave, Whoville, IN 45123

Phone 000-987-6543

This form documents the completion of remedial activities performed on my property. My signature will designate that I am satisfied with the restoration of my property, and that no items are in question, now, or at any time in the future, except those items listed below, if any.

Comments

Restoration Items in Question:

1. Roll netting on sod to be trimmed off.
2. Stone left side, more stone to be added, taper from building
3. At double doors back left corner, add rock up to lip to allow vehicle to get in.
4. Also add rock at back of building in middle in front of concrete ledge.
5. Also add rock in open parking area & grade the tops off of the high spots.
6. Check outside of fence on 7th Street, clean up dirt clods rolling under sod & fence.
7.

Property Inspection Date 12/04/98

Lawn Care Instructions Reviewed/Delivered 12/04/98

Sara O'Mara	Sara O'Mara	12/09/98
Resident Signature	Printed Name	Date
Brad W. Bradley	Brad W. Bradley	02/12/99
USEPA Representative Signature	Printed Name	Date

APPENDIX N
Examples of Clean Letters

EPA LOGO AND ADDRESS

Date

Name Address
City, State
Zip

Dear :
The U.S. Environmental Protection Agency (EPA) has completed the cleanup of the lead contamination in your yard located at [ADDRESS, CITY, STATE], in connection with the [SITE NAME] site in [CITY, STATE] (the Site). By way of this letter, U.S. EPA is certifying that your yard has been cleaned up to less than [CLEAN-UP LEVEL] parts per million lead, the level which U.S. EPA considers protective of children's health at the Site.

Thank you for your cooperation in this clean-up effort. It has been our pleasure to work with you. If you have any questions concerning this letter or need further information, please contact me at [PROJECT MANAGER'S PHONE NUMBER & EMAIL].

Sincerely,

[PROJECT MANAGER NAME]
Remedial Project Manager

EPA LOGO AND ADDRESS

Date

Name Address
City, State
Zip

Dear :
The United States Environmental Protection Agency (U.S. EPA) has sampled your yard located at [ADDRESS, CITY, STATE] for lead. The results of this sampling, which are enclosed with this letter, indicate that your yard contains less than [CLEAN-UP LEVEL] per million lead, the level which U.S. EPA considers protective of children's health at the [SITE NAME, CITY, STATE]. Thus, U.S. EPA will not need to perform soil clean-up activities in your yard.

If you have any questions concerning this letter or the enclosure, please contact me at [PROJECT MANAGER'S PHONE NUMBER & EMAIL].

Sincerely,

PROJECT MANAGER NAME
Remedial Project Manager Enclosure

ENCLOSURE

Analytical results for [ADDRESS]
in parts per million (ppm) of lead:

Depth Zone (inches)	Yards		OR Quadrant			
	Front	Back	1	2	3	4
0 to 1	ppm	ppm	ppm	ppm	ppm	ppm
1 to 6	ppm	ppm	ppm	ppm	ppm	ppm
6 to 12	ppm	ppm	ppm	ppm	ppm	ppm
18 to 24	ppm	ppm	ppm	ppm	ppm	ppm
Deeper Zones (if applicable)	ppm	ppm	ppm	ppm	ppm	ppm
Drip Zone Composite	ppm	ppm	ppm	ppm	ppm	ppm

Mr. John Smith
123 N. Main
Joplin, Missouri 64108

Dear Mr. Smith,

This letter serves as written notification that a lead-contaminated soil clean-up action was performed under authority of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 as amended by the Superfund Amendments and reauthorization Act of 1986 on property you have an interest in at the Jasper County, National Priorities Listed Superfund site. Our records show that your property located at **123 N. Main** was included in this action. The clean-up action conducted by the U.S. Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (COE) addressed residences with soil lead levels over 800 ppm, day care facilities, and residences with children under six years of age with blood lead levels over 15 g/dL.

Briefly, the primary objective of the clean-up action on your property was to remove highly lead-contaminated near-surface yard soils that were located at your residence. In some cases, trees, shrubs, flowers, and other vegetation were left in place. As a result, a small amount of lead-contaminated soil may be left near the surface on your property. This small amount of contamination should not cause a health threat under normal circumstances. In the future if additional landscaping, or planting requiring excavation below six inches are done, care should be exercised to minimize recontamination.

The excavation criteria for the project were as follows:

A) From the surface to 12 inches, excavation continued until 500 ppm or less lead levels concentrations were achieved;

B) If the residual lead concentrations at a depth of one foot exceeded 1,500 ppm a “marker barrier” was placed at that depth. The marker barrier used was the temporary orange plastic construction- type fence. This material is permeable and will allow water and plant roots to pass through it. Only a small number of properties required the installation of the barrier. The primary purpose of this marker barrier is to inhibit and alert individuals excavating in these areas in future years.

In general, all areas of the yard that exceeded 500 mg/kg lead at the surface were removed. Soil brought in to backfill the excavation contained less than 240 mg/kg lead.

IF YOU HAVE PLANS TO DO ANY EXCAVATION WORK AT YOUR PROPERTY AND YOU ENCOUNTER THE ORANGE BARRIER PLEASE CONTACT YOUR LOCAL HEALTH DEPARTMENT, THE MISSOURI DEPARTMENT OF NATURAL RESOURCES, OR THE EPA FOR GUIDANCE.

Please save this document for your permanent records. In the event you sell or transfer the property to someone you can show the next owner that a lead cleanup was performed. If you require more specific information concerning the excavation on your property, please feel free to contact me at (xxx) xxx-xxxx and email.

Sincerely,

(Project Manager)

APPENDIX O
Sample Questionnaire – Possible Sources of Lead Exposures

Appendix O

Sample Questionnaire - Possible Sources of Lead Exposure

Provider: Administer this form to the parent or guardian to find possible source(s) of lead exposure.

Provider and Patient Information

Provider Information *(Please print clearly)*

Provider's Name (Last, First)		**Clinic Name**		
Mailing Address	**City**	**State**	**Zip**	**County**
( ) **Telephone**	( ) **Fax**			
Job Title	**Signature**			**Date**

Patient Information *(Please print clearly)*

Child's Last Name	**First Name**			**M.I.**
__ / __ / ____ **Date of Birth** (mm/dd/yyy)	**Medicaid Number**	**Language Spoken** (check one): ☐ English ☐ Spanish ☐ Other:______		
Parent/Guardian's Name	( ) **Telephone**	( ) **Alternate Telephone**		
Physical Address/ Apt. #	**City**	**State**	**Zip**	☐ Yes ☐ No **Primary Address** (check one)
Mailing Address/ P.O. Box (if different from physical) **City**		**State**	**Zip**	

Interview Questions

1. **Was your home probably built before 1978?** ☐ Yes ☐ No
   ¿Se construyó su casa probablemente antes de 1978?

2. **How long have you lived at this address?**
   ¿Cuánto tiempo ha vivido en esta dirección? (Years/Anos)______________(Months/Meses) ______________

3. **What was your previous address?** ____
   ¿Cuál era su dirección anterior? ____

4. **Is there any peeling paint on the outside or inside or your home?** ☐ Yes ☐ No
   ¿Hay pintura desprendida en tiras dentro o fuera de su hogar?

5. **Has any recent remodeling of your home involved paint removal or the use of old or recycled lumber?** ☐ Yes ☐ No
   ¿Ha habido renovaciones recientes de su hogar que hayan involucrado el removimiento de pintura o el uso de maderas viejas o recicladas?

6. **If your house is heated by a wood-burning stove or fireplace, is painted wood burned as fuel?** ☐ Yes ☐ No
   Si calienta usted su casa con estufa de leña o chimenea ¿Quema usted madera recubierta de pintura como combustible?

Page 1 of 2

Appendix O

Sample Questionnaire - Possible Sources of Lead Exposure

7. **Does your child spend time at any other building (daycare center, grandparent's house, neighbor's house, etc.) that was probably built before 1978 or that has had recent renovations?** ☐Yes ☐No
   ¿Pasa su niño o niña tiempo en algún otro edificio (centro de guardería, de los abuelos, casa de vecinos, etc.) que probablemente halla sido construido antes de 1978 o que haya tenido renovaciones recientes?
   What is the address? ____________________
   ¿Cuál es la dirección? ____________________

8. **Have other members of the family or any of your child's friends had high blood lead levels?** ☐Yes ☐No
   ¿Han tenido otros miembros de la familia o cualquiera de los amigos de sus niños altos niveles de plomo en la sangre?
   If yes, who? ____________________
   ¿Si su respuesta fue si, quienes? ____________________

9. **Does your child eat candy imported from other countries, especially from Mexico?** ☐Yes ☐No
   ¿Su hijo(a) come dulces importados, especialmente de México?

10. **Does your child put non-food items, like paint or dirt, in his/her mouth?** ☐Yes ☐No
    ¿Se lleva a lo boca, su niño o niña, cosas no comestibles (como pintura o tierra)?

11. **Are there factories near the place where your child spends most of his time?** ☐Yes ☐No
    ¿Se encuentran fábricas cerca del lugar en donde su niño o niña pasa la mayor parte del tiempo?

12. **Does anyone in your home make bullets, fishing weights, stained glass, pottery, or work on automobiles near the house?** ☐Yes ☐No
    ¿Alguien en su hogar manufactura balas, pesas para cañas de pescar, vidrio de colores; que manufacture o apliqué vidriado a la cerámica o que arregle autos cerca de la casa?

13. **Where are members of your household employed?** ____________________
    ¿En dónde trabajan los miembros de su familia? ____________________
    What is their main job? ____________________
    ¿Principalmente en qué trabajan? ____________________

14. **Are acid-containing foods like fruit juices stored in pottery, porcelain, pewter, leaded crystal, or cans?** ☐Yes ☐No
    ¿Almacena usted comida de alto contenido de ácido, como jugos de fruta, en recipientes de barro, porcelana, peltre, cristal de plomo, o en latas?

15. **Do you cook or store food in a bean pot or in pottery that is glazed?** ☐Yes ☐No
    ¿Cocina o guarda usted comida en olla para frijoles, en alfarería recubierta con vidriado que contenga plomo?

16. **Does anyone in your family use alternative, traditional, or home remedies, such as Greta, Azarcon, Maria Luisa, or Pay-loo-ah?** ☐Yes ☐No
    ¿Hay alguno de su familia que use remedios alternativos, tradicionales, o caseros, como Greta, Azarcon, María Luisa, o Pay-loo Ah?

17. **Was lead education provided to the parent/guardian in the form of:**
    Printed Material (brochure, pamphlet), and/or ☐Yes ☐No
    Provider-Parent counseling? ☐Yes ☐No

Page 2 of 2