STATE OF NEW MEXICO
BEFORE THE WATER QUALITY CONTROL COMMISSION

IN THE MATTER OF PROPOSED AMENDMENTS TO *GROUND WATER AND SURFACE WATER PROTECTION* REGULATIONS, 20.6.2 NMAC	)	No. WQCC 17-3 (R)

LAUN-DRY'S STATEMENT OF INTENT TO PRESENT TECHNICAL EVIDENCE

In accordance with NMAC 20.1.6.200 (E), the scheduling order, and by and through undersigned counsel, Laun-Dry submits this Statement of Intent to Present Technical Evidence in support of its position and proposed further amendments not contained in NMED's petition

1. The name of the person filing the Notice of Intent:

   This statement is being filed on behalf of Laun-Dry by undersigned counsel.

2. Identify each technical witness the person intends to present, and state the qualifications of that witness, including a description of their educational and work background

   Jay Snyder. ***See*** Summary of Direct technical testimony qualifications, educational and work background, ***attached.***

3. If the hearing will be conducted at multiple locations, indicate the location or locations at which the witnesses will be present

   N/A

4. Include a copy of the direct testimony of each technical witness in narrative form, and state the estimated duration of the direct oral testimony of that witness

   See Summary of Direct technical testimony qualifications, educational and work background, ***attached.*** (45 minutes estimated direct)

5. Include the text of any recommended modifications to the proposed regulatory change

NMAC 20.6.2.4104 C (changes in bold):

"C. If the source of the water pollution to be abated is a facility that operated under a discharge plan, the secretary may require the responsible person(s) to submit a financial assurance plan which covers the estimated costs to conduct the actions required by the abatement plan. Such a financial assurance plan shall be consistent with any financial assurance requirements adopted by the commission."

NMAC 20.6.2.4103 (C) (2) (changes in bold):

"[T]he standards of Section 20.6.2.3103 A, B, or C NMAC shall be met, or background concentration as set forth in 20.6.2.4101.B shall be met. The existing conditions including existing ph as set forth in 20.6.2.3101 and 3103 shall not be used for purposes of abatement pursuant to 20.6.2.4103 NMAC."

20.6.2.7 (R) (2) NMAC (changes in bold)

"A 'responsible person' **means a facility owner or operator, transporter or person potentially responsible for or contributing to an unauthorized discharge or other contamination and** required to submit an abatement plan or who submits an abatement plan pursuant to this part."

6. List and attach all exhibits anticipated to be offered by that person at the hearing.

A. Jay Snyder—CV
B. NMED Risk Assessment Guidance
C. Technical Infeasibility EPA Guidance
D. Chapter 9 CERCLA

Respectfully submitted,
DOMENICI LAW FIRM, P.C.

Pete V. Domenici, Jr., Esq.
Lorraine Hollingsworth, Esq.
Reed Easterwood, Esq.
320 Gold Ave. SW Suite 1000
Albuquerque, New Mexico 87102
(505) 883-6250

Attorneys for Laun-Dry

CERTIFICATE OF SERVICE

I certify that a copy of the foregoing was served on the following via e-mail unless otherwise noted on September 11, 2017:

Ms. Pam Casataneda, Administrator*
Water Quality Control Commission
Room N-2168, Runnels building
1190 St. Francis Dr.
Santa Fe, New Mexico 87505
pam.castaneda@state.nm.us
1 Original, 2 hard copies, and 10 electronic copies sent via personal courier

New Mexico Environmental Department
Office of General Counsel
John Verheul
Lara Katz
P.O. Box 5469
Santa Fe, New Mexico 87502
john.verheul@state.nm.us
lara.katz@state.nm.us

Pete Domenici
Lorraine Hollingsworth
Domenici Law Firm, P.C.
320 Gold Ave. SW, suite 1000
Albuquerque, NM 87102
pdomenici@domenicilaw.com
lhollingsworth@domenicilaw.com

Louis W. Rose
Kari Olson
P.O. Box 2307
Santa Fe, NM 87504
lrose@montand.com
Kolson@montand.com

Timothy A. Dolan
Office of Laboratory Counsel
Los Alamos National Laboratory
P.O. Box 1663, MS A187
Los Alamos, NM 87545
tdolan@lanl.gov

Rachel Conn
Projects Director
Amigos Bravos
P.O. Box 238
Taos, NM 87571
Rconn@amigosbravos.org

Dalva L. Moellenberg
1239 Paseo de Peralta
Santa Fe, NM 87501
DLM@gknet.com

Micheal Bowen
Executive Director
1470 St. Francis Drive
Santa Fe, NM 87505
nmma@comcast.net

Jaimie Park
Douglas Meiklejohn
Eric Jantz
Jonathan Block
New Mexico Law Center
1405 Luisa Street, Suite 5
Santa Fe, NM 87505
jpark@nmelc.org
dmeiklejohn@nmelc.org

William C. Olson
14 Cosmic Way
Lamy, NM 87540
Billjeanie.olson @gmail.com

John Grubesic
Office of the Attorney General Post Office Drawer 1508
Santa Fe, NM 87504-1508
jgrubesic@nmag.gov

William Brancard
Cheryl Bada
Energy, Minerals and Natural Resources
Department
1220 South St. Francis Drive
Santa Fe, NM 87505
billblanchard@state.nm.us
Cheryl.bada@state.nm.us

Reed Easterwood, Esq.

STATE OF NEW MEXICO
BEFORE THE WATER QUALITY CONTROL COMMISSION

IN THE MATTER OF PROPOSED AMENDMENTS TO *GROUND WATER AND SURFACE WATER PROTECTION* REGULATIONS, 20.6.2 NMAC	)	**No. WQCC 17-3 (R)**

SUMMARY OF JAY SNYDER'S DIRECT TECHNICAL TESTIMONY

I. INTRODUCTION

This testimony is submitted in support of Laun-Dry by Jay Snyder, P.G., Senior Hydrogeologist of EA Engineering Science and Technology, Inc., Albuquerque, New Mexico; and environmental consultant of Laun-Dry for the hearing on NMED's Petition currently set in Santa Fe, New Mexico,

TESTIMONY OF JAY SNYDER

II. BACKGROUND

Mr. Snyder is a senior hydrogeologist and operations manager currently employed by EA Engineering, Science, and Technology, Inc. PBC in Albuquerque, New Mexico. He is also licensed as a Professional Engineer in Colorado, Professional Geologist licensed in the states of Alabama, Arkansas, Arizona, California, Idaho, Kansas, Louisiana, Minnesota, Nebraska, Oregon, Texas, Utah and Wisconsin, Certified Hydrogeologist in the state of California, Professional Groundwater Hydrologist (American Institute of Hydrology), and a licensed soil and groundwater remediation contractor in the state of New Mexico.

He has over 27 years of professional experience in the environmental industry, serving a variety of federal, state, and commercial clients, which includes permitting numerous remediation systems, Class V injection wells, discharge plans, air quality permits, and expert testimony and opinions regarding contamination of soil and groundwater. Mr. Snyder has a Bachelor of Science in Geology from the University of Wisconsin-Platteville (1982), Bachelor of Science in Meteorology from Texas A&M University (1988), a Master of Science in Geology and Geophysics from New Mexico State University (1986), and a Master of Science in Geological Engineering from the University of Idaho (2014).

He has served as Program Manager for State-Lead Contracts with New Mexico Environment Department ("NMED"), New Mexico Department of Transportation ("NMDOT"), and Texas Commission on Environmental Quality ("TCEQ") for investigation and cleanup at leaking underground storage tank (LUST) sites, Voluntary Cleanup Sites, Brownfields Sites, and Superfund Sites. He has served as lead Hydrogeologist for investigation and cleanup activities at Naval Air Station Fallon, Nevada, Hunters Point Naval Shipyard, San Francisco, China Lake Naval Weapons Center, Ridgecrest, California, Titanium Metals Corporation Plant Site, Henderson, Nevada, and at National Priorities List (NPL) Sites throughout Region 6 for Tetra Tech's EPA Response Action Contract. He was Corrective Action Project Manager (CAPM) of record for over 100 responsible party LUST sites in West Texas for investigation, risk-based corrective action, feasibility testing, and cleanup. He served as Lead Hydrogeologist for (1) Stage 1 and Stage 2 Abatement Plan Activities, Dona Ana Dairies, Mesquite New Mexico, (2) Stage 1 Abatement, Cal-Maine Foods Egg Farm, Bernalillo County, New Mexico, Stage 1 Abatement for Rockview, High Lonesome, and Tom Visser Dairies.

He presently serves as Lead Hydrogeologist for: (1) EA Engineering's USEPA Region 6 Response Action Contract for Remedial Investigation, Feasibility Study, Remedial Design, Remedial Action, and Long Term Remedial Action for groundwater assessment and cleanup at Superfund Sites in USEPA Region 6, (2) Bulk Fuel Farms Corrective Action, Kirtland Air Force Base, New Mexico, (3) Remedial Investigations and Feasibility Studies at Hill Air Force Base, Utah and King Salmon Air Force Station, Alaska, (4) EA's Region 9 EPA Response Action Contract, (5) Senior Hydrogeologist for Spirit Lake Sediment Remediation, EPA Great Lakes Program, Duluth, Minnesota, and (6) over 60 leaking petroleum storage tank sites in New Mexico and Texas.

He has consulted in Alaska, California, Nebraska, Nevada, Arizona, New Mexico, Texas, Oklahoma, Arkansas, and Louisiana at literally hundreds of sites, and has assessed and/or cleaned up sites with fuel hydrocarbon, chlorinated solvents, creosote and other wood preservatives, chromium, lead, arsenic, radionuclide, perchlorate, and septic/animal waste contamination. Mr. Snyder hs assessed literally hundreds of LUST and fuel hydrocarbon sites in his career.

Mr. Snyder has participated in the NMED Petroleum Storage Tank Bureau ("PSTB") Risk-Based Corrective Action working group for LUST contaminated sites, NMED PSTB Scientist Certification working group, TCEQ Standardized Assessment Report Format working group, and Langley Air Force Base, Virginia Installation Restoration Program ("IRP") Committee.

Mr. Snyder has extensive experience with regulatory requirements and interpretation of rules including: (1) review of Applicable, Relevant, and Appropriate Requirements (ARAR) for Superfund Sites, in which cleanup standards, whether promulgated or guidance, are reviewed and established, including Federal Maximum contaminant levels, (MCLs), New Mexico Water Quality Control Commission (WQCC) standards (20 NMAC 6.2.3103), NMED Soil Screening Guidelines, EPA Risk Screening Levels, and other Risk-Based Corrective Action goals; (2) preparation of air quality permit applications for cleanup, including evaluation of applicability and requirements for New Source Review and Source Registration; (3) preparation of discharge plans including Class V Injection Wells; (4) review and implementation of construction code and

Construction Industries Division rules; and (5) Office of State Engineer rules for well construction, plugging and abandonment, and for appropriation of underground water of the State.

III. SUMMARY OF DIRECT TESTIMONY

A. In re 20.6.2.4104 (C)

Laun-Dry proposes the following amendment (in bold):

"C. **If the source of the water pollution to be abated is a facility that operated under a discharge plan, the secretary** may require the responsible person(s) to submit a financial assurance plan which covers the estimated costs to conduct the actions required by the abatement plan. Such a financial assurance plan shall be consistent with any financial assurance requirements adopted by the commission."

i. Engineering basis tying possibility of financial assurance to discharge plans

Financial assurance for facilities permitted to engage in discharge of pollutants under a DP provides assurance in the event an upset in treatment or containment of the pollutants results in groundwater contamination above NMWQCC or DP limits. Operationally, this provides incentive for the Permittee to avoid unauthorized discharges and provides a mechanism for cleanup if necessary. Operational requirements under a DP are typically well defined and well constrained.

Abatement Plans (AP) are designed to define the nature and extent of releases, whether under a DP, or just related to a Section 1203 release not related to a DP. What is known about a release site that did not operate under a DP can vary widely, and a considerable amount of Stage 1 Abatement site characterization may be required prior to establishing estimates of cleanup costs. The costs associated with the AP vary considerably with the nature of contaminants released, nature of soil and depth to groundwater, location of nearest potential receptors, and advancements and innovation in technologies to cleanup contaminant plumes. Because these costs can vary considerably based on approach and change in approach over time, quantifying equitable financial assurance is difficult.

ii. Economic basis tying possibility of financial assurance to discharge plans

In my experience, the regulated communities under discharge plans in the state of New Mexico and elsewhere constitute middle to large cap private industry and, municipalities and other state political subdivisions. Previously the NMED had the discretion to require financial assurance to these sectors of the regulated community. This discretion makes sense given the highly technical infrastructure associated with intentional permitted discharges such as evaporation ponds, waste water treatment systems under permit. Risk of contamination and potential liability under discharge permitted operations is apparent and the state of the art with respect to containment and mitigation is just that—aspirational and not static. In these sectors, allocations of costs in part or total is reasonable.

The same analysis, however, does not necessarily follow regarding low capitalized private "responsible parties." In my experience, I have had several clients of limited means that have worked through abatement using a variety of economic means including New Mexico's Corrective Action Fund, private insurance, as negotiated as part of property transfer, etc. Requiring financial assurance early in the abatement process may prove sufficient burden to slow the abatement process.

B. In re 20.6.2.4103 (C) (2)

Laun-Dry proposes the following amendment (in bold):

the standards of Section 20.6.2.3103 A, B, or C NMAC shall be met, or background concentration as set forth in 20.6.2.4101.B shall be met. The existing conditions including existing ph as set forth in 20.6.2.3101 and 3103 shall not be used for purposes of abatement pursuant to 20.6.2.4103 NMAC.

i. Scientific basis for the proposed amendment

Background is in law and practice tied to TCE standards under the regulations.

ii. Engineering basis for the proposed amendment

The proposed amendment provides further clarity as to defining Background in relation to exceeding standards annunciated under subsection A, B, and C of 20.6.2.3103 NMAC.

iii. Economic basis for the proposed amendment

The proposed prohibition on completing abatement on the bases of meeting the standards under subsection A, B, or C protects a Responsible Person's ability and right to establish sources of contamination are from a source other that the Responsible Person's facility. There is a right to seek contribution from other persons pursuant to 20.6.2.7 B (1) NMAC.

C. In re 20.6.2.7 (R) (2) NMAC

Laun-Dry proposes the following amendment (in bold):

"A 'responsible person' **means a facility owner or operator, transporter or person potentially responsible for or contributing to an unauthorized discharge or other contamination** and required to submit an abatement plan or who submits an abatement plan pursuant to this part."

i. Other specialized knowledge for the proposed

'Responsible Person' should be tied to an unauthorized discharge or release of contaminants to the soil and/or groundwater. It should follow the language of 'Release' as defined in Chapter 9 of CERLCLA. A 'Responsible Person' as used in abatement should be associated with a release of regulated contaminants.

In addition to facility owner and operator status explicitly linked to "responsible person" throughout 20.6.2 et seq., the proposed amendment language has precedent in New Mexico Storage Tank regulations at 20.5.1.7 (O) , under *The Solid Waste Act*, NMSA 1978 § 74-9-34 (B), and under Section 107(a) of CERCLA. The proposed amendment keeps language from the current definition that implicates and encourages voluntary remediation and it does not include additional terms of art not otherwise already addressed in the regulations.

This concludes my testimony.

Jay Snyder, P.G., P.E., C.Hg.

Senior Hydrogeologist

Mr. Snyder has 28 years of professional experience in the environmental industry, serving a variety of federal, state, and commercial clients. He worked as a business development manager, program manager, project manager, and senior technical reviewer. He has managed hundreds of hydrogeologic investigations, pilot tests and remedial action plans at leaking underground storage tank facilities, Resource Conservation and Recovery Act (RCRA) facilities, Superfund sites, and oil and gas facilities. He specializes in risk-based corrective action at hydrocarbon contaminated sites, remedial investigations at hazardous waste sites, and evaluation of remedial alternatives at a wide variety of sites, including fuel hydrocarbon, chlorinated solvent, heavy metals, and wood treatment sites.

Mr. Snyder applied a wide variety of remedial technologies at sites, including groundwater pump and treat, air sparging, multiphase extraction, *in situ* thermal desorption, soil vapor extraction, *in situ* bioremediation, monitored natural attenuation, land farming, chemical oxidation, and permeable reactive barriers. He has permitted numerous remediation systems, including Class V injection wells, discharge plans, and New Source Review for air emissions.

Mr. Snyder has served as hydrogeology technical lead for U.S. Environmental Protection Agency (EPA) Region 6 Response Action Contract; Installation Restoration Program activities at Naval Air Station Fallon, Nevada; and the TIMET facility in Henderson, Nevada. He served as the program manager for New Mexico Environment Department, New Mexico State Highway and Transportation Department, Texas Natural Resource Conservation Commission (TNRCC) State, and TNRCC Responsible Party Section contracts. Mr. Snyder also participated in the Langley Air Force Base Installation Restoration Program, the New Mexico Environment Department risk-based corrective action working group, and the TNRCC Investigation Report Form working group.

Qualifications

Education

M.S.; Geological Engineering, University of Idaho; 2014
M.S.; Geology/Geophysics; New Mexico State University; 1986
B.S.; Meteorology; Texas A&M University; 1988
B.S.; Geology; University of Wisconsin at Platteville; 1982

Registrations/Certifications

Professional Geologist—AL (No.1454); AR (No. 1852); AZ (No. 45804); CA (No. 8048); ID (No. PGL-1550); KS (No. 905); LA (No. 438), NE (G-0366); OR (No. G2454); TX (No. 867); UT (No. 8947362-2250); and WI (No. 1306-13)
Professional Engineer—CO (No. PE.0051233); 2016
Certified Hydrogeologist—CA (No. 978); 2013
Professional Hydrologist Groundwater – American Institute of Hydrology (13-HGW-5005)
Licensed Soil and Groundwater Remediation Contractor; NM (GS-29); 2005

Specialized Training

Geochemistry and Hydrology of Waste Rocks, Tailing, and Pit Lakes, New Mexico Tech; Fall 2015
Vapor Intrusion – Learning the Current Approaches, at Battelle Conference on Recalcitrant Compounds, Monterey, California; 2012
Horizontal Wells: Enhanced Access for Characterization and Remediation, at Battelle Conference on Recalcitrant Compounds, Monterey, California; 2012
Environmental Forensics, Northwest Environmental Training Center, 2012
Stable Isotopes in Environmental and Forensic Geochemistry, at Battelle Conference on Recalcitrant Compounds, Monterey, California; 2010
Contaminant Chemistry and Transport in Soil and Groundwater, Northwest Environmental Training Center; 2008
Texas Risk Reduction Program Training, TNRCC and University of Houston; 2000
Remediation by Natural Attenuation, National Groundwater Association; 1999
RCRA Refinery Workshop, EPA Region 8, Denver; 1998
Risk-Based Corrective Action, University of Houston; 1998
Operating Permits (Title V), Trinity Consultants; 1996
Project Management Training, Fred Pryor Seminar; 1994
Air Dispersion Modeling Short Course, Trinity Consultants; 1992
Vadose Zone Hydrology Short Course, Daniel B. Stephens & Associates, Inc.; 1991
RCRA Training, PRC EMI; 1990
OSHA 40-Hour Hazardous Waste Operations Training
OSHA 40-Hour Annual Refresher
OSHA 8-Hour Hazardous Waste Operations Supervisor/Manager
OSHA 10-Hour Certified Construction
CPR and First Aid Training

Professional Affiliations

American Society of Civil Engineers; Member
Association of Ground Water Scientists and Engineers

Experience

Years with EA: 8 Total Years: 28

Mr. Snyder has conducted numerous remedial investigations, aquifer pumping tests, and treatability studies including: (1) soil vapor extraction; (2) multiphase extraction; (3) air and ozone sparging; (4) *in situ* reductive dechlorination and reduction of metals; and (5) chemical oxidation, feasibility studies, and remedial designs. He serves as hydrogeology technical lead on numerous of projects.

Professional Experience

Environmental Services—Specializes in risk-based corrective action at hydrocarbon contaminated sites, remedial investigations at hazardous waste sites, contaminant fate and transport, and evaluation of remedial alternatives at a wide variety of sites, including fuel hydrocarbon, chlorinated solvent, heavy metals, and wood treatment sites.

Remedial Technologies—Applied a wide variety of remedial technologies at sites, including groundwater pump and treat, air sparging, multiphase extraction, *in situ* thermal desorption, soil vapor extraction, *in situ* bioremediation, *in situ* reductive dechlorination and in *in situ* reduction of metals, monitored natural attenuation, land farming, chemical oxidation, and permeable reactive barriers.

Permitting—Has permitted numerous remediation systems, including Class V injection wells, discharge plans, and New Source Review for air emissions.

Publications and Presentations

Snyder, J.T., F. Barranco, K. Min, and S. Saalfield. 2017. A Field Scale Pilot Study of Chromium Reduction and ERD in a Declared Aquifer. Presented at Remediation Technology (RemTEC) Summit 2017, Denver Colorado.

Snyder, J.T., V. Mustafin, and T. Curley. 2017. Biosparging Pilot Test in a Confined Aquifer. Presented at Remediation Technology (RemTEC) Summit 2017, Denver Colorado.

Snyder, J.T., K. Waldron, M. Wilkinson, D. Beistel, and P. Jurena. 2014. A Design for Cold Region Monitoring Wells and Piezometers. Association of Environmental and Engineering Geologists Technical Session 8 – Groundwater/Environmental Site Characterization. 57th Annual Meeting, Scottsdale, Arizona.

Snyder, J.T., J. Frain, T. Telesak, G. Baumgarten, and C. Hueni. 2014. Use of Passive Soil Gas to Indicate Change in Remedy at a Dry Cleaner Site. Battelle Ninth International Conference, Remediation of Chlorinated and Recalcitrant Compounds, Monterey, California.

Saalfield, S., S. Styger, S. Wallace, J. Snyder, J. Frain, and V. Mallot. 2014. Secondary Metals Release Associated with In Situ Chemical Reduction. Battelle Ninth International Conference, Remediation of Chlorinated and Recalcitrant Compounds, Monterey, California.

Snyder, J.T. 1986. Heat Flow in the Southern Mesilla Basin with an Analysis of the East Potrillo Geothermal System, Doña Ana County, New Mexico. Master's Thesis. New Mexico State University, Las Cruces. 252 pp.

Snyder, J.T. and C.A. Swanberg. 1984. Heat Flow in the Southern Mesilla Bolson, Southern Rio Grande Rift, New Mexico. In New Mexico Geological Society Spring Conference Abstracts, p. 27.

Swanberg C. and J. Snyder. 1983. Terrestrial Heat Flow in New Mexico: Preliminary Analysis of the Private Database. *EOS Transactions of the American Geophysical Union*. 64(45): 836.

EA Project Experience

Former Price's Valley Gold Dairy, Bernalillo, New Mexico; Groundwater Technical Lead and Project Manager—Prepared petition for Alternative Abatement Standards under New Mexico Water Quality Control Commission Regulations for alternative nitrate, chloride, and total dissolved solids groundwater standards to facilitate abatement completion in a perched aquifer at the former dairy. Provided expert testimony in support of the alternative standards before the Water Quality Control Commission. Successfully petitioned for Technical Infeasibility Demonstration for abatement of contaminants in the regional aquifer, successfully resulting in abatement completion. Designed groundwater pump and discharge system for removal of "hot-spot" nitrate contamination.

Kirtland Air Force Base Bulk Fuel Farm Corrective Action, Albuquerque, New Mexico; Groundwater Technical Lead—Designed groundwater extraction well, designed multi-level monitoring well, evaluate plume capture and mass removed, design aquifer pumping test, and identify groundwater data gaps.

Main Street Plume Superfund Site (National Priorities List), Burnet, Texas; Groundwater Technical Lead—Prepared conceptual site model, designed multi-level monitoring wells, and designed passive soil gas monitoring network for source area and migration pathway evaluation. Site is impacted with tetrachloroethene from a dry cleaner impacting a karst aquifer network.

EVR-Wood Superfund Site (National Priorities List), Jennings, Louisiana; Groundwater Technical Lead—Assisted with conceptual site model for former refinery and wood treater operation along Bayou Nezpique in Acadian Parish. The site overlies the Chicot Aquifer, a major source of irrigation water for agriculture. Activities included refining, bulk fuel storage, and wood treating. Remedial investigation activities included sampling pits, Geoprobe boring of multiple small dumps and other source areas, and investigation of the tank farm and other process areas. A number of monitoring wells were installed to evaluate shallow surficial sand water bearing zones (which have been dewatered at the site by irrigation withdrawals), and the upper part of the Chicot aquifer system "massive sand" unit. Several single well recovery pumping tests were performed as well as a bail down recovery test in low yielding strata.

Arkwood, Inc. Superfund Site (National Priorities List), Omaha, Arkansas—EPA is conducting a dioxin re-evaluation for the site. In addition, EPA continues to conduct Five-Year Reviews of the site remedy. These Five-Year Reviews ensure that the site soil and groundwater remedies remain protective of human health and the environment. The next Five-Year Review will be completed in 2016.

Jones Road Groundwater Plume Site (National Priorities List), Houston, Texas; EPA Region 6; Groundwater Technical Lead—Prepared conceptual site model for multi-aquifer (Chicot and Evangeline) system impacted with chlorinated ethenes. Designed and conducted passive soil gas survey to pinpoint source area, designed Continuous Multichannel Tubing multi-level monitoring well to assess dense non-aqueous phase liquid in multiple aquifers and aquicludes, designed field scale treatability studies for *in situ* reductive dechlorination.
Project Date: November 2010 – Present
Project Value – $1,010,420; Contract Type – Time & Materials; EA Project No. – 1434270; EA Project Manager – Ted Telisak

Van der Horst Groundwater Plume Site (National Priorities List), Terrell, Texas; EPA Region 6; Groundwater Technical Lead—Prepared conceptual site model for two-aquifer (water table and Nacatoch Sand) system impacted with hexavalant chromium from plating operations. Designed hydrogeologic investigation to delineate both aquifer systems and establish hydraulic communication and vertical migration pathways. Oversaw drilling and field activities for plume delineation, aquifer pumping tests, and *in situ* chemical reduction treatability studies.
Project Date: October 2010 – Present
Project Value – $1,085,164; Contract Type – Time & Materials; EA Project No. – 1434263; EA Project Manager – Doug McReynolds

***Eielson Air Force Base, Fairbanks, Alaska; Air Force Center for Engineering and the Environment; Geologist/Hydrogeologist*—**Prepared conceptual site models for multiple source areas impacted with chlorinated solvents, fuel hydrocarbons, polychlorinated biphenyls, and metals. Scoped and directed development of Uniform Federal Policy for Quality Assurance Project Plans. Designed vertical and horizontal delineation program at trichloroethylene site using direct-push techniques and triad approach with Waterloo APS sampler for continuous permeability and soil type profiling, and groundwater sample collection to 200 ft below ground surface.
Project Date: January 2011 – Present
Project Value – $5 million; Contract Type – Time & Materials; EA Project No. – Various; EA Project Manager – Mark Wilkinson

***King Salmon Air Force Station, King Salmon, Alaska; Air Force Center for Engineering and the Environment; Hydrogeology Technical Lead*—**Technical lead for source area and solute plume characterization for chlorinated solvent plume in multi-layered aquifer system. Scoped field work for mapping of potential source areas using passive soil gas samplers and soil sampling, plume delineation in multi-layer aquifer system, evaluation of nature and permeability of aquitard separating aquifers, design, oversight and review of aquifer pumping tests in affected aquifers, development of conceptual site model, and remedial alternative evaluation. Senior technical review of work plans, Quality Assurance Project Plans, and technical reports
Project Date: January 2011 – Present
Project Value – $1 million; Contract Type – Time & Materials; EA Project No. – Various; EA Project Manager – Steve Wrenn

***Fort Sumner Army Air Field (Formerly Used Defense Site), Fort Sumner, New Mexico; Bristol Environmental Remediation Services; Groundwater Technical Lead*—**Designed and installed BARCAD multi-level monitoring wells in Chinle Formation water bearing zones at Formerly Used Defense Site. Drilling included RotaSonic and Stratex casing advance methods. Reviewed and developed conceptual site model for groundwater pathways.
Project Date: 2009 – Present
Project Value – $400,000; Contract Type – Firm-Fixed Price; EA Project No. – 6237101; EA Project Manager – Devon Jercinovic

***Midessa Groundwater Plume Site (National Priorities List), Midland, Texas; EPA Region 6; Groundwater Technical Lead*—**Prepared conceptual site model for two-aquifer (Ogallala and Trinity aquifers) system impacted with chlorinated solvents related to oil field maintenance activities. Designed hydrogeologic investigation to delineate both aquifer systems and establish hydraulic communication and vertical migration pathways. Oversaw drilling and field activities for plume delineation, aquifer pumping tests and analyses, and field scale treatability studies.
Project Date: October 2010 – Present
Project Value – $1,085,164; Contract Type – Time & Materials; EA Project No. – 1434263; EA Project Manager – Luis Vega

***West County Road 112 Groundwater Plume Site (National Priorities List), Midland, Texas; EPA Region 6; Groundwater Technical Lead*—**Prepared conceptual site model for two-aquifer (Ogallala and Trinity aquifers) system impacted with hexavalant chromium from injection modeling cooling water operations. Plume extends over a two-mile length and has impacted over 100 domestic supply wells. Designed hydrogeologic investigation to delineate both aquifer systems and establish hydraulic communication and vertical migration pathways. Oversaw drilling and field activities for plume delineation, and designed aquifer pumping tests and *in situ* chemical reduction treatability studies.
Project Date: October 2010 – Present
Project Value – $1,085,164; Contract Type – Time & Materials; EA Project No. – 1434263; EA Project Manager – Luis Vega

***Sprague Road Groundwater Plume Site (National Priorities List), Ector County, Texas; EPA Region 6; Groundwater Technical Lead*—**Technical lead for a treatability study for *in situ* reduction of hexavalent chromium plume using emulsified vegetable oil and lactic acid to reduce chromium and precipitate in place. Installed and

logged over 20 injection and monitoring wells, injected aquifer amendments, and evaluated performance monitoring data.
Project Date: 2010 – Present
Project Value – $7 million; Contract Type – Time & Materials; EA Project No. – 1434207; EA Project Manager – Stan Wallace

Sandy Beach Road Groundwater Plume Site (National Priorities List), Pelican Bay, Texas; EPA Region 6; Groundwater Technical Lead—Designed and installed water table groundwater monitoring wells as well as deep (>400 ft deep) monitoring wells at a large chlorinated solvent plume in Tarrant County, Texas. Designed and oversaw 72-hour pumping test, two slug tests, and six single well recovery tests to map out permeability to support fate and transport modeling. Senior technical review of remedial investigation.
Project Date: 2010 – Present
Project Value – $2.7 million; Contract Type – Time & Materials; EA Project No. – 1434213; EA Project Manager – Terri McMillan

East 67th Street Groundwater Plume Site (National Priorities List), Odessa, Texas; EPA Region 6; Groundwater Technical Lead—Senior technical reviewer of Remedial Investigation and groundwater Remedial Alternatives for Feasibility Study. Designed field scale Treatability Studies for in situ reductive dechlorination, soil vapor extraction, and hydraulic testing.
Project Date: 2010 – Present
Project Value – $1 million; Contract Type – Time & Materials; EA Project No. – 1434211; EA Project Manager – Luis Vega

New Mexico Environment Department Brownfields Program, Albuquerque, New Mexico; Northwest New Mexico Council of Governments; Program Manager—Phase I Environmental Site Assessments include Old Alamogordo Landfill, Ponderosa Products, Inc., Elementary School in House, Old Railroad Depot in Tucumcari, and Phase II Environmental Site Assessments include Old Alamogordo Landfill, the Del Norte Gun Club, and Ponderosa Products, Inc.
Project Date: 2010 – Present
Project Value – $60,000; Contract Type – Time; EA Project No. – 14783.01; EA Project Manager – Cristina Radu

Eagle Picher/Carefree Batteries Superfund Site (National Priorities List), Socorro, New Mexico; EPA Region 6; Groundwater Technical Lead—Technical lead for groundwater pathways at the Eagle Picher/Carefree Batteries Superfund Site (National Priorities List). Responsible for: (1) source area characterization, (2) evaluation of migration pathways, (3) delineation of horizontal and vertical extent of chlorinated solvent plume, (4) scoping vertical delineation multi-level groundwater sampling system, and (5) fate and transport of contaminants. Assist in scoping data gaps for the Remedial Investigation and in support of the Feasibility Study. Scoping and specifying pumping tests and analyses for aquifer characterization.
Project Date: 2009 – Present
Project Value – $2.9 million; Contract Type – Time & Materials; EA Project No. – 1434243; EA Project Manager – Luis Vega

Iron King Mine, Humbolt-Dewey, Arizona, EPA Region 6; Groundwater Technical Lead—Technical lead for groundwater pathways at the Iron King Mine Superfund Site (National Priorities List). Responsible for evaluating soil/tailing to groundwater leaching pathway, impacts to groundwater, and scoping data gaps for the remedial investigation and in support of the Feasibility Study.
Project Date: 2008 – Present
Project Value – $3.3 million; Contract Type – Time & Materials; EA Project No. – 1434234; EA Project Manager – Doug McReynolds

Bandera Road Superfund Site, San Antonio, Texas; EPA Region 6; Groundwater Technical Lead—Technical lead for groundwater issues at the Bandera Road Superfund Site (National Priorities List). Responsible for evaluating potential migration pathways for chlorinated solvent in fractured limestone and chalk, scoping geophysical investigation of preferential flow paths, scoping pilot tests for cleanup of source area contamination, and review of potential for monitored natural attenuation zones.
Project Date: 2008 – Present
Project Value – $2.4 million; Contract Type – Time & Materials; EA Project No. – 1434237; EA Project Manager – Doug McReynolds

Texarkana Wood Preserving Superfund Site, Texarkana, Texas; EPA Region 6; Hydrogeology Technical Lead—Technical lead for feasibility study at a dense non-aqueous phase liquid creosote wood treating facility. Technologies evaluated include soil/dense non-aqueous phase liquid stabilization, slurry walls/containment, *in situ* chemical oxidation, and monitored natural attenuation.
Project Date: 2008 – Present
Project Value – $1.1 million; Contract Type – Time and Materials; EA Project No. – 1434258; EA Project Manager – Ted Telisak

Titanium Metals Plant, Henderson, Nevada; Titanium Metals Inc; Lead Hydrogeologist—Senior groundwater hydrology lead on evaluation of fate and transport of groundwater plumes, remedial investigation design, and aquifer testing and analysis.
Project Date: 2008–2012
Project Value – $350,000; Contract Type – Time and Materials; EA Project No. – 1464901; EA Project Manager – Jay Snyder

Groundwater Abatement, Dona Ana Dairies, Mesquite, New Mexico, Lead Hydrogeologist—Senior groundwater hydrology lead on Stage 1 and Stage 2 Abatement of groundwater impacts by dairy wastes. Duties include plume delineation, basic groundwater hydrology, and surface water – groundwater interaction.
Project Date: 2008 – Present
Project Value – $300,000+ Contract Type – Time and Materials; EA Project No. – 1464102 and 1464103; EA Project Manager – Teri McMillan

Cal-Maine Foods Egg Plant, Bernalillo County, New Mexico; Lead Hydrogeologist—Senior groundwater hydrology lead on Stage 1 Abatement Plans for assessment of groundwater impacts by egg laying and egg washing operations. Duties include development of conceptual site model, source characterization, plume delineation, basic groundwater hydrology, and evaluation of dilution attenuation factors for soil leaching to groundwater pathway.
Project Date: 2008 – Present
Project Value – $132,125; Contract Type – Time and Materials; EA Project No. – 1464502; EA Project Manager – Teri McMillan

Monitored Natural Attenuation Sites Remedial Action; Allsup Petroleum, Inc. Various Sites, New Mexico; Project Manager/Technical Lead—Project manager and technical lead for remedial action at monitored natural attenuation sites. Scope of work includes Mann-Kendall analysis of groundwater contaminant concentrations trends, verification of monitored natural attenuation mechanisms, and petition to New Mexico Water Quality Control Commission for alternative abatement standards.
Project Date: 2008 – Present
Project Value – $100,000+; Contract Type – Time & Materials; EA Project No. – Varies; EA Project Manager – Teri McMillan

Other Project Experience

Installation Restoration Program Sites, Naval Air Station, Fallon, Nevada; Department of Navy; 2004–2005; Senior Hydrogeologist—Senior hydrogeologist and groundwater technical lead on evaluation of remedial alternatives of groundwater plumes contaminated with fuel hydrocarbons and chlorinated solvents. Activities include technical evaluation of existing hydraulic control system, *in situ* bioremediation, slurry walls, and monitored natural attenuation.

Voluntary Remediation Program Applications, Albuquerque, New Mexico; Schwartzman, Inc.; 2002–2006; Project Manager—Project manager and technical lead for processing commercial land tracts through New Mexico Voluntary Remediation Program as innocent owner applicants for covenant to sue. Activities include Phase I environmental site assessment, Existing Data Reports regarding encroachment contamination, limited Phase II sampling, completion reporting, and all other programmatic aspects.

Hans Bazen Site, Los Lunas, New Mexico; New Mexico Environment Department; 2004–2005; Project Manager—Project manager and senior technical lead for hydrogeologic investigation, 14,000 cubic yd removal action, and feasibility analysis of groundwater alternatives for state-lead leaking underground storage tank site.

Mike's Auto Detail Site, Belen, New Mexico; New Mexico Environment Department; 2004–2005; Project Manager—Project manager and senior technical lead for hydrogeologic investigation, aquifer analysis, soil vapor extraction pilot testing, and remedial design for state-lead leaking underground storage tank site. Remedial design includes thermally enhanced multiphase extraction.

Marion Creosote Site, Marion, Louisiana; EPA Region 6; 2003–2005; Hydrogeology Lead—Groundwater technical lead for feasibility study and remedial design for creosote impacted site (National Priorities List). Final remedy entails steam stripping with *in situ* thermal desorption in concert with limited removal action.

Sprague Road Groundwater Plume Remedial Action, Odessa, Texas; EPA Region 6; 2001–2005; Hydrogeology Lead—Senior technical lead for remedial action at a National Priorities List site with chromium contamination in groundwater. Activities include vadose zone and groundwater flow modeling and development of extraction well field scenarios, aquifer pumping tests, infiltration tests, chromium fate and transport, and selection of treatment technologies.

Sol Lynn Superfund Site Feasibility Study, Houston, Texas; EPA Region 6; 2004–2005; Hydrogeology Lead—Technical lead for feasibility study at a National Priorities List site contaminated with trichloroethylene, dichloroethene, and vinyl chloride. Remedies evaluated included *in situ* bioremediation, monitored natural attenuation, *in situ* thermal desorption, and permeable reactive barriers. Evaluated all aspects of aerobic/anaerobic direct and cometabolic biodegradation mechanisms, partitioning of contaminants, fate and transport, and degradation byproducts and their fate.

Ouachita-Nevada Wood Treatment Superfund Site Remedial Investigation/Feasibility Study, Reader, Arkansas; EPA Region 6; 2003–2005; Technical Lead—Technical lead for remedial investigation and feasibility study at a National Priorities List site contaminated with pentachlorophenol and polynuclear aromatic hydrocarbons. Activities included evaluation of all aspects of aerobic biodegradation mechanisms and pentachloralphenol fate and transport. Geologist of record for remedial investigation.

Turtle Bayou Superfund Site Remedial Design, Turtle Bayou, Texas; EPA Region 6; 2001–2005; Hydrogeology Lead—Technical lead for *in situ* bioremediation and monitored natural attenuation remedy for a National Priorities List site contaminated with vinyl chloride, 1,1-dichloroethane, 1,1-dichloroethene, benzene, and tertiary butyl alcohol. Evaluated all aspects of aerobic/anaerobic direct and cometabolic biodegradation mechanisms, partitioning of contaminants, fate and transport, and degradation byproducts and their fate.

Allsup's #137, Los Chavez, New Mexico; Allsup Petroleum Inc.; 2000–2005; Project Manager**—**Project manager for removal of 13,500 yd^3 of petroleum hydrocarbon contaminated soil and implementation of monitored natural attenuation remedy. Assessment work included completion of plume delineation, assessment of geochemical indicators for monitored natural attenuation, and calculation of aquifer assimilative capacity.

Former Belen Maintenance Yard, Belen, New Mexico; City of Belen; 2002–2005; Project Manager**—**Project manager for removal of 7,500 cubic yd of petroleum hydrocarbon contaminated soil and implementation of monitored natural attenuation remedy. Removal action included reconstructing city intersection including utilities. monitored natural attenuation implementation included completion of plume delineation, assessment of geochemical indicators for monitored natural attenuation, and calculation of aquifer assimilative capacity.

Multi-Site Contracts; Texas; TNRCC; 1998–2000; Program Manager**—**Program manager for TNRCC state-lead contracts—leaking petroleum storage tank monitoring, leaking petroleum storage tank site activities, and Superfund remedial investigation. Duties included all bid and marketing efforts, supervising all site activities and serving as primary contact for TNRCC Project Managers. Responsible for supervising the technical and administrative execution of contract work orders. Activities included preparation of work plans and cost estimates, implementation of work orders, review of invoices, verification of quality assurance/quality control procedures, review of all reports and submittals, maintaining project schedules and budgets, and maintaining compliance with TNRCC regulations and policies.

Sampson Horrice Remedial Investigation and Removal Action, Dallas, Texas; TNRCC; 1998–2000; Project Manager**—**Remedial investigation of state-lead Superfund site where over 300 drums of paint waste were disposed. Activities included over 3,000 linear feet of exploratory trenching, over 30 shallow soil borings, surface water and sediment sampling, drum content sampling, and monitoring well construction and sampling. Coordinated preparation of Field Sampling Plan, and Health and Safety Plan, and establishment of data quality objectives. Trenching phase of the project was performed in Level B personal protective equipment. Activities also included performing a removal action of buried drums in the main waste area.

South Valley Superfund Site, Albuquerque, New Mexico; Schwartzman, Inc.;1992–1995; Project Manager—
Project manager for litigation support of chlorinated solvent contaminated properties within the South Valley Superfund site in Albuquerque, New Mexico. Support included providing assessment of contaminant distribution, technical review of proposed remedial action, technical input to formulation of complaints, and technical assistance to deposition of defendants and their consultants.

Hobbs City Wells Site, Hobbs, New Mexico; New Mexico Environment Department;1993–1996; Project Manager and Technical Lead**—**Provided deposition in cost recovery case involving the Hobbs City Wells underground storage tank site. Support included timing of releases, evaluation of fuel hydrocarbons present, and elimination of potential sources of contaminates in case.

Litigation Support, Ector County, Texas; Fisher, Gallegher & Lewis;1993–1995; Staff Hydrogeologist—*Field* team leader for oil filed brine contamination related to secondary oil recovery. Provided field oversight and real-time scoping of plume delineation, volume estimates and worth of impacted groundwater, fate and transport, and costing of remedial alternatives.

Corrective Action for Leaking Petroleum Storage Tanks; Various RPR Clients in West Texas; 1995–2000; Marketing/Program Manager**—**Marketing and program/project manager for risk-based corrective action services for leaking underground storage tanks and the oil and gas sector. Provided senior technical review, site assessments, selection of remedial technologies, remedial design, and quality assurance/quality control for over 200 contaminated sites in West Texas. Activities included hydrogeologic site assessment, Tier 1 and 2 risk assessments, remedial technology screening, preparation of remedial action plans, and operation and maintenance evaluation. Permitted remediation systems including Class V injection wells and Standard Exemptions for air emissions.

Spill Prevention Control and Countermeasure Plans; City of Lubbock, Texas; 1997; Technical Reviewer**—**Senior technical reviewer for over 40 spill prevention control and countermeasure plans prepared for fuel storage and service facilities and electrical generating stations and substations.

Corrective Action for Natural Gas Facilities; Multi-Site; Enron; 1993–2004; Project Manager and Senior Technical Reviewer**—**Served as project manager and senior technical reviewer (contaminant hydrogeology) for assessment and remediation activities at seven natural gas compressor stations and one gas processing plant in southeast New Mexico. Activities included hydrogeologic characterization, aquifer testing, feasibility testing, and remedial design/remedial action.

Maintenance Yards; Various Yards, New Mexico; New Mexico Department of Transportation; 1993–1995; Program Manager**—**Contract liaison and program manager for multiple sites, including Belen, Bernalillo, Santa Rosa, Tucumcari, Nara Visa, and Artesia maintenance patrol yards.

Corrective Action for Leaking Underground Storage Tanks; New Mexico Environment Department, Multiple Locations, New Mexico; 1992; Program Manager**—**Program and project manager for corrective action at over 40 underground storage tank sites in New Mexico, including Hobbs City Wells, Tatum Cotton Butane, Lee's Gung Fu, and Schwartzman Packing Company underground storage tank sites. Remedial designs included soil vapor extraction with thermal and catalytic oxidation, *in situ* bioremediation, aboveground biological land treatment, and groundwater pump-and-treat and reinjection. Prepared discharge plans and New Source Review (authority to construct) permits for numerous remediation systems. Duties also included bid/proposal preparation and corporate interface with New Mexico Environment Department Underground Storage Tank Bureau.

Engineering Cost Evaluation, Naval Air Station Fallon, Fallon, Nevada; Department of Navy, 1991; Project Manager**—**Prepared work plans, cost analysis, and final report for 27 underground storage tanks at the facility. Cost estimates included refitting options in accordance with all applicable federal underground storage tank regulations, replacement with new underground storage tanks and replacement with aboveground tanks.

Holloman Air Force Base Groundwater Assessment; Holloman Air Force Base, New Mexico; EPA Region 6; 1990–1991; Project Manager**—**Prepared work plan, cost estimate, and quality assurance project plan. Contracted analytical services. Fieldwork consisted of split sampling monitoring wells for RCRA Appendix IX groundwater monitoring list constituents.

Chevron Chemical Company Technical Evaluation; Richmond, California; EPA Region 9; 1991; Project Manager**—**Performed technical evaluation of current conditions at Chevron Chemical Company's Richmond, California, plant. Provided technical assistance to EPA Region 9 in assessing the compliance status of Chevron's Richmond Refinery in Richmond, California, including evaluation of Chevron's Current Conditions Report and a proposed refinery-wide groundwater extraction trench system.

Petro-Processors Superfund Site; Baton Rouge, Louisiana; EPA; 1990–1991; Resident Observer**—**Responsibilities included analysis of pumping test data; review of groundwater and solute transport modeling; review of remedial design specifications; daily observation and inspection of construction activities, geotechnical borings and recovery well construction; review of quality control/quality assurance testing and procedures; and review of air quality monitoring data.

RCRA Compliance; Various Locations; New Mexico and Louisiana; EPA Region 6; 1990–1991; Project Manager**—**Project manager for RCRA Implementation at eight facilities in New Mexico and Louisiana. Prepared work plans, cost estimates, and quality assurance project plans for Requests for Information activities. Performed RCRA Facility Assessments at Fort Chaffee, Arkansas, and Fort Wingate, New Mexico. Provided technical review of RCRA closure plan and post-closure care compliance for landfills and hazardous waste landfills/landfarms at Cannon Air Force Base and Navajo Refining Co. in New Mexico. Provided technical oversight for Requests for Information at the Giant Refinery (Gallup, New Mexico); Navajo Refinery (Artesia, New Mexico); Kirtland Air Force Base (Albuquerque, New Mexico); Cannon Air Force Base (Clovis, New Mexico); Laguna Industries (Laguna Pueblo, New Mexico); and General Electric Apparatus Shop (Albuquerque, New Mexico). Performed split sampling of groundwater, surface sediment, and subsurface soil. Prepared quality assurance project plans and health and safety plans, contracted laboratories, reviewed analytical results, and prepared final reports.

Meteorological Support; Langley Air Force Base, Virginia; Langley Air Force Base; 1987–1990; Wing Weather Officer (Active Duty)—Provided operational weather forecasts in support of over $3 billion in assets to Commander, 1st Tactical Fighter Wing, Langley Air Force Base, Virginia. Prepared and delivered daily briefings to Commander and Wing Staff and during periods of impending and occurring severe weather. Served on the base Environmental Policy Committee and provided input to the base Installation Restoration Program. Performed air dispersion modeling to assist in disaster preparedness contingency plans for Langley.

Tucson International Airport Quality Assurance Project Plan; Tucson, Arizona; Tucson Airport Authority; 1993; Staff Hydrogeologist—Prepared the quality assurance project plan for a remedial investigation/feasibility study being conducted to determine the extent of chlorinated solvents in the vadose zone at Tucson International Airport.

Geophysical Surveys; Southern New Mexico; New Mexico State University; 1982–1985; Research Assistant—Research assistant on a variety of geophysical surveys in southern New Mexico that included: (1) shallow and deep seismic refraction and reflection surveys in the Tularosa and Jornada del Muerto Basins and in the Burro Mountains, (2) gravity surveys in the Mesilla Basin and Burro Mountains, (3) magnetic surveys in the Burro Mountains, and (4) shallow resistivity surveys.

Employment History

Employer—EA Engineering, Science, and Technology, Inc., PBC
Dates of Employment—2008 – Present
Title—Operations Manager Albuquerque

Employer—Golder Associates – Albuquerque, New Mexico
Dates of Employment—2005–2008
Title—Senior Consultant—Hydrogeology and Project Manager

Employer—Tetra Tech EMI – Albuquerque, New Mexico
Dates of Employment—2000–2005
Title—Office Manager and Senior Hydrogeologist

Employer—Daniel B. Stephens & Associates, Inc. – Albuquerque, New Mexico
Dates of Employment—1991–2000
Title—Texas Operations Manager, Project Group Leader, Business Development Manager

Employer—PRC Environmental Management, Inc. – Albuquerque, New Mexico
Dates of Employment—1991–1992
Title—Staff Hydrogeologist, Project Manager

Employer—U.S. Air Force – Langley Air Force Base, Virginia
Dates of Employment—1986–1990
Title—Wing Weather Officer (Active Duty), 1st Tactical Fighter Wing

Employer—New Mexico State University – Las Cruces, New Mexico
Dates of Employment—1982–1985
Title—Teaching and Research Assistant

List of Technical Skills and Specializations

- Construction oversight
- Contaminant hydrogeology
- Design and implementation of monitored natural attenuation
- Fate and transport of contaminants
- Feasibility studies and pilot testing
- Fractured aquifer cleanup
- Hydrogeologic characterization
- Performance assessment
- Permits for corrective action systems
- Remedial design
- Risk-based corrective action at waste sites

NEW MEXICO ENVIRONMENT
DEPARTMENT

Risk Assessment Guidance for Site Investigations and Remediation

December 2014

EXECUTIVE SUMMARY

This guidance document is being developed in coordination with the New Mexico Environment Department's (NMED) Hazardous Waste Bureau (HWB) and the Ground Water Quality Bureau.

This guidance document sets forth recommended approaches based on current State and Federal practices and intended for used as guidance for employees of NMED and for facilities within the State of New Mexico.

In the past, the material contained within this document existed in three separate guidance and/or position papers. In order to streamline the risk assessment process and ensure consistency between guidance/position papers, these documents have been combined into one document: *Risk Assessment Guidance for Site Investigations and Remediation*.

The *Risk Assessment Guidance for Site Investigations and Remediation* dated July 2014 replaces and supersedes previous versions of this document as well as the following documents:

- *Technical Background Document for Development of Soil Screening Levels*, Revision 6.0, 2012,
- *New Mexico Environment Department TPH Screening Guidelines*, October 2006, and
- *Risk-Based Remediation of Polychlorinated Biphenyls at RCRA Corrective Action Sites*, NMED Position Paper, March 2000.

This *Risk Assessment Guidance for Site Investigations and Remediation* is organized into two volumes.

- Volume I – Tier 1: Soil Screening Guidance Technical Background Document
- Volume II - Screening-Level Ecological Risk Assessments

Volume I contains information related to conducting screening level human health risk assessments. Previously, the soil screening levels (SSLs) were available in the *Technical Background Document for Development of Soil Screening Levels* while the screening levels for total petroleum hydrocarbons (TPH) were found in the *New Mexico Environment Department TPH Screening Guidelines*. Now both are contained in Volume I. Volume I also summarizes SSLs for select Aroclors and congeners of polychlorinated biphenyls (PCBs). Additional details for derivation of more site-specific SSLs for PCBs are contained within Appendix D.

Volume II provides guidance for conducting a scoping assessment for ecological risk as previously contained within the *Technical Background Document for Development of Soil Screening Levels.*

SUMMARY OF CHANGES

The following table summarizes changes to the "Risk Assessment Guidance for Investigations and Remediation," Volumes I and II. Specific changes are as follows:

Item	Section	Change	Date
VOLUME I TIER 1: SOIL SCREENING GUIDANCE TECHNICAL BACKGROUND DOCUMENT			
1	Global	Update default exposure parameters; includes changes to text, tables, equations, and soil screening levels in Appendix A	November 2014
2	Global	General edits and clarifications	November 2014
3	Table of Acronyms	Updated	November 2014
4	Table of Contents	Updated	November 2014
5	Summary of Changes	Added new section summarizing changes to document by revision number and date	November 2014
6	Section 1.2.1 and Table 1-1	Addition of tap-water exposure, vapor intrusion and beef ingestion pathways	November 2014
7	Section 2.1	Additional chemical-specific information added for clarification. Includes changes or additions to dioxin/furans, polychlorinated biphenyls (PCBs), hexavalent and total chromium, vanadium, xylene, phenanthrene, and polycyclic aromatic hydrocarbons (PAHs)	November 2014
8	Section 2.1.7	Section added addressing emerging contaminants	November 2014
9	Section 2.2.1 and Equations 12-17	Incorporated carcinogenic and mutagenic effects to calculation of trichloroethylene (TCE) specific soil screening levels	November 2014
10	Section 2.4	Modified to include dermal exposure	November 2014
11	Equations 24-26	Equations were modified and added to include dermal contact with tap water pathway	November 2014
12	Equation 27	Changed noncarcinogenic exposure parameters from adult exposure to child exposure (tap water)	November 2014
13	Equations 29-30 and Equations 31-35	Added dermal pathway to equations for vinyl chloride and mutagens	November 2014
14	Section 2.5	Section added addressing the vapor	November

Item	Section	Change	Date
		intrusion pathway and derivation of vapor screening levels	2014
15	Section 2.6	Section added describing the evaluation of the beef ingestion pathway	November 2014
16	Section 2.7.2	Section added describing background threshold values	November 2014
17	Section 2.7.3	Clarification added on determination of constituents of potential concern	November 2014
18	Section 2.7.7	Section added providing guidance for calculation of exposure-point concentrations	November 2014
19	Section 3.4	Added list of sources used for deriving chemical property information	November 2014
20	Section 5.0	Clarification added to text on the use of the SSLs	November 2014
21	Section 5.1	Section added describing chromium speciation and tiered approach to using chromium screening levels	November 2014
22	Section 5.2	Section added describing derivation of screening levels for essential nutrients	November 2014
23	Section 6.0	Updated Total Petroleum Hydrocarbon (TPH) methodology; removed groundwater screening levels.	November 2014
24	Section 7.0	Updated references	November 2014
25	Table A-1	Updated NMED screening levels	November 2014
26	Table A-2	Updated default exposure parameters	November 2014
27	Table A-3	Table added displaying vapor intrusion screening levels	November 2014
28	Tables B-1 and B-2	Updated chemical property information with references added	November 2014
29	Table B-3	Table added showing input parameters and chemical properties for dermal tap-water pathway	November 2014
30	Table C-1	Updated toxicity data	November 2014
VOLUME 2 SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENTS			
1	Global	Updating of reference	November 2014
2	Global	General editorial corrections	November 2014
3	Section 3	Additional clarification of Screening Level	November

Item	Section	Change	Date
		Ecological Risk Assessments (SLERA) for Phase I – revised Tier 1 assessments and added updated methodologies and equations	2014
4	Section 4	Added Tier 2 SLERA methodologies and equations	November 2014
5	Section 5	Site-specific ecological risk assessments added as Tier 3 process	November 2014

VOLUME I

TIER 1: SOIL SCREENING GUIDANCE TECHNICAL BACKGROUND DOCUMENT

TABLE OF CONTENTS
VOLUME I

Contents **Page**

TABLE OF CONTENTS, Cont.

<u>Tables</u>

TABLE OF CONTENTS, Cont.

Figures

Appendices

LIST OF ACRONYMS

AI	Adequate Intake
ASTDR	Agency for Toxic Substances and Disease Registry
BGS	Below Ground Surface
BTV	Background Threshold Value
C	Celsius
CalEPA	California Environmental Protection Agency
CMTP	Composite Model for Leachate Migration with Transformation Products
COPC	Contaminants of Potential Concern
CSM	Conceptual Site Model
DAF	Dilution Attenuation Factor
DQO	Data Quality Objectives
EPA/ORD	Environmental Protection Agency Office of Research and Development
EPC	Exposure Point Concentration
EPH	Extractable Petroleum Hydrocarbons
EPI	Estimation Program Interface
GWQB	Groundwater Quality Bureau
HEAST	Health Effects Assessment Summary Tables
HWB	Hazardous Waste Bureau
IEUBK	Integrated Exposure Uptake Biokinetic
IRIS	Integrated Risk Information System
IUPAC	International Union of Pure and Applied Chemistry
IUR	Inhalation Unit Risk
J&E	Johnson and Ettinger
MADEP	Massachusetts Department of Environmental Protection
MCL	Maximum Contaminant Level
MDL	Minimum Detection Limit
MRL	Minimum Risk Level
NAPL	Non-aqueous Phase Liquid
NHL	Non-Hodgkin's Lymphoma
NJDEP	New Jersey Department of Environmental Protection
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NRCS	National Resource Conservation Service
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PEF	Particulate Emission Factor
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane Sulfonate
PPRTV	Provisional Peer-reviewed Toxicity Value
PRG	Preliminary Remediation Goal
RAGS	Risk Assessment Guidance for Superfund
RAIS	Risk Assessment Information System
RCRA	Resource Conservation and Recovery Act

LIST OF ACRONYMS, Cont.

RDA	Recommended Daily Allowance
RfC	Reference Concentration
RfD	Reference Dose
RSL	Regional Screening Level
SCEM	Site Conceptual Exposure Model
SL	Screening Level
SQL	Sample Quantitation Level
SSG	Soil Screening Guidance
SSL	Soil Screening Level
SVOC	Semi-volatile Organic Compound
TCDD	Tetrachlorodibenzo-p-dioxin
TCE	Tricholorethylene
TEF	Toxicity Equivalency Factor
TEQ	Toxicity Equivalent
TPH	Total Petroleum Hydrocarbon
UCL	Upper Confidence Limit
UL	Upper Intake Limit
US EPA	United States Environmental Protection Agency
USGS	United States Geologic Survey
UTL	Upper Tolerance Limit
VF	Volatilization Factor
VISL	Vapor Intrusion Screening Level
VOC	Volatile Organic Compound
VPH	Volatile Petroleum Hydrocarbons
WHO	World Health Organization
WQCC	Water Quality Control Commission

1.0 INTRODUCTION

The New Mexico Environment Department (NMED) Hazardous Waste Bureau (HWB) and the Ground Water Quality Bureau (GWQB) have developed this soil screening guidance (SSG) for internal department use within corrective action programs. The SSG discusses the methodology used to derive chemical-specific soil screening levels (SSLs), tap water screening levels, and vapor intrusion screening levels (VISLs). In addition, guidance is provided to assist in identifying and evaluating appropriate exposure pathways and receptors. Finally, this document provides generic SSLs, tap water SLs, and VISLs for chemicals commonly found at contaminated sites based on default exposure parameters under residential and non-residential land-use scenarios.

The SSG provides site managers with a framework for developing and applying the SSLs, and is likely to be most useful for determining whether areas or entire sites are contaminated to an extent that warrants further investigation. It is intended to assist and streamline the site investigation and corrective action process by focusing resources on those sites or areas that pose the greatest risk to human health and the environment. Implementation of the methodologies outlined within this SSG may significantly reduce the time necessary to complete site investigations and cleanup actions at certain sites, as well as improve the consistency of these investigations.

Between various sites there can exist a wide spectrum of contaminant types and concentrations. The level of concern associated with those concentrations depends on several factors, including the likelihood of exposure to concentrations that could impact human health or ecological receptors. At one end of the spectrum are levels that clearly warrant a response action; at the other end are levels that are below regulatory concern. Appropriate cleanup goals for a site may fall anywhere within this range depending on site-specific conditions. Screening levels such as SSLs identify the lower end of this spectrum – levels below which there is generally no need for further concern—provided the conditions associated with the development of the SSLs are consistent with the site being evaluated. It is important to note that SSLs do not in themselves represent cleanup standards, and the SSLs alone do not trigger the need for a response action or define “unacceptable” levels of contamination in soil.

1.1 Organization of the Document

The NMED SSG is organized into five major sections with supporting appendices. The remainder of Section 1 addresses the purpose of the NMED SSLs and outlines the scope of the document. Section 2 outlines the receptors, exposure pathways, and exposure assumptions used in calculating the NMED SSLs. It also discusses the risk levels on which the SSLs are predicated and presents the SSL model assumptions. Finally, Section 2 discusses site assessment/characterization activities that should be completed prior to comparing site contaminant concentrations with SSLs. These activities include development of data quality objectives, conducting site sampling, preparation of a preliminary conceptual site model (CSM), and identification of contaminants of potential concern (COPCs). Section 3 provides a detailed description of the process used to develop pathway-specific SSLs. Included in this section is a discussion of the human health basis for the SSLs, additive risk, and acute exposures. Additional topics discussed in Section 3 include chemical specific parameters used to develop the SSLs and calculation of volatilization factors, particulate emission factors and soil saturation limits. Section 4 presents methodologies for assessing the potential for migration of contaminants to groundwater from contaminated soil in concert with generic and site-specific leaching models. Section 5 addresses special use considerations for addressing contaminant concentrations in soil and notes specific problems that can arise when applying the SSLs to specific sites. Finally, Section 6 addresses the screening criteria that should be applied at sites with potential petroleum releases. Soil and tap water screening levels for contaminants are presented in Table A-1 of Appendix A. Table A-2 of Appendix A presents the default exposure factor values used in the generation of the NMED SSLs. Screening levels for the vapor intrusion pathway are presented in Table A-3 of Appendix A. Physical-chemical values used in the calculation of the SSLs are presented in Tables B-1, B-2, and B-3 of Appendix B. Toxicity criteria are presented in Table C-1 of Appendix C. Additional discussion of polychlorinated biphenyls (PCBs) is provided in Appendix D.

1.2 Scope of the Soil Screening Guidance

The SSG incorporates readily obtainable site data and utilizes methods from various United States Environmental Protection Agency (US EPA) risk assessment guidance and derives site-specific screening levels for selected contaminants and exposure pathways. Key attributes of the SSG include default values for generic SSLs where site-specific information is unavailable, and the identification of parameters for which site-specific information is needed for the development of site-specific SSLs. The goal of the SSG is to provide a consistent approach for developing site-specific SSLs for evaluating facilities under the auspices of the corrective action process within NMED.

The NMED SSLs are based on a 1E-05 target risk for carcinogens, or a hazard quotient of 1.0 for noncarcinogens. In instances where an individual contaminant has the capacity to elicit both types of responses, the SSLs preferentially report the screening value representative of the lowest (most stringent) contaminant concentration in environmental media. SSLs for migration to groundwater are based on NMED-specific tap water SSLs. As such, the NMED SSLs serve as a generic benchmark for screening level comparisons of contaminant concentrations in soil. NMED anticipates that the SSLs will be used as a tool to facilitate prompt identification of those contaminants and areas that represent the greatest risks to human health and the environment. While concentrations above the NMED SSLs presented in this document do not automatically designate a site as “contaminated” or trigger the need for a response action, detected concentrations in site soils exceeding screening levels suggest that further evaluation is appropriate. Further evaluation may include additional sampling to better characterize the nature and extent of contamination, consideration of background levels, reevaluation of COPCs or associated risk and hazard using site-specific parameters, and/or a reassessment of the assumptions associated with the generic SSLs (e.g., appropriateness of route-to-route extrapolations, use of chronic toxicity values to evaluate childhood and construction-worker exposures).

Prior to calculating site-specific SSLs, each relevant chemical specific parameter value and toxicological datum should be checked against the most recent version of its source to determine if updated data are available.

In the event that a NMED SSL is not listed for a given chemical, other sources of screening levels should be consulted, such as the US EPA Regional Screening Levels (RSLs) (US EPA, 2014a or most current), or a review of toxicological data should be conducted and if available, a screening level calculated for that given chemical. Care should be used when other sources of screening levels are used to ensure that target risk/levels used in development of the levels are consistent with those applied by NMED. For example, the US EPA carcinogenic RSLs are based on a 1E-06 risk level and must be adjusted to a 1E-05 risk level for use. RSLs for noncarcinogens are provided for hazards of 1.0 and 0.1; the RSLs based on a hazard quotient of 1.0 should be applied.

1.2.1 Exposure Pathways

A complete exposure pathway consists of (1) a source, (2) a mechanism of contaminant release, (3) a receiving or contact medium, (4) a potential receptor population, and (5) an exposure route. All five elements must be present for the exposure pathway to be considered complete. SSLs have been developed for use in evaluating several exposure scenarios representing a variety of potential land uses: residential, commercial/industrial, and construction. The SSG presents lists of potential pathways for each scenario, though these lists are not intended to be exhaustive. Instead, each list represents a set of typical exposure pathways likely to account for the majority of exposure to contaminants in soil or other media at a given site. These include:

- Direct (and incidental) ingestion of soil,
- Dermal contact with soil,
- Inhalation of volatiles and fugitive dusts from contaminated soil,
- Migration of chemicals through soil to an underlying potable aquifer or water-bearing unit,
- Ingestion of tap water during domestic use,
- Dermal contact with tap water during domestic use,
- Inhalation of volatile organic compounds (VOCs) volatilized from tap water into indoor air during domestic use,
- Inhalation of volatiles in indoor air via the subsurface vapor intrusion pathway, and
- Ingestion of potentially contaminated beef.

Under some site-specific situations, additional complete exposure pathways may be identified. In these cases, a site-specific evaluation of risk is warranted under which additional exposure pathways can be considered. If other land uses and exposure scenarios are determined to be more appropriate for a site (e.g., home gardening, recreational land use, hunting, and/or Native American land use), the exposure pathways addressed in this document should be modified or augmented accordingly or a site-specific risk assessment should be conducted. Early identification of the need for additional information is important because it facilitates development of a defensible sampling and analysis strategy.

The exposure pathways addressed in this guidance are presented by land-use scenario in Table 1-1.

Table 1-1. Exposure Pathways Evaluated in Soil Screening Guidance

Potential Exposure Pathway	**Residential**	**Commercial /Industrial**	**Construction**
Direct ingestion of soil	✓	✓	✓
Dermal contact with soil	✓	✓	✓
Inhalation of dust and volatiles from soil	✓	✓	✓
Inhalation of VOCs from vapor intrusion	✓	✓	--
Ingestion of tap water	✓	--	--
Dermal contact with tap water	✓	--	--
Inhalation of VOCs volatilized from tap water during domestic use	✓	--	--
Ingestion of beef	✓	--	--

1.2.2 Exposure Assumptions

SSLs represent risk-based concentrations in soil derived from equations combining exposure assumptions with toxicity criteria following the US EPA's preferred tiered hierarchy of toxicological data. The models and assumptions used were developed to be consistent with the Superfund concept of "reasonable maximum exposure" (US EPA 1989 and 2009). This is intended to provide an upper-bound estimate of chronic exposure by combining both average and conservative (i.e., 90th to 95th percentile) values in the calculations. The default intake and duration assumptions presented here are intended to be protective of all potentially exposed populations for each land use consideration. Exposure point concentrations in soil should reflect either directly measured or estimated values using fate and transport models. When assessing chronic, long-term exposures, the maximum detected site concentration should be used for an initial screen against the SSLs. A more refined assessment may include use of an estimate of the average [95 percent upper confidence level (UCL) of the mean] concentration if sufficient site data are available to allow for an accurate estimation of the UCL. Where the potential for acute toxicity may be of concern, estimates based on the maximum exposure may be more appropriate.

The resulting estimate of exposure is then compared with chemical-specific toxicity criteria. To calculate the SSLs, the exposure equations and pathway models are rearranged to back calculate an "acceptable level" of a contaminant in soil corresponding to a specific level of target risk or hazard.

1.2.3 Target Risk and Hazard

Target risk and hazard levels for human health are risk management-based criteria for carcinogenic and non-carcinogenic responses, respectively, to determine: (1) whether site-related contamination poses an unacceptable risk to human health and requires corrective action or (2) whether implemented corrective action(s) sufficiently protects human health. If an estimated risk or hazard falls within the target range, the risk manager must decide whether or not the site poses an unacceptable risk. This decision should take into account the degree of inherent conservatism or level of uncertainty associated with the site-specific estimates of risk and hazard. An estimated risk that exceeds these targets, however, does not necessarily indicate that current conditions are not safe or that they present an unacceptable risk. Rather, a site risk calculation that exceeds a target value may simply indicate the need for further evaluation or refinement of the exposure model.

For cumulative exposure via the ingestion, inhalation, and dermal pathways, toxicity criteria are used to calculate an acceptable level of contamination in soil. SSLs are based on a carcinogenic risk level of one-in-one-hundred thousand (1E-05) and a non-carcinogenic hazard quotient of 1.0. A carcinogenic risk level is defined as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. The non-carcinogenic hazard quotient assumes that there is a level of exposure below which it is unlikely for even sensitive populations to experience adverse health effects.

1.2.4 SSL Model Assumptions

The models used to calculate inhalation exposure and protection of groundwater based on potential migration of contaminants in soil are intended to be utilized at an early stage in the site investigation process when information regarding the site may be limited. For this reason, the models incorporate a number of simplifying assumptions. For instance, the models assume an infinite contaminant source, i.e. a constant concentration is maintained for the duration of the exposure period. Although this is a highly conservative assumption, finite source models require accurate data regarding source size and volume. Such data are unlikely to be available from limited sampling efforts. The models also assume that contamination is homogeneous throughout the source and that no biological or chemical degradation occurs. Where sufficient site-specific data are available, more detailed finite-source models may be used in place of the default model assumptions presented in this SSG.

2.0 DEVELOPMENT OF PATHWAY SPECIFIC SOIL SCREENING LEVELS

The following sections present the technical basis and limitations used to calculate SSLs, tap water screening levels (SLs), VISLs, and beef ingestion SLs for residential, commercial/industrial, and construction land use scenarios. The equations used to evaluate inhalation and migration to groundwater include a number of easily obtainable site-specific input parameters. Where site-specific data are not available, conservative default values are presented. The equations used are presented in Sections 2.2 through 2.6. Generic SSLs and tap water screening levels are calculated using these default values and are presented in Table A-1 of Appendix A. Vapor intrusion screening levels were calculated for chemicals considered toxic and volatile and are presented in Table A-3.

2.1 Human Health Basis

The toxicity criteria used for calculating the SSLs are presented in Table C-1 of Appendix C. The selected toxicity values were based on chronic exposure. The primary sources for the human health benchmarks follow the US EPA Superfund programs tiered hierarchy of human health toxicity values (US EPA 2003). Although the US EPA 2003 identified several Tier 3 sources, a hierarchy among the Tier 3 sources was not assigned by the US EPA. For the calculation of NMED SSLs, the following hierarchy of sources was applied in the order listed, and is similar to the hierarchy utilized in the calculation of US EPA's RSLs (US EPA, 2014a):

1) Integrated Risk Information System (IRIS) (US EPA, 2014c) (www.epa.gov/iris),

2) Provisional peer reviewed toxicity values (PPRTVs) (http://hhpprtv.ornl.gov/) and appendices,

3) Agency for Toxic Substances and Disease Registry (ATSDR) (http://www.atsdr.cdc.gov/) and minimal risk levels (MRLs) (http://www.atsdr.cdc.gov/mrls/index.asp),

4) California EPA's Office of Environmental and Health Hazard Assessment values (CalEPA) (http://www.oehha.ca.gov/air/allrels.html and http://www.oehha.ca.gov/risk/pdf/tcdb072109alpha.pdf), and

5) Health Effects Assessment Summary Tables (HEAST) (US EPA 1997a).

Special assumptions were also applied in determining appropriate toxicological data for certain chemicals.

Dioxins/Furans. Toxicity data for the dioxin and furan congeners were assessed using the 2005 World Health Organization's (WHO) toxicity equivalency factors (TEF) (Van den berg, et al 2006) and are summarized in Table 2-1. When screening risk assessments are performed for dioxins/furans at a site, the following TEFs should be applied to the analytical results and summed for each sample location; the sum, or toxicity equivalent (TEQ), should be compared to the NMED SSL for 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD).

Table 2-1. Dioxin and Furan Toxicity Equivalency Factors

Dioxin and Furan Congeners	TEF
Chlorinated dibenzo-p-dioxins	
2,3,7,8-TCDD	1
1,2,3,7,8-PeCDD	1
1,2,3,4,7,8-HxCDD	0.1
1,2,3,6,7,8-HxCDD	0.1
1,2,3,7,8,9-HxCDD	0.1
1,2,3,4,6,7,8-HpCDD	0.01
OCDD	0.0003
Chlorinated dibenzofurans	
2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDF	0.03
2,3,4,7,8-PeCDF	0.3
1,2,3,4,7,8-HxCDF	0.1
1,2,3,6,7,8-HxCDF	0.1

Dioxin and Furan Congeners	TEF
1,2,3,7,8,9-HxCDF	0.1
2,3,4,6,7,8-HxCDF	0.1
1,2,3,4,6,7,8-HpCDF	0.01
1,2,3,4,7,8,9-HpCDF	0.01
OCDF	0.0003

Polychlorinated biphenyls (PCBs). Toxicity data for Aroclors were taken from the IRIS database. Aroclor 1016 is considered low risk; therefore, toxicity values deemed as "lowest risk" were applied. It was assumed that all of the other Aroclors were considered high risk; as such, toxicity values deemed as "highest risk" were applied.

Toxicity data for the dioxin-like PCBs were calculated relative to 2,3,7,8-TCDD toxicity. TEFs for non-ortho [International Union of Pure and Applied Chemistry (IUPAC) numbers 77, 81, 126, and 169)] and mono-ortho congeners (IUPAC numbers 105, 114, 118, 123, 156, 157, 167, and 189) were assessed using the 2005 WHO TEFs (Van den Berg, et al 2006) while TEFs for di-ortho congeners (IUPAC numbers 170 and 180) are taken from Ahlborg, et al, 1993 (see Table 2-2).

Table 2-2. PCB TEFs

IUPAC No.	Structure	TEF
77	3,3',4,4'-TetraCB	0.0001
81	3,4,4',5-TetraCB	0.0003
105	2,3,3',4,4'-PeCB	0.00003
114	2,3,4,4',5-PeCB	0.00003
118	2,3',4,4',5-PeCB	0.00003
123	2',3,4,4',5-PeCB	0.00003
126	3,3',4,4',5-PeCB	0.1
156	2,3,3',4,4',5-HxCB	0.00003
157	2,3,3',4,4',5'-HxCB	0.00003
167	2,3',4,4',5,5'-HxCB	0.00003
169	3,3',4,4',5,5'-HxCB	0.03
189	2,3,3',4,4',5,5'-HpCB	0.00003
170	2,2',3,3',4,4',5-HpCB	0.0001
180	2,2',3,4,4',5,5'-HpCB	0.00001

Cadmium. IRIS provides an oral reference dose (RfD) for both water and food. For deriving the tap water SSL, the RfD for water was applied and for the soil-based SSL, the RfD for food was applied.

Vanadium. The oral reference dose (RfD) for vanadium was calculated based on the RfDo for vanadium pentoxide and factoring out the molecular weight of the oxide ion.

Lead. The US EPA recommended levels for lead, based on blood-lead modeling (Integrated Exposure Uptake Biokinetic Model, IEUBK) were applied.

Total Chromium. Toxicity data for total chromium were adjusted based on a ratio of 1:6 (hexavalent chromium:trivalent chromium). If there is reason to believe that this ratio for total chromium is not representative of site conditions, then valence-specific site concentrations and SSLs for trivalent chromium (chromium (III)) and hexavalent chromium (chromium (VI)) should be applied. See Section 5.1 for further information on the use of chromium screening levels.

Chromium (VI). The oral cancer slope factor selected for chromium (VI) is based on a publication by the New Jersey Department of Environmental Protection (NJDEP) entitled *Derivation of Ingestion-Based Soil Remediation Criterion for* Cr^{+6} *Based on the NTP Chronic Bioassay Data for Sodium Dichromate Dihydrate* (April 8, 2009). This publication presents cancer potency values derived from a two-year dose-response study conducted by the National Toxicology Program (2008). NJDEP derived an oral cancer potency value of 0.5 mg/kg-day for chromium (VI). See Section 5.1 for further information on the use of chromium screening levels.

The inhalation unit risk (IUR) factor for chromium (VI) was derived by multiplying the total chromium IUR by seven (7) to account for a chrome speciation ratio of 1:6 (chromium (VI):chromium (III)). See Section 5.1 for further information on the use of chromium screening levels.

Xylenes. Toxicity criteria for xylenes (mixture) from US EPA's IRIS were used as surrogate values for the three isomers of xylenes (o-xylene, m-xylene, and p-xylene) based on structural similarity.

Phenanthrene. Based on structural similarity, toxicity data for pyrene were used as surrogate values for phenanthrene.

Polycyclic aromatic hydrocarbons (PAHs). Toxicity data for PAHs were calculated by applying TEFs relative to benzo(a)pyrene. The selected TEFs presented in US EPA (1993) were applied in the calculation of NMED SSLs and are listed in Table 2-3.

Table 2-3. Polycyclic Aromatic Hydrocarbon Toxicity Equivalency Factors

Poylycyclic Aromatic Hydrocarbon	TEF
Benzo(a)pyrene	1.0
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.01
Chrysene	0.001
Dibenz(a,h)anthracene	1.0
Indeno(1,2,3-cd)pyrene	0.1

2.1.1 Additive Risk

It is important to note that no consideration is provided in the calculation of individual NMED SSLs for additive risk when exposures to multiple chemicals occur. The SSG addresses this issue in Section 5. Because the NMED SSLs for carcinogenic effects correspond to a 1E-05 risk level individually, exposure to multiple contaminants may result in a cumulative site risk that is above the anticipated risk management range. While carcinogenic risks of multiple chemicals are simply added together, the issue of additive hazard is more complex for noncarcinogens because of the theory that a threshold exists for noncarcinogenic effects. This threshold is defined as the level below which adverse effects are not expected to occur, and represents the basis for the RfD and reference concentration (RfC). Since adverse effects are not expected to occur at the RfD or RfC and the SSLs are derived by setting the potential exposure dose to the RfD or RfC, the SSLs do not address the risk of exposure to multiple chemicals at levels where the individual chemicals alone would not be expected to cause any adverse effects. In such cases, the SSLs may not provide an accurate indicator for the likelihood of harmful effects. As a first-tier screening approach, noncarcinogenic effects should be considered additive. In the event that the hazard index results in a value above the target level of 1, noncarcinogenic effects may be evaluated for those chemicals with the same toxic endpoint and/or mechanism of action. The sources provided in Section 2.1 should be consulted to determine the endpoint and/or target organ system prior to attempting to evaluate the additive health effects resulting from simultaneous exposure to multiple non-carcinogenic contaminants.

2.1.2 Acute Exposures

The exposure assumptions used to develop the SSLs are based on a chronic exposure scenario and do not account for situations where high-level exposures may result in acute toxic effects. Such situations may arise when contaminant concentrations are very high, or may result from specific site-related conditions and/or behavioral patterns (e.g., pica behavior in children). Such exposures may be of concern for those contaminants that primarily exhibit acute health effects. For example, toxicological information regarding cyanide and phenol indicate that acute effects may be of concern for children exhibiting pica behavior. Pica is typically described as a compulsive craving to ingest non-food items (such as clay or paint). Although it can be exhibited by adults as well, it is typically of greatest concern in children because they often exhibit behavior (e.g., outdoor play activities and greater hand-to-mouth contact) that results in greater exposure to soil than for a typical adult. In addition, children also have a lower overall body weight relative to the predicted intake.

2.1.3 Early-Life Exposures to Carcinogens

US EPA's (2005a) Supplemental Guidance states that early life exposures (i.e., neonatal and early life) to certain carcinogens can result in an increase in cancer risk later in life. US EPA's (2005a) suggests that age-specific factors be applied to the estimated cancer risks. These factors should address four life stages: 1) children under 2 years of age; 2) children aged 2 to 6 years; 3) children 6 years to 16 years of age; and 4) children over 16 years of age. Effects of mutagenicity have been incorporated into the SSLs for those contaminants which are considered carcinogenic by a mutagenic mode of action.

2.1.4 Direct Ingestion

Exposure to contaminants through incidental ingestion of soil can result from the inadvertent consumption of soils adhering to the hands, food items, or objects that are placed into the mouth. It can also result from swallowing dust particles that have been inhaled and deposited in the mouth. Commercial/industrial, construction workers, and residential receptors may inadvertently ingest soil that adheres to their hands while involved in work- or recreation-related activities. Calculation of SSLs for direct ingestion are based on the methodology presented in US EPA's *Risk Assessment Guidance for Superfund (RAGS): Volume I - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals), Interim* (US EPA 1991), *Soil Screening Guidance: Technical Background Document* (US EPA 1996a), and *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (US EPA 2002a).

2.1.5 Dermal Absorption

Exposure to soil contaminants may result from dermal contact with contaminated soil and the subsequent absorption of contaminants through the skin. Contact with soil is most likely to occur as a result of digging, gardening, landscaping, or outdoor recreation activities. Excavation activities may also be a potential source of exposure to contaminants, particularly for construction workers. Calculation of the SSLs for dermal contact with soil under the residential exposure scenario is based on the methodology presented in US EPA's *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals), Interim* (1991), and *Soil Screening Guidance: Technical Background Document* (US EPA 1996a). The suggested default input values used to develop the NMED SSLs are consistent with US EPA's interim *RAGS, Part E, Supplemental Guidance for Dermal Risk Assessment* (US EPA 2004a).

2.1.6 Inhalation

US EPA toxicity data indicate that risks from exposure to some chemicals via the inhalation pathway far outweigh the risk via ingestion or dermal contact; therefore, the NMED SSLs have been designed to address inhalation of volatiles and fugitive dusts. To address the soil/sediment-to-air pathways, the SSL calculations incorporate a volatilization factor (VF) for volatile contaminants (See Section 3.1) and a particulate emission factor (PEF) (See Section 3.3) for semi-volatile and inorganic contaminants. The SSLs follow the procedures for evaluating inhalation soil, VOCs, and fugitive dust particles presented in US EPA's *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment), Final (US EPA 2009), Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals), Interim* (US EPA 1991), *Soil Screening Guidance: Technical Background Document* (US EPA 1996a), *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (US EPA 2005a), and *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (US EPA 2002a).

VOCs may adhere to soil particles or be present in interstitial air spaces in soil, and may volatilize into ambient air. This pathway may be particularly significant if the VOC emissions are concentrated in indoor spaces of onsite buildings, or buildings that may be built in the future. If volatiles are present in subsurface media (e.g., soil-gas or groundwater), volatilization through the vadose zone and into indoor air could occur. NMED VISLs were calculated to address this type of exposure using the methods outlined in Section 2.5. VOCs are considered those chemicals having a Henry's Law constant greater than 1E-05 atmospheres – cubic meter per mole (atm-m^3/mole) and a molecular weight less than 200 grams per mole (g/mole).

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

2.1.7 Contaminants of Emerging Concern

Contaminants of emerging concern are those contaminants possibly present in environmental media that are suspected to elicit adverse effects to human and ecological receptors, but do not have established health standards or established analytical methods. These contaminants may include but are not limited to perfluorinated compounds, such as perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS). As many agencies, including the US EPA, are working to understand the types of effects and levels of concern in environmental media, it is important to consider whether emerging contaminants may be present at facilities in New Mexico. For facilities where contaminants of emerging concern are detected in site media, and specifically PFOAs and PFOSs, a qualitative discussion of potential exposure and impact on overall risk/hazard must be included in the risk assessment.

2.2 Soil Screening Levels for Residential Land Uses

Residential exposures are assessed based on child and adult receptors. As discussed below, the child forms the basis for evaluation of noncarcinogenic effects incurred under residential exposures, while carcinogenic responses are modeled based upon age-adjusted values to account for exposures averaged over a lifetime. Under most circumstances, onsite residential receptors are expected to be the most conservative receptor basis for risk assessment purposes due to the assumption that exposure occurs 24 hours (hr) a day, 350 days per year (yr), extending over a 26-year exposure duration. Table 2-4 provides a summary of the exposure characteristics and parameters associated with a residential land use receptor (US EPA, 2014b).

Table 2-4. Summary of the Residential Land Use Receptors

Exposure Characteristics	- Substantial soil exposure (esp. children) - High soil ingestion rate (esp. children) - Significant time spent indoors - Long-term exposure - Surface and subsurface soil exposure (0-10 feet below ground surface, bgs)
Default Exposure Parameters	
Exposure frequency (days/yr)	350
Exposure duration (yr)	6 (child) 20 (adult)
Soil ingestion rate (mg/day)	200 (child) 100 (adult)
Body Weight (kg)	15 (child) 80 (adult)
Skin surface area exposed (cm^2)	2,690 (child) 6,032(adult)
Skin-soil adherence factor (mg/cm^2)	0.2 (child) 0.07 (adult)
cm^2 – square centimeters kg - kilograms mg – milligrams	

2.2.1 Residential Receptors

A residential receptor is assumed to be a long-term receptor occupying a dwelling within the site boundaries, and thus, is exposed to contaminants 24 hours per day, and is assumed to live at the site for 26 years [representing the 90th percentile of the length of time someone lives in a single location (US EPA, 2014b)], remaining onsite for 350 days per year. Exposure to soil (to depths of zero to 10 feet below ground surface) is expected to occur during home maintenance activities, yard work and landscaping, and outdoor play activities. The SSLs do not take into consideration ingestion of homegrown produce/meat/dairy or inhalation of volatiles migrating indoors via vapor intrusion. If these pathways are complete, analysis of risks resulting from these additional exposure pathways must be determined (refer to Sections 2.5 and 2.6) and added to the risks determined using the SSL screen (Equations 55 and 56).

Contaminant intake is assumed to occur via three exposure pathways – direct ingestion, dermal absorption, and inhalation of volatiles and fugitive dusts. For the residential scenario, both adult and child receptors were evaluated because children often exhibit behavior (e.g., greater hand-to-mouth contact) that can result in greater exposure to soils than those associated with a typical adult. In addition, children also have a lower overall body weight relative to the predicted intake.

Equations 1 and 2 are used to calculate cumulative SSLs for a residential receptor exposed to non-carcinogenic and carcinogenic contaminants via all three exposure pathways (ingestion of soil, inhalation of soil, and dermal contact with soil). Default exposure parameters are provided for use when site-specific data are not available.

Noncarcinogenic contaminants are evaluated based solely on childhood exposures using Equation 1. By combining the higher contaminant intake rates with the lower relative body weight, "childhood only" exposures lead to a lower, or more conservative, risk-based concentration compared to an adult-only exposure. In addition, this approach is considered conservative because it combines the higher 6-year exposure for children with chronic toxicity criteria.

Unlike non-carcinogens, the duration of exposure to carcinogens is averaged over the lifetime of the receptor because of the assumption that cancer may develop even after actual exposure has ceased. As a result, the total dose received is averaged over a lifetime of 70 years. In addition, to be protective of exposures in a residential setting, the carcinogenic exposure parameter values are age-adjusted to account for exposures incurred in children (1-6 years of age) and adults (26 years, 90th percentile for current resident time, US EPA, 2014b). Carcinogenic exposures are age-adjusted to account for the physiological differences between children and adults as well as behavioral differences that result in markedly different relative rates of exposure. Equations 3 and 4 are used to calculate age-adjusted ingestion, dermal and inhalation factors which account for the differences in soil ingestion rate, skin surface area, soil adherence factors, inhalation rate, and body weight for children versus adults. The age-adjusted factors calculated using these equations are applied in Equation 2 to develop generic NMED SSLs for carcinogenic effects.

Equation 1
Combined Exposures to Noncarcinogenic Contaminants in Soil, Residential Scenario

$$C_{oral} = \frac{THQ \times AT_r \times BW_c}{EF_r \times ED_c \times \left(1/RfD_o\right) \times IRS_c \times (10^{-6})}$$

$$C_{inh} = \frac{THQ \times AT_r}{EF_r \times ED_c \times ET_{rs} \times \left(1/RfC\right) \times \left[\left(1/VF_s\right) + (1/PEF_w)\right]}$$

$$C_{dermal} = \frac{THQ \times AT_r \times BW_c}{EF_r \times ED_c \times \left[1/\left(RfD_o \times GIABS\right)\right] \times SA_c \times AF_c \times ABS_d \times 10^{-6}}$$

Combined Exposures:

$$SSL_{res} = \frac{1}{\dfrac{1}{C_{oral}} + \dfrac{1}{C_{inh}} + \dfrac{1}{C_{dermal}}}$$

Parameter	Definition (units)	Default
C_{oral}	Contaminant concentration via oral ingestion (mg/kg)	Chemical-specific
C_{dermal}	Contaminant concentration via dermal adsorption (mg/kg)	Chemical-specific
C_{inh}	Contaminant concentration via inhalation (mg/kg)	Chemical-specific
SSL_{res}	Soil screening level, all pathways (mg/kg)	Chemical-specific
THQ	Target hazard quotient	1
BW_c	Body weight, child (kg)	15
AT_r	Averaging time, noncarcinogens (days)	ED_c x 365
EF_r	Exposure frequency, resident (day/yr)	350
ED_c	Exposure duration, child (yr)	6
ET_{rs}	Exposure time, resident (hr/day x day/hr)	1
IRS_c	Soil ingestion rate, child (mg/day)	200
RfD_o	Oral reference dose (mg/kg-day)	Chemical-specific
SA_c	Dermal surface area, child (cm^2/day)	2,690
AF_c	Soil adherence factor, child (mg/cm^2)	0.2
GIABS	Fraction absorbed in gastrointestinal tract (unitless)	Chemical-specific
ABS_d	Skin absorption factor (unitless)	Chemical-specific
RfC	Inhalation reference concentration (mg/m^3)	Chemical-specific
10^{-6}	Unit conversion factor (kg/mg)	10^{-6}
VF_s	Volatilization factor for soil (m^3/kg)	See Equation 45
PEF_w	Particulate emission factor (m^3/kg)	See Equation 48

Equation 2
Combined Exposures to Carcinogenic Contaminants in Soil, Residential Scenario

$$C_{oral} = \frac{TR \times AT_r}{CSF_o \times IFS_{adj} \times 10^{-6}}$$

$$C_{inh} = \frac{TR \times AT_r}{IUR \times 1000 \times EF_r \times \left(\frac{1}{VF_s} + \frac{1}{PEF_w} \right) \times ED_r \times ET_{rs}}$$

$$C_{dermal} = \frac{TR \times AT_r}{DFS_{adj} \times \frac{CSF_o}{GIABS} \times ABS_d \times 10^{-6}}$$

Combined Exposures:

$$SSL_{res} = \frac{1}{\frac{1}{C_{oral}} + \frac{1}{C_{inh}} + \frac{1}{C_{dermal}}}$$

Parameter	Definition (units)	Default
C_{oral}	Contaminant concentration via oral ingestion (mg/kg)	Chemical-specific
C_{dermal}	Contaminant concentration via dermal adsorption (mg/kg)	Chemical-specific
C_{inh}	Contaminant concentration via inhalation (mg/kg)	Chemical-specific
SSL_{res}	Soil screening level, all pathways (mg/kg)	Chemical-specific
TR	Target cancer risk	1E-05
AT_r	Averaging time, carcinogens (days)	25,550
EF_r	Exposure frequency, resident (day/yr)	350
IFS_{adj}	Age-adjusted soil ingestion factor (mg/kg)	See Equation 3
CSF_o	Oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	Chemical-specific
DFS_{adj}	Age-adjusted dermal factor (mg/kg)	See Equation 4
ABS_d	Skin absorption factor (unitless)	Chemical-specific
1000	Unit conversion factor (µg/mg)	1000
IUR	Inhalation unit risk $(\mu g/m^3)^{-1}$	Chemical-specific
ED_r	Exposure duration, resident (yr)	26
ET_{rs}	Exposure time, resident (hr/day x day/hr)	1
10^{-6}	Unit conversion factor (kg/mg)	10^{-6}
GIABS	Fraction absorbed in gastrointestinal tract (unitless)	Chemical-specific
VF_s	Volatilization factor for soil (m^3/kg)	See Equation 45
PEF	Particulate emission factor (m^3/kg)	See Equation 48

Equation 3
Calculation of Age-Adjusted Soil Ingestion Factor

$$IFS_{adj} = \frac{EF \times ED_c \times IRS_c}{BW_c} + \frac{EF \times (ED_r - ED_c) \times IRS_a}{BW_a}$$

Parameter	Definition (units)	Default
IFS_{adj}	Age-adjusted soil ingestion factor for carcinogens (mg/kg)	36,750
EF	Exposure frequency (day/yr)	350
ED_c	Exposure duration, child (yr)	6
IRS_c	Soil ingestion rate, child (mg/day)	200
BW_c	Body weight, child (kg)	15
ED_r	Exposure duration, resident (yr)	26
IRS_a	Soil ingestion rate, adult (mg/day)	100
BW_a	Body weight, adult (kg)	80

Equation 4
Calculation of Age-Adjusted Soil Dermal Factor

$$DFS_{adj} = \frac{EF \times ED_c \times SA_c \times AF_c}{BW_c} + \frac{EF \times (ED_r - ED_c) \times SA_a \times AF_a}{BW_a}$$

Parameter	Definition (units)	Default
DFS_{adj}	Age-adjusted dermal factor for carcinogens (mg /kg)	112,266
EF	Exposure frequency (day/yr)	350
ED_c	Exposure duration, child (yr)	6
AF_c	Soil adherence factor, child (mg/cm^2)	0.2
SA_c	Dermal surface area, child (cm^2/day)	2,690
BW_c	Body weight, child (kg)	15
ED_r	Exposure duration, resident (yr)	26
AF_a	Soil adherence factor, adult (mg/cm^2)	0.07
SA_a	Dermal surface area, adult (cm^2/day)	6,032
BW_a	Body weight, adult (kg)	80

Equations 1 and 2 are appropriate for all chemcials with the exception of vinyl chloride, trichloroethylene, and those carcinogens exhibiting mutegenic toxicity. For vinyl chloride, the US EPA IRIS database provides cancer slope factors for both a child and an adult. The child-based cancer slope factor takes into consideration potential risks during the developmental stages of childhood, and thus, is more protective than the adult cancer slope factor. The equations used to derive the SSLs for vinyl chloride incorporate age adjustments for exposure and are presented in Equation 5. As vinyl chloride does not have an adsorption factor, dermal risks are not assessed.

Equation 5
Combined SSL for Vinyl Chloride
Residential Scenario

$$C_{vc-oral} = \frac{TR}{\left(\frac{CSF_o \times IFS_{adj} \times 10^{-6}}{AT_r}\right) + \left(\frac{CSF_o \times IRS_c \times 10^{-6}}{BW_c}\right)}$$

$$C_{vc-inh} = \frac{TR}{\left(\frac{IUR \times EF_r \times ED \times ET_{rs} \times 1000}{AT_r \times VF} + \left(\frac{IUR}{VF} \times 1000\right)\right)}$$

Combined Exposures:

$$SSL_{res-vc} = \frac{1}{\frac{1}{C_{vc-oral}} + \frac{1}{C_{vc-inh}}}$$

Parameter	**Definition (units)**	**Default**
$C_{vc\text{-}oral}$	Contaminant concentration (mg/kg)	Chemical-specific
$C_{vc\text{-}inh}$	Contaminant concentration (mg/kg)	Chemical-specific
$C_{res\text{-}vc}$	Combined SSL for vinyl chloride (mg/kg)	Chemical-specific
TR	Target cancer risk	1E-05
BW_c	Body weight, child (kg)	15
AT_r	Averaging time, carcinogens (days)	25,550
EF_r	Exposure frequency, resident (day/yr)	350
IFS_{adj}	Age-adjusted soil ingestion factor (mg/kg)	See Equation 3
CSF_o	Oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	Chemical-specific
IRS_c	Child soil ingestion factor (mg/day)	200
10^{-6}	Unit conversion factor (kg/mg)	10^{-6}
IUR	Inhalation unit risk $(\mu g/m^3)^{-1}$	Chemical-specific
EF_r	Exposure frequency, resident (day/yr)	350
ED	Exposure duration (yr)	26
ET_{rs}	Exposure time (hr/day x day/hr)	1
1000	Conversion factor (μg/mg)	1000
VF	Volatilization factor for soil (m^3/kg)	See Equation 43

Equations 6 through 11 show the derivation of the SSLs for carcinogenic chemicals exhibiting mutagenic properties. Mutagenicity is only assessed for the residential scenario.

Equation 6
SSL for Ingestion of Soil- Mutagens

$$C_{mu-oral} = \frac{TR \times AT_r}{CSF_o \times IFSM_{adj} \times 10^{-6}}$$

Parameter	Definition (units)	Default
$C_{mu\text{-}oral}$	Contaminant concentration (mg/kg)	Chemical-specific
TR	Target cancer risk	1E-05
AT_r	Averaging time, carcinogens (days)	25,550
CSF_o	Oral cancer slope factor (mg/kg-day$)^{-1}$	Chemical-specific
$IFSM_{adj}$	Age-adjusted soil ingestion rate, mutagens (mg/kg)	See Equation 7
10^{-6}	Conversion factor (kg/mg)	10^{-6}

Equation 7
Calculation of Age-Adjusted Soil Ingestion Factor, Mutagens

$$IFSM_{adj} = \frac{EF_c \times ED_{0-2} \times IRS_c \times 10}{BW_c} + \frac{EF_c \times ED_{2-6} \times IRS_c \times 3}{BW_c} + \frac{EF_a \times ED_{6-16} \times IRS_a \times 3}{BW_a} + \frac{EF_a \times ED_{16-26} \times IRS_a \times 1}{BW_a}$$

Parameter	Definition (units)	Default
$IFSM_{adj}$	Age-adjusted soil ingestion factor for mutagens (mg/kg)	166,833
ED_{0-2}	Exposure duration, child (yr)	2
ED_{2-6}	Exposure duration, child (yr)	4
ED_{6-16}	Exposure duration, adult (yr)	10
ED_{16-26}	Exposure duration, adult (yr)	10
EF_c	Exposure frequency, child (days/yr)	350
EF_a	Exposure frequency, adult (days/yr)	350
IRS_c	Soil ingestion rate, child (mg/day)	200
IRS_a	Soil ingestion rate, adult (mg/day)	100
BW_c	Body weight, child (kg)	15
BW_a	Body weight, adult (kg)	80

Equation 8
SSL for Inhalation of Soil- Mutagens

$$C_{mu-inh}=\frac{TR\times AT_r}{\left(ET_{rs}\times 1000\right)\times\left[\left(ED_{0-2}\times EF\times IUR\times 10\right)+\left(ED_{2-6}\times EF\times IUR\times 3\right)+\left(ED_{6-16}\times EF\times IUR\times 3\right)+\left(ED_{16-26}\times EF\times IUR\times 1\right)\right]\times\left(\frac{1}{VF_s}+\frac{1}{PEF_w}\right)}$$

Parameter	Definition (units)	Default
$C_{mu\text{-}inh}$	Contaminant concentration (mg/kg)	Chemical-specific
TR	Target cancer risk	1E-05
AT_r	Averaging time, carcinogens (days)	25,550
IUR	Inhalation Unit Risk (µg/m^3)$^{-1}$	Chemical-specific
EF	Exposure frequency, (day/yr)	350
ED	Exposure duration (yr)	
	ED_{0-2} (yr)	2
	ED_{2-6} (yr)	4
	ED_{6-16} (yr)	10
	ED_{16-26} (yr)	10
ET_{rs}	Exposure time (hr/day x day/hr)	1
1000	Conversion factor (µg/mg)	1000
VF_s	Volatilization factor for soil (m^3/kg)	See Equation 45
PEF	Particulate emission factor (m^3/kg)	See Equation 48

Equation 9
SSL for Dermal Contact with Soil- Mutagens

$$C_{mu-dermal}=\frac{TR\times AT_r}{\frac{CSF_o}{GIABS}\times DFSM_{adj}\times ABS_d\times 10^{-6}}$$

Parameter	Definition (units)	Default
$C_{mu\text{-}dermal}$	Contaminant concentration (mg/kg)	Chemical-specific
TR	Target cancer risk	1E-05
AT_r	Averaging time, carcinogens (days)	25,550
CSF_o	Oral cancer slope factor (mg/kg-day$^{)-1}$	Chemical-specific
GIABS	Fraction absorbed in gastrointestinal tract (unitless)	Chemical-specific
$DFSM_{adj}$	Age-adjusted soil contact factor, mutagens (mg/kg)	See Equation 10
ABS_d	Skin absorption factor (unitless)	Chemical-specific
10^{-6}	Conversion factor (kg/mg)	10^{-6}

Equation 10
Calculation of Age-Adjusted Soil Contact Factor, Mutagens

$$DFSM_{adj} = \frac{ED_{0-2} \times AF_c \times SA_c \times 10}{BW_c} + \frac{ED_{2-6} \times AF_c \times SA_c \times 3}{BW_c} + \frac{ED_{6-16} \times AF_a \times SA_a \times 3}{BW_a} + \frac{ED_{16-26} \times AF_a \times SA_a \times 1}{BW_a}$$

Parameter	Definition (units)	Default
$DFSM_{adj}$	Age-adjusted soil contact factor for mutagens (mg/kg)	475,599
ED_{0-2}	Exposure duration, child (yr) x EF (350 days/yr))	700
ED_{2-6}	Exposure duration, child (yr) x EF (350 days/yr))	1,400
ED_{6-16}	Exposure duration, adult (yr) x EF (350 days/yr))	3,500
ED_{16-26}	Exposure duration, adult (yr) x EF (350 days/yr))	3,500
AF_c	Soil adherence factor, child (mg/cm^2)	0.02
AF_a	Soil adherence factor, adult (mg/ cm^2)	0.07
SA_c	Exposed skin area, child, (cm^2/day)	2,690
SA_a	Exposed skin area, adult, (cm^2/day)	6,032
BW_c	Body weight, child (kg)	15
BW_a	Body weight, adult (kg)	80

The overall SSL for the residential scenario for mutagens is determined following Equation 11.

Equation 11
Determination of the Combined SSL
Mutagens

$$SSL_{res-mu} = \frac{1}{\frac{1}{C_{mu-oral}} + \frac{1}{C_{mu-inh}} + \frac{1}{C_{mu-dermal}}}$$

Parameter	Definition (units)	Default
SSL_{res-mu}	Cumulative SSL for mutagens (mg/kg)	Chemical-specific
$C_{mu-oral}$	Concentration from soil ingestion (mg/kg)	See Equation 6
C_{mu-inh}	Concentration from inhalation (mg/kg)	See Equation 8
$C_{mu-dermal}$	Concentration from dermal exposure (mg/kg	See Equation 9

For trichloroethylene (TCE), the US EPA IRIS (US EPA, 2014c) database provides data on both carcinogenity and mutagenicity. Mutagenic effects assessed include Non-Hodgkin's lymphoma (NHL), and impact to the liver and kidneys. The SSL equations for TCE present in Equations 12 through 17 allow assessment of both cancer and mutagenic effects.

Equation 12
SSL for Ingestion of Soil - Trichloroethylene (TCE)
Residential Scenario

$$C_{TCE-oral} = \frac{TR \times AT}{\left(CSF_o \times 10^{-6} \times \left(\left(CAF_o \times IFS_{adj}\right) + \left(MAF_o \times IFSM_o\right)\right)\right)}$$

Parameter	Definition (units)	Default
$C_{TCE\text{-}oral}$	Contaminant concentration, ingestion soil (mg/kg)	Chemical-specific
TR	Target cancer risk	1E-05
AT	Averaging time, carcinogens (days)	25,550
CSF_o	Oral cancer slope factor (mg/kg-day$)^{-1}$	Chemical-specific
10^{-6}	Unit conversion factor (kg/mg)	10^{-6}
CAF_o	Adjusted oral cancer slope factor (mg/kg-day$^{)-1}$	See Equation 13
IFS_{adj}	Age-adjusted soil ingestion factor for carcinogens (mg/kg)	See Equation 6
MAF_o	Adjusted oral mutagenic slope factor (mg/kg-day$^{)-1}$	See Equation 13
$IFSM_o$	Age-adjusted soil ingestion factor for mutagens (mg/kg)	See Equation 7

Equation 13
Adjusted Oral Slope Factors - TCE
Residential Scenario

$$CAF_o = \frac{CSF_{o-NHL+Liver}}{CSF_{adult}}$$

$$MAF_o = \frac{CSF_{o-kidney}}{CSF_{adult}}$$

Parameter	Definition (units)	Default
CAF_o	Adjusted oral cancer slope factor	0.804
CSF_{adult}	Oral cancer slope factor (mg/kg-day$^{)-1}$	0.046
$CSF_{o\text{-}NHL+liver}$	Oral cancer slope factor, NHL (2.16E-02) and Liver (1.55E-02), (mg/kg-day$)^{-1}$	0.0370
MAF_o	Adjusted oral mutagenic slope factor	0.202
$CSF_{o\text{-}kidney}$	Oral cancer slope factor, kidney (mg/kg-day$^{)-1}$	0.00933

Equation 14
SSL for Inhalation of Soil- TCE

$$C_{mu-inh} = \frac{TR \times AT_r}{IUR \times \left(\frac{1}{VF_s} + \frac{1}{PEF}\right) \times 1000 \times (1/24) \times \left[(CAF_i \times EF \times ED_r \times ET_r) + (seebelow)\right]}$$

$$\left[(ED_{0-2}EF_{0-2} \times ET_{0-2} \times MAF_i \times 10) + (ED_{2-6}EF_{2-6} \times ET_{2-6} \times MAF_i \times 3) + (ED_{6-16}EF_{6-16} \times ET_{6-16} \times MAF_i \times 3) + (ED_{16-26}EF_{16-26} \times ET_{16-26} \times MAF_i \times 1)\right]$$

Parameter	Definition (units)	Default
$C_{TCE-inh}$	Contaminant concentration (mg/kg)	Chemical-specific
TR	Target cancer risk	1E-05
AT_r	Averaging time, carcinogens (days)	25,550
IUR	Inhalation Unit Risk (µg/m^3)$^{-1}$	Chemical-specific
EF	Exposure frequency, (day/yr)	350
ED	Exposure duration (day)	
	ED_{0-2} (yr)	2
	ED_{2-6} (yr)	4
	ED_{6-16} (yr))	10
	ED_{16-26} (yr)	10
	ED_r (yr)	26
ET_r	Exposure time (hr/day)	1
1000	Conversion factor (µg/mg)	1000
1/24	Conversion factor (day/hr)	1/24
CAF_i	Adjusted inhalation cancer unit risk (µg/m^3)$^{-1}$	See Equation 15
MAF_i	Adjusted inhalation mutagenic unit risk (µg/m^3)$^{-1}$	See Equation 15
VF_s	Volatilization factor for soil (m^3/kg)	See Equation45
PEF	Particulate emission factor (m^3/kg)	See Equation 48

Equation 15
Adjusted Inhalation Unit Risks - TCE
Residential Scenario

$$CAF_i = \frac{IUR_{NHL+Liver}}{IUR_{adult}}$$

$$MAF_i = \frac{IUR_{kidney}}{IUR_{adult}}$$

Parameter	Definition (units)	Default
CAF_i	Adjusted carcinogenic inhalation unit risk $(\mu g/m^3)^{-1}$	0.756
IUR_{adult}	Inhalation unit risk, $(\mu g/m^3)^{-1}$	4.1E-06
$IUR_{NHL+liver}$	Inhalation unit risk, NHL (2E-06) and Liver (1E-06), $(\mu g/m^3)^{-1}$	3.1E-06
MAF_i	Adjusted mutagenic inhalation unit risk $(\mu g/m^3)^{-1}$	0.244
IUR_{kidney}	Inhalation unit risk, kidney, $(\mu g/m^3)^{-1}$	1E-06

Equation 16
SSL for Dermal Contact with Soil - Trichloroethylene (TCE)
Residential Scenario

$$C_{TCE-der} = \frac{TR \times AT}{\frac{CSF_o}{GIABS} \times 10^{-6} \times \left(\left(CAF_o \times DFS_{adj} \times ABS\right) + \left(MAF_o \times DFSM_{adj} \times ABS\right)\right)}$$

Parameter	Definition (units)	Default
$C_{TCE\text{-}der}$	Contaminant concentration (mg/kg)	Chemical-specific
TR	Target cancer risk	1E-05
AT	Averaging time, carcinogens (days)	25,550
CSF_o	Oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	Chemical-specific
GIABS	Fraction of contaminant absorbed in gastrointestinal tract (unitless)	Chemical-specific
10^{-6}	Unit conversion factor (kg/mg)	1E-06
CAF_o	Adjusted oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	See Equation 13
DFS_{adj}	Resident soil dermal contact factor- age-adjusted (mg/kg)	See Equation 4
ABS	Skin absorption factor (unitless)	Chemical-specific
MAF_o	Oral mutagenic slope factor $(mg/kg\text{-}day)^{-1}$	See Equation 13
$DFSM_{adj}$	Resident Mutagenic soil dermal contact factor- age-adjusted (mg/kg)	See Equation 10

Equation 17
Determination of the Combined SSL
TCE

$$SSL_{res-TCE} = \frac{1}{\frac{1}{C_{TCE-oral}} + \frac{1}{C_{TCE-inh}} + \frac{1}{C_{TCE-der}}}$$

Parameter	**Definition (units)**	**Default**
$SSL_{res\text{-}TCE}$	Cumulative SSL for mutagens (mg/kg)	Chemical-specific
$C_{TCE\text{-}oral}$	Concentration from soil ingestion (mg/kg)	See Equation 12
$C_{TCE\text{-}inh}$	Concentration from inhalation (mg/kg)	See Equation 14
$C_{TCE\text{-}der}$	Concentration from dermal exposure (mg/kg)	See Equation 16

2.3 Soil Screening Levels for Non-residential Land Uses

Non-residential land uses encompass all commercial and industrial land uses and focus on two very different receptors – a commercial/industrial worker and a construction worker. Unlike those calculated for residential land-uses, NMED SSLs for non-residential land uses are based solely on exposures to adults. Consequently, exposures to carcinogens are not age-adjusted. Due to the wide range of activities and exposure levels a non-residential receptor may be exposed to during various work-related activities, it is important to ensure that the default exposure parameters are representative of site-specific conditions. Table 2-5 provides a summary of the exposure characteristics and parameters for non-residential land use receptors (USEPA, 2014b).

Table 2-5. Summary of Non-Residential Land Use Receptors

Receptor	**Commercial/Industrial Worker**	**Construction Worker**
Exposure Characteristics	• Substantial soil exposures • High soil ingestion rate • Long-term exposure • Exposure to surface and shallow subsurface soils (0-1 foot bgs) • Adult-only exposure	• Exposed during construction activities only • Short-term exposure • Very high soil ingestion and dust inhalation rates • Exposure to surface and subsurface soils (0-10 feet bgs)
Default Exposure Parameters		
Exposure frequency (days/yr)	225	250
Exposure duration (yr)	25	1
Soil ingestion rate (mg/day)	100	330
Body Weight (kg)	80	80
Skin surface area exposed (cm^2)	3,470	3,470
Skin-soil adherence factor (mg/ cm^2)	0.12	0.3

2.3.1 Commercial/Industrial Worker

The commercial/industrial scenario is considered representative of on-site workers who spend all or most of their workday outdoors. A commercial/industrial worker is assumed to be a long-term receptor exposed during the course of a work day as either (1) a full time employee of a company operating on-site who spends most of the work day conducting maintenance or manual labor activities outdoors or (2) a worker who is assumed to regularly perform grounds-keeping activities as part of his/her daily responsibilities. Exposure to surface and shallow subsurface soils (i.e., at depths of zero to 1 ft below ground surface) is expected to occur during moderate digging associated with routine maintenance and grounds-keeping activities. A commercial/industrial receptor is expected to be the most highly exposed receptor in the outdoor environment under generic or day-to-day commercial/industrial conditions. Thus, the screening levels for this receptor are expected to be protective of other reasonably anticipated indoor and outdoor workers at a commercial/industrial facility. However, screening levels developed for the commercial/industrial worker may not be protective of a construction worker due to the latter's increased soil contact rate during construction activities. In addition, the SSLs for the commercial/industrial worker do not account for inhalation of volatiles indoors via vapor intrusion.

Equations 18 and 19 were used to develop generic SSLs for cumulative exposure to carcinogenic and non-carcinogenic contaminants by all exposure pathways. Default exposure parameters (US EPA 2002a and US EPA 2014b) are provided and were used in calculating the NMED SSLs.

Equation 18
Combined Exposures to Carcinogenic Contaminants in Soil
Commercial/Industrial Scenario

$$C_{CI-oral} = \frac{TR \times AT_{CI} \times BW_{CI}}{CSF_o \times EF_{CI} \times ED_{CI} \times IR_{CI} \times 10^{-6}}$$

$$C_{CI-inh} = \frac{TR \times AT_{CI}}{IUR \times 1000 \times EF_{CI} \times \left(\frac{1}{VF_s} + \frac{1}{PEF_w}\right) \times ED_{CI} \times ET_{CI}}$$

$$C_{CI-dermal} = \frac{TR \times AT_{CI} \times BW_{CI}}{EF_{CI} \times ED_{CI} \times \frac{CSF_o}{GIABS} \times SA_{CI} \times AF_{CI} \times ABS_d \times 10^{-6}}$$

<u>Combined Exposures:</u>

$$SSL_{CI} = \frac{1}{\frac{1}{C_{CI-oral}} + \frac{1}{C_{CI-inh}} + \frac{1}{C_{CI-dermal}}}$$

Parameter	Definition (units)	Default
$C_{CI\text{-}oral}$	Contaminant concentration via oral ingestion (mg/kg)	Chemical-specific
$C_{CI\text{-}dermal}$	Contaminant concentration via dermal adsorption (mg/kg)	Chemical-specific
$C_{CI\text{-}inh}$	Contaminant concentration via inhalation (mg/kg)	Chemical-specific
SSL_{CI}	Contaminant concentration, all pathways (mg/kg)	Chemical-specific
TR	Target Risk	1E-05
BW_{CI}	Body weight, adult (kg)	80
AT_{CI}	Averaging time, carcinogens (days)	25,550
EF_{CI}	Exposure frequency, commercial/industrial (day/yr)	225
ED_{CI}	Exposure duration, commercial/industrial (yr)	25
IR_{CI}	Soil ingestion rate, commercial/industrial (mg/day)	100
CSF_o	Oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	Chemical-specific
SA_{CI}	Dermal surface area, commercial/industrial (cm^2/day)	3,470
AF_{CI}	Soil adherence factor, commercial/industrial (mg/cm^2)	0.12
ABS_d	Skin absorption factor (unitless)	Chemical-specific
ET_{CI}	Exposure time, commercial/industrial (8 hr/per 24 hr)	0.33
IUR	Inhalation unit risk $(\mu g/m^3)^{-1}$	Chemical-specific
1000	Unit conversion (µg/mg)	1000
VF_s	Volatilization factor for soil (m^3/kg)	See Equation 45
PEF	Particulate emission factor (m^3/kg)	See Equation 48

Equation 19
Combined Exposures to Noncarcinogenic Contaminants in Soil
Commercial/Industrial Scenario

$$C_{CI-oral} = \frac{THQ \times AT_{CI} \times BW_a}{EF_{CI} \times ED_{CI} \times \left(1/RfD_o\right) \times IR_{CI} \times (10^{-6})}$$

$$C_{CI-inh} = \frac{THQ \times AT_{CI}}{EF_{CI} \times ED_{CI} \times ET_{CI} \times \left(1/RfC\right) \times \left[\left(1/VF_s\right) + (1/PEF_w)\right]}$$

$$C_{CI-dermal} = \frac{THQ \times AT_{CI} \times BW_a}{EF_{CI} \times ED_{CI} \times \left[1/\left(RfD_o \times GIABS\right)\right] \times SA_{CI} \times AF_{CI} \times ABS_d \times 10^{-6}}$$

<u>Combined Exposures:</u>

$$SSL_{CI} = \frac{1}{\frac{1}{C_{CI-oral}} + \frac{1}{C_{CI-inh}} + \frac{1}{C_{CI-dermal}}}$$

Parameter	Definition (units)	Default
$C_{CI\text{-}oral}$	Contaminant concentration via oral ingestion (mg/kg)	Chemical-specific
$C_{CI\text{-}dermal}$	Contaminant concentration via dermal adsorption (mg/kg)	Chemical-specific
$C_{CI\text{-}inh}$	Contaminant concentration via inhalation (mg/kg)	Chemical-specific
SSL_{CI}	Soil screening level, all pathways (mg/kg)	Chemical-specific
THQ	Target hazard quotient	1
BW_a	Body weight, adult (kg)	80
AT_{CI}	Averaging time, noncarcinogens (days)	ED x 365
EF_{CI}	Exposure frequency, commercial/industrial (day/yr)	225
ED_{CI}	Exposure duration, commercial/industrial (yr)	25
IR_{CI}	Soil ingestion rate, commercial/industrial (mg/day)	100
10^{-6}	Unit conversion factor (kg/mg)	10^{-6}
RfD_o	Oral reference dose (mg/kg-day)	Chemical-specific
SA_{CI}	Dermal surface area, commercial/industrial (cm^2/day)	3,470
AF_{CI}	Soil adherence factor, commercial/industrial (mg/cm^2)	0.12
GIABS	Fraction absorbed in gastrointestinal tract (unitless)	Chemical-specific
ABS_d	Skin absorption factor (unitless)	Chemical-specific
ET_{CI}	Exposure time(8 hr/day per 1 day/24 hr)	0.33
RfC	Reference concentration (mg/m^3)	Chemical-specific
VF_s	Volatilization factor for soil (m^3/kg)	See Equation 45
PEF	Particulate emission factor (m^3/kg)	See Equation 48

2.3.2 Construction Worker

A construction worker is assumed to be a receptor that is exposed to contaminated soil during the work day for the duration of a single on-site construction project. If multiple construction projects are anticipated, it is assumed that different workers will be employed for each project. The activities for this receptor typically involve substantial exposures to surface and subsurface soils (i.e., at depths of zero to 10 feet bgs) during excavation, maintenance, and building construction projects (intrusive operations). A construction worker is assumed to be exposed to contaminants via the following pathways: incidental soil ingestion, dermal contact with soil, and inhalation of contaminated outdoor air (volatile and particulate emissions). While a construction worker receptor is assumed to have a higher soil ingestion rate than a commercial/industrial worker due to the type of activities performed during construction projects, the exposure frequency and duration are assumed to be significantly shorter due to the short-term nature of construction projects. However, chronic toxicity information was used when developing screening levels for a construction worker receptor. This approach is significantly more conservative than using sub-chronic toxicity data because it combines the higher soil exposures for construction workers with chronic toxicity criteria. Equations 20 and 21 were used to develop generic SSLs for cumulative exposure to carcinogenic and non-carcinogenic contaminants by all exposure pathways for a construction worker. Default exposure parameters (US EPA 2002a and US EPA 2014b) are provided and were used in calculating the NMED SSLs.

Equation 20
Combined Exposures to Carcinogenic Contaminants in Soil Construction Worker Scenarios

$$C_{CW-oral} = \frac{TR \times AT_{CW} \times BW_{CW}}{CSF_o \times EF_{CW} \times ED_{CW} \times IR_{CW} \times 10^{-6}}$$

$$C_{CW-inh} = \frac{TR \times AT_{CW}}{IUR \times 1000 \times EF_{CW} \times \left(\frac{1}{VF_{cw}} + \frac{1}{PEF_{cw}} \right) \times ED_{CW} \times ET_{CW}}$$

$$C_{CW-dermal} = \frac{TR \times AT_{CW} \times BW_{CW}}{EF_{CW} \times ED_{CW} \times \frac{CSF_o}{GIABS} \times SA_{CW} \times AF_{CW} \times ABS_d \times 10^{-6}}$$

<u>Combined Exposures:</u>

$$SSL_{CW} = \frac{1}{\frac{1}{C_{CW-oral}} + \frac{1}{C_{CW-inh}} + \frac{1}{C_{CW-dermal}}}$$

Parameter	Definition (units)	Default
$C_{CW\text{-}oral}$	Contaminant concentration via oral ingestion (mg/kg)	Chemical-specific
$C_{CW\text{-}dermal}$	Contaminant concentration via dermal adsorption (mg/kg)	Chemical-specific
$C_{CW\text{-}inh}$	Contaminant concentration via inhalation (mg/kg)	Chemical-specific
SSL_{CW}	Contaminant concentration, all pathways (mg/kg)	Chemical-specific
TR	Target Risk	1E-05
BW_{CW}	Body weight, adult (kg)	80
AT_{CW}	Averaging time, carcinogens (days)	25,550
EF_{CW}	Exposure frequency, construction worker (day/yr)	250
ED_{CW}	Exposure duration, construction worker (years)	1
IR_{CW}	Soil ingestion rate, construction worker (mg/day)	330
CSF_o	Oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	Chemical-specific
SA_{CW}	Dermal surface area, construction worker (cm^2/day)	3,470
AF_{CW}	Soil adherence factor, construction worker (mg/cm^2)	0.3
ABS_d	Skin absorption factor (unitless)	Chemical-specific
ET_{CW}	Exposure time, construction worker (8 hours/day per 1 day/24 hours)	0.33
IUR	Inhalation unit risk $(\mu g/m^3)^{-1}$	Chemical-specific
1000	Unit conversion (µg/mg)	1000
VF_{cw}	Volatilization factor for soil, construction worker (m^3/kg)	See Equation 46
PEF_{cw}	Particulate emission factor, construction worker (m^3/kg)	See Equation 49

Equation 21
Combined Exposures to Noncarcinogenic Contaminants in Soil Construction Worker Scenario

$$C_{CW-oral} = \frac{THQ \times AT_{CW} \times BW_{CW}}{EF_{CW} \times ED_{CW} \times \left(1/RfD_o\right) \times IR_{CW} \times (10^{-6})}$$

$$C_{CW-inh} = \frac{THQ \times AT_{CI}}{EF_{CW} \times ED_{CW} \times ET_{CW} \times \left(1/RfC\right) \times \left[\left(1/VF_{cw}\right) + (1/PEF_{cw})\right]}$$

$$C_{CW-dermal} = \frac{THQ \times AT_{CW} \times BW_{cw}}{EF_{CW} \times ED_{CW} \times \left[1/\left(RfD_o \times GIABS\right)\right] \times SA_{CW} \times AF_{CW} \times ABS_d \times 10^{-6}}$$

Combined Exposures:

$$SSL_{CW} = \frac{1}{\dfrac{1}{C_{CW-oral}} + \dfrac{1}{C_{CW-inh}} + \dfrac{1}{C_{CW-dermal}}}$$

Parameter	Definition (units)	Default
$C_{CW\text{-}oral}$	Contaminant concentration via oral ingestion (mg/kg)	Chemical-specific
$C_{CW\text{-}dermal}$	Contaminant concentration via dermal adsorption (mg/kg)	Chemical-specific
$C_{CW\text{-}inh}$	Contaminant concentration via inhalation (mg/kg)	Chemical-specific
SSL_{CW}	Soil screening level, all pathways (mg/kg)	Chemical-specific
THQ	Target hazard quotient	1
BW_{cw}	Body weight, adult (kg)	80
AT_{CW}	Averaging time, noncarcinogens (days)	ED x 365
EF_{CW}	Exposure frequency, construction worker (day/yr)	250
ED_{CW}	Exposure duration, construction worker (years)	1
IR_{CW}	Soil ingestion rate, construction worker (mg/day)	330
10^{-6}	Unit conversion factor (kg/mg)	10^{-6}
RfD_o	Oral reference dose (mg/kg-day)	Chemical-specific
SA_{CW}	Dermal surface area, construction worker (cm^2/day)	3,470
AF_{CW}	Soil adherence factor, construction worker (mg/cm^2)	0.3
GIABS	Fraction absorbed in gastrointestinal tract (unitless)	Chemical-specific
ABS_d	Skin absorption factor (unitless)	Chemical-specific
ET_{CW}	Exposure time(8 hours/day per 1 day/24 hour)	0.33
RfC	Reference concentration (mg/m^3)	Chemical-specific
VF_{cw}	Volatilization factor for soil, construction worker (m^3/kg)	See Equation 46
PEF_{cw}	Particulate emission factor, construction worker (m^3/kg)	See Equation 49

2.3.3 Alternative Evaluation for Lead

Exposure to lead can result in neurotoxic and developmental effects. The primary receptors of concern are children, whose nervous systems are still undergoing development and who also exhibit behavioral tendencies that increase their likelihood of exposure (e.g., pica). These effects may occur at exposures so low that they may be considered to have no threshold, and are evaluated based on a blood lead level (rather than the external dose as reflected in the RfD/RfC methodology). Therefore, US EPA views it to be inappropriate to develop noncarcinogenic "safe" exposure levels (i.e., RfDs) for lead. Instead, US EPA's lead assessment workgroup has recommended the use of the IEUBK model that relates measured lead concentrations in environmental media with an estimated blood-lead level (US EPA 1994 and 1998). The model is used to calculate a blood lead level in children when evaluating residential land use and in adults (based on a pregnant mother's capacity to contribute to fetal blood lead levels). It is also used for adults in evaluating occupational scenarios at sites where access by children is reliably restricted. The NMED SSLs presented in Appendix A include values for lead that were calculated by using the IEUBK to back-calculate a soil concentration for each receptor that would not result in an estimated blood-lead concentration of 10 micrograms per deciliter (μg/dL) or greater (residential adult of 400 mg/kg and industrial and construction worker of 800 mg/kg).

2.4 Tap Water Screening Levels

Exposure to contaminants can occur through the ingestion of and dermal contact with domestic/household water and inhalation of volatiles in domestic/household water. NMED tap water screening levels were developed for residential land-use only. If it is determined that commercial/industrial receptors are potentially exposed to contaminated water through ingestion, dermal contact, and/or inhalation, these pathways must be evaluated via the methods outlined in this document and utilizing appropriate exposure parameters. The calculations of the NMED tap water screening levels for domestic water are based upon the methodology presented in RAGS, Part B (US EPA 1991), Part E (US EPA, 2004) and the revised default exposure factors (US EPA, 2014b). The screening levels are based upon ingestion of and dermal contact with contaminants in water, and inhalation of volatile contaminants volatilized from water during domestic use. To estimate the exposure dose from dermal contact with tap water, the skin permeability coefficient (K_p) and absorbed dose per event (DA_{event}) were considered, as outlined in US EPA's (2004a) RAGS Part E. While ingestion and dermal contact were considered for all chemicals, inhalation of volatiles from water was considered for those chemicals with a minimum Henry's Law constant of approximately 1E-05 atm-m^3/mole and with a maximum molecular weight of approximately 200 g/mole. To address the groundwater-to-air pathways, the tap water screening levels incorporate a volatilization factor (K) of 0.5 liters per cubic meter (L/m^3) for volatile contaminants (US EPA, 1991); this derived value defines the relationship between the concentration of a contaminant in household water and the average concentration of the volatilized contaminant in air as a result of all uses of household water (i.e., showering, laundering, dish washing).

As ingestion, dermal contact, and inhalation rates may be different for children and adults, carcinogenic risks were calculated using age-adjusted factors, which were obtained from RAGS, Part B (US EPA 1991) and Part E (US EPA, 2004a). Equations 22 through 28 show how SLs for carcinogenic and non-carcinogenic contaminants were developed. Similar to soil, separate equations are used for vinyl chloride (Equations 29 and 30) and carcinogens exhibiting mutagenic toxicity (Equations 31-35) such as trichloroethylene.

Equation 22
Combined Exposures to Carcinogenic Contaminants in Tap Water
Residential Scenario

$$C_{oral} = \frac{TR \times AT_c \times 1000}{CSF_o \times IFW_{adj}}$$

C_{derm} = See Equations 24 - 26

$$C_{inh} = \frac{TR \times AT_c}{EF_r \times ED_r \times ET_{rw} \times IUR \times K}$$

Combined Exposures:

$$SL_{tap} = \frac{1}{\frac{1}{C_{oral}} + \frac{1}{C_{derm}} + \frac{1}{C_{inh}}}$$

Parameter	Definition (units)	Default
C_{oral}	Contaminant concentration, ingestion (µg/L)	Chemical-specific
C_{derm}	Contaminant concentration, dermal (µg/L) (See Equations 24-26)	Chemical-Specific
C_{inh}	Contaminant concentration, inhalation (µg/L)	Chemical-specific
SL_{tap}	Tap water screening level (µg/L)	Chemical-specific
TR	Target risk	1E-05
AT_c	Averaging time, carcinogens (days)	25,550
EF_r	Exposure frequency, resident (day/yr)	350
1000	Unit conversion (µg/mg)	1000
IFW_{adj}	Age-adjusted water ingestion rate, resident (L /kg) (See Equation 23)	328
CSF_o	Oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	Chemical-specific
ED_r	Exposure duration (yr)	26
ET_{rw}	Exposure time, resident, tap water (24 hr/day per 1day/24 hr)	1
IUR	Inhalation unit risk $(\mu g/m^3)^{-1}$	Chemical-specific
K	Andelman volatilization factor (L/m^3)	0.5

Equation 23
Calculation of Age-Adjusted Tap Water Ingestion Factor

$$IFW_{adj} = \frac{EF \times ED_c \times IRW_c}{BW_c} + \frac{EF \times \left(ED_r - ED_c\right) \times IRW_a}{BW_a}$$

Parameter	Definition (units)	Default
IFW_{adj}	Age-adjusted water ingestion factor for carcinogens (L/kg)	328
EF	Exposure frequency (day/yr)	350
ED_c	Exposure duration, child (yr)	6
IRW_c	Water ingestion rate, child (L/day)	0.78
BW_c	Body weight, child (kg)	15
ED_r	Exposure duration, resident adult (yr)	26
ED_c	Exposure duration, resident child (yr)	6
IRW_a	Water ingestion rate, adult (L/day)	2.5
BW_a	Body weight, adult (kg)	80

Equation 24
Dermal Exposure to Carcinogenic Contaminants in Tap Water
Residential Scenario

For inorganic constituents:

$$C_{derm} = \frac{DA_{event\_carc} \times 1000\ (cm^3/L)}{K_p \times t_{event\_adj}}$$

For organic constituents:

If $t_{event\_adj} \leq t^*$, then:

$$C_{derm} = \frac{DA_{event\_carc} \times 1000\ (cm^3/L)}{2 \times FA \times K_p \times \sqrt{\frac{6\tau_{event} \times t_{event\_adj}}{\pi}}}$$

If $t_{event\_adj} > t^*$, then:

$$C_{derm} = \frac{DA_{event\_carc} \times 1000\ (cm^3/L)}{FA \times K_p \times \left[\frac{t_{event\_adj}}{1+B} + 2\tau_{event}\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

Where:

$$DA_{event\_carc} = \frac{TR \times AT_c \times 1000(\mu g/mg)}{\left(\frac{CSF_o}{GIABS}\right) \times DFW_{adj}}$$

Parameter	Definition (units)	Default
C_{derm}	Contaminant concentration, dermal (µg/L)	Chemical-specific
$DA_{event\ carc}$	Absorbed dose per event, carcinogens (mg/cm^2-event)	Chemical-specific
K_p	Dermal permeability coefficient of compound in water (cm/hr)	Chemical-specific
$t_{event\text{-}adj}$	Age-adjusted dermal exposure time per event, resident (hr/event)	See Equation 25
t*	Time to reach steady state (hr)	2.4 x τ_{event}
FA	Fraction absorbed water (unitless)	Chemical-specific
τ_{event}	Lag time per event (hr/event)	Chemical-specific
B	Ratio of permeability coefficient through the stratum corneum to permeability coefficient across the viable epidermis (unitless)	Chemical-specific
TR	Target risk	1E-05
AT_c	Averaging time, resident, carcinogens (days)	25,550
CSF_o	Oral cancer slope factor (mg/kg-day)$^{-1}$	Chemical-specific
GIABS	Fraction absorbed in gastrointestinal tract (unitless)	Chemical-specific
EF_r	Exposure frequency, resident (day/yr)	350
DFW_{adj}	Age-adjusted dermal exposure factor, water, resident (cm^2-event /kg)	See Equation 26

Equation 25
Calculation of Age-adjusted Dermal Exposure Time per Event, Tap Water Residential Scenario

$$t_{event\_adj} = \frac{\left(t_{event\_c} \times ED_c\right) + \left(t_{event\_a} \times (ED_r - ED_c)\right)}{ED_r}$$

Parameter	Definition (units)	Default
$t_{event\ adj}$	Age-adjusted dermal exposure time per event, resident (hr/event)	0.6708
$t_{event\ c}$	Dermal exposure time per event, child (hr/event)	0.54
$t_{event\ a}$	Dermal exposure time per event, adult (hr/event)	0.71
ED_c	Exposure duration, child (yr)	6
ED_r	Exposure duration, resident (yr)	26

Equation 26
Calculation of Age-adjusted Dermal Exposure Factor, Tap Water Residential Scenario

$$DFW_{adj} = \left(\frac{EF \times EV_c \times ED_c \times SA_c}{BW_c}\right) + \left(\frac{EF \times EV_a \times ED_a \times SA_a}{BW_a}\right)$$

Parameter	Definition (units)	Default
DFW_{adj}	Age-adjusted dermal exposure factor, tap water, resident (cm^2-event /kg)	2,721,670
EF	Exposure frequency (day/yr)	350
EV_c	Event frequency, child (events/day)	1
ED_c	Exposure duration, child (yr)	6
SA_c	Skin surface area available for water contact, child (cm^2)	6,378
BW_c	Body weight, child (kg)	15
EV_a	Event frequency, adult (events/day)	1
ED_a	Exposure duration, adult (yr)	20
SA_a	Skin surface area available for water contact, adult (cm^2)	20,900
BW_a	Body weight, adult (kg)	80

Equation 27
Combined Exposures to Noncarcinogenic Contaminants in Tap Water Residential Scenario

$$C_{oral} = \frac{THQ \times BW_c \times 1000 \times AT_{nc}}{EF_r \times ED_c \times \left(\frac{1}{RfD_o}\right) \times IRW_c}$$

$$C_{derm} = See\ Equation\ 22$$

$$C_{inh} = \frac{THQ \times AT_{nc} \times 1000}{EF_r \times ED_c \times ET_{rw} \times \left(\frac{1}{RfC}\right) \times K}$$

<u>Combined Exposures:</u>

$$SL_{tap} = \frac{1}{\frac{1}{C_{oral}} + \frac{1}{C_{inh}} + \frac{1}{C_{derm}}}$$

Parameter	Definition (units)	Default
C_{oral}	Contaminant concentration, ingestion (µg/L)	Chemical-specific
C_{derm}	Contaminant concentration, dermal (µg/L)	See Equation 28
C_{inh}	Contaminant concentration, inhalation (µg/L)	Chemical-specific
SL_{tap}	Tap water screening level (µg/L)	Chemical-specific
THQ	Target hazard quotient	1
BW_c	Body weight, child (kg)	15
AT_{nc}	Averaging time, noncarcinogens (days)	ED_c x 365
1000	Unit conversion (µg/mg)	1000
EF_r	Exposure frequency, resident (day/yr)	350
ED_c	Exposure duration, child resident (yr)	6
IRW_a	Water ingestion rate, child resident (L/day)	0.78
RfD_o	Oral reference dose(mg/kg-day)	Chemical-specific
ET_{rw}	Exposure time (24 hr/day per 1day/24 hr)	1
RfC	Reference concentration (mg/m^3)	Chemical-specific
K	Andelman volatilization factor (L/m^3)	0.5

Equation 28
Dermal Exposure to Non-carcinogenic Contaminants in Tap Water
Residential Scenario

For inorganic constituents:

$$C_{derm} = \frac{DA_{event\_nc} \times 1000\ (cm^3/L)}{K_p \times t_{event\_c}}$$

For organic constituents:

If $t_{event\_c} \leq t^*$, then:

$$C_{derm} = \frac{DA_{event\_nc} \times 1000\ (cm^3/L)}{2 \times FA \times K_p \times \sqrt{\frac{6\tau_{event} \times t_{event\_c}}{\pi}}}$$

If $t_{event\_c} > t^*$, then:

$$C_{derm} = \frac{DA_{event\_nc} \times 1000\ (cm^3/L)}{FA \times K_p \times \left[\frac{t_{event\_c}}{1+B} + 2\tau_{event}\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

Where:

$$DA_{event\_nc} = \frac{THQ \times AT_{nc} \times 1000(\mu g/mg) \times BW_c}{\left(\frac{1}{RfD_o \times GIABS}\right) \times EV_c \times ED_c \times EF_r \times SA_c}$$

Parameter	Definition (units)	Default
C_{derm}	Contaminant concentration, dermal (µg/L)	Chemical-specific
$DA_{event\ nc}$	Absorbed dose per event, noncarcinogens (µg/cm^2-event)	Chemical-specific
K_p	Dermal permeability coefficient of compound in water (cm/hr)	Chemical-specific
t_{event_c}	Dermal exposure time per event, child (hr/event)	1
t*	Time to reach steady state (hr)	2.4 x τ_{event}
FA	Fraction absorbed water (unitless)	Chemical-specific
τ_{event}	Lag time per event (hr/event)	Chemical-specific
B	Ratio of permeability coefficient through the stratum corneum to permeability coefficient across the viable epidermis (unitless)	Chemical-specific
THQ	Target hazard quotient	1
AT_{nc}	Averaging time, resident, non-carcinogens (days)	365 x ED_c
BW_c	Body weight, child (kg)	15
GIABS	Fraction absorbed in gastrointestinal tract (unitless)	Chemical-specific
RfD_o	Oral reference dose (mg/kg-day)	Chemical-specific
EV_c	Event frequency, child (events/day)	1
ED_c	Exposure duration, child (yr)	6
EF_r	Exposure frequency, resident (day/yr)	350
SA_c	Skin surface area available for contact, child (cm^2)	6,378

Equation 29
Combined Carcinogenic Exposures to Vinyl Chloride in Tap Water
Residential Scenario

$$C_{oral} = \frac{TR}{\left(\frac{CSF_o \times IFW_{adj} \times 0.001}{AT} + \frac{CSF_o \times IRW_c \times 0.001}{BW_c}\right)}$$

$$C_{derm} = See\ Equation\ 30$$

$$C_{inh} = \frac{TR}{\left(\frac{IUR \times EF_r \times ED_r \times ET_{rw} \times K}{AT} + \left(IUR \times K\right)\right)}$$

<u>Combined Exposures:</u>

$$SL_{tap} = \frac{1}{\frac{1}{C_{oral}} + \frac{1}{C_{inh}} + \frac{1}{C_{derm}}}$$

Parameter	Definition (units)	Default
C_{oral}	Contaminant concentration, ingestion (µg/L)	Chemical-specific
C_{derm}	Contaminant concentration, dermal (µg/L)	See Equation 30
C_{inh}	Contaminant concentration, inhalation (µg/L)	Chemical-specific
SL_{tap}	Tap water screening level (µg/L)	Chemical-specific
TR	Target risk	1E-05
AT	Averaging time, carcinogens (days)	25,550
EF_r	Exposure frequency, resident (day/yr)	350
0.001	Unit conversion (mg/µg)	0.001
IFW_{adj}	Age-adjusted water ingestion rate, resident (L/kg)	See Equation 23
IRW_c	Child water ingestion rate, resident (L/day)	1
CSF_o	Oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	Chemical-specific
ED_r	Exposure duration (yr)	26
ET_{rw}	Exposure time (24 hours/day per 1day/24 hr)	1
IUR	Inhalation unit risk $(µg/m^3)^{-1}$	Chemical-specific
K	Andelman volatilization factor (L/m^3)	0.5

Equation 30
Carcinogenic Dermal Exposure to Vinyl Chloride in Tap Water
Residential Scenario

If $t_{event\_adj} \leq t^*$, then:

$$C_{derm} = \frac{DA_{event\_vc} \times 1000\ (cm^3/L)}{2 \times FA \times K_p \times \sqrt{\frac{6\tau_{event} \times t_{event\_adj}}{\pi}}}$$

If $t_{event\_adj} > t^*$, then:

$$C_{derm} = \frac{DA_{event\_vc} \times 1000\ (cm^3/L)}{FA \times K_p \times \left[\frac{t_{event\_adj}}{1+B} + 2\tau_{event}\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

Where:

$$DA_{event\_vc} = \frac{TR}{\left[\frac{\left(\frac{CSF_o}{GIABS}\right) \times DFW_{adj}}{AT_r \times 1000\,\frac{\mu g}{mg}}\right] + \left[\frac{\left(\frac{CSF_o}{GIABS}\right) \times EV_c \times SA_c}{BW_c \times 1000\,\frac{\mu g}{mg}}\right]}$$

Parameter	Definition (units)	Default
$t_{event\ adj}$	Age-adjusted dermal exposure time per event, resident (hr/event)	See Equation 25
t^*	Time to reach steady state (hr)	2.4 x τ_{event}
τ_{event}	Lag time per event (hr/event)	Chemical-specific
C_{derm}	Contaminant concentration, dermal (µg/L)	Chemical-specific
$DA_{event\ vc}$	Absorbed dose per event, vinyl chloride (µg/cm^2-event)	Chemical-specific
FA	Fraction absorbed water (unitless)	Chemical-specific
K_p	Dermal permeability coefficient of compound in water (cm/hr)	Chemical-specific
B	Ratio of permeability coefficient through the stratum corneum to permeability coefficient across the viable epidermis (unitless)	Chemical-specific
TR	Target risk	1E-05
AT_r	Averaging time, resident, carcinogens (days)	25,550
EF_r	Exposure frequency, resident (day/yr)	350
CSF_o	Oral cancer slope factor (mg/kg-day)$^{-1}$	Chemical-specific
GIABS	Fraction absorbed in gastrointestinal tract (unitless)	Chemical-specific
DFW_{adj}	Age-adjusted dermal exposure factor, tap water, resident (cm^2-event /kg)	See Equation 26
EV_c	Event duration, child (events/day)	1
SA_c	Skin surface area available for contact, child (cm^2)	6,378
BW_c	Body weight, child (kg)	15

Equation 31
Combined Exposures to Mutagenic Contaminants in Tap Water
Residential Exposure

$$C_{mu-oral} = \frac{TR \times AT_r \times 1000}{CSF_o \times IFWM_{adj}}$$

$$C_{mu-derm} = See\ Equations\ 27 - 29$$

$$C_{mu-inh} = \frac{TR \times AT_r}{\left(EF_r \times ET_{rs} \times K\right) \times \left[\left(ED_{0-2} \times IUR \times 10\right) + \left(ED_{2-6} \times IUR \times 3\right) + \left(ED_{6-16} \times IUR \times 3\right) + \left(ED_{16-26} \times IUR \times 1\right)\right]}$$

<u>Combined Exposures:</u>

$$SL_{tap-mu} = \frac{1}{\dfrac{1}{C_{mu-oral}} + \dfrac{1}{C_{mu-inh}} + \dfrac{1}{C_{mu-derm}}}$$

Parameter	**Definition (units)**	**Default**
$C_{mu\text{-}oral}$	Contaminant concentration, ingestion (µg/L)	Chemical-specific
$C_{mu\text{-}derm}$	Contaminant concentration, dermal (µg/L	See Equations 33-35
$C_{mu\text{-}inh}$	Contaminant concentration, inhalation (µg/L)	Chemical-specific
$SL_{tap\text{-}mu}$	Tap water screening level (µg/L)	Chemical-specific
TR	Target cancer risk	1E-05
AT_r	Averaging time, carcinogens (days)	25,550
CSF_o	Oral cancer slope factor (mg/kg-day$)^{-1}$	Chemical-specific
EF_r	Exposure frequency, resident (day/yr)	350
ET_{rw}	Exposure time (24 hr/day per 1day/24 hr)	1
K	Andelman volatilization factor (L/m^3)	0.5
$IFWM_{adj}$	Age-adjusted water ingestion rate, mutagens (L/kg)	See Equation 32
1000	Conversion factor (µg/mg)	1000
ED_{0-2}	Exposure duration, child (yr)	2
ED_{2-6}	Exposure duration, child (yr)	4
ED_{6-16}	Exposure duration, adult (yr)	10
ED_{16-26}	Exposure duration, adult (yr)	10
IUR	Inhalation unit risk (µg/m^3)$^{-1}$	Chemical-specific

Equation 32
Calculation of Age-Adjusted Tap Water Ingestion Factor, Mutagens

$$IFWM_{adj} = \frac{EF \times ED_{0-2} \times IRW_c \times 10}{BW_c} + \frac{EF \times ED_{2-6} \times IRW_c \times 3}{BW_c} + \frac{EF \times ED_{6-16} \times IRW_a \times 3}{BW_a} + \frac{EF \times ED_{16-26} \times IRW_a \times 1}{BW_a}$$

Parameter	Definition (units)	Default
$IFWM_{adj}$	Age-adjusted water ingestion factor for mutagens (L/kg)	1,019.9
ED_{0-2}	Exposure duration, child (yr)	2
ED_{2-6}	Exposure duration, child (yr)	4
ED_{6-16}	Exposure duration, adult (yr)	10
ED_{16-26}	Exposure duration, adult (yr)	10
EF	Exposure frequency (days/yr)	350
IRW_c	Water ingestion rate, child (L/day)	0.78
IRW_a	Water ingestion rate, adult (L/day)	2.5
BW_c	Body weight, child (kg)	15
BW_a	Body weight, adult (kg)	80

Equation 33
Dermal Exposure to Mutagenic Contaminants in Tap Water
Residential Scenario

For inorganic constituents:

$$C_{mu-derm} = \frac{DA_{event\_mu} \times 1000\ (cm^3/L)}{K_p \times t_{event\_mu\_adj}}$$

For organic constituents:

If $t_{event\_mu\_adj} \leq t^*$, then:

$$C_{mu-derm} = \frac{DA_{event\_mu} \times 1000\ (cm^3/L)}{2 \times FA \times K_p \times \sqrt{\frac{6\tau_{event} \times t_{event\_mu\_adj}}{\pi}}}$$

If $t_{event\_mu\_adj} > t^*$, then:

$$C_{mu-derm} = \frac{DA_{event\_mu} \times 1000\ (cm^3/L)}{FA \times K_p \times \left[\frac{t_{event\_mu\_adj}}{1+B} + 2\tau_{event}\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

Where:

$$DA_{event\_mu} = \frac{TR \times AT_r \times 1000(\mu g/mg)}{\left(\frac{CSF_o}{GIABS}\right) \times DFW_{mu\_adj}}$$

Parameter	Definition (units)	Default
$C_{mu\text{-}derm}$	Contaminant concentration, mutagens, dermal (µg/L)	Chemical-specific
$DA_{event\ mu}$	Absorbed dose per event, mutagens (µg/cm^2-event)	Chemical-specific
K_p	Dermal permeability coefficient of compound in water (cm/hr)	Chemical-specific
$t_{event\text{-}mu\_adj}$	Age-adjusted dermal exposure time per event, mutagens, resident (hr/event)	See Equation 34
t*	Time to reach steady state (hr)	2.4 x τ_{event}
FA	Fraction absorbed water (unitless)	Chemical-specific
τ_{event}	Lag time per event (hr/event)	Chemical-specific
B	Ratio of permeability coefficient through the stratum corneum to permeability coefficient across the viable epidermis (unitless)	Chemical-specific
TR	Target risk	1E-05
AT_r	Averaging time, resident, carcinogens (days)	25,550
CSF_o	Oral cancer slope factor (mg/kg-day)$^{-1}$	Chemical-specific
GIABS	Fraction absorbed in gastrointestinal tract (unitless)	Chemical-specific
EF_r	Exposure frequency, resident (day/yr)	350
DFW_{mu_adj}	Age-adjusted dermal tap water exposure factor, mutagens, resident (cm^2-event /kg)	See Equation 35

Equation 34
Calculation of Age-Adjusted Tap Water Dermal Exposure Time per Event, Mutagens Residential Scenario

$$t_{event\_mu\_adj} = \frac{t_{event_{0-2}} \times ED_{0-2} + t_{event_{2-6}} \times ED_{2-6} + t_{event_{6-16}} \times ED_{6-16} + t_{event_{16-26}} \times ED_{16-26}}{ED_{0-2} + ED_{2-6} + ED_{6-16} + ED_{16-26}}$$

Parameter	Definition (units)	Default
$t_{event\_mu\_adj}$	Age-adjusted dermal exposure time per event, mutagens, tap water, resident (hr/event)	0.671
t_{event_0-2}	Dermal exposure time per event, tap water, resident 0-2 years (hr/event)	0.54
ED_{0-2}	Exposure duration, resident 0-2 years (yr)	2
t_{event_2-6}	Dermal exposure time per event, tap water, resident 2-6 years (hr/event)	0.54
ED_{2-6}	Exposure duration, resident 2-6 years (yr)	4
t_{event_6-16}	Dermal exposure time per event, tap water, resident 6-16 years (hr/event)	0.71
ED_{6-16}	Exposure duration, resident 6-16 years (yr)	10
t_{event_16-26}	Dermal exposure time per event, tap water, resident 16-26 years (hr/event)	0.71
ED_{16-26}	Exposure duration, resident 16-26 years (yr)	10

Equation 35
Calculation of Age-Adjusted Tap Water Dermal Exposure Factor, Mutagens

$$DFW_{mu\_adj} = \left[\frac{EF \times EV_{0-2} \times ED_{0-2} \times SA_c \times 10}{BW_c}\right] + \left[\frac{EF \times EV_{2-6} \times ED_{2-6} \times SA_c \times 3}{BW_c}\right] + \left[\frac{EF \times EV_{6-16} \times ED_{6-16} \times SA_a \times 3}{BW_a}\right] + \left[\frac{EF \times EV_{16-30} \times ED_{16-26} \times SA_a \times 1}{BW_a}\right]$$

Parameter	Definition (units)	Default
DFW_{mu_adj}	Age-adjusted tap water dermal exposure factor, mutagens, resident (cm^2-event /kg)	8,419,740
EV_{0-2}	Event frequency, resident 0-2 years (events/day)	1
ED_{0-2}	Exposure duration, resident 0-2 years (yr)	2
SA_c	Skin surface area available for contact, child (cm^2)	6,378
EV_{2-6}	Event frequency, resident 2-6 years (events/day)	1
ED_{2-6}	Exposure duration, resident 2-6 years (yr)	4
EV_{6-16}	Event frequency, resident 6-16 years (events/day)	1
ED_{6-16}	Exposure duration, resident 6-16 years (yr)	10
EF	Event frequency (days/yr)	350
SA_a	Skin surface area available for contact, adult (cm^2)	20,900
EV_{16-26}	Event frequency, resident 16-26 yr (events/day)	1
ED_{16-26}	Exposure duration, resident 16-26 (yr)	10
BW_c	Body weight, child (kg)	15
BW_a	Body weight, adult (kg)	80

Equation 36
Combined Exposures to TCE in Tap Water
Residential Exposure

$$C_{TCE-oral} = \frac{TR \times AT_r \times 1000}{CSF_o \times ((CAF_o \times IFW_{adj}) + (MAF_o \times IFWM_{adj}))}$$

$$C_{TCE-derm} = See\ Equation\ 37$$

$$C_{TCE-inh} = \frac{TR \times AT_r}{(ET_{rs} \times K \times IUR) \times [(EF_r \times ED_{rs} \times CAF_i) + AgeTerms]}$$

$$Age\ Terms = ((\,[(ED_{0-2} \times EF_{r\times} \times MAF_i \times 10) + (ED_{2-6} \times EF_{r\times} \times MAF_i \times 3) + (ED_{6-16} \times EF_{r\times} \times MAF_i \times 3) + (ED_{16-26} \times EF_{r\times} \times MAF_i \times 1)]\,))$$

<u>Combined Exposures:</u>

$$SL_{tap-TCE} = \frac{1}{\frac{1}{C_{TCE-oral}} + \frac{1}{C_{TCE-inh}} + \frac{1}{C_{TCE-derm}}}$$

Parameter	Definition (units)	Default
$C_{TCE\text{-}oral}$	Contaminant concentration, ingestion (µg/L)	Chemical-specific
$C_{TCE\text{-}derm}$	Contaminant concentration, dermal (µg/L) (See Equations 37-39)	Chemical-specific
$C_{TCE\text{-}inh}$	Contaminant concentration, inhalation (µg/L)	Chemical-specific
$SL_{tap\text{-}TCE}$	Tap water screening level (µg/L)	Chemical-specific
TR	Target cancer risk	1E-05
AT_r	Averaging time, carcinogens (days)	25,550
CSF_o	Oral cancer slope factor (mg/kg-day$)^{-1}$	Chemical-specific
CAF_o	Adjusted oral cancer slope factor (µg/m^3)$^{-1}$	See Equation 13
IFW_{adj}	Age-adjusted ingestion oral ingestion factor (L/kg)	See Equation 23
MAF_o	Age-adjusted mutagenic slope factor (µg/m^3)$^{-1}$	See Equation 13
$IFWM_{adj}$	Age-adjusted water ingestion rate, mutagens (L/kg)	See Equation 32
EF_r	Exposure frequency, resident (day/yr)	350
ET_{rw}	Exposure time (24 hr/day per 1day/24 hr)	1
K	Andelman volatilization factor (L/m^3)	0.5
IUR	Inhalation unit risk (µg/m^3)$^{-1}$	Chemical-specific
CAF_i	Adjusted inhalation cancer unit risk (µg/m^3)$^{-1}$	See Equation 15
MAF_i	Adjusted inhalation mutagenic unit risk (µg/m^3)$^{-1}$	See Equation 15
1000	Conversion factor (µg/mg)	1000
$ED_{0\text{-}2}$	Exposure duration, child (yr)	2
$ED_{2\text{-}6}$	Exposure duration, child (yr)	4
$ED_{6\text{-}16}$	Exposure duration, adult (yr)	10
$ED_{16\text{-}26}$	Exposure duration, adult (yr)	10

Equation 37
Dermal Exposure to TCE in Tap Water
Residential Scenario

If $t_{event\ \_adj} \leq t^*$, then:

$$C_{TCE-derm} = \frac{DA_{event\_TCE} \times 1000\ (cm^3/L)}{2 \times FA \times K_p \times \sqrt{\frac{6\tau_{event} \times t_{event\_mu\_adj}}{\pi}}}$$

If $t_{event\_adj} > t^*$, then:

$$C_{TCE-derm} = \frac{DA_{event\_TCE} \times 1000\ (cm^3/L)}{FA \times K_p \times \left[\frac{t_{event\_mu\_adj}}{1+B} + 2\tau_{event}\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]}$$

Where:

$$DA_{event\_TCE} = \frac{TR \times AT_r \times 1000(\mu g/mg)}{\left(\frac{CSF_o}{GIABS}\right) \times \left(\left(CAF_o \times DFW_{adj}\right) + \left(MAF_o \times DFWM_{adj}\right)\right)}$$

Parameter	**Definition (units)**	**Default**
$C_{mu\text{-}derm}$	Contaminant concentration, mutagens, dermal (µg/L)	Chemical-specific
$DA_{event\ mu}$	Absorbed dose per event, mutagens (µg/cm^2-event)	Chemical-specific
K_p	Dermal permeability coefficient of compound in water (cm/hr)	Chemical-specific
$t_{event\ adj}$	Age-adjusted dermal exposure time per event, resident (hr/event)	See Equation 25
t*	Time to reach steady state (hr)	2.4 x τ_{event}
$t_{event\ \_mu\_adj}$	Age-adjusted dermal exposure time per event, mutagens, resident (hr/event)	See Equation 34
FA	Fraction absorbed water (unitless)	Chemical-specific
τ_{event}	Lag time per event (hr/event)	Chemical-specific
B	Ratio of permeability coefficient through the stratum corneum to permeability coefficient across the viable epidermis (unitless)	Chemical-specific
TR	Target risk	1E-05
AT_r	Averaging time, resident, carcinogens (days)	25,550
CSF_o	Oral cancer slope factor (mg/kg-day)$^{-1}$	Chemical-specific
GIABS	Fraction absorbed in gastrointestinal tract (unitless)	Chemical-specific
CAF_o	Adjusted oral cancer slope factor	See Equation 13
MAF_o	Adjusted oral mutagenic slope factor	See Equation 13
DFW_{adj}	Age-adjusted dermal tap water exposure factor, resident (cm^2-event /kg)	See Equation 26
$DFWM_{adj}$	Age-adjusted dermal tap water exposure factor, mutagens, resident (cm^2-event /kg)	See Equation 35

2.5 Vapor Intrusion Screening Levels

Residential receptors and commercial/industrial workers could be exposed to volatile compounds vaporized from subsurface media (soil gas and/or groundwater) through pore spaces in the vadose zone and building foundations (or slabs) into indoor air. Per US EPA guidance (US EPA, 2002d), this pathway must be evaluated if: 1) there are compounds present in subsurface media that are sufficiently volatile and toxic, and 2) there are existing or planned buildings where exposure could occur. A chemical is considered to be sufficiently volatile if its Henry's law constant is 1 x 10^{-5} atm-m^3/mole or greater and its molecular weight is approximately 200 g/mole or less. A chemical is considered to be sufficiently toxic if the vapor concentration of the pure component poses an incremental life time cancer risk greater than 1E-05 or the noncancer hazard index is greater than 1.0. VISLs were calculated for chemicals which are sufficiently volatile and toxic for evaluation of the vapor intrusion pathway following the guidance in the VISL User's Guide (US EPA, 2014d) and NMED-specific input parameters and are summarized in Table A-3. The list of chemicals included in Table A-3 is not comprehensive of all potential volatile and toxic compounds that may be present in site media. If volatile and toxic constituents are detected in site media and are not listed in Table A-3, VISLs should be calculated following the methodologies herein and risks addressed..

The US EPA (2002d) vapor intrusion guidance does not support the use of bulk soil data for evaluation of the vapor intrusion pathway; active soil gas and/or groundwater data must be used as appropriate. As such, VISLs are neither available nor recommended for soil. It is noted, however, that bulk soil data can be used in a qualitative sense to determine delineation of a vapor source or in determining if soil has been impacted and additional evaluation (e.g., soil gas) is needed. Conversely, it must not be assumed that non-detect results of volatile compounds in soil equates to an absence of a vapor source.

The NMED VISLs should be used as a first tier screening assessment. However, if site concentrations exceed the VISLs, it is recommended that the assumptions underlying the NMED VISL calculations be reviewed and a determination made as to whether they are applicable at each site. Site-specific factors may result in unattenuated or enhanced transport of vapors towards a receptor, and consequently are likely to render the VISLs target subsurface concentrations overly or underly conservative.

Application of the VISLs is appropriate as a first tier screening assessment for all sites except those where the following conditions apply. If any of the below are applicable to a site, a site specific evaluation must be conducted:

- Very shallow groundwater sources [e.g., depth to water is less than five (5) ft below foundation level];
- Shallow soil contamination resulting in vapor sources (e.g., VOCs are found at significant levels within 10 ft of the base of the foundation);
- Buildings with significant openings to the subsurface (e.g., sumps, unlined crawlspaces, earthen floors) or significant preferential pathways, either naturally-occurring or anthropogenic (not including typical utility perforations present in most buildings);
- Vapor sources originating in landfills where methane is generated in sufficient quantities to induce advective transport into the vadose zone;
- Vapor sources originating in commercial or industrial settings where vapor-forming chemicals can be released within an enclosed space and the vapor density of a chemical

may result in significant advective transport of the vapors downward through cracks and openings in floors and into the vadose zone; and/or

- Leaking vapors from gas transmission lines.

It is emphasized that the NMED VISLs are not meant to be used as action standards or cleanup levels. Rather, they should be used as a tool to estimate potential cumulative risks and/or hazards from exposure to volatile and toxic chemicals at a site where the underlying assumptions are deemed appropriate and if further evaluation is required (See Section 2.5.2, Evaluation of the Vapor Intrusion Pathway).

2.5.1 Calculation of Vapor Intrusion Screening Levels

NMED VISLs were calculated per US EPA (2002d, 2009, and 2013b) methods and guidance. A risk-based target indoor air concentration was used as a basis for back-calculating an allowable amount of a contaminant in soil-gas and/or groundwater assuming a certain amount of attenuation and dilution through the vadose zone and into the building.

Attenuation is the reduction in concentrations that occurs through migration in the subsurface combined with the dilution that occurs when vapor enters a building and mix with indoor air. The attenuation factor is expressed as the ratio of concentrations of chemicals in indoor air to the concentrations in subsurface vapor. Although attenuation factors are site specific and can vary depending on a number of variables (e.g. soil type, depth of contamination, building characteristics and indoor air exchange rates), NMED VISLs were calculated utilizing US EPA default attenuation factors which are based on conservative assumptions and empirical data. As recommended by US EPA (2002d and 2013b), a default attenuation factor of 0.1[1] was applied to establish soil-gas VISLs, and a default attenuation factor of 0.001[2] was applied in establishing groundwater VISLs. Soil-gas VISLs were calculated by dividing the risk-based target indoor air concentration by the default attenuation factor, as shown in Equation 38. Equation 39 also shows that groundwater VISLs were calculated by dividing the risk-based target indoor air concentration by the default attenuation factor, and converting the vapor phase concentration to a groundwater concentration utilizing a conversion factor and Henry's Law Constants to estimate partitioning between the aqueous phase and vapor phase, assuming equilibrium between the two phases.

---

[1] The USEPA's draft guidance for vapor intrusion (November 2012) proposes a new value of 0.03 for the attenuation of soil gas. This guidance is under review; upon finalization of the guidance, the default attenutation factor for soil gas will be evaluated and if warranted, new generic VISLs will be evaluated and a revision to this NMED guidance issued.

[2] The USEPA's draft guidance for vapor intrusion (November 2012) proposes no change to the groundwater attenuation factor (0.001) as presented herein.

Equation 38
Calculation of Vapor Intrusion Screening Levels

$$VISL_{sg} = \frac{C_{indoor}}{\alpha}$$

$$VISL_{gw} = \frac{C_{indoor}}{HLC \times \alpha \times 1000L/m^3}$$

Parameter	Definition (units)	Default
$VISL_{sg}$	Vapor intrusion screening level for soil-gas (µg/m^3)	Chemical and receptor-specific
$VISL_{gw}$	Vapor intrusion screening level for groundwater (µg/L)	Chemical and receptor-specific
C_{indoor}	Target indoor air concentration (µg/m^3)	Chemical and receptor-specific
α	Attenuation coefficient (unitless)	0.1 (soil-gas) 0.001 (groundwater)
HLC	Henry's Law Constant at standard temperature of 25 C (unitless)	Chemical-specific

The NMED groundwater VISLs were calculated based on a default standard temperature of 25 degrees Celsius (C). Although groundwater temperatures at many sites in New Mexico would likely be lower than 25 degrees C, this default value was selected in order to be protective of all sites in New Mexico.

The risk-based target indoor air concentrations were calculated using US EPA (2009, 2013b, and 2014b) algorithms, current toxicity data, and exposure factors used in the evaluation of other exposure pathways outlined in this document. Equations 39 through 42 present the formulas and exposure parameters used for calculating risk-based target indoor air concentrations for residential receptors. Separate indoor air concentrations were calculated for carcinogenic and noncarcinogenic contaminants, and alternate methods were utilized for vinyl chloride and other compounds that are carcinogenic via a mutagenic mode of action. Equations 43 through 55 present the formulas and exposure parameters used for calculating carcinogenic and noncarcinogenic target indoor air concentrations for the commercial/industrial scenario. Target indoor air concentrations for ecological receptors and the construction worker scenario were not calculated as the vapor intrusion exposure pathway is typically incomplete for receptors that spend their time outdoors. Under unique circumstances, such as work being conducted in a trench or other low lying areas where vapors could accumulate, special assessment of the vapor intrusion pathway may be required for the construction worker. The need for evaluation of the construction worker will be made on a case-by-case basis.

Equation 39
Calculation of Target Indoor Air Concentrations – Carcinogens Residential Scenario

$$C_{indoor} = \frac{TR \times AT_c}{EF \times ED \times ET \times IUR}$$

Parameter	Definition (units)	Default
C_{indoor}	Target indoor air concentration (µg/m^3)	Chemical-specific
TR	Target risk level	1E-05
AT_c	Averaging time for carcinogens (days)	25,550
EF	Exposure frequency (days)	350
ED	Exposure duration (yr)	26
ET	Exposure time (24 hr/day x 1 day/24 hr)	1
IUR	Inhalation unit risk (µg/m^3)$^{-1}$	Chemical-specific

Equation 40
Calculation of Target Indoor Air Concentrations – Noncarcinogens Residential Scenario

$$C_{indoor} = \frac{THQ \times AT_{nc} \times 1000 \mu g/mg}{EF \times ED \times ET \times \left(\frac{1}{RfC}\right)}$$

Parameter	Definition (units)	Default
C_{indoor}	Target indoor air concentration (µg/m^3)	Chemical-specific
THQ	Target hazard quotient	1
AT_{nc}	Averaging time for noncarcinogens (days)	ED x 365
EF	Exposure frequency (days)	350
ED	Exposure duration (yr)	26
ET	Exposure time (24 hr/day x 1 day/24 hr)	1
RfC	Inhalation reference concentration (mg/m^3)	Chemical-specific

Equation 41
Calculation of Target Indoor Air Concentrations – Vinyl Chloride Residential Scenario

$$C_{indoor} = \frac{TR}{IUR + \left(\frac{EF \times ED \times ET \times IUR}{AT_c}\right)}$$

Parameter	Definition (units)	Default
C_{indoor}	Target indoor air concentration (µg/m^3)	Chemical-specific
TR	Target risk level	1E-05
AT_c	Averaging time for carcinogens (days)	25,550
EF	Exposure frequency (days)	350
ED	Exposure duration (yr)	26
ET	Exposure time (24 hr/day x 1 day/24 hr)	1
IUR	Inhalation unit risk (µg/m^3)$^{-1}$	Chemical-specific

Equation 42
Calculation of Target Indoor Air Concentrations – Mutagens
Residential Scenario

$$C_{indoor} = \frac{TR \times AT_c}{EF \times ET \times [(ED_{0-2} \times IUR \times 10) + (ED_{2-6} \times IUR \times 3) + (ED_{6-16} \times IUR \times 3) + (ED_{16-26} \times IUR \times 1)]}$$

Parameter	Definition (units)	Default
C_{indoor}	Target indoor air concentration (µg/m^3)	Chemical-specific
TR	Target risk level	1E-05
AT_c	Averaging time for carcinogens (days)	25,550
EF	Exposure frequency (days)	350
ED_{0-2}	Exposure duration (0-2 yr)	2
ED_{2-6}	Exposure duration (2-6 yr)	4
ED_{6-16}	Exposure duration (6-16 yr)	10
ED_{16-26}	Exposure duration (16-26 yr)	10
ET	Exposure time (24 hr/day x 1 day/24 hr)	1
IUR	Inhalation unit risk (µg/m^3)$^{-1}$	Chemical-specific

Equation 43
Calculation of Target Indoor Air Concentrations – Carcinogens
Commercial/Industrial Scenario

$$C_{indoor} = \frac{TR \times AT_c}{EF \times ED \times ET \times IUR}$$

Parameter	Definition (units)	Default
C_{indoor}	Target indoor air concentration (µg/m^3)	Chemical-specific
TR	Target risk level	1E-05
AT_c	Averaging time for carcinogens (days)	25,550
EF	Exposure frequency (days)	225
ED	Exposure duration (yr)	25
ET	Exposure time (8 hr/day x 1 day/24 hr)	0.33
IUR	Inhalation unit risk (µg/m^3)$^{-1}$	Chemical-specific

Equation 44
Calculation of Target Indoor Air Concentrations – Noncarcinogens
Commercial/Industrial Scenario

$$C_{indoor} = \frac{THQ \times AT \times 1000 \mu g/mg}{EF \times ED \times ET \times \left(\frac{1}{RfC}\right)}$$

Parameter	Definition (units)	Default
C_{indoor}	Target indoor air concentration (µg/m^3)	Chemical-specific
THQ	Target hazard quotient	1
AT	Averaging time for noncarcinogens (days)	ED x 365
EF	Exposure frequency (days)	225
ED	Exposure duration (yr)	25

ET	Exposure time (8 hr/day x 1 day/24 hr)	0.33
RfC	Inhalation reference concentration (mg/m^3)	Chemical-specific

2.5.2 Evaluation of the Vapor Intrusion Pathway

During the investigation phase, if VOCs are detected in soil and/or site history indicate the potential for VOCs in site media, soil gas samples and groundwater sampling are likely to be required. The need for collection of soil gas data will be made on a case-by-case basis with input from NMED.

The assessment of the soil gas and groundwater data should include evaluation of the vapor intrusion pathway. Two types of soil gas data are collected: passive and active. Passive soil gas results are used for nature and extent purposes only; to determine the absence or presence of VOCs. Active soil gas data are required for quantitative risk assessments.

Chemicals that should be considered for the vapor intrusion pathway include those with a Henry's law constant of approximately 1 x 10^{-5} atm-m^3/mole or greater, a molecular weight of approximately 200 g/mole or less, and known to pose a potential cancer risk or noncancer hazard through the inhalation pathway. If all three of these criteria are met, the constituent is considered volatile and toxic. Table A-3 contains the VISLs for chemicals which met these three criteria. However, this list in Table A-3 is <u>not</u> comprehensive and any additional compounds meeting the above three criteria not listed in Table A-3 and present in site media will require additional analyses following the methods contained herein.

For each site investigation conducted in New Mexico, one of the following three designations shall be made for the vapor intrusion pathway: 1) incomplete pathway and no action required; 2) potentially complete pathway and a qualitative evaluation required; or 3) complete pathway and quantitative evaluation required.

2.5.2.1 Incomplete Pathway; No Action Required

If volatile and toxic compounds are not detected in soil gas and/or groundwater, meaning all the results were 100% non-detects, then the vapor intrusion pathway is considered incomplete. The risk assessment must include a brief discussion of this determination.

2.5.2.2 Potentially Complete Pathway; Qualitative Discussion

If <u>all</u> of the following criteria are met during investigation sampling, the pathway is considered potentially complete and a qualitative discussion of the vapor intrusion pathway will be required:

- Detections of volatile and toxic compounds are minimally detected (e.g., once or twice) in site media (soil, soil gas, and/or groundwater);
- Concentrations are below screening levels (i.e., VISLs for soil-gas and/or groundwater Table A-3);
- There is no suspected source(s) for volatile and toxic compounds; and

- Concentrations are decreasing with depth (for soil).

In addition, if volatile and toxic compounds were present at a site but the source(s) and associated contaminated soil have been removed and the following criteria have been met, only a qualitative assessment of the vapor intrusion pathway will be required:

- Confirmation sampling indicates removal of the source with minimal volatile and toxic compounds detected in soil/soil gas or groundwater data,
- Concentrations are below screening levels (i.e., VISLs for soil-gas and/or groundwater; Table A-3),
- No evidence to suggest dense/sinking vapors, and
- Concentrations decrease with depth.

2.5.2.3 Complete Pathway; Quantitative Assessment

If volatile and toxic compounds are detected consistently in site media during investigation or confirmation sampling, concentrations are detected at depth or show increasing concentrations with depth in soil, and/or there is potentially a source(s) for the volatile and toxic compounds based on site history, a quantitative assessment of the vapor intrusion pathway is required following a tiered approach, until the conditions of a given step are met.

Step 1. Compare the maximum detected concentration for soil gas or groundwater against the NMED VISLs. If active soil gas data are collected from soils located outside of a structure or below a slab, the VISL target sub slab and exterior soil gas concentrations for a target cancer risk of 1E-05 and a target hazard quotient of 1.0 should be applied. The VISL target groundwater concentrations for a target cancer risk of 1E-05 and a target hazard quotient of 1.0 should be applied for groundwater data. It is important to note that cumulative risk and hazard estimates from the vapor intrusion pathway must be added to the cumulative risk and hazard from other exposures at the site (e.g., soil and tap water exposure pathways) per Equations 57 and 58. The NMED VISLs may be modified using additional site-specific data and as approved by NMED. If the risks/hazards are acceptable, no additional evaluation is needed; otherwise, procede to Step 2.

Step 2. Under previous guidance, more refined modeling for the vapor intrusion pathway was typically conducted using the Johnson and Ettinger (J&E) model (US EPA, 2004b). However, in looking at new (draft) USEPA guidance, if initial screening using VISLs results in excess risk, USEPA is leaning away from use of the J&E model and is proposing a lines of evidence and additional data collection approach. If the screening analyses following the approach in Step 1 results in excess risk/hazard, the following should be conducted.

Evaluation of the vapor intrusion pathway should be based on multiple lines of evidence developed to support a refined and technically defensible CSM and a thorough characterization of potential subsurface vapor sources. This can be accomplished by gathering and interpreting information on:

- Subsurface vapor sources. This should include a thorough review of the site history and identification of potential subsurface vapor sources. This information should be accompanied by media specific data to confirm the presence of a vapor source at the site. The media-specific data should reflect spatial and temporal variations. Groundwater and soil gas concentrations should be compared to NMED VISLs to evaluate source strength and the potential for impacts to human health, if the vapor intrusion pathway is complete.
- Vapor migration and attenuation in the vadose zone. This should include soil gas data that represents spatial and vertical variations in soil gas concentrations, information on site geology and hydrogeology, and identification of any preferential pathways (e.g., utility conduits in the subsurface) for chemical vapors between the source and building.
- The building foundation. This should include information on construction materials, preferential pathways (i.e., openings) in the foundation, heating/cooling/ventilation system characteristics, photoionization detector readings at potential openings to the subsurface, grab samples of indoor air close to potential vapor entry points, and information on building pressure gradients.
- The building interior. This should include coinciding subslab soil gas and indoor air measurements, results of site-specific transport modeling, and comparisons of subslab soil gas and indoor air sampling results to determine site-specific attenuation factors.
- Sources of VOCs within the building and in ambient air. Information is needed to identify sources of VOCs, inside and outside of the building that could potentially impact indoor air concentrations of VOCs. Note that outdoor air samples should be taken at the same time that coinciding subslab soil gas and indoor air samples are taken.
- Additional lines of evidence, such as statistical analysis of the gathered data.

The collected lines of evidence should be assessed for concordance. If concordance can be reached, decisions regarding the vapor intrusion pathway can be made with confidence. However, some lines of evidence may not be definitive. Indoor air and subsurface soil gas concentrations can vary greatly both temporally and spatially. Some individual lines of evidence may be inconsistent with other lines of evidence and lead to the need for additional evaluation. If concordance among the lines of evidence cannot be determined, the evaluation of the vapor intrusion pathway should move to Step 3.

<u>Step 3</u>: When lines of evidence are not concordant and the weight of evidence does not support a confident decision, additional sampling or collecting additional lines of evidence may be appropriate, depending upon the CSM.

Step 4: If it is determined that vapor intrusion can potentially impact human health, NMED generally recommends that a human health risk assessment be conducted to determine whether the potential for human health risks posed to building occupants is within or exceeds acceptable NMED levels. The risk posed to building occupants by vapor intrusion depends upon chemical toxicity, vapor concentration in indoor air, the amount of time the occupants spend in the building, and other variables. NMED recommends that risk assessment guidance be used to identify, develop, and combine information about these variables to characterize health risks stemming from vapor intrusion from subsurface vapor sources.

2.6 Beef Ingestion Soil Screening Levels

For those sites greater than two acres in size, grazing of cattle must be evaluated to determine if beef ingestion is a plausible and complete exposure pathway. If grazing is not permitted (or could not be permitted due to land use restrictions), or the land does not support grazing (e.g., insufficient forage and/or water availability, terrain, or highly industrialized area), a qualitative assessment of this pathway must be provided. However, if grazing is viable or if a facility may potentially allow grazing on lands at some time in the future, a quantitative assessment of the pathway, ingestion of beef from cattle grazing on potentially contaminated sites, is required. The preliminary remediation goals (PRGs) for beef ingestion from the Risk Assessment Information System (RAIS) on-line tool should be used to assess this pathway. The steps to determine the beef ingestion PRGs are listed below:

- Access the on-line PRG calculator (http://rais.ornl.gov/cgi-bin/prg/PRG_search?select=chem),
- Select farmer scenario,
- Select site-specific PRG type and chronic toxicity,
- Select chemical(s) of concern,
- Select “Retrieve”,
- Under “Common parameters for ingestion of Produce, Milk, and Beef”, update the following parameters:
    - BWa (body weight - adult) 80 kg
    - EDag (exposure duration - resident) 26 yr
    - TR (target cancer risk) 1E-05 unitless
- Under “PRG for Contaminated Food Products”, obtain the PRG for ingestion of beef (cancer and non-cancer as appropriate).

Once the beef ingestion PRGs have been determined, site concentrations should be compared with the beef ingestion PRGs and estimated risks and hazards should be added to the cumulative risk/hazards as shown in Equations 57 and 58.

2.7 Site Assessment and Characterization

The Site Assessment/Site Characterization phase is intended to provide additional spatial and contextual information about the site, which may be used to determine if there is any reason to believe that receptors and/or complete exposure pathways may exist at or in the locality of the site where a release of hazardous waste/constituents has occurred. In addition, the site assessment phase serves as the initial information gathering phase to determine whether potential exposures are sufficiently similar to those upon which the NMED SSLs are predicated to support comparison. Finally, this phase can help to identify sites in need of a more detailed assessment of potential risk. A CSM providing a list of the potentially exposed receptors and potentially complete exposure pathways in the scoping report is used to determine whether further assessment (i.e., a screening level assessment) and/or interim measures are required or whether the site poses minimal threat to human and ecological receptors at or near the site.

The ultimate purpose of the site assessment phase is to address the question: Are exposure pathways complete with regard to contaminant contact by receptors? A complete site assessment will consists of several steps:

- Develop data quality objectives and conduct site sampling;
- Determine background threshold values (BTVs);
- Identify preliminary COPCs;
- Develop a preliminary site conceptual exposure model (SCEM);
- Determine exposure intervals;
- Compare maximum COPC concentrations for consideration of complete exposure pathways with SSLs; and
- If the site maximums are above the SSLs, a Tier 2 approach may be deemed appropriate by NMED using the 95% UCL value for contaminant concentrations (or detection/quantitation limits for non-detect results).

2.7.1 Development of Data Quality Objectives

Before any additional environmental samples are collected, data quality objectives (DQOs) should be developed. The DQOs should address the qualitative and quantitative nature of the sampling data, in terms of relative quality and intent for use, to ensure that any data collected will be appropriate for the intended purpose. Development of the DQOs should consider not only precision, accuracy, representativeness, completeness, and comparability of the data, but also the sampling locations, types of laboratory analyses used, sensitivity of detection limits of the analytical techniques, the resulting data quality, and the employment of adequate quality assurance/quality control measures.

2.7.2 Determination of Background Threshold Values

Site-specific BTVs ahould be established during a site-specific soil background study, as approved by NMED. Sample size, locations, other site-specific parameters for background data sets should be outlined during the DQO process as presented in the work plan. Guidance on the process of conducting a background soil study is beyond the scope of this document. However, the following criteria are representative of a defensible background data set:

- Includes a sufficient number of data for statistical analyses;
- Free of outliers;
- Reliably representative of the variations in background media (e.g., soil types or groundwater horizons);
- Collected from areas where there is no potential for site contamination based on site history;
- Areas are not impacted by neighboring areas of contamination (off-site migration);
- Collected from areas that are upwind of contaminated soil;
- Collected from areas that are upgradient of site contamination;
- Collected from soil types that are lithologically comparable to the samples that will be collected from contaminated areas; and
- Collected from depths that correspond to the exposure intervals that will be evaluated during human and ecological risk assessments.

An adequate sample size will likely capture a reliable representation of the background population while meeting the minimum sample size requirements for calculating BTVs and conducting hypothesis testing. US EPA (2013a) recommends 10 to 15 samples for each background data set, but more are preferable. While it is possible to calculate BTVs with small data sets containing as few as three samples, these results are not considered representative and reliable enough to make cleanup or remediation decisions. Therefore, a minimum sample size of 10 is required in order to calculate BTVs and conduct hypothesis testing. The size of the background area and size of the site or facility under study should also be considered in determining sample size. That is, if the background and site areas are relatively large, then a larger background data set (e.g., > 10 samples) should be considered (US EPA, 2013a). Background soil data are often grouped according to depth (e.g., surface vs. subsurface) or soil type. It is important to note that the minimum sample size of 10 should be met for each grouping of data in order to compute BTVs for each soil horizon or soil type.

Determination of BTVs should be conducted using current ProUCL software and guidance. In general, BTVs should be based on 95% upper tolerance limits (UTLs) with 95% coverage. The exception to this would be on a case-by-case basis where the estimated 95% UTL is significantly greater (more than 1.5 times) than the maximum detected concentration. This may be an indication that the 95% UTL is based on the accommodation of low-probability outliers (which may or may not be attributable to the background population) or highly skewed data sets and/or possibly inadequate sample size. In these cases, the project team may choose to evaluate the possibility of additional potential outliers or collection of more data. In lieu of collection of additional data to resolve the elevated UTL issue, the maximum detected concentration should be used as the BTV.

2.7.3 Identification of COPCs

COPCs are those substances (including transformation or breakdown compounds and companion products) likely to be present in environmental media affected by a release. Identification of COPCs should begin with existing knowledge of the process, product, or waste from which the release originated. For example, if facility operations deal primarily with pesticide manufacturing then pesticides should be considered COPCs. Contaminants identified during current or previous site investigation activities should also be evaluated as COPCs. A site-specific COPC list for soil may be generated based on maximum detected (or, if deemed appropriate by NMED, the 95% UCL value) concentrations (US EPA 2002b) and a comparison of detection/quantitation limits for non-detect results to the NMED SSLs. This list may be refined through a site-specific risk assessment.

Per US EPA guidance (US EPA 1989), if there is site history to indicate a chemical was potentially used/present at a site or if there is insufficient site history to demonstrate that a chemical could not be present, and the chemical was detected in at least one sample, this chemical must be included as a COPC and evaluated in the screening assessment.

For inorganics, a comparison of site concentrations to appropriate background concentrations may be conducted prior to evaluation against SSLs. Those inorganics that are present at levels indicative of natural background may be eliminated as COPCs. Comparison to background must be conducted following current US EPA Guidance and as outlined herein. The general process is a tiered approach.

<u>Step 1.</u> Compare the maximum detected site concentration to the site-specific background reference values (upper tolerance limit) determined for each soil type at the site. If the site maximum is less than the background reference value, it is assumed that the site concentrations are representative of background and the metal/inorganic is not retained as a COPC. If there is no background value for a constituent, then it will be retained as a COPC.

<u>Step 2:</u> If the maximum site concentration is greater than the background reference value, then a two-sample hypothesis test should be used to compare the distributions of the site data to the distributions of background data to determine if site concentrations are elevated compared with background. A simple comparison to the range of background is not acceptable. Background can vary across a site (especially larger sites) and not allow for soil type to be taken into consideration. Further, a range can mask low level contamination.

The most recent version of US EPA's ProUCL statistical software will be used for hypothesis testing. ProUCL will also be used to determine the most appropriate test (parametric or nonparametric) based on the distribution of the data. Appropriate methods in ProUCL will also be used to compute site-to-background comparisons based on censored data sets containing non-detect values. In addition, a review of graphical displays (e.g., box plots and Q-Q plots) may also be provided in order to provide further justification in determining whether site concentrations are elevated compared with background. These graphical plots can be also be generated by ProUCL software.

Note that the above two-sample test can only be used for site data sets that have a sufficient number of samples (i.e., n ≥ 8) and number of detections (i.e, ≥ 5 detected observations). While a minimum of 10 background data samples are now required, there may be sites where background has been previously conducted and may contain fewer than 10 samples. Site-to-background point-by-point comparisons will be conducted for site data sets containing fewer than eight samples and fewer than five detected observations. As stated in the current version of ProUCL User's Guide (US EPA, 2013a), hypothesis testing is only considered to be reliable with sufficient sample size (n ≥ 8) and frequency of detection (≥ 5 detected observations). If there are not at least eight samples in the site data set and at least five detections, then the site maximum detected concentrations will be compared to the corresponding background value (i.e., 95% upper tolerance limit) as noted in Step 1 or additional data must be collected to conduct a two-tailed test.

Step 3: Additional lines of evidence may be used to justify exclusion of an inorganic as being site related, such as site history, number of non-detects, etc. For areas where a hotspot may be present, additional actions are required and the constuent(s) must be retained as a COPC. Comparison of site data to regional data (such as US Geological Survey (USGS) databases not specific to the site) or simple comparison to a range of data are not acceptable lines of evidence.

2.7.4 Development of a Preliminary Conceptual Site Model

A CSM is a graphical representation of three-dimensional site conditions that conveys what is known or suspected, at a discrete point in time, about the site-specific sources, releases, release mechanisms, contaminant fate and transport, exposure routes, and potential receptors. The CSM is generally documented by written descriptions and supported by maps, geological cross-sections, tables, diagrams and other illustrations to communicate site conditions. When preparing a CSM, the facility should decide the scope, quantity, and relevance of the information to be included, balancing the need to present as complete a picture as possible to document current site conditions and justify risk management actions, with the need to keep the information focused and exclude extraneous data.

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

- Are there potential land uses present (now or in the foreseeable future) other than those covered by the SSLs? (refer to US EPA 1989).
- Are there other likely human exposure pathways that were not considered in development of the SSLs (e.g. vapor intrusion, direct exposure to groundwater, local fish consumption,

raising homegrown produce, beef, dairy, or other livestock)? (refer to US EPA 1989).

- Are there potential ecological concerns? (*Guidance for Assessing Ecological Risks Posed by Chemicals: Screening Level Ecological Risk Assessment*; NMED 2014).

If any conditions such as these exist, the SSLs may need to be adjusted to reflect this new information.

2.7.5 Determine Exposure Intervals

Based on current and potential land-use scenarios, receptors for completed exposure pathways can be exposed to varying depths of soil, or soil exposure intervals. Per US EPA (US EPA 1989), depth of samples should be considered and surface soils should be evaluated separately from subsurface soils due to possible differences in exposure levels that would be encountered by different receptors. Exposure intervals for each receptor are based on the types of activities in which each receptor is likely to be involved. Default exposure intervals are summarized in Table 2-6.

It is assumed that commercial/industrial workers would only be exposed to surface soils (0-1 feet bgs). As stated in Section 2.3.1, this receptor may be involved in moderate digging associated with routine maintenance and grounds keeping activities. Therefore, COPC concentrations in soil in the surface soil interval (0-1 feet bgs) should be considered when evaluating exposure by a commercial/industrial worker receptor.

As stated in Section 2.3.2, a construction worker is assumed to be exposed to surface and subsurface soils up to depths of 0-10 ft bgs. Construction workers are involved in digging, excavation, maintenance and building construction projects and could be exposed to surface as well as subsurface soil. Therefore, a soil exposure interval of 0-10 feet bgs should be considered when evaluating exposure to soil by a construction worker.

Residents could be exposed to surface and subsurface soils during home maintenance activities, yard work, landscaping, and outdoor play activities. Therefore, an exposure soil interval of 0-10 feet bgs should be assumed when evaluating soil exposure by a residential receptor.

Exposure to COPCs in soil by ecological receptors should be addressed separately in a tiered approach as outlined in Volume 2 of this document and by NMED (2014). However, a discussion of soil exposure intervals for ecological receptors is warranted here because ecological receptors are considered in the CSM and depending on the types of ecological receptors, there can be a differential in exposure levels due to soil exposure intervals. Burrowing animals would be exposed to deeper soils, whereas all other animals would only be exposed to surface and shallow subsurface soils. Therefore, maximum concentrations of COPCs in soil 0-10 feet bgs should be assessed for burrowing animals. Maximum COPC concentrations in soil 0-5 ft bgs should be assessed for all other animals.

Table 2-6. Soil Exposure Intervals

Receptor	Exposure Intervals (Soil)
Resident (adult and child)	0 – 10 ft bgs
Commercial/Industrial Worker	0 – 1 ft bgs
Construction Worker	0 – 10 ft bgs
Vapor Intrusion	Depth of maximum detection
Ecological Receptors (non-burrowing)	0 – 5 ft bgs
Ecological Receptors (burrowing)	0 – 10 ft bgs

2.7.6 Compare COPC Maximum Concentrations with SSLs

The final step in the site assessment phase is to compare maximum detected COPC concentrations in soil with SSLs based on the complete exposure pathways identified by the preliminary CSM and assessing total risk/hazard from all constituents (refer to Section 5). These concentrations should also be compared against the SSL leaching values to determine which contaminants present in soil have the capacity to leach to underlying groundwater and impact these resources adversely. As stated earlier, those contaminants exhibiting concentrations in excess of the SSLs represent the initial soil COPC list for a given site. Refinement of this list may be necessary based on a host of factors, including elevated detection or quantitation limits.

2.7.7 Calculation of Exposure Point Concentrations

If it is determined that further assessment is warranted (see Section 5), refinement of EPCs should be conducted. US EPA (1989) recommends using the average concentration to represent "a reasonable estimate of the concentration likely to be contacted over time". US EPA's (1992b) *Supplemental Guidance to RAGS: Calculating the Concentration Term* states that, "because of the uncertainty associated with estimating the true average concentration at a site, the 95 percent upper confidence limit (UCL) of the arithmetic mean should be used for this variable."

Upper confidence limits should only be calculated for data sets that meet the US EPA (2013a) minimum requirements for calculating UCLs. The minimum requirements for calculating UCLs are: 1) each data set must contain at least eight samples (i.e., $n \geq 8$) for the analyte being evaluated; and 2) there must be a minimum of six detections (i.e., ≥ 5 detected observations) for the analyte being evaluated. Although it is possible to calculate UCLs with small datasets (i.e., $n \leq 8$) and low frequencies of detection (i.e., ≤ 5 detected observations), these estimates are not considered reliable and representative enough to make defensible and correct cleanup and remediation decisions (US EPA, 2013a). Therefore, UCLs should only be calculated for data sets that meet the minimum requirements for calculation UCLs.

UCLs should be calculated using the most current version of US EPA's ProUCL statistical software package. Statistical methods for calculating UCLs are dependent on the distribution of the data. Therefore, when calculating UCLs, ProUCL should be used to perform statistical tests in order to determine the distribution of the site data. If assumptions about the distribution cannot be made, then nonparametric methods can be utilized. ProUCL recommends a computational method for calculation of the 95% UCL based on the assumed distribution.

Using parametric and nonparametric methods, ProUCL will typically return several possible values for the UCL. Professional judgment should be used in selecting the most appropriate UCL; however, the UCL recommended by ProUCL is based on the data distribution and is typically the most appropriate value to be adopted as the EPC for use in risk assessments. It is important to note that the UCL should not be greater than the maximum detected concentration.

Non-detects (censored datasets) should be evaluated following the appropriate methodology outlined in the most recent version of US EPA's ProUCL Technical Guide. Currently, ProUCL guidance recommends regression on order statistics methods for handling non-detects in environmental data sets. Use of one-half the minimum detection limit (MDL) or sample quantitation limit (SQL), or other simple substitution methods, are not considered appropriate methods for handling non-detects.

3.0 CHEMICAL-SPECIFIC AND PHYSICAL-CHEMICAL PARAMETERS

Chemical-specific parameters required for calculating SSLs include the organic carbon normalized soil-water partition coefficient for organic compounds (K_{oc}), the soil-water partition coefficient (K_d), water solubility (S), octanol-water partition coefficient (K_{ow}), Henry's Law constant (H), diffusivity in air (D_a), and diffusivity in water (D_w). The following sections describe these values and present methodologies for calculating additional values necessary for calculating the NMED SSLs.

3.1 Volatilization Factor for Soil

Volatile chemicals, defined as those chemicals having a Henry's Law constant greater than 1E-05 atm-m^3/mole and a molecular weight less than 200 g/mole, were screened for inhalation exposures using a volatilization factor (VF) for soils. The soil-to-air VF_s is used to define the relationship between the concentration of the contaminant in soil and the flux of the volatilized contaminant to ambient air. The emission terms used in the VF are chemical-specific and were calculated from physical-chemical information obtained from several sources including: US EPA's *Soil Screening Guidance: Technical Background Document* (US EPA, 1996a), *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (US EPA 2002a), US EPA Master Physical and Chemical Parameter table for development of US EPA Regional Screening Levels (refer to US EPA 2014a), US EPA's *Basics of Pump and Treat Groundwater Remediation Technology* (US EPA 1990), US EPA's *Dermal Exposure Assessment* (US EPA 1992a), *Superfund Public Health Evaluation Manual* (US EPA 1986), US EPA's *Additional Environmental Fate Constants* (US EPA 1995), Hazardous Substance Release/Health Effects Database (ATSDR 2003), the RAIS database (DOE 2005), and the CHEMFACTS database (US EPA 2000). The VF_s for the residential and commercial/industrial scenarios is calculated using Equation 45 while the $VF_{s\text{-}cw}$ for the construction worker is calculated using Equation 46.

Equation 45
Derivation of the Volatilization Factor for Residential and Commercial/Industrial Scenarios

$$VF_s = \frac{Q / C_{vol} \times \left(3.14 \times D_A \times T\right)^{0.5} \times 10^{-4}}{\left(2 \times \rho_b \times D_A\right)}$$

Where:

$$D_A = \frac{\left[\frac{\left(\theta_a^{10/3} D_a H' + \theta_w^{10/3} D_w\right)}{n^2}\right]}{\rho_b K_d + \theta_w + \theta_a H'}$$

Parameter	Definition (units)	Default
VF_s	Volatilization factor for soil (m^3/kg)	Chemical-specific
D_A	Apparent diffusivity (cm^2/s)	Chemical-specific
Q/C_{vol}	Inverse of the mean concentration at the center of a 0.5- acre-square source (g/m^2-s per kg/m^3)	68.18
T	Exposure interval (s)	9.5E+08
ρ_b	Dry soil bulk density (g/cm^3)	1.5
n	Total soil porosity 1 - (ρ_b/ρ_s)	0.43
θ_a	Air-filled soil porosity (n - θ_w)	0.17
θ_w	Water-filled soil porosity	0.26
ρ_s	Soil particle density (g/cm^3)	2.65
D_a	Diffusivity in air (cm^2/s)	Chemical-specific
H’	Dimensionless Henry’s Law constant	Chemical-specific
D_w	Diffusivity in water (cm^2/s)	Chemical-specific
K_d	Soil-water partition coefficient (cm^3/g) = K_{oc} x f_{oc} (organics)	Chemical-specific
K_{oc}	Soil organic carbon partition coefficient (cm^3/g)	Chemical-specific
f_{oc}	Fraction organic carbon in soil (g/g)	0.0015

Equation 46
Derivation of the Volatilization Factor for Construction Worker Scenario

$$VF_{s-cw} = \left(\frac{\left(3.14 \times D_A \times T\right)^{0.5}}{2 \times \rho_b \times D_A}\right) \times 10^{-4} \times Q / C \times (1 / F_D)$$

Where:

$$D_A = \frac{\left[\frac{\left(\theta_a^{10/3} D_a H' + \theta_w^{10/3} D_w\right)}{n^2}\right]}{\rho_b K_d + \theta_w + \theta_a H'}$$

Parameter	Definition (units)	Default
$VF_{s\text{-}cw}$	Volatilization factor for soil, construction worker (m^3/kg)	Chemical-specific
D_A	Apparent diffusivity (cm^2/s)	Chemical-specific
Q/C	Inverse of the mean concentration at the center of a 0.5- acre-square source (g/m^2-s per kg/m^3)	14.31
T	Exposure interval (s)	3.15E+07
10^{-4}	Conversion factor (m^2/cm^2)	1E-04
F_D	Dispersion correction factor (unitless)	0.185
ρ_b	Dry soil bulk density (g/cm^3)	1.5
n	Total soil porosity $1 - (\rho_b/\rho_s)$	0.43
θ_a	Air-filled soil porosity $(n - \theta_w)$	0.17
θ_w	Water-filled soil porosity	0.26
ρ_s	Soil particle density (g/cm^3)	2.65
D_a	Diffusivity in air (cm^2/s)	Chemical-specific
H’	Dimensionless Henry’s Law constant	Chemical-specific
D_w	Diffusivity in water (cm^2/s)	Chemical-specific
K_d	Soil-water partition coefficient (cm^3/g) = K_{oc} x f_{oc} (organics)	Chemical-specific
K_{oc}	Soil organic carbon partition coefficient (cm^3/g)	Chemical-specific
f_{oc}	Fraction organic carbon in soil (g/g)	0.0015

While most of the parameters used to calculate apparent diffusivity (D_A) are either chemical-specific or default values, several state-specific values were used which are more representative of soil conditions found in New Mexico. The default values for θ_w, θ_a, and ρ_b in Equations 45 and 46 are 0.26, 0.17 and 1.5 g/cm^3, respectively. These values represent mean values from a National Resources Conservation Service (NRCS) soil survey database for New Mexico that includes over 1200 sample points (U.S. Department of Agriculture 2000). US EPA guidance (US EPA 2001a) provides additional methodologies for estimating site-specific air-filled soil porosities and water-filled soil porosities.

It should be noted that the basic principle of the VF model (i.e., Henry’s Law) is applicable only if the soil contaminant concentration is at or below soil saturation, C_{sat}. Above the soil saturation limit, the model cannot predict an accurate VF-based SSL.

3.2 Soil Saturation Limit

C_{sat} describes a chemical-physical soil condition that integrates certain chemical-specific properties with physical attributes of the soil to estimate the contaminant concentration at which the soil pore water, pore air, and surface sorption sites are saturated with contaminants. Above this concentration, the contaminants may be present in free phase within the soil matrix – as non-aqueous phase liquids (NAPLs) for substances that are liquid at ambient soil temperatures, and pure solid phases for compounds that are solids at ambient soil temperatures (US EPA 1996a). Generic C_{sat} concentrations should not be interpreted as confirmation of a saturated soil condition, but as estimates of when this condition may occur. It should be noted that C_{sat} concentrations are not risk-based values. Instead, they correspond to a theoretical threshold above which free phase contaminant may exist. C_{sat} concentrations, therefore, serve to identify an upper limit to the applicability of generic risk-based soil criteria, because certain default assumptions and models used in the generic algorithms are not applicable when free phase contaminant is present in soil. The basic principle of the volatilization model is not applicable when free-phase contaminants are present. How these cases are handled depends on whether the contaminant is liquid or solid at ambient temperatures. Liquid contaminants that have VF-based screening levels that exceed the “sat” concentration are set equal to “C_{sat}” whereas for solids (e.g., PAHs), soil screening decisions are based on appropriate other pathways of concern at the site (e.g., ingestion and dermal contact). Equation 47, given below is used to calculate C_{sat} for each volatile contaminant considered within the SSLs.

Equation 47
Derivation of the Soil Saturation Limit

$$C_{sat} = \frac{S}{\rho_b}\left(K_d \rho_b + \theta_w + H' \theta_a\right)$$

Parameter	Definition (units)	Default
C_{sat}	Soil saturation concentration (mg/kg)	Chemical-specific
S	Solubility in water (mg/L-water)	Chemical-specific
ρ_b	Dry soil bulk density (kg/L)	1.5
K_d	Soil-water partition coefficient (L/kg; $K_{oc} \times f_{oc}$)	Chemical-specific
K_{oc}	Soil organic carbon/water partition coefficient (L/kg)	Chemical-specific
f_{oc}	Fraction organic carbon in soil (g/g)	0.0015
θ_w	Water-filled soil porosity (L_{water}/L_{soil})	0.26
H′	Dimensionless Henry’s Law constant	Chemical-specific
θ_a	Air-filled soil porosity ($n - \theta_w$),(L_{air}/L_{soil})	0.17
n	Total soil porosity ($1 - (\rho_b/\rho_s)$), (L_{pore}/L_{soil})	0.43
ρ_s	Soil particle density (kg/L)	2.65

Chemical-specific parameters used in Equation 47 were obtained from physical-chemical information presented in several sources including: US EPA’s *Soil Screening Guidance: Technical Background Document* (US EPA 1996a and US EPA 2002a), the US EPA Regional Screening Levels (US EPA 2014a), US EPA’s *Basics of Pump and Treat Groundwater remediation Technology* (US EPA 1990), US EPA’s *Dermal Exposure Assessment* (US EPA 1992a), *Superfund Public Health Evaluation Manual* (US EPA 1986), US EPA’s *Additional Environmental Fate Constants* (US EPA 1995), Hazardous Substance Release/Health Effects Database (ATSDR 2003), the RAIS, CHEMFACTS, WATER9, and PHYSPROP databases, and EPISUITE.

3.3 Particulate Emission Factor

Inhalation of chemicals adsorbed to suspended respirable particles is assessed using a chemical-specific PEF, which relates the contaminant concentration in soil to the concentration of respirable particles in the air due to fugitive dust emissions from contaminated soils. This guidance addresses dust generated from open sources, which is termed “fugitive” because it is not discharged into the atmosphere in a confined flow stream. For further details on the methodology associated with the PEF model, the reader is referred to US EPA's *Soil Screening Guidance: Technical Background Document* (US EPA 1996a), *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (US EPA 2002a) and *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (US EPA 2005b).

It is important to note that the PEF for use in evaluating exposure of residential and commercial/industrial receptors addresses only windborne dust emissions and does not consider emissions from traffic or other forms of mechanical disturbance, which could lead to a greater level of exposure. The PEF for use in evaluating construction worker exposures considers windborne dust emissions and emissions from vehicle traffic associated with construction activities. Therefore, the fugitive dust pathway should be considered carefully when developing the CSM at sites where receptors may be exposed to fugitive dusts by other mechanisms. Equation 48 is used to calculate a New Mexico region-specific PEF value, used for both the residential and commercial/industrial exposure scenarios. A scenario-specific PEF value was calculated for a construction worker receptor (PEF_{cw}) using Equation 49.

Equation 48
Derivation of the Particulate Emission Factor
Residential and Commercial/Industrial Scenarios

$$PEF = Q/C_{wind} \times \frac{3{,}600\ \mathrm{sec/hr}}{0.036 \times (1 - V) \times \left(\frac{U_m}{U_t}\right)^3 \times F(x)}$$

Parameter	Definition (units)	Default
PEF	Particulate emission factor (m^3/kg)	6.61E+09
Q/C_{wind}	Inverse of a mean concentration at center of a 0.5-acre-square source (g/m^2-s per kg/m^3)	81.85
V	Fraction of vegetative cover (unitless)	0.5
U_m	Mean annual windspeed (m/s)	4.02
U_t	Equivalent threshold value of windspeed at 7 m (m/s)	11.32
F(x)	Function dependent on U_m/U_t derived using Cowherd et al. (1985) (unitless)	0.0553

Equation 49
Derivation of the Particulate Emission Factor
Construction Worker Scenario

$$PEF_{CW} = Q/C_{CW} \times \frac{1}{F_D}\left[\frac{T \times A_R}{556 \times \left(\frac{W}{3}\right)^{0.4} \times \frac{(365\ \mathrm{days/yr} - P)}{365\ \mathrm{days/yr}} \times \sum VKT}\right]$$

Parameter	Definition (units)	Default
PEF_{CW}	Particulate emission factor for a construction worker (m^3/kg)	2.1E+06

Q/C_{CW}	Inverse of a mean concentration at center of a 0.5-acre-square source (g/m^2-s per kg/m^3)	23.02
F_D	Dispersion correction factor (unitless)	0.185
T	Total time over which construction occurs (s)	7.2E+06
A_R	Surface area of road segment (m^2)	274.2
W	Mean vehicle weight (tons)	8
P	Number of days with at least 0.01 inches of precipitation (days/yr)	60
ΣVKT	sum of fleet vehicle kilometers traveled during the exposure duration (km)	168.75

3.4 Physical-Chemical Parameters

Several chemical-specific parameters are required for calculating SSLs including the organic carbon normalized soil-organic carbon/water partition coefficients for organic compounds (K_{oc}), the soil-water partition coefficient for organic and inorganic constituents (K_d), the solubility of a compound in water (S), Henry's Law constant (H), air diffusivity (D_a), water diffusivity (D_w), molecular weight, the octanol-water partition coefficient (K_{ow}), and the dermal permeability coefficient in water (K_p). Prior to calculating site-specific SSLs, each relevant chemical specific parameter value presented in Appendix B should be checked against the most recent version of its source to determine if updated data are available. Tables B-1, B-2, and B-3 in Appendix B provide the chemical-specific parameters used in calculating the NMED SSLs. Chemical-specific parameters were selected from the following sources in the order listed:

- Organic carbon partition coefficient (K_{oc}; L/kg). US EPA (2012b) Estimation Program Interface (EPI) Suite software, v4.11.
- Soil-water partition coefficient (K_d; cm^3/g). For organics, $K_d = K_{oc}$ x fraction of organic carbon in soil, (f_{oc} NMED default value of 0.15%). For inorganics, 1) US EPA (2002a); 2) Baes (1984) Figure 2.31.
- Water solubility (S; mg/L at 25 °C). US EPA (2012b) EPI Suite software, v4.11.
- Henry's Law constant (H; atm-m^3/mole at 25 °C). 1) US EPA (2012b) EPI Suite software, v4.11: a) experimental values; b) estimated values via the bond method; c) estimated values via the group method; and 2) US EPA (2002a).
- Diffusivity in air (D_a; cm^2/s). 1) US EPA (2006) Water 9 v3.0; 2) US EPA (2002a).
- Diffusivity in water (D_w; cm^2/s). 1) US EPA (2006) Water 9 v3.0; 2) US EPA (2002a).
- Molecular weight (MW). US EPA (2012b) EPI Suite software, v4.11.
- Dermal permeability coefficient in water (Kp; cm/hr). US EPA (2012a) EPI Suite software, v.4.11.

3.4.1 Solubility, K_{ow}, and Henry's Law Constant

The solubility of a contaminant refers to the maximum amount that can be dissolved in a fixed volume of solvent, usually pure water, at a specific temperature and pH. A chemical with a high solubility readily dissolves in water, while a low solubility indicates an inability to dissolve. Water solubility is generally predicted based on correlations with the octanol-water partition coefficient (K_{ow}). Solubility is used to calculate soil saturation limits for the NMED SSLs.

The octanol-water partition coefficient (K_{ow}) of a chemical is the ratio of a chemical's solubility in octanol versus its solubility in water at equilibrium. Essentially, this chemical-specific property is used as an indication of a contaminant's propensity to migrate from soil to water. It is an important parameter and is used in the assessment of environmental fate and transport for organic chemicals.

The Henry's Law constant (H) is used when evaluating air exposure pathways. For all chemicals that are capable of exchanging across the air-water interface, there is a point at which the rate of volatilization into the air and dissolution to the water or soil will be equal. The ratio of gas- and liquid-phase concentrations of the chemical at this equilibrium point is represented by H, which is used to determine the rate at which a contaminant will volatilize from soil to air. Values for H may be calculated using the following equation and the values for S, vapor pressure (VP), and MW.

$$H = \frac{VP \text{ x } MW}{S}$$

Equation 50

The dimensionless form of Henry's Law constant (H′) used in calculating soil saturation limits and volatilization factors for the NMED SSLs was calculated by multiplying H by a factor of 41 to convert the Henry's Law constant to a unitless value.

3.4.2 Soil Organic Carbon/Water Partition Coefficients (K_{oc})

The soil organic carbon-water partition coefficient (K_{oc}) is a measure of a chemical's tendency to adsorb to organic carbon present in soil. High K_{oc} values indicate a tendency for the chemical to adsorb to soil particles rather than remain dissolved in the soil solution. Strongly adsorbed molecules will not migrate unless the soil particle to which they are adsorbed moves (as in erosion). K_{oc} values of less than 500 indicate weak adsorption and a potential for leaching. K_{oc} is calculated using the following equation:

$$K_{oc} = \frac{\text{concentration adsorbed/concentration dissolved}}{\text{\% organic carbon in soil}}$$

Equation 51

K_{oc} can also be calculated by dividing the K_d value by the fraction of organic carbon (f_{oc}) present in the soil or sediment. It should be noted that a strong linear relationship exists between K_{oc} and K_{ow} and that this relationship can be used to predict K_{oc}.

3.4.3 Soil/Water Partition Coefficients (K_d)

The soil-water partition coefficient (K_d) for organic chemicals is the ratio of a contaminant's distribution between soil and water particles. The soil-water partitioning behavior of nonionizing and ionizing organic compounds differs because the partitioning of ionizing organics can be influenced by soil pH. K_d values were used in calculating soil saturation limits and VFs used in developing the NMED SSLs.

For organic compounds, K_d represents the tendency of a chemical to adsorb to the organic carbon fraction in soils, and is represented by:

$$K_d = K_{oc} \text{ x } f_{oc}$$ **Equation 52**

Where:

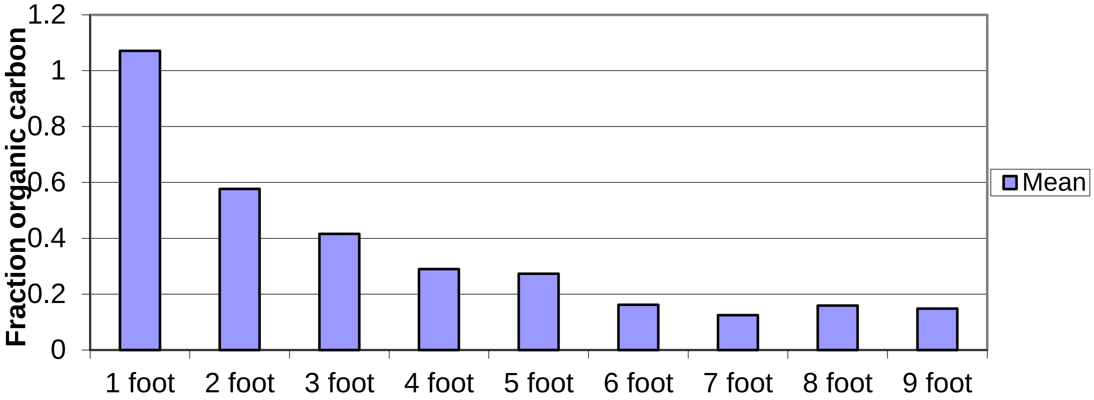
K_{oc} = organic carbon partition coefficient (L/kg or cm^3/g); and
f_{oc} = fraction of organic carbon in soil (mg/mg).

This relationship is generally valid for volatile halogenated hydrocarbons as long as the fraction of organic carbon in soil is above approximately 0.001 (0.1 percent) (Piwoni and Banaerjee, 1989 Schwarzenbach and Westall 1981). For low organic carbon soils ($f_{oc} < 0.001$), Piwoni and Banerjee (1989) developed the following empirical correlation for organic chemicals:

$$\log K_d = 1.01 \log K_{ow} - 0.36$$ **Equation 53**

The use of a fixed K_{oc} value in the soil-water partition equation for the migration to groundwater pathway is only valid for hydrophobic non-ionizing organic chemicals. For organic chemicals that ionize in the soil environment, existing in both neutral and ionized forms within the normal soil pH range, K_{oc} values must consider the relative proportions and differences in sorptive properties of these forms. For the equations and applications of developing K_{oc} values for ionizing organic acids as a function of pH, the reader is referred to US EPA 1996. The default value used for f_{oc} in development of NMED SSLs is 0.0015 (0.15%). This value represents the median value of 212 data points included in the NRCS soil survey database for New Mexico (U.S. Department of Agriculture 2000). Only samples collected from a depth of greater than 5 feet were included in the calculation of the mean f_{oc} value. Shallow soil samples tend to have higher f_{oc} values as shown in Figure 3-1. There is a steady decline in f_{oc} value with depth until approximately 5 feet bgs. Below 5 feet, there is little variability in the f_{oc} value. Because a lower f_{oc} value provides a more conservative calculation of SSL, a value representative of deeper soil conditions is used as the default value.

Figure 3-1 Mean Value - Fraction Organic Carbon (f_{oc})
All Counties in New Mexico



As with organic chemicals, development of the NMED SSLs for inorganic constituents (i.e., metals) requires a soil-water partition coefficient (K_d) for each contaminant. K_d values for metals are affected by a variety of soil conditions, most notably pH, oxidation-reduction conditions, iron oxide content, soil organic matter content, cation exchange capacity and major ion chemistry. US EPA developed default K_d values for metals using either an equilibrium geochemical speciation model (MINTEQ2) or from empirical pH-dependent adsorption relationships developed by USEPA's Office of Research and Development (EPA/ORD) (US EPA 1996a).

4.0 MIGRATION OF CONTAMINANTS TO GROUNDWATER

Generic SSLs were developed that address the potential for migration of contaminants from soil to groundwater. The methodology used to calculate generic SSLs addresses the potential leaching of contaminants from the vadose zone to groundwater. This method does not take into account any additional attenuation associated with contaminant transport in groundwater. The SSLs developed from this analysis are risk-based values incorporating NMED-specific tap water SSLs. This methodology is modeled after US EPA's *Soil Screening Guidance: Technical Background Document* (US EPA 1996a) and the *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (US EPA 2002a).*

4.1 Overview of the SSL Model Approach

Two approaches to developing soil leachate-based SSLs are presented, the generic model and the site-specific model. Both models use the same set of equations to calculate SSLs and are based on leaching to groundwater scenarios that NMED believes are protective of groundwater. The generic model calculates SSLs using default parameter values generally representative of conditions in New Mexico. These values are presented in Tables B-1 and B-2 of Appendix B. The site-specific model provides the flexibility of using site-specific meteorological, soil and hydrological data to calculate SSLs, while retaining the simplicity and ease of use associated with the generic model.

The development of soil leachate SSLs is based upon a two step process. The first step is the development of a Dilution Attenuation Factor (DAF). The DAF accounts for leachate mixing in the aquifer. A leachate concentration that is protective of groundwater is back calculated by multiplying the groundwater standard for a given constituent by the DAF. That leachate concentration is then used to back calculate an SSL that is protective of groundwater using a simple linear equilibrium soil/water partition equation. For the generic SSL approach, default parameter values are used for all non-chemical specific parameters. At sites that are not adequately represented by the default values and where more site-specific data are available, it may be more appropriate to use the site-specific SSL model. The site-specific model uses the same spreadsheet equations to calculate SSLs as those in the generic look-up table; however, site-specific data are used in the site-specific model.

The following sections of this document provide a general description of the leaching to groundwater pathway SSL model (generic and site-specific) including the assumptions, equations, and input parameters. Justification for the default parameters used in the generic model is also provided. Additionally, a sensitivity analysis was performed on each of the input parameters to provide guidance on when use of the site-specific model may be warranted. Applicability and limitations of the generic and site-specific models are also presented.

4.2 Model Assumptions

Assumptions regarding the release and distribution of contaminants in the subsurface that are incorporated into the SSL methodology include the following:

- The source is infinite (a constant concentration is maintained for the duration of the exposure period).
- Contamination is uniformly distributed from the surface to the water table.
- Soil/water partitioning is instantaneous and follows a linear equilibrium isotherm.
- There is no attenuation of the contaminant in soil or the aquifer (i.e., no irreversible adsorption, chemical transformation or biological degradation).
- The potentially impacted aquifer is unconfined and unconsolidated with homogenous and isotropic hydrologic properties.
- The receptor well (point of exposure) is at the downgradient edge of the source and is screened within the potentially impacted aquifer.
- NAPLs are not present.

4.3 Soil Water Partition Equation

US EPA's *Supplemental Soil Screening Guidance: Technical Background Document* (US EPA 1996a) and *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (US EPA 2002a) developed an equation to estimate contaminant release in soil leachate based on the Freundlich adsorption isotherm. The Freundlich equation was modified to relate the sorbed concentration to the total concentration measured in a soil sample (which includes contaminants associated with solid soil, soil-water and soil-air components) (Feenstra 1991). Equation 54, given below, is used to calculate SSLs corresponding to target soil leachate concentrations (C_w).

Equation 54
Soil Screening Level For Leaching To Groundwater Pathway

$$SSL = C_w \text{ x } \left[K_d + \left(\frac{\theta_w + \theta_a H'}{\rho_b} \right) \right]$$

Parameter	Definition (units)	Default
SSL	Soil Screening Level for migration to groundwater pathway (mg/kg)	Chemical-Specific
C_w	Target soil leachate concentration (mg/L)	Chemical-Specific
K_d	Soil /water partition coefficient (L/kg)	Chemical-Specific
θ_w	Water-filled soil porosity (L_{water}/L_{soil})	0.26
θ_a	Air-filled soil porosity (L_{air}/L_{soil}), n - θ_w	0.17
n	Total soil porosity (L_{pore}/L_{soil}), 1 - (ρ_b/ρ_s)	0.43
ρ_s	Soil particle density (kg/L)	2.65
ρ_b	Dry soil bulk density (kg/L)	1.5
H′	Dimensionless Henry's Law constant	Chemical-Specific

Target soil leachate concentrations (C_w) are equivalent to the NMED-specific tap water SSLs multiplied by a DAF.

$$C_w = \text{Tap Water SSL x DAF} \qquad \textbf{Equation 55}$$

The derivation of the DAF is discussed in subsequent sections of this document.

4.4 Dilution Attenuation Factor

Contaminants transported as a leachate through soil to groundwater are affected by physical, chemical, and biological processes that can significantly reduce their concentration. These processes include adsorption, biological degradation, chemical transformation, and dilution from mixing of the leachate with groundwater. The total reduction in concentration between the source of the contaminant (vadose zone soil) and the point of groundwater withdrawal is defined as the ratio of contaminant concentration in soil leachate to the concentration in groundwater at the point of withdrawal. This ratio is termed a dilution/attenuation factor (DAF; US EPA 1996a and 1996b). The higher the DAF value the greater the degree of dilution and attenuation of contaminants along the migration flow path. A DAF of 1 implies no reduction in contaminant concentration occurs.

Development of New Mexico SSLs considers only the dilution of contaminant concentration through mixing with groundwater in the aquifer directly beneath the source. This is consistent with the conservative assumptions used in the SSL methodology including an infinite source, soil contamination extending from surface to groundwater and the point of exposure occurring at the downgradient edge of the source. The ratio of contaminant concentration in soil leachate to the concentration in groundwater at the point of withdrawal that considers only dilution processes is calculated using the simple water balance equation (Equation 56), described below.

Equation 56
Dilution/Attenuation Factor (DAF)

$$\mathrm{DAF} = 1 + \left(\frac{\mathrm{K} \times \mathrm{i} \times \mathrm{D}}{\mathrm{I} \times \mathrm{L}} \right)$$

Where:

$$\mathrm{D} = \left(0.0112 \times \mathrm{L}^2\right)^{0.5} + \mathrm{D_a}\left(1 - \exp\left[\frac{-\mathrm{L} \times \mathrm{I}}{\mathrm{K} \times \mathrm{i} \times \mathrm{D_a}}\right]\right)$$

Parameter	Definition (units)	Default
DAF	Dilution/attenuation factor (unitless)	Site-Specific
K	Aquifer hydraulic conductivity (m/yr)	Site-Specific
i	Hydraulic gradient (m/m)	Site-Specific
D	Mixing zone depth (m)	Site-Specific
I	Infiltration rate (m/yr)	Site-Specific
L	Source length parallel to groundwater flow (m)	Site-Specific
D_a	Aquifer thickness (m)	Site-Specific

Most of these parameters are available from routine environmental site investigations. The mixing zone depth incorporates one additional parameter, the aquifer thickness (D_a).

For the calculation of SSLs, the DAF is used to back calculate the target soil leachate concentration (C_w in Equation 55) from an appropriate groundwater concentration, such as the tap water SSL, a Water Quality Control Commission (WQCC) standard, or a Federal Maximum Contaminant Level (MCL). For example, if the WQCC standard for a constituent is 0.1 mg/L and the DAF is 20, the target soil leachate concentration would be 2 mg/L.

The US EPA conducted an extensive evaluation of the range and distribution of DAFs to select a default value to be used for developing generic SSLs that would be reasonably protective of groundwater quality (US EPA 1996a, 1996b, and 2002a). The evaluation included a probabilistic modeling exercise using US EPA's Composite Model for Leachate Migration with Transformation Products (CMTP). A cumulative frequency distribution of DAF values was developed from the model output. Results of the Monte Carlo modeling analysis indicate that for a 0.5 acre source area a DAF of approximately 170 is protective of groundwater at 90 percent of the sites. Groundwater is protected at 95 percent of the sites with a DAF of 7.

US EPA applied the simple SSL water balance dilution model (Equation 55) to 300 sites included in surveys of hydrogeologic investigations to further evaluate the range and distribution of DAF values. Results of this analysis indicated that a DAF of 10 was protective of groundwater for a 30-acre source and that a DAF of 20 was protective of groundwater for a 0.5 acre-source (US EPA 1996a, 1996b, and 2002a).

An assessment was performed of US EPA's methodology to determine whether a default DAF value of 20 for a 0.5 acre source, and a DAF of 10 for a 30 acre source, would be appropriate for use as default values for sites in New Mexico. Typical New Mexico conditions may be notably different than conditions represented by areas included in the US EPA analysis of DAFs. For example, infiltration rates across much of New Mexico are substantially less than the average range of 0.15 to 0.24 m/yr reported for many of the hydrogeologic regions used in the US EPA analysis. In addition, effective porosity was assumed to be 0.35, presumably because this value is representative of the most prevalent aquifer type in the databases used (US EPA 1996a). However, the regions included in the US EPA analysis also contain extensive glacial, regolith, lacustrine, swamp, and marsh deposits which have high percentages of fine-grained sediments and thus, are not representative of typical New Mexico sandy soils. Sandy soils typically have higher hydraulic conductivities than more fine-grained soils and subsequently higher Darcian velocities, under equal hydraulic gradient. According to the DAF equation (Equation 56), soils with relatively greater hydraulic conductivities will tend to result in a higher calculated DAF.

An assessment was made of input parameters to the DAF equation. In order to support a DAF that is protective of the most vulnerable groundwater environments in New Mexico (i.e. areas close to perennial streams or where groundwater is very shallow), environmental parameters typical of those areas in New Mexico were used to assess the DAF. This assessment indicated that the DAF is most sensitive to variations in hydraulic conductivity. This is because this parameter exhibits such large variations in the natural environment. If a hydraulic conductivity value representative of a fine-grained sand is used in the DAF equation, along with an infiltration rate representative of New Mexico's arid to semi-arid environments, then the result is a DAF of approximately 20. NMED believes that a DAF of 20 for a 0.5 acre source area is protective of groundwater in New Mexico. If the default DAF is not representative of conditions at a specific site, then it is appropriate to calculate a site-specific DAF based upon available site data.

4.5 Limitations on the Use of the Dilution Attenuation Factor

Because of assumptions used in SSL model approach, use of the DAF model may be inappropriate for certain conditions, including sites where:

- Adsorption or degradation processes are expected to significantly attenuate contaminant concentrations in the soil or aquifer media;
- Saturated thickness is significantly less than 12 meters thick;

- Fractured rock or karst aquifer types exist (violates the unconfined, unconsolidated, homogeneous, isotropic assumptions);
- Facilitated transport is significant (colloidal transport, transport via dissolved organic matter, or transport via solvents other than water); and/or
- NAPLs are present.

For sites that have these types of conditions, consideration should be given to application of a more detailed site-specific analysis than either the generic or site-specific models described herein.

4.6 Generic SSLs for Protection of Groundwater

The migration to groundwater pathway model, incorporating the assumptions previously stated, the soil-water partition equation, and the DAF, was used to develop NMED SSLs. Default values based on conditions predominant in New Mexico were used for the input parameters in the soil-water partition equation. The NMED SSLs are presented for both default DAF values of 1 and 20.

Target soil leachate concentrations (C_w) are equivalent to the appropriate groundwater standards multiplied by a DAF. To maintain an approach that is protective of groundwater quality in the development of generic SSLs, a DAF of 20 is selected as reasonably protective. However SSLs are provided for two DAFs in Appendix A. The use of the SSL listed for a DAF of 20 is advised unless site-specific data on hydrologic conditions are available, and these indicate that the generic DAF is not representative of site conditions. As will be demonstrated in the sensitivity analysis section of this document, calculation of an SSL using the migration to groundwater pathway model is most sensitive to the DAF. The inclusion of the SSL for a DAF of 1 is provided for convenience to the user. If data on hydrologic conditions are readily available, a site specific DAF can be calculated and multiplied by the generic SSL for a DAF of 1 to provide a site-specific SSL.

The generic approach may be inappropriate for use at sites where conditions are substantially different from the default values used to develop the generic soil leachate SSLs.

4.7 Development of Site Specific SSLs for Protection of Groundwater

New Mexico, as with any other state, offers a variety of geologic and hydrologic conditions that may not be readily represented by a single default parameter value.

Site specific conditions may differ considerably from the typical or average conditions represented by the default values used to calculate generic SSLs. The site-specific model can be used to address the variability inherent in environmental conditions across and within the state.

Application of the site-specific model to develop soil leachate SSLs is the same as the generic approach except that site-specific values are used. Use of the site-specific model approach may incorporate replacement of all default values used for the generic SSLs with site-specific values, or may only include substitution of a single key parameter, such as hydraulic conductivity. The decision to use the site-specific model approach instead of the generic approach should be based on consideration of the sensitivity of the calculated SSL to specific parameters and the availability of those parameters as site-specific data. Sufficient site-specific data may be available such that each of the default values used for developing generic SSLs can be readily substituted with a more representative site-derived value. Conversely, limited site-specific data may restrict the number of default values to be replaced.

The NMED SSLs are generally more sensitive to the DAF than to other parameters in the soil-water partition equation. Fortunately, information needed to derive the DAF is usually available for sites that have undergone even the most basic levels of environmental investigation. Apart from the DAF, SSLs are most sensitive to the soil-water partition coefficient (K_d) as the values for this parameter can range over several orders of magnitude, particularly for metals. Although the K_d term may be critical in developing protective SSLs, information required to evaluate this parameter is more difficult to obtain and less likely to be available. Porosity and bulk density are not particularly sensitive because of the relatively small range of values encountered in subsurface conditions.

Using benzene as a representative contaminant, a sensitivity analysis was performed to compare a generic soil leachate SSL to site-specific model results simulating a range of model input parameters that might be representative of different conditions in New Mexico. The generic soil leachate SSL calculated using the New Mexico default values and a DAF of 1 is 2.8 μg/kg. These results are summarized in Table 4-1. As shown, the resulting SSLs for benzene range from 1.3 to 6.1 μg/kg for the various sensitivity simulations compared to the generic SSL of 2.8 μg/kg. These results indicate that the calculation of SSLs using the site-specific approach is not overly sensitive to the reasonable range of porosity (air and water filled), bulk density and fraction of organic carbon (f_{oc}) expected for New Mexico or even for a range of values for chemical-specific properties. The generic SSL for benzene of 2.8 μg/kg is representative of values that could be calculated using a spectrum of input parameters, exclusive of the DAF term. Unless there are sufficient data to calculate a site-specific DAF, there is little benefit derived from using the site-specific model approach instead of the generic SSL.

Table 4-1. Input Parameters and Resulting SSLs for the Sensitivity Analysis of the Soil-Water Partition Equation - Migration to Groundwater Pathway Model

Input parameter (NMED default value)	Sensitivity Analysis Values	Resulting SSLs
Bulk density (default value = 1.55 gm/cm)	Lower Limit = 1.20 Upper Limit = 1.90	3.4 2.5
Air filled porosity (default value = 0.18)	Lower Limit = 0.04[a] Upper Limit = 0.25[b]	1.3 3.5
Fraction organic carbon (default value = 0.0015)	Lower Limit = 0.0005 Upper Limit = 0.007	2.2 6.1
Volume water content (default value = 0.26)	Lower Limit = 0.05[c] Upper Limit = 0.40[c]	1.8 3.5
K_{oc} (default value = 58.9 ml/g)	Lower Limit = 30 Upper Limit = 120	2.4 3.7
Dimensionless Henry's Law constant (default value = 0.228)	Lower Limit = 0.1 Upper Limit = 0.4	2.7 3.0

[a] total porosity was reduced from 0.44 to 0.10 for this simulation
[b] total porosity was increased from 0.44 to 0.6 for this simulation
[c] total porosity remained at 0.44 for this simulation.

As previously stated, calculation of SSLs is most sensitive to the DAF term. The input parameter values and resulting DAFs for the sensitivity analysis are included in Table 4-2. Effects on the DAFs are, from greatest to least, the Darcian velocity (hydraulic conductivity multiplied by the hydraulic gradient), infiltration rates, size of the contaminated area, and the aquifer thickness. Corresponding effects on DAFs for each of these parameters and discussion of the relevance of the use of default values versus site-specific conditions are summarized below.

Table 4-2. Input Parameters and Resulting DAFs for the Sensitivity Analysis of the Dilution Attenuation Factor-Migration to Groundwater Pathway Model

Parameter	Groundwater Velocity (m/yr)	Infiltration Rate (m/yr)	Source Length (m)	Aquifer thickness (m)	Mixing Zone Depth (m)	Dilution Attenuation Factor (DAF)
Groundwater Velocity	2.2	0.13	45	12	7.15	3.7
Groundwater Velocity	22	0.13	45	12	5.03	19.9
Groundwater Velocity	220	0.13	45	12	4.79	181.1
Infiltration Rate	22	0.065	45	12	4.89	37.8
Infiltration Rate	22	0.13	45	12	5.03	19.9
Infiltration Rate	22	0.26	45	12	5.28	10.9
Source Length	22	0.13	22.5	12	2.51	19.9
Source Length	22	0.13	45	12	5.03	19.9
Source Length	22	0.13	348.4	12	38.76*	6.8
Aquifer Thickness	22	0.13	45	3	5.02*	12.3
Aquifer Thickness	22	0.13	45	12	5.03	19.9
Aquifer Thickness	22	0.13	45	48	5.03	19.9

Note: If mixing zone depth calculation is greater than aquifer thickness, then aquifer thickness is used to calculate the DAF.

Higher Darcian velocity results in higher DAFs. Slower mixing of groundwater with soil leachate occurs at lower groundwater velocity. Thus, using a lower velocity constitutes a more conservative approach. Sandy soils typically have higher hydraulic conductivities than more fine-grained soils and subsequently higher Darcian velocity (under equal hydraulic gradient). Use of a sandy soil type will generally be less conservative (result in higher DAFs) with respect to protection of groundwater quality.

Lower infiltration rates result in higher DAFs. Therefore, using a higher infiltration rate is a more conservative approach (results in a lower DAF).

Larger source sizes result in lower DAFs. The default DAF used to develop SSLs for a 0.5 acre source may not be protective of groundwater at sites larger than 0.5 acre. However, the selection of a second source size is arbitrary. If generic SSLs are developed for a 30 acre source, then those values are considered overly conservative for a 12 acre source. Conversely, SSLs developed for a 30 acre source will be less protective of a 40 acre source. Rather than develop a separate set of generic SSLs for a second (or third or fourth) source size, the following two approaches are proposed.

- As the size of the source area increases, the assumptions underlying the generic model are less applicable. One of the conservative assumptions in the generic SSL approach is the uniform distribution of contaminants throughout the vadose zone. There are few sites that have relatively uniform soil contamination (both laterally and vertically) of a single constituent in an area of greater than 0.5 acres (22,000 ft^2). Soil contamination at large facilities (such as federal facilities) are usually concentrated in discrete portions of the site. Contamination at large sites is commonly the result of multiple sources. It is advisable to attempt to subdivide the facility by source and contaminant type and then apply generic SSLs to those smaller source areas.
- If this approach is impractical, calculation of site specific DAFs is recommended. Most of the parameters required for these calculations are available from routine environmental site investigations or can be reasonably estimated from general geologic and hydrologic studies.

Thin aquifers will result in lower DAFs. The nominal aquifer thickness used in the sensitivity analysis was 12 meters (m). Reducing the aquifer thickness to 3 m results in a 40 percent reduction in the DAF. Increasing the aquifer thickness beyond the nominal value has very little impact.

The significant effects of the DAF on the calculation of SSLs, coupled with the common availability of site-specific data used to calculate the DAF, suggest that use of the site specific modeling approach should at least incorporate recalculation of the DAF term. If data are available that indicate soil properties significantly different than the default values (such as high or low f_{oc} for organic contaminants, or highly acidic or basic conditions for metal contaminants) the K_d term should also be evaluated and recalculated.

4.8 Detailed Model Analysis for SSL Development

Sites that have complex or heterogeneous subsurface conditions may require more detailed evaluation for development of SSLs that are reasonably, but not overly, protective of groundwater and surface water resources. These types of sites may require more complex models that can address a wide range of variability in environmental site conditions including soil properties, contaminant mass concentration and distribution, contaminant degradation and transformation, recharge rates and recharge concentration, and depth to the water table. Model codes suitable for these types of more detailed analyses range from simple one-dimensional analytical models to complex three-dimensional numerical models. Note that resource requirements (data, time and cost) increase for the more complex codes. The selection of an appropriate code needs to balance the required accuracy of the output with the level of effort necessary to develop the model.

4.9 Summary of the Migration to Groundwater Pathway SSLs

SSLs for New Mexico have been developed for the migration to groundwater pathway, and are provided in Table A-1 of Appendix A. The NMED SSLs were developed using default parameter values representative of environmental conditions in New Mexico and utilize a DAF of 20. This approach maintains the conservative approach of the SSL methodology and is protective of groundwater quality under a wide range of site conditions. Soil contaminant concentrations can be compared directly to the generic SSLs to determine if additional investigation is necessary to evaluate potential leaching and migration of contaminants from the vadose zone to groundwater in excess of NMED-specific tap water SSLs.

Site-specific SSLs can be developed by substituting site-related data for the default values in the leaching to groundwater pathway model. SSLs developed from this model are most sensitive to the DAF. SSLs are also provided in the lookup table for a DAF of 1. If data on hydrologic conditions are readily available, a site specific DAF can be calculated.

5.0 USE OF THE SSLS

For screening sites with multiple contaminants, the following procedure should be followed: take the site-specific concentration (first step screening assessments should use the maximum reported concentration) and divide by the SSL concentration for each analyte. For multiple contaminants, simply add the ratio for each chemical. For carcinogens, multiply the sum by the NMED target risk level of 1E-05 as shown in Equation 57. Equation 58 shows the sum of the ratios is multiplied by the NMED target hazard of 1.0 for non-carcinogens.

$$\text{Site Risk} = \left(\frac{\text{conc}_x}{\text{SSL}_x} + \frac{\text{conc}_y}{\text{SSL}_y} + \frac{\text{conc}_z}{\text{SSL}_z} + \ldots + \frac{\text{conc}_i}{\text{SSL}_i} \right) \times 10^{-5} \qquad \textbf{Equation 57}$$

$$\text{Site Hazard Index (HI)} = \left(\frac{\text{conc}_x}{\text{SSL}_x} + \frac{\text{conc}_y}{\text{SSL}_y} + \frac{\text{conc}_z}{\text{SSL}_z} + \ldots + \frac{\text{conc}_i}{\text{SSL}_i} \right) \times 1 \qquad \textbf{Equation 58}$$

Site risks and hazard indices for any additional completed exposure pathways not included in the SSLs (e.g., vapor intrusion or ingestion of potentially contaminated produce/meat/dairy) should be added to the results of Equations 57 and 58. For noncarcinogenic effects, constituents can be grouped according to the same toxic endpoint and/or mechanism of action. The sources provided in Section 2.1 should be consulted to determine the endpoint and/or target organ system.

It is important to remember that site concentrations should be developed for each receptor and corresponding soil horizons, or exposure intervals. As discussed in Section 2.7.5 and summarized in Table 2-6, it is assumed that residential and construction worker receptors are exposed to soil from 0-10 ft bgs, while commercial/industrial receptors are exposed to soil 0-1 ft bgs. An exposure interval of 0-5 ft bgs should be assumed for non-burrowing ecological receptors and shallow rooted plants, and an exposure interval of 0-10 ft bgs should be assumed for burrowing receptors and deep rooted plants. For the vapor intrusion and soil-to-groundwater migration pathways, maximum concentrations regardless of sampling depth should be considered for all receptors.

Site risks less than the NMED target level of 1E-05 and hazard indices less than the NMED target level of one (1) indicate that concentrations at the site are unlikely to result in adverse health impacts. If the total cancer risk is greater than the target risk level of 1E-5 or if the hazard index is greater than one, concentrations at the site warrant further, site-specific evaluation. Further site-specific evaluation may include refinement of receptor-specific exposure point concentrations via calculation of UCLs (Section 2.5). The calculated UCLs may then be used as the input concentrations for Equations 57 and 58. As stated in Section 1.2, further evaluation may also include additional sampling to better characterize the nature and extent of contamination, consideration of background levels, reevaluation of COPCs or associated risk and hazard using site-specific parameters, and/or a reassessment of the assumptions associated with the generic NMED SSLs.

As with any risk-based tool, the potential exists for misapplication. In most cases the root cause will be a lack of understanding of the intended use of NMED SSLs. In order to prevent misuse of SSLs, the following should be avoided:

- Applying SSLs to a site without adequately developing a CSM that identifies relevant exposure pathways and exposure scenarios,
- Failing to consider additional exposure pathways not included in the SSLs,
- Using the SSLs as cleanup levels without verifying numbers with a toxicologist or risk assessor, and
- Failing to consider the effects of additivity when screening multiple chemicals.

When generic NMED SSLs are used for screening level evaluations at a facility, site-specific conditions must be evaluated for each receptor to determine if the exposure assumptions associated with the generic NMED SSLs are appropriate for comparison with the available site data. The exposure assumptions for each receptor on which the generic NMED SSLs are based are shown in Table A-2. Therefore, Table A-2 should be consulted when the generic NMED SSLs are being applied at a facility. If the exposure assumptions presented in Table A-2 are not protective of the exposure and types of receptors found at a facility, NMED should be consulted to determine if refinement of the generic SSLs based on site-specific exposure paramters is appropriate.

5.1 Use of Chromium Screening Levels

Elemental chromium (Cr) is naturally present and considered stable in the ambient environment in one of two valence states: chromium (III) and chromium (VI). Chromium (III) occurs in chromite compounds or minerals and concentrations in soil/groundwater result from the weathering of minerals. Chromium (III) is the most stable state of environmental chromium; chromium (VI) in the environment is man-made, present in chromate and dichromate compounds, and is the more toxic of the oxidation states. (http://rais.ornl.gov/tox/profiles/chromium.html#t21).

The oxidation state of Cr has a significant effect on its transport and fate in the environment. The equilibrium distribution of the Cr between the two oxidation states is controlled by the redox environment. Oxidation depends on a variety of factors and is a function of pH and the rate of electron exchange, or standard reduction potential (Eh). Chromium (VI) is converted to the less toxic and much less mobile form of chromium (III) by reduction reactions. The corresponding oxidation of chromium (III) to chromium (VI) can also occur under oxidizing conditions.

The degree to which chromium (III) can interact with other soil constituents is limited by the fact that most chromium (III) is present in the form of insoluble chromium oxide precipitates rendering chromium (III) relatively stable in most soils. Oxidation of chromium (III) to chromium (VI) can occur under specific environmental conditions with influencing factors including the soil pH, chromium (III) concentration, presence of competing metal ions, availability of manganese oxides, presence of chelating agents (i.e., low molecular weight organic compounds), and soil water activity. Chromium (III) oxidation is favored under acidic conditions, where the increased solubility of chromium (III) at lower pH enables increased contact with oxidizing agents. Aside from decreasing soil pH, chromium (III) solubility is enhanced by chelation to low molecular weight compounds such as citric or fulvic acids. Conversely, factors influencing the reduction of chromium (VI) to chromium (III) in soil include soil pH, the presence of electron donors such as organic matter or ferrous ions, and soil oxygen levels (CEQG, 1999). Chromium reducing action of organic matter increases with decreasing pH.

Figure 5-1 (TCEQ, 2002) shows a generalized Eh-pH diagram for the chromium-water system. Chromium (III) exists over a wide range of Eh and pH conditions (e.g., Cr^{3+}, $Cr(OH)_3$, and CrO_2^-) while chromium (VI) exists only in strongly oxidizing conditions (e.g., $HCrO^-_4$ and CrO^2_4).

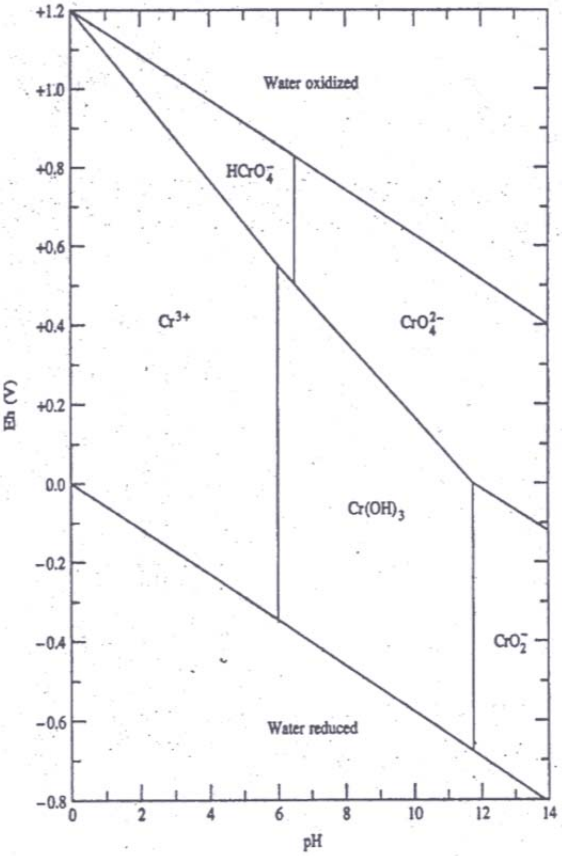


Figure 5-1. Eh-pH Diagram for Chromium

Generally, groundwater containing high concentrations of chromium is more likely to be comprised of chromium (VI) than chromium (III) because chromium (III) is more likely to have precipitated as Cr_2O_3 x H_2O and, to a lesser extent, adsorbed. Chromium (VI) is highly mobile in groundwaters with neutral to basic pH. In acidic groundwaters chromium (VI) can be moderately adsorbed by pH-dependent minerals such as iron and aluminum oxides. Under favorable conditions, chromium (VI) reduces to chromium (III) rapidly via ferrous iron, organic matter, and microbes. The oxidation of chromium (III) to chromium (VI) by dissolved oxygen and monoxides is kinetically slower (TCEQ, 2002). Redox conditions and pH dominate Cr speciation and thus are important parameters required for assessment of groundwater data.

The RSL tables no longer contain risk-based screening levels for total chromium (with the exception of air). The US EPA deleted the total chromium values due to uncertainty associated with the previously applied ratio of trivalent to hexavalent chromium. The concern was that an assumed ratio (1:6) had the potential to both under- and over-estimate risk.

For sites where chromium is to be included for analysis, a tiered process should be applied. If there is site history sufficient to identify chromium (VI) as a potential site contaminant, such as the site previously housed a plating operation or soil/water chemistry may allow for speciation, analyses of media (soil and/or groundwater) should include hexavalent and total chromium in the analytical suite along with determination of pH (water samples) and Eh to assess chemical state.

Comparison of the species-specific data can be compared to representative background concentrations.

If site history does not indicate a known source for chromium (VI), the data (soil and/or groundwater) should be analyzed for total chromium. If the site levels of total chromium are within background, no additional analyses would be required (chromium would drop from the risk assessment as a constituent of concern). However, if the total chromium concentrations are statistically different (using a 95% confidence level) from background for soil or if chromium appears to be a site contaminant in groundwater, a two tiered approach should be applied:

1. A more detailed review of the site history should be conducted to see if there were any potential sources for chromium (VI) or any processes that could have resulted in an alteration of speciation (such as introduction of acids). If there is no potential source, or it does not appear that any other chemicals or contaminants are present that may have altered the speciation of Cr, and this can be documented, no additional analyses will be required and the data may be evaluated as total chromium. Table A-1 includes derived screening levels for total chromium, using the methodology outlined in this document and assuming a ratio of chromium (VI) to chromium (III) of 1:6.

2. If there is a potential source for chromium (VI) or the data are statistically different (using a 95% confidence level) from background, additional sampling should be conducted to determine speciation. The species-specific data will then be compared to the trivalent and hexavalent chromium NMED screening levels presented in Table A-1.

5.2 Essential Nutrients

Essential nutrients are naturally occurring inorganic constituents that are essential for human health in trace amounts, but may be toxic in high doses. Inorganics classified as essential nutrients that do not have published toxicity data (from the US EPA [2003] recommended hierarchy of sources) may be eliminated from further consideration in the risk assessments if they are detected in soil at concentrations that would not cause adverse effects to human health or the environment. Inorganics classified as essential nutrients that could be naturally occurring and do not have published toxicity data include: calcium, chloride, magnesium, phosphorous, potassium, and sodium.

Soil screening levels were calculated based upon dietary guidelines. The Institute of Medicine of the National Academy of Sciences has developed dietary guidelines for essential nutrients which include tolerable upper intake levels (ULs), recommended daily allowances (RDAs), and adequate intakes (AIs) (NAP, 2011 and 2006). A UL is the highest average daily intake level likely to pose no risk of adverse health effects to most individuals within the general population. As intake increases above the UL, the potential risk of adverse effects may increase. RDAs and AIs are the daily dietary intake levels of a nutrient considered to be sufficient within an age group. Screening levels for essential nutrients were calculated for three different types of receptors (industrial worker, resident, and construction worker). The UL/RDA/AI was selected for industrial and construction workers based on an adult age group; for residents, levels were selected for a child age group.

The SSLs were derived using ULs and if an UL was not available, the more conservative of the available RDAs or AIs was utilized. Screening levels were calculated using the exposure assumptions in Equation 59 for ingestion of soil only and are presented in Table 5-1.

Table 5-1. Soil Screening Levels for Essential Nutrients

Essential Nutrient and Receptor	Upper Level (UL) or Adequate Intake (AI) (mg/day)		Soil Screening Level (mg/kg)
Calcium			
Industrial Worker	2000	UL	3.24E+07
Resident	2500	UL	1.30E+07
Construction worker	2000	UL	8.85E+06
Chloride			
Industrial Worker	3400	UL	5.52E+07
Resident	2300	UL	1.20E+07
Construction worker	3400	UL	1.50E+07
Magnesium			
Industrial Worker	350	UL	5.68E+06
Resident	65	UL	3.39E+05
Construction worker	350	UL	1.55E+06
Phosphorous			
Industrial Worker	3000	UL	4.87E+07
Resident	3000	UL	1.56E+07
Construction worker	3000	UL	1.33E+07
Potassium			
Industrial Worker	4500	AI	7.30E+07
Resident	3000	AI	1.56E+07
Construction worker	4500	AI	1.99E+07
Sodium			
Industrial Worker	2200	UL	3.57E+07
Resident	1500	UL	7.82E+06
Construction worker	2200	UL	9.73E+06

ULs and AIs taken from The National Academies Press (2011 and 2006)

Equation 59
Calculation of SSLs for Essential Nutrients

$$SSL_{en} = \frac{DI \times AT}{IR \times CF \times EF \times ED}$$

Parameter	Definition (units)	Default
SSL_{en}	Soil screening level for essential nutrients (mg/kg)	Chemical-specific
DI	Daily intake (UL, RDA or AI) (mg/day)	Chemical-specific
AT	Averaging time (365 day/yr x ED)	Receptor-specific
IR	Ingestion rate (mg/day)	
	Industrial worker	100
	Resident (child)	200
	Construction worker	330
CF	Conversion factor (1E-06 kg/mg)	1E-06
EF	Exposure frequency (day/yr)	
	Industrial worker	225
	Resident (child)	350
	Construction worker	250
ED	Exposure duration (yr)	
	Industrial worker	25
	Resident (child)	6
	Construction worker	1

If the maximum detected concentration of an essential nutrient at a site is below the soil SSLs, then exposure is not likely to cause adverse effects to receptors, and the inorganic constituent may be eliminated from further evaluation in the risk assessments.

6.0 TOTAL PETROLEUM HYDROCABONS (TPH)

In some instances, it may be practical to assess areas of soil contamination that are the result of releases of petroleum products using total petroleum hydrocarbon (TPH) analyses. TPH results may be used to delineate the extent of petroleum-related contamination at these sites and ascertain if the residual level of petroleum products in soil represents an unacceptable risk to future users of the site. Petroleum hydrocarbons consist of complex mixtures of compounds, some of which are regulated constituents while others are not. In addition, the amount and types of the constituent compounds in a petroleum hydrocarbon release differ widely depending on what type of product was spilled and how the spill has weathered. This variability makes it difficult to determine the toxicity of weathered petroleum products in soil solely from TPH results; however, these results can be used to approximate risk in some cases, depending upon the nature of the petroleum product, the release scenario, how well the site has been characterized, and the anticipated potential future land uses.

Site cleanup decisions cannot be based solely on the results of TPH sampling. Rather, the soil screening levels for TPH in Table 6-2 must be used in conjunction with the screening levels for individual petroleum-related contaminants listed in Table A-1 for soil exposure, threat to ground water, and vapor intrusion. The TPH screening levels are not designed to be protective of exposure to these individual contaminants. Sites with petroleum product releases must be tested for VOCs, SVOCs, and if warranted, metals and PCBs, to determine if other potentially toxic constituents are present. Sites with unknown oil or waste oil releases must be tested for VOCs, SVOCs, metals, and PCBs.

The toxicity of petroleum hydrocarbons depends on their classification as aliphatic or aromatic and on their carbon number/molecular weight. Because TPH is essentially a summation of the three fractions, C11-C22 Aromatics, C9-C18 Aliphatics and C19-C36 Aliphatics, NMED derived TPH soil-screening values based on reasonable assumptions about the composition of petroleum products commonly found at contaminated sites, as shown in Table 6-1.

Table 6-1. TPH Compositional Assumptions[a] Used in Deriving Screening Levels

Petroleum Product	C11-C22 Aromatics	C9-C18 Aliphatics	C19-C36 Aliphatics
Diesel #2/ new crankcase oil	60%	40%	0%
#3 and #6 Fuel Oil	70%	30%	0%
Kerosene and jet fuel	30%	70%	0%
Mineral oil dielectric fluid	20%	40%	40%
Unknown oil	100%	0%	0%
Waste Oil[b]	0%	0%	100%

[a] From MADEP, 2002

[b] Compositional assumption for waste oil developed by NMED is based on review of chromatographs of several types of waste oil.

TPH soil screening levels were calculated based on the noncarcinogenic toxicity of the hydrocarbon fractions as applicable to the ingestion and dermal exposure pathways, weighted according to the assumed composition of the petroleum product. Ceiling values that account for exposure pathways and factors that were not considered in the toxicity calculations, including public welfare concerns related to odors, were used where more conservative. (MADEP 2014.)

Table 6-2. TPH Soil Screening Levels

Petroleum Product	Residential Exposure (mg/kg)	Industrial/Occupational Exposure (mg/kg)
Diesel #2/crankcase oil	1000	3000
#3 and #6 Fuel Oil	1000	3000
Kerosene and jet fuel	1000	3000

Mineral oil dielectric fluid	1800	3800
Unknown oil	1000	3800
Waste Oil	3000	5000
Gasoline	Not applicable	Not applicable

Mineral oil based hydraulic fluids can be evaluated for petroleum fraction toxicity using the screening guidelines from Table 6-2 specified for waste oil, because this type of hydraulic fluid is composed of approximately the same range of carbon fractions as waste oil. However, these hydraulic fluids often contain proprietary additives that may be significantly more toxic than the oil itself; these additives must be considered on a site- and product-specific basis (see ATSDR, 1997). Use of alternate screening levels requires prior written approval from the NMED.

The TPH soil screening levels are based solely on human health considerations related to direct soil exposure, not ecological risk considerations, protection of surface or ground water, or potential indoor air impacts from soil vapor. Potential soil vapor impacts shall be evaluated for individual petroleum-related contaminants listed in Table A-1 and following the methodology in Section 2.5 of this guidance.

7.0 REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR). 1997. Toxicological Profile for Hydraulic fluids.

Ahlborg UG, Becking GC, Birnbaum LS, Brouwer A, Derks HJGM, Feeley M, Color G, Hanberg A, Larsen JC, Liem AKD, Safe SH, Schlatter C, Wvern F, Younes M, Yrjinheikki E. 1993. *Toxic Equivalency Factors for Dioxin-Like PCBs Report on a WHO-ECEH and IPCS Consultation*. December 1993 http://epa-prgs.ornl.gov/chemicals/help/documents/TEF_PCB170_PCB180.pdf

Baes, C.F. 1984. Oak Ridge National Laboratory. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture.

Canadian Environmental Quality Guidelines (CEQG), 1999. *Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health.* http://enviroreporter.com/files/1997_Canadian_Chromium_soil_guidelines.pdf

Center for Disease Control, Agency for Toxic Substances and Disease Registry. 2003. *Hazardous Substances Database*. http://www.atsdr.cdc.gov/hazdat.html

Enfield, C. G., R.F. Carsel, S.E. Cohen, T. Phan, and D.M. Walters. 1982. *Approximating Pollutant Transport to Ground Water*. Groundwater, vol. 20, no. 6, pp. 711-722.

Feenstra, S., D.M. Mackay and J.D. Cherry, 1991. *A method for assessing residual NAPL based on organic chemical concentrations in soil samples*. Groundwater Monitoring Review, vol. 11, no. 2, pp 128-136.

Massachusetts Department of Environmental Protection Bureau of Waste Site Cleanup and Office of Research and Standards (MADEP). 1994. "Background Documentation for the Development of the MCP Numerical Standards."

MADEP, 2002. "Characterizing Risks Posed by Petroleum Contaminated Sites: Implementation of the MADEP VPH/EPH Approach," Policy, October 31, 2002.

MADEP, 2003. "Updated Petroleum Hydrocarbon Fraction Toxicity Values for the VPH/EPH/APH Methodology." November 2003.

MADEP, 2014. Spreadsheets for the Development of the MCP Numerical Standards. June.

The National Academies Press (NAP), 2006. *Dietary Reference Intakes: The Essential Guide to Nutrient Requirements*. Institute of Medicine of the National Academies. Washington, DC.
The National Academies Press, 2011. *Dietary Reference Intakes for Calcium and Vitamin D*. Institute of Medicine of the National Academies. Washington, DC.

New Jersey Department of Environmental Protection, 2009. *Derivation of Ingestion-Based Soil Remediation Criterion for Cr+6 Based on the NTP Chronic Bioassay Data for Sodium Dichromate Dihydrate*.

New Mexico Environment Department, Hazardous and Radioactive Materials Bureau (NMED). 2000. *Assessing Human Health Risks Posed by Chemicals: Screening-level risk Assessment*. Santa Fe, New Mexico.

New Mexico Environment Department (NMED), 2014. *Guidance for Assessing Ecological Risks Posed by Chemicals: Screening-Level Ecological Risk Assessment*.

New Mexico Administrative Code (NMAC) 20.6.2, New Mexico Water Quality Control Commission Regulations, September 15, 2002.

Piwoni, M.D., and P. Banaerjee. 1989. *Sorption of organic solvents from aqueous solution onto subsurface solids*. Journal of Contaminant Hydrology, vol. 4, no. 2, pp 163-179.

Scharwzenbach, R.P. and J.C. Westall. 1981. *Transport of non-polar organic compounds from surface water to groundwater*. Environmental Science Technology, vol. 15, no.1, pp. 1360-1367.

Texas Commission on Environmental Quality (TCEQ), 2002. http://www.tceq.texas.gov/assets/public/remediation/trrp/chromium.pdf

United States Department of Agriculture, 2000. *National Resources Conservation Service, Soil Survey Laboratory Database-New Mexico-All counties*.

United States Department of Energy, 2004. RAIS, Risk Assessment Information System. http://risk.lsd.ornl.gov/index.shtml

United States Environmental Protection Agency (US EPA). 1986. *Superfund Public Health Evaluation Manual*. Office of Emergency and Remedial Response and Office of Solid Waste and Emergency Response. Washington, D.C.

US EPA. 1988. *Superfund Exposure Assessment Manual* (EPA/540/1-88/001). Office of Emergency and Remedial Response, Washington, D.C.

US EPA. 1989. *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Interim Final* (EPA/540/1-89/002). Office of Emergency and Remedial Response, Washington, D.C.

US EPA. 1990. *Basics of Pump and Treat Groundwater remediation Technology* (EPA/600/8-90/003) Office of Research and Development. March.

US EPA. 1991. *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals), Interim Final* (EPA 9285.6-03). Office of Emergency and Remedial Response, Washington, D.C.

US EPA. 1992a. *Dermal Exposure Assessment: Principles and Applications* (EPA600/8-91/011B). Office of Health and Environmental Assessment, Washington, D.C.

US EPA. 1992b. *Supplemental Guidance to RAGS: Calculating the Concentration Term* (9285.7-081). Office of Solid Waste and Emergency Response, Washington, D.C.

US EPA. 1993. *Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons*. (EPA/600/R-93/089). Office of Research and Development, Washington D.C.

US EPA. 1994. *Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities* (EPA/540/F-94/043). Office of Solid Waste and Emergency Response. Washington, D.C.

US EPA. 1995. *Additional Environmental Fate Constants*. Office of Emergency and Remedial Response, Washington D.C.

US EPA. 1996a. *Soil Screening Guidance. Technical Background Document* (EPA/540/R95/128). Office of Emergency and Remedial Response, Washington D.C.

US EPA. 1996b. *Soil Screening Guidance. Users Guide, Second Edition* (EPA 9355.4-23). Office of Emergency and Remedial Response, Washington D.C.

US EPA. 1996c. *Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Associated with Adult to Lead in Soil.* December.

US EPA. 1997a. *Health Effects Assessment Summary Tables: FY 1997 Update* (HEAST). National Center for Environmental Assessment, Office of Research and Development and Office of Emergency and Remedial Response, Washington, D.C.

US EPA. 1997b. *Exposure Factors Handbook*, (EPA/600/P-95/002Fa). Office of Research and Development, Washington, D.C.

US EPA. 1998. *Clarification to the 1994 Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities*. OWSER Directive 9200.4-27, EPA/540/F-98/030. August.

US EPA. 2000. *CHEMFACT Database*. http://www.epa.gov/chemfact/. Office of Pollution Prevention and Toxics. Washington, D.C.

US EPA. 2002a. *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*. Office of Emergency and Remedial Response, Washington, D.C. OSWER 9355.4-24. December. http://www.epa.gov/superfund/health/conmedia/soil/pdfs/ssg_main.pdf

US EPA. 2002b. *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites*. Office of Solid Waste and Emergency Response, OSWER 9285.6-10. December 2002.

US EPA. 2002c. Current Drinking Water Standards. http://www.epa.gov/safewater/mcl.html.

US EPA, 2002d. *OSWER Draft Guidance for Evaluating the Vapor Intrusion of Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)*. EPA530-D-02-004. November 2002.

US EPA. 2003. Memorandum: Human Health Toxicity Values in Superfund Risk Assessments, OSWER Directive 9285.7-53. December 3. http://www.epa.gov/oswer/riskassessment/pdf/hhmemo.pdf

US EPA. 2004a. *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Interim Guidance*. Office of Solid Waste and Emergency Response, Washington, D.C. http://www.epa.gov/oswer/riskassessment/ragse/index.htm

US EPA, 2004b. *User's Guide for Evaluating Subsurface Vapor Intrusion Into Buildings*. February, 2004.

US EPA. 2005a. *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities, Peer Review Draft* (EPA/530/D-98/001a). Office of Solid Waste and Emergency Response, Washington, D.C.

US EPA. 2005b. *Supplemental Guidance for Assessing Susceptibility from Early-life Exposure to Carcinogens*. EPA/630/R-03/003F. Washington, D.C.

US EPA. 2006. Water9, Version 3.0. Wastewater Treatment Model.

US EPA. 2009. *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation*

Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment), Final. Office of Solid Waste and Emergency Response, Washington, D.C. http://www.epa.gov/oswer/riskassessment/ragsf/pdf/partf_200901_final.pdf

US EPA. 2012. Estimation Programs Interface (EPI) Suite™ for Microsoft® Windows, v 4.11. Washington, DC, USA.

US EPA. 2013a. *ProUCL Version 5.0.00 Technical Guide (Draft). Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations*. EPA/600/R-07/041. September, 2013.

US EPA, 2013b. Vapor Intrusion Screening Levels. http://www.epa.gov/oswer/vaporintrusion/guidance.html

US EPA. 2014a. Regional Screening Levels for Chemical Contaminants at Superfund Sites. May. http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm

US EPA. 2014b. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. OSWER Directive 9200.1-120. February.

US EPA. 2014c. *Integrated Risk Information System* (IRIS). http://www.epa.gov/iris.

US EPA, 2014d. Vapor Intrusion Screening Level (VISL) Calculator User's Guide. May. http://www.epa.gov/oswer/vaporintrusion/documents/VISL-UsersGuide.pdf

Van den Berg, *et.al*, 2006. *The 2005 World Health Organization Re-evaluation of Human and Mammalian Toxic Equivalency factors for Dioxin and Dioxin-like Compounds.* ToxiSci Advance Access, July 7, 2006.

APPENDIX A

NMED SOIL SCREENING LEVELS (SSLs)

Appendix A

State of New Mexico Soil Screening Levels

Table A-1 provides State of New Mexico Soil Screening Levels (SSLs), as developed by the New Mexico Environment Department (NMED) Hazardous Waste Bureau (HWB) and the Ground Water Quality Bureau Voluntary Remediation Program for chemicals most commonly associated with environmental releases within the state. These NMED SSLs are derived using default exposure parameter values (refer to Equations in Volume I) and chemical- and State of New Mexico-specific physical parameters (as presented in Tables B-1, B-2, and B-3 of Appendix B). These default values are assumed to be appropriately conservative in the face of uncertainty and are likely to be protective for the majority of site conditions relevant to soil exposures within New Mexico. Note that SSLs are derived using the appropriate equations provided in Volume I for noncarcinogens, carcinogens, mutagens, and for vinyl chloride and trichloroethylene.

However, the NMED SSLs are not necessarily protective of all known human exposure pathways, reasonable land uses or ecological threats. Thus, before applying NMED SSLs at a site, it is extremely important to compare the conceptual site model (CSM) with the assumptions upon which the NMED SSLs are predicated to ensure that the site conditions and exposure pathways match those used to develop the NMED SSLs. Table A-2 lists the exposure assumptions that were applied in the calculations of the NMED SSLs. If this comparison indicates that the site at issue is more complex than the corresponding SSL scenarios, or that there are significant exposure pathways not accounted for by the NMED SSLs, then the NMED SSLs are insufficient for use in a defensible assessment of the site. A more detailed site-specific approach will be necessary to evaluate the additional pathways or site conditions.

Table A-1

Column 1:	The first column in Table A-1 presents the names of the chemicals for which NMED has developed SSLs.
Column 2:	The second column presents NMED SSLs predicated on residential soil exposures.
Column 3, 5, 7, and 9:	These columns present indicator categories for the NMED SSL residential, industrial, construction, and tap water basis, whether predicated on carcinogenic (c) and noncarcinogenic (n) effects. In some cases, the risk-based SSL is greater than the soil saturation limit, and in these cases, the SSL is denoted as either "cs" or "ns" depending on carcinogenicity or non-carcinogenicity, respectively. In the case where a noncarcinogenic SSL is greater than the ceiling limit (1E+05), the SSL is denoted as "nl" and in a few cases, "nls" is used to indicate the SSL is both above the saturation level and the ceiling limit. NMED SSLs predicated on a carcinogenic endpoint reflect age-adjusted child-to-adult exposures. NMED SSLs predicated on a noncarcinogenic endpoint reflect child-only exposures. Detected concentrations above a saturation value ("cs", "ns", or "nsl") may indicate the presence of nonaqueous phase liquid (NAPL).

Columns 4 and 6: The fourth and sixth columns present NMED SSLs analogous to Column 1, with the exception that these values correspond to Industrial/Occupational and Construction worker (adult-only) exposures, respectively.

Column 8: Presents the tap water SL for the residential scenario.

Columns 10 and 11: The tenth column presents NMED SSLs for the migration to groundwater pathway developed using a default dilution attenuation factor (DAF) of 1, which assume no effective dilution or attenuation. These values can be considered at sites where little or no dilution or attenuation of soil leachate concentrations is expected (e.g., shallow water tables, karst topography). Column 11 presents NMED SSLs for the migration to groundwater pathway developed using a DAF of 20 to account for natural processes that reduce contaminant concentrations in the subsurface. The SSLs based on a DAF of 20 are default SSLs that should be applicable at most sites.

As noted above, separate NMED SSLs are presented for use in evaluating three discrete potential receptor populations: Residential, Industrial/Occupational, and Construction. Each NMED SSL considers incidental ingestion of soil, inhalation of volatiles from soil (limited to those chemicals noted as volatile organic compounds [VOCs] within Table B-2) and/or particulate emissions from impacted soil, and dermal contact with soil.

Generally, if a contaminant is detected at a level in soil exceeding the most relevant NMED SSL, and the site-specific CSM is in general agreement with the underlying assumptions upon which the NMED SSLs are predicated, this result indicates the potential for adverse human health effects to occur. Conversely, if no contaminants are detected above the most relevant NMED SSL, this tends to indicate to the user that environmental conditions may not necessitate remedial action of the surface soil or the vadose zone.

A detection above a NMED SSL does not indicate that unacceptable exposures are, in fact, occurring. The NMED SSLs are predicated on relatively conservative exposure assumptions and an exceedance only tends to indicate the potential for adverse effects. The NMED SSLs do not account for additive exposures, whether for carcinogenic or noncarcinogenic endpoints. Section 5 of Volume I addresses a methodology by which an environmental manager may determine whether further site-evaluation is warranted, however, this methodology does not replace the need for defensible risk assessment where indicated. The SSLs also do not account for ingestion of homegrown produce/animals or the vapor intrusion pathway. If these or other exposure pathways are complete, additional analyses may be warranted.

The NMED SSLs address a basic subset of exposures fundamental to the widest array of environmentally-impacted sites within the State of New Mexico. The NMED SSLs cannot address all relevant exposure pathways associated with all sites. The utility of the NMED SSLs depends heavily upon the understanding of site conditions as accurately reflected in the CSM and nature and extent of contamination determinations. Consideration of the NMED SSLs does not preclude the need for site-specific risk assessment in all instances.

Table A-3 provides State of New Mexico vapor intrusion screening levels (VISLs) for chemicals most commonly associated with environmental releases within the state and that are determined to be sufficiently volatile and toxic. A chemical is considered to be sufficiently volatile if its Henry's law constant is approximately 1 x 10^{-5} atm-m^3/mole or greater and its molecular weight is approximately 200 g/mole or less. A chemical is considered to be sufficiently toxic if the vapor concentration of the pure component poses an incremental life time cancer risk greater than 1E-05 or the noncancer hazard index is greater than 1.0. The NMED VISLs calculated for chemicals in Table A-3 are sufficiently volatile and toxic to be considered for the vapor intrusion pathway. The list of chemicals included in Table A-3 is <u>not</u> comprehensive of all potential volatile and toxic compounds that may be present in site media. If volatile and toxic constituents are detected in site media and are not listed in Table A-3, VISLs should be calculated following the methodologies herein and risks addressed. The NMED VISLs are derived using default exposure parameter values (refer to Equations in Volume I) and chemical-specific physical parameters (as presented in Tables B-1 and B-2 of Appendix B). These default values are assumed to be appropriately conservative in the face of uncertainty and are likely to be protective for the majority of site conditions relevant to vapor intrusion exposures within New Mexico.

<u>Table A-3</u>

Column 1:	The first column in Table A-3 presents the names of the chemicals for which NMED has developed VISLs.
Columns 2 and 6:	These columns present NMED indoor air screening levels predicated on residential and commercial/industrial exposures, respectively. These indoor air screening levels were used to derive VISLs for soil-gas and groundwater.
Columns 3 and 7	These columns present indicator categories for the NMED indoor air residential and commercial/industrial screening levels, whether predicated on carcinogenic (c) or noncarcinogenic (n) effects.
Columns 4 and 8:	The fourth and eighth columns present NMED VISLs for volatiles detected in soil-gas for the residential and commercial/industrial exposures, respectively.
Columns 5 and 9:	The fifth and ninth columns present NMED VISLs for volatiles detected in groundwater for the residential and commercial/industrial exposures, respectively.

Table A-1: NMED Soil Screening Levels

Chemical	**Residential Soil (mg/kg)**	**End-point**	**Industrial/ Occupational Soil (mg/kg)**	**End-point**	**Construction Worker Soil (mg/kg)**	**End-point**	**Tap Water (ug/L)**	**End-point**	**Risk-based SSL for a DAF of 1 (mg/kg)**	**Risk-based SSL for a DAF of 20 (mg/kg)**
Acenaphthene	3.48E+03	n	5.05E+04	n	1.51E+04	n	5.35E+02	n	4.12E+00	8.25E+01
Acetaldehyde	2.49E+02	n	1.17E+03	n	2.17E+02	n	1.88E+01	n	3.29E-03	6.58E-02
Acetone	6.63E+04	n	9.60E+05	nls	2.42E+05	nls	1.41E+04	n	2.49E+00	4.98E+01
Acrylonitrile	4.93E+00	c	2.46E+01	c	3.52E+01	n	5.23E-01	c	9.77E-05	1.95E-03
Acetophenone	7.82E+03	ns	1.30E+05	nls	3.54E+04	ns	1.92E+03	n	4.82E-01	9.64E+00
Acrolein	4.54E-01	n	2.16E+00	n	4.01E-01	n	4.15E-02	n	7.29E-06	1.46E-04
Aldrin	3.11E-01	c	1.50E+00	c	8.07E+00	n	4.54E-02	c	5.60E-03	1.12E-01
Aluminum	7.80E+04	n	1.29E+06	nl	4.14E+04	n	1.99E+04	n	2.99E+04	5.97E+05
Anthracene	1.74E+04	n	2.53E+05	nl	7.53E+04	n	1.72E+03	n	4.25E+01	8.51E+02
Antimony	3.13E+01	n	5.19E+02	n	1.42E+02	n	7.26E+00	n	3.28E-01	6.56E+00
Arsenic	4.25E+00	c	2.15E+01	c	5.74E+01	n	5.13E-01	c	1.50E-02	2.99E-01
Barium	1.56E+04	n	2.55E+05	nl	4.39E+03	n	3.28E+03	n	1.35E+02	2.70E+03
Benzene	1.78E+01	c	8.72E+01	c	1.42E+02	n	4.54E+00	c	1.90E-03	3.80E-02
Benzidine	5.18E-03	c	1.12E-01	c	8.12E-01	c	1.07E-03	c	2.09E-06	4.17E-05
Benzo(a)anthracene	1.53E+00	c	3.23E+01	c	2.40E+02	c	3.43E-01	c	9.11E-02	1.82E+00
Benzo(a)pyrene	1.53E-01	c	3.23E+00	c	2.40E+01	c	3.43E-02	c	3.02E-02	6.05E-01
Benzo(b)fluoranthene	1.53E+00	c	3.23E+01	c	2.40E+02	c	3.43E-01	c	3.09E-01	6.17E+00
Benzo(k)fluoranthene	1.53E+01	c	3.23E+02	c	2.31E+03	c	3.43E+00	c	3.02E+00	6.05E+01
Beryllium	1.56E+02	n	2.58E+03	n	1.48E+02	n	1.24E+01	n	9.79E+00	1.96E+02
a-BHC (a-Hexachlorocyclohexane, a-HCH)	8.45E-01	c	4.07E+00	c	2.97E+01	c	6.80E-02	c	2.98E-04	5.96E-03
b-BHC (b-Hexachlorocyclohexane, b-HCH)	2.96E+00	c	1.43E+01	c	1.04E+02	c	2.38E-01	c	1.04E-03	2.09E-02
g-BHC (Lindane)	5.63E+00	c	2.83E+01	c	9.43E+01	n	4.08E-01	c	1.79E-03	3.58E-02
1,1-Biphenyl	6.32E+01	n	2.98E+02	n	5.46E+01	n	8.34E-01	n	6.56E-03	1.31E-01
Bis(2-chloroethyl) ether	3.11E+00	c	1.57E+01	c	1.95E+00	c	1.36E-01	c	3.03E-05	6.05E-04
Bis(2-chloroisopropyl) ether	9.93E+01	c	5.19E+02	cs	3.54E+03	cs	9.76E+00	c	2.37E-03	4.73E-02
Bis(2-ethylhexyl) phthalate	3.80E+02	c	1.83E+03	c	5.38E+03	n	5.56E+01	c	9.99E+00	2.00E+02
Bis(chloromethyl) ether	2.08E-03	c	1.02E-02	c	4.81E-02	c	7.20E-04	c	1.50E-07	3.00E-06
Boron	1.56E+04	n	2.59E+05	nl	5.14E+04	n	3.95E+03	n	1.25E+01	2.51E+02
Bromodichloromethane	6.19E+00	c	3.02E+01	c	1.43E+02	c	1.34E+00	c	3.10E-04	6.21E-03
Bromomethane	1.77E+01	n	9.45E+01	n	1.79E+01	n	7.54E+00	n	1.71E-03	3.43E-02
1,3-Butadiene	6.86E-01	c	3.41E+00	c	2.02E+00	n	1.80E-01	c	1.04E-04	2.07E-03

Chemical	Residential Soil (mg/kg)	End-point	Industrial/ Occupational Soil (mg/kg)	End-point	Construction Worker Soil (mg/kg)	End-point	Tap Water (ug/L)	End-point	Risk-based SSL for a DAF of 1 (mg/kg)	Risk-based SSL for a DAF of 20 (mg/kg)
2-Butanone (Methyl ethyl ketone, MEK)	3.74E+04	n	4.11E+05	nls	9.17E+04	ns	5.56E+03	n	1.00E+00	2.01E+01
tert-Butyl methyl ether (MTBE)	9.75E+02	c	4.82E+03	c	2.42E+04	cs	1.43E+02	c	2.77E-02	5.53E-01
Cadmium	7.05E+01	n	1.11E+03	n	7.21E+01	n	6.24E+00	n	4.69E-01	9.39E+00
Carbon disulfide	1.55E+03	ns	8.54E+03	ns	1.62E+03	ns	8.10E+02	n	2.21E-01	4.42E+00
Carbon tetrachloride	1.07E+01	c	5.25E+01	c	2.02E+02	n	4.53E+00	c	1.66E-03	3.33E-02
Chlordane	1.77E+01	c	8.90E+01	c	1.53E+02	n	2.23E+00	c	1.13E-01	2.26E+00
2-Chloroacetophenone	1.72E+05	nl	8.12E+05	nl	2.81E+02	n				
2-Chloro-1,3-butadiene	1.75E-01	c	8.48E-01	c	3.95E+00	c	1.87E-01	c	9.83E-05	1.97E-03
1-Chloro-1,1-difluoroethane	1.09E+05	nls	5.15E+05	nls	9.58E+04	ns	1.04E+05	n	5.34E+01	1.07E+03
Chlorobenzene	3.78E+02	ns	2.16E+03	ns	4.12E+02	ns	7.76E+01	n	4.18E-02	8.36E-01
1-Chlorobutane	3.13E+03	ns	5.19E+04	ns	1.42E+04	ns	6.31E+02	n	2.27E-01	4.53E+00
Chlorodifluoromethane	1.02E+05	nls	4.83E+05	nls	8.98E+04	ns	1.04E+05	n	4.27E+01	8.55E+02
Chloroform	5.90E+00	c	2.87E+01	c	1.34E+02	c	2.29E+00	c	5.46E-04	1.09E-02
Chloromethane	4.11E+01	c	2.01E+02	c	2.35E+02	n	2.03E+01	c	4.76E-03	9.51E-02
b-Chloronaphthalene	6.26E+03	n	1.04E+05	nl	2.83E+04	ns	7.33E+02	n	2.85E+00	5.70E+01
o-Chloronitrobenzene	1.78E+01	c	8.55E+01	c	8.39E+01	n	2.35E+00	c	1.71E-03	3.42E-02
p-Chloronitrobenzene	6.16E+01	n	9.16E+02	n	2.57E+02	n	1.79E+01	n	1.28E-02	2.57E-01
2-Chlorophenol	3.91E+02	n	6.49E+03	n	1.77E+03	n	9.10E+01	n	5.76E-02	1.15E+00
2-Chloropropane	2.86E+02	n	1.35E+03	ns	2.51E+02	ns	2.09E+02	n	6.31E-02	1.26E+00
o-Chlorotoluene	1.56E+03	ns	2.60E+04	ns	7.08E+03	ns	2.33E+02	n	1.78E-01	3.56E+00
Chromium III	1.17E+05	nl	1.95E+06	nl	5.31E+05	nl	1.36E+04	n	2.46E+07	4.91E+08
Chromium VI	3.05E+00	c	7.21E+01	c	6.69E+01	c	2.52E-01	c	4.84E-03	9.68E-02
Chromium (Total)	9.66E+01	c	5.05E+02	c	1.34E+02	n	5.59E+00	c	1.01E+04	2.01E+05
Chrysene	1.53E+02	c	3.23E+03	c	2.31E+04	c	3.43E+01	c	9.30E+00	1.86E+02
Copper	3.13E+03	n	5.19E+04	n	1.42E+04	n	7.90E+02	n	2.78E+01	5.56E+02
Crotonaldehyde	3.66E+00	c	1.91E+01	c	1.30E+02	c	4.04E-01	c	7.11E-05	1.42E-03
Cumene (isopropylbenzene)	2.36E+03	ns	1.42E+04	ns	2.74E+03	ns	4.47E+02	n	5.69E-01	1.14E+01
Cyanide	1.12E+01	n	6.33E+01	n	1.21E+01	n	1.46E+00	n	2.61E-04	5.22E-03
Cyanogen	7.82E+01	n	1.30E+03	n	3.54E+02	n	1.99E+01	n	4.01E-03	8.01E-02
Cyanogen bromide	7.04E+03	n	1.17E+05	nl	3.19E+04	n	1.80E+03	n	5.29E-01	1.06E+01
Cyanogen chloride	3.91E+03	n	6.49E+04	n	1.77E+04	n	9.99E+02	n	2.94E-01	5.88E+00
DDD	2.22E+01	c	1.07E+02	c	7.78E+02	c	3.06E-01	c	5.39E-02	1.08E+00
DDE	1.57E+01	c	7.55E+01	c	5.49E+02	c	2.29E+00	c	4.04E-01	8.08E+00

Chemical	**Residential Soil (mg/kg)**	**End-point**	**Industrial/ Occupational Soil (mg/kg)**	**End-point**	**Construction Worker Soil (mg/kg)**	**End-point**	**Tap Water (ug/L)**	**End-point**	**Risk-based SSL for a DAF of 1 (mg/kg)**	**Risk-based SSL for a DAF of 20 (mg/kg)**
DDT	1.87E+01	c	9.50E+01	c	1.62E+02	n	2.29E+00	c	5.80E-01	1.16E+01
Dibenz(a,h)anthracene	1.53E-01	c	3.23E+00	c	2.40E+01	c	1.06E-01	c	3.05E-01	6.11E+00
1,2-Dibromo-3-chloropropane	8.58E-02	c	1.18E+00	c	5.53E+00	c	3.36E-03	c	1.17E-06	2.34E-05
Dibromochloromethane	1.39E+01	c	6.74E+01	c	3.40E+02	c	1.68E+00	c	3.77E-04	7.54E-03
1,2-Dibromoethane	6.72E-01	c	3.31E+00	c	1.63E+01	c	7.46E-02	c	1.76E-05	3.52E-04
1,4-Dichloro-2-butene	1.15E-01	c	5.58E-01	c	2.59E+00	c	1.34E-02	c	5.00E-06	9.99E-05
1,2-Dichlorobenzene	2.15E+03	ns	1.30E+04	ns	2.50E+03	ns	3.02E+02	n	2.29E-01	4.58E+00
1,4-Dichlorobenzene	3.28E+01	c	1.59E+02	c	7.46E+02	c	4.81E+00	c	3.60E-03	7.20E-02
3,3-Dichlorobenzidine	1.18E+01	c	5.70E+01	c	4.10E+02	c	1.24E+00	c	6.14E-03	1.23E-01
Dichlorodifluoromethane	1.82E+02	n	8.65E+02	ns	1.61E+02	n	1.97E+02	n	3.61E-01	7.23E+00
1,1-Dichloroethane	7.86E+01	c	3.83E+02	c	1.82E+03	cs	2.75E+01	c	6.79E-03	1.36E-01
1,2-Dichloroethane	8.32E+00	c	4.07E+01	c	5.38E+01	n	1.71E+00	c	4.07E-04	8.14E-03
cis-1,2-Dichloroethene	1.56E+02	n	2.60E+03	ns	7.08E+02	n	3.65E+01	n	9.18E-03	1.84E-01
trans-1,2-Dichloroethene	2.95E+02	n	1.61E+03	ns	3.05E+02	n	9.32E+01	n	2.35E-02	4.69E-01
1,1-Dichloroethene	4.40E+02	n	2.26E+03	ns	4.24E+02	n	2.84E+02	n	9.74E-02	1.95E+00
2,4-Dichlorophenol	1.85E+02	n	2.75E+03	n	8.07E+02	n	4.53E+01	n	4.13E-02	8.25E-01
1,2-Dichloropropane	1.78E+01	c	8.68E+01	c	2.54E+01	n	4.37E+00	c	1.21E-03	2.43E-02
1,3-Dichloropropene	2.93E+01	c	1.46E+02	c	1.30E+02	n	4.70E+00	c	1.40E-03	2.80E-02
Dicyclopentadiene	1.73E+00	n	8.14E+00	n	1.51E+00	n	6.25E-01	n	1.71E-03	3.42E-02
Dieldrin	3.33E-01	c	1.60E+00	c	1.17E+01	c	1.71E-02	c	5.18E-04	1.04E-02
Diethyl phthalate	4.93E+04	n	7.33E+05	nl	2.15E+05	nl	1.48E+04	n	4.89E+00	9.79E+01
Di-n-butyl phthalate (Dibutyl phthalate)	6.16E+03	n	9.16E+04	n	2.69E+04	n	8.85E+02	n	1.69E+00	3.38E+01
2,4-Dimethylphenol	1.23E+03	n	1.83E+04	n	5.38E+03	n	3.54E+02	n	3.22E-01	6.45E+00
4,6-Dinitro-o-cresol	4.93E+00	n	7.33E+01	n	2.15E+01	n	1.51E+00	n	1.97E-03	3.94E-02
2,4-Dinitrophenol	1.23E+02	n	1.83E+03	n	5.38E+02	n	3.88E+01	n	3.35E-02	6.71E-01
2,4-Dinitrotoluene	1.71E+01	c	8.23E+01	c	5.36E+02	n	2.37E+00	c	2.46E-03	4.91E-02
2,6-Dintitrotoluene	3.56E+00	c	1.72E+01	c	8.09E+01	n	4.84E-01	c	5.10E-04	1.02E-02
2,4/2,6-Dintrotoluene Mixture	7.83E+00	c	3.77E+01	c	2.77E+02	c	1.06E+00	c	1.12E-03	2.23E-02
1,4-Dioxane	5.33E+01	c	2.57E+02	c	1.88E+03	c	7.76E+00	c	1.38E-03	2.75E-02
1,2-Diphenylhydrazine	6.66E+00	c	3.21E+01	c	2.34E+02	c	7.73E-01	c	1.88E-03	3.76E-02
Endosulfan	3.70E+02	n	5.50E+03	n	1.61E+03	n	9.87E+01	n	1.02E+00	2.04E+01
Endrin	1.85E+01	n	2.75E+02	n	8.07E+01	n	2.23E+00	n	6.77E-02	1.35E+00
Epichlorohydrin	4.27E+01	n	2.15E+02	n	4.02E+01	n	2.05E+00	n	3.86E-04	7.72E-03

Chemical	Residential Soil (mg/kg)	End-point	Industrial/ Occupational Soil (mg/kg)	End-point	Construction Worker Soil (mg/kg)	End-point	Tap Water (ug/L)	End-point	Risk-based SSL for a DAF of 1 (mg/kg)	Risk-based SSL for a DAF of 20 (mg/kg)
Ethyl acetate	1.82E+03	n	8.75E+03	n	1.63E+03	n	1.45E+02	n	2.64E-02	5.28E-01
Ethyl acrylate	1.45E+02	c	7.57E+02	c	5.16E+03	cs	1.56E+01	c	2.99E-03	5.97E-02
Ethyl chloride	1.90E+04	ns	8.95E+04	ns	1.66E+04	ns	2.09E+04	n	5.37E+00	1.07E+02
Ethyl ether	1.56E+04	ns	2.60E+05	nls	7.08E+04	ns	3.93E+03	n	7.60E-01	1.52E+01
Ethyl methacrylate	2.73E+03	ns	1.78E+04	ns	3.48E+03	ns	4.55E+02	n	9.15E-02	1.83E+00
Ethylbenzene	7.51E+01	c	3.68E+02	cs	1.77E+03	cs	1.49E+01	c	1.31E-02	2.62E-01
Ethylene oxide	5.02E+00	c	2.48E+01	c	1.23E+02	c	5.08E-01	c	9.09E-05	1.82E-03
Fluoranthene	2.32E+03	n	3.37E+04	n	1.00E+04	n	8.02E+02	n	6.69E+01	1.34E+03
Fluorene	2.32E+03	n	3.37E+04	n	1.00E+04	n	2.88E+02	n	4.00E+00	8.00E+01
Fluoride	4.69E+03	n	7.78E+04	n	1.81E+04	n	1.18E+03	n	1.78E+02	3.56E+03
Furan	7.24E+01	n	1.15E+03	n	3.54E+02	n	1.92E+01	n	6.12E-03	1.22E-01
Heptachlor	1.18E+00	c	5.70E+00	c	4.15E+01	c	4.39E-02	c	2.73E-03	5.45E-02
Hexachlorobenzene	3.33E+00	c	1.60E+01	c	1.17E+02	c	4.87E-01	c	4.61E-03	9.22E-02
Hexachloro-1,3-butadiene	6.16E+01	n	3.29E+02	c	2.69E+02	n	2.95E+00	c	4.39E-03	8.79E-02
Hexachlorocyclopentadiene	3.70E+02	n	5.49E+03	n	8.67E+02	n	2.78E+01	n	6.68E-02	1.34E+00
Hexachloroethane	4.31E+01	n	6.41E+02	c	1.88E+02	n	6.80E+00	n	3.31E-03	6.62E-02
n-Hexane	6.15E+02	ns	3.20E+03	ns	6.03E+02	ns	3.19E+02	n	2.78E+00	5.57E+01
HMX	3.85E+03	n	6.33E+04	n	1.74E+04	n	1.00E+03	n	9.72E-01	1.94E+01
Hydrazine anhydride	1.78E+00	c	8.55E+00	c	5.99E+01	c	2.60E-01	c	4.50E-05	9.00E-04
Hydrogen cyanide	1.02E+01	n	5.72E+01	n	1.09E+01	n	1.46E+00	n	2.61E-04	5.22E-03
Indeno(1,2,3-c,d)pyrene	1.53E+00	c	3.23E+01	c	2.40E+02	c	3.43E-01	c	1.00E+00	2.01E+01
Iron	5.48E+04	n	9.08E+05	nl	2.48E+05	nl	1.38E+04	n	3.48E+02	6.96E+03
Isobutanol (Isobutyl alcohol)	1.85E+04	n	2.75E+05	nl	8.07E+04	n	5.91E+03	n	1.05E+00	2.10E+01
Isophorone	5.61E+03	c	2.70E+04	c	5.37E+04	n	7.79E+02	c	2.11E-01	4.22E+00
Lead	4.00E+02	IEUBK	8.00E+02	IEUBK	8.00E+02	IEUBK				
Lead (tetraethyl-)	6.16E-03	n	9.16E-02	n	3.54E-02	n	1.24E-03	n	4.70E-06	9.41E-05
Maleic hydrazide	3.08E+04	n	4.58E+05	nl	1.35E+05	nl	1.00E+04	n	1.79E+00	3.57E+01
Manganese	1.05E+04	n	1.60E+05	nl	4.64E+02	n	2.02E+03	n	1.31E+02	2.63E+03
Mercury (elemental)	2.38E+01	ns	1.12E+02	ns	2.07E+01	ns	6.26E-01	n	3.27E-02	6.54E-01
Mercury (methyl)	7.82E+00	n	1.30E+02	n	3.54E+01	n	1.96E+00	n	4.45E-04	8.89E-03
Mercury (salts)	2.35E+01	n	3.89E+02	ns	7.71E+01	n	4.92E+00	n	2.56E-01	5.13E+00
Methacrylonitrile	7.70E+00	n	1.23E+02	n	3.28E+01	n	1.91E+00	n	3.71E-04	7.43E-03
Methomyl	1.54E+03	n	2.29E+04	n	6.73E+03	n	4.98E+02	n	9.37E-02	1.87E+00

Chemical	Residential Soil (mg/kg)	End-point	Industrial/ Occupational Soil (mg/kg)	End-point	Construction Worker Soil (mg/kg)	End-point	Tap Water (ug/L)	End-point	Risk-based SSL for a DAF of 1 (mg/kg)	Risk-based SSL for a DAF of 20 (mg/kg)
Methyl acetate	7.82E+04	ns	1.30E+06	nls	3.54E+05	nls	1.99E+04	n	3.55E+00	7.11E+01
Methyl acrylate	3.50E+02	n	1.85E+03	n	3.48E+02	n	3.90E+01	n	7.13E-03	1.43E-01
Methyl isobutyl ketone	5.81E+03	ns	8.16E+04	ns	2.02E+04	ns	1.24E+03	n	2.40E-01	4.80E+00
Methyl methacrylate	1.11E+04	ns	5.65E+04	ns	1.06E+04	ns	1.39E+03	n	2.61E-01	5.22E+00
Methyl styrene (alpha)	5.48E+03	ns	9.08E+04	ns	2.48E+04	ns	7.65E+02	n	9.43E-01	1.89E+01
Methyl styrene (mixture)	2.73E+02	ns	2.20E+03	ns	4.49E+02	ns	3.73E+01	n	4.70E-02	9.40E-01
Methylcyclohexane	5.50E+03	ns	2.59E+04	ns	4.82E+03	ns	6.26E+03	n	1.58E+01	3.16E+02
Methylene bromide (Dibromomethane)	5.79E+01	n	2.88E+02	n	5.39E+01	n	8.00E+00	n	1.68E-03	3.35E-02
Methylene chloride	4.09E+02	n	5.13E+03	ns	1.21E+03	n	1.06E+02	n	2.35E-02	4.71E-01
Molybdenum	3.91E+02	n	6.49E+03	n	1.77E+03	n	9.87E+01	n	1.99E+00	3.98E+01
Naphthalene	4.97E+01	c	2.41E+02	c	1.59E+02	n	1.65E+00	c	4.11E-03	8.23E-02
Nickel	1.56E+03	n	2.57E+04	n	7.53E+02	n	3.72E+02	n	2.42E+01	4.85E+02
Nitrate	1.25E+05	nl	2.08E+06	nl	5.66E+05	nl	3.16E+04	n	2.13E+01	4.25E+02
Nitrite	7.82E+03	n	1.30E+05	nl	3.54E+04	n	1.97E+03	n	1.33E+00	2.66E+01
Nitrobenzene	6.04E+01	c	2.93E+02	c	3.53E+02	n	1.40E+00	c	7.20E-04	1.44E-02
Nitroglycerin	6.16E+00	n	9.16E+01	n	2.69E+01	n	1.96E+00	n	6.80E-04	1.36E-02
N-Nitrosodiethylamine	7.94E-03	c	1.71E-01	c	1.25E+00	c	1.65E-03	c	4.92E-07	9.84E-06
N-Nitrosodimethylamine	2.34E-02	c	5.03E-01	c	2.14E+00	n	4.90E-03	c	1.02E-06	2.03E-05
N-Nitrosodi-n-butylamine	7.81E-01	c	3.77E+00	c	2.46E+01	c	2.72E-02	c	4.21E-05	8.41E-04
N-Nitrosodiphenylamine	1.09E+03	c	5.24E+03	c	3.79E+04	c	1.21E+02	c	4.98E-01	9.95E+00
N-Nitrosopyrrolidine	2.54E+00	c	1.22E+01	c	8.89E+01	c	3.70E-01	c	1.15E-04	2.30E-03
m-Nitrotoluene	6.16E+00	n	9.16E+01	n	2.69E+01	n	1.74E+00	n	1.25E-03	2.50E-02
o-Nitrotoluene	3.16E+01	c	1.65E+02	c	3.19E+02	n	3.13E+00	c	2.28E-03	4.56E-02
p-Nitrotoluene	2.47E+02	n	1.60E+03	c	1.08E+03	n	4.24E+01	c	3.05E-02	6.09E-01
Pentachlorobenzene	4.93E+01	n	7.33E+02	n	2.15E+02	n	3.07E+00	n	1.76E-02	3.52E-01
Pentachlorophenol	9.85E+00	c	4.45E+01	c	3.46E+02	c	4.00E-01	c	3.04E-03	6.08E-02
Perchlorate	5.48E+01	n	9.08E+02	ns	2.48E+02	n	1.38E+01	n	5.85E-03	1.17E-01
Phenanthrene	1.74E+03	n	2.53E+04	n	7.53E+03	n	1.70E+02	n	4.30E+00	8.59E+01
Phenol	1.85E+04	n	2.75E+05	nl	7.74E+04	n	5.76E+03	n	2.62E+00	5.23E+01
Polychlorinatedbiphenyls (PCBs)										
Aroclor 1016	3.98E+00	n	5.74E+01	n	1.72E+01	n	1.40E+00	n	1.01E-01	2.01E+00
Aroclor 1221	1.81E+00	c	8.57E+00	c	5.53E+01	cs	5.54E-02	c	7.08E-04	1.42E-02
Aroclor 1232	1.86E+00	c	8.82E+00	c	5.76E+01	cs	5.54E-02	c	7.08E-04	1.42E-02

Chemical	Residential Soil (mg/kg)	End-point	Industrial/ Occupational Soil (mg/kg)	End-point	Construction Worker Soil (mg/kg)	End-point	Tap Water (ug/L)	End-point	Risk-based SSL for a DAF of 1 (mg/kg)	Risk-based SSL for a DAF of 20 (mg/kg)
Aroclor 1242	2.43E+00	c	1.15E+01	c	8.53E+01	c	3.89E-01	c	4.57E-02	9.14E-01
Aroclor 1248	2.43E+00	c	1.15E+01	c	8.53E+01	c	3.89E-01	c	4.48E-02	8.96E-01
Aroclor 1254	1.14E+00	n	1.15E+01	c	4.91E+00	n	3.89E-01	c	7.63E-02	1.53E+00
Aroclor 1260	2.43E+00	c	1.15E+01	c	8.53E+01	c	3.89E-01	c	2.04E-01	4.09E+00
2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB 170)	3.75E-01	c	1.77E+00	c	1.72E+00	n	5.99E-02	c	3.21E-02	6.42E-01
2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB 180)	3.75E+00	c	1.77E+01	c	1.72E+01	n	5.99E-01	c	3.14E-01	6.29E+00
2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB 189)	1.25E+00	c	5.89E+00	c	5.73E+00	n	2.00E-01	c	1.05E-01	2.10E+00
2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167)	1.25E+00	c	5.89E+00	c	5.73E+00	n	2.00E-01	c	6.27E-02	1.25E+00
2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 157)	1.25E+00	c	5.89E+00	c	5.73E+00	n	2.00E-01	c	6.40E-02	1.28E+00
2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156)	1.25E+00	c	5.89E+00	c	5.73E+00	n	2.00E-01	c	6.40E-02	1.28E+00
3,3',4,4',5,5'-Hexachlorobiphenyl (PCB 169)	1.25E-03	c	5.89E-03	c	5.73E-03	n	2.00E-04	c	6.27E-05	1.25E-03
2',3,4,4',5-Pentachlorobiphenyl (PCB 123)	1.25E+00	c	5.89E+00	c	5.73E+00	n	2.00E-01	c	3.91E-02	7.83E-01
2',3',4,4',5-Pentachlorobiphenyl (PCB 118)	1.25E+00	c	5.89E+00	c	5.73E+00	n	2.00E-01	c	3.84E-02	7.67E-01
2',3,3',4,4'-Pentachlorobiphenyl (PCB 105)	1.25E+00	c	5.89E+00	c	5.73E+00	n	2.00E-01	c	3.91E-02	7.83E-01
2,3,4,4',5-Pentachlorobiphenyl (PCB 114)	1.25E+00	c	5.89E+00	c	5.73E+00	n	2.00E-01	c	3.91E-02	7.83E-01
3,3',4,4',5-Pentachlorobiphenyl (PCB 126)	3.75E-04	c	1.77E-03	c	1.72E-03	n	5.99E-05	c	1.15E-05	2.30E-04
3,3',4,4'-Tetrachlorobiphenyl (PCB 77)	3.75E-01	c	1.77E+00	c	1.72E+00	n	5.99E-02	c	7.03E-03	1.41E-01
3,4,4',5-Tetrachlorobiphenyl (PCB 81)	1.25E-01	c	5.89E-01	c	5.73E-01	n	2.00E-02	c	2.34E-03	4.69E-02
Propylene oxide	2.56E+01	c	1.33E+02	c	7.99E+02	n	2.66E+00	c	4.82E-04	9.65E-03
Pyrene	1.74E+03	n	2.53E+04	n	7.53E+03	n	1.17E+02	n	9.59E+00	1.92E+02
RDX (Hexahydro-1,3,5-trinitro-1,3,5-triazine	6.04E+01	c	3.11E+02	c	1.01E+03	n	7.02E+00	c	2.16E-03	4.31E-02
Selenium	3.91E+02	n	6.49E+03	n	1.75E+03	n	9.87E+01	n	5.11E-01	1.02E+01
Silver	3.91E+02	n	6.49E+03	n	1.77E+03	n	8.12E+01	n	6.88E-01	1.38E+01
Strontium	4.69E+04	n	7.79E+05	nl	2.12E+05	nl	1.18E+04	n	4.17E+02	8.33E+03
Styrene	7.26E+03	ns	5.13E+04	ns	1.02E+04	ns	1.21E+03	n	1.03E+00	2.06E+01
Sulfolane	6.16E+01	n	9.16E+02	n	2.65E+02	n	2.00E+01	n	3.75E-03	7.49E-02
2,3,7,8-TCDD	4.90E-05	c	2.48E-04	c	2.26E-04	n	5.99E-06	c	2.24E-06	4.48E-05
2,3,7,8-TCDF	4.90E-04	c	2.48E-03	c	1.72E-02	c	2.01E-06	c	4.22E-07	8.44E-06
1,2,4,5-Tetrachlorobenzene	1.85E+01	n	2.75E+02	n	8.07E+01	n	1.66E+00	n	5.83E-03	1.17E-01
1,1,1,2-Tetrachloroethane	2.81E+01	c	1.37E+02	c	6.59E+02	cs	5.72E+00	c	1.80E-03	3.59E-02
1,1,2,2-Tetrachloroethane	7.98E+00	c	3.94E+01	c	1.97E+02	c	7.57E-01	c	2.40E-04	4.80E-03
Tetrachloroethene	1.11E+02	ns	6.29E+02	ns	1.20E+02	ns	4.03E+01	n	1.60E-02	3.21E-01
Tetryl (Trinitrophenylmethylnitramine)	1.56E+02	n	2.59E+03	n	7.06E+02	n	3.94E+01	n	2.79E-01	5.59E+00

Chemical	**Residential Soil (mg/kg)**	**End-point**	**Industrial/ Occupational Soil (mg/kg)**	**End-point**	**Construction Worker Soil (mg/kg)**	**End-point**	**Tap Water (ug/L)**	**End-point**	**Risk-based SSL for a DAF of 1 (mg/kg)**	**Risk-based SSL for a DAF of 20 (mg/kg)**
Thallium	7.82E-01	n	1.30E+01	n	3.54E+00	n	1.97E-01	n	1.41E-02	2.81E-01
Toluene	5.23E+03	ns	6.13E+04	ns	1.40E+04	ns	1.09E+03	n	6.07E-01	1.21E+01
Toxaphene	4.84E+00	c	2.33E+01	c	1.70E+02	c	1.53E-01	c	1.77E-02	3.54E-01
Tribromomethane (Bromoform)	6.74E+02	c	3.25E+03	c	5.38E+03	n	9.19E+01	c	2.05E-02	4.11E-01
1,1,2-Trichloro-1,2,2-trifluoroethane	5.08E+04	ns	2.43E+05	nls	4.53E+04	ns	5.50E+04	n	1.60E+02	3.20E+03
1,2,4-Trichlorobenzene	8.29E+01	n	4.23E+02	ns	7.91E+01	n	3.98E+00	n	8.82E-03	1.76E-01
1,1,1-Trichloroethane	1.44E+04	ns	7.25E+04	ns	1.36E+04	ns	8.00E+03	n	2.55E+00	5.11E+01
1,1,2-Trichloroethane	2.61E+00	n	1.24E+01	n	2.30E+00	n	4.15E-01	n	1.11E-04	2.23E-03
Trichloroethylene	6.77E+00	n	3.65E+01	n	6.90E+00	n	2.82E+00	n	8.75E-04	1.75E-02
Trichlorofluoromethane	1.23E+03	ns	6.03E+03	ns	1.13E+03	ns	1.14E+03	n	7.84E-01	1.57E+01
2,4,5-Trichlorophenol	6.16E+03	n	9.16E+04	n	2.69E+04	n	1.17E+03	n	3.31E+00	6.62E+01
2,4,6-Trichlorophenol	6.16E+01	n	9.16E+02	n	2.69E+02	n	1.19E+01	n	3.37E-02	6.74E-01
1,1,2-Trichloropropane	3.91E+02	n	6.49E+03	ns	1.77E+03	ns	8.81E+01	n	2.79E-02	5.59E-01
1,2,3-Trichloropropane	5.10E-02	c	1.21E+00	c	6.31E+00	n	7.47E-03	c	2.60E-06	5.21E-05
Triethylamine	1.93E+02	n	9.09E+02	n	1.69E+02	n	1.46E+01	n	3.65E-03	7.31E-02
2,4,6-Trinitrotoluene	3.60E+01	n	5.73E+02	n	1.61E+02	n	9.80E+00	n	4.30E-02	8.61E-01
Uranium (soluable salts)	2.34E+02	n	3.88E+03	ns	2.77E+02	ns	5.92E+01	n	2.67E+01	5.33E+02
Vanadium	3.94E+02	n	6.53E+03	n	6.14E+02	n	6.31E+01	n	6.31E+01	1.26E+03
Vinyl acetate	2.56E+03	n	1.24E+04	ns	2.30E+03	ns	4.09E+02	n	7.52E-02	1.50E+00
Vinyl bromide	2.71E+00	c	1.31E+01	c	8.46E+00	n	1.75E+00	c	4.62E-04	9.23E-03
Vinyl chloride	7.42E-01	c	2.84E+01	c	1.61E+02	c	2.01E-01	c	6.75E-05	1.35E-03
m-Xylene	7.64E+02	ns	3.73E+03	ns	6.96E+02	ns	1.93E+02	n	1.48E-01	2.97E+00
o-Xylene	8.05E+02	ns	3.94E+03	ns	7.36E+02	ns	1.93E+02	n	1.49E-01	2.98E+00
Xylenes	8.71E+02	ns	4.28E+03	ns	7.98E+02	ns	1.93E+02	n	1.49E-01	2.98E+00
Zinc	2.35E+04	n	3.89E+05	nl	1.06E+05	nl	5.96E+03	n	3.71E+02	7.41E+03

c – carcinogen
cs - carcinogenic, SSL may exceed saturation
DAF – Dilution Attenuation Factor
mg/kg – milligrams per kilogram
n – noncarcinogenic
nl - noncarcinogen, SSL may exceed ceiling limit
ns - noncarcinogen, SSL may exceed saturation
nls - noncarcinogen, SSL may exceed both saturation and ceiling limit
SSL – Soil Screening Level
µg/L – micrograms per liter

Table A-2			
Default Exposure Factors			
Symbol	**Definition (units)**	**Default**	**Reference**
CSF_o	Cancer slope factor oral $(mg/kg\text{-}day)^{-1}$	Chem.-spec.	See Appendix C
IUR	Inhalation Unit Risk $(\mu g/m^3)^{-1}$	Chem.-spec.	See Appendix C
RfD_o	Reference dose oral (mg/kg-day)	Chem.-spec.	See Appendix C
RfC	Inhalation Reference Concentration (mg/m^3)	Chem.-spec.	See Appendix C
TR	Target cancer risk	1E-05	NMED-specified value
THQ	Target hazard quotient	1	NMED-specified value
BW	Body weight (kg)		
	-- adult	80	US EPA, 2014
	-- child	15	US EPA, 2014
AT	Averaging time (days)		
	-- carcinogens	25550	US EPA, 2014
	-- noncarcinogens	ED*365	
GIABS	Fraction absorbed in gastrointestinal tract (unitless)	Chem.-spec.	See Appendix C
SA	Exposed surface area for soil/dust (cm^2/day)		
	– adult resident	6,032	US EPA, 2014
	– adult worker	3,470	US EPA, 2014
	-- child	2,690	US EPA, 2014
SA	Exposed surface area for water exposure (cm^2)		
	– adult resident	20,900	US EPA, 2014
	– child resident	6,378	US EPA, 2014
AF	Adherence factor, soils (mg/cm^2)		
	– adult resident	0.07	US EPA, 2014
	– adult worker	0.12	US EPA, 2014
	-- child resident	0.2	US EPA, 2014

	– construction worker	0.3	US EPA, 2014
ABS	Skin absorption defaults (unitless):		
	– semi-volatile organics	Chem.-spec.	See Appendix C
	– volatile organics	Chem.-spec.	See Appendix C
	– inorganics	Chem.-spec.	See Appendix C
IRW	Drinking water ingestion rate (L/day)		
	-- adult	2.5	US EPA, 2014
	-- child	0.78	US EPA, 2014
IRS	Soil ingestion (mg/day)		
	-- adult resident	100	US EPA, 2014
	-- child resident	200	US EPA, 2014
	-- commercial/industrial worker	100	US EPA, 2002
	construction worker	330	US EPA, 2002
EF	Exposure frequency (days/yr)		
	-- residential	350	US EPA, 2014
	-- commercial/industrial	225	US EPA, 2002
	– construction worker	250	US EPA, 2002
ED	Exposure duration (years)		
	-- residential	20[a]	US EPA, 2014
	-- child	6	US EPA, 1991
	-- commercial/industrial	25	US EPA, 2014
	– construction worker	1	US EPA, 2002
ET	Exposure time (unitless)		
	--residential	1	24 hours/day
	--commercial/industrial	0.33	8 hours/day
	--construction worker	0.33	8 hours/day
t_{event_a}	Dermal exposure time per event, water, adult resident (hours/event)	0.71	US EPA, 2014
t_{event_c}	Dermal exposure time per event, water, child resident (hours/event)	0.54	US EPA, 2014
PEF	Particulate emission factor (m^3/kg)	Chem.-spec.	US EPA, 2002

VFs	Volatilization factor for soil (m^3/kg)	Chem.-spec.	US EPA, 2002
K	Andelman volatilization factor for water (L/m^3)	0.5	US EPA, 1991
C_{sat}	Soil saturation concentration (mg/kg)	Chem.-spec.	US EPA, 2002

[a] Exposure duration for lifetime residents is assumed to be 26 years total. For carcinogens, exposures are combined for children (6 years) and adults (20 years).

Chem.-spec.- Chemical-specific value

References

US EPA. 2014. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. OSWER Directive 9200.1-120. February.

US EPA. 2004. *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Interim Guidance.* Office of Solid Waste and Emergency Response, Washington, D.C. http://www.epa.gov/oswer/riskassessment/ragse/index.htm

US EPA. 2002. *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites.* Office of Emergency and Remedial Response, Washington, D.C. OSWER 9355.4-24. December. http://www.epa.gov/superfund/health/conmedia/soil/pdfs/ssg_main.pdf

US EPA. 1991. *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals), Interim Final* (EPA 9285.6-03). Office of Emergency and Remedial Response, Washington, D.C.

Table A-3. NMED Vapor Intrusion Screening Levels (VISLs)

Chemical	Residential Indoor Air (µg/m^3)	Endpoint	Residential Soil-gas (µg/m^3)	Residential Groundwater (µg/L)	Industrial/ Occupational Indoor Air (µg/m^3)	Endpoint	Industrial/ OccupationalSoil -gas (µg/m^3)	Industrial/ Occupational Groundwater (µg/L)
Acetaldehyde	9.39E+00	n	9.39E+01	3.43E+03	4.42E+01	n	4.42E+02	1.62E+04
Acetone	3.23E+04	n	3.23E+05	2.25E+07	1.52E+05	n	1.52E+06	1.06E+08
Acrylonitrile	4.13E-01	c	4.13E+00	7.30E+01	2.02E+00	c	2.02E+01	3.58E+02
Acrolein	2.09E-02	n	2.09E-01	4.17E+00	9.83E-02	n	9.83E-01	1.97E+01
Benzene	3.60E+00	c	3.60E+01	1.58E+01	1.76E+01	c	1.76E+02	7.76E+01
1,1-Biphenyl	4.17E-01	n	4.17E+00	3.30E+01	1.97E+00	n	1.97E+01	1.56E+02
Bis(2-chloroethyl) ether	8.51E-02	c	8.51E-01	1.22E+02	4.17E-01	c	4.17E+00	5.98E+02
Bis(chloromethyl) ether	4.53E-04	c	4.53E-03	2.53E-03	2.22E-03	c	2.22E-02	1.24E-02
Bromodichloromethane	7.59E-01	c	7.59E+00	8.73E+00	3.72E+00	c	3.72E+01	4.28E+01
Bromomethane	5.21E+00	n	5.21E+01	1.73E+01	2.46E+01	n	2.46E+02	8.17E+01
1,3-Butadiene	9.36E-01	c	9.36E+00	3.10E-01	4.59E+00	c	4.59E+01	1.52E+00
2-Butanone (Methyl ethyl ketone, MEK)	5.21E+03	n	5.21E+04	2.24E+06	2.46E+04	n	2.46E+05	1.05E+07
tert-Butyl methyl ether (MTBE)	1.08E+02	c	1.08E+03	4.49E+03	5.29E+02	c	5.29E+03	2.20E+04
Carbon disulfide	7.30E+02	n	7.30E+03	1.24E+03	3.44E+03	n	3.44E+04	5.83E+03
Carbon tetrachloride	4.68E+00	c	4.68E+01	4.14E+00	2.29E+01	c	2.29E+02	2.03E+01
2-Chloro-1,3-butadiene	9.36E-02	c	9.36E-01	4.07E-02	4.59E-01	c	4.59E+00	1.99E-01
1-Chloro-1,1-difluoroethane	5.21E+04	n	5.21E+05	2.16E+04	2.46E+05	n	2.46E+06	1.02E+05
Chlorobenzene	5.21E+01	n	5.21E+02	4.09E+02	2.46E+02	n	2.46E+03	1.93E+03
Chlorodifluoromethane	5.21E+04	n	5.21E+05	3.13E+04	2.46E+05	n	2.46E+06	1.48E+05
Chloroform	1.22E+00	c	1.22E+01	8.11E+00	5.98E+00	c	5.98E+01	3.98E+01
Chloromethane	1.56E+01	c	1.56E+02	4.31E+01	7.65E+01	c	7.65E+02	2.11E+02

Chemical	**Residential Indoor Air (µg/m^3)**	**Endpoint**	**Residential Soil-gas (µg/m^3)**	**Residential Groundwater (µg/L)**	**Industrial/ Occupational Indoor Air (µg/m^3)**	**Endpoint**	**Industrial/ OccupationalSoil -gas (µg/m^3)**	**Industrial/ Occupational Groundwater (µg/L)**
2-Chloropropane	1.04E+02	n	1.04E+03	1.45E+02	4.92E+02	n	4.92E+03	6.85E+02
Cumene (isopropylbenzene)	4.17E+02	n	4.17E+03	8.85E+02	1.97E+03	n	1.97E+04	4.17E+03
Cyanide	8.34E-01	n	8.34E+00	1.53E+02	3.93E+00	n	3.93E+01	7.21E+02
1,2-Dibromo-3-chloropropane	1.69E-03	c	1.69E-02	2.80E-01	2.29E-02	c	2.29E-01	3.81E+00
Dibromochloromethane	1.04E+00	c	1.04E+01	3.24E+01	5.10E+00	c	5.10E+01	1.59E+02
1,2-Dibromoethane	4.68E-02	c	4.68E-01	1.76E+00	2.29E-01	c	2.29E+00	8.61E+00
1,4-Dichloro-2-butene	6.68E-03	c	6.68E-02	2.46E-01	3.28E-02	c	3.28E-01	1.20E+00
1,2-Dichlorobenzene	2.09E+02	n	2.09E+03	2.65E+03	9.83E+02	n	9.83E+03	1.25E+04
1,4-Dichlorobenzene	2.55E+00	c	2.55E+01	2.58E+01	1.25E+01	c	1.25E+02	1.27E+02
Dichlorodifluoromethane	1.04E+02	n	1.04E+03	7.42E+00	4.92E+02	n	4.92E+03	3.50E+01
1,1-Dichloroethane	1.75E+01	c	1.75E+02	7.62E+01	8.60E+01	c	8.60E+02	3.73E+02
1,2-Dichloroethane	1.08E+00	c	1.08E+01	2.23E+01	5.29E+00	c	5.29E+01	1.09E+02
trans-1,2-Dichloroethene	6.26E+01	n	6.26E+02	3.74E+02	2.95E+02	n	2.95E+03	1.76E+03
1,1-Dichloroethene	2.09E+02	n	2.09E+03	1.95E+02	9.83E+02	n	9.83E+03	9.19E+02
1,2-Dichloropropane	2.81E+00	c	2.81E+01	2.43E+01	1.38E+01	c	1.38E+02	1.19E+02
1,3-Dichloropropene	7.02E+00	c	7.02E+01	4.82E+01	3.44E+01	c	3.44E+02	2.36E+02
Dicyclopentadiene	3.13E-01	n	3.13E+00	1.22E-01	1.47E+00	n	1.47E+01	5.76E-01
Epichlorohydrin	1.04E+00	n	1.04E+01	8.37E+02	4.92E+00	n	4.92E+01	3.94E+03
Ethyl acetate	7.30E+01	n	7.30E+02	1.33E+04	3.44E+02	n	3.44E+03	6.26E+04
Ethyl chloride	1.04E+04	n	1.04E+05	2.29E+04	4.92E+04	n	4.92E+05	1.08E+05
Ethyl methacrylate	3.13E+02	n	3.13E+03	1.33E+04	1.47E+03	n	1.47E+04	6.28E+04
Ethylbenzene	1.12E+01	c	1.12E+02	3.48E+01	5.51E+01	c	5.51E+02	1.70E+02
Ethylene oxide	3.19E-01	c	3.19E+00	5.26E+01	1.56E+00	c	1.56E+01	2.58E+02
n-Hexane	7.30E+02	n	7.30E+03	9.89E+00	3.44E+03	n	3.44E+04	4.66E+01
Hydrogen cyanide	8.34E-01	n	8.34E+00	1.53E+02	3.93E+00	n	3.93E+01	7.21E+02

Chemical	Residential Indoor Air (µg/m^3)	Endpoint	Residential Soil-gas (µg/m^3)	Residential Groundwater (µg/L)	Industrial/ Occupational Indoor Air (µg/m^3)	Endpoint	Industrial/ OccupationalSoil -gas (µg/m^3)	Industrial/ Occupational Groundwater (µg/L)
Mercury (elemental)	3.13E-01	n	3.13E+00	6.69E-01	1.47E+00	n	1.47E+01	3.16E+00
Methacrylonitrile	3.13E+01	n	3.13E+02	3.09E+03	1.47E+02	n	1.47E+03	1.46E+04
Methyl acrylate	2.09E+01	n	2.09E+02	2.56E+03	9.83E+01	n	9.83E+02	1.21E+04
Methyl isobutyl ketone	3.13E+03	n	3.13E+04	5.53E+05	1.47E+04	n	1.47E+05	2.61E+06
Methyl methacrylate	7.30E+02	n	7.30E+03	5.58E+04	3.44E+03	n	3.44E+04	2.63E+05
Methyl styrene (mixture)	4.17E+01	n	4.17E+02	3.34E+02	1.97E+02	n	1.97E+03	1.57E+03
Methylcyclohexane	3.13E+03	n	3.13E+04	1.77E+02	1.47E+04	n	1.47E+05	8.36E+02
Methylene bromide (Dibromomethane)	4.17E+00	n	4.17E+01	1.24E+02	1.97E+01	n	1.97E+02	5.83E+02
Methylene chloride	6.26E+02	n	6.26E+03	4.70E+03	2.95E+03	n	2.95E+04	2.21E+04
Naphthalene	8.26E-01	c	8.26E+00	4.58E+01	4.05E+00	c	4.05E+01	2.24E+02
Nitrobenzene	7.02E-01	c	7.02E+00	7.13E+02	3.44E+00	c	3.44E+01	3.50E+03
N-Nitrosodi-n-butylamine	1.75E-02	c	1.75E-01	3.24E+01	8.60E-02	c	8.60E-01	1.59E+02
Aroclor 1221	4.93E-02	c	4.93E-01	1.63E+00	2.41E-01	c	2.41E+00	8.00E+00
Aroclor 1232	4.93E-02	c	4.93E-01	1.63E+00	2.41E-01	c	2.41E+00	8.00E+00
Propylene oxide	7.59E+00	c	7.59E+01	2.66E+03	3.72E+01	c	3.72E+02	1.30E+04
Styrene	1.04E+03	n	1.04E+04	9.25E+03	4.92E+03	n	4.92E+04	4.36E+04
1,1,1,2-Tetrachloroethane	3.79E+00	c	3.79E+01	3.70E+01	1.86E+01	c	1.86E+02	1.81E+02
1,1,2,2-Tetrachloroethane	4.84E-01	c	4.84E+00	3.22E+01	2.37E+00	c	2.37E+01	1.58E+02
Tetrachloroethene	4.17E+01	n	4.17E+02	5.75E+01	1.97E+02	n	1.97E+03	2.71E+02
Toluene	5.21E+03	n	5.21E+04	1.92E+04	2.46E+04	n	2.46E+05	9.03E+04
1,1,2-Trichloro-1,2,2-trifluoroethane	3.13E+04	n	3.13E+05	1.45E+03	1.47E+05	n	1.47E+06	6.84E+03
1,2,4-Trichlorobenzene	2.09E+00	n	2.09E+01	3.58E+01	9.83E+00	n	9.83E+01	1.69E+02
1,1,1-Trichloroethane	5.21E+03	n	5.21E+04	7.39E+03	2.46E+04	n	2.46E+05	3.49E+04
1,1,2-Trichloroethane	2.09E-01	n	2.09E+00	6.17E+00	9.83E-01	n	9.83E+00	2.91E+01
Trichloroethylene	2.09E+00	n	2.09E+01	5.16E+00	9.83E+00	n	9.83E+01	2.43E+01

Chemical	**Residential Indoor Air ($\mu g/m^3$)**	**Endpoint**	**Residential Soil-gas ($\mu g/m^3$)**	**Residential Groundwater (µg/L)**	**Industrial/ Occupational Indoor Air ($\mu g/m^3$)**	**Endpoint**	**Industrial/ OccupationalSoil -gas ($\mu g/m^3$)**	**Industrial/ Occupational Groundwater (µg/L)**
Trichlorofluoromethane	7.30E+02	n	7.30E+03	1.84E+02	3.44E+03	n	3.44E+04	8.65E+02
1,2,3-Trichloropropane	3.13E-01	n	3.13E+00	2.22E+01	1.47E+00	n	1.47E+01	1.05E+02
Triethylamine	7.30E+00	n	7.30E+01	1.19E+03	3.44E+01	n	3.44E+02	5.63E+03
Vinyl acetate	2.09E+02	n	2.09E+03	9.96E+03	9.83E+02	n	9.83E+03	4.69E+04
Vinyl bromide	8.77E-01	c	8.77E+00	1.74E+00	4.30E+00	c	4.30E+01	8.53E+00
Vinyl chloride	1.68E+00	c	1.68E+01	1.47E+00	3.13E+01	c	3.13E+02	2.74E+01
m-Xylene	1.04E+02	n	1.04E+03	3.54E+02	4.92E+02	n	4.92E+03	1.67E+03
o-Xylene	1.04E+02	n	1.04E+03	4.91E+02	4.92E+02	n	4.92E+03	2.31E+03
Xylenes	1.04E+02	n	1.04E+03	4.91E+02	4.92E+02	n	4.92E+03	2.31E+03

APPENDIX B

CHEMICAL AND PHYSICAL PROPERTIES

Table B-1: Chemical CAS and Molecular Weight

Chemical	**Chemical Abstracts Service (CAS) Registry Number**	**Molecular Weight (MW) (g/mole)**	**Ref.**
Acenaphthene	83-32-9	154.21	EPI
Acetaldehyde	75-07-0	44.05	EPI
Acetone	67-64-1	58.08	EPI
Acrylonitrile	107-13-1	53.06	EPI
Acetophenone	98-86-2	120.15	EPI
Acrolein	107-02-8	56.06	EPI
Aldrin	309-00-2	364.92	EPI
Aluminum	7429-90-5	26.98	P
Anthracene	120-12-7	178.24	EPI
Antimony	7440-36-0	121.76	P
Arsenic	7440-38-2	74.92	P
Barium	7440-39-3	137.33	P
Benzene	71-43-2	78.11	EPI
Benzidine	92-87-5	184.24	EPI
Benzo(a)anthracene	56-55-3	228.3	EPI
Benzo(a)pyrene	50-32-8	252.32	EPI
Benzo(b)fluoranthene	205-99-2	252.32	EPI
Benzo(k)fluoranthene	207-08-9	252.32	EPI
Beryllium	7440-41-7	9.01	P
a-BHC (HCH)	319-84-6	290.83	EPI
b-BHC (HCH)	319-85-7	290.83	EPI
g-BHC	58-89-9	290.83	EPI
1,1-Biphenyl	92-52-4	154.21	EPI
Bis(2-chloroethyl) ether	111-44-4	143.01	EPI
Bis(2-chloroisopropyl) ether	108-60-1	171.07	EPI
Bis(2-ethylhexyl) phthalate	117-81-7	390.57	EPI
Bis(chloromethyl) ether	542-88-1	114.96	EPI
Boron	7440-42-8	10.81	P
Bromodichloromethane	75-27-4	163.83	EPI
Bromomethane	74-83-9	94.94	EPI
1,3-Butadiene	106-99-0	54.09	EPI
2-Butanone (Methyl ethyl ketone, MEK)	78-93-3	72.11	EPI
tert-Butyl methyl ether (MTBE)	1634-04-4	88.15	EPI

Chemical	**Chemical Abstracts Service (CAS) Registry Number**	**Molecular Weight (MW) (g/mole)**	**Ref.**
Cadmium	7440-43-9	112.41	P
Carbon disulfide	75-15-0	76.13	EPI
Carbon tetrachloride	56-23-5	153.82	EPI
Chlordane	12789-03-6	409.78	EPI
2-Chloroacetophenone	532-27-4	154.6	EPI
2-Chloro-1,3-butadiene	126-99-8	88.54	EPI
1-Chloro-1,1-difluoroethane	75-68-3	100.5	EPI
Chlorobenzene	108-90-7	112.56	EPI
1-Chlorobutane	109-69-3	92.57	EPI
Chlorodifluoromethane	75-45-6	86.47	EPI
Chloroform	67-66-3	119.38	EPI
Chloromethane	74-87-3	50.49	EPI
b-Chloronaphthalene	91-58-7	162.62	EPI
o-Chloronitrobenzene	88-73-3	157.56	EPI
p-Chloronitrobenzene	100-00-5	157.56	EPI
2-Chlorophenol	95-57-8	128.56	EPI
2-Chloropropane	75-29-6	78.54	EPI
o-Chlorotoluene	95-49-8	126.59	EPI
Chromium III	16065-83-1	52	P
Chromium VI	18540-29-9	52	P
Chromium (Total)		52	P
Chrysene	218-01-9	228.3	EPI
Copper	7440-50-8	63.55	P
Crotonaldehyde	123-73-9	70.09	EPI
Cumene (isopropylbenzene)	98-82-8	120.2	EPI
Cyanide	57-12-5	27.03	EPI
Cyanogen	460-19-5	52.04	EPI
Cyanogen bromide	506-68-3	105.92	EPI
Cyanogen chloride	506-77-4	61.47	EPI
DDD	72-54-8	320.05	EPI
DDE	72-55-9	318.03	EPI
DDT	50-29-3	354.49	EPI
Dibenz(a,h)anthracene	53-70-3	278.36	EPI
1,2-Dibromo-3-chloropropane	96-12-8	236.33	EPI
Dibromochloromethane	124-48-1	208.28	EPI

Chemical	**Chemical Abstracts Service (CAS) Registry Number**	**Molecular Weight (MW) (g/mole)**	**Ref.**
1,2-Dibromoethane	106-93-4	187.86	EPI
1,4-Dichloro-2-butene	764-41-0	125	EPI
1,2-Dichlorobenzene	95-50-1	147	EPI
1,4-Dichlorobenzene	106-46-7	147	EPI
3,3-Dichlorobenzidine	91-94-1	253.13	EPI
Dichlorodifluoromethane	75-71-8	120.91	EPI
1,1-Dichloroethane	75-34-3	98.96	EPI
1,2-Dichloroethane	107-06-2	98.96	EPI
cis-1,2-Dichloroethene	156-59-2	96.94	EPI
trans-1,2-Dichloroethene	156-60-5	96.94	EPI
1,1-Dichloroethene	75-35-4	96.94	EPI
2,4-Dichlorophenol	120-83-2	163	EPI
1,2-Dichloropropane	78-87-5	112.99	EPI
1,3-Dichloropropene	542-75-6	110.97	EPI
Dicyclopentadiene	77-73-6	132.21	EPI
Dieldrin	60-57-1	380.91	EPI
Diethyl phthalate	84-66-2	222.24	EPI
Di-n-butyl phthalate (Dibutyl phthalate)	84-74-2	278.35	EPI
2,4-Dimethylphenol	105-67-9	122.17	EPI
4,6-Dinitro-o-cresol	534-52-1	198.14	EPI
2,4-Dinitrophenol	51-28-5	184.11	EPI
2,4-Dinitrotoluene	121-14-2	182.14	EPI
2,6-Dintitrotoluene	606-20-2	182.14	EPI
2,4/2,6-Dintrotoluene Mixture	25321-14-6	182.14	EPI
1,4-Dioxane	123-91-1	88.11	EPI
1,2-Diphenylhydrazine	122-66-7	184.24	EPI
Endosulfan	115-29-7	406.92	EPI
Endrin	72-20-8	380.91	EPI
Epichlorohydrin	106-89-8	92.53	EPI
Ethyl acetate	141-78-6	88.11	EPI
Ethyl acrylate	140-88-5	100.12	EPI
Ethyl chloride	75-00-3	64.52	EPI
Ethyl ether	60-29-7	74.12	EPI
Ethyl methacrylate	97-63-2	114.15	EPI
Ethylbenzene	100-41-4	106.17	EPI

Chemical	**Chemical Abstracts Service (CAS) Registry Number**	**Molecular Weight (MW) (g/mole)**	**Ref.**
Ethylene oxide	75-21-8	44.05	EPI
Fluoranthene	206-44-0	202.26	EPI
Fluorene	86-73-7	166.22	EPI
Fluoride	7782-41-4	19	P
Furan	110-00-9	68.08	EPI
Heptachlor	76-44-8	373.32	EPI
Hexachlorobenzene	118-74-1	284.78	EPI
Hexachloro-1,3-butadiene	87-68-3	260.76	EPI
Hexachlorocyclopentadiene	77-47-4	272.77	EPI
Hexachloroethane	67-72-1	236.74	EPI
n-Hexane	110-54-3	86.18	EPI
HMX	2691-41-0	296.16	EPI
Hydrazine anhydride	302-01-2	32.05	EPI
Hydrogen cyanide	74-90-8	27.03	EPI
Indeno(1,2,3-c,d)pyrene	193-39-5	276.34	EPI
Iron	7439-89-6	55.85	P
Isobutanol (Isobutyl alcohol)	78-83-1	74.12	EPI
Isophorone	78-59-1	138.21	EPI
Lead	7439-92-1	207.2	P
Lead (tetraethyl-)	78-00-2	323.45	EPI
Maleic hydrazide	123-33-1	112.09	EPI
Manganese	7439-96-5	54.94	P
Mercury (elemental)	7439-97-6	200.59	EPI
Mercury (methyl)	22967-92-6	215.63	EPI
Mercury Chloride (Mercury Salts)	7487-94-7	271.5	EPI
Methacrylonitrile	126-98-7	67.09	EPI
Methomyl	16752-77-5	162.21	EPI
Methyl acetate	79-20-9	74.08	EPI
Methyl acrylate	96-33-3	86.09	EPI
Methyl isobutyl ketone	108-10-1	100.16	EPI
Methyl methacrylate	80-62-6	100.12	EPI
Methyl styrene (alpha)	98-83-9	118.18	EPI
Methyl styrene (mixture)	25013-15-4	118.18	EPI
Methylcyclohexane	108-87-2	98.19	EPI
Methylene bromide (Dibromomethane)	74-95-3	173.84	EPI

Chemical	**Chemical Abstracts Service (CAS) Registry Number**	**Molecular Weight (MW) (g/mole)**	**Ref.**
Methylene chloride	75-09-2	84.93	EPI
Molybdenum	7439-98-7	95.96	P
Naphthalene	91-20-3	128.18	EPI
Nickel	7440-02-0	58.69	EPI
Nitrate	14797-55-8	62	EPI
Nitrite	14797-65-0	47.01	EPI
Nitrobenzene	98-95-3	123.11	EPI
Nitroglycerin	55-63-0	227.09	EPI
N-Nitrosodiethylamine	55-18-5	102.14	EPI
N-Nitrosodimethylamine	62-75-9	74.08	EPI
N-Nitrosodi-*n*-butylamine	924-16-3	158.25	EPI
N-Nitrosodiphenylamine	86-30-6	198.23	EPI
N-Nitrosopyrrolidine	930-55-2	100.12	EPI
m-Nitrotoluene	99-08-1	137.14	EPI
o-Nitrotoluene	88-72-2	137.14	EPI
p-Nitrotoluene	99-99-0	137.14	EPI
Pentachlorobenzene	608-93-5	250.34	EPI
Pentachlorophenol	87-86-5	266.34	EPI
Perchlorate	14797-73-0	99.45	ToxNet
Phenanthrene	85-01-8	178.24	EPI
Phenol	108-95-2	94.11	EPI
Polychlorinatedbiphenyls (PCBs)			
Aroclor 1016	12674-11-2	257.55	EPI
Aroclor 1221	11104-28-2	188.66	EPI
Aroclor 1232	11141-16-5	188.66	EPI
Aroclor 1242	53469-21-9	291.99	EPI
Aroclor 1248	12672-29-6	291.99	EPI
Aroclor 1254	11097-69-1	326.44	EPI
Aroclor 1260	11096-82-5	395.33	EPI
2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB 170)	35065-30-6	395.33	EPI
2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB 180)	35065-29-3	395.33	EPI
2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB 189)	39635-31-9	395.33	EPI
2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167)	52663-72-6	360.88	EPI
2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 157)	69782-90-7	360.88	EPI
2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156)	38380-08-4	360.88	EPI

Chemical	**Chemical Abstracts Service (CAS) Registry Number**	**Molecular Weight (MW) (g/mole)**	**Ref.**
3,3',4,4',5,5'-Hexachlorobiphenyl (PCB 169)	32774-16-6	360.88	EPI
2',3,4,4',5-Pentachlorobiphenyl (PCB 123)	65510-44-3	326.44	EPI
2',3',4,4',5-Pentachlorobiphenyl (PCB 118)	31508-00-6	326.44	EPI
2',3,3',4,4'-Pentachlorobiphenyl (PCB 105)	32598-14-4	326.44	EPI
2,3,4,4',5-Pentachlorobiphenyl (PCB 114)	74472-37-0	326.44	EPI
3,3',4,4',5-Pentachlorobiphenyl (PCB 126)	57465-28-8	326.44	EPI
3,3',4,4'-Tetrachlorobiphenyl (PCB 77)	32598-13-3	291.99	EPI
3,4,4',5-Tetrachlorobiphenyl (PCB 81)	70362-50-4	291.99	EPI
Propylene oxide	75-56-9	58.08	EPI
Pyrene	129-00-0	202.26	EPI
RDX	121-82-4	222.12	EPI
Selenium	7782-49-2	78.96	P
Silver	7440-22-4	107.87	P
Strontium	7440-24-6	87.62	P
Styrene	100-42-5	104.15	EPI
Sulfolane	126-33-0	120.17	EPI
2,3,7,8-TCDD	1746-01-6	321.98	EPI
2,3,7,8-TCDF	51207-31-9	305.98	EPI
1,2,4,5-Tetrachlorobenzene	95-94-3	215.89	EPI
1,1,1,2-Tetrachloroethane	630-20-6	167.85	EPI
1,1,2,2-Tetrachloroethane	79-34-5	167.85	EPI
Tetrachloroethene	127-18-4	165.83	EPI
Tetryl (Trinitrophenylmethylnitramine)	479-45-8	287.15	EPI
Thallium	7440-28-0	204.38	P
Toluene	108-88-3	92.14	EPI
Toxaphene	8001-35-2	413.82	EPI
Tribromomethane (Bromoform)	75-25-2	252.73	EPI
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	187.38	EPI
1,2,4-Trichlorobenzene	120-82-1	181.45	EPI
1,1,1-Trichloroethane	71-55-6	133.41	EPI
1,1,2-Trichloroethane	79-00-5	133.41	EPI
Trichloroethylene	79-01-6	131.39	EPI
Trichlorofluoromethane	75-69-4	137.37	EPI
2,4,5-Trichlorophenol	95-95-4	197.45	EPI
2,4,6-Trichlorophenol	88-06-2	197.45	EPI

Chemical	**Chemical Abstracts Service (CAS) Registry Number**	**Molecular Weight (MW) (g/mole)**	**Ref.**
1,1,2-Trichloropropane	598-77-6	147.43	EPI
1,2,3-Trichloropropane	96-18-4	147.43	EPI
Triethylamine	121-44-8	101.19	EPI
2,4,6-Trinitrotoluene	118-96-7	227.13	EPI
Uranium (soluable salts)		238.03	P
Vanadium	7440-62-2	50.94	EPI
Vinyl acetate	108-05-4	86.09	P
Vinyl bromide	593-60-2	106.95	EPI
Vinyl chloride	75-01-4	62.5	EPI
m-Xylene	108-38-3	106.17	EPI
o-Xylene	95-47-6	106.17	EPI
Xylenes	1330-20-7	106.17	EPI
Zinc	7440-66-6	65.38	P

EPI= US EPA. 2012. Estimation Programs Interface (EPI) Suite™ for Microsoft® Windows, v 4.11. Washington, DC, USA.
g/mole – grams per mole
P = periodic table of the elements
Ref – reference
ToxNet – Toxicological Data Network, US National Library of Medicine, http://chem.sis.nlm.nih.gov/chemidplus/rn/14797-73-0

Table B-2: Physical and Chemical Properties

Chemical	**H (atm-m^3/mole)**	**Ref.**	**H' (unitless)**	**D_a (cm^2/s)**	**Ref.**	**D_w (cm^2/s)**	**Ref.**	**K_{oc} (cm^3/g)**	**Ref.**	**K_d (cm^3/g)**	**Ref.**	**S (mg/L-water)**	**Ref.**	**D_A (cm^2/s)**	**Res/Ind. VF (m^3/kg)**	**Comm/ VF (m^3/kg)**	**Soil SAT (mg/kg)**	**VOC**
Acenaphthene	1.84E-04	EPI	7.54E-03	4.76E-02	W9	7.69E-06	W9	5.03E+03	EPI	7.54E+00	CALC	3.90E+00	EPI	4.91E-07	1.77E+05	3.66E+04		1
Acetaldehyde	6.67E-05	EPI	2.73E-03	1.24E-01	W9	1.41E-05	W9	1.00E+00	EPI	1.50E-03	CALC	1.00E+06	EPI	2.20E-05	2.65E+04	5.47E+03	1.75E+05	1
Acetone	3.50E-05	EPI	1.44E-03	1.24E-01	W9	1.14E-05	W9	2.36E+00	EPI	3.55E-03	CALC	1.00E+06	EPI	1.23E-05	3.54E+04	7.31E+03	1.77E+05	1
Acrylonitrile	1.38E-04	EPI	5.66E-03	1.28E-01	W9	1.66E-05	W9	8.51E+00	EPI	1.28E-02	CALC	7.45E+04	EPI	4.11E-05	1.94E+04	4.00E+03	1.39E+04	1
Acetophenone	1.04E-05	EPI	4.26E-04	6.00E-02	W9	8.73E-06	W9	5.19E+01	EPI	7.78E-02	CALC	6.13E+03	EPI	2.37E-06	8.07E+04	1.67E+04	1.54E+03	1
Acrolein	1.22E-04	EPI	5.00E-03	1.05E-01	W9	1.22E-05	W9	1.00E+00	EPI	1.50E-03	CALC	2.12E+05	EPI	3.18E-05	2.20E+04	4.55E+03	3.72E+04	1
Aldrin	4.40E-05	EPI	1.80E-03	1.96E-02	W9	4.86E-06	W9	8.20E+04	EPI	1.23E+02	CALC	1.70E-02	EPI	4.35E-09				
Aluminum										1.50E+03	Baes							
Anthracene	5.56E-05	EPI	2.28E-03	3.85E-02	W9	7.74E-06	W9	1.64E+04	EPI	2.45E+01	CALC	4.34E-02	EPI	4.69E-08	5.73E+05	1.18E+05		1
Antimony										4.50E+01	SSG							
Arsenic										2.90E+01	SSG							
Barium										4.10E+01	SSG							
Benzene	5.55E-03	EPI	2.28E-01	8.80E-02	W9	1.02E-05	W9	1.46E+02	EPI	2.19E-01	CALC	1.79E+03	EPI	4.65E-04	5.75E+03	1.19E+03	7.48E+02	1
Benzidine	5.17E-11	EPI	2.12E-09	3.26E-02	W9	1.50E-05	W9	1.19E+03	EPI	1.79E+00	CALC	3.22E+02	EPI	3.04E-07				
Benzo(a)anthracene	1.20E-05	EPI	4.92E-04	5.10E-02	W9	9.00E-06	W9	1.77E+05	EPI	2.65E+02	CALC	9.40E-03	EPI	2.26E-09				
Benzo(a)pyrene	4.57E-07	EPI	1.87E-05	4.30E-02	W9	9.00E-06	W9	5.87E+05	EPI	8.81E+02	CALC	1.62E-03	EPI	4.15E-10				
Benzo(b)fluoranthene	6.57E-07	EPI	2.69E-05	2.23E-02	W9	5.56E-06	W9	5.99E+05	EPI	8.99E+02	CALC	1.50E-03	EPI	2.52E-10				
Benzo(k)fluoranthene	5.84E-07	EPI	2.39E-05	2.23E-02	W9	5.56E-06	W9	5.87E+05	EPI	8.81E+02	CALC	8.00E-04	EPI	2.56E-10				
Beryllium										7.90E+02	SSG							
a-BHC (HCH)	5.14E-06	EPI	2.11E-04	2.21E-02	W9	5.57E-06	W9	2.81E+03	EPI	4.21E+00	CALC	8.00E+00	EPI	6.08E-08				
b-BHC (HCH)	5.14E-06	EPI	2.11E-04	2.21E-02	W9	5.57E-06	W9	2.81E+03	EPI	4.21E+00	CALC	8.00E+00	EPI	6.08E-08				
g-BHC	5.10E-06	EPI	2.09E-04	2.75E-02	W9	7.34E-06	W9	2.81E+03	EPI	4.21E+00	CALC	8.00E+00	EPI	7.92E-08				
1,1-Biphenyl	3.08E-04	EPI	1.26E-02	4.04E-02	W9	8.15E-06	W9	5.13E+03	EPI	7.69E+00	CALC	6.94E+00	EPI	6.70E-07	1.52E+05	3.13E+04		1
Bis(2-chloroethyl) ether	1.70E-05	EPI	6.97E-04	4.13E-02	W9	9.49E-06	W9	3.22E+01	EPI	4.83E-02	CALC	1.72E+04	EPI	2.96E-06	7.22E+04	1.49E+04	3.81E+03	1
Bis(2-chloroisopropyl) ether	7.42E-05	EPI	3.04E-03	6.02E-02	W9	6.41E-06	W9	4.58E+01	EPI	6.87E-02	CALC	1.70E+03	EPI	8.37E-06	4.29E+04	8.86E+03	4.12E+02	1
Bis(2-ethylhexyl) phthalate	2.70E-07	EPI	1.11E-05	3.51E-02	W9	3.66E-06	W9	1.20E+05	EPI	1.79E+02	CALC	2.70E-01	EPI	8.31E-10				
Bis(chloromethyl) ether	4.36E-03	EPI	1.79E-01	7.62E-02	W9	9.38E-06	W9	9.70E+00	EPI	1.45E-02	CALC	2.20E+04	EPI	6.36E-04	4.92E+03	1.02E+03	4.58E+03	1
Boron										3.00E+00	Baes							
Bromodichloromethane	2.12E-03	EPI	8.69E-02	5.61E-02	W9	1.06E-05	W9	3.18E+01	EPI	4.77E-02	CALC	3.03E+03	EPI	2.06E-04	8.64E+03	1.78E+03	7.00E+02	1
Bromomethane	7.34E-03	EPI	3.01E-01	7.28E-02	W9	1.21E-05	W9	1.32E+01	EPI	1.98E-02	CALC	1.52E+04	EPI	9.36E-04	4.06E+03	8.38E+02	3.45E+03	1
1,3-Butadiene	7.36E-02	EPI	3.02E+00	2.49E-01	W9	1.08E-05	W9	3.96E+01	EPI	5.94E-02	CALC	7.35E+02	EPI	1.27E-02	1.10E+03	2.28E+02	4.22E+02	1
2-Butanone (Methyl ethyl ketone, MEK)	5.69E-05	EPI	2.33E-03	8.08E-02	W9	9.80E-06	W9	4.51E+00	EPI	6.77E-03	CALC	2.23E+05	EPI	1.23E-05	3.54E+04	7.31E+03	4.02E+04	1
tert-Butyl methyl ether (MTBE)	5.87E-04	EPI	2.41E-02	8.59E-02	W9	1.01E-05	W9	1.16E+01	EPI	1.73E-02	CALC	5.10E+04	EPI	1.06E-04	1.21E+04	2.49E+03	9.86E+03	1
Cadmium										7.50E+01	SSG							

Chemical	**H (atm-m^3/mole)**	**Ref.**	**H' (unitless)**	**D$_a$ (cm^2/s)**	**Ref.**	**D$_w$ (cm^2/s)**	**Ref.**	**K$_{oc}$ (cm^3/g)**	**Ref.**	**K$_d$ (cm^3/g)**	**Ref.**	**S (mg/L-water)**	**Ref.**	**D$_A$ (cm^2/s)**	**Res/Ind. VF (m^3/kg)**	**Comm/ VF (m^3/kg)**	**Soil SAT (mg/kg)**	**VOC**
Carbon disulfide	1.44E-02	EPI	5.90E-01	1.04E-01	W9	1.00E-05	W9	2.17E+01	EPI	3.26E-02	CALC	2.16E+03	EPI	2.18E-03	2.66E+03	5.49E+02	5.89E+02	1
Carbon tetrachloride	2.76E-02	EPI	1.13E+00	7.80E-02	W9	8.80E-06	W9	4.39E+01	EPI	6.58E-02	CALC	7.93E+02	EPI	2.33E-03	2.57E+03	5.31E+02	2.91E+02	1
Chlordane	4.86E-05	EPI	1.99E-03	1.79E-02	W9	4.37E-06	W9	3.38E+04	EPI	5.07E+01	CALC	5.60E-02	EPI	1.02E-08				
2-Chloroacetophenone	3.46E-06	EPI	1.42E-04	3.83E-02	W9	8.71E-06	W9	9.89E+01	EPI	1.48E-01	CALC	1.64E+03	EPI	1.24E-06				
2-Chloro-1,3-butadiene	5.61E-02	EPI	2.30E+00	1.04E-01	W9	1.00E-05	W9	6.07E+01	EPI	9.11E-02	CALC	8.75E+02	EPI	4.42E-03	1.87E+03	3.86E+02	4.59E+02	1
1-Chloro-1,1-difluoroethane	5.88E-02	EPI	2.41E+00	7.69E-02	W9	9.54E-06	W9	4.39E+01	EPI	6.58E-02	CALC	1.40E+03	EPI	3.51E-03	2.10E+03	4.33E+02	7.17E+02	1
Chlorobenzene	3.11E-03	EPI	1.28E-01	7.30E-02	W9	8.70E-06	W9	2.34E+02	EPI	3.51E-01	CALC	4.98E+02	EPI	1.68E-04	9.57E+03	1.98E+03	2.68E+02	1
1-Chlorobutane	1.67E-02	EPI	6.85E-01	7.72E-02	W9	9.57E-06	W9	7.22E+01	EPI	1.08E-01	CALC	1.10E+03	EPI	1.43E-03	3.29E+03	6.79E+02	3.95E+02	1
Chlorodifluoromethane	4.06E-02	EPI	1.66E+00	1.01E-01	W9	1.28E-05	W9	3.18E+01	EPI	4.77E-02	CALC	2.77E+03	EPI	3.99E-03	1.97E+03	4.06E+02	1.13E+03	1
Chloroform	3.67E-03	EPI	1.50E-01	1.04E-01	W9	1.00E-05	W9	3.18E+01	EPI	4.77E-02	CALC	7.95E+03	EPI	6.39E-04	4.91E+03	1.01E+03	1.89E+03	1
Chloromethane	8.82E-03	EPI	3.62E-01	1.26E-01	W9	6.50E-06	W9	1.32E+01	EPI	1.98E-02	CALC	5.32E+03	EPI	1.89E-03	2.86E+03	5.90E+02	1.25E+03	1
b-Chloronaphthalene	3.20E-04	EPI	1.31E-02	4.92E-02	W9	8.79E-06	W9	2.48E+03	EPI	3.72E+00	CALC	1.17E+01	EPI	1.70E-06	9.53E+04	1.97E+04		1
o-Chloronitrobenzene	9.30E-06	EPI	3.81E-04	5.37E-02	W9	9.37E-06	W9	3.71E+02	EPI	5.56E-01	CALC	4.41E+02	EPI	7.83E-07				
p-Chloronitrobenzene	4.89E-06	EPI	2.00E-04	5.01E-02	W9	8.52E-06	W9	3.63E+02	EPI	5.45E-01	CALC	2.25E+02	EPI	6.07E-07				
2-Chlorophenol	1.12E-05	EPI	4.59E-04	6.60E-02	W9	9.46E-06	W9	3.07E+02	EPI	4.60E-01	CALC	2.85E+04	EPI	1.06E-06	1.21E+05	2.49E+04	1.80E+04	1
2-Chloropropane	1.75E-02	EPI	7.18E-01	8.88E-02	W9	1.01E-05	W9	3.18E+01	EPI	4.77E-02	CALC	3.10E+03	EPI	2.04E-03	2.75E+03	5.67E+02	9.37E+02	1
o-Chlorotoluene	3.57E-03	EPI	1.46E-01	6.28E-02	W9	8.70E-06	W9	3.83E+02	EPI	5.74E-01	CALC	3.74E+02	EPI	1.17E-04	1.15E+04	2.37E+03	2.86E+02	1
Chromium III										1.80E+06	SSG							
Chromium VI										1.90E+01	SSG							
Chromium (Total)										1.80E+06	SSG							
Chrysene	5.23E-06	EPI	2.14E-04	2.44E-02	W9	6.21E-06	W9	1.81E+05	EPI	2.71E+02	CALC	2.00E-03	EPI	1.10E-09				
Copper										3.50E+01	Baes							
Crotonaldehyde	1.94E-05	EPI	7.95E-04	1.02E-01	W9	1.18E-05	W9	1.79E+00	EPI	2.69E-03	CALC	1.81E+05	EPI	7.14E-06	4.64E+04	9.59E+03	3.19E+04	1
Cumene (isopropylbenzene)	1.15E-02	EPI	4.72E-01	6.50E-02	W9	7.10E-06	W9	6.98E+02	EPI	1.05E+00	CALC	6.13E+01	EPI	2.33E-04	8.12E+03	1.68E+03	7.81E+01	1
Cyanide	1.33E-04	EPI	5.45E-03	1.56E-01	W9	1.77E-05	W9	2.84E+00	EPI	4.26E-03	CALC	1.00E+06	EPI	5.01E-05	1.75E+04	3.62E+03	1.78E+05	1
Cyanogen	5.40E-03	EPI	2.21E-01	1.23E-01	W9	1.37E-05	W9	1.83E+00	EPI	2.74E-03	CALC	1.19E+08	EPI	1.32E-03	3.42E+03	7.07E+02		1
Cyanogen bromide	2.45E-02	EPI	1.00E+00	7.32E-02	W9	9.25E-06	W9	4.67E+00	EPI	7.01E-03	CALC	1.08E+05	EPI	2.42E-03	2.52E+03	5.21E+02		1
Cyanogen chloride	2.45E-02	EPI	1.00E+00	1.29E-01	W9	1.57E-05	W9	4.67E+00	EPI	7.01E-03	CALC	1.58E+05	EPI	4.28E-03	1.90E+03	3.92E+02		1
DDD	6.60E-06	EPI	2.71E-04	2.27E-02	W9	5.79E-06	W9	1.18E+05	EPI	1.76E+02	CALC	9.00E-02	EPI	1.64E-09				
DDE	4.16E-05	EPI	1.71E-03	2.38E-02	W9	5.87E-06	W9	1.18E+05	EPI	1.76E+02	CALC	4.00E-02	EPI	3.55E-09				
DDT	8.32E-06	EPI	3.41E-04	1.99E-02	W9	4.95E-06	W9	1.69E+05	EPI	2.53E+02	CALC	5.50E-03	EPI	1.04E-09				
Dibenz(a,h)anthracene	1.41E-07	EPI	5.78E-06	2.11E-02	W9	5.24E-06	W9	1.91E+06	EPI	2.87E+03	CALC	1.03E-03	EPI	7.30E-11				
1,2-Dibromo-3-chloropropane	1.47E-04	EPI	6.03E-03	2.68E-02	W9	7.02E-06	W9	1.16E+02	EPI	1.74E-01	CALC	1.23E+03	EPI	5.30E-06	5.39E+04	1.11E+04	4.28E+02	1
Dibromochloromethane	7.83E-04	EPI	3.21E-02	3.66E-02	W9	1.05E-05	W9	3.18E+01	EPI	4.77E-02	CALC	2.70E+03	EPI	5.25E-05	1.71E+04	3.54E+03	6.07E+02	1
1,2-Dibromoethane	6.50E-04	EPI	2.67E-02	4.30E-02	W9	8.44E-06	W9	3.96E+01	EPI	5.94E-02	CALC	3.91E+03	EPI	4.85E-05	1.78E+04	3.68E+03	9.22E+02	1
1,4-Dichloro-2-butene	6.64E-04	EPI	2.72E-02	7.25E-02	W9	8.12E-06	W9	1.32E+02	EPI	1.97E-01	CALC	5.80E+02	EPI	5.21E-05	1.72E+04	3.55E+03	2.17E+02	1

Chemical	**H (atm-m^3/mole)**	**Ref.**	**H' (unitless)**	**D_a (cm^2/s)**	**Ref.**	**D_w (cm^2/s)**	**Ref.**	**K_{oc} (cm^3/g)**	**Ref.**	**K_d (cm^3/g)**	**Ref.**	**S (mg/L-water)**	**Ref.**	**D_A (cm^2/s)**	**Res/Ind. VF (m^3/kg)**	**Comm/ VF (m^3/kg)**	**Soil SAT (mg/kg)**	**VOC**
1,2-Dichlorobenzene	1.92E-03	EPI	7.87E-02	6.90E-02	W9	7.90E-06	W9	3.83E+02	EPI	5.74E-01	CALC	8.00E+01	EPI	7.00E-05	1.48E+04	3.06E+03	6.05E+01	1
1,4-Dichlorobenzene	2.41E-03	EPI	9.88E-02	6.90E-02	W9	7.90E-06	W9	3.75E+02	EPI	5.63E-01	CALC	8.13E+01	EPI	8.88E-05	1.32E+04	2.72E+03		1
3,3-Dichlorobenzidine	2.84E-11	EPI	1.16E-09	2.59E-02	W9	6.74E-06	W9	3.19E+03	EPI	4.79E+00	CALC	3.10E+00	EPI	5.40E-08				
Dichlorodifluoromethane	3.43E-01	EPI	1.41E+01	6.65E-02	W9	9.92E-06	W9	4.39E+01	EPI	6.58E-02	CALC	2.80E+02	EPI	4.94E-03	1.77E+03	3.65E+02	5.13E+02	1
1,1-Dichloroethane	5.62E-03	EPI	2.30E-01	7.42E-02	W9	1.05E-05	W9	3.18E+01	EPI	4.77E-02	CALC	5.04E+03	EPI	6.72E-04	4.79E+03	9.89E+02	1.25E+03	1
1,2-Dichloroethane	1.18E-03	EPI	4.84E-02	1.04E-01	W9	9.90E-06	W9	3.96E+01	EPI	5.94E-02	CALC	5.10E+03	EPI	2.06E-04	8.64E+03	1.78E+03	1.21E+03	1
cis-1,2-Dichloroethene	4.08E-03	EPI	1.67E-01	8.86E-02	W9	1.13E-05	W9	3.96E+01	EPI	5.94E-02	CALC	3.50E+03	EPI	5.72E-04	5.19E+03	1.07E+03	8.81E+02	1
trans-1,2-Dichloroethene	4.08E-03	EPI	1.67E-01	7.03E-02	W9	1.19E-05	W9	3.96E+01	EPI	5.94E-02	CALC	3.50E+03	EPI	4.55E-04	5.82E+03	1.20E+03	8.81E+02	1
1,1-Dichloroethene	2.61E-02	EPI	1.07E+00	9.00E-02	W9	1.04E-05	W9	3.18E+01	EPI	4.77E-02	CALC	2.42E+03	EPI	2.73E-03	2.38E+03	4.91E+02	8.28E+02	1
2,4-Dichlorophenol	4.29E-06	EPI	1.76E-04	4.89E-02	W9	8.77E-06	W9	4.92E+02	EPI	7.38E-01	CALC	4.50E+03	EPI	4.74E-07				
1,2-Dichloropropane	2.82E-03	EPI	1.16E-01	7.82E-02	W9	8.73E-06	W9	6.07E+01	EPI	9.11E-02	CALC	2.80E+03	EPI	3.17E-04	6.97E+03	1.44E+03	7.77E+02	1
1,3-Dichloropropene	3.55E-03	EPI	1.46E-01	6.26E-02	W9	1.00E-05	W9	7.22E+01	EPI	1.08E-01	CALC	2.80E+03	EPI	2.98E-04	7.20E+03	1.49E+03	8.35E+02	1
Dicyclopentadiene	6.25E-02	EPI	2.56E+00	5.57E-02	W9	7.75E-06	W9	1.51E+03	EPI	2.27E+00	CALC	5.19E+01	EPI	5.06E-04	5.52E+03	1.14E+03		1
Dieldrin	1.00E-05	EPI	4.10E-04	1.92E-02	W9	4.74E-06	W9	2.01E+04	EPI	3.01E+01	CALC	2.50E-01	EPI	8.73E-09				
Diethyl phthalate	6.10E-07	EPI	2.50E-05	2.49E-02	W9	6.35E-06	W9	1.05E+02	EPI	1.57E-01	CALC	1.08E+03	EPI	7.81E-07				
Di-n-butyl phthalate (Dibutyl phthalate)	1.81E-06	EPI	7.42E-05	4.38E-02	W9	7.86E-06	W9	1.16E+03	EPI	1.74E+00	CALC	1.12E+01	EPI	1.80E-07				
2,4-Dimethylphenol	9.51E-07	EPI	3.90E-05	6.43E-02	W9	8.69E-06	W9	4.92E+02	EPI	7.38E-01	CALC	7.87E+03	EPI	4.06E-07				
4,6-Dinitro-o-cresol	1.40E-06	EPI	5.74E-05	2.76E-02	W9	6.91E-06	W9	7.54E+02	EPI	1.13E+00	CALC	1.98E+02	EPI	2.22E-07				
2,4-Dinitrophenol	8.60E-08	EPI	3.53E-06	2.73E-02	W9	9.06E-06	W9	4.61E+02	EPI	6.91E-01	CALC	2.79E+03	EPI	4.17E-07				
2,4-Dinitrotoluene	5.40E-08	EPI	2.21E-06	2.03E-01	W9	7.06E-06	W9	5.76E+02	EPI	8.63E-01	CALC	2.00E+02	EPI	2.75E-07				
2,6-Dintitrotoluene	7.47E-07	EPI	3.06E-05	3.70E-02	W9	7.76E-06	W9	5.87E+02	EPI	8.81E-01	CALC	3.52E+02	EPI	3.03E-07				
2,4/2,6-Dintrotoluene Mixture	9.26E-08	EPI	3.80E-06	3.75E-02	W9	7.89E-06	W9	5.87E+02	EPI	8.81E-01	CALC	2.70E+02	EPI	2.99E-07				
1,4-Dioxane	4.80E-06	EPI	1.97E-04	2.29E-01	W9	1.02E-05	W9	2.63E+00	EPI	3.95E-03	CALC	1.00E+06	EPI	4.75E-06				
1,2-Diphenylhydrazine	4.78E-07	EPI	1.96E-05	3.47E-02	W9	7.36E-06	W9	1.51E+03	EPI	2.26E+00	CALC	2.21E+02	EPI	1.23E-07				
Endosulfan	6.50E-05	EPI	2.67E-03	1.85E-02	W9	4.55E-06	W9	6.76E+03	EPI	1.01E+01	CALC	4.50E-01	EPI	6.38E-08				
Endrin	1.00E-05	EPI	4.10E-04	1.92E-02	W9	4.74E-06	W9	2.01E+04	EPI	3.01E+01	CALC	2.50E-01	EPI	8.73E-09				
Epichlorohydrin	3.04E-05	EPI	1.25E-03	8.60E-02	W9	9.80E-06	W9	9.91E+00	EPI	1.49E-02	CALC	6.59E+04	EPI	7.58E-06	4.51E+04	9.31E+03	1.24E+04	1
Ethyl acetate	1.34E-04	EPI	5.49E-03	7.32E-02	W9	9.70E-06	W9	5.58E+00	EPI	8.37E-03	CALC	8.00E+04	EPI	2.35E-05	2.56E+04	5.29E+03	1.46E+04	1
Ethyl acrylate	3.39E-04	EPI	1.39E-02	7.70E-02	W9	8.60E-06	W9	1.07E+01	EPI	1.60E-02	CALC	1.50E+04	EPI	5.61E-05	1.66E+04	3.42E+03	2.86E+03	1
Ethyl chloride	1.11E-02	EPI	4.55E-01	2.71E-01	W9	1.15E-05	W9	2.17E+01	EPI	3.26E-02	CALC	6.71E+03	EPI	4.64E-03	1.82E+03	3.76E+02	1.73E+03	1
Ethyl ether	1.23E-03	EPI	5.04E-02	7.82E-02	W9	8.61E-06	W9	9.70E+00	EPI	1.45E-02	CALC	6.04E+04	EPI	1.99E-04	8.79E+03	1.82E+03	1.17E+04	1
Ethyl methacrylate	5.73E-04	EPI	2.35E-02	6.53E-02	W9	8.37E-06	W9	1.67E+01	EPI	2.50E-02	CALC	5.40E+03	EPI	7.56E-05	1.43E+04	2.95E+03	1.09E+03	1
Ethylbenzene	7.88E-03	EPI	3.23E-01	7.50E-02	W9	7.80E-06	W9	4.46E+02	EPI	6.69E-01	CALC	1.69E+02	EPI	2.67E-04	7.59E+03	1.57E+03	1.49E+02	1
Ethylene oxide	1.48E-04	EPI	6.07E-03	1.04E-01	W9	1.45E-05	W9	3.24E+00	EPI	4.86E-03	CALC	1.00E+06	EPI	3.74E-05	2.03E+04	4.19E+03	1.79E+05	1
Fluoranthene	8.86E-06	EPI	3.63E-04	2.51E-02	W9	6.35E-06	W9	5.55E+04	EPI	8.32E+01	CALC	2.60E-01	EPI	4.09E-09				
Fluorene	9.62E-05	EPI	3.94E-03	4.40E-02	W9	7.88E-06	W9	9.16E+03	EPI	1.37E+01	CALC	1.69E+00	EPI	1.43E-07	3.28E+05	6.77E+04		1

Chemical	**H (atm-m^3/mole)**	**Ref.**	**H' (unitless)**	**D_a (cm^2/s)**	**Ref.**	**D_w (cm^2/s)**	**Ref.**	**K_{oc} (cm^3/g)**	**Ref.**	**K_d (cm^3/g)**	**Ref.**	**S (mg/L-water)**	**Ref.**	**D_A (cm^2/s)**	**Res/Ind. VF (m^3/kg)**	**Comm/ VF (m^3/kg)**	**Soil SAT (mg/kg)**	**VOC**
Fluoride										1.50E+02	Baes							
Furan	5.40E-03	EPI	2.21E-01	1.04E-01	W9	1.22E-05	W9	8.00E+01	EPI	1.20E-01	CALC	1.00E+04	EPI	7.02E-04	4.68E+03	9.68E+02	3.18E+03	1
Heptachlor	2.94E-04	EPI	1.21E-02	2.23E-02	W9	5.69E-06	W9	4.13E+04	EPI	6.19E+01	CALC	1.80E-01	EPI	4.56E-08				
Hexachlorobenzene	1.70E-03	EPI	6.97E-02	5.42E-02	W9	5.91E-06	W9	6.20E+03	EPI	9.29E+00	CALC	6.20E-03	EPI	3.89E-06				
Hexachloro-1,3-butadiene	1.03E-02	EPI	4.22E-01	5.61E-02	W9	6.16E-06	W9	8.45E+02	EPI	1.27E+00	CALC	3.20E+00	EPI	1.54E-04				
Hexachlorocyclopentadiene	2.70E-02	EPI	1.11E+00	2.79E-02	W9	7.21E-06	W9	1.40E+03	EPI	2.11E+00	CALC	1.80E+00	EPI	1.25E-04				
Hexachloroethane	3.89E-03	EPI	1.59E-01	2.50E-03	W9	6.80E-06	W9	1.97E+02	EPI	2.95E-01	CALC	5.00E+01	EPI	8.50E-06				
n-Hexane	1.80E+00	EPI	7.38E+01	2.00E-01	W9	7.77E-06	W9	1.32E+02	EPI	1.97E-01	CALC	9.50E+00	EPI	1.64E-02	9.70E+02	2.00E+02	8.30E+01	1
HMX	8.67E-10	EPI	3.55E-08	2.69E-02	W9	7.15E-06	W9	5.32E+02	EPI	7.97E-01	CALC	9.44E+03	EPI	2.93E-07				
Hydrazine anhydride								1.60E-02	EPI	2.39E-05	CALC							
Hydrogen cyanide	1.33E-04	EPI	5.45E-03	1.97E-01	W9	1.82E-05	W9	2.84E+00	EPI	4.26E-03	CALC	1.00E+06	EPI	6.25E-05	1.57E+04	3.24E+03	1.78E+05	1
Indeno(1,2,3-c,d)pyrene	3.48E-07	EPI	1.43E-05	2.25E-02	W9	5.66E-06	W9	1.95E+06	EPI	2.93E+03	CALC	1.90E-04	EPI	7.79E-11				
Iron										2.50E+01	Baes							
Isobutanol (Isobutyl alcohol)	9.78E-06	EPI	4.01E-04	8.60E-02	W9	9.30E-06	W9	2.92E+00	EPI	4.38E-03	CALC	8.50E+04	EPI	3.96E-06	6.24E+04	1.29E+04		1
Isophorone	6.64E-06	EPI	2.72E-04	6.23E-02	W9	6.76E-06	W9	6.52E+01	EPI	9.77E-02	CALC	1.20E+04	EPI	1.60E-06				
Lead										9.00E+02	Baes							
Lead (tetraethyl-)	5.68E-01	EPI	2.33E+01	2.46E-02	W9	6.40E-06	W9	6.48E+02	EPI	9.72E-01	CALC	2.90E-01	EPI	1.47E-03				
Maleic hydrazide	2.65E-11	EPI	1.09E-09	5.81E-02	W9	8.14E-06	W9	3.30E+00	EPI	4.95E-03	CALC	4.51E+03	EPI	1.81E-06				
Manganese										6.50E+01	Baes							
Mercury (elemental)	1.14E-02	SSG	4.67E-01	3.07E-02	SSG	6.30E-06	SSG			5.20E+01	SSG	6.00E-02	EPI	2.67E-06	7.60E+04	1.57E+04	3.13E+00	1
Mercury (methyl)	7.22E-03	EPI	2.96E-01	2.40E-02	W9	6.04E-06	W9	1.32E+01	EPI	1.98E-02	CALC	3.13E+04	EPI					
Mercury Chloride (Mercury Salts)										5.20E+01	Baes							
Methacrylonitrile	2.47E-04	EPI	1.01E-02	1.12E-01	W9	1.32E-05	W9	1.31E+01	EPI	1.96E-02	CALC	2.54E+04	EPI	5.95E-05	1.61E+04	3.32E+03	4.93E+03	1
Methomyl	1.97E-11	EPI	8.08E-10	2.84E-02	W9	6.47E-06	W9	1.00E+01	EPI	1.50E-02	CALC	5.80E+04	EPI	1.36E-06				
Methyl acetate	1.15E-04	EPI	4.72E-03	9.57E-02	W9	1.10E-05	W9	3.06E+00	EPI	4.60E-03	CALC	2.43E+05	EPI	2.70E-05	2.39E+04	4.94E+03	4.34E+04	1
Methyl acrylate	1.99E-04	EPI	8.16E-03	8.66E-02	W9	1.02E-05	W9	5.84E+00	EPI	8.77E-03	CALC	4.94E+04	EPI	3.96E-05	1.97E+04	4.07E+03	9.04E+03	1
Methyl isobutyl ketone	1.38E-04	EPI	5.66E-03	7.50E-02	W9	7.80E-06	W9	1.26E+01	EPI	1.89E-02	CALC	1.90E+04	EPI	2.29E-05	2.59E+04	5.35E+03	3.66E+03	1
Methyl methacrylate	3.19E-04	EPI	1.31E-02	7.70E-02	W9	8.60E-06	W9	9.14E+00	EPI	1.37E-02	CALC	1.50E+04	EPI	5.36E-05	1.70E+04	3.50E+03	2.83E+03	1
Methyl styrene (alpha)	2.55E-03	EPI	1.05E-01	2.64E-01	W9	1.14E-05	W9	6.98E+02	EPI	1.05E+00	CALC	8.90E+01	EPI	2.18E-04	8.42E+03	1.74E+03	1.10E+02	1
Methyl styrene (mixture)	3.05E-03	EPI	1.25E-01	6.55E-02	W9	8.66E-06	W9	7.16E+02	EPI	1.07E+00	CALC	8.90E+01	EPI	6.32E-05	1.56E+04	3.22E+03	1.12E+02	1
Methylcyclohexane	4.30E-01	EPI	1.76E+01	7.35E-02	W9	8.52E-06	W9	2.34E+02	EPI	3.51E-01	CALC	1.40E+01	EPI	4.98E-03	1.76E+03	3.63E+02	3.53E+01	1
Methylene bromide (Dibromomethane)	8.22E-04	EPI	3.37E-02	4.30E-02	W9	8.44E-06	W9	2.17E+01	EPI	3.26E-02	CALC	1.19E+04	EPI	6.86E-05	1.50E+04	3.10E+03	2.50E+03	1
Methylene chloride	3.25E-03	EPI	1.33E-01	1.01E-01	W9	1.17E-05	W9	2.17E+01	EPI	3.26E-02	CALC	1.30E+04	EPI	5.92E-04	5.10E+03	1.05E+03	2.87E+03	1
Molybdenum										2.00E+01	Baes							
Naphthalene	4.40E-04	EPI	1.80E-02	5.90E-02	W9	7.50E-06	W9	1.54E+03	EPI	2.32E+00	CALC	3.10E+01	EPI	4.26E-06	6.01E+04	1.24E+04		1
Nickel										6.50E+01	SSG							

Chemical	**H (atm-m^3/mole)**	**Ref.**	**H' (unitless)**	**D_a (cm^2/s)**	**Ref.**	**D_w (cm^2/s)**	**Ref.**	**K_{oc} (cm^3/g)**	**Ref.**	**K_d (cm^3/g)**	**Ref.**	**S (mg/L-water)**	**Ref.**	**D_A (cm^2/s)**	**Res/Ind. VF (m^3/kg)**	**Comm/ VF (m^3/kg)**	**Soil SAT (mg/kg)**	**VOC**
Nitrate										5.00E-01	Baes							
Nitrite										5.00E-01	Baes							
Nitrobenzene	2.40E-05	EPI	9.84E-04	7.60E-02	W9	8.60E-06	W9	2.26E+02	EPI	3.40E-01	CALC	2.09E+03	EPI	2.08E-06	8.61E+04	1.78E+04	1.07E+03	1
Nitroglycerin	8.66E-08	EPI	3.55E-06	2.90E-02	W9	7.76E-06	W9	1.16E+02	EPI	1.74E-01	CALC	1.38E+03	EPI	8.91E-07				
N-Nitrosodiethylamine	3.63E-06	EPI	1.49E-04	7.65E-02	W9	9.51E-06	W9	8.29E+01	EPI	1.24E-01	CALC	1.06E+05	EPI	1.64E-06				
N-Nitrosodimethylamine	1.82E-06	EPI	7.46E-05	1.04E-01	W9	1.00E-05	W9	2.28E+01	EPI	3.42E-02	CALC	1.00E+06	EPI	2.28E-06				
N-Nitrosodi-*n*-butylamine	1.32E-05	EPI	5.41E-04	4.42E-02	W9	7.27E-06	W9	9.15E+02	EPI	1.37E+00	CALC	1.27E+03	EPI	3.37E-07	2.14E+05	4.42E+04		1
N-Nitrosodiphenylamine	1.21E-06	EPI	4.96E-05	2.83E-02	W9	7.19E-06	W9	2.63E+03	EPI	3.95E+00	CALC	3.50E+01	EPI	7.26E-08				
N-Nitrosopyrrolidine	4.89E-08	EPI	2.00E-06	8.20E-02	W9	1.04E-05	W9	9.19E+01	EPI	1.38E-01	CALC	1.00E+06	EPI	1.33E-06				
m-Nitrotoluene	9.30E-06	EPI	3.81E-04	5.86E-02	W9	8.64E-06	W9	3.63E+02	EPI	5.45E-01	CALC	5.00E+02	EPI	7.79E-07				
o-Nitrotoluene	1.25E-05	EPI	5.13E-04	5.87E-02	W9	8.67E-06	W9	3.71E+02	EPI	5.56E-01	CALC	6.50E+02	EPI	8.72E-07	1.33E+05	2.75E+04	4.74E+02	1
p-Nitrotoluene	5.63E-06	EPI	2.31E-04	5.85E-02	W9	8.61E-06	W9	3.63E+02	EPI	5.45E-01	CALC	4.42E+02	EPI	6.59E-07				
Pentachlorobenzene	7.03E-04	EPI	2.88E-02	5.70E-02	W9	6.30E-06	W9	3.71E+03	EPI	5.56E+00	CALC	8.31E-01	EPI	2.82E-06				
Pentachlorophenol	2.45E-08	EPI	1.00E-06	5.60E-02	W9	6.10E-06	W9	4.96E+03	EPI	7.44E+00	CALC	1.40E+01	EPI	3.19E-08				
Perchlorate										2.50E-01	Baes							
Phenanthrene	4.23E-05	EPI	1.73E-03	3.75E-02	W9	7.47E-06	W9	1.67E+04	EPI	2.50E+01	CALC	1.15E+00	EPI	3.68E-08	6.47E+05	1.34E+05		1
Phenol	3.33E-07	EPI	1.37E-05	8.20E-02	W9	9.10E-06	W9	1.87E+02	EPI	2.81E-01	CALC	8.28E+04	EPI	8.20E-07				
Polychlorinatedbiphenyls																		
Aroclor 1016	2.00E-04	EPI	8.20E-03	3.25E-02	W9	7.26E-06	W9	4.77E+04	EPI	7.16E+01	CALC	4.20E-01	EPI	4.00E-08				
Aroclor 1221	7.36E-04	EPI	3.02E-02	3.25E-02	W9	7.26E-06	W9	8.40E+03	EPI	1.26E+01	CALC	1.45E+00	EPI	7.67E-07	1.42E+05	2.93E+04	1.85E+01	1
Aroclor 1232	7.36E-04	EPI	3.02E-02	2.56E-02	W9	6.56E-06	W9	8.40E+03	EPI	1.26E+01	CALC	1.45E+00	EPI	6.07E-07	1.59E+05	3.29E+04	1.85E+01	1
Aroclor 1242	1.90E-04	EPI	7.79E-03	2.37E-02	W9	6.02E-06	W9	7.81E+04	EPI	1.17E+02	CALC	2.77E-01	EPI	1.73E-08				
Aroclor 1248	4.40E-04	EPI	1.80E-02	2.16E-02	W9	5.50E-06	W9	7.65E+04	EPI	1.15E+02	CALC	1.00E-01	EPI	3.48E-08				
Aroclor 1254	2.83E-04	EPI	1.16E-02	2.02E-02	W9	5.00E-06	W9	1.31E+05	EPI	1.96E+02	CALC	3.40E-03	EPI	1.26E-08				
Aroclor 1260	3.36E-04	EPI	1.38E-02	2.28E-02	W9	5.83E-06	W9	3.50E+05	EPI	5.25E+02	CALC	1.14E-02	EPI	6.24E-09				
2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB 170)	9.00E-06	EPI	3.69E-04	1.78E-02	W9	4.19E-06	W9	3.57E+05	EPI	5.35E+02	CALC	3.47E-03	EPI	4.30E-10				
2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB 180)	1.00E-05	EPI	4.10E-04	1.78E-02	W9	4.19E-06	W9	3.50E+05	EPI	5.25E+02	CALC	3.85E-03	EPI	4.52E-10				
2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB 189)	5.07E-05	EPI	2.08E-03	1.78E-02	W9	4.19E-06	W9	3.50E+05	EPI	5.25E+02	CALC	7.53E-04	EPI	9.99E-10				
2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167)	6.85E-05	EPI	2.81E-03	1.82E-02	W9	4.43E-06	W9	2.09E+05	EPI	3.14E+02	CALC	2.23E-03	EPI	2.14E-09				
2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 157)	6.85E-05	EPI	2.81E-03	1.82E-02	W9	4.43E-06	W9	2.14E+05	EPI	3.20E+02	CALC	1.72E-03	EPI	2.09E-09				
2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156)	1.43E-04	EPI	5.86E-03	1.82E-02	W9	4.43E-06	W9	2.14E+05	EPI	3.20E+02	CALC	5.33E-03	EPI	3.78E-09				
3,3',4,4',5,5'-Hexachlorobiphenyl (PCB 169)	6.85E-05	EPI	2.81E-03	1.82E-02	W9	4.43E-06	W9	2.09E+05	EPI	3.14E+02	CALC	5.10E-04	EPI	2.14E-09				
2',3,4,4',5-Pentachlorobiphenyl (PCB 123)	9.24E-05	EPI	3.79E-03	1.92E-02	W9	4.70E-06	W9	1.31E+05	EPI	1.96E+02	CALC	1.60E-02	EPI	4.55E-09				
2',3',4,4',5-Pentachlorobiphenyl (PCB 118)	2.88E-04	EPI	1.18E-02	1.92E-02	W9	4.70E-06	W9	1.28E+05	EPI	1.92E+02	CALC	1.34E-02	EPI	1.24E-08				

Chemical	**H (atm-m^3/mole)**	**Ref.**	**H' (unitless)**	**D_a (cm^2/s)**	**Ref.**	**D_w (cm^2/s)**	**Ref.**	**K_{oc} (cm^3/g)**	**Ref.**	**K_d (cm^3/g)**	**Ref.**	**S (mg/L-water)**	**Ref.**	**D_A (cm^2/s)**	**Res/Ind. VF (m^3/kg)**	**Comm/ VF (m^3/kg)**	**Soil SAT (mg/kg)**	**VOC**
2',3,3',4,4'-Pentachlorobiphenyl (PCB 105)	2.83E-04	EPI	1.16E-02	1.92E-02	W9	4.70E-06	W9	1.31E+05	EPI	1.96E+02	CALC	3.40E-03	EPI	1.20E-08				
2,3,4,4',5-Pentachlorobiphenyl (PCB 114)	9.24E-05	EPI	3.79E-03	1.92E-02	W9	4.70E-06	W9	1.31E+05	EPI	1.96E+02	CALC	1.60E-02	EPI	4.55E-09				
3,3',4,4',5-Pentachlorobiphenyl (PCB 126)	9.24E-05	EPI	3.79E-03	1.92E-02	W9	4.70E-06	W9	1.28E+05	EPI	1.92E+02	CALC	9.39E-03	EPI	4.64E-09				
3,3',4,4'-Tetrachlorobiphenyl (PCB 77)	9.40E-06	EPI	3.85E-04	2.04E-02	W9	5.03E-06	W9	7.81E+04	EPI	1.17E+02	CALC	5.69E-04	EPI	2.35E-09				
3,4,4',5-Tetrachlorobiphenyl (PCB 81)	1.25E-04	EPI	5.13E-03	2.04E-02	W9	5.03E-06	W9	7.81E+04	EPI	1.17E+02	CALC	5.32E-02	EPI	1.03E-08				
Propylene oxide	6.96E-05	EPI	2.85E-03	1.04E-01	W9	1.00E-05	W9	5.19E+00	EPI	7.79E-03	CALC	5.90E+05	EPI	1.80E-05	2.92E+04	6.04E+03	1.07E+05	1
Pyrene	1.19E-05	EPI	4.88E-04	2.77E-02	W9	7.24E-06	W9	5.43E+04	EPI	8.15E+01	CALC	1.35E-01	EPI	5.12E-09	1.73E+06	3.58E+05		1
RDX	2.00E-11	EPI	8.20E-10	3.11E-02	W9	8.49E-06	W9	8.91E+01	EPI	1.34E-01	CALC	5.97E+01	EPI	1.10E-06				
Selenium										5.00E+00	SSG							
Silver										8.30E+00	SSG							
Strontium										3.50E+01	Baes							
Styrene	2.75E-03	EPI	1.13E-01	7.10E-02	W9	8.00E-06	W9	4.46E+02	EPI	6.69E-01	CALC	3.10E+02	EPI	9.11E-05	1.30E+04	2.69E+03	2.65E+02	1
Sulfolane	4.85E-06	EPI	1.99E-04	7.13E-02	W9	9.85E-06	W9	9.08E+00	EPI	1.36E-02	CALC	2.93E+05	EPI	2.83E-06				
2,3,7,8-TCDD	5.00E-05	EPI	2.05E-03	1.04E-01	W9	5.60E-06	W9	2.49E+05	EPI	3.74E+02	CALC	2.00E-04	EPI	6.12E-09				
2,3,7,8-TCDF	1.67E-05	EPI	6.85E-04	2.35E-02	W9	6.10E-06	W9	1.40E+05	EPI	2.09E+02	CALC	6.92E-04	EPI	1.90E-09				
1,2,4,5-Tetrachlorobenzene	1.00E-03	EPI	4.10E-02	3.19E-02	W9	8.75E-06	W9	2.22E+03	EPI	3.33E+00	CALC	5.95E-01	EPI	3.71E-06				
1,1,1,2-Tetrachloroethane	2.50E-03	EPI	1.03E-01	7.10E-02	W9	7.90E-06	W9	8.60E+01	EPI	1.29E-01	CALC	1.07E+03	EPI	2.26E-04	8.26E+03	1.71E+03	3.36E+02	1
1,1,2,2-Tetrachloroethane	3.67E-04	EPI	1.50E-02	7.10E-02	W9	7.90E-06	W9	9.49E+01	EPI	1.42E-01	CALC	2.83E+03	EPI	3.36E-05	2.14E+04	4.42E+03	8.98E+02	1
Tetrachloroethene	1.77E-02	EPI	7.26E-01	7.20E-02	W9	8.20E-06	W9	9.49E+01	EPI	1.42E-01	CALC	2.06E+02	EPI	1.27E-03	3.48E+03	7.19E+02	8.20E+01	1
Tetryl (Trinitrophenylmethylnitramine)	2.71E-09	EPI	1.11E-07	2.06E-02	W9	5.08E-06	W9	4.61E+03	EPI	6.91E+00	CALC	7.40E+01	EPI	2.85E-08				
Thallium										7.10E+01	SSG							
Toluene	6.64E-03	EPI	2.72E-01	8.70E-02	W9	8.60E-06	W9	2.34E+02	EPI	3.51E-01	CALC	5.26E+02	EPI	4.14E-04	6.10E+03	1.26E+03	2.92E+02	1
Toxaphene	6.00E-06	EPI	2.46E-04	2.16E-02	W9	5.51E-06	W9	7.72E+04	EPI	1.16E+02	CALC	2.91E-02	EPI	2.33E-09				
Tribromomethane (Bromoform)	5.35E-04	EPI	2.19E-02	1.49E-02	W9	1.03E-05	W9	3.18E+01	EPI	4.77E-02	CALC	3.10E+03	EPI	1.60E-05				
1,1,2-Trichloro-1,2,2-trifluoroethane	5.26E-01	EPI	2.16E+01	7.80E-02	W9	8.20E-06	W9	1.97E+02	EPI	2.95E-01	CALC	1.70E+02	EPI	5.60E-03	1.66E+03	3.43E+02	4.95E+02	1
1,2,4-Trichlorobenzene	1.42E-03	EPI	5.82E-02	3.00E-02	W9	8.23E-06	W9	1.36E+03	EPI	2.03E+00	CALC	4.90E+01	EPI	7.79E-06	4.45E+04	9.18E+03	1.08E+02	1
1,1,1-Trichloroethane	1.72E-02	EPI	7.05E-01	7.80E-02	W9	8.80E-06	W9	4.39E+01	EPI	6.58E-02	CALC	1.29E+03	EPI	1.67E-03	3.04E+03	6.27E+02	4.12E+02	1
1,1,2-Trichloroethane	8.24E-04	EPI	3.38E-02	7.80E-02	W9	8.80E-06	W9	6.07E+01	EPI	9.11E-02	CALC	1.10E+03	EPI	9.65E-05	1.26E+04	2.61E+03	2.95E+02	1
Trichloroethylene	9.85E-03	EPI	4.04E-01	7.90E-02	W9	9.10E-06	W9	6.07E+01	EPI	9.11E-02	CALC	1.28E+03	EPI	9.98E-04	3.93E+03	8.12E+02	3.97E+02	1
Trichlorofluoromethane	9.70E-02	EPI	3.98E+00	8.70E-02	W9	9.70E-06	W9	4.39E+01	EPI	6.58E-02	CALC	1.10E+03	EPI	4.86E-03	1.78E+03	3.68E+02	7.59E+02	1
2,4,5-Trichlorophenol	1.62E-06	EPI	6.64E-05	2.91E-02	W9	7.03E-06	W9	1.78E+03	EPI	2.67E+00	CALC	1.20E+03	EPI	1.05E-07				
2,4,6-Trichlorophenol	2.60E-06	EPI	1.07E-04	2.61E-02	W9	6.30E-06	W9	1.78E+03	EPI	2.67E+00	CALC	8.00E+02	EPI	9.77E-08				
1,1,2-Trichloropropane	3.17E-04	EPI	1.30E-02	5.78E-02	W9	9.32E-06	W9	9.49E+01	EPI	1.42E-01	CALC	1.90E+03	EPI	2.41E-05	2.53E+04	5.22E+03	6.03E+02	1
1,2,3-Trichloropropane	3.43E-04	EPI	1.41E-02	7.10E-02	W9	7.90E-06	W9	1.16E+02	EPI	1.74E-01	CALC	1.75E+03	EPI	2.87E-05	2.32E+04	4.79E+03	6.10E+02	1
Triethylamine	1.49E-04	EPI	6.11E-03	8.81E-02	W9	7.88E-06	W9	5.08E+01	EPI	7.62E-02	CALC	6.86E+04	EPI	2.21E-05	2.64E+04	5.45E+03	1.72E+04	1
2,4,6-Trinitrotoluene	2.08E-08	EPI	8.53E-07	2.94E-02	W9	7.90E-06	W9	2.81E+03	EPI	4.22E+00	CALC	1.15E+02	EPI	7.15E-08				

Chemical	**H (atm-m^3/mole)**	**Ref.**	**H' (unitless)**	**D_a (cm^2/s)**	**Ref.**	**D_w (cm^2/s)**	**Ref.**	**K_{oc} (cm^3/g)**	**Ref.**	**K_d (cm^3/g)**	**Ref.**	**S (mg/L-water)**	**Ref.**	**D_A (cm^2/s)**	**Res/Ind. VF (m^3/kg)**	**Comm/ VF (m^3/kg)**	**Soil SAT (mg/kg)**	**VOC**
Uranium (soluable salts)										4.50E+02	Baes							
Vanadium										1.00E+03	SSG							
Vinyl acetate	5.11E-04	EPI	2.10E-02	8.50E-02	W9	9.20E-06	W9	5.58E+00	EPI	8.37E-03	CALC	2.00E+04	EPI	9.57E-05	1.27E+04	2.62E+03	3.68E+03	1
Vinyl bromide	1.23E-02	EPI	5.04E-01	8.69E-02	W9	1.17E-05	W9	2.17E+01	EPI	3.26E-02	CALC	5.08E+03	EPI	1.62E-03	3.09E+03	6.38E+02	1.34E+03	1
Vinyl chloride	2.78E-02	EPI	1.14E+00	1.06E-01	W9	1.23E-05	W9	2.17E+01	EPI	3.26E-02	CALC	8.80E+03	EPI	3.50E-03	2.10E+03	4.34E+02	2.95E+03	1
m-Xylene	7.18E-03	EPI	2.94E-01	7.00E-02	W9	7.80E-06	W9	3.75E+02	EPI	5.63E-01	CALC	1.61E+02	EPI	2.60E-04	7.70E+03	1.59E+03	1.24E+02	1
o-Xylene	5.18E-03	EPI	2.12E-01	8.70E-02	W9	1.00E-05	W9	3.83E+02	EPI	5.74E-01	CALC	1.06E+02	EPI	2.33E-04	8.14E+03	1.68E+03	8.18E+01	1
Xylenes	5.18E-03	EPI	2.12E-01	7.37E-02	W9	9.34E-06	W9	3.83E+02	EPI	5.74E-01	CALC	1.06E+02	EPI	1.97E-04	8.84E+03	1.83E+03	8.18E+01	1
Zinc										6.20E+01	SSG							

Notes:

MW – Molecular weight	H – Henry's Law Constant
H' – Dimensionless Henry's Law Constant	D_a – Diffusivity in air
D_w – Diffusivity in water	K_{oc} – Soil organic carbon partition coefficient
K_d – Soil-water partition coefficient	S - Solubility in water
D_A – Apparent diffusivity (calculated for VOCs only)	VF – Volatilization factor (calculated for VOCs only)
SAT – Soil saturation limit (calculated for VOCs not solid at soil temperature only)	VOC – Volatile organic compound

EPI= US EPA. 2012. Estimation Programs Interface (EPI) Suite™ for Microsoft® Windows, v 4.11. Washington, DC, USA.
W9= US EPA. 2006. Water9, Version 3.0. Wastewater Treatment Model
CALC =Calculated;
SSG=US EPA. 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. Office of Emergency and Remedial Response, Washington, D.C. OSWER 9355.4-24. December. http://www.epa.gov/superfund/health/conmedia/soil/pdfs/ssg_main.pdf
Baes= Baes, C.F. 1984. Oak Ridge National Laboratory. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture

a -Hnery's Law Constants obtained from 1) EPI Suite Version 4.11 (a. experimental value; b. bond method, then c. group method) 2) US EPA Soil Screening Guidance (2002).

d -H' values = H*41 (US EPA Soil Screening Guidance, 2002)

c- Da and Dw values obtained from 1) US EPA (2006) Water 9 Wastewater Treatment Model; 2) US EPA Soil Screening Guidance (2002)

d- Koc values obtained from US EPA EPI Suite, Version 4.11 (a. MCI method; b. Kow method)

b -foc = 1.5E-03: Soil Survey Laboratory Database for New Mexico, National Resources Conservation Service, U.S. Dept of Agriculture
e- Kd for organics = Koc * foc. Kds for inorganics obtained from 1) US EPA Soil Screening Guidance (2002); 2) Baes, C.F. 1984. Oak Ridge National Laboratory. *A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture*.

The Kd value for elemental mercury is based on the Kd for mercury 2+

The Kd value for methyl mercury Is based on the Kd for mercury 2+

The Kd value for mercury salts is based on the Kd for mercury 2+

The Kd values for nitrate and nitrite are based on the Kd for nitrogen

The Kd value for perchlorate is based on the Kd for chlorine

Table B-3: Physical and Chemical Constants for the Dermal Tap-Water Pathway

Chemical	CAS. NO.	MW (g/mole)	Ref.	Kp (cm/hr)	Ref.	FA (unitless)	Ref.	τ_{event} (hr/event)	B (unitless)	b	c	t* (hr)	DA_event carc	DA_event noncarc	DA_event mutagen
Acenaphthene	83-32-9	154.21	EPI	8.60E-02	EPI	1	E	7.67E-01	4.11E-01	6.20E-01	6.47E-01	1.84E+00		1.47E-01	
Acetaldehyde	75-07-0	44.05	EPI	5.27E-04	EPI	1	E	1.85E-01	1.35E-03	3.04E-01	3.34E-01	4.45E-01			
Acetone	67-64-1	58.08	EPI	5.12E-04	EPI	1	E	2.22E-01	1.50E-03	3.04E-01	3.34E-01	5.33E-01		2.13E+00	
Acrylonitrile	107-13-1	53.06	EPI	1.16E-03	EPI	1	E	2.08E-01	3.25E-03	3.05E-01	3.36E-01	5.00E-01	1.74E-04	9.48E-02	
Acetophenone	98-86-2	120.15	EPI	3.72E-03	EPI	1	E	4.94E-01	1.57E-02	3.13E-01	3.44E-01	1.19E+00		2.37E-01	
Acrolein	107-02-8	56.06	EPI	7.48E-04	EPI	1	E	2.16E-01	2.15E-03	3.05E-01	3.35E-01	5.19E-01		1.19E-03	
Aldrin	309-00-2	364.92	EPI	2.93E-01	EPI	1	E	1.16E+01	2.15E+00	4.07E+00	2.26E+00	4.77E+01	5.47E-06	7.11E-05	
Aluminum	7429-90-5	26.98	P	1.00E-03	E	1	E	1.49E-01	2.00E-03	3.04E-01	3.35E-01	3.57E-01		2.37E+00	
Anthracene	120-12-7	178.24	EPI	1.42E-01	EPI	1	E	1.05E+00	7.29E-01	9.82E-01	9.22E-01	4.04E+00		7.11E-01	
Antimony	7440-36-0	121.76	P	1.00E-03	E	1	E	5.05E-01	4.24E-03	3.06E-01	3.36E-01	1.21E+00		1.42E-04	
Arsenic	7440-38-2	74.92	P	1.00E-03	E	1	E	2.76E-01	3.33E-03	3.05E-01	3.36E-01	6.62E-01	6.26E-05	7.11E-04	
Barium	7440-39-3	137.33	P	1.00E-03	E	1	E	6.17E-01	4.51E-03	3.06E-01	3.36E-01	1.48E+00		3.32E-02	
Benzene	71-43-2	78.11	EPI	1.49E-02	EPI	1	E	2.87E-01	5.06E-02	3.35E-01	3.68E-01	6.90E-01	1.71E-03	9.48E-03	
Benzidine	92-87-5	184.24	EPI	1.13E-03	EPI	1	E	1.13E+00	5.90E-03	3.07E-01	3.37E-01	2.71E+00	4.08E-07	7.11E-03	1.32E-07
Benzo(a)anthracene	56-55-3	228.3	EPI	5.52E-01	EPI	1	E	1.99E+00	3.21E+00	7.99E+00	3.29E+00	8.47E+00	1.29E-04		4.16E-05
Benzo(a)pyrene	50-32-8	252.32	EPI	7.13E-01	EPI	1	E	2.72E+00	4.36E+00	1.38E+01	4.42E+00	1.18E+01	1.29E-05		4.16E-06
Benzo(b)fluoranthene	205-99-2	252.32	EPI	4.17E-01	EPI	1	E	2.72E+00	2.55E+00	5.37E+00	2.64E+00	1.13E+01	1.29E-04		4.16E-05
Benzo(k)fluoranthene	207-08-9	252.32	EPI	6.91E-01	EPI	1	E	2.72E+00	4.22E+00	1.31E+01	4.29E+00	1.18E+01	1.29E-03		4.16E-04
Beryllium	7440-41-7	9.01	P	1.00E-03	E	1	E	1.18E-01	1.15E-03	3.04E-01	3.34E-01	2.83E-01		3.32E-05	
a-BHC (HCH)	319-84-6	290.83	EPI	2.06E-02	EPI	1	E	4.47E+00	1.35E-01	3.92E-01	4.29E-01	1.07E+01	1.49E-05	1.90E-02	
b-BHC (HCH)	319-85-7	290.83	EPI	2.06E-02	EPI	1	E	4.47E+00	1.35E-01	3.92E-01	4.29E-01	1.07E+01	5.22E-05		
g-BHC	58-89-9	290.83	EPI	2.06E-02	EPI	0.9	E	4.47E+00	1.35E-01	3.92E-01	4.29E-01	1.07E+01	8.53E-05	7.11E-04	
1,1-Biphenyl	92-52-4	154.21	EPI	9.87E-02	EPI	1	E	7.67E-01	4.71E-01	6.80E-01	6.98E-01	1.84E+00	1.14E-02	1.19E+00	
Bis(2-chloroethyl) ether	111-44-4	143.01	EPI	1.78E-03	EPI	1	E	6.64E-01	8.19E-03	3.08E-01	3.39E-01	1.59E+00	8.53E-05		
Bis(2-chloroisopropyl) ether	108-60-1	171.07	EPI	7.64E-03	EPI	1	E	9.53E-01	3.84E-02	3.27E-01	3.59E-01	2.29E+00	1.34E-03		
Bis(2-ethylhexyl) phthalate	117-81-7	390.57	EPI	1.13E+00	EPI	0.8	E	1.62E+01	8.59E+00	4.99E+01	8.62E+00	7.28E+01	6.71E-03	4.74E-02	
Bis(chloromethyl) ether	542-88-1	114.96	EPI	8.55E-04	EPI	1	E	4.62E-01	3.53E-03	3.05E-01	3.36E-01	1.11E+00	4.27E-07		
Boron	7440-42-8	10.81	P	1.00E-03	E	1	E	1.21E-01	1.26E-03	3.04E-01	3.34E-01	2.90E-01		4.74E-01	
Bromodichloromethane	75-27-4	163.83	EPI	4.02E-03	EPI	1	E	8.68E-01	1.98E-02	3.15E-01	3.47E-01	2.08E+00	1.51E-03	4.74E-02	
Bromomethane	74-83-9	94.94	EPI	2.84E-03	EPI	1	E	3.57E-01	1.06E-02	3.10E-01	3.40E-01	8.57E-01		3.32E-03	
1,3-Butadiene	106-99-0	54.09	EPI	1.64E-02	EPI	1	E	2.11E-01	4.64E-02	3.32E-01	3.65E-01	5.06E-01	2.76E-05		
2-Butanone (Methyl ethyl ketone, MEK)	78-93-3	72.11	EPI	9.62E-04	EPI	1	E	2.66E-01	3.14E-03	3.05E-01	3.35E-01	6.39E-01		1.42E+00	
tert-Butyl methyl ether (MTBE)	1634-04-4	88.15	EPI	2.11E-03	EPI	1	E	3.27E-01	7.62E-03	3.08E-01	3.38E-01	7.85E-01	5.22E-02		
Cadmium	7440-43-9	112.41	P	1.00E-03	E	1	E	4.47E-01	4.08E-03	3.06E-01	3.36E-01	1.07E+00		3.07E-05	

Chemical	**CAS. NO.**	**MW (g/mole)**	**Ref.**	**Kp (cm/hr)**	**Ref.**	**FA (unitless)**	**Ref.**	**τ_{event} (hr/event)**	**B (unitless)**	**b**	**c**	**t* (hr)**	**DA_event carc**	**DA_event noncarc**	**DA_event mutagen**
Carbon disulfide	75-15-0	76.13	EPI	1.14E-02	EPI	1	E	2.80E-01	3.83E-02	3.27E-01	3.59E-01	6.73E-01		2.37E-01	
Carbon tetrachloride	56-23-5	153.82	EPI	1.63E-02	EPI	1	E	7.63E-01	7.78E-02	3.52E-01	3.87E-01	1.83E+00	1.34E-03	9.48E-03	
Chlordane	12789-03-6	409.78	EPI	1.07E-01	EPI	0.7	E	2.07E+01	8.33E-01	1.12E+00	1.01E+00	7.96E+01	2.68E-04	1.19E-03	
2-Chloroacetophenone	532-27-4	154.6	EPI	4.06E-03	EPI	1	E	7.71E-01	1.94E-02	3.15E-01	3.46E-01	1.85E+00			
2-Chloro-1,3-butadiene	126-99-8	88.54	EPI	2.38E-02	EPI	1	E	3.29E-01	8.61E-02	3.58E-01	3.93E-01	7.89E-01		4.74E-02	
1-Chloro-1,1-difluoroethane	75-68-3	100.5	EPI	9.89E-03	EPI	1	E	3.84E-01	3.81E-02	3.27E-01	3.59E-01	9.21E-01			
Chlorobenzene	108-90-7	112.56	EPI	2.82E-02	EPI	1	E	4.48E-01	1.15E-01	3.78E-01	4.14E-01	1.08E+00		4.74E-02	
1-Chlorobutane	109-69-3	92.57	EPI	2.69E-02	EPI	1	E	3.46E-01	9.95E-02	3.67E-01	4.03E-01	8.31E-01		9.48E-02	
Chlorodifluoromethane	75-45-6	86.47	EPI	2.68E-03	EPI	1	E	3.20E-01	9.59E-03	3.09E-01	3.40E-01	7.68E-01			
Chloroform	67-66-3	119.38	EPI	6.83E-03	EPI	1	E	4.89E-01	2.87E-02	3.21E-01	3.53E-01	1.17E+00	4.94E-03	2.37E-02	
Chloromethane	74-87-3	50.49	EPI	3.28E-03	EPI	1	E	2.01E-01	8.96E-03	3.09E-01	3.39E-01	4.83E-01	7.22E-03		
b-Chloronaphthalene	91-58-7	162.62	EPI	7.49E-02	EPI	1	E	8.55E-01	3.67E-01	5.79E-01	6.11E-01	2.05E+00		1.90E-01	
o-Chloronitrobenzene	88-73-3	157.56	EPI	6.30E-03	EPI	1	E	8.01E-01	3.04E-02	3.22E-01	3.54E-01	1.92E+00	3.13E-04	7.11E-03	
p-Chloronitrobenzene	100-00-5	157.56	EPI	7.93E-03	EPI	1	E	8.01E-01	3.83E-02	3.27E-01	3.59E-01	1.92E+00	1.49E-02	2.37E-03	
2-Chlorophenol	95-57-8	128.56	EPI	7.99E-03	EPI	1	E	5.51E-01	3.48E-02	3.25E-01	3.57E-01	1.32E+00		1.19E-02	
2-Chloropropane	75-29-6	78.54	EPI	1.04E-02	EPI	1	E	2.89E-01	3.54E-02	3.25E-01	3.57E-01	6.94E-01			
o-Chlorotoluene	95-49-8	126.59	EPI	5.72E-02	EPI	1	E	5.37E-01	2.48E-01	4.76E-01	5.15E-01	1.29E+00		4.74E-02	
Chromium III	16065-83-1	52	P	1.00E-03	E	1	E	2.05E-01	2.77E-03	3.05E-01	3.35E-01	4.93E-01		4.62E-02	
Chromium VI	18540-29-9	52	P	2.00E-03	E	1	E	2.05E-01	5.55E-03	3.07E-01	3.37E-01	4.93E-01	4.69E-06	1.78E-04	1.52E-06
Chromium (Total)		52	P	1.00E-03	E	1	E	2.05E-01	2.77E-03	3.05E-01	3.35E-01	4.93E-01	1.71E-05	3.96E-02	
Chrysene	218-01-9	228.3	EPI	5.96E-01	EPI	1	E	1.99E+00	3.46E+00	9.15E+00	3.54E+00	8.52E+00	1.29E-02		4.16E-03
Copper	7440-50-8	63.55	P	1.00E-03	E	1	E	2.38E-01	3.07E-03	3.05E-01	3.35E-01	5.72E-01		9.48E-02	
Crotonaldehyde	123-73-9	70.09	EPI	1.59E-03	EPI	1	E	2.59E-01	5.12E-03	3.06E-01	3.37E-01	6.22E-01	4.94E-05	2.37E-03	
Cumene (isopropylbenzene)	98-82-8	120.2	EPI	8.97E-02	EPI	1	E	4.95E-01	3.78E-01	5.89E-01	6.20E-01	1.19E+00		2.37E-01	
Cyanide	57-12-5	27.03	EPI	7.54E-04	EPI	1	E	1.49E-01	1.51E-03	3.04E-01	3.34E-01	3.57E-01		1.42E-03	
Cyanogen	460-19-5	52.04	EPI	8.90E-04	EPI	1	E	2.05E-01	2.47E-03	3.05E-01	3.35E-01	4.93E-01		2.37E-03	
Cyanogen bromide	506-68-3	105.92	EPI	2.55E-04	EPI	1	E	4.11E-01	1.01E-03	3.04E-01	3.34E-01	9.88E-01		2.13E-01	
Cyanogen chloride	506-77-4	61.47	EPI	3.94E-04	EPI	1	E	2.32E-01	1.19E-03	3.04E-01	3.34E-01	5.57E-01		1.19E-01	
DDD	72-54-8	320.05	EPI	2.51E-01	EPI	0.8	E	6.51E+00	1.73E+00	2.89E+00	1.85E+00	2.62E+01	3.91E-04		
DDE	72-55-9	318.03	EPI	5.45E-01	EPI	0.8	E	6.34E+00	3.74E+00	1.05E+01	3.81E+00	2.73E+01	2.76E-04		
DDT	50-29-3	354.49	EPI	6.28E-01	EPI	0.7	E	1.01E+01	4.55E+00	1.50E+01	4.61E+00	4.42E+01	2.76E-04	1.19E-03	
Dibenz(a,h)anthracene	53-70-3	278.36	EPI	9.53E-01	EPI	0.6	E	3.80E+00	6.12E+00	2.61E+01	6.16E+00	1.69E+01	1.29E-05		4.16E-06
1,2-Dibromo-3-chloropropane	96-12-8	236.33	EPI	6.85E-03	EPI	1	E	2.21E+00	4.05E-02	3.28E-01	3.61E-01	5.31E+00	1.17E-04	4.74E-04	3.79E-05
Dibromochloromethane	124-48-1	208.28	EPI	2.89E-03	EPI	1	E	1.54E+00	1.60E-02	3.13E-01	3.44E-01	3.70E+00	1.12E-03	4.74E-02	
1,2-Dibromoethane	106-93-4	187.86	EPI	2.78E-03	EPI	1	E	1.18E+00	1.47E-02	3.12E-01	3.43E-01	2.84E+00	4.69E-05	2.13E-02	
1,4-Dichloro-2-butene	764-41-0	125	EPI	1.66E-02	EPI	1	E	5.26E-01	7.14E-02	3.48E-01	3.83E-01	1.26E+00			

Chemical	**CAS. NO.**	**MW (g/mole)**	**Ref.**	**Kp (cm/hr)**	**Ref.**	**FA (unitless)**	**Ref.**	**τ_{event} (hr/event)**	**B (unitless)**	**b**	**c**	**t* (hr)**	**DA_event carc**	**DA_event noncarc**	**DA_event mutagen**
1,2-Dichlorobenzene	95-50-1	147	EPI	4.46E-02	EPI	1	E	6.99E-01	2.08E-01	4.45E-01	4.84E-01	1.68E+00		2.13E-01	
1,4-Dichlorobenzene	106-46-7	147	EPI	4.53E-02	EPI	1	E	6.99E-01	2.11E-01	4.48E-01	4.86E-01	1.68E+00	1.74E-02	1.66E-01	
3,3-Dichlorobenzidine	91-94-1	253.13	EPI	1.28E-02	EPI	1	E	2.75E+00	7.83E-02	3.53E-01	3.87E-01	6.59E+00	2.09E-04		
Dichlorodifluoromethane	75-71-8	120.91	EPI	8.95E-03	EPI	1	E	4.99E-01	3.79E-02	3.27E-01	3.59E-01	1.20E+00		4.74E-01	
1,1-Dichloroethane	75-34-3	98.96	EPI	6.75E-03	EPI	1	E	3.76E-01	2.58E-02	3.19E-01	3.51E-01	9.03E-01	1.65E-02	4.74E-01	
1,2-Dichloroethane	107-06-2	98.96	EPI	4.20E-03	EPI	1	E	3.76E-01	1.61E-02	3.13E-01	3.44E-01	9.03E-01	1.03E-03	1.42E-02	
cis-1,2-Dichloroethene	156-59-2	96.94	EPI	9.55E-03	EPI	1	E	3.66E-01	3.62E-02	3.26E-01	3.58E-01	8.80E-01		4.74E-03	
trans-1,2-Dichloroethene	156-60-5	96.94	EPI	9.55E-03	EPI	1	E	3.66E-01	3.62E-02	3.26E-01	3.58E-01	8.80E-01		4.74E-02	
1,1-Dichloroethene	75-35-4	96.94	EPI	1.17E-02	EPI	1	E	3.66E-01	4.43E-02	3.31E-01	3.63E-01	8.80E-01		1.19E-01	
2,4-Dichlorophenol	120-83-2	163	EPI	2.06E-02	EPI	1	E	8.59E-01	1.01E-01	3.68E-01	4.04E-01	2.06E+00		7.11E-03	
1,2-Dichloropropane	78-87-5	112.99	EPI	7.53E-03	EPI	1	E	4.51E-01	3.08E-02	3.22E-01	3.54E-01	1.08E+00	2.61E-03	2.13E-01	
1,3-Dichloropropene	542-75-6	110.97	EPI	8.34E-03	EPI	1	E	4.39E-01	3.38E-02	3.24E-01	3.56E-01	1.05E+00	9.39E-04	7.11E-02	
Dicyclopentadiene	77-73-6	132.21	EPI	3.60E-02	EPI	1	E	5.78E-01	1.59E-01	4.09E-01	4.47E-01	1.39E+00		1.90E-01	
Dieldrin	60-57-1	380.91	EPI	3.26E-02	EPI	0.8	E	1.43E+01	2.45E-01	4.74E-01	5.13E-01	3.42E+01	5.87E-06	1.19E-04	
Diethyl phthalate	84-66-2	222.24	EPI	3.60E-03	EPI	1	E	1.84E+00	2.06E-02	3.16E-01	3.47E-01	4.43E+00		1.90E+00	
Di-n-butyl phthalate (Dibutyl phthalate)	84-74-2	278.35	EPI	4.20E-02	EPI	0.9	E	3.80E+00	2.70E-01	4.94E-01	5.32E-01	9.12E+00		2.37E-01	
2,4-Dimethylphenol	105-67-9	122.17	EPI	1.09E-02	EPI	1	E	5.07E-01	4.63E-02	3.32E-01	3.65E-01	1.22E+00		4.74E-02	
4,6-Dinitro-o-cresol	534-52-1	198.14	EPI	3.15E-03	EPI	1	E	1.35E+00	1.71E-02	3.14E-01	3.45E-01	3.24E+00		1.90E-04	
2,4-Dinitrophenol	51-28-5	184.11	EPI	1.87E-03	EPI	1	E	1.13E+00	9.76E-03	3.09E-01	3.40E-01	2.71E+00		4.74E-03	
2,4-Dinitrotoluene	121-14-2	182.14	EPI	3.08E-03	EPI	1	E	1.10E+00	1.60E-02	3.13E-01	3.44E-01	2.64E+00	3.03E-04	4.74E-03	
2,6-Dintitrotoluene	606-20-2	182.14	EPI	3.70E-03	EPI	1	E	1.10E+00	1.92E-02	3.15E-01	3.46E-01	2.64E+00	6.26E-05	7.11E-04	
2,4/2,6-Dintrotoluene Mixture	25321-14-6	182.14	EPI	4.16E-03	EPI	1	E	1.10E+00	2.16E-02	3.17E-01	3.48E-01	2.64E+00	1.38E-04		
1,4-Dioxane	123-91-1	88.11	EPI	3.32E-04	EPI	1	E	3.27E-01	1.20E-03	3.04E-01	3.34E-01	7.85E-01	9.39E-04	7.11E-02	
1,2-Diphenylhydrazine	122-66-7	184.24	EPI	1.30E-02	EPI	1	E	1.13E+00	6.79E-02	3.46E-01	3.80E-01	2.71E+00	1.17E-04		
Endosulfan	115-29-7	406.92	EPI	2.86E-03	EPI	1	E	1.99E+01	2.22E-02	3.17E-01	3.48E-01	4.79E+01		1.42E-02	
Endrin	72-20-8	380.91	EPI	3.26E-02	EPI	0.8	E	1.43E+01	2.45E-01	4.74E-01	5.13E-01	3.42E+01		7.11E-04	
Epichlorohydrin	106-89-8	92.53	EPI	9.44E-04	EPI	1	E	3.46E-01	3.49E-03	3.05E-01	3.36E-01	8.31E-01	9.48E-03	1.42E-02	
Ethyl acetate	141-78-6	88.11	EPI	1.53E-03	EPI	1	E	3.27E-01	5.52E-03	3.07E-01	3.37E-01	7.85E-01		2.13E+00	
Ethyl acrylate	140-88-5	100.12	EPI	3.24E-03	EPI	1	E	3.82E-01	1.25E-02	3.11E-01	3.42E-01	9.16E-01	1.96E-03		
Ethyl chloride	75-00-3	64.52	EPI	6.07E-03	EPI	1	E	2.41E-01	1.88E-02	3.15E-01	3.46E-01	5.79E-01			
Ethyl ether	60-29-7	74.12	EPI	2.35E-03	EPI	1	E	2.73E-01	7.78E-03	3.08E-01	3.39E-01	6.55E-01		4.74E-01	
Ethyl methacrylate	97-63-2	114.15	EPI	6.98E-03	EPI	1	E	4.58E-01	2.87E-02	3.21E-01	3.53E-01	1.10E+00		2.13E-01	
Ethylbenzene	100-41-4	106.17	EPI	4.93E-02	EPI	1	E	4.13E-01	1.95E-01	4.35E-01	4.74E-01	9.91E-01	8.53E-03	2.37E-01	
Ethylene oxide	75-21-8	44.05	EPI	5.60E-04	EPI	1	E	1.85E-01	1.43E-03	3.04E-01	3.34E-01	4.45E-01	3.03E-04		
Fluoranthene	206-44-0	202.26	EPI	3.08E-01	EPI	1	E	1.43E+00	1.68E+00	2.78E+00	1.81E+00	5.72E+00		9.48E-02	
Fluorene	86-73-7	166.22	EPI	1.10E-01	EPI	1	E	8.95E-01	5.45E-01	7.59E-01	7.61E-01	2.15E+00		9.48E-02	

Chemical	**CAS. NO.**	**MW (g/mole)**	**Ref.**	**Kp (cm/hr)**	**Ref.**	**FA (unitless)**	**Ref.**	**τ_{event} (hr/event)**	**B (unitless)**	**b**	**c**	**t* (hr)**	**DA_event carc**	**DA_event noncarc**	**DA_event mutagen**
Fluoride	7782-41-4	19	P	1.00E-03	E	1	E	1.34E-01	1.68E-03	3.04E-01	3.34E-01	3.22E-01		1.42E-01	
Furan	110-00-9	68.08	EPI	5.05E-03	EPI	1	E	2.53E-01	1.60E-02	3.13E-01	3.44E-01	6.06E-01		2.37E-03	
Heptachlor	76-44-8	373.32	EPI	5.44E-02	EPI	0.8	E	1.29E+01	4.04E-01	6.14E-01	6.42E-01	3.10E+01	2.09E-05	1.19E-03	
Hexachlorobenzene	118-74-1	284.78	EPI	2.54E-01	EPI	0.9	E	4.13E+00	1.65E+00	2.69E+00	1.77E+00	1.65E+01	5.87E-05	1.90E-03	
Hexachloro-1,3-butadiene	87-68-3	260.76	EPI	8.10E-02	EPI	0.9	E	3.03E+00	5.03E-01	7.13E-01	7.25E-01	7.27E+00	1.20E-03	2.37E-03	
Hexachlorocyclopentadiene	77-47-4	272.77	EPI	1.03E-01	EPI	1	E	3.54E+00	6.54E-01	8.86E-01	8.56E-01	1.39E+01		1.42E-02	
Hexachloroethane	67-72-1	236.74	EPI	4.15E-02	EPI	1	E	2.22E+00	2.46E-01	4.75E-01	5.13E-01	5.34E+00	2.35E-03	1.66E-03	
n-Hexane	110-54-3	86.18	EPI	2.01E-01	EPI	1	E	3.19E-01	7.18E-01	9.67E-01	9.12E-01	1.24E+00		1.42E-01	
HMX	2691-41-0	296.16	EPI	4.36E-05	EPI	1	E	4.78E+00	2.89E-04	3.03E-01	3.34E-01	1.15E+01		1.19E-01	
Hydrazine anhydride	302-01-2	32.05	EPI	4.36E-05	EPI	1	E	1.59E-01	9.49E-05	3.03E-01	3.33E-01	3.81E-01	3.13E-05		
Hydrogen cyanide	74-90-8	27.03	EPI	7.54E-04	EPI	1	E	1.49E-01	1.51E-03	3.04E-01	3.34E-01	3.57E-01		1.42E-03	
Indeno(1,2,3-c,d)pyrene	193-39-5	276.34	EPI	1.24E+00	EPI	0.6	E	3.70E+00	7.93E+00	4.28E+01	7.97E+00	1.66E+01	1.29E-04		4.16E-05
Iron	7439-89-6	55.85	P	1.00E-03	E	1	E	2.16E-01	2.87E-03	3.05E-01	3.35E-01	5.18E-01		1.66E+00	
Isobutanol (Isobutyl alcohol)	78-83-1	74.12	EPI	1.92E-03	EPI	1	E	2.73E-01	6.36E-03	3.07E-01	3.38E-01	6.55E-01		7.11E-01	
Isophorone	78-59-1	138.21	EPI	3.54E-03	EPI	1	E	6.24E-01	1.60E-02	3.13E-01	3.44E-01	1.50E+00	9.88E-02	4.74E-01	
Lead	7439-92-1	207.2	P	1.00E-03	E	1	E	1.52E+00	5.54E-03	3.07E-01	3.37E-01	3.65E+00			
Lead (tetraethyl-)	78-00-2	323.45	EPI	1.37E-02	EPI	1	E	6.80E+00	9.48E-02	3.64E-01	3.99E-01	1.63E+01		2.37E-07	
Maleic hydrazide	123-33-1	112.09	EPI	1.02E-04	EPI	1	E	4.46E-01	4.15E-04	3.04E-01	3.34E-01	1.07E+00		1.19E+00	
Manganese	7439-96-5	54.94	P	1.00E-03	E	1	E	2.13E-01	2.85E-03	3.05E-01	3.35E-01	5.12E-01		1.33E-02	
Mercury (elemental)	7439-97-6	200.59	EPI	1.00E-03	E	1	E	1.39E+00	5.45E-03	3.07E-01	3.37E-01	3.35E+00			
Mercury (methyl)	22967-92-6	215.63	EPI	1.00E-03	E	1	E	1.69E+00	5.65E-03	3.07E-01	3.37E-01	4.06E+00		2.37E-04	
Mercury Chloride (Mercury Salts)	7487-94-7	271.5	EPI	1.00E-03	E	1	E	3.48E+00	6.34E-03	3.07E-01	3.38E-01	8.35E+00		4.98E-05	
Methacrylonitrile	126-98-7	67.09	EPI	1.86E-03	EPI	1	E	2.49E-01	5.86E-03	3.07E-01	3.37E-01	5.99E-01		2.37E-04	
Methomyl	16752-77-5	162.21	EPI	4.82E-04	EPI	1	E	8.50E-01	2.36E-03	3.05E-01	3.35E-01	2.04E+00		5.93E-02	
Methyl acetate	79-20-9	74.08	EPI	7.92E-04	EPI	1	E	2.73E-01	2.62E-03	3.05E-01	3.35E-01	6.55E-01		2.37E+00	
Methyl acrylate	96-33-3	86.09	EPI	1.75E-03	EPI	1	E	3.19E-01	6.25E-03	3.07E-01	3.38E-01	7.65E-01		7.11E-02	
Methyl isobutyl ketone	108-10-1	100.16	EPI	3.19E-03	EPI	1	E	3.82E-01	1.23E-02	3.11E-01	3.42E-01	9.17E-01		1.90E-01	
Methyl methacrylate	80-62-6	100.12	EPI	3.55E-03	EPI	1	E	3.82E-01	1.37E-02	3.12E-01	3.43E-01	9.16E-01		3.32E+00	
Methyl styrene (alpha)	98-83-9	118.18	EPI	6.99E-02	EPI	1	E	4.82E-01	2.92E-01	5.13E-01	5.50E-01	1.16E+00		1.66E-01	
Methyl styrene (mixture)	25013-15-4	118.18	EPI	6.60E-02	EPI	1	E	4.82E-01	2.76E-01	4.99E-01	5.37E-01	1.16E+00		1.42E-02	
Methylcyclohexane	108-87-2	98.19	EPI	1.10E-01	EPI	1	E	3.72E-01	4.19E-01	6.28E-01	6.54E-01	8.94E-01			
Methylene bromide (Dibromomethane)	74-95-3	173.84	EPI	2.23E-03	EPI	1	E	9.88E-01	1.13E-02	3.10E-01	3.41E-01	2.37E+00		2.37E-02	
Methylene chloride	75-09-2	84.93	EPI	3.54E-03	EPI	1	E	3.14E-01	1.25E-02	3.11E-01	3.42E-01	7.53E-01	4.69E-02	1.42E-02	1.52E-02
Molybdenum	7439-98-7	95.96	P	1.00E-03	E	1	E	3.62E-01	3.77E-03	3.06E-01	3.36E-01	8.69E-01		1.19E-02	
Naphthalene	91-20-3	128.18	EPI	4.66E-02	EPI	1	E	5.48E-01	2.03E-01	4.41E-01	4.80E-01	1.32E+00		4.74E-02	
Nickel	7440-02-0	58.69	EPI	2.00E-04	E	1	E	2.24E-01	5.89E-04	3.04E-01	3.34E-01	5.37E-01		1.90E-03	

Chemical	**CAS. NO.**	**MW (g/mole)**	**Ref.**	**Kp (cm/hr)**	**Ref.**	**FA (unitless)**	**Ref.**	**τ_{event} (hr/event)**	**B (unitless)**	**b**	**c**	**t* (hr)**	**DA_event carc**	**DA_event noncarc**	**DA_event mutagen**
Nitrate	14797-55-8	62	EPI	1.00E-03	E	1	E	2.34E-01	3.03E-03	3.05E-01	3.35E-01	5.61E-01		3.79E+00	
Nitrite	14797-65-0	47.01	EPI	1.00E-03	E	1	E	1.93E-01	2.64E-03	3.05E-01	3.35E-01	4.62E-01		2.37E-01	
Nitrobenzene	98-95-3	123.11	EPI	5.41E-03	EPI	1	E	5.14E-01	2.31E-02	3.17E-01	3.49E-01	1.23E+00		4.74E-03	
Nitroglycerin	55-63-0	227.09	EPI	9.94E-04	EPI	1	E	1.96E+00	5.76E-03	3.07E-01	3.37E-01	4.71E+00	5.52E-03	2.37E-04	
N-Nitrosodiethylamine	55-18-5	102.14	EPI	8.72E-04	EPI	1	E	3.92E-01	3.39E-03	3.05E-01	3.36E-01	9.41E-01	6.26E-07		2.02E-07
N-Nitrosodimethylamine	62-75-9	74.08	EPI	2.51E-04	EPI	1	E	2.73E-01	8.31E-04	3.04E-01	3.34E-01	6.55E-01	1.84E-06	1.90E-05	5.95E-07
N-Nitrosodi-n-butylamine	924-16-3	158.25	EPI	1.13E-02	EPI	1	E	8.08E-01	5.47E-02	3.37E-01	3.71E-01	1.94E+00	1.74E-05		
N-Nitrosodiphenylamine	86-30-6	198.23	EPI	1.45E-02	EPI	1	E	1.35E+00	7.85E-02	3.53E-01	3.88E-01	3.25E+00	1.92E-02		
N-Nitrosopyrrolidine	930-55-2	100.12	EPI	3.21E-04	EPI	1	E	3.82E-01	1.24E-03	3.04E-01	3.34E-01	9.16E-01	4.47E-05		
m-Nitrotoluene	99-08-1	137.14	EPI	1.13E-02	EPI	1	E	6.15E-01	5.09E-02	3.35E-01	3.68E-01	1.48E+00		2.37E-04	
o-Nitrotoluene	88-72-2	137.14	EPI	8.99E-03	EPI	1	E	6.15E-01	4.05E-02	3.28E-01	3.61E-01	1.48E+00	4.27E-04	2.13E-03	
p-Nitrotoluene	99-99-0	137.14	EPI	1.00E-02	EPI	1	E	6.15E-01	4.50E-02	3.31E-01	3.64E-01	1.48E+00	5.87E-03	9.48E-03	
Pentachlorobenzene	608-93-5	250.34	EPI	1.68E-01	EPI	0.9	E	2.65E+00	1.02E+00	1.42E+00	1.19E+00	1.02E+01		1.90E-03	
Pentachlorophenol	87-86-5	266.34	EPI	1.27E-01	EPI	0.9	E	3.26E+00	7.97E-01	1.07E+00	9.83E-01	1.25E+01	2.35E-04	1.19E-02	
Perchlorate	14797-73-0	99.45	EPI	1.00E-03	E	1	E	3.79E-01	3.84E-03	3.06E-01	3.36E-01	9.08E-01		1.66E-03	
Phenanthrene	85-01-8	178.24	EPI	1.44E-01	EPI	1	E	1.05E+00	7.39E-01	9.95E-01	9.31E-01	4.04E+00		7.11E-02	
Phenol	108-95-2	94.11	EPI	4.34E-03	EPI	1	E	3.53E-01	1.62E-02	3.13E-01	3.44E-01	8.48E-01		7.11E-01	
Polychlorinatedbiphenyls															
Aroclor 1016	12674-11-2	257.55	EPI	3.05E-01	EPI	0.6	E	2.91E+00	1.88E+00	3.29E+00	2.00E+00	1.18E+01	1.34E-03	1.66E-04	
Aroclor 1221	11104-28-2	188.66	EPI	1.68E-01	EPI	0.6	E	1.20E+00	8.88E-01	1.20E+00	1.06E+00	4.60E+00	4.69E-05		
Aroclor 1232	11141-16-5	188.66	EPI	1.68E-01	EPI	0.6	E	1.20E+00	8.88E-01	1.20E+00	1.06E+00	4.60E+00	4.69E-05		
Aroclor 1242	53469-21-9	291.99	EPI	5.45E-01	EPI	0.6	E	4.53E+00	3.58E+00	9.71E+00	3.65E+00	1.94E+01	4.69E-05		
Aroclor 1248	12672-29-6	291.99	EPI	4.75E-01	EPI	0.6	E	4.53E+00	3.12E+00	7.61E+00	3.20E+00	1.92E+01	4.69E-05		
Aroclor 1254	11097-69-1	326.44	EPI	7.51E-01	EPI	0.6	E	7.07E+00	5.22E+00	1.93E+01	5.27E+00	3.10E+01	4.69E-05	4.74E-05	
Aroclor 1260	11096-82-5	395.33	EPI	9.86E-01	EPI	0.6	E	1.72E+01	7.54E+00	3.89E+01	7.58E+00	7.69E+01	4.69E-05		
2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB 170)	35065-30-6	395.33	EPI	2.96E+00	EPI	0.6	E	1.72E+01	2.26E+01	3.33E+02	2.27E+01	7.95E+01	7.22E-06	1.66E-05	
2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB 180)	35065-29-3	395.33	EPI	2.96E+00	EPI	0.6	E	1.72E+01	2.26E+01	3.33E+02	2.27E+01	7.95E+01	7.22E-05	1.66E-04	
2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB 189)	39635-31-9	395.33	EPI	2.96E+00	EPI	0.6	E	1.72E+01	2.26E+01	3.33E+02	2.27E+01	7.95E+01	2.41E-05	5.53E-05	
2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167)	52663-72-6	360.88	EPI	1.43E+00	EPI	0.5	E	1.10E+01	1.04E+01	7.30E+01	1.05E+01	5.00E+01	2.41E-05	5.53E-05	
2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 157)	69782-90-7	360.88	EPI	1.66E+00	EPI	0.5	E	1.10E+01	1.21E+01	9.76E+01	1.22E+01	5.02E+01	2.41E-05	5.53E-05	
2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156)	38380-08-4	360.88	EPI	1.66E+00	EPI	0.5	E	1.10E+01	1.21E+01	9.76E+01	1.22E+01	5.02E+01	2.41E-05	5.53E-05	
3,3',4,4',5,5'-Hexachlorobiphenyl (PCB 169)	32774-16-6	360.88	EPI	1.24E+00	EPI	0.5	E	1.10E+01	9.06E+00	5.53E+01	9.09E+00	4.97E+01	2.41E-08	5.53E-08	
2',3,4,4',5-Pentachlorobiphenyl (PCB 123)	65510-44-3	326.44	EPI	1.00E+00	EPI	0.6	E	7.07E+00	6.95E+00	3.32E+01	6.99E+00	3.15E+01	2.41E-05	5.53E-05	
2',3',4,4',5-Pentachlorobiphenyl (PCB 118)	31508-00-6	326.44	EPI	1.24E+00	EPI	0.6	E	7.07E+00	8.62E+00	5.02E+01	8.65E+00	3.18E+01	2.41E-05	5.53E-05	
2',3,3',4,4'-Pentachlorobiphenyl (PCB 105)	32598-14-4	326.44	EPI	7.51E-01	EPI	0.6	E	7.07E+00	5.22E+00	1.93E+01	5.27E+00	3.10E+01	2.41E-05	5.53E-05	
2,3,4,4',5-Pentachlorobiphenyl (PCB 114)	74472-37-0	326.44	EPI	1.00E+00	EPI	0.6	E	7.07E+00	6.95E+00	3.32E+01	6.99E+00	3.15E+01	2.41E-05	5.53E-05	

Chemical	**CAS. NO.**	**MW (g/mole)**	**Ref.**	**Kp (cm/hr)**	**Ref.**	**FA (unitless)**	**Ref.**	**τ_{event} (hr/event)**	**B (unitless)**	**b**	**c**	**t* (hr)**	**DA_event carc**	**DA_event noncarc**	**DA_event mutagen**
3,3',4,4',5-Pentachlorobiphenyl (PCB 126)	57465-28-8	326.44	EPI	1.00E+00	EPI	0.6	E	7.07E+00	6.95E+00	3.32E+01	6.99E+00	3.15E+01	7.22E-09	1.66E-08	
3,3',4,4'-Tetrachlorobiphenyl (PCB 77)	32598-13-3	291.99	EPI	9.17E-01	EPI	0.6	E	4.53E+00	6.03E+00	2.54E+01	6.07E+00	2.01E+01	7.22E-06	1.66E-05	
3,4,4',5-Tetrachlorobiphenyl (PCB 81)	70362-50-4	291.99	EPI	5.84E-01	EPI	0.6	E	4.53E+00	3.84E+00	1.10E+01	3.91E+00	1.95E+01	2.41E-06	5.53E-06	
Propylene oxide	75-56-9	58.08	EPI	7.74E-04	EPI	1	E	2.22E-01	2.27E-03	3.05E-01	3.35E-01	5.33E-01	3.91E-04		
Pyrene	129-00-0	202.26	EPI	2.01E-01	EPI	1	E	1.43E+00	1.10E+00	1.55E+00	1.26E+00	5.53E+00		7.11E-02	
RDX	121-82-4	222.12	EPI	3.36E-04	EPI	1	E	1.84E+00	1.93E-03	3.04E-01	3.35E-01	4.42E+00	8.53E-04	7.11E-03	
Selenium	7782-49-2	78.96	P	1.00E-03	E	1	E	2.91E-01	3.42E-03	3.05E-01	3.36E-01	6.98E-01		1.19E-02	
Silver	7440-22-4	107.87	P	6.00E-04	E	1	E	4.22E-01	2.40E-03	3.05E-01	3.35E-01	1.01E+00		4.74E-04	
Strontium	7440-24-6	87.62	P	1.00E-03	E	1	E	3.25E-01	3.60E-03	3.05E-01	3.36E-01	7.80E-01		1.42E+00	
Styrene	100-42-5	104.15	EPI	3.72E-02	EPI	1	E	4.02E-01	1.46E-01	3.99E-01	4.37E-01	9.65E-01		4.74E-01	
Sulfolane	126-33-0	120.17	EPI	1.02E-04	EPI	1	EPI	4.94E-01	4.30E-04	3.04E-01	3.34E-01	1.19E+00		2.37E-03	
2,3,7,8-TCDD	1746-01-6	321.98	EPI	8.08E-01	EPI	0.5	E	6.67E+00	5.58E+00	2.19E+01	5.63E+00	2.94E+01	7.22E-10	1.66E-09	
2,3,7,8-TCDF	51207-31-9	305.98	EPI	6.57E-01	EPI	1	E	5.43E+00	4.42E+00	1.42E+01	4.48E+00	2.36E+01	7.22E-09		
1,2,4,5-Tetrachlorobenzene	95-94-3	215.89	EPI	1.17E-01	EPI	1	E	1.70E+00	6.61E-01	8.95E-01	8.62E-01	6.66E+00		7.11E-04	
1,1,1,2-Tetrachloroethane	630-20-6	167.85	EPI	1.59E-02	EPI	1	E	9.14E-01	7.92E-02	3.53E-01	3.88E-01	2.19E+00	3.61E-03	7.11E-02	
1,1,2,2-Tetrachloroethane	79-34-5	167.85	EPI	6.94E-03	EPI	1	E	9.14E-01	3.46E-02	3.25E-01	3.57E-01	2.19E+00	4.69E-04	4.74E-02	
Tetrachloroethene	127-18-4	165.83	EPI	3.34E-02	EPI	1	E	8.91E-01	1.65E-01	4.13E-01	4.51E-01	2.14E+00	4.47E-02	1.42E-02	
Tetryl (Trinitrophenylmethylnitramine)	479-45-8	287.15	EPI	4.74E-04	EPI	1	E	4.26E+00	3.09E-03	3.05E-01	3.35E-01	1.02E+01		4.74E-03	
Thallium	7440-28-0	204.38	P	1.00E-03	E	1	E	1.46E+00	5.50E-03	3.07E-01	3.37E-01	3.52E+00		2.37E-05	
Toluene	108-88-3	92.14	EPI	3.11E-02	EPI	1	E	3.44E-01	1.15E-01	3.77E-01	4.14E-01	8.27E-01		1.90E-01	
Toxaphene	8001-35-2	413.82	EPI	5.18E-02	EPI	0.8	E	2.18E+01	4.05E-01	6.15E-01	6.42E-01	5.23E+01	8.53E-05		
Tribromomethane (Bromoform)	75-25-2	252.73	EPI	2.35E-03	EPI	1	E	2.73E+00	1.44E-02	3.12E-01	3.43E-01	6.56E+00	1.19E-02	4.74E-02	
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	187.38	EPI	1.75E-02	EPI	1	E	1.18E+00	9.21E-02	3.62E-01	3.97E-01	2.82E+00		7.11E+01	
1,2,4-Trichlorobenzene	120-82-1	181.45	EPI	7.05E-02	EPI	1	E	1.09E+00	3.65E-01	5.77E-01	6.09E-01	2.62E+00	3.24E-03	2.37E-02	
1,1,1-Trichloroethane	71-55-6	133.41	EPI	1.26E-02	EPI	1	E	5.87E-01	5.60E-02	3.38E-01	3.72E-01	1.41E+00		4.74E+00	
1,1,2-Trichloroethane	79-00-5	133.41	EPI	5.04E-03	EPI	1	E	5.87E-01	2.24E-02	3.17E-01	3.48E-01	1.41E+00	1.65E-03	9.48E-03	
Trichloroethylene	79-01-6	131.39	EPI	1.16E-02	EPI	1	E	5.71E-01	5.11E-02	3.35E-01	3.68E-01	1.37E+00	2.04E-03	1.19E-03	4.36E-04
Trichlorofluoromethane	75-69-4	137.37	EPI	1.27E-02	EPI	1	E	6.17E-01	5.73E-02	3.39E-01	3.73E-01	1.48E+00		7.11E-01	
2,4,5-Trichlorophenol	95-95-4	197.45	EPI	3.62E-02	EPI	1	E	1.34E+00	1.96E-01	4.36E-01	4.74E-01	3.21E+00		2.37E-01	
2,4,6-Trichlorophenol	88-06-2	197.45	EPI	3.46E-02	EPI	1	E	1.34E+00	1.87E-01	4.29E-01	4.68E-01	3.21E+00	8.53E-03	2.37E-03	
1,1,2-Trichloropropane	598-77-6	147.43	EPI	9.60E-03	EPI	1	E	7.03E-01	4.48E-02	3.31E-01	3.64E-01	1.69E+00		1.19E-02	
1,2,3-Trichloropropane	96-18-4	147.43	EPI	7.52E-03	EPI	1	E	7.03E-01	3.51E-02	3.25E-01	3.57E-01	1.69E+00	3.13E-06	9.48E-03	1.01E-06
Triethylamine	121-44-8	101.19	EPI	3.90E-03	EPI	1	E	3.87E-01	1.51E-02	3.13E-01	3.43E-01	9.29E-01			
2,4,6-Trinitrotoluene	118-96-7	227.13	EPI	9.63E-04	EPI	1	E	1.96E+00	5.58E-03	3.07E-01	3.37E-01	4.71E+00	3.13E-03	1.19E-03	
Uranium (soluable salts)	--	238.03	P	1.00E-03	E	1	E	2.26E+00	5.93E-03	3.07E-01	3.37E-01	5.42E+00		7.11E-03	
Vanadium	7440-62-2	50.94	EPI	1.00E-03	E	1	E	2.03E-01	2.75E-03	3.05E-01	3.35E-01	4.86E-01		3.11E-04	

Chemical	**CAS. NO.**	**MW (g/mole)**	**Ref.**	**Kp (cm/hr)**	**Ref.**	**FA (unitless)**	**Ref.**	**τ_{event} (hr/event)**	**B (unitless)**	**b**	**c**	**t* (hr)**	**DA_event carc**	**DA_event noncarc**	**DA_event mutagen**
Vinyl acetate	108-05-4	86.09	P	1.57E-03	EPI	1	E	3.19E-01	5.60E-03	3.07E-01	3.37E-01	7.65E-01		2.37E+00	
Vinyl bromide	593-60-2	106.95	EPI	4.35E-03	EPI	1	E	4.17E-01	1.73E-02	3.14E-01	3.45E-01	1.00E+00			
Vinyl chloride	75-01-4	62.5	EPI	8.38E-03	EPI	1	E	2.35E-01	2.55E-02	3.19E-01	3.51E-01	5.64E-01	1.30E-04	7.11E-03	3.06E+05
m-Xylene	108-38-3	106.17	EPI	5.32E-02	EPI	1	E	4.13E-01	2.11E-01	4.47E-01	4.86E-01	9.91E-01		4.74E-01	
o-Xylene	95-47-6	106.17	EPI	5.00E-02	EPI	1	E	4.13E-01	1.98E-01	4.38E-01	4.76E-01	9.91E-01		4.74E-01	
Xylenes	1330-20-7	106.17	EPI	5.00E-02	EPI	1	E	4.13E-01	1.98E-01	4.38E-01	4.76E-01	9.91E-01		4.74E-01	
Zinc	7440-66-6	65.38	P	6.00E-04	E	1	E	2.44E-01	1.87E-03	3.04E-01	3.35E-01	5.86E-01		7.11E-01	

K_p – Dermal permeability coefficient in water
FA – Fraction absorbed
T_{event} – Lag time per event
B – Ratio of the permeability coefficient of chemical through the stratum corneum relative to its permeability coefficient across the viable epidermis
b, c – Correlation coefficients (see RAGS Part E).
t* - Time to reach steady state
DA$_{\_event}$ Carc. – Absorbed dose per event, carcinogens
DA$_{\_event}$ Noncarc – Absorbed dose per event, noncarcinogens
DA$_{\_event}$ Mutagens – Absorbed dose per event, mutagens

E = US EPA. 2004. Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Interim Guidance. Office of Solid Waste and Emergency Response, Washington, D.C. http://www.epa.gov/oswer/riskassessment/ragse/index.htm
EPI= US EPA. 2012. Estimation Programs Interface (EPI) Suite™ for Microsoft® Windows, v 4.11. Washington, DC, USA.

APPENDIX C

TOXICITY DATA

Table C-1: Human Health Benchmarks Used for Calculating SSLs

Chemical	SF$_o$ (mg/kg-day)$^{-1}$	Ref.	IUR (ug/m^3)$^{-1}$	Ref.	RfD$_o$ (mg/kg-day)	Ref.	RfCi (mg/m^3)	Ref.	Mutagen	GIABS	Ref.	Dermal ABS	Ref.
Acenaphthene					6.00E-02	IRIS				1	E	0.13	E
Acetaldehyde			2.20E-06	IRIS			9.00E-03	IRIS		1	E		
Acetone					9.00E-01	IRIS	3.10E+01	ATSDR		1	E		
Acrylonitrile	5.40E-01	IRIS	6.80E-05	IRIS	4.00E-02	ATSDR	2.00E-03	IRIS		1	E		
Acetophenone					1.00E-01	IRIS				1	E		
Acrolein					5.00E-04	IRIS	2.00E-05	IRIS		1	E		
Aldrin	1.72E+01	IRIS	4.90E-03	IRIS	3.00E-05	IRIS				1	E	0.1	E
Aluminum					1.00E+00	PPRTV	5.00E-03	PPRTV		1	E		
Anthracene					3.00E-01	IRIS				1	E	0.13	E
Antimony					4.00E-04	IRIS				0.15	E		
Arsenic	1.50E+00	IRIS	4.30E-03	IRIS	3.00E-04	IRIS	1.50E-05	CalEPA		1	E	0.03	E
Barium					2.00E-01	IRIS	5.00E-04	HEAST		0.07	E		
Benzene	5.50E-02	IRIS	7.80E-06	IRIS	4.00E-03	IRIS	3.00E-02	IRIS		1	E		
Benzidine	2.30E+02	IRIS	6.70E-02	IRIS	3.00E-03	IRIS			M	1	E	0.1	E
Benzo(a)anthracene	7.30E-01	PPRTV	1.10E-04	CalEPA					M	1	E	0.13	E
Benzo(a)pyrene	7.30E+00	IRIS	1.10E-03	CalEPA					M	1	E	0.13	E
Benzo(b)fluoranthene	7.30E-01	EPA TEF	1.10E-04	CalEPA					M	1	E	0.13	E
Benzo(k)fluoranthene	7.30E-02	EPA TEF	1.10E-04	CalEPA					M	1	E	0.13	E
Beryllium			2.40E-03	IRIS	2.00E-03	IRIS	2.00E-05	IRIS		0.007	E		
a-BHC (HCH)	6.30E+00	IRIS	1.80E-03	IRIS	8.00E-03	ATSDR				1	E	0.1	E
b-BHC (HCH)	1.80E+00	IRIS	5.30E-04	IRIS						1	E	0.1	E
g-BHC	1.10E+00	CalEPA	3.10E-04	CalEPA	3.00E-04	IRIS				1	E	0.04	E
1,1-Biphenyl	8.20E-03	IRIS			5.00E-01	IRIS	4.00E-04	PPRTV		1	E		
Bis(2-chloroethyl) ether	1.10E+00	IRIS	3.30E-04	IRIS						1	E		
Bis(2-chloroisopropyl) ether	7.00E-02	HEAST								1	E		
Bis(2-ethylhexyl) phthalate	1.40E-02	IRIS	2.40E-06	CalEPA	2.00E-02	IRIS				1	E	0.1	E
Bis(chloromethyl) ether	2.20E+02	IRIS	6.20E-02	IRIS						1	E		
Boron					2.00E-01	IRIS	2.00E-02	HEAST		1	E		
Bromodichloromethane	6.20E-02	IRIS	3.70E-05	CalEPA	2.00E-02	IRIS				1	E		
Bromomethane					1.40E-03	IRIS	5.00E-03	IRIS		1	E		
1,3-Butadiene	3.40E+00	CalEPA	3.00E-05	IRIS			2.00E-03	IRIS		1	E		
2-Butanone (Methyl ethyl ketone, MEK)					6.00E-01	IRIS	5.00E+00	IRIS		1	E		

Chemical	SF$_o$ (mg/kg-day)$^{-1}$	Ref.	IUR (ug/m^3)$^{-1}$	Ref.	RfD$_o$ (mg/kg-day)	Ref.	RfCi (mg/m^3)	Ref.	Mutagen	GIABS	Ref.	Dermal ABS	Ref.
tert-Butyl methyl ether (MTBE)	1.80E-03	CalEPA	2.60E-07	CalEPA			3.00E+00	IRIS		1	E		
Cadmium			1.80E-03	IRIS	1.00E-03	IRIS	1.00E-05	ATSDR		0.025	E	0.001	E
Carbon disulfide					1.00E-01	IRIS	7.00E-01	IRIS		1	E		
Carbon tetrachloride	7.00E-02	IRIS	6.00E-06	IRIS	4.00E-03	IRIS	1.00E-01	IRIS		1	E		
Chlordane	3.50E-01	IRIS	1.00E-04	IRIS	5.00E-04	IRIS	7.00E-04	IRIS		1	E	0.04	E
2-Chloroacetophenone							3.00E-05	IRIS		1	E	0.1	E
2-Chloro-1,3-butadiene			3.00E-04	IRIS	2.00E-02	HEAST	2.00E-02	IRIS		1	E		
1-Chloro-1,1-difluoroethane							5.00E+01	IRIS		1	E		
Chlorobenzene					2.00E-02	IRIS	5.00E-02	PPRTV		1	E		
1-Chlorobutane					4.00E-02	PPRTV				1	E		
Chlorodifluoromethane							5.00E+01	IRIS		1	E		
Chloroform	1.90E-02	IRIS	2.30E-05	IRIS	1.00E-02	IRIS	9.80E-02	ATSDR		1	E		
Chloromethane	1.30E-02	HEAST	1.80E-06	HEAST			9.00E-02	IRIS		1	E		
b-Chloronaphthalene					8.00E-02	IRIS				1	E		
o-Chloronitrobenzene	3.00E-01	PPRTV			3.00E-03	PPRTV	1.00E-05	PPRTV		1	E	0.1	E
p-Chloronitrobenzene	6.30E-03	PPRTV			1.00E-03	PPRTV	6.00E-04	PPRTV		1	E	0.1	E
2-Chlorophenol					5.00E-03	IRIS				1	E		
2-Chloropropane							1.00E-01	HEAST		1	E		
o-Chlorotoluene					2.00E-02	IRIS				1	E		
Chromium III					1.50E+00	IRIS				0.013	E		
Chromium VI	5.00E-01	NJ	8.40E-02	IRIS	3.00E-03	IRIS	1.00E-04	IRIS	M	0.025	E		
Chromium (Total)	7.14E-02	NJ, adjusted	1.20E-02	IRIS	1.29E+00	IRIS, adjusted	1.43E-05	IRIS, adjusted		0.013	E		
Chrysene	7.30E-03	EPA TEF	1.10E-05	CalEPA					M	1	E	0.13	E
Copper					4.00E-02	HEAST				1	E		
Crotonaldehyde	1.90E+00	HEAST			1.00E-03	PPRTV				1	E		
Cumene (isopropylbenzene)					1.00E-01	IRIS	4.00E-01	IRIS		1	E		
Cyanide					6.00E-04	IRIS	8.00E-04	IRIS		1	E		
Cyanogen					1.00E-03	IRIS				1	E		
Cyanogen bromide					9.00E-02	IRIS				1	E		
Cyanogen chloride					5.00E-02	IRIS				1	E		
DDD	2.40E-01	IRIS	6.90E-05	CalEPA						1	E	0.1	E
DDE	3.40E-01	IRIS	9.70E-05	CalEPA						1	E	0.1	E
DDT	3.40E-01	IRIS	9.70E-05	IRIS	5.00E-04	IRIS				1	E	0.03	E
Dibenz(a,h)anthracene	7.30E+00	EPA TEF	1.20E-03	CalEPA					M	1	E	0.13	E

Chemical	**SF$_o$ (mg/kg-day)$^{-1}$**	**Ref.**	**IUR (ug/m^3)$^{-1}$**	**Ref.**	**RfD$_o$ (mg/kg-day)**	**Ref.**	**RfCi (mg/m^3)**	**Ref.**	**Mutagen**	**GIABS**	**Ref.**	**Dermal ABS**	**Ref.**
1,2-Dibromo-3-chloropropane	8.00E-01	PPRTV	6.00E-03	PPRTV	2.00E-04	PPRTV	2.00E-04	IRIS	M	1	E	0.1	E
Dibromochloromethane	8.40E-02	IRIS	2.70E-05	CalEPA	2.00E-02	IRIS				1	E	0.1	E
1,2-Dibromoethane	2.00E+00	IRIS	6.00E-04	IRIS	9.00E-03	IRIS	9.00E-03	IRIS		1	E		
1,4-Dichloro-2-butene			4.20E-03	PPRTV						1	E		
1,2-Dichlorobenzene					9.00E-02	IRIS	2.00E-01	HEAST		1	E		
1,4-Dichlorobenzene	5.40E-03	CalEPA	1.10E-05	CalEPA	7.00E-02	ATSDR	8.00E-01	IRIS		1	E		
3,3-Dichlorobenzidine	4.50E-01	IRIS	3.40E-04	CalEPA						1	E	0.1	E
Dichlorodifluoromethane					2.00E-01	IRIS	1.00E-01	PPRTV		1	E		
1,1-Dichloroethane	5.70E-03	CalEPA	1.60E-06	CalEPA	2.00E-01	PPRTV				1	E		
1,2-Dichloroethane	9.10E-02	IRIS	2.60E-05	IRIS	6.00E-03	PPRTV	7.00E-03	PPRTV		1	E		
cis-1,2-Dichloroethene					2.00E-03	IRIS				1	E		
trans-1,2-Dichloroethene					2.00E-02	IRIS	6.00E-02	PPRTV		1	E		
1,1-Dichloroethene					5.00E-02	IRIS	2.00E-01	IRIS		1	E		
2,4-Dichlorophenol					3.00E-03	IRIS				1	E	0.1	E
1,2-Dichloropropane	3.60E-02	CalEPA	1.00E-05	CalEPA	9.00E-02	ATSDR	4.00E-03	IRIS		1	E		
1,3-Dichloropropene	1.00E-01	IRIS	4.00E-06	IRIS	3.00E-02	IRIS	2.00E-02	IRIS		1	E		
Dicyclopentadiene					8.00E-2	PPRTV	3.00E-4	PPRTV		1	E		
Dieldrin	1.60E+01	IRIS	4.60E-03	IRIS	5.00E-05	IRIS				1	E	0.1	E
Diethyl phthalate					8.00E-01	IRIS				1	E	0.1	E
Di-n-butyl phthalate (Dibutyl phthalate)					1.00E-01	IRIS				1	E	0.1	E
2,4-Dimethylphenol					2.00E-02	IRIS				1	E	0.1	E
4,6-Dinitro-o-cresol					8.00E-05	PPRTV				1	E	0.1	E
2,4-Dinitrophenol					2.00E-03	IRIS				1	E	0.1	E
2,4-Dinitrotoluene	3.10E-01	CalEPA	8.90E-05	CalEPA	2.00E-03	IRIS				1	E	0.102	E
2,6-Dintitrotoluene	1.50E+00	PPRTV			3.00E-04	PPRTV				1	E	0.099	E
2,4/2,6-Dintrotoluene Mixture	6.80E-01	IRIS								1	E	0.1	E
1,4-Dioxane	1.00E-01	IRIS	5.00E-06	IRIS	3.00E-02	IRIS	3.00E-02	IRIS		1	E	0.1	E
1,2-Diphenylhydrazine	8.00E-01	IRIS	2.20E-04	IRIS						1	E	0.1	E
Endosulfan					6.00E-03	IRIS				1	E	0.1	E
Endrin					3.00E-04	IRIS				1	E	0.1	E
Epichlorohydrin	9.90E-03	IRIS	1.20E-06	IRIS	6.00E-03	PPRTV	1.00E-03	IRIS		1	E		
Ethyl acetate					9.00E-01	IRIS	7.00E-02	PPRTV		1	E		
Ethyl acrylate	4.80E-02	HEAST								1	E		
Ethyl chloride							1.00E+01	IRIS		1	E		

Chemical	**SF$_o$ (mg/kg-day)$^{-1}$**	**Ref.**	**IUR (ug/m^3)$^{-1}$**	**Ref.**	**RfD$_o$ (mg/kg-day)**	**Ref.**	**RfCi (mg/m^3)**	**Ref.**	**Mutagen**	**GIABS**	**Ref.**	**Dermal ABS**	**Ref.**
Ethyl ether					2.00E-01	IRIS				1	E		
Ethyl methacrylate					9.00E-02	HEAST	3.00E-01	PPRTV		1	E		
Ethylbenzene	1.10E-02	CalEPA	2.50E-06	CalEPA	1.00E-01	IRIS	1.00E+00	IRIS		1	E		
Ethylene oxide	3.10E-01	CalEPA	8.80E-05	CalEPA			3.00E-02	CalEPA		1	E		
Fluoranthene					4.00E-02	IRIS				1	E	0.13	E
Fluorene					4.00E-02	IRIS				1	E	0.13	E
Fluoride					6.00E-02	IRIS	1.30E-02	CalEPA		1	E		
Furan					1.00E-03	IRIS				1	E	0.03	E
Heptachlor	4.50E+00	IRIS	1.30E-03	IRIS	5.00E-04	IRIS				1	E	0.1	E
Hexachlorobenzene	1.60E+00	IRIS	4.60E-04	IRIS	8.00E-04	IRIS				1	E	0.1	E
Hexachloro-1,3-butadiene	7.80E-02	IRIS	2.20E-05	IRIS	1.00E-03	PPRTV				1	E	0.1	E
Hexachlorocyclopentadiene					6.00E-03	IRIS	2.00E-04	IRIS		1	E	0.1	E
Hexachloroethane	4.00E-02	IRIS	1.10E-05	CalEPA	7.00E-04	IRIS	3.00E-02	IRIS		1	E	0.1	E
n-Hexane					6.00E-02	HEAST	7.00E-01	IRIS		1	E		
HMX					5.00E-02	IRIS				1	E	0.006	E
Hydrazine anhydride	3.00E+00	IRIS	4.90E-03	IRIS			3.00E-05	PPRTV		1	E	0.1	E
Hydrogen cyanide					6.00E-04	IRIS	8.00E-04	IRIS		1	E		
Indeno(1,2,3-c,d)pyrene	7.30E-01	EPA TEF	1.10E-04	CalEPA					M	1	E	0.13	E
Iron					7.00E-01	PPRTV				1	E		
Isobutanol (Isobutyl alcohol)					3.00E-01	IRIS				1	E	0.1	E
Isophorone	9.50E-04	IRIS			2.00E-01	IRIS	2.00E+00	CalEPA		1	E	0.1	E
Lead										1	E		
Lead (tetraethyl-)					1.00E-07	IRIS				1	E	0.1	E
Maleic hydrazide					5.00E-01	IRIS				1	E	0.1	E
Manganese					1.40E-01	IRIS	5.00E-05	IRIS		0.04	E		
Mercury (elemental)							3.00E-04	IRIS		1	E		
Mercury (methyl)					1.00E-04	IRIS				1	E		
Mercuric Chloride (Mercury Salts)					3.00E-04	IRIS	3.00E-05	CalEPA		0.07	E		
Methacrylonitrile					1.00E-04	IRIS	3.00E-02	PPRTV		1	E		
Methomyl					2.50E-02	IRIS				1	E	0.1	E
Methyl acetate					1.00E+00	PPRTV				1	E		
Methyl acrylate					3.00E-02	HEAST	2.00E-02	PPRTV		1	E		
Methyl isobutyl ketone					8.00E-02	HEAST	3.00E+00	IRIS		1	E		
Methyl methacrylate					1.40E+00	IRIS	7.00E-01	IRIS		1	E		

Chemical	**SF_o (mg/kg-day)$^{-1}$**	**Ref.**	**IUR (ug/m^3)$^{-1}$**	**Ref.**	**RfD_o (mg/kg-day)**	**Ref.**	**RfCi (mg/m^3)**	**Ref.**	**Mutagen**	**GIABS**	**Ref.**	**Dermal ABS**	**Ref.**
Methyl styrene (alpha)					7.00E-02	HEAST				1	E		
Methyl styrene (mixture)					6.00E-03	HEAST	4.00E-02	HEAST		1	E		
Methylcyclohexane							3.00E+00	HEAST		1	E		
Methylene bromide (Dibromomethane)					1.00E-02	HEAST	4.00E-03	PPRTV		1	E		
Methylene chloride	2.00E-03	IRIS	1.00E-08	IRIS	6.00E-03	IRIS	6.00E-01	IRIS	M	1	E		
Molybdenum					5.00E-03	IRIS				1	E		
Naphthalene			3.40E-05	CalEPA	2.00E-02	IRIS	3.00E-03	IRIS		1	E	0.13	E
Nickel (soluble salts)			2.60E-04	CalEPA	2.00E-02	IRIS	9.00E-05	ATSDR		0.04	E		
Nitrate					1.60E+00	IRIS				1	E		
Nitrite					1.00E-01	IRIS				1	E		
Nitrobenzene			4.00E-05	IRIS	2.00E-03	IRIS	9.00E-03	IRIS		1	E		
Nitroglycerin	1.70E-02	PPRTV			1.00E-04	PPRTV				1	E	0.1	E
N-Nitrosodiethylamine	1.50E+02	IRIS	4.30E-02	IRIS					M	1	E	0.1	E
N-Nitrosodimethylamine	5.10E+01	IRIS	1.40E-02	IRIS	8.00E-06	PPRTV	4.00E-05	PPRTV	M	1	E	0.1	E
N-Nitrosodi-*n*-butylamine	5.40E+00	IRIS	1.60E-03	IRIS						1	E	0.1	E
N-Nitrosodiphenylamine	4.90E-03	IRIS	2.60E-06	CalEPA						1	E	0.1	E
N-Nitrosopyrrolidine	2.10E+00	IRIS	6.10E-04	IRIS						1	E	0.1	E
m-Nitrotoluene					1.00E-04	PPRTV				1	E	0.1	E
o-Nitrotoluene	2.20E-01	PPRTV			9.00E-04	PPRTV				1	E		
p-Nitrotoluene	1.60E-02	PPRTV			4.00E-03	PPRTV				1	E	0.1	E
Pentachlorobenzene					8.00E-04	IRIS				1	E	0.1	E
Pentachlorophenol	4.00E-01	IRIS	5.10E-06	CalEPA	5.00E-03	IRIS				1	E	0.25	E
Perchlorate					7.00E-04	IRIS				1	E		
Phenanthrene					3.00E-02	IRIS				1	E	0.13	E
Phenol					3.00E-01	IRIS	2.00E-01	CalEPA		1	E	0.1	E
Polychlorinatedbiphenyls													
Aroclor 1016	7.00E-02	IRIS	2.00E-05	IRIS	7.00E-05	IRIS				1	E	0.14	E
Aroclor 1221	2.00E+00	IRIS	5.70E-04	IRIS						1	E	0.14	E
Aroclor 1232	2.00E+00	IRIS	5.70E-04	IRIS						1	E	0.14	E
Aroclor 1242	2.00E+00	IRIS	5.70E-04	IRIS						1	E	0.14	E
Aroclor 1248	2.00E+00	IRIS	5.70E-04	IRIS						1	E	0.14	E
Aroclor 1254	2.00E+00	IRIS	5.70E-04	IRIS	2.00E-05	IRIS				1	E	0.14	E
Aroclor 1260	2.00E+00	IRIS	5.70E-04	IRIS						1	E	0.14	E
2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB 170)	1.30E+01	WHO TEF	3.80E-03	WHO TEF	7.00E-06	WHO TEF	4.00E-04	WHO TEF		1	E	0.14	E

Chemical	**SF$_o$ (mg/kg-day)$^{-1}$**	**Ref.**	**IUR (ug/m^3)$^{-1}$**	**Ref.**	**RfD$_o$ (mg/kg-day)**	**Ref.**	**RfCi (mg/m^3)**	**Ref.**	**Mutagen**	**GIABS**	**Ref.**	**Dermal ABS**	**Ref.**
2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB 180)	1.30E+00	WHO TEF	3.80E-04	WHO TEF	7.00E-05	WHO TEF	4.00E-03	WHO TEF		1	E	0.14	E
2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB 189)	3.90E+00	WHO TEF	1.14E-03	WHO TEF	2.33E-05	WHO TEF	1.33E-03	WHO TEF		1	E	0.14	E
2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167)	3.90E+00	WHO TEF	1.14E-03	WHO TEF	2.33E-05	WHO TEF	1.33E-03	WHO TEF		1	E	0.14	E
2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 157)	3.90E+00	WHO TEF	1.14E-03	WHO TEF	2.33E-05	WHO TEF	1.33E-03	WHO TEF		1	E	0.14	E
2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156)	3.90E+00	WHO TEF	1.14E-03	WHO TEF	2.33E-05	WHO TEF	1.33E-03	WHO TEF		1	E	0.14	E
3,3',4,4',5,5'-Hexachlorobiphenyl (PCB 169)	3.90E+03	WHO TEF	1.14E+00	WHO TEF	2.33E-08	WHO TEF	1.33E-06	WHO TEF		1	E	0.14	E
2',3,4,4',5-Pentachlorobiphenyl (PCB 123)	3.90E+00	WHO TEF	1.14E-03	WHO TEF	2.33E-05	WHO TEF	1.33E-03	WHO TEF		1	E	0.14	E
2',3',4,4',5-Pentachlorobiphenyl (PCB 118)	3.90E+00	WHO TEF	1.14E-03	WHO TEF	2.33E-05	WHO TEF	1.33E-03	WHO TEF		1	E	0.14	E
2',3,3',4,4'-Pentachlorobiphenyl (PCB 105)	3.90E+00	WHO TEF	1.14E-03	WHO TEF	2.33E-05	WHO TEF	1.33E-03	WHO TEF		1	E	0.14	E
2,3,4,4',5-Pentachlorobiphenyl (PCB 114)	3.90E+00	WHO TEF	1.14E-03	WHO TEF	2.33E-05	WHO TEF	1.33E-03	WHO TEF		1	E	0.14	E
3,3',4,4',5-Pentachlorobiphenyl (PCB 126)	1.30E+04	WHO TEF	3.80E+00	WHO TEF	7.00E-09	WHO TEF	4.00E-07	WHO TEF		1	E	0.14	E
3,3',4,4'-Tetrachlorobiphenyl (PCB 77)	1.30E+01	WHO TEF	3.80E-03	WHO TEF	7.00E-06	WHO TEF	4.00E-04	WHO TEF		1	E	0.14	E
3,4,4',5-Tetrachlorobiphenyl (PCB 81)	3.90E+01	WHO TEF	1.14E-02	WHO TEF	2.33E-06	WHO TEF	1.33E-04	WHO TEF		1	E	0.14	E
Propylene oxide	2.40E-01	IRIS	3.70E-06	IRIS			3.00E-02	IRIS		1	E		
Pyrene					3.00E-02	IRIS				1	E	0.13	E
RDX	1.10E-01	IRIS			3.00E-03	IRIS				1	E	0.015	E
Selenium					5.00E-03	IRIS	2.00E-02	CalEPA		1	E		
Silver					5.00E-03	IRIS				0.04	E		
Strontium					6.00E-01	IRIS				1	E		
Styrene					2.00E-01	IRIS	1.00E+00	IRIS		1	E		
Sulfolane					1.00E-03	PPRTV	2.00E-03	PPRTV		1	E	0.1	E
2,3,7,8-TCDD	1.30E+05	CalEPA	3.80E+01	CalEPA	7.00E-10	IRIS	4.00E-08	CalEPA		1	E	0.03	E
2,3,7,8-TCDF	1.30E+04	WHO TEF	3.80E+00	WHO TEF						1	E	0.03	E
1,2,4,5-Tetrachlorobenzene					3.00E-04	IRIS				1	E	0.1	E
1,1,1,2-Tetrachloroethane	2.60E-02	IRIS	7.40E-06	IRIS	3.00E-02	IRIS				1	E		
1,1,2,2-Tetrachloroethane	2.00E-01	IRIS	5.80E-05	CalEPA	2.00E-02	IRIS				1	E		
Tetrachloroethene	2.10E-03	IRIS	2.60E-07	IRIS	6.00E-03	IRIS	4.00E-02	IRIS		1	E		
Tetryl (Trinitrophenylmethylnitramine)					2.00E-03	PPRTV				1	E	0.00065	E
Thallium					1.00E-05	PPRTV				1	E		
Toluene					8.00E-02	IRIS	5.00E+00	IRIS		1	E		
Toxaphene	1.10E+00	IRIS	3.20E-04	IRIS						1	E	0.1	E
Tribromomethane (Bromoform)	7.90E-03	IRIS	1.10E-06	IRIS	2.00E-02	IRIS				1	E	0.1	E
1,1,2-Trichloro-1,2,2-trifluoroethane					3.00E+01	IRIS	3.00E+01	HEAST		1	E		
1,2,4-Trichlorobenzene	2.90E-02	PPRTV			1.00E-02	IRIS	2.00E-03	PPRTV		1	E		

Chemical	**SF$_o$ (mg/kg-day)$^{-1}$**	**Ref.**	**IUR (ug/m^3)$^{-1}$**	**Ref.**	**RfD$_o$ (mg/kg-day)**	**Ref.**	**RfCi (mg/m^3)**	**Ref.**	**Mutagen**	**GIABS**	**Ref.**	**Dermal ABS**	**Ref.**
1,1,1-Trichloroethane					2.00E+00	IRIS	5.00E+00	IRIS		1	E		
1,1,2-Trichloroethane	5.70E-02	IRIS	1.60E-05	IRIS	4.00E-03	IRIS	2.00E-04	PPRTV		1	E		
Trichloroethylene	4.6E-02	IRIS	4.10E-06	IRIS	5.00E-04	IRIS	2.00E-03	IRIS	M	1	E		
Trichlorofluoromethane					3.00E-01	IRIS	7.00E-01	HEAST		1	E		
2,4,5-Trichlorophenol					1.00E-01	IRIS				1	E	0.1	E
2,4,6-Trichlorophenol	1.10E-02	IRIS	3.10E-06	IRIS	1.00E-03	PPRTV				1	E	0.1	E
1,1,2-Trichloropropane					5.00E-03	IRIS				1	E		
1,2,3-Trichloropropane	3.00E+01	IRIS			4.00E-03	IRIS	3.00E-04	IRIS	M	1	E		
Triethylamine							7.00E-03	IRIS		1	E		
2,4,6-Trinitrotoluene	3.00E-02	IRIS			5.00E-04	IRIS				1	E	0.032	E
Uranium (soluable salts)					3.00E-03	IRIS	4.00E-05	ATSDR		1	E		
Vanadium					5.04E-03	IRIS	1.00E-04	ATSDR		0.026	E		
Vinyl acetate					1.00E+00	HEAST	2.00E-01	IRIS		1	E		
Vinyl bromide			3.20E-05	HEAST			3.00E-03	IRIS		1	E		
Vinyl chloride	7.20E-01	IRIS	4.40E-06	IRIS	3.00E-03	IRIS	1.00E-01	IRIS	M	1	E		
m-Xylene					2.00E-01	IRIS	1.00E-01	IRIS		1	E		
o-Xylene					2.00E-01	IRIS	1.00E-01	IRIS		1	E		
Xylenes					2.00E-01	IRIS	1.00E-01	IRIS		1	E		
Zinc					3.00E-01	IRIS				1	E		

Notes:
CSF$_o$ – Oral Cancer Slope Factor
IUR– Inhalation Unit Risk
RfD$_o$ – Oral Reference Dose
RfC – Inhalation Reference Concentration
Dermal ABS – Dermal absorption coefficient
GIABS – Gastrointestinal absorption coefficient adjusted – Toxicity data for total chromium has been adjusted based on a ratio of 6:1 (CrIII:CrVI)
E = US EPA. 2004. Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Interim Guidance. Office of Solid Waste and Emergency Response, Washington, D.C. http://www.epa.gov/oswer/riskassessment/ragse/index.htm
EPA TEF – US EPA (1993) toxicity equivalency factors applied to polycyclic aromatic hydrocarbons
ATSDR – Agency for Toxic Substances and Disease Registry
Cal EPA – California Environmental Protection Agency
HEAST – Health Effects Assessment Summary Tables
IRIS – Integrated Risk Information System
PPTRV – Provisional Peer Reviewed Toxicity Value
NJ – New Jersey Department of Environmental Protection (2009)

WHO TEF – World Health Organization Toxicity Equivalency Factor

-Toxicity data for total chromium has been adjusted based on a ratio of 6:1 (CrIII:CrVI)
-For GI absorption, a value of 1 was used for all organics as directed in RAGS Part E. A default value of 1 was used for inorganics not listed in RAGS Part E.
-Pyrene toxicity data used as surrogate data for phenanthrene.
-Aroclor 1016 is considered the lowest risk, so it was assigned a "lowest risk" value from IRIS. All other Aroclors were assigned a "highest risk" value from IRIS.
-Toxicity data for total xylenes used as a surrogate for all other isomers of xylene (o-, m-, and p-xylene)
-The RfDo value for vanadium is based on RfD for vanadium pentoxide, and adjusted for molecular weight.
-The RfDo value for cadmium is based on the RfDo for food. An RfDo of 0.0005 mg/kg-d was used for the tap water pathways as directed in IRIS (US EPA, 2014).

APPENDIX D

Guidance for Risk-based Remediation of Polychlorinated Biphenyls (PCBs) at RCRA Corrective Action Sites

Guidance for Risk-based Remediation of Polychlorinated Biphenyls (PCBs) at RCRA Corrective Action Sites[3]

July 2014

---

[3] This document is intended as guidance for employees of the New Mexico Environment Department's (NMED) Hazardous Waste Bureau (HWB) and Resource Conservation and Recovery Act (RCRA)-regulated facilities within the State of New Mexico. This guidance does not constitute rule-making and may not be relied upon to create a right or benefit, substantive or procedural, enforceable at law or in equity, by any person. HWB may take action at variance to this guidance and reserves the right to modify this guidance at any time without public notice.

Table of Contents

List of Tables

ACRONYMNS AND ABBREVIATIONS

µg/g	microgram per gram
µg/L	microgram per liter
AOC	Area of Concern
AT	Averaging Time
BMP	Best Management Practices
BW	Body Weight
CSF	Cancer Slope Factor
CWA	Clean Water Act
DD	Daily Dose
ECD	Electron Capture Detector
ED	Exposure Duration
EF	Exposure Frequency
ELCD	Electrolytic Conductivity Detector
GC/MS	Gas Chromatography/Mass Spectral Detector
HR	High Resolution
HRGC	High Resolution Gas Chromatography
HRMS	High Resolution Mass Spectral Detector
HWB	Hazardous Waste Bureau
IR	Ingestion Rate
IRIS	Integrated Risk Information System
LADD	Lifetime Average Daily Dose
mg/m^3	milligram per cubic meter
mg/kg	milligram per kilogram
mg/L	milligram per liter
ng/L	nanogram per liter
NMED	New Mexico Environment Department
PCB	Polychlorinated Biphenyl
PCDD	Polychlorinated Dibenzo-dioxins
PCDF	Polychlorinated Dibenzo-furans
pg/L	picogram per liter
ppb	parts per billion
ppm	parts per million
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
SWMU	Solid Waste Management Unit
TCDD	2,3,7,8-tetrachloro-dibenzo-dioxin
TCDF	2,3,7,8-tetrachloro-dibenzo-furan
TEF	Toxicity Equivalency Factor
TEQ	Toxicity Equivalency Quotient

TRV	Toxicity Reference Value
TSS	Total Suspended Solids
US EPA	United States Environmental Protection Agency

Guidance for Risk-based Remediation of Polychlorinated Biphenyls at RCRA Corrective Action Sites

1.0 SCOPE

This document focuses on remedial activities at sites where polychlorinated biphenyls (**PCBs**) have been identified or are suspected of being present as one of the contaminants of potential concern. The intent of this document is to expedite the remedial action process and provide a cost-effective and consistent method for the evaluation and reduction of the risk posed to human health and the environment by PCBs.

This document **does not** discuss the complex regulations governing PCBs or the sampling methodologies for PCBs or other associated contaminants. This document **does** assume that the nature and extent of PCB contamination have been defined using a site conceptual model and **does** discuss and recommend analytical methods applicable to evaluating the risk to human and ecological health for PCBs in environmental media.

This paper **does not** discuss the risk posed to ground water quality by PCB contamination; state ground water standards and federal drinking water standards[4] exist for the protection of ground water. No state or federal soil/sediment standards exist to protect ground water from the transport of PCBs from contaminated soil/sediments; however, the risk associated with the transport of PCBs from contaminated soil/sediments to ground water should be evaluated to ensure that state and federal standards for ground water are not exceeded. Methods for the evaluation of this threat to ground water are **not**, at this time, specifically addressed in this document.

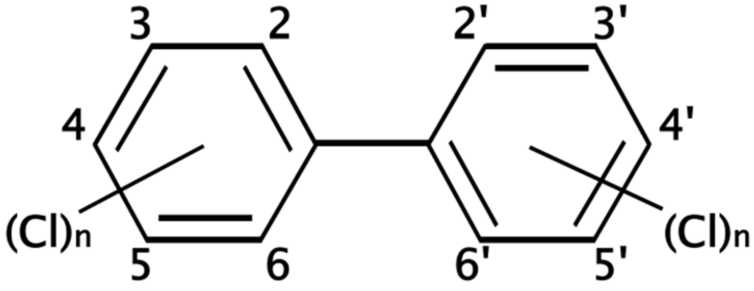
2.0 BACKGROUND INFORMATION

PCBs are a class of chlorinated organic compounds which found widespread application since their introduction into commerce in 1923. Their properties include thermal stability; resistance to acids, bases and oxidation; and resistance to direct electrical current. They were commonly used in transformers and capacitors, hydraulic and heat transfer equipment, compressors and vacuum pumps, plasticizers (surface coatings and sealants), and some paints and inks. Domestic production of commercial PCBs ceased in 1977; however, PCBs in existence at that time are still in use today.

The general chemical structure of chlorinated biphenyls is as follows:

---

[4] PCBs in ground water may not exceed the Safe Drinking Water Act's maximum contaminant level of 0.5 micrograms per liter (µg/L) in drinking water (Title 40 Code of Federal Regulations Parts 141-147 and 149) or the State of New Mexico's Water Quality Control Commission Regulations' standard of 1 µg/L in ground water with 10,000 milligrams per liter (mg/L) or less total dissolved solids (Title 20 New Mexico Annotated Code Chapter 6.2).



The number and position of chlorines in the biphenyl molecule determine the physical and chemical properties of the PCB molecule. There are a total of 209 possible *congeners*[5] of PCBs, each one resulting from the chlorination of different substitution positions and varying degrees of chlorination. In general, PCB molecules with higher degrees of chlorination are more resistant to biodegradation and are more persistent in the environment.

PCB congeners may be found in commercial preparations or complex mixtures known by the names Askarel, Aroclor, Clophen, Phenoclor, Kanechlor, and Pyralène. In the United States, PCB mixtures were marketed under the trade name of Aroclor. Each Aroclor has a four-digit numeric designation: the first two digits are “12" (indicating the biphenyl parent molecule) followed by two more digits indicating the percent chlorine content by weight in the mixture. For example, Aroclor 1254 has 54% chlorine by weight. Aroclor 1016 is the exception: it contains 41% chlorine by weight (ATSDR, 1995).

PCBs are a group of environmentally persistent organic chemicals that possess the inherent properties of compounds that bioaccumulate (i.e., high octanol/water partition coefficient and low water solubility). PCBs also have the following properties of environmental relevance: low vapor pressure and low flammability.

PCBs are toxic to humans and other animals (Eisler, 1986; ATSDR, 1995; and US EPA, 1996 and 1997a). PCBs adversely impact reproduction in wildlife and in experimental animals. Other common toxic effects in mammals and birds include thymic atrophy (a wasting syndrome), microsomal enzyme induction, porphyria (manifestations include intermittent nervous system dysfunction and/or sensitivity of skin to sunlight) and related liver damage, chloracne, estrogenic activity, immunosuppression, and tumor promotion. PCBs can be transferred to young mammals (including humans) transplacentally and in breast milk.

The United States Environmental Protection Agency (**US EPA**) and International Agency for Research on Cancer classified PCBs as Group B2; probable human carcinogens, based on sufficient evidence of carcinogenicity (manifested as hepatocellular carcinomas) in experimental animals and inadequate (due to confounding exposures to other potential carcinogens or lack of exposure quantification), yet suggestive evidence of excess risk of liver cancer in humans (US EPA, 2010 and US EPA, 2014). Recent studies have indicated that all PCB mixtures can cause

---

[5] *Congener* means any single, unique, well-defined chemical compound in the PCB category.

cancer; however, different mixtures exhibit different carcinogenic potencies (Cogliano, 1998). In addition, environmental processes may alter the PCB mixtures affecting its carcinogenic potency (see *Environmental Processes*).

The stability and lipophilicity of PCBs promote their biomagnification (i.e., the uptake of a chemical through ingestion resulting in the concentration of the chemical in tissue being greater than that of its food) once they enter the aquatic and terrestrial food chains. Through the food chain, living organisms selectively bioaccumulate persistent congeners of PCBs. Environmentally-aged PCB mixtures appear to be more toxic and persistent in the organism than commercial PCB mixtures. Biomagnification through trophic transfer governs PCB levels in animals, especially those occupying the top of the food web. Therefore, PCBs in food sources represent the most important exposure source to humans and wildlife.

In certain situations, PCBs can become contaminated with the far more toxic polychlorinated dibenzofurans (**PCDFs**) and chlorinated dibenzo-dioxins (**PCDDs**). Therefore, the presence of PCDFs and PCDDs should always be investigated if any of the following processes existed or are suspected of existing:

- Combustion or incineration of PCB-contaminated waste or waste oils, or highly variable waste streams (such as municipal and commercial waste for which PCB contamination is suspected);
- Manufacture of PCBs[6];
- Pyrolysis of PCBs;
- Photolysis of PCBs;
- Incidental fire of transformers and capacitors containing PCBs; or
- Treatment with chlorinating compounds (e.g., hydrochloric acid, chlorine, etc.).

3.0 ENVIRONMENTAL PROCESSES

PCBs occur as mixtures of congeners in the environment. *Partitioning*[7], chemical and biological transformation, and preferential bioaccumulation may change the composition of the PCB mixture over time: the environmentally-aged PCB mixture may vary considerably from the original congener composition (US EPA, 1996b and ATSDR, 1995). Altered PCB mixtures have been known to persist in the environment for many years.

PCBs adsorb to organic matter, sediments, and soil. Their affinity to adsorb increases with the chlorine content of the PCBs and the amount of organic matter present. PCBs can volatilize or disperse as aerosols providing an effective means of transport in the environment. Congeners with low chlorine content tend to be more volatile and more water soluble.

---

[6] The concentration of PCDFs in commercial PCB samples ranged from 0.2 mircrograms per gram (µg/g) to 13.6 µg/g (ATSDR, 1993). Eisler (1986) reported PCDFs impurities ranging from 0.8 to 33 milligrams per kilogram (mg/kg) in some domestic and foreign PCB mixtures.

[7] *Partitioning* includes environmental processes by which different fractions of a mixture separate into air, water, sediment, and soil.

The highly chlorinated Aroclors (Aroclor 1248, 1254, and 1260) resist both chemical and biological transformation (i.e., degradation) in the environment. Biological degradation of highly chlorinated Aroclors to lower chlorinated PCBs can occur under anaerobic conditions[8]. The extent of this dechlorination[9] is limited by the PCB chlorine content and soil/sediment PCB concentrations. Anaerobic bacteria in soil/sediments remove chlorines from low chlorinated PCBs (1 to 4 chlorines) and open the carbon rings through oxidation. PCBs with higher chlorine content are extremely resistant to oxidation and hydrolysis. Photolysis can also slowly break down highly chlorinated PCB congeners.

PCBs bioaccumulate and biomagnify through the food chain because they are highly lipid-soluble. The mixture of congeners found in biotic tissue will differ dramatically from the mixture of congeners originally released to the environment because bioaccumulation and biomagnification concentrate PCB congeners of higher chlorine content up through the food chain. This is because different congeners can exhibit different rates of metabolism and elimination in living organisms (Van den Berg, et al., 1998 and Cogliano, 1998).

By altering the congener composition of PCB mixtures, these environmental processes can substantially increase or decrease the toxicity of environmental PCBs mixture (Cogliano, 1998). Therefore, information on these environmental processes along with the results of congener-specific analyses of environmental and biota samples should be used to substantiate modeling of exposure to and health risks resulting from environmental PCBs.

4.0 PCB CLEANUP LEVELS

PCB-contaminated soil/sediments should be remediated to either 1) a default concentration of 1 mg/kg or part per million (**ppm**) *total PCBs* (defined as the sum of congeners, Aroclors or *homologues*[10]), 2) a risk-based generic screening level (see media-specific screening levels in Appendix A of Volume 1) or 3) a *site-specific risk-based PCB concentration level*[11] established through performing a health risk evaluation. Site-specific risk-based PCB concentrations may be calculated from equations presented in *Risk Evaluation*. Once the calculations have been completed for all receptors, the lowest computed risk-based PCB concentration in a medium would represent the PCB remediation goal for that medium. These PCB remediation goals may be refined, if necessary, in the higher-level, site-specific risk assessment.

---

[8] However, certain fungi have been demonstrated to degrade PCBs under aerobic conditions.

[9] Note that dechlorination is not synonymous with detoxification because it may result in the formation of carcinogenic congeners.

[10] A *homologue* is a subcategory of PCBs having an equal number of chlorine substituents. *Substituent* means an atom or group that replaces another atom or group in a molecule. PCB homologues can be quantified using EPA Method 680 or estimated using regression equations such as those found in NOAA, 1993.

[11] A *risk-based PCB concentration level* means the PCB concentration above which some adverse health effects may be produced in human and/or ecological receptors, and below which adverse health effects are unlikely to occur.

Table D-1 presents the corrective action cleanup options for the remediation of PCB-contaminated soil/sediments and data quality recommendations regarding the PCB analyses of environmental media samples.

Table D-1. PCB Cleanup Options In Soil/Sediment and Data Quality Recommendations[12]

Cleanup Option	Corrective Action Steps		Data Quality Recommendations
Default Option 1	1	Delineate the nature and horizontal and vertical extent of contamination	Estimate total PCBs as the sum of Aroclors or homologues (using a quantitation limit of 50 parts per billion [ppb] or 1 ppb, respectively) in environmental media
	2	Remediate to 1 ppm	
	3	Conduct post-remediation monitoring, as necessary	
Default Option 2	1	Delineate the nature and horizontal and vertical extent of contamination	Estimate total PCBs as the sum of Aroclors or homologues (using a quantitation limit of 50 parts per billion [ppb] or 1 ppb, respectively) in environmental media
	2	Remediate to generic risk-based screening level (See Appendix A of Volume 1))	
	3	Conduct post-remediation monitoring, as necessary	
Site-Specific, Risk-Based	1	Delineate the nature and horizontal and vertical extent of contamination	Estimate total PCBs as the sum of Aroclors or homologues (using a quantitation limit of 50 ppb or 1 ppb, respectively) and/or congener-specific environmental and biota concentrations (using a quantitation limit in the low parts per trillion)
	2	Perform health risk evaluation	
	3	Establish risk-based concentrations for all human and environmental receptors	
	4	Remediate to the lowest risk-based concentration	
	5	Conduct post-remediation monitoring, as necessary	

The following is a listing of potential PCB target analytes[13]. The 12 PCB congeners indicated in boldface italics are those which are recommended for quantitation as potential target analytes when performing a risk-based cleanup. The 16 additional congeners listed in plain text may provide valuable information, but are not required for the evaluation of risk. The analyses of all 209 congeners would greatly improve the estimate of total PCB concentrations.

---

[12] Modified from Valoppi, et al., 1999.

[13] The number in parentheses refers to the identification system used to specify a particular congener.

Table D-2. Potential PCB Target Analytes

2,4′-Dichlorobiphenyl (8)
2,2′,5-Trichlorobiphenyl (18)
2,4,4′-Trichlorobiphenyl (28)
2,2′,3,5′-Tetrachlorobiphenyl (44)
2,2′,5,5′-Tetrachlorobiphenyl (52)
2,3′,4,4′-Tetrachlorobiphenyl (66)
3,3′,4,4′-Tetrachlorobiphenyl (77)
3,4,4′,5-Tetrachlorobiphenyl (81)
2,2′4,5,5′-Pentachlorobiphenyl (101)
2,3,3′,4,4′-Pentachlorobiphenyl (105)
2,3,4,4′,5-Pentachlorobiphenyl (114)
2,3′,4,4′,5-Pentachlorobiphenyl (118)
2′,3,4,4′,5′-Pentachlorobiphenyl (123)
3,3′,4,4′,5-Pentachlorobiphenyl(126) 2,2′,3,3′,4,4′-Hexachlorobiphenyl (128)
2,2′,3,4,4′,5′-Hexachlorobiphenyl (138)
2,2′,4,4′,5,5′-Hexachlorobiphenyl (153)
2,3,3′,4,4′,5-Hexachlorobiphenyl (156)
2,3,3′,4,4′,5′-Hexachlorobiphenyl (157)
2,3′,4,4′,5,5′-Hexachlorobiphenyl (167)
3,3′,4,4′,5,5′-Hexachlorobiphenyl (169)
2,2′,3,3′,4,4′,5-Heptachlorobiphenyl (170)
2,2′,3,4,4′,5,5′-Heptachlorobiphenyl (180)
2,2′,3,4′,5,5′,6-Heptachlorobiphenyl (187)
2,3,3′,4,4′,5,5′-Heptachlorobiphenyl (189)
2,2′,3,3′,4,4′,5,6-Octachlorobiphenyl (195)
2,2′,3,3′,4,4′,5,5′,6-Nonachlorobiphenyl (206)
2,2′,3,3′,4,4′,5,5′,6,6′-Decachlorobiphenyl (209)

The 16 PCB congeners in plain text have been indicated as target analytes by the National Oceanic and Atmospheric Administration based on their toxicity, ubiquitousness in the marine environment, presence in commercial Aroclor mixtures, etc. (NOAA, 1993).

5.0 ANALYTICAL METHODS

Aroclors are often used to characterize PCB exposures; however, the use of Aroclors in estimating the human health or ecological risk can be both imprecise and inappropriate because the PCB mixtures to which humans and other biota may be exposed may be considerably different from the original Aroclor mixtures released to the environment. In addition, traditional analytical methods for Aroclor analyses produce estimates that are prone to errors. Both qualitative and quantitative errors may arise from interpreting gas chromatography (**GC**) data.

GCs configured with electron capture detectors (**ECD**) or electrolytic conductivity detectors (**ELCD**) are particularly prone to error. The GC/ECD and GC/ELCD produce a chromatogram that is compared with the characteristic chromatographic patterns of the different Aroclors (US EPA, 1996a). For environmentally weathered and altered mixtures, an absence of these characteristic patterns can suggest the absence of Aroclors even if some congeners are present in high concentrations. Additionally, and commonly, the presence of interferents may also mask the characteristic response pattern of the Aroclors. The “pattern recognition” technique is inherently subjective, and different analysts may reach different conclusions regarding the presence or absence of Aroclors.

GCs configured with mass spectral detectors (**GC/MS**) allow identification of individual chemical compounds. GC/MS also produces a chromatogram, and additionally includes mass spectral information about the chemical identity of each peak in the chromatogram. Therefore, GC/MS adds a qualitative line of evidence above that included in GC/ECD or GC/ELCD techniques. GC/MS may be subject to interference, misinterpretation, or other problems.

High resolution (**HR**) isotope dilution GC/high resolution MS (**HRGC/HRMS**), while not as common technique as GC-ECD or GC-MS, is a specific GC/MS technique that has proven reliable for PCB analysis. In HRGC/HRMS exhaustive sample clean-up techniques are employed, and isotopic tracers are used to support identification.

Therefore, the HWB recommends the use of HRGC/HRMS analyses in evaluating health risks to humans and the environment. If HRGC/HRMS methods are not employed, then site specific data must be used to demonstrate that the methods employed are appropriate to the site, or HRGC/HRMS confirmation must be integrated into the analytical plan, for instance on a one in 20 sample basis, or a for a minimum number of samples, or as otherwise agreed. Both detections and non-detections should be confirmed.

Results of GC techniques may be expressed as Aroclors, congeners, homologues, or as total PCBs in units of weight/weight [mg/kg, µg/kg, nanogram per kilogram (ng/kg)] or weight/volume [µg/L or pictogram per liter (pg/L)]. It is necessary to specify the reporting requirements prior to analysis and negotiate the analytical list and reporting limits. Results must be reported on a dry weight basis for soil, sediment and waste samples (excluding liquids).

In addition to the traditional GC analysis, a number of biological and immunological assays are now available, as well as field GC. These may be suited for use as screening methods to guide day-to-day remediation efforts, but are not suited to evaluating health risks to humans and the environment as stand-alone methodologies.

Table D-3. Analytical Methods for PCBs

Method	Technology	Report As[1]	Approximate Detection Limits	Comments
SW-846 8082A	GC/ECD or GC/ELCD	Aroclors Congeners	50-100 µg/kg	Must supply site-specific performance data or use HRGC/HRMS confirmation
SW-8270D	GC/MS	Aroclors	>1000 µg/kg[2]	Detection limits may not support project data quality objectives
SW-846 8275A	GC/MS	Congeners	200 µg/kg	
Method 1668B	HRGC/HRMS	Congeners	<1µg/kg, often in the ng/kg range[2]	Use this method for confirmation

NOTES:

[1] Reporting types have been limited to those mentioned in the subject methods. Laboratories may offer additional reporting modalities, such as homologues and total PCBs.

[2] Detection Limits not specified in the method. Various sample preparation options and matrix effects may affect results

6.0 STORM WATER RUNOFF MONITORING RECOMMENDATIONS

The potential for transport to human or ecological receptors (including ground and surface water) should be evaluated for all corrective action sites impacted or suspected of being impacted by PCBs. PCB concentrations in storm water runoff resulting from contaminated soil/sediments should be monitored **and** the soils remediated to ensure that there is no release or runoff from the Solid Waste Management Unit (**SWMU**) or Area of Concern (**AOC**) which results in a total PCB concentration in excess of the Clean Water Act (**CWA**)-recommended freshwater aquatic life chronic criterion of 0.014 µg/L[14] (unfiltered water) to a *water of the State*.[15] Likewise, concentrations of PCB-contaminated stream bottom, lake or reservoir deposits should not result in total PCB concentrations in unfiltered water which exceeds the CWA-recommended freshwater aquatic life chronic criterion of 0.014 µg/L.

The evaluation of a site's PCB concentrations and erosion potential will aid in determining and prioritizing the corrective actions and best management practices (**BMPs**) necessary to protect surface water quality. Each facility should develop a method for evaluating the erosion potential[16] and present the methodology to the NMED HWB for approval prior to implementation. This evaluation should be conducted on all known or suspected PCB sites. All PCB sites with elevated erosion potentials should implement BMPs to reduce transport of PCB-contaminated sediments and soils. BMP effectiveness should be evaluated and monitored regularly through a formalized inspection and maintenance program. BMPs should be implemented as interim actions or stabilization measures which are consistent with a final remedy and should not be misconstrued as a final remedy.

NMED's HWB believes that controlling the total suspended solids (**TSS**) load of storm water runoff may effectively control PCB migration in surface water because PCBs are hydrophobic, tend to adsorb to soil and organic particles, and are transported in suspended sediments during storm runoff events. Therefore, the TSS should be monitored to aid in predicting and, therefore, potentially controlling the transport of PCBs into *watercourses*[17].

Storm water samples should be collected from storm water events which are greater than 0.1 inches in magnitude (US EPA, 1992). Grab samples should be collected within the first 30 minutes or as soon as practical, but not more than 1 hour after runoff discharge begins. A sufficient quantity of runoff should be collected (i.e., 5 liters) because additional analyses for PCBs may be required based upon the TSS analytical results. The runoff samples should be analyzed for TSS using Method 2540D of the most recent edition of the *Standard Methods for the Examination of Water and* Wastewater.

---

[14] This concentration is the Clean Water Act §304(a) recommended chronic criterion for aquatic life (http://water.epa.gov/scitech/swguidance/standards/current/index.cfm).

[15] *Water(s) of the State* means all interstate and intrastate water including, natural ponds and lakes, playa lakes, reservoirs, perennial streams and their tributaries, intermittent streams, sloughs, prairie potholes and wetlands (Title 20 New Mexico Annotated Code Chapter 6.1).

[16] NMED HWB recommends the approach to evaluating erosion potential presented in the *Matrix Approach to Contaminant Transport Potential* (Mays and Veenis, 1998).

[17] *Watercourse* means any river, creek, arroyo, canyon, draw, or wash, or any other channel having definite banks and beds with visible evidence of the occasional flow of water (Title 20 New Mexico Annotated Code Chapter 6.1).

Grab samples should be used for monitoring. Composite samples may **not** be used for monitoring; however, flow-weighted composite samples may be used in the development and validation of storm water contaminant transport modeling.

The following bullets describe recommended trigger levels and actions based on the analytical results of TSS analyses:

- If TSS is less than 100 mg/L, no action is required.
- If TSS is greater than 100 mg/L, but less than 1,000 mg/L, then the effectiveness of existing BMPs should be evaluated and repaired as necessary, and additional BMPs may need to be implemented to reduce TSS loading
- If the TSS is greater than 1,000 mg/L, then the remaining portion of the sample should be centrifuged and the solids analyzed for PCBs using EPA SW-846 Method 8082 (US EPA, 1997d), EPA Method 680, or draft EPA Method 1668 (Alford-Stevens, et al., 1985 and US EPA, 1996a).

7.0 RISK EVALUATION

The risk to human health and the environment must be evaluated for all corrective action *solid waste management units/areas of concern*[18] (**SWMU/AOCs**) impacted or suspected of being impacted by PCBs and having a potential for transport to a human or ecological receptor. The risk posed by PCBs at these SWMU/AOCs may be modeled (based on adequate available data) and should be monitored to ensure an acceptable level of risk[19] (see *Storm Water Runoff Monitoring Recommendations)*.

As discussed in *Environmental Processes*, the congener composition of environmentally-aged PCBs can dramatically differ from the original Aroclor mixture released to the environment. Consequently, environmental processes can affect both exposure to, and toxicity of, environmental PCBs. Therefore, the approach to evaluating health risks from environmental PCBs differs depending upon whether the PCB congener- or Aroclor-specific (or homologue-specific) data are available for the environmental media (see also *PCB Cleanup Levels*).

PCB congeners with chlorine atoms in positions 2 and 6 (ortho) are generally more readily metabolized, while those with chlorines in positions 4 and 4' (para) or positions 3, 4 or 3, 4, 5 on one or both rings tend to be more toxic and are retained mainly in fatty tissues (Eisler, 1986). Persistent congeners may retain biological activity long after the exposure. The most toxic PCB congeners can assume a conformation, generally similar to that of 2, 3, 7, 8-tetrachloro-dibenzo-dioxin (**TCDD**), and are approximate stereo analogs of this compound (Hoffman, et al., 1996).

---

[18] *SWMU* means “any discernable unit at which solid wastes have been placed at any time, irrespective of whether the unit was intended for the management of solid or hazardous waste. Such units include any area at a facility at which solid wastes have been routinely and systematically released.” *AOC* “...refers to releases which warrant investigation or remediation under the authorities discussed above, regardless of whether they are associated with a specific SWMU...”

[19] A risk or hazard is considered *acceptable* if an estimated risk/hazard is below pre-established target risk and/or hazard levels.

These dioxin-like congeners share a common mechanism of toxicity involving binding to the aryl hydrocarbon receptor; the same mechanism of action is believed to induce the toxicity of PCDDs and PCDFs. These congeners were assigned toxicity equivalency factors (**TEFs**) expressed as a fraction of the toxicity of 2,3,7,8-TCDD. Therefore, when PCB congener-specific analytical data are available, risk evaluation of human and ecological health should consider both dioxin-like and other adverse health effects. Two sections within this document (*Human Health, Carcinogenic Effects, Dioxin-like Toxicity Approach* and *Ecological Health, Dioxin-like PCBs*) provide guidance for applying these TEFs where congener-specific analyses are available. If only Aroclor/homologue concentrations are available for a site, total PCB concentrations reported as the sum of Aroclor/homologue concentrations should be used to estimate the risk to human health and the environment.

If a health risk evaluation is based on total PCB concentrations (estimated as the sum of Aroclors or PCB homologues) and the individual congeners comprising the PCB mixtures cannot be identified, the uncertainty and potential bias in the resulting risk estimates should be described in the risk assessment report. For example, if total PCB concentrations have been estimated based on Aroclor analyses, conservative assumptions should be made about the mixture composition and toxicity: the assumption that congeners with greater than four chlorines per PCB molecule comprise greater than 0.5% of total PCBs present in a given abiotic medium at the site triggers the selection of the highest cancer slope factor from Table D-3. Whereas, total PCB concentrations estimated based on the results of PCB homologue analyses may allow for a refinement of these conservative assumptions. More detailed information on an approach to evaluating the health risk from environmental PCBs and PCB data requirements can be found in US EPA (1996b); Van den Berg, et al. (1998); Cogliano (1998); Giesy and Kannan (1998) and Valoppi, et al. (1999).

7.1 Human Health

Since PCBs may cause both carcinogenic and non-carcinogenic adverse human health effects, separate risk assessments must be performed for each of these health effects.

7.1.1Carcinogenic Effects

The evaluation of carcinogenic risk from exposure to PCB mixtures (i.e., represented by total PCBs or PCB congeners) should follow the slope factor approach described in *PCBs: Cancer Dose-Response Assessment and Application to Environmental Mixtures* (US EPA, 1996b) and as outlined below. This approach distinguishes among toxic potencies of different PCB mixtures by utilizing information regarding environmental processes. In the absence of PCB congener- or homologue-specific analyses (i.e., if total PCB concentrations were estimated based on Aroclor analyses), this approach requires conservative assumptions about the risk and persistence of PCB mixtures at the site.

If congener-specific concentrations are available and congener analyses indicate that congeners with more than 4 (four) chlorines comprise greater that 0.5 percent of total PCBs in a given medium, the slope factor approach should be supplemented by the analysis of dioxin toxicity equivalency quotient (**TEQ**). Risk from *dioxin-like congeners*[20] should be added to the risk estimated for the rest of the PCB mixture which does not exhibit dioxin-like toxicity.

If other dioxin-like compounds (i.e., PCDDs and/or PCDFs) are present at a site in addition to PCBs, TEQs for dioxin-like PCBs should be added to TEQs calculated for those other dioxin-like compounds to yield a total TEQ. A slope factor for 2,3,7,8-TCDD should be applied to this total TEQ. Under these circumstances, the concentrations of dioxin-like PCBs should be subtracted from the total PCB concentration to avoid overestimating risks from dioxin-like PCBs by evaluating them twice.

7.1.1.1 Slope Factor Approach

Site-specific carcinogenic risk evaluations should be performed using PCB cancer potency or slope factors specific to the exposure scenarios and pathways at a particular site. Table D-4 provides the criteria for using these slope factors (categorized into high, medium, and low levels of risk and PCB persistence) that address a variety of exposure scenarios and the toxicity of PCB mixtures in the environment. A review of recent research on PCB toxicity that formed the basis for the derivation of these slope factors and a discussion of uncertainties surrounding toxicity information can be found in US EPA (1996b) and Cogliano (1998).

The slope factors in Table D-4 represent the upper-bound slopes that are recommended for evaluating human health risk from carcinogenic effects of PCBs. Both the upper-bound and central-estimate slopes are available from the US EPA's Integrated Risk Information System (**IRIS**). The central-estimate slopes can be used to support the analysis of uncertainties inherent in available toxicity information on PCBs.

---

[20] *Dioxin-like congeners* of PCBs are those with dioxin-like health effects and are evaluated using dioxin TEQs (Van den Berg, et al., 1998). A complete listing of PCB congeners can be found at http:\\www.epa.gov/grtlakes/toxteam/pcbid/table.htm (US EPA's Great Lakes website).

Table D-4. PCB Cancer Slope Factor Values by Level of Risk and Persistence[21]

CRITERIA FOR USE	LEVEL OF RISK AND PERSISTENCE	PCB CANCER SLOPE FACTOR VALUES[22] [risk per mg/kg-day]
Food chain exposure	High	2.0
Sediment/soil ingestion		
Dust/aerosol inhalation		
Dermal exposure (if an absorption factor has been applied)		
Presence of dioxin-like, tumor-promoting, or persistent congeners		
Early-life (less than 6 years old) exposure by all pathways and to all mixtures		
Congeners with greater than four chlorines per PCB molecule comprise greater than 0.5% of the total PCBs present		
Congeners with greater than four chlorines per PCB molecule comprise less than 0.5% of the total PCBs present (all pathways except soil ingestion by adults)		
Ingestion of water-soluble (less chlorinated) congeners	Medium	0.4
Inhalation of evaporated (less chlorinated) congeners		
Dermal exposure (if no absorption factor has been applied)		
Congeners with greater than four chlorines per PCB molecule comprise less than 0.5% of the total PCBs present (soil ingestion by adults only)	Low	0.07

The cancer slope factors in Table D-4 characterize the toxic potency of different environmental mixtures of PCBs. Information on potential exposure pathways and PCB mixture composition at a given site guides in the selection of the appropriate cancer slope factors for risk assessment.

The highest slope factor in Table D-4 (2.0 per mg/kg-day) corresponds to the high risk and persistence of environmental PCB mixtures and, as such, should be selected for pathways (including food chain exposures, ingestion of soil and sediment, inhalation of dust or aerosol,

---

[21] Modified from Cogliano, 1998 and US EPA, 1996b and 1998c.

[22] See IRIS (US EPA, 2014).

exposure to dioxin-like, tumor-promoting or persistent congeners, and early-life exposure) where environmental processes act to increase risk.

A lower slope factor (0.4 per mg/kg-day) corresponds to the low risk and persistence of environmental PCB mixtures and is appropriate for exposure pathways (such as ingestion of water-soluble congeners and inhalation of evaporated congeners) where environmental processes act to decrease risk.

Finally, the lowest slope factor in Table D-4 (0.07 per mg/kg-day) corresponds to the lowest risk and persistence of environmental PCB mixtures and should be selected for soil ingestion by adults when congener or homologue analyses confirm that congeners with greater than four chlorine atoms per PCB molecule comprise less than 0.5% of the total PCBs present at the site.

Once the appropriate slope factor has been selected, it is multiplied by a lifetime average daily dose (**LADD**) to estimate the risk of cancer (see US EPA, 1996b for sample risk calculations). Because the use of Aroclors to characterize PCB exposures can be both imprecise and inappropriate, total PCBs or congener analyses should be used in the following LADD calculation:

$$\mathbf{LADD = (C_T \times IR \times ED \times EF) / (BW \times AT)} \qquad \textit{Equation D-1}$$

Where:

LADD =	Lifetime average daily dose (mg/kg-day)
C_T =	Total PCBs or total non-dioxin-like congener concentration in a medium (mg/L [water], mg/kg [soil], or milligram per cubic meter (mg/m^3) [air])
IR =	Intake rate (L/day [water], mg/day [soil], or mg/m^3 [air])
ED =	Exposure duration (years)
EF=	Exposure frequency (days/year)
BW =	Average body weight of the receptor over the exposure period (kg)
AT=	Averaging time - the period over which exposure is averaged (days)[23]

The cancer slope factors and recommended Aroclor fate and transport properties (Table D-5), should be used to evaluate the carcinogenic risk posed by PCB mixtures or PCB congeners which do not exhibit a dioxin-like toxicity.

---

[23] For carcinogens, the averaging time is 25,550 days based on a lifetime exposure of 70 years.

Table D-5. Cancer Slope Factors and Fate & Transport Properties For PCBs

	CRITERIA: Congeners with equal to or greater than four (4) chlorines comprise . . .	**CARCINOGENIC EFFECTS**	
		Dioxin-like PCBs	**Other PCB Congeners**[24]
CANCER SLOPE FACTORS[25] **(mg/kg-day)$^{-1}$**	. . . **greater than 0.5%** of the total PCBs present	1.3E+05[26]	2.0
	. . . **less than 0.5%** of the total PCBs present	NA[27]	0.07
FATE & TRANSPORT PROPERTIES	. . . **greater than 0.5%** of the total PCBs present	Aroclor 1254	Aroclor 1254
	. . . **less than 0.5%** of the total PCBs present	Aroclor 1016	Aroclor 1016

For example, if a PCB mixture contains 45% congeners with greater than four chlorines, the cancer slope factor for 2,3,7,8-TCDD and the fate and transport properties of Aroclor 1254 would be used.

If the following special exposure conditions exist, a slope factor of 0.4 may be applied to PCBs which do not exhibit dioxin-like toxicity: ingestion of water-soluble congeners, inhalation of evaporated congeners or dermal exposure (with no applied absorption factor).

7.1.1.2 Dioxin-like Toxicity Approach

Dioxin-like PCBs are some of the moderately chlorinated PCB congeners (see Table D-5) which have been demonstrated to produce dioxin-like effects[28] in humans. The dioxin-like toxicity approach should be implemented **only** when congener-specific concentrations are available for environmental media at a site. In this approach, individual dioxin-like PCB congener concentrations are multiplied by TEFs that represent the potency of a given congener relative to 2,3,7 8-TCDD (see Table 2-2 in Volume I).

---

[24] *Other PCB congeners* mean those congeners which do not exhibit dioxin-like toxicity.

[25] PCB cancer slope factors can be found in IRIS (US EPA, 2014).

[26] US EPA, 2014

[27] *NA* means not applicable. Do not evaluate dioxin-like PCBs if they comprise less than 0.5% of the total PCBs present; evaluate the other PCB congeners.

[28] Dioxin-like congeners can react with the aryl hydrocarbon receptor, the toxicity mechanism that is believed to initiate the adverse effects of PCDDs and PCDFs.

Table 2-2 of Volume I lists the TEF values derived for dioxin-like PCB congeners. Using TEF values in the risk evaluation allows for the estimation of a combined risk resulting from an exposure to a mixture of dioxin-like PCB congeners (assuming that the risks are additive).

The carcinogenic risk resulting from exposure to dioxin-like PCBs should be estimated by calculating the TEQ. The TEQ is the sum of each congener-specific concentration in the medium multiplied by its corresponding congener-specific TEF value. Multiplying the congener-specific medium concentration by the corresponding congener-specific TEF value provides a relative (i.e., "toxicity-weighted") measure of the dioxin concentration within a medium.

The TEQ for dioxin-like PCBs should be calculated as indicated in the following equation:

$$\mathbf{TEQ = \Sigma\ (C_{mi}\ x\ TEF_i)} \qquad \textit{Equation D-2}$$

Where:

TEQ = Toxicity equivalency quotient (mg/L [water] or mg/kg [soil or sediment])
C_{mi} = Concentration of *i*th congener in medium (mg/L [water] or mg/kg [soil or sediment])
TEF_i = Toxicity equivalency factor for *i*th congener (unitless)

Once the dioxin TEQ has been determined, the LADD should be calculated using the following equation:

$$\mathbf{LADD = (TEQ\ x\ IR\ x\ ED\ x\ EF)\ /\ (BW\ x\ AT)} \qquad \textit{Equation D-3}$$

Where:

LADD = Lifetime average daily dose (mg/kg-day)
TEQ = Toxicity equivalency quotient (mg/L [water], mg/kg [soil], or mg/m^3 [air])
IR = Intake rate (L/day [water], mg/day [soil], or mg/m^3 [air])
ED = Exposure duration (years)
EF = Exposure frequency (days/year)
BW = Average body weight of the receptor over the exposure period (kg)
AT = Averaging time - the period over which exposure is averaged (days)

The following equation can be used to estimate carcinogenic risk from dioxin-like PCBs:

$$\mathbf{Cancer\ Risk = LADD\ x\ CSF_{TCDD}} \qquad \textit{Equation D-4}$$

Where:

LADD =Lifetime average daily dose (mg/kg-day)
CSF_{TCDD} =Cancer slope factor for 2,3,7,8-TCDD[29]

7.1.2 Non-Carcinogenic Effects

For Aroclors having reference doses (**RfDs**) specified in IRIS (e.g., Aroclor 1254, 1016, etc.), the non-carcinogenic risk should also be evaluated. The evaluation of non-carcinogenic risk should follow the approach typical for other non-PCB chemicals. However, fate and transport properties of the recommended Aroclor (see Table D-6) should be used to evaluate the risk posed.

Table D-6. Toxicological and Fate & Transport Properties For PCBs With Human Health Non-Carcinogenic Effects and Ecological Health Non-Dioxin-Like Effects

CRITERIA: Congeners with equal to or greater than four (4) chlorines comprise . . .	**NON-CARCINOGENIC EFFECTS AND FATE AND TRANSPORT PROPERTIES**
. . . **greater than 0.5%** of the total PCBs present	Aroclor 1254
. . . **less than 0.5%** of the total PCBs present	Aroclor 1016

The RfD derived for Aroclor 1254 should typically be used when conducting a risk assessment. The RfD derived for Aroclor 1016 can be used when at least 99.5% of the mass of the PCB mixture has fewer than four (4) chlorine atoms per molecule as determined by a chromatography/spectroscopy analytical method. Using Table D-6, determine which Aroclor most accurately represents the PCB mixture of concern. Use the RfD and fate and transport properties of this Aroclor as a surrogate to evaluate the non-carcinogenic effects of the PCB mixture.

7.2 Ecological Health

Since PCBs adversely impact both community- and class-specific guild measurement receptors, risks must be estimated for each receptor within both groups. Plants and invertebrates should be evaluated as community measurement receptors (see *Exposure Assessment for Community Measurement Receptors, Section 7.2.1.1*).

---

[29] The cancer slope factor for 2,3,7,8-TCDD should be obtained from the most recent IRIS (US EPA, 2014). The current oral cancer slope factor for 2,3,7,8-TCDD of 1.3E+05 $(mg/kg\text{-}day)^{-1}$ is based on the administered dose from a 105-week dietary rat study and was adopted for inhalation exposure (US EPA, 2014).

When congener-specific concentrations are available, risk from exposure to dioxin-like PCBs should be estimated separately and added to the risk estimated for the remainder of the PCB mixture which does not exhibit dioxin-like toxicity. The resulting risk is likely to be overestimated if toxicity data from total PCBs is applied to those congeners which do not exhibit dioxin-like toxicity. This overestimation of risk should be addressed within the uncertainty analysis of the risk assessment report.

In the absence of PCB congener-specific data, total PCB concentrations, reported as the sum of Aroclor or homologue concentrations, should be used to estimate receptor exposure to PCBs and the toxicity value of the most toxic Aroclor present should be used in the site-specific ecological risk assessment.

7.2.1 Dioxin-like PCBs

Ecological risks to community- and class-specific guild measurement receptors from dioxin-like PCBs should be estimated by calculating a TEQ and then dividing it by the toxicity value for 2,3,7,8-TCDD (which is assumed to be the most toxic dioxin).

If in addition to PCBs, other dioxin-like compounds (i.e., PCDDs and/or PCDFs) are present at a site, TEQs for dioxin-like PCBs should be added to the TEQs calculated for those other dioxin-like compounds to yield a total TEQ. The 2,3,7,8-TCDD toxicity value should be applied to this total TEQ. For this evaluation, the concentrations of dioxin-like PCBs should be subtracted from the total PCB concentrations to avoid overestimating risks from dioxin-like PCBs by evaluating them twice.

The TEF values listed in Table 2-1 of Volume I and in Table D-7 below should be used in the TEQ calculation to convert the exposure media concentration of individual congeners to a relative measure of concentration within a medium.

Table D-7. Fish Toxicity Equivalency Factor Values For Dioxin-Like PCBs[30]

CONGENER	FISH TOXICITY EQUIVALENCY FACTOR VALUES[31]
3,3′,4,4′-Tetrachlorobiphenyl (77)[11]	0.0001
3,4,4′,5-Tetrachlorobiphenyl (81)	0.0005
2,3,3′,4,4′-Pentachlorobiphenyl (105)	<0.000005[32]
2,3,4,4′,5-Pentachlorobiphenyl (114)	<0.000005
2,3′,4,4′,5-Pentachlorobiphenyl (118)	<0.000005
2′,3,4,4′,5′-Pentachlorobiphenyl (123)	<0.000005
3,3′,4,4′,5-Pentachlorobiphenyl (126)	0.005
2,3,3′,4,4′,5-Hexachlorobiphenyl (156)	<0.000005
2,3,3′,4,4′,5′-Hexachlorobiphenyl (157)	<0.000005
2,3′,4,4′,5,5′-Hexachlorobiphenyl (167)	<0.000005
3,3′,4,4′,5,5′-Hexachlorobiphenyl (169)	<0.000005
2,3,3′,4,4′,5,5′-Heptachlorobiphenyl (189)	<0.000005

Because congener-specific fate and transport data are not available for each of the dioxin-like PCBs listed in Table 2-1 of Volume I and Table D-7, the fate and transport properties of Aroclor 1254 should be used in exposure modeling.

7.2.1.1 Exposure Assessment for Community Measurement Receptors

To evaluate the exposure of water, sediment and soil communities to dioxin-like PCBs, a media-specific TEQ should be calculated. The TEQ is the sum of each congener-specific concentration (in the respective media to which the community is exposed) multiplied by its corresponding congener-specific TEF value derived for fish (Table D-7).

The TEQ for community measurement receptors exposed to dioxin-like PCBs should be calculated as indicated in the following equation:

$$\mathbf{TEQ = \Sigma\ (C_{mi}\ x\ TEF_i)} \qquad \textit{Equation D-5}$$

Where:

---

[30] Modified from the *Report from the Workshop on the Application of 2,3,7,8-TCDD Toxicity Equivalency Factors to Fish and Wildlife* (US EPA, 1998b).

[31] The surrogate TEF values for fish are presented because invertebrate-specific TEF values have not yet been developed.

[32] For all fish TEFs of "<0.000005," use the value of 0.000005 as a conservative estimate.

TEQ = Toxicity equivalency quotient (µg/L [water] or µg/kg [dry weight soil or sediment])
C_{mi} = Concentration of *i*th congener in abiotic media (µg/L [water] or µg/kg [dry weight soil or sediment])
TEF_i = Toxicity equivalency factor (fish) for *i*th congener (unitless) (Table D-7)

Risk to the water, sediment or soil community is subsequently evaluated by comparing the media-specific TEQ to the media-specific toxicity value for 2,3,7,8-TCDD:

$$\mathbf{Risk = TEQ\ /\ TRV}_{\mathrm{TCDD}} \qquad \textit{Equation D-6}$$

where:

TEQ = Toxicity equivalency quotient (µg/L [water] or µg/kg [dry weight soil or sediment])
TRV_{TCDD} = Toxicity reference value for 2,3,7,8-TCDD (µg/L [water] or µg/kg [dry weight soil or sediment])

7.2.1.2 Exposure Assessment for Class-Specific Guild Measurement Receptors

To evaluate the exposure of class-specific guild measurement receptors to dioxin-like PCBs, congener-specific daily doses of food items (i.e., abiotic media, plants, animals, etc.) ingested by a measurement receptor (**DD_i**) should be converted to a TEQ-based daily dose (**DD_{TEQ}**). This DD_{TEQ} can subsequently be compared to the 2,3,7,8-TCDD toxicity values for an evaluation of the risk posed to class-specific guild measurement receptors.

The DD_{TEQ} for each measurement receptor should be calculated as shown in the following equation:

$$\mathbf{DD_{TEQ} = \Sigma\ DD_i \times TEF_{MR}} \qquad \textit{Equation D-7}$$

Where:

DD_{TEQ} = Daily dose of PCB TEQ (µg/kg fresh body weight-day)
DD_i = Daily dose of *i*th congener (µg/kg fresh body weight-day)
TEF_{MR} = Toxicity equivalency factor (specific to measurement receptor) (unitless) (Table D-8)

Risk to the class-specific guild being evaluated can be estimated by dividing the DD_{TEQ} by the toxicity reference value for 2,3,7,8-TCDD:

$$\mathbf{Risk = TEQ\ /\ TRV}_{\mathrm{TCDD}} \qquad \textit{Equation D-8}$$

Where:

---

[33] The congener-specific daily doses of food items ingested by a measurement receptor should be calculated in accordance with the most current EPA and/or State guidance.

DD_{TEQ} = Daily dose of PCB TEQ (µg/kg fresh body weight-day)
TRV_{TCDD} = Toxicity reference value for 2,3,7,8-TCDD (µg/kg fresh body weight-day)

7.2.2 Other PCB Congeners

In addition to the dioxin-like PCB congeners, the remaining PCBs should be evaluated like other bioaccumulating organic contaminants by assessing ecological risks to community- and class-specific guild measurement receptors. The fate and transport properties of Aroclor 1254[34] should be used in the exposure modeling when evaluating the risk from PCB mixtures containing congeners with equal to or greater than 4 chlorines in quantities **greater** than 0.5% of the total PCBs. And, the fate and transport properties of Aroclor 1016[35] should be used in the exposure modeling when evaluating risks from PCB mixtures containing **less** than 0.5 % of PCB congeners with more than 4 chlorines (see Table D-6).

8.0 CONCLUSION

PCBs, which are a class of organic compounds that are persistent in the environment, are toxic to both humans and biota. PCBs may in certain instances become contaminated with more toxic PCDFs and PCDDs. Therefore, the potential presence of these compounds should also be evaluated and possibly investigated.

Based on federal and state regulations and standards, the NMED recommends that PCB-contaminated sediment/soils be remediated to either 1 mg/kg total PCBs or the most stringent of the calculated health risk-based concentrations in order to adequately protect human health and the environment.

Unless soil/sediments are remediated to 1 mg/kg total PCBs, the risk posed by PCBs to human health and the environment should be evaluated using a risk-based approach. All corrective action SWMU/AOCs impacted or suspected of being impacted by PCBs and having a potential for transport to a human or ecological receptor should be evaluated and monitored, as necessary, to protect human health and the environment.

PCB concentrations in soil/sediments should also be protective of both surface water and ground water resources; PCB concentrations in surface water should not exceed 0.014 µg/L and PCB concentrations in ground water cannot exceed 0.5 µg/L (drinking water) or 1 µg/L in ground water with 10,000 mg/L or less total dissolved solids).

9.0 REFERENCES

Advances in Modern Environmental Toxicology, Volume XV, *Risk Assessment and Risk Management of Industrial and Environmental Chemicals*. Edited by Cothren, Mehuman,

---

[34] Approximately 77% of Aroclor 1254 is composed of PCB congeners with more than 4 chlorines.

[35] Approximately 99% of Aroclor 1016 is comprised of PCB congeners with 4 or less chlorines.

and Marcus and published by Princeton Scientific Publishing Co., Inc., Princeton, New Jersey, 1988.

Agency for Toxic Substances and Disease Registry (ATSDR). 1993. *Toxicological Profile for Chlorodibenzofurans*. US Department of Health and Human Services, Public Health Service. Atlanta, Georgia.

Agency for Toxic Substances and Disease Registry (ATSDR). 1995. *Toxicological Profile for Polychlorinated Biphenyls*. Draft for Public Comment. US Department of Health and Human Services, Public Health Service. Atlanta, Georgia.

Agency for Toxic Substances and Disease Registry (ATSDR). 1997. *Toxicological Profile for Chlorinated Dibenzo-p-Dioxin*. Draft for Public Comment. US Department of Health and Human Services, Public Health Service, Atlanta, Georgia.

Alford-Stevens A., T.A. Bellar, J.W. Eichelberger, and W.L. Budde. November 1985. *Method 680: Determination of Pesticides and PCBs in Water and Soil/Sediment by Gas chromatography/Mass Spectrometry*. US EPA Office of Research and Development, Cincinnati, Ohio.

Cogliano J. V. 1998. *Assessing the Cancer Risk from Environmental PCBs*. Environmental Health Perspectives, Volume 106, Number 6, pp. 317-323

Eisler R. 1986. *Polychlorinated Biphenyl Hazard to Fish, Wildlife, and Invertebrates: A synoptic Review*. Contaminant Hazard Reviews Report No. 7, Biological Report 85 (1.7), 72 p. US Department of Interior, Fish and Wildlife Service.

Giesy J. P. and K. Kannan. 1998. *Dioxin-Like and Non-Dioxin-Like Toxic Effects of Polychlorinated Biphenyls (PCBs): Implications for Risk Assessment*. Critical Reviews in Toxicology, Volume 28, Number 6, pp. 511-569.

Hoffman D. J., C. P. Rice, and T. J. Kubiak. 1996. *PCBs and Dioxins in Birds*. Environmental Contaminants in Wildlife. SETAC Special Publication Series. CRC Press, Inc.

Federal Register, Volume 61, Number 85. May 1, 1990. *Correction Action for Releases from Solid Waste Management Units at Hazardous Waste Management Facilities*.

Federal Register, Volume 55, Number 145. July 27, 1990. *Resource Conservation and Recovery Act, Proposed Subpart S.*

Federal Register, Volume 63, Number 124. June 29, 1998. *Disposal of Polychlorinated Biphenyls (PCBs); Final Rule.*

Federal Register, Volume 63, Number 237. December 10, 1998. *National Recommended Water Quality Criteria*, Notice; Republication.

Mays, D.C. and Veenis, Steven. July 1998. *Matrix Approach to Contaminant Transport Potential*. Practice Periodical of Hazardous, Toxic, and Radioactive Waste Management.

New Mexico Environment Department (NMED) Hazardous and Radioactive Materials (HRM) Bureau. 1998. *Document Requirement Guide*, Section III.c.6, *Risk-based Decision Tree*.

NMED. 2011. NMED Technical Background Document for Development of Soil Screening Levels. http://www.nmenv.state.nm.us/hwb/guidance.html

National Oceanic and Atmospheric Administration (NOAA), 1993. *Sampling and Analytical methods of the National Status and Trends Program, National Benthic Surveillance and Mussel Watch Projects 1984-1992.* National Ocean Service, Office of Ocean Resources Conservation and Assessment, Silver Spring, MD, Technical Memorandum NOS ORCA 71, Vol. 1.

Safe Drinking Water Act. Title 40 Code of Federal Regulations, parts 141 through 147 and 149 [40 CFR Parts 141-147 and 149].

State of New Mexico Standards for Interstate and Intrastate Streams, Title 20 New Mexico Annotated Code, Chapter 6, Part 1 [20 NMAC 6.1]. January 23, 1995.

State of New Mexico Ground and Surface Water Quality Protection Standards, Title 20 New Mexico Annotated Code, Chapter 6, Part 2 [20 NMAC 6.2]. December 1, 1995.

US EPA. 1989. Risk Assessment Guidance for Superfund, Volume 1, *Human Health Evaluation Manual (Part A)*, Interim Final. Office of Emergency and Remedial Response, Washington, DC, 20460. EPA/540/1-89/002.

US EPA. July 1992. *NPDES Storm Water Sampling Guidance Document*. Office of Water (EN-336). EPA 833-B-92-001.

US EPA. 1996a. *Method 8082 - Polychlorinated Biphenyls (PCBs) by Gas Chromatography.* Test Methods for Evaluating Solid Waste, Volume IB - Laboratory Manual - Physical/Chemical Methods. Third edition, Update 3, Revision 0. SW-846. Washington, D.C.

US EPA. 1996b. *PCBs: Cancer Dose-Response Assessment and Application to Environmental Mixtures*. Office of Research and Development, Washington, DC. EPA/600/P-96/001A.

US EPA. 1997a. *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisory*. Volume 2: Risk Assessment and Fish Consumption Limits. Second Edition. Office of Water, Washington, D.C. EPA 823-B-97-009.

US EPA. 1997b. *Health Effects Assessment Summary Tables: FY 1997 Update*. National Center for Environmental Assessment (NCEA), Office of Research and Development and Office of Emergency and Remedial Response, Washington, D.C.

US EPA. 1997c. *Method 1668 - Toxic Polychlorinated Biphenyls by Isotope Dilution High Resolution Gas Chromatography/High Resolution Mass Spectometry*. Office of Water, Offices of Science and Technology, Engineering and Analyses Division, Washington, D.C.

US EPA. 1998a. Memorandum: *Clarification Regarding Use of SW-846 Methods*. Office of Solid Waste, Washington, D.C.

US EPA. 1998b. *Report from the Workshop on the Application of 2,3,7,8-TCDD Toxicity Equivalency Factors to Fish and Wildlife, Chicago, Illinois, January 20-22, 1998*. Eastern Research Group, Inc. Submitted to US EPA Risk Assessment Forum. US EPA. 1998c. *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*. Peer Review Draft. Office of Solid Waste and Emergency Response, Washington, DC, 20460. EPA 530-D-98-001a.

US EPA. 1999. *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities*. Peer Review Draft. Solid Waste and Emergency Response, Dallas, Texas, 75202. EPA 530-D-99-001A

US EPA. 2014. Integrated Risk Information System (IRIS) Data Base, Office of Research and Development/National Center for Environmental Assessment.

US EPA. Region 5 Toxics Reduction Team Website: http://www.epa.gov/grtlakes/toxteam/pcbid/table.htm.

Valoppi, L., M. Petreas, R. M. Donohoe, L. Sullivan, and C.A. Callaham. 1999. *Use of PCB Congener and Homologue Analysis in Ecological Risk Assessment*. Environmental Toxicology and Risk Assessment: Recent Achievements in Environmental Fate and Transport, Ninth Volume, ASTM STP 1381, F. T. Price, K. V. Brix, and N. K. Lane, Eds., American Society for Testing and Materials, West Conshohocken, Pennsylvania.

Van den Berg, M., L. Birnbaum, S. T. C. Bosveld, B. Brunstr_m, P. Cook, M. Feeley, J. P. Giesy, A. Hanberg, R. Hasegawa, S. W. Kennedy, T. Kubiak, J. C. Larsen, F. X. Rolaf van Leeuwen, A. K. Djien Liem, C. Nolt, R. E. Peterson, L. Poellinger, S. Safe, D. Schrenk, D. Tillitt, M. Tysklind, M. Younes, F. Waern, and T. Zacharewski, 1998. *Toxic Equivalency Factors (TEFs) for PCBs, PCDDs, PCDFs for Humans and Wildlife*. Environmental Health Perspectives. Vol. 106, No. 12, pp. 775-792.

VOLUME 2
SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENTS

PHASE I
Scoping Assessment

TABLE OF CONTENTS

Figures

Tables

Attachments

Acronymns and Abbreviations

AOC	Areas of Concern
AUF	Area Use Factor
BAF	Bioaccumulation/Biomagnification Factor
bgs	below ground surface
COPEC	Constituent of Potential Ecological Concern
EPC	Exposure Point Concentration
ft	foot
GAERPC	Guidance for Assessing Ecological Risks Posed by Chemicals
HI	Hazard Index
HQ	Hazard Quotient
kg	kilogram
LOAEL	Lowest-observed adverse effect level
LULC	land use and land cover
mg	milligram
NMED	New Mexico Environment Department
NOAEL	No-observed adverse effect level
PCSEM	Preliminary Conceptual Site Exposure Model
PUF	Plant Uptake Factor
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
SLERA	Screening Level Ecological Risk Assessment
SLHQ	Screening Level Hazard Quotient
SSG	Soil Screening Guidance
SWMU	Solid Waste Management Unit
T&E	Threatened and Endangered
TRV	Toxicity Reference Value
UCL	Upper Confidence Level
US EPA	United States Environmental Protection Agency

1.0 INTRODUCTION

The purpose of an ecological risk assessment is to evaluate the potential adverse effects that chemical contamination has on the plants and animals that make up ecosystems. The risk assessment process provides a way to develop, organize and present scientific information so that it is relevant to environmental decisions.

The New Mexico Environment Department (NMED) has developed a tiered procedure for the evaluation of ecological risk. Volume II of this *Risk Assessment Guidance for Investigations and Remediation* (SSG) outlines the steps for the Phase I Assessment, to include a qualitative scoping assessment and a quantitative screening assessment. If more detailed assessments are required or the Phase II Assessment is needed, additional guidance may be found in the *Guidance for Assessing Ecological Risks Posed by Chemicals: Screening-Level Ecological Risk Assessment* (GAERPC) (NMED, 2014). Briefly, the tiers of the procedure are organized as follows:

PHASE I – SCOPING AND SCREENING ASSESSMENTS

- Scoping Assessment
- Screening Assessment (Tier 1 and 2)

PHASE II - SITE-SPECIFIC ASSESSMENTS

- Site-Specific Ecological Risk Assessment (Tier 3)

As discussed above and illustrated in Figure 1, the Scoping Assessment is the first phase of the Screening-Level Ecological Risk Assessment process as defined by the NMED GAERPC. This document provides specific procedures to assist the facility in conducting the first phase (Scoping and Screening Assessments), Screening-Level Ecological Risk Assessment process outlined in the GAERPC. The purpose of the Scoping Assessment is to gather information, which will be used to determine if there is “any reason to believe that ecological receptors and/or complete exposure pathways exist at or in the locality of the site” (NMED, 2014). The scoping assessment step also serves as the initial information-gathering phase for sites clearly in need of a more detailed assessment of potential ecological risk. This document outlines the methodology for conducting a Scoping Assessment, and includes a Site Assessment Checklist (Attachment A), which serves as tool for gathering information about the facility property and surrounding areas. Although the GAERPC provides a copy of the US Environmental Protection Agency (US EPA) Checklist for Ecological Assessment/Sampling (US EPA, 1997), the attached Site Assessment Checklist provides an expanded, user-friendly template, which both guides the user as to what information to collect and furnishes an organized structure in which to enter the information.

After the Site Assessment Checklist has been completed, the assessor must use the collected information to generate a Scoping Assessment Report and Preliminary Conceptual Site Exposure Model (PCSEM). Guidance for performing these tasks is provided in this document, and in the GAERPC. The Scoping Assessment Report and PCSEM are subsequently used to address the first in a series of Technical Decision Points of the tiered GAERPC process. Technical Decision Points are questions which must be answered by the assessor after the completion of certain phases in the process. The resulting answer to the question determines the next step to be undertaken by the facility. The first Technical Decision Point, as illustrated in Figure 1, is to decide: *Is Ecological Risk Suspected?*

If the answer to the first Technical Decision Point is "no" (that is, ecological risk is not suspected), the assessor may use the Exclusion Criteria Checklist and Decision Tree (Attachment B) to help confirm or deny that possibility. However, it is unlikely that any site containing potential ecological habitat or receptors will meet the Site Exclusion Criteria.

If ecological risk is suspected, the facility will usually be directed to proceed to the Tier 1 Screening Level Ecological Risk Assessment (SLERA) and refined Tier 2 SLERA. A SLERA is a simplified risk assessment that can be conducted with limited site-specific data by defining assumptions for parameters that lack site-specific data (US EPA, 1997). Values used for screening are consistently biased in the direction of overestimating risk to ensure that sites that might pose an ecological risk are properly identified. The completed Site Assessment Checklist is a valuable source of information needed for the completion of the SLERA. Additional information on performing a SLERA can be found in the GAERPC (NMED, 2014) and in a number of EPA guidance documents (e.g., US EPA, 1997; US EPA, 1998).

2.0 SCOPING ASSESSMENT

The Scoping Assessment serves as the initial information gathering and evaluation for the Phase I process. A Scoping Assessment consists of the following steps:

- Compile and Assess Basic Site Information (using Site Assessment Checklist)
- Conduct Site Visit
- Identify Preliminary Contaminants of Potential Ecological Concern
- Develop a Preliminary Conceptual Site Exposure Model
- Prepare a Scoping Assessment Report

The following subsections provide guidance for completing each step of the Scoping Assessment. For additional guidance, readers should refer to the GAERPC (NMED, 2014).

2.1 Compile and Assess Basic Site Information

The first step of the Scoping Assessment process is to compile and assess basic site information. Since the purpose of the Scoping Assessment is to determine if ecological habitats, receptors, and complete exposure pathways are likely to exist at the site, those items are the focus of the information gathering. The Site Assessment Checklist (Attachment A) should be used to complete this step. The questions in the Site Assessment Checklist should be addressed as completely as possible with the information available before conducting a site visit.

In many cases, a large portion of the Site Assessment Checklist can be completed using reference materials and general knowledge of the site. A thorough file search should be conducted to compile all potential reference materials. Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA) and Facility Investigation (RFI) reports, inspection reports, RCRA Part B Permit Applications, and facility maps can all be good sources of the information needed for the Site Assessment Checklist.

Habitats and receptors which may be present at the site can be identified by contacting local and regional natural resource agencies. Habitat types may be determined by reviewing land use and land cover maps (LULC), which are available via the Internet at http://www.nationalatlas.gov/scripts. Additional sources of general information for the identification of ecological receptors and habitats are listed in the introduction section of the Site Assessment Checklist (Attachment A).

After all available information has been compiled and entered into the Site Assessment Checklist, the assessor should review the checklist and identify data gaps. Plans should then be made to obtain the missing information by performing additional research and/or by observation and investigation during the site visit.

2.2 Site Visit

When performing a Scoping Assessment, at least one site visit should be conducted to directly assess ecological features and conditions. As discussed in the previous section, completion of the Site Assessment Checklist should have begun during the compilation of basic site information. The site visit allows for verification of the information obtained from the review of references and other information sources. The current land and surface water usage and characteristics at the site can be observed, as well as direct and indirect evidence of receptors. In addition to the site, areas adjacent to the site and all areas where ecological receptors are likely to contact site-related chemicals (i.e., all areas which may have been impacted by the release or migration of chemicals from the site) should be observed or visited and addressed in the Site Assessment Checklist. The focus of the habitat and receptor observations should be on a community level. That is, dominant plant and animal species and habitats (e.g., wetlands, wooded areas) should be identified during the site visit. Photographs should be taken during the site visit and attached to the Scoping Assessment Report. Photographs are particularly useful for documenting the nature, quality, and distribution of vegetation, other ecological features, potential exposure pathways, and any evidence of contamination or impact. While the focus of the survey is on the community level, the U.S. Fish and Wildlife Service and the New Mexico Natural Heritage Program should be contacted prior to the site visit. The intent is to determine if state listed and/or federal listed Threatened & Endangered (T&E) species or sensitive habitats may be present at the site, or if any other fish or wildlife species could occur in the area (as indicated in the Site Assessment Checklist, Section IIID). A trained biologist or ecologist should conduct the biota surveys to appropriately characterize major habitats and to determine whether T&E species are present or may potentially use the site. The site assessment should also include a general survey for T&E species and any sensitive habitats (e.g. wetlands, perennial waters, breeding areas), due to the fact that federal and state databases might not be complete.

Site visits should be conducted at times of the year when ecological features are most apparent (i.e., spring, summer, early fall). Visits during winter might not provide as much evidence of the presence or absence of receptors and potential exposure pathways.

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

2.3 Identify Contaminants of Potential Ecological Concern

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

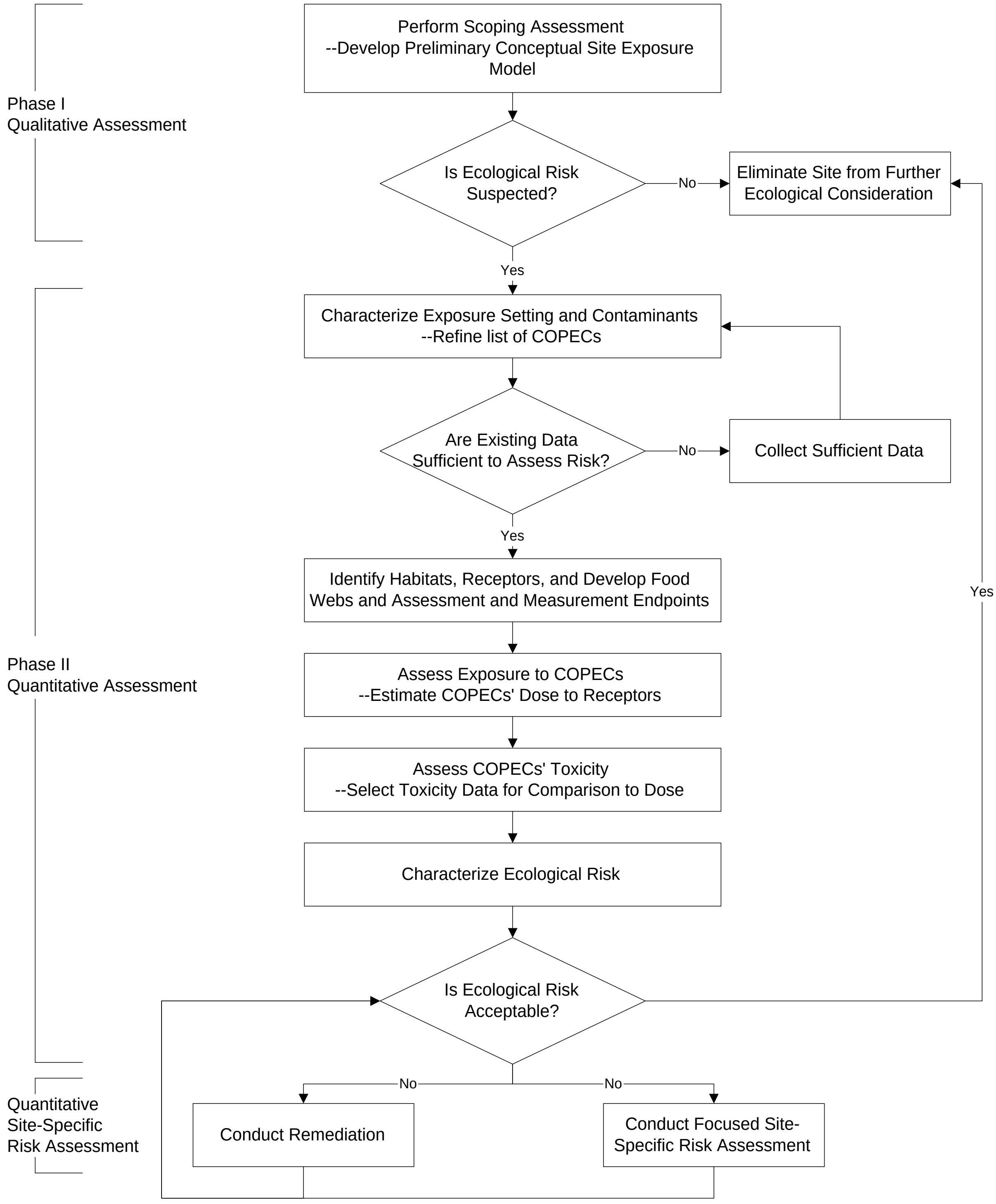
2.4 Developing the Preliminary Conceptual Site Exposure Model

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

A complete exposure pathway is defined as a pathway having all of the following attributes (US EPA, 1998; NMED, 2014):

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

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



Adapted from GAERPC (NMED 2000).

Figure 1. NMED Ecological Risk Assessment Process

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

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

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

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

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

For further guidance on constructing a PCSEM, consult the GAERPC (NMED, 2014), and US EPA guidance on corrective action, to include the site conceptual exposure model builder (http://www.epa.gov/osw/hazard/correctiveaction/resources/guidance/index.htm).

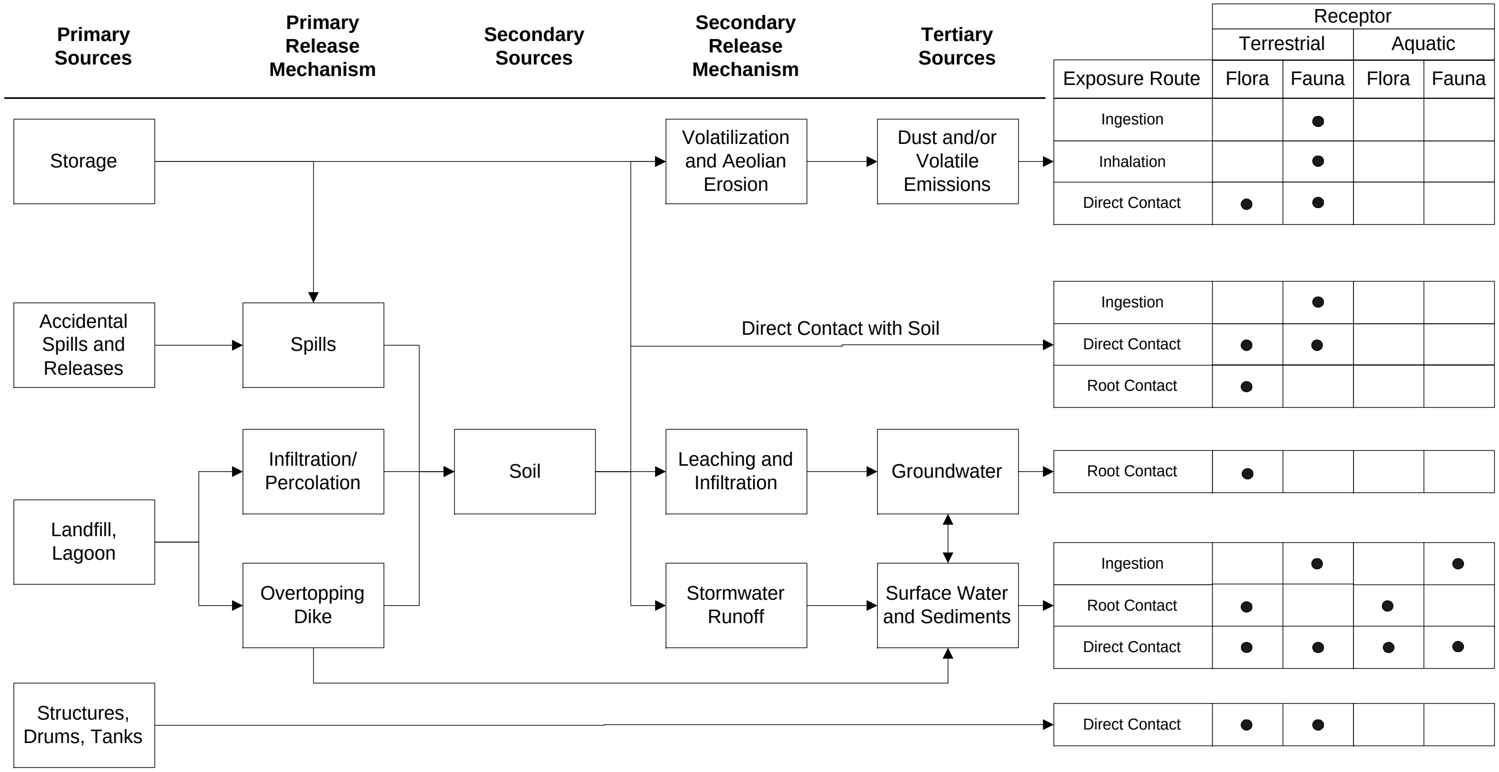
2.5 Assembling the Scoping Assessment Report

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

- Existing Data Summary
- Site Visit Summary (including a completed Site Assessment Checklist)

- Evaluation of Receptors and Pathways
- Recommendations
- Attachments (e.g. photographs, field notes, telephone conversation logs with natural resource agencies)
- References/Data Sources

After completion, the Scoping Assessment Report and PCSEM should be submitted to NMED for review and approval. These documents will serve as a basis for decisions regarding future actions at the site.



	Receptor			
	Terrestrial		Aquatic	
Exposure Route	Flora	Fauna	Flora	Fauna
Ingestion		●		
Inhalation		●		
Direct Contact	●	●		
Ingestion		●		
Direct Contact	●	●		
Root Contact	●			
Root Contact	●			
Ingestion		●		●
Root Contact	●		●	
Direct Contact	●	●	●	●
Direct Contact	●	●		

Adapted from GAERPC (NMED 2000).

Figure 2. Example Preliminary Conceptual Site Exposure Model Diagram for a Hypothetical Site

2.6 Site Exclusion Criteria

If the assessor believes that the answer to the first Technical Decision Point (Is Ecological Risk Suspected?) is "no" based on the results of the PCSEM and Scoping Assessment Report, it should be determined whether the facility meets the NMED Site Exclusion Criteria.

Exclusion criteria are defined as those conditions at an affected property which eliminate the need for a SLERA. The three criteria are as follows:

- Affected property does not include viable ecological habitat.
- Affected property is not utilized by potential receptors.
- Complete or potentially complete exposure pathways do not exist due to affected property setting or conditions of affected property media.

The Exclusion Criteria Checklist and associated Decision Tree (Attachment B) can be used as a tool to help the user determine if an affected site meets the exclusion criteria. The checklist assists in making a conservative, qualitative determination of whether viable habitats, ecological receptors, and/or complete exposure pathways exist at or in the locality of the site where a release of hazardous waste/constituents has occurred. Thus, meeting the exclusion criteria means that the facility can answer "no" to the first Technical Decision Point.

If the affected property meets the Site Exclusion Criteria, based on the results of the checklist and decision tree, the facility must still submit a Scoping Assessment Report to NMED which documents the site conditions and justification for how the criteria have been met. Upon review and approval of the exclusion by the appropriate NMED Bureau, the facility will not be required to conduct any further evaluation of ecological risk. However, the exclusion is not permanent; a future change in circumstances may result in the affected property no longer meeting the exclusion criteria.

2.7 Technical Decision Point: Is Ecological Risk Suspected?

As discussed in the beginning of this document, the Scoping Assessment is the first phase of the GAERPC ecological risk assessment process (Figure 1). Following the submission of the Scoping Assessment Report and PCSEM, NMED will decide upon one of the following three recommendations for the site:

- No further ecological investigation at the site, or
- Continue the risk assessment process, and/or
- Undertake a removal or remedial action.

If the information presented in the Scoping Assessment Report supports the answer of "no" to the first Technical Decision Point, and the site meets the exclusion criteria, the site will likely be excused from further consideration of ecological risk. However, this is only true if it can be documented that a complete exposure pathway does not exist and will not exist in the future at the site based on current conditions. For those sites where valid pathways for potential exposure exist or are likely to exist in the future, further ecological risk assessment (usually in the form of a SLERA) will be required. However, if the Scoping Assessment indicates that a detailed assessment is warranted, the facility would not be required to conduct a SLERA. Instead the facility would move directly to Phase II and the Site-Specific Ecological Risk Assessment (Tier 3).

3.0 TIER 1 SCREENING LEVELS ECOLOGICAL RISK ASSESSMENT (SLERA)

If the PSCEM indicates complete exposure pathways, a SLERA is most likely the next step. The data collected during the scoping assessment is used to define facility-wide conditions and define the steps needed for the SLERA and includes the below items. The SLERA should contain a detailed discussion of each of these items.

- Characterization of the environmental setting, including current and future land uses. Ecological assessments must include the evaluation of present day conditions and land uses but also evaluate future land uses.
- Identification of known or likely chemical stressors (chemicals of potential ecological concern, COPECs). The characterization data from the site (e.g., facility investigation) is evaluated to determine what constituents are present in which media. Selection of COPEC should follow the same methodology as outlined in Volume I.
- Identification of the fate and transport pathways that are complete. This includes an understanding of how COPECs may be mobilized from one media to another.
- Identification of the assessment endpoints that should be used to assess impact of the receptors; what is the environmental value to be protected.
- Identification of the complete exposure pathways and exposure routes (as identified in the example in Figure 2). What are the impacted media (soil, surface water, sediment, groundwater, and/or plants) and how might the representative receptors be exposed (direct ingestion, inhalation, and/or direct contact)?
- Species likely to be impacted and selection of representative receptors. From the list of species likely to be present on-site, what species are to be selected to represent specific trophic levels?

3.1 Selection of Representative Species

Sites may include a wide range of terrestrial, semi-aquatic, and aquatic wildlife. A generalized food web is shown in Figure 3. Wildlife receptors for the SLERA should be selected to represent the trophic levels and habitats present or potentially present at the site and include any Federal threatened and endangered species and State sensitive species.

As there are typically numerous species of wildlife and plants present at a given facility or site and in the surrounding areas, only a few key receptors need to be selected for quantitative evaluation in the SLERA, which are representative of the ecological community and varying trophic levels in the food web. Possible receptors that may be evaluated in the SLERAs at each site include the following:

- Plant community,
- Deer mouse,
- Horned lark,
- Kit fox (evaluated at sites greater than 267 acres),
- Pronghorn (evaluated at sites greater than 342 acres), and
- Red-tailed hawk (evaluated at sites greater than 177 acres).

The above key receptors selected as the representative species represent the primary producers as well as the three levels of consumer (primary, secondary, and tertiary).

3.1.1 Plants

The plant community will be evaluated quantitatively in the SLERAs at all sites. Specific species of plants will not be evaluated separately; rather the plant community will be evaluated as a whole. The plant community provides a necessary food source directly or indirectly through the food web for wildlife receptors.

3.1.2 Deer Mouse

The deer mouse (Peromyscus maniculatus) is a common rodent throughout much of North America and it can thrive in a variety of habitats. The deer mouse was selected as a representative receptor because it is prevalent in the vicinity of most sites in New Mexico, and it represents one of the several species of omnivorous rodents that may be present at sites. Small rodents are also a major food source for larger omnivorous and carnivorous species. The deer mouse receptor will be evaluated at all sites, regardless of size. The deer mouse has a relatively small home range and could therefore be substantially exposed to COPECs at sites if their home range is located within a solid waste management unit (SWMU) or other corrective action site.

Based on a review of literature (OEHHA, 1999) and from the Natural Diversity Information Source (CDW, 2011), a dietary composition consisting of 26% invertebrates and 74% plant matter will be assumed for the deer mouse.

3.1.3 Horned Lark

The horned lark (*Eremophila alpestris*) is a common widespread terrestrial bird. It spends much of its time on the ground and its diet consists mainly of insects and seeds. The horned lark receptor was chosen because it is prevalent in New Mexico and represents one of the many small terrestrial bird species that could be present. Since the horned lark spends most of its time on the ground, it also provides a conservative measure of effect since it has a higher rate of incidental ingestion of soil than other song birds. The horned lark is also a major food source for omnivorous intermediate species, and top avian carnivores. The horned lark will be evaluated based on an omnivorous diet of invertebrates and plant matter. The horned lark receptor will be evaluated at all sites, regardless of size. The horned lark has a relatively small home range and could therefore be substantially exposed to COPECs at sites if their home range is located within a SWMU or other corrective action unit.

It will be assumed that the horned lark's diet consists of 75% plant matter, and 25% animal matter based on a study conducted by Doctor, *et al*, 2000.

3.1.4 Kit Fox

The kit fox (*Vulpes macrotis*) is native to the western United States and Mexico. Its diet consists of mostly small mammals. Although the kit fox's diet may also consist of plant matter during certain times of the year, the kit fox will be evaluated as a carnivore, with a diet consisting of 100% prey items. It was selected as a key receptor because it is sensitive species and is common in New Mexico, and the surrounding area at most sites in New Mexico provides suitable habitat for the kit fox. The kit fox also is representative of a mammalian carnivore within the food web.

The kit fox will only be evaluated at sites that are larger than 276 acres. A kit fox has a large home range size (2767 acres) (Zoellick & Smith, 1992) and it is assumed that risks are negligible from exposure to COPECs at sites that are less than 10% of the receptors home range. Unless the area use factor (AUF) is at least 10%, food items potentially contaminated with COPECs and incidental soil ingestion at the site would not contribute significantly to the receptor's diet and exposure to COPECs. The kit fox diet will be based on composition of 100% prey.

3.1.5 Red-Tailed Hawk

The red-tailed hawk (*Buteo jamaicensis*) was selected as a top carnivore avian key receptor. The red-tailed hawk is widespread throughout New Mexico and is one of the most common birds of prey. It hunts primarily rodents, rabbits, birds, and reptiles. The red-tailed hawk was chosen as a key receptor since it is a common species through New Mexico. The red-tailed hawk will only be evaluated at sites that are larger than 177 acres. The red-tailed hawk has a large home range size (1770 acres) (US EPA, 1993b), and risks to the red-tailed hawk from exposure to COPECs at sites smaller than 177 acres (10% of the home range) would be negligible. The red-tailed hawk diet will be based on composition of 100% prey.

3.1.6 Pronghorn Antelope

The pronghorn (*Antilocapra Americana*) is a popular big game species that occurs in western Canada, United States, and northern Mexico. Its diet consists mainly of sagebrush and other shrubs, grasses, and forbs. The pronghorn was selected as a key receptor representative of large herbivorous species of wildlife. The pronghorn will only be evaluated at sites that are larger than 342 acres. The pronghorn has a large home range size (3422 acres) (Reynolds, 1984), and risks to the pronghorn from exposure to COPECs at sites smaller than 342 acres (10% of the home range) would be negligible. It is assumed that 100% of the diet is from grazing.

3.2 Exposure Pathways

The scoping survey will provide a summary of potentially complete exposure pathways, along with potentially exposed receptor types. A complete exposure pathway is defined as a pathway having all of the following attributes:

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

If any of the above components are missing from the exposure pathway, it is not a complete pathway for the site. A discussion regarding all possible exposure pathways and the rationale/justification for eliminating any pathways will be included in the risk assessment.

Affected media that ecological receptors may be exposed to at sites are soil, biota, and surface water or groundwater (through springs). Surface water, sediment, and groundwater should be evaluated based on site-specific conditions.

Wildlife receptors could be exposed to COPECs that have been assimilated into biota. Ingestion of contaminated plant and animal matter, as a necessary component of the receptor's diet, will be evaluated quantitatively in the SLERAs. However, for the Tier-1 SLERA, it will conservatively be assumed that 100% of the wildlife receptors' dietary intake consists of site soil.

For soil, two soil intervals should be evaluated:

- For all non-burrowing receptors, the soil interval to be considered is between zero (0) and five (5) feet below ground surface (ft bgs).
- For all burrowing receptors and plants, the soil interval to be evaluated is 0 – 10 ft bgs.

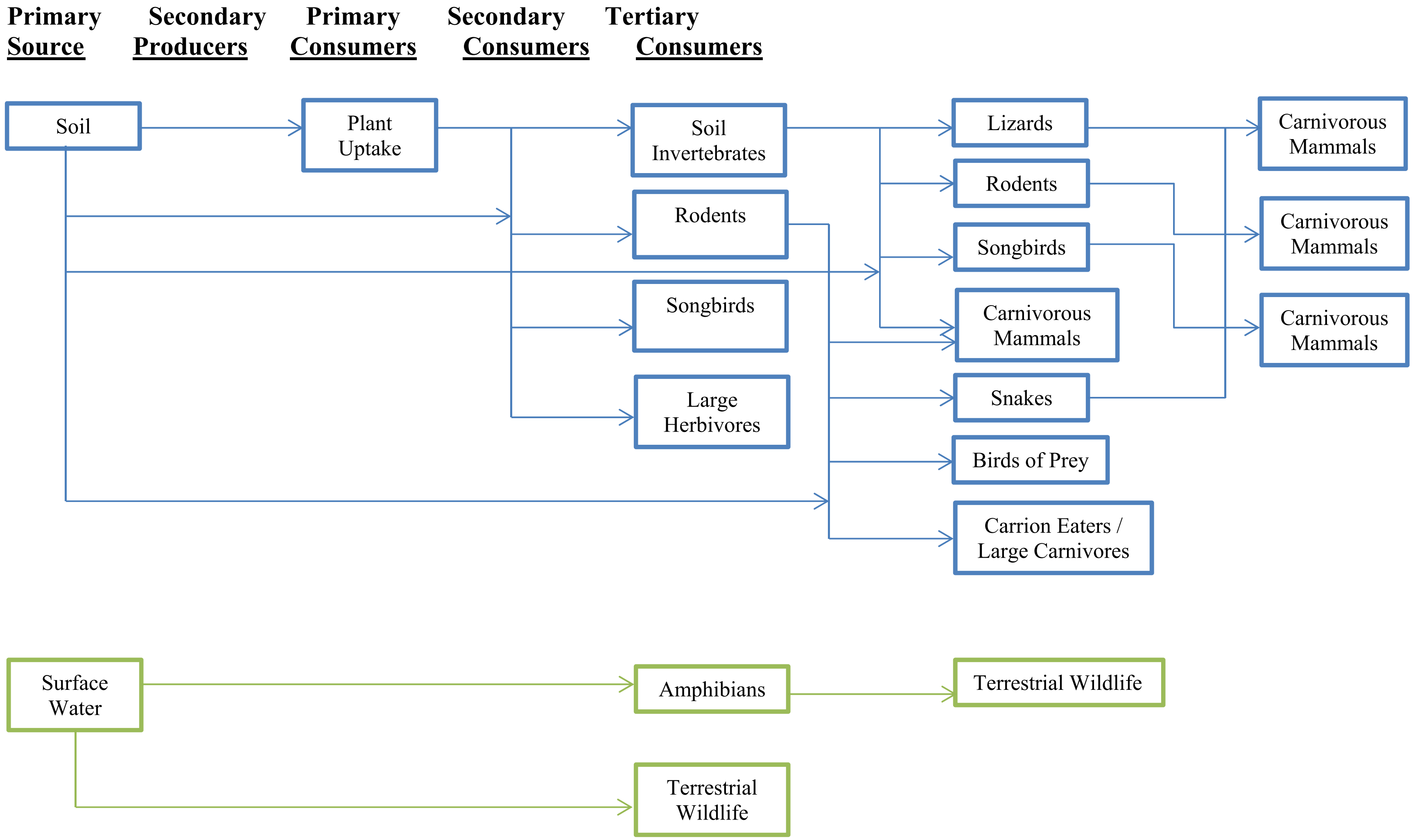


Figure 3. Generic Food Web.

3.3 SLERA Exposure Estimation

For the initial SLERA, conservative assumptions should be applied as follows:

- Maximum detected concentrations (0-10 ft bgs for all receptors) will be utilized in calculating exposure doses.
- 100% of the diet is assumed to contain the maximum concentration of each COPEC detected in the site media.
- Minimum reported body weights should be applied.
- Maximum dietary intake rates should be used.
- It will be assumed that 100% of the diet consists of direct ingestion of contaminated soil.
- It is assumed that the bioavailability is 100% at each site.
- Foraging ranges are initial set equal to the size of the site being evaluated. This means that the AUF in the SLERA is set to a value of one.

The equation and exposure assumptions for calculating the Tier 1 exposure doses for the deer mouse are presented in Equation 1.

Equation 1. Calculation of Tier 1 Exposure Dose for COPECs in Soil; Deer Mouse

$$Exposure\ Dose = \frac{(C_s \times (IR * ww{:}dw)\ \times AUF)}{BW}$$

Parameter	Definition (units)	Value	Reference
Exposure Dose	Estimated receptor-specific contaminant intake (mg/kg of body weight/day)	calculated	--
C_s	Chemical concentration in soil (mg/kg)	Site-specific	Maximum detected concentration (0-10 ft bgs)
IR	Ingestion rate (kg food [ww]/day)	0.007	Maximum reported total dietary intake (US EPA, 1993b)
ww:dw	Wet-weight to dry weight conversion factor for ingested matter	0.22	78-percent moisture
AUF	Area use factor (the ratio of the site exposure area to the receptor foraging range) (unitless)	1	Maximum possible value
BW	Body weight (kg)	0.014	Minimum reported adult body weight (CDW, 2011)

The equation and exposure assumptions for calculating the Tier 1 exposure dose for the horned lark are presented in Equation 2.

Equation 2. Calculation of Tier 1 Exposure Dose for COPECs in Soil; Horned Lark

$$Exposure\ Dose = \frac{(C_s \times (IR * ww{:}dw) \times AUF)}{BW}$$

Parameter	Definition (units)	Value	Reference
Exposure Dose	Estimated receptor-specific contaminant intake (mg/kg of body weight/day)	Calculated	--
C_s	Chemical concentration in soil (mg/kg)	Site-specific	Maximum detected concentration (0-10 ft bgs)
IR	Ingestion rate (kg food [ww]/day)	0.024	Maximum reported total dietary intake; American robin (US EPA, 1993b)
ww:dw	Wet-weight to dry weight conversion factor for ingested matter	0.22	78-percent moisture
AUF	Area use factor (the ratio of the site exposure area to the receptor foraging range) (unitless)	1	Maximum possible value
BW	Body weight (kg)	0.025	Minimum reported adult body weight (Trost, 1972)

The equation and exposure assumptions for calculating the Tier 1 exposure doses for the kit fox are presented in Equation 3.

Equation 3. Calculation of Tier 1 Exposure Dose for COPECs in Soil; Kit Fox

$$Exposure\ Dose = \frac{(C_s \times\ (IR * ww{:}dw) \times AUF)}{BW}$$

Parameter	Definition (units)	Value	Reference
Exposure Dose	Estimated receptor-specific contaminant intake (mg/kg of body weight/day)	calculated	--
C_s	Chemical concentration in soil (mg/kg)	Site-specific	Maximum detected concentration (0-10 ft bgs)
IR	Ingestion rate (kg food [ww]/day)	0.18	Maximum reported total dietary intake (OEHHA, 2003)
ww:dw	Wet-weight to dry weight conversion factor for ingested matter	0.22	78-percent moisture
AUF	Area use factor (the ratio of the site exposure area to the receptor foraging range) (unitless)	1	Maximum possible value
BW	Body weight (kg)	1.6	Minimum reported adult body weight (OEHHA, 2003)

The equation and exposure assumptions for calculating the Tier 1 exposure doses for the red-tailed hawk are presented in Equation 4.

Equation 4 Calculation of Tier 1 Exposure Dose for COPECs in Soil; Red-tailed Hawk			
$$Exposure\ Dose = \frac{(C_s\ \times (IR * ww{:}dw) \times AUF)}{BW}$$			
Parameter	**Definition (units)**	**Value**	**Reference**
Exposure Dose	Estimated receptor-specific contaminant intake (mg/kg of body weight/day)	Calculated	--
C_s	Chemical concentration in soil (mg/kg)	Site-specific	Maximum detected concentration (0-10 ft bgs)
IR	Ingestion rate (kg food [ww]/day)	0.12	Maximum reported total dietary intake (US EPA, 1993b)
ww:dw	Wet-weight to dry weight conversion factor for ingested matter	0.22	78-percent moisture
AUF	Area use factor (the ratio of the site exposure area to the receptor foraging range) (unitless)	1	Maximum possible value
BW	Body weight (kg)	0.96	Minimum reported adult body weight (US EPA, 1993b)

The equation and exposure assumptions for calculating the Tier 1 exposure doses for the pronghorn are presented in Equation 5.

Equation 5. Calculation of Tier 1 Exposure Dose for COPECs in Soil; Pronghorn			
$$Exposure\ Dose = \frac{(C_s \times (IR * ww{:}dw) \times AUF)}{BW}$$			
Parameter	**Definition (units)**	**Value**	**Reference**
Exposure Dose	Estimated receptor-specific contaminant intake (mg/kg of body weight/day)	calculated	--
C_s	Chemical concentration in soil (mg/kg)	Site-specific	Maximum detected concentration (0-10 ft bgs)
IR	Ingestion rate (kg wet matter/day) Based on equation: $IR=a(BW)^b$ where: a=2.606, b=0.628	0.74	Dry matter intake rate for herbivores (based on Nagy, 2001)
ww:dw	Wet-weight to dry weight conversion factor for ingested matter	0.22	78-percent moisture
AUF	Area use factor (the ratio of the site exposure area to the receptor foraging range) (unitless)	1	Maximum possible value
BW	Body weight (kg)	47	Minimum reported adult body weight (O'Gara, 1978)

Exposure doses will not be calculated for plants. For the Tier 1 exposure assessment, it will be assumed that the exposure concentrations for plants are equal to the maximum detected concentrations of COPECs in soil (0-10 ft bgs).

3.4 Effects Assessment

The effects assessment evaluated the potential toxic effects on the receptors being exposed to the COPECs. The effects assessment includes selection of appropriate toxicity reference values (TRVs) for the characterization and evaluation of risk. TRVs are receptor and chemical specific exposure rates at which no adverse effects have been observed, or at which low adverse effects are observed. TRVs that are based on studies with no adverse effects are called no observed adverse effects levels (NOAELs). TRVs that are based on studies with low adverse effects are termed lowest observed adverse effects levels (LOAELs).

For the initial SLERA, the preference for TRVs is based on chronic or long term exposure, when available. The TRVs should be selected from peer-reviewed toxicity studies and from primary literature. Initial risk characterization should be conducted using the lowest appropriate chronic NOAEL for non-lethal or reproductive effects. If a TRV is not available and/or no surrogate data could be identified, the exclusion of potential toxicity associated with the COPEC will be qualitatively addressed in the uncertainty analysis of the risk assessment. Other factors that may be included in this discussion is frequency of detection, depth of detections, and special analysis of the detections.

3.5 Risk Characterization

Assessment endpoints are critical values to be protected (US EPA, 1997c). The assessment endpoint will be to ensure the survival and reproduction of all ecological receptors to maintain populations. This will be accomplished by determining whether COPECs at each site are present at levels that would adversely affect the population size of ecological receptors by limiting their abilities to reproduce.

For plants, the Tier 1 screening level hazard quotients for plants will be calculated by comparing exposure doses (i.e., maximum detected concentrations of COPECs; 0-10 ft bgs) to an effect concentration. The equation for screening level hazad quotient (SLHQ) for plants is shown in Equation 6.

Equation 6. Calculation of Screening-Level Hazard Quotients for Plant Receptors

$$SLHQ = \frac{C_s}{Effect\ Concentration}$$

Parameter	Definition (units)
SLHQ	Screening level hazard quotient (unitless)
C_s	Chemical concentration in soil (mg COPEC / kg soil dry weight)

Effect Concentration	Concentration at which adverse effects are not expected (mg/kg)

Tier 1 SLHQs for wildlife receptors will be calculated by comparing estimated exposure doses derived using Equations 1 through 5 for each of the key receptors determined to have complete habitat and exposure pathways at the site to NOAEL-based TRVs. The derivation of SLHQ for the key receptors (except plants) is shown in Equation 7.

Equation 7 Calculation of Screening-Level Hazard Quotients for Wildlife Receptors

$$SLHQ = \frac{Dose}{TRV}$$

Parameter	**Definition (Units)**
SLHQ	Screening-level hazard quotient (unitless)
Dose	Estimated receptor-specific contaminant intake, from Equations 1 through 5 (mg/kg of body weight/day)
TRV	NOAEL-based TRV (mg/kg/day)
C_s	Chemical concentration in soil (mg COPEC / kg soil dry weight)

HQs are calculated for each receptor and each COPEC. For each receptor, additive risk must be evaluated. For the initial screening assessment, it is assumed that all COPECs have equal potential risk to the receptor. The overall hazard index (HI) is then calculated for each receptor using Equation 3:

$$HI = HQ_x + HQ_Y + \ldots + HQ_z \qquad \text{Equation 8}$$

Where:

HI = Hazard Index (unitless)
HQ_x = Hazard quotient for each COPEC (unitless)

NMED applies a target risk level for ecological risk assessments of 1.0. If the HI for any receptor is above this target risk level, then there is a potential for adverse effects on ecological receptors and additional evaluation following the Tier 2 SLERA process is required.

As with all risk assessments, the SLERA should include a discussion of the uncertainties. More detailed information may be found in the *Guidance for Assessing Ecological Risks Posed by Chemicals: Screening-Level Ecological Risk Assessment (NMED, 2014).*

4.0 TIER 2 SLERA

The Tier 2 exposure assessment will consist of calculating refined estimates of exposure doses which will utilize exposure assumptions that are more realistic. The following assumptions will apply to Tier 2 exposure doses:

- Exposure Point Concentration (EPC) – 95 % upper confidence level of the mean (UCLs) will be utilized as the EPC (if sufficient data are available – refer to Volume I for determination of EPCs and UCLs).
- AUF – Site-specific value between 0 and 1, based on the ratio of the exposure area (size of SWMU or corrective action site) to the receptor's average home range size, as shown in Equation 9; if a receptor's home range size is less than the exposure area, a value of 1 will be assumed.

$$AUF = \frac{Exposure\ Area\ of\ Site\ (acres)}{Average\ Home\ Range\ (acres)} \qquad \textbf{Equation 9}$$

- Bioavailability – It will be assumed that the bioavailability is 100% at each site.
- Body weight – The average reported adult body weight will be applied.
- Ingestion rate – The average reported ingestion rate will be applied.
- Dietary composition – Receptor-specific percentages of plant, animal, and soil matter will be considered. Concentrations of COPECs in dietary elements (plant and animal matter) will be predicted by the use of bio-uptake and bioaccumulation modeling.
- Wet-weight to dry-weight conversion factor – Because body weight is reported as wet-weight (kg), and soil concentrations are reported as dry-weight (mg/kg), a wet-weight to dry-weight conversion factor will also be applied when calculating exposure doses.

The Tier 2 exposure doses for wildlife receptors will include one, two or all three of the following elements, depending on the receptor being evaluated: 1) ingestion of plant matter; 2) ingestion of animal (or invertebrate) matter; and 3) incidental ingestion of soil. Bio-uptake and bioaccumulation modeling will be utilized to predict the concentrations of COPECs in plants and animal/invertebrate matter that could be ingested by wildlife receptors. Evaluation of surface and/or groundwater should be discussed with NMED.

Plant uptake factors (PUFs) will be used to predict the concentrations of COPECs in plants. The PUFs for inorganic constituents are summarized in Table 1. For organic COPECs, the PUFs are based on the octanol-water partition coefficient (K_{ow}), which will be obtained from US EPA databases or primary literature.

If a PUF is not available, then a value of one (1) will be applied which assumes 100% assimilation. The equation and variables that will be used to predict COPEC concentrations in plants are shown in Equation 10.

Equation 10. Calculation of COPEC Concentrations in Plants		
$C_{plant} = C_{soil} \times PUF$		
Parameter	**Definition (Units)**	**Value**
C_{plant}	COPEC concentration in plant (mg/kg dry weight)	Calculated
C_{soil}	Concentration of COPEC in soil (EPC) (mg/kg dry weight)	Site-specific
PUF	Plant-uptake factor (unitless)	For inorganics (see Table 1) For organic constituents (Travis and Arms, 1988): PUF = 1.588 – 0.578 log K_{ow} K_{ow}- obtain from EPA, 2011b or most current

Table 1. Plant Uptake Factors for Inorganics

Analyte	Plant Uptake Factor (PUF)	Analyte	Plant Uptake Factor (PUF)
Aluminum	4.0E-03	Magnesium	1.0E+00
Antimony	2.0E-01	Manganese	2.5E-01
Arsenic	4.0E-02	Mercury	9.0E-01
Barium	1.5E-01	Molybdenum	2.5E-01
Beryllium	1.0E-02	Nickel	6.0E-02
Boron	4.0E+00	Potassium	1.0E+00
Cadmium	5.5E-01	Selenium	2.5E-02
Calcium	3.5E+00	Silver	4.0E-01
Chromium	7.5E-03	Sodium	7.5E-02
Cobalt	2.0E-02	Thallium	4.0E-03
Copper	4.0E-01	Tin	3.0E-02
Iron	4.0E-03	Vanadium	5.5E-03
Lead	4.5E-02	Zinc	1.5E+00
From Baes, *et.al,* 1994			

Concentrations of COPECs in animal matter (invertebrates and prey species) will be predicted by applying bioaccumulation or biomagnification factors (BAFs). The BAFs will be selected from primary literature sources. If BAF data are not available, a default value of 1 will be used, which will conservatively assume 100% assimilation. Methodology for determining BAFs for soil to plants, soil to earthworms, and soil to small mammals may be found in US EPA (2003(b) and 2005). The equation and variables for predicting concentrations in animal matter are shown in Equation 11.

Equation 11. Calculation of COPEC Concentrations in Prey

$$C_{prey} = C_{soil} \times BAF$$

Parameter	Definition (Units)	Value
C_{prey}	COPEC concentration in prey (mg/kg dry weight)	Calculated
C_{soil}	Concentration of COPEC in soil (EPC) (mg/kg dry weight)	Site-specific
BAF	Bioaccumulation/Biomagnification factor	Chemical-specific (see US EPA 2003(b) and 2005)

The equation and exposure assumptions that will be used to calculate the Tier 2 exposure doses for the deer mouse are shown in Equation 12.

Equation 12. Calculation of Tier 2 Exposure Dose for COPECs in Soil; Deer Mouse

$$Exposure\ Dose = \frac{\left[\left(C_{plant} \times \frac{IR_{plant}}{ww:dw}\right) + \left(C_{invert} \times \frac{IR_{invert}}{1/ww:dw}\right) + (C_{soil} \times IR_{soil} \times ST) \times AUF\right]}{BW}$$

Parameter	Definition (Units)	Value	Reference
Exposure dose	Estimated receptor-specific contaminant intake (mg/kg of body weight/day)	Calculated	--
C_{plant}	COPEC concentration in plants (mg final COPEC/kg plant dry weight)	Calculated	See Equation 10
IR_{total}	Receptor-specific average ingestion rate based on total dietary intake (kg wet weight/day)	0.004	US EPA 1993b
IR_{plant}	Receptor-specific plant-matter ingestion rate (kg food wet weight/day)	0.003	Based on an average ingestion rate of 0.004 kg/day (US EPA, 1993b) and a diet of 74% plant matter (OEHHA, 1999)
ww:dw	Wet-weight to dry weight conversion factor for ingested matter	0.22	78-percent moisture
C_{invert}	Invertebrate EPC (mg final COPEC/kg invertebrate dry weight)	Calculated	See Equation 11
IR_{invert}	Receptor-specific animal matter ingestion rate (kg food wet weight/day)	0.001	Based on an average ingestion rate of 0.004 kg/day (US EPA, 1993b) and a diet of 26% invertebrate matter (OEHHA, 1999)
C_{soil}	Surface-soil EPC (mg final COPEC/kg soil dry weight)	Site-specific	95% UCL if available, or maximum (0-0.5 ft bgs)
IR_{soil}	Receptor-specific incidental soil ingestion rate (kg soil dry weight/day)	0.000018	Based on < 2% (Beyer et. al, 1994); Average ingestion rate of (0.004

			kg/day wet weight * 0.22 ww:dw) * 2%.
ST	Bioavailability factor for constituents ingested in soil (assumed to be 1.0 for all constituents)	1.0	Conservative default (assume 100% bioavailability)
AUF	area use factor (maximum value = 1); ratio of area of site to average receptor foraging range (0.3 acres for deer mouse)	Site-specific	US EPA, 1993b
BW	average adult body weight (kg)	0.02	CDW, 2011

The equation and exposure assumptions that will be used to calculate the Tier 2 exposure doses for the horned lark are shown in Equation 13.

Equation 13. Calculation of Tier 2 Exposure Dose for COPECs in Soil; Horned Lark

$$Exposure\ Dose = \frac{\left[\left(C_{plant} \times \frac{IR_{plant}}{ww:dw}\right) + \left(C_{invert} \times \frac{IR_{invert}}{1/ww:dw}\right) + (C_{soil} \times IR_{soil} \times ST) \times AUF\right]}{BW}$$

Parameter	**Definition (Units)**	**Value**	**Reference**
Exposure dose	Estimated receptor-specific contaminant intake (mg/kg of body weight/day)	Calculated	--
C_{plant}	COPEC concentration in plants (mg final COPEC/kg plant dry weight)	Calculated	See Equation 10
IR_{total}	Receptor-specific average ingestion rate based on total dietary intake (kg food wet weight/day)	0.035	US EPA 1993b; based on average ingestion rate for American robin adjusted for horned lark body weight.
IR_{plant}	Receptor-specific plant-matter ingestion rate (kg food wet weight/day)	0.026	Based on average ingestion rate of 0.035 kg/day (US EPA 1993b) and a diet of 75% plant matter (Doctor, *et* al, 2000) and US EPA, 1993b
ww:dw	Wet-weight to dry weight conversion factor for ingested matter	0.22	78-percent moisture
C_{invert}	Invertebrate EPC (mg final COPEC / kg invertebrate dry weight)	Site-specific	See Equation 11
IR_{invert}	Receptor-specific animal matter ingestion rate (kg food wet weight/day)	0.009	Based on average ingestion rate of 0.035 kg/day (US EPA 1993b) and a diet of 25% invertebrates (Doctor, et al, 2000) and US EPA, 1993b
C_{soil}	Surface-soil EPC (mg final COPEC / kg soil dw)	Site-specific	95% UCL if available, or maximum (0-0.5 ft bgs)
IR_{soil}	Receptor-specific incidental soil ingestion rate	0.00077	Based on 10% (Baer, *et*

	(kg/day dry weight)		*al*, 1994). Average ingestion rate of (0.035 kg/day (wet weight) * 0.22 ww:dw) * 10%).
ST	Bioavailability factor for constituents ingested in soil (assumed to be 1 for all constituents)	1	Conservative default (assume 100% bioavailability)
AUF	Area use factor (maximum value = 1); ratio of area of site to average receptor foraging range (4 acres for horned lark)	Area of site (acres) / 4 acres	Beason, 1995
BW	Average adult body weight (kg)	0.033	Trost, 1972

The equation and exposure assumptions that will be used to calculate the Tier 2 exposure doses for the kit fox are shown in Equation 14.

Equation 14. Calculation of Tier 2 Exposure Dose for COPECs in Soil; Kit Fox

$$Exposure\ Dose = \frac{\left[\left(C_{prey} \times \frac{IR_{prey}}{1/ww:dw}\right) + (C_{soil} \times IR_{soil} \times ST) \times AUF\right]}{BW}$$

Parameter	Definition (Units)	Value	Reference
Exposure dose	Estimated receptor-specific contaminant intake (mg/kg of body weight/day)	Calculated	--
C_{prey}	Prey EPC (mg final COPEC / kg prey dry weight)	Calculated	See Equation 11
IR_{prey}	Receptor-specific animal matter ingestion rate (kg food wet weight/day)	0.13	Based on an average ingestion rate of 0.13 kg/day (OEHHA, 2003) and a diet of 100% animal matter
ww:dw	Wet-weight to dry weight conversion factor for ingested matter	0.22	78-percent moisture
C_{soil}	Surface and subsurface-soil (0-10 ft bgs) EPC (mg final COPEC / kg soil dw)	Site-specific	95% UCL if available, or maximum (0-10 ft bgs)
IR_{soil}	Receptor-specific incidental soil ingestion rate (kg soil dry weight/day)	0.0008	Based on 2.8% (Beyer et.al., 1994). Average ingestion rate of (0.13 kg/day (wet weight) *0.22 ww:dw) * 2.8%).
ST	Bioavailability factor for constituents ingested in soil (assumed to be 1for all constituents)	1	Conservative default (assume 100% bioavailability)
AUF	Area use factor (maximum value = 1); ratio of area of site to average receptor foraging range (1713 acres for kit fox)	Site-specific	--
BW	Average adult body weight (kg)	2.0	OEHHA, 2003

The equation and exposure assumptions that will be used to calculate the Tier 2 exposure doses for the red-tailed hawk are shown in Equation 15.

Equation 15. Calculation of Tier 2 Exposure Dose for COPECs in Soil; Red-Tailed Hawk

$$Exposure\ Dose = \frac{\left[\left(C_{prey} \times \frac{IR_{prey}}{1/ww{:}dw}\right) + (C_{soil} \times IR_{soil} \times ST) \times AUF\right]}{BW}$$

Parameter	Definition (Units)	Value	Reference
Exposure dose	Estimated receptor-specific contaminant intake (mg/kg of body weight/day)	Calculated	--
C_{prey}	Prey EPC (mg final COPEC / kg prey dry weight)	Calculated	See Equation 11
IR_{prey}	receptor-specific animal matter ingestion rate (kg food wet weight/day)	0.1	Based on an average ingestion rate of 0.1 kg/day (US EPA 1993b) and a diet of 100% animal matter
ww:dw	Wet-weight to dry weight conversion factor for ingested matter	0.22	78-percent moisture
C_{soil}	surface-soil EPC (mg final COPEC / kg soil dw)	Site-specific	95% UCL if available, or maximum (0-0.5 ft bgs)
IR_{soil}	receptor-specific incidental soil ingestion rate (kg soil dry weight/day)	0.0004	Based on < 2% (Beyer et. al., 1994). Average ingestion rate of (0.12 kg/day (wet weight) *0.22) * 2%).
ST	bioavailability factor for constituents ingested in soil (assumed to be 1 for all constituents)	1	Conservative default (assume 100% bioavailability)
AUF	area use factor (maximum value = 1); ratio of area of site to average receptor foraging range (1770 acres for red-tailed hawk)	Site-specific	--
BW	average adult body weight (kg)	1.1	US EPA, 1993b

The equation and exposure assumptions that will be used to calculate the Tier 2 exposure doses for the pronghorn are shown in Equation 16.

Equation 16. Calculation of Tier 2 Exposure Dose for COPECs in Soil; Pronghorn

$$Exposure\ Dose = \frac{\left[\left(C_{plant} \times \frac{IR_{plant}}{1/ww:dw}\right) + (C_{soil} \times IR_{soil} \times ST) \times AUF\right]}{BW}$$

Parameter	Definition (Units)	Value	Reference
Exposure dose	Estimated receptor-specific contaminant intake (mg/kg of body weight/day)	Calculated	--
C_{plant}	COPEC concentration in plants (mg final COPEC/kg plant dry weight)	Calculated	See Equation 10
IR_{plant}	receptor-specific plant-matter ingestion rate (kg food wet weight/day)	1.4	Based on an average ingestion rate of 1.4 kg/day (US FWS, 2005) and a diet of 100% plant matter
ww:dw	Wet-weight to dry weight conversion factor for ingested matter	0.22	78-percent moisture
C_{soil}	surface-soil EPC (mg final COPEC / kg soil dw)		95% UCL if available, or maximum (0-0.5 ft bgs)
IR_{soil}	receptor-specific incidental soil ingestion rate (kg soil dry weight/day)	0.006	Based on < 2% (Beyer et. al., 1994). Average ingestion rate of (1.4 kg/day (wet weight) * 0.22 ww:dw) * 2%).
ST	bioavailability factor for constituents ingested in soil (assumed to be 1.0 for all constituents)	1	Conservative default (assume 100% bioavailability)
AUF	area use factor (maximum value = 1); ratio of area of site to average receptor foraging range (3422 acres for pronghorn)	Site-specific	Zoellick & Smith, 1992
BW	Average adult body weight (kg)	50	O'Gara, 1978

4.1.1 Toxicity Assessment – Tier 2

The Tier 2 TRVs will be based on LOAELs. The LOAEL will be used as it is more representative of population risks.

4.1.2 Risk Characterization – Tier 2

Risk characterization for Tier 2 will be conducted by calculating HQs for plant and wildlife receptors using a similar method as in the Tier 1 SLERA. The equation and assumptions for calculating the Tier 2 HQs for wildlife receptors are shown in Equation 17.

Equation 17. Calculation of Tier 2 Hazard Quotients for Wildlife Receptors

$$HQ = \frac{Dose}{TRV}$$

Parameter	**Definition (Units)**
HQ	Hazard quotient (unitless)
Dose	Estimated receptor-specific contaminant intake (mg/kg of body weight/day)
TRV	Toxicity reference value (mg/kg/day) based on lowest observed adverse effects level (LOAEL)

For plants, a qualitative discussion of the potential for adverse risk will be provided in the assessment. Comparison of TRVs to soil concentrations based on the 95% UCL may be provided.

Summation of HQs will be added for COPECs that have a similar receptor-specific mode of toxicity. If the Tier 2 HI is less than one, adverse ecological effects are not expected and no further action will be taken.

For sites that have an HI equal to or greater than one, the site may require: 1) additional evaluation under a weight-of-evidence analysis; 2) a Tier 3 ERA; or 3) a corrective measures study.

Per US EPA (1997c), Tier 2 ecological risk characterization should include a discussion of the uncertainties since many assumptions may or may not accurately reflect site conditions. Therefore, a discussion of the uncertainties associated with the Tier 2 SLERA will be included in the report.

5.0 TIER 3: PHASE II - QUANTITATIVE ASSESSMENT

In the event that the SLERA does not show that levels of contamination in the impacted media are below the target level of 1.0, additional quantitative analyses may be warranted. This may include incorporation of biota studies to evaluate impact at the site. NMED should be consulted prior to conducting a Tier 3 assessment.

6.0 REFERENCES

Baes, C.F. and R.D. Sharp, 1983. *A Proposal for Estimation of Soil Leaching and Leaching Constants for Use in Assessment Models*. *Journal of Environmental Quality*. V12 No. 1 January-March.

Baes, C.F., R.D. Sharp, A.L. Sjoreen, and R.W. Shor, 1994. *A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture*. Oak Ridge National Laboratory, ORNL-5786, September.

Beason, Robert C., 1995. *Horned Lark*. The Birds of North America. No. 195.

Beyer, W.N., Conner, E.E. Connor, and S. Gerould, 1994. *Estimates of Soil Ingestion by Wildlife*. Journal of Wildlife Management. 58: 375-382. https://fp.auburn.edu/sfws/ditchkoff/Nutrition%20Class%20Papers/Beyer%20et%20al.%201994.pdf

Canadian Environmental Quality Guidelines (CEQG), 1999. *Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health.* http://enviroreporter.com/files/1997_Canadian_Chromium_soil_guidelines.pdf

Colorado Division of Wildlife (CDW), 2011. Natural Diversity Information Source, http://ndis.nrel.colostate.edu/wildlifespx.asp?SpCode=050072.

Doctor, P.G, K.A Gano, and N.K Lane, 2000. *Evaluation of a Terrestrial Foodweb Model to Set Soil Cleanup Levels,* in *Environmental Toxicology and Risk Assessment*, ASTM STP 1381.

Kincaid, C.T., M.P. Bergeron, C.R. Cole, M.D. Freshley, N. Hassig, V.G. Johnson, D.I. Kaplan, R.J. Serne, G.P. Steile, D.L. Strenge, P.D. Thorne, L.W. Vail, G.A. Whyatt, and S.K. Wurstner, March 1998. "Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site," Pacific Northwest Laboratory report PNNL-11800, Richland, Washington.

Koenig, Rich and Von Isaman, 2010. Top Soil Quality Guidelines for Landscaping. http://extension.usu.edu/files/publications/publication/AG-SO-02.pdf

Los Alamos National Laboratory (LANL), 1997. *Administrative Procedure 4.5*, Draft

McAttee, 1905. *The Horned Larks and their Relation to Agriculture*. Biological Survey Bulletin No. 23. United States Department of Agriculture.

Nagy, K.A., 2001. *Food Requirements of Wild Animals: Predictive Equations for Free-living Mammals, Reptiles, and Birds.* Nutritional Abstracts and Reviews - Series B: Livestock Feeds and Feeding, 71(10)1R-12R. October.

New Mexico Department of Environment (NMED), 2012. February 2012 NMED Risk Assessment Guidance for Site Investigations and Remediation. http://www.nmenv.state.nm.us/HWB/guidance.html

Naval Facilities Engineering Command (NFEC), 2003. *Guidance for Environmental Background Analysis: Volume III Groundwater.* October.

New Mexico Environment Department (NMED), 2014. *Guidance for Assessing Ecological Risks Posed by Chemicals: Screening-Level Ecological Risk Assessment*.

Oak Ridge National Laboratory (ORNL), 2007. *Reevaluation of 1999 Health-Based Environmental Screening Levels (HBESLs) for Chemical Warfare Agents.*

Office of Environmental Health and Hazard (OEHHA), 1999. *Exposure Factors for Deer Mice.* Cal/Ecotox Database. Available online: http://oehha.ca.gov/cal_ecotox/.

OEHHA, 2003. *Exposure Factors for Kit Fox.* Cal/Ecotox Database. Available online: http://oehha.ca.gov/cal_ecotox/.

O'Gara, Bart W., 1978. *Antilocapra Americana*. Mammalian Species. 90:1-7.

Reynolds, Timothy, 1985. *Daily Summer Movements, Activity Patterns, and Home Range of Pronghorn. Northwest Science*. 58:4.

U.S. Environmental Protection Agency (US EPA), 1996. *Soil Screening Guidance: User's Guide.* Office of Solid Waste and Emergency Response. Washington, DC. EPA-540-R-96/018. July.

U.S. EPA, 1997. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*, Environmental Response Team, Interim Final, June 5.

U.S.EPA, 1998. *Guidelines for Ecological Risk Assessment*, Risk Assessment Forum, Final, April. EPA/630/R-95/002F; http://www.epa.gov/ncea/ecorisk.htm.

ATTACHMENT A
SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT
SCOPING ASSESSMENT
SITE ASSESSMENT CHECKLIST

INTRODUCTION

This checklist has been developed as a tool for gathering information about the facility property and surrounding areas, as part of the scoping assessment. Specifically, the checklist assists in the compilation of information on the physical and biological aspects of the site including the site environmental setting, usage of the site, releases at the site, contaminant fate and transport mechanisms, and the area's habitats, receptors, and exposure pathways. The completed checklist can then be used to construct the preliminary conceptual site exposure model (PCSEM) for the site. In addition, the checklist and PCSEM will serve as the basis for the scoping assessment report. Section III of this document provides further information on using the completed checklist to develop the PCSEM.

In general, the checklist is designed for applicability to all sites; however, there may be unusual circumstances which require professional judgment in order to determine the need for further ecological evaluation (*e.g.,* cave-dwelling receptors). In addition, some of the questions in the checklist may not be relevant to all sites. Some facilities may have large amounts of data available regarding contaminant concentrations and hydrogeologic conditions at the site, while other may have only limited data. In either case, the questions on the checklist should be addressed as completely as possible with the information available.

Habitats and receptors, which may be present at the site, can be identified by direct or indirect[36] observations and by contacting local and regional natural resource agencies. Habitat types may be determined by reviewing land use and land cover maps (LULC), which are available via the Internet at http://www.nationalatlas.gov/mapit.html. With regard to receptors, it should be noted that receptors are often present at a site even when they are not observed. Therefore, for the purposes of this checklist, it should be assumed that receptors are present if viable habitat is present. The presence of receptors should be confirmed by contacting one or several of the organizations listed below.

Sources of general information available for the identification of ecological receptors and habitats include:

- U.S. Fish and Wildlife Service (http://www.fws.gov)
- Biota Information System of New Mexico (BISON-M) maintained by the New Mexico Department of Game and Fish (NMGF) (http://151.199.74.229/states/nm.htm)
- U.S. Forest Service (USFS) (http://www.fs.fed.us/)
- New Mexico Forestry Division (NMFD) of the Energy, Minerals and Natural Resources Department (http://www.emnrd.state.nm.us/forestry/index.htm)
- U.S. Bureau of Land Management (USBLM) (http://www.blm.gov/nhp/index.htm) or (http://www.nm.blm.gov/www/new_home_2.html)
- United States Geological Service (USGS) (http://www.usgs.gov)

---

[36] Examples of indirect observations that indicate the presence of receptors include: tracks, feathers, burrows, scat

- National Wetland Inventory Maps (http://wetlands.fws.gov)
- National Audubon Society (http://www.audobon.com)
- National Biological Information Infrastructure (http://biology.usgs.gov)
- Sierra Club (http://www.sierraclub.org)
- National Geographic Society (http://www.nationalgeographic.com)
- New Mexico Natural Heritage Program (http://nmnhp.unm.edu/)
- State and National Parks System
- Local universities
- Tribal organizations

INSTRUCTIONS FOR COMPLETING THE CHECKLIST

The checklist consists of four sections: Site Location, Site Characterization, Habitat Evaluation, and Exposure Pathway Evaluation. Answers to the checklist should reflect existing conditions and should not consider future remedial actions at the site. Completion of the checklist should provide sufficient information for the preparation of a PCSEM and scoping report and allow for the identification of any data gaps.

Section I - Site Location, provides general site information, which identifies the facility being evaluated, and gives specific location information. Site maps and diagrams, which should be attached to the completed checklist, are an important part of this section. The following elements should be clearly illustrated: 1) the location and boundaries of the site relative to the surrounding area, 2) any buildings, structures or important features of the facility or site, and 3) all ecological areas or habitats identified during completion of the checklist. It is possible that several maps will be needed to clearly and adequately illustrate the required elements. Although topographical information should be illustrated on at least one map, it is not required for every map. Simplified diagrams (preferably to scale) of the site and surrounding areas will usually suffice.

Section II - Site Characterization, is intended to provide additional temporal and contextual information about the site, which may have an impact on determining whether a certain area should be characterized as ecologically viable habitat or contains receptors. Answers to the questions in Section II will help the reviewer develop a broader and more complete evaluation of the ecological aspects of a site.

Section III - Habitat Evaluation, provides information regarding the physical and biological characteristics of the different habitat types present at or in the locality of the site. Aquatic features such as lakes, ponds, streams, arroyos and ephemeral waters can be identified by reviewing aerial photographs, LULC and topographic maps and during site reconnaissance visits. In New Mexico, there are several well-defined terrestrial communities, which occur naturally. Typical communities include wetlands, forest (e.g., mixed conifer, ponderosa pine and pinyon juniper), scrub/shrub, grassland, and desert. Specific types of vegetation characterize each of these communities and can be used to identify them. Field guides are often useful for identifying vegetation types. A number of sites may be in areas that have been disturbed by human activities and may no longer match any of the naturally occurring communities typical of the southwest.

Particularly at heavily used areas at facilities, the two most common of these areas are usually described as “weed fields” and “lawn grass”. Vegetation at “weed fields” should be examined to determine whether the weeds consist primarily of species native to the southwest or introduced species such as Kochia. Fields of native weeds and lawn grass are best evaluated using the short grass prairie habitat guides.

The applicable portions of Section III of the checklist should be completed for each individual habitat identified. For example, the questions in Section III.A of the checklist should be answered for each wetland area identified at or in the locality of the site and the individual areas must be identified on a map or maps.

Section IV- Exposure Pathway Evaluation is used to determine if contaminants at the site have the potential to impact habitat identified in Section III. An exposure pathway is the course a chemical or physical agent takes from a source to an exposed organism. Each exposure pathway includes a source (or release from a source), an environmental transport mechanism, an exposure point, and an exposure route. A complete exposure pathway is one in which each of these components, as well as a receptor to be exposed, is present. Essentially, this section addresses the fate and transport of contaminants that are known or suspected to have been released at the site. In most cases, without a complete exposure pathway between contaminants and receptors, additional ecological evaluation is not warranted.

Potential transport pathways addressed in this checklist include migration of contaminants via air dispersion, leaching into groundwater, soil erosion/runoff, groundwater discharge to surface water, and irradiation. Due to New Mexico’s semi-arid climate, vegetation is generally sparse. The sparse vegetation, combined with the intense nature of summer storms in New Mexico, results in soil erosion that occurs sporadically over a very brief time frame. Soil erosion may be of particular concern for sites located in steeply sloped areas. Several questions within Section IV of this checklist have been developed to aid in the identification of those sites where soil erosion/runoff would be an important transport mechanism.

USING THE CHECKLIST TO DEVELOP THE PRELIMINARY CONCEPTUAL SITE EXPOSURE MODEL

The completed Site Assessment Checklist can be used to construct the PCSEM. An example PCSEM diagram is presented in Figure 1. The CSM illustrates actual and potential contaminant migration and exposure pathways to associated receptors. The components of a complete exposure pathway are simplified and grouped into three main categories: sources, release mechanisms, and potential receptors. As a contaminant migrates and/or is transformed in the environment, sources and release mechanisms may expand into primary, secondary, and tertiary levels. For example, Figure 1 illustrates releases from inactive lagoons (primary sources) through spills (primary release mechanism), which migrate to surface and subsurface soils (secondary sources), which are then leached (secondary release mechanism) to groundwater (tertiary source). Similarly, exposures of various trophic levels to the contaminant(s) and consequent exposures via the food chain may lead to multiple groups of receptors. For example, Figure 1 illustrates groups of both aquatic and terrestrial receptors which may be exposed and subsequently serve as tertiary release mechanisms to receptors which prey on them.

Although completing the checklist will not provide the user with a readymade PCSEM, a majority of the components of the PCSEM can be found in the answers to the checklist. It is then up to the user to put the pieces together into a comprehensive whole. The answers from Section II of the checklist, Site Characterization, can be used to identify sources of releases. The answers to Section IV, Exposure Pathway Evaluation, will assist users in tracing the migration pathways of releases in the environment, thus helping to identify release mechanisms and sources. The results of Section III, Habitat Evaluation, can be used to both identify secondary and tertiary sources and to identify the types of receptors which may be exposed. Appendix B of the NMED's *Guidance for Assessing Ecological Risks Posed by Chemicals: Screening-Level Ecological Assessment* also contains sample food webs which may be used to develop the PCSEM.

Once all of the components have been identified, one can begin tracing the steps between the primary releases and the potential receptors. For each potential receptor, the user should consider all possible exposure points (e.g., prey items, direct contact with contaminated soil or water, etc.) then begin eliminating pathways, which are not expected to result in exposure to the contaminant at the site. Gradually, the links between the releases and receptors can be filled in, resulting in potential complete exposure pathways.

For further guidance on constructing a PCSEM, consult the NMED's *Guidance for Assessing Ecological Risks Posed by Chemicals: Screening-Level Ecological Assessment* (2000), and EPA's Office of Solid Waste and Emergency *Response's Soil Screening Guidance: User's Guide* (1996).

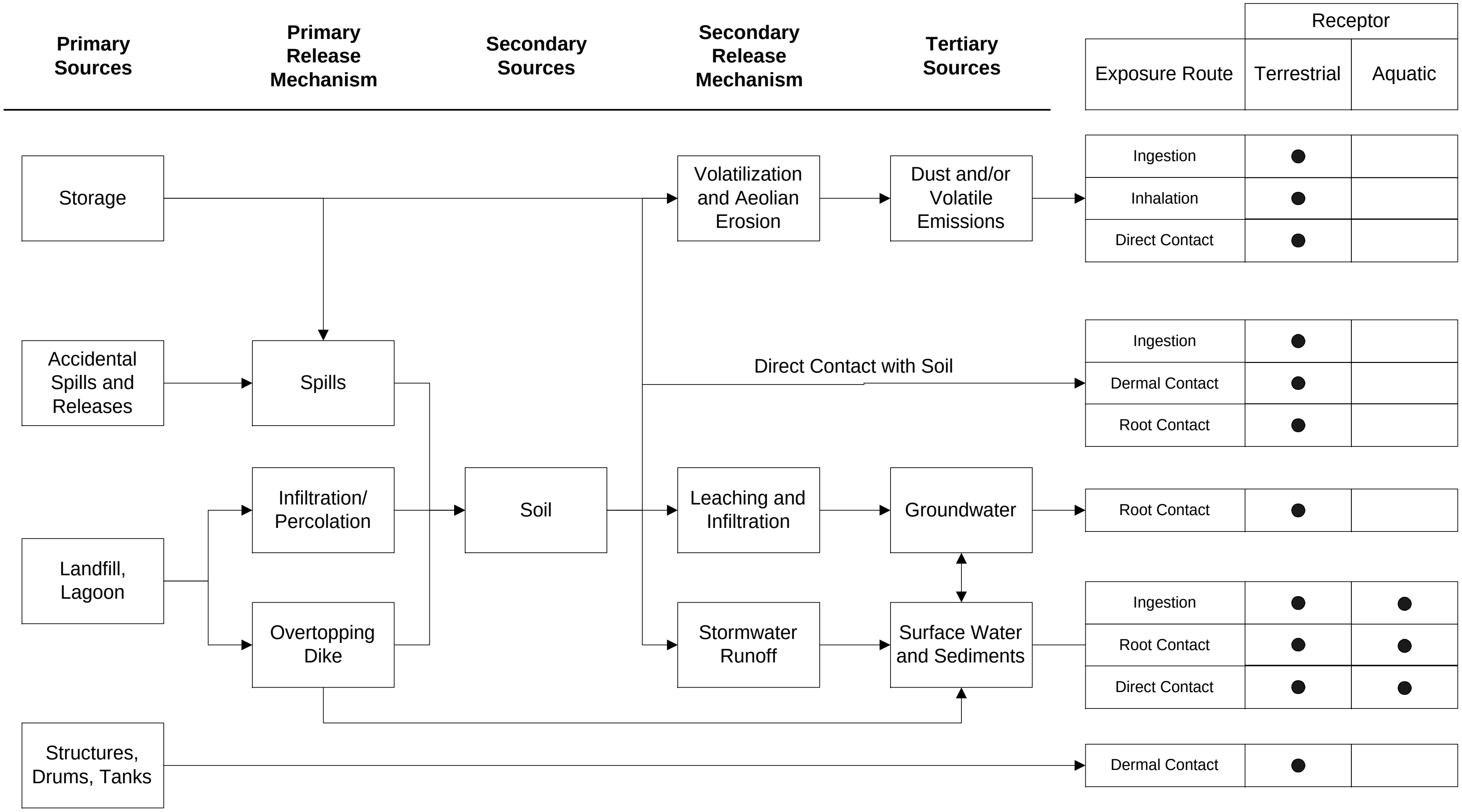


Figure 1. Example Preliminary Conceptual Site Exposure Model Diagram

NEW MEXICO ENVIRONMENT DEPARTMENT
SITE ASSESSMENT CHECKLIST

I. SITE LOCATION

1. Site Name:____
US EPA I.D. Number:____
Location:____
County:______________________
City:___________________________State:____________

2. Latitude:_________________________ Longitude:____________________________

3. Attach site maps, including a topographical map, a diagram which illustrates the layout of the facility (e.g., site boundaries, structures, etc.), and maps showing all habitat areas identified in Section III of the checklist. Also, include maps which illustrate known release areas, sampling locations, and any other important features, if available.

II. SITE CHARACTERIZATION

1. Indicate the approximate area of the site (i.e., acres or sq. ft)
____

2. Provide an approximate breakdown of the land uses on the site:

_____% Heavy Industrial
_____% Residential
_____% Recreational[a]
_____% Light Industrial
_____% Rural
_____% Undisturbed
_____% Urban
_____% Agricultural[b]
_____% Other[c]

[a]For recreational areas, please describe the usage of the area (e.g., park, playing field, etc.):
____

[b]For agricultural areas, please list the crops and/or livestock which are present:
____

[c]For areas designated as “other”, please describe the usage of the area:
____

3. Provide an approximate breakdown of the land uses in the area surrounding the site. Indicate the radius (in miles) of the area described: ___________________

_____% Heavy Industrial
_____% Residential
_____% Recreational[a]
_____% Light Industrial
_____% Rural
_____% Undisturbed
_____% Urban
_____% Agricultural[b]
_____% Other [c]

[a]For recreational areas, please describe the usage of the area (e.g., park, playing field, golf course, etc.):

____

[b]For agricultural areas, please list the crops and/or livestock which are present:

____

[c]For areas designated as "other", please describe the usage of the area:

____

____

4. Describe reasonable and likely future land and/or water use(s) at the site.

____

____

____

____

____

____

5. Describe the historical uses of the site. Include information on chemical releases that may have occurred as a result of previous land uses. For each chemical release, provide information on the form of the chemical released (i.e., solid, liquid, vapor) and the known or suspected causes or mechanism of the release (i.e., spills, leaks, material disposal, dumping, explosion, etc.).

____

____

____

____

____

6. If any movement of soil has taken place at the site, describe the degree of the disturbance. Indicate the likely source of any disturbances (e.g., erosion, agricultural, mining, industrial activities, removals, etc.) and estimate when these events occurred.

____

____

____

7. Describe the current uses of the site. Include information on recent (previous 5 years) disturbances or chemical releases that have occurred. For each chemical release, provide information on the form of the chemical released and the causes or mechanism of the release.

____
____
____
____
____

8. Identify the location or suspected location of chemical releases at the site. Provide an estimate of the distance between these locations and the areas identified in Section III.

____
____
____
____
____

9. Identify the suspected contaminants of concern (COCs) at the site. If known, include the maximum contaminant levels. Please indicate the source of data cited (e.g., RFI, confirmatory sampling, etc.).

____
____
____
____
____
____
____

10. Identify the media (e.g., soil (surface or subsurface), surface water, air, groundwater) which are known or suspected to contain COCs.________________

____

11. Indicate the approximate depth to groundwater (in feet below ground surface [(bgs)].

____

12. Indicate the direction of groundwater flow (e.g., north, southeast, etc.)

____

III. HABITAT EVALUATION

III.A Wetland Habitats

Are any wetland[37] areas such as marshes or swamps on or adjacent to the site?

☐ Yes ☐ No

If yes, indicate the wetland area on the attached site map and answer the following questions regarding the wetland area. If more than one wetland area is present on or adjacent to the site, make additional copies of the following questions and fill out for each individual wetland area. Distinguish between wetland areas by using names or other designations (such as location), and clearly identify each area on the site map. Also, obtain and attach a National Wetlands Inventory Map (or maps) to illustrate each wetland area.

Identify the sources of the observations and information (e.g., National Wetland Inventory, Federal or State Agency, USGS topographic maps) used to make the determination that wetland areas are or are not present.

____
____
____
____

If no wetland areas are present, proceed to Section III.B.

Wetland Area Questions

☐ Onsite ☐ Offsite

Name or
Designation:____

1. Indicate the approximate area of the wetland (acres or ft^2)_________________

2. Identify the type(s) of vegetation present in the wetland.

   ☐ Submergent (i.e., underwater) vegetation
   ☐ Emergent (i.e., rooted in the water, but rising above it) vegetation
   ☐ Floating vegetation
   ☐ Scrub/shrub

---

[37] Wetlands are defined in 40 CFR §232.2 as " Areas inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions." Examples of typical wetlands plants include: cattails, cordgrass, willows and cypress trees. National wetland inventory maps may be available at http:\\nwi.fws.gov. Additional information on wetland delineation criteria is also available from the Army Corps of Engineers.

☐ Wooded
☐ Other (Please describe):____

3. Estimate the vegetation density of the wetland area.

☐ Dense (i.e., greater than 75% vegetation)
☐ Moderate (i.e., 25% to 75% vegetation)
☐ Sparse (i.e., less than 25% vegetation)

4. Is standing water present? ☐ Yes ☐ No

If yes, is the water primarily: ☐ Fresh or ☐ Brackish
Indicate the approximate area of the standing water (ft^2):

____
Indicate the approximate depth of the standing water, if known (ft. or in.)_________

5. If known, indicate the source of the water in the wetland.

☐ Stream/River/Creek/Lake/Pond
☐ Flooding
☐ Groundwater
☐ Surface runoff

6. Is there a discharge from the facility to the wetland? ☐ Yes ☐ No
If yes, please describe:____
____
____
____
____
_

Wetland Area Questions (Continued)

7. Is there a discharge from the wetland? ☐ Yes ☐ No
If yes, indicate the type of aquatic feature the wetland discharges into:

- ☐ Surface stream/River (Name:_____________________________)
- ☐ Lake/Pond (Name:_____________________________)
- ☐ Groundwater
- ☐ Not sure

8. Does the area show evidence of flooding? ☐ Yes ☐ No
If yes, indicate which of the following are present (mark all that apply):

- ☐ Standing water
- ☐ Water-saturated soils
- ☐ Water marks
- ☐ Buttressing
- ☐ Debris lines
- ☐ Mud cracks
- ☐ Other (Please describe):____

9. Animals observed in the wetland area or suspected to be present based on indirect evidence or file material:

- ☐ Birds
- ☐ Fish
- ☐ Mammals
- ☐ Reptiles (e.g., snakes, turtles)
- ☐ Amphibians (e.g., frogs, salamanders)
- ☐ Sediment-dwelling invertebrates (e.g., mussels, crayfish, insect nymphs)

Specify species, if known:

____

____

____

____

III.B Aquatic Habitats

III.B.1 Non-Flowing Aquatic Features

Are any non-flowing aquatic features (such as ponds or lakes) located at or adjacent to the site?

☐ Yes ☐ No

If yes, indicate the aquatic feature on the attached site map and answer the following questions regarding the non-flowing aquatic features. If more than one non-flowing aquatic feature is present on or adjacent to the site, make additional copies of the following questions and fill out for each individual aquatic feature. Distinguish between aquatic features by using names or other designations, and clearly identify each area on the site map.

If no, proceed to Section III.B.2.

Non-Flowing Aquatic Feature Questions

☐ Onsite ☐ Offsite

Name or Designation:____

1. Indicate the type of aquatic feature present:

   - ☐ Natural (e.g., pond or lake)
   - ☐ Man-made (e.g., impoundment, lagoon, canal, etc.)

2. Estimate the approximate size of the water body (in acres or sq. ft.)_______________

3. If known, indicate the depth of the water body (in ft. or in.).______________________

Non-Flowing Aquatic Feature Questions (Continued)

4. Indicate the general composition of the bottom substrate. Mark all sources that apply from the following list.

☐ Bedrock
☐ Boulder (>10 in.)
☐ Cobble (2.5 - 10 in.)
☐ Gravel (0.1 - 2.5 in.)
☐ Sand
☐ Silt
☐ Clay
☐ Muck (fine/black)
☐ Concrete
☐ Debris
☐ Detritus
☐ Other (please specify):____

5. Indicate the source(s) of the water in the aquatic feature. Mark all sources that apply from the following list.

☐ River/Stream/Creek
☐ Groundwater
☐ Industrial Discharge
☐ Surface Runoff
☐ Other (please specify):____

6. Is there a discharge from the facility to the aquatic feature? ☐ Yes ☐ No

If yes, describe the origin of each discharge and its migration path:

____
____
____
____

7. Does the aquatic feature discharge to the surrounding environment? ☐ Yes ☐ No

If yes, indicate the features from the following list into which the aquatic feature discharges, and indicate whether the discharge occurs onsite or offsite:

☐ River/Stream/Creek ☐ onsite ☐ offsite
☐ Groundwater ☐ onsite ☐ offsite
☐ Wetland ☐ onsite ☐ offsite
☐ Impoundment ☐ onsite ☐ offsite
☐ Other (please describe)____

Non-Flowing Aquatic Feature Questions (Continued)

8. Animals observed in the vicinity of the aquatic feature or suspected to be present based on indirect evidence or file material:

☐ Birds
☐ Fish
☐ Mammals
☐ Reptiles (e.g., snakes, turtles)
☐ Amphibians (e.g., frogs, salamanders)
☐ Sediment-dwelling invertebrates (e.g., mussels, crayfish, insect nymphs)

Specify species, if known:

____
____
____
____

III.B.2 Flowing Aquatic Features

Are any flowing aquatic features (such as streams or rivers) located at or adjacent to the site?

☐ Yes ☐ No

If yes, indicate the aquatic feature on the attached site map and answer the following questions regarding the flowing aquatic features. If more than one flowing aquatic feature is present on or adjacent to the site, make additional copies of the following questions and fill out for each individual aquatic feature. Distinguish between aquatic features by using names or other designations, and clearly identify each area on the site map

If no, proceed to Section III.C.

Flowing Aquatic Feature Questions

☐ Onsite ☐ Offsite

Name or Designation:____

1. Indicate the type of flowing aquatic feature present.

   - ☐ River
   - ☐ Stream
   - ☐ Creek
   - ☐ Brook
   - ☐ Dry wash
   - ☐ Arroyo
   - ☐ Intermittent stream
   - ☐ Artificially created (ditch, etc.)
   - ☐ Other (specify)
   - ☐

2. Indicate the general composition of the bottom substrate.

☐ Bedrock	☐ Sand	☐ Concrete
☐ Boulder (>10 in.)	☐ Silt	☐ Debris
☐ Cobble (2.5 - 10 in.)	☐ Clay	☐ Detritus
☐ Gravel (0.1 - 2.5 in.)	☐ Muck (fine/black)	

☐ Other (please specify):____

3. Describe the condition of the bank (e.g., height, slope, extent of vegetative cover) of the aquatic feature.

____
____
____
____

4. Is there a discharge from the facility to the aquatic feature? ☐ Yes ☐ No

If yes, describe the origin of each discharge and its migration path:

____
____
____
____

5. Indicate the discharge point of the water body. Specify name, if known.

Flowing Aquatic Feature Questions (Continued)

6. If the flowing aquatic feature is a dry wash or arroyo, answer the following questions.

   ☐Check here if feature is not a dry wash or arroyo

   If known, specify the average number of days in a year in which flowing water is present in the feature: ____

   Is standing water or mud present? Check all that apply.

   ☐Standing water
   ☐Mud
   ☐Neither standing water or mud

   Does the area show evidence of recent flow (e.g., flood debris clinging to vegetation)?

   ☐Yes
   ☐No
   ☐Not sure

7. Animals observed in the vicinity of the aquatic feature or suspected to be present based on indirect evidence or file material:

   ☐ Birds
   ☐ Fish
   ☐ Mammals
   ☐ Reptiles (e.g., snakes, turtles)
   ☐ Amphibians (e.g., frogs, salamanders)
   ☐ Sediment-dwelling invertebrates (e.g., mussels, crayfish, insect nymphs)

   Specify species, if known:

   ____
   ____
   ____
   ____

III.C Terrestrial Habitats

III.C.1 Wooded

Are any wooded areas on or adjacent to the site? ☐ Yes ☐ No

If yes, indicate the wooded area on the attached site map and answer the following questions. If more than one wooded area is present on or adjacent to the site, make additional copies of the following questions and fill out for each individual wooded area. Distinguish between wooded areas by using names or other designations, and clearly identify each area on the site map.

If no, proceed to Section III.C.2.

Wooded Area Questions

☐ On-site ☐ Off-site

Name or Designation:____

1. Estimate the approximate size of the wooded area (in acres or sq. ft.)______________

2. Indicate the dominant type of vegetation in the wooded area.

   ☐ Evergreen
   ☐ Deciduous
   ☐ Mixed

   Dominant plant species, if known:_______________________________________

3. Estimate the vegetation density of the wooded area.

   ☐Dense (i.e., greater than 75% vegetation)
   ☐Moderate (i.e., 25% to 75% vegetation)
   ☐Sparse (i.e., less than 25% vegetation)

4. Indicate the predominant size of the trees at the site. Use diameter at chest height.

   ☐ 0-6 inches
   ☐ 6-12 inches
   ☐ >12 inches
   ☐ No single size range is predominant

5. Animals observed in the wooded area or suspected to be present based on indirect evidence or file material:

   ☐ Birds
   ☐ Mammals
   ☐ Reptiles (e.g., snakes, lizards)
   ☐ Amphibians (e.g., toads, salamanders)

   Specify species, if known:
   ____
   ____
   ____
   ____

III.C.2 Shrub/Scrub

Are any shrub/scrub areas on or adjacent to the site? ☐ Yes ☐ No

> If yes, indicate the shrub/scrub area on the attached site map and answer the following questions. If more than one shrub/scrub area is present on or adjacent to the site, make additional copies of the following questions and fill out for each individual shrub/scrub area. Distinguish between shrub/scrub areas, using names or other designations, and clearly identify each area on the site map.

If no, proceed to Section III.C.3.

Shrub/Scrub Area Questions

☐ Onsite ☐ Offsite

Name or Designation:____

1. Estimate the approximate size of the shrub/scrub area (in acres or sq. ft.).__________

2. Indicate the dominant type of shrub/scrub vegetation present, if known.

____

____

____

____

3. Estimate the vegetation density of the shrub/scrub area.

☐ Dense (i.e., greater than 75% vegetation)
☐ Moderate (i.e., 25% to 75% vegetation)
☐ Sparse (i.e., less than 25% vegetation)

4. Indicate the approximate average height of the scrub/shrub vegetation.

☐ 0-2 feet
☐ 2-5 feet
☐ >5 feet

5. Animals observed in the shrub/scrub area or suspected to be present based on indirect evidence or file material:

☐Birds
☐Mammals
☐Reptiles (e.g., snakes, lizards)
☐Amphibians (e.g., toads, salamanders)

Specify species, if known:

____

____

____

____

III.C.3 Grassland

Are any grassland areas on or adjacent to the site? ☐ Yes ☐ No

If yes, indicate the grassland area on the attached site map and answer the following questions. If more than one grassland area is present on or adjacent to the site, make additional copies of the following questions and fill out for each individual grassland area. Distinguish between grassland areas by using names or other designations, and clearly identify each area on the site map.

If no, proceed to Section III.C.4.

Grassland Area Questions

☐ Onsite ☐ Offsite

Name or Designation:____

1. Estimate the approximate size of the grassland area (in acres or sq. ft.).__________

2. Indicate the dominant plant type, if known.

____
____
____
____

3. Estimate the vegetation density of the grassland area.

   ☐ Dense (i.e., greater than 75% vegetation)
   ☐ Moderate (i.e., 25% to 75% vegetation)
   ☐ Sparse (i.e., less than 25% vegetation)

4. Indicate the approximate average height of the dominant plant type (in ft. or in.)_

5. Animals observed in the grassland area or suspected to be present based on indirect evidence or file material:

   ☐Birds
   ☐Mammals
   ☐Reptiles (e.g., snakes, lizards)
   ☐Amphibians (e.g., toads, salamanders)

   Specify species, if known:

III.C.4 Desert

Are any desert areas on or adjacent to the site? ☐ Yes ☐ No

If yes, indicate the desert area on the attached site map and answer the following questions. If more than one desert area is present on or adjacent to the site, make additional copies of the following questions and fill out for each individual desert area. Distinguish between desert areas by using names or other designations, and clearly identify each area on the site map.

If no, proceed to Section III.C.5.

Desert Area Questions

☐ Onsite ☐ Offsite

Name or Designation:____

1. Estimate the approximate size of the desert area (in acres or sq. ft.)._________

2. Describe the desert area (e.g., presence or absence of vegetation, vegetation types, presence/size of rocks, sand, etc.)

____
____
____
____
____
____
____
____
____

3. Animals observed in the desert area or suspected to be present based on indirect evidence or file material:

☐Birds
☐Mammals
☐Reptiles (e.g., snakes, lizards)
☐Amphibians (e.g., toads, salamanders)

Specify species, if known:

____

III.C.5 Other

1. Are there any other terrestrial communities or habitats on or adjacent to the site which were not previously described?

☐ Yes ☐ No

If yes, indicate the "other" area(s) on the attached site map and describe the area(s) below. Distinguish between onsite and offsite areas. If no, proceed to Section III.D.

III.D Sensitive Environments and Receptors

1. Do any other potentially sensitive environmental areas[38] exist adjacent to or within 0.5 miles of the site? If yes, list these areas and provide the source(s) of information used to identify sensitive areas. *Do not answer "no" without confirmation from the U.S. Fish and Wildlife Service and appropriate State of New Mexico division.*

---

[3] Areas that provide unique and often protected habitat for wildlife species. These areas are typically used during critical life stages such as breeding, hatching, rearing of young and overwintering. Refer to **Table 1** at the end of this document for examples of sensitive environments.

2. Are any areas on or near (i.e., within 0.5 miles) the site which are owned or used by local tribes? If yes, describe. *Contact the Tribal Liaison in the Office of the Secretary (505)827-2855 to obtain this information.*

4. Does the site serve or potentially serve as a habitat, foraging area, or refuge by rare, threatened, endangered, candidate and/or proposed species (plants or animals), or any otherwise protected species? If yes, identify species. *This information should be obtained from the U.S. Fish and Wildlife Service and appropriate State of New Mexico division.*

5. Is the site potentially used as a breeding, roosting or feeding area by migratory bird species? If yes, identify which species.

6. Is the site used by any ecologically[39], recreationally, or commercially important

---

[39] Ecologically important species include populations of species which provide a critical (i.e., not replaceable) food resource for higher organisms and whose function as such would not be replaced by more tolerant species; or perform a critical ecological function (such as organic matter decomposition) and whose functions will not be replaced by other species. Ecologically important species include pest and opportunistic species that populate an area if they serve as a food source for other species, but do not include domesticated animals (e.g., pets and livestock) or plants/animals whose existence is maintained by continuous human interventions (e.g., fish hatcheries, agricultural crops, etc.,)

species? If yes, explain.

____

IV. EXPOSURE PATHWAY EVALUATION

1. Do existing data provide sufficient information on the nature, rate, and extent of contamination at the site?

☐ Yes
☐ No
☐ Uncertain

Please provide an explanation for your answer:______________________________

2. Do existing data provide sufficient information on the nature, rate, and extent of contamination in offsite affected areas?

☐ Yes
☐ No
☐ Uncertain
☐ No offsite contamination

Please provide an explanation for your answer:______________________________

3. Do existing data address potential migration pathways of contaminants at the site?

☐ Yes
☐ No
☐ Uncertain

Please provide an explanation for your answer:____
_

____

____

____

____

4. Do existing data address potential migration pathways of contaminants in offsite affected areas?

   ☐ Yes
   ☐ No
   ☐ Uncertain
   ☐ No offsite contamination

   Please provide an explanation for your answer:______________________________

5. Are there visible indications of stressed habitats or receptors on or near (i.e., within 0.5 miles) the site that may be the result of a chemical release? If yes, explain. Attach photographs if available.

6. Is the location of the contamination such that receptors might be reasonably expected to come into contact with it? For soil, this means contamination in the soil 0 to 5 feet below ground surface (bgs). If yes, explain.

7. Are receptors located in or using habitats where chemicals exist in air, soil, sediment or surface water? If yes, explain.

8. Could chemicals reach receptors via groundwater? Can chemicals leach or dissolve to groundwater? Are chemicals mobile in groundwater? Does groundwater discharge into receptor habitats? If yes, explain.

____

____

____

____

____

____

____

9. Could chemicals reach receptors through runoff or erosion? Answer the following questions:

What is the approximate distance from the contaminated area to the nearest watercourse or arroyo?

☐ 0 feet (i.e., contamination has reached a watercourse or arroyo)
☐ 1-10 feet
☐ 11-20 feet
☐ 21-50 feet
☐ 51-100 feet
☐ 101-200 feet
☐ > 200 feet
☐ > 500 feet
☐ > 1000 feet

What is the slope of the ground in the contaminated area?

☐ 0-10%
☐ 10-30%
☐ > 30%

What is the approximate amount of ground and canopy vegetative cover in the contaminated area?

☐ < 25%
☐ 25-75%
☐ > 75%

Is there visible evidence of erosion (e.g., a rill or gully) in or near the contaminated area?

☐ Yes
☐ No
☐ Do not know

Do any structures, pavement, or natural drainage features direct run-on flow (i.e., surface flows originating upstream or uphill from the area of concern) into the contaminated area?

☐ Yes
☐ No
☐ Do not know

10. Could chemicals reach receptors through the dispersion of contaminants in air (e.g., volatilization, vapors, fugitive dust)? If yes, explain.

____
____
____
____
____
____

11. Could chemicals reach receptors through migration of non-aqueous phase liquids (NAPLs)? Is a NAPL present at the site that might be migrating towards receptors or habitats? Could NAPL discharge contact receptors or their habitat?

____
____
____
____
____
____
____

12. Could receptors be impacted by external irradiation at the site? Are gamma emitting radionuclides present at the site? Is the radionuclide contamination buried or at the surface?

____
____
____
____
____
____
____

PHOTOGRAPHIC DOCUMENTATION

During the site visit(s), photographs should be taken to document the current conditions at the site and to support the information entered in the checklist. For example, photographs may be used to document the following:

- The nature, quality, and distribution of vegetation at the site
- Receptors or evidence of receptors
- Potentially important ecological features, such as ponds and drainage ditches
- Potential exposure pathways
- Any evidence of contamination or impact

The following space may be used to record photo subjects.

SUMMARY OF OBSERVATIONS AND SITE SETTING

Include information on significant source areas and migration pathways that are likely to constitute complete exposure pathways.

Checklist Completed by____

Affiliation____

Author Assisted by____

Date____

TABLE 1
EXAMPLES OF SENSITIVE ENVIRONMENTS

National Parks and National Monuments

Designated or Administratively Proposed Federal Wilderness Areas

National Preserves

National or State Wildlife Refuges

National Lakeshore Recreational Areas

Federal land designated for protection of natural ecosystems

State land designated for wildlife or game management

State designated Natural Areas

Federal or state designated Scenic or Wild River

All areas that provide or could potentially provide critical habitat[1] for state and federally listed Threatened or Endangered Species, those species that are currently petitioned for listing, and species designated by other agencies as sensitive or species of concern

All areas that provide or could potentially provide habitat for state protected species as defined in the Wildlife Code, Chapter 17 of the New Mexico Statutes

All areas that provide or could potentially provide habitat for migratory birds as protected by the Migratory Bird Treaty Act (16 U.S.C. §§ 703-712)

All areas that provide or could potentially provide habitat for bald eagles and golden eagles as protected by the Bald and Golden Eagle Protection Act (16 U.S.C. 668-668d)

All areas that provide or could potentially provide habitat for song birds as protected by the State of New Mexico statute (New Mexico Statute, 1978, Chapter 17, Game and Fish, 17-2-13)

---

1 Critical habitats are defined by the Endangered Species Act (50 CFR §424.02(d)) as:

> 1) Specific areas within the geographical area currently occupied by a species, at the time it is listed in accordance with the Act, on which are found those physical or biological features (I) essential to the conservation of the species and (ii) that may require special management considerations or protection, and 2) Specific areas outside the geographical area occupied by a species at the time it is listed upon a determination by the Secretary [of Interior] that such areas are essential for the conservation of the species.

All areas that provide or could potentially provide habitat for hawks, vultures and owls as protected by the State of New Mexico statute (New Mexico Statute, 1978, Chapter 17, Game and Fish, 17-2-14)

All areas that provide or could potentially provide habitat for horned toads and Bullfrogs as protected by the State of New Mexico statute (New Mexico Statute, 1978, Chapter 17, Game and Fish, 17-2-15 and 16, resp.)

All perennial waters (e.g., rivers, lakes, playas, sloughs, ponds, etc)

All ephemeral drainage (e.g., arroyos, puddles/pools, intermittent streams, etc) that provide significant wildlife habitat or that could potentially transport contaminants off site to areas that provide wildlife habitat

All riparian habitats

All perennial and ephemeral wetlands (not limited to jurisdictional wetlands)

All areas that are potentially important breeding, staging, and overwintering habitats as well as other habitats important for the survival of animals during critical periods of their life cycle.

ATTACHMENT B

ECOLOGICAL SITE EXCLUSION CRITERIA CHECKLIST AND DECISION TREE

NEW MEXICO ECOLOGICAL EXCLUSION CRITERIA CHECKLIST

The following questions are designed to be used in conjunction with the Ecological Exclusion Criteria Decision Tree (Figure 1). After answering each question, refer to the Decision Tree to determine the appropriate next step. In some cases, questions will be omitted as the user is directed to another section as indicated by the flow diagram in the Decision Tree. For example, if the user answers "yes" to Question 1 of Section I, he or she is directed to proceed to Section II.

I. Habitat

In the following questions, "affected property" refers to all property on which a release has occurred or is believed to have occurred, including off-site areas where contamination may have occurred or migrated.

1. Are any of the below-listed sensitive environments at, adjacent to, or in the locality[1] of the affected property?

    - National Park or National Monument
    - Designated or administratively proposed Federal Wilderness Area
    - National Preserve
    - National or State Wildlife Refuge
    - Federal or State land designated for wildlife or game management
    - State designated Natural Areas
    - All areas that are owned or used by local tribes
    - All areas that are potentially important breeding, staging, and overwintering habitats as well as other habitats important for the survival of animals during critical periods of their life cycle
    - All areas that provide or could potentially provide habitat for state and federally listed Threatened or Endangered Species, those species that are currently petitioned for listing, and species designated by other agencies as sensitive or species of concern
    - All areas that provide or could potentially provide habitat for state protected species as defined in the Wildlife Code, Chapter 17 of the New Mexico Statutes
    - All areas that provide or could potentially provide habitat for migratory birds as protected by the Migratory Bird Treaty Act (16 U.S.C. §§ 703-712)
    - All areas that provide or could potentially provide habitat for bald eagles and golden eagles as protected by the Bald and Golden Eagle Protection Act (16 U.S.C. 668-668d)
    - All areas that provide or could potentially provide habitat for song birds as protected by the state of New Mexico statute (New Mexico Statute, 1978, Chapter

---

[1] *Locality* of the site refers to any area where an ecological receptor is likely to contact site-related chemicals. The locality of the site considers the likelihood of contamination migrating over time and places the site in the context of its general surrounding. Therefore, the locality is typically larger than the site and the areas adjacent to the site.

17, Game and Fish, 17-2-13)

- All areas that provide or could potentially provide habitat for hawks, vultures and owls as protected by the state of New Mexico statute (New Mexico Statute, 1978, Chapter 17, Game and Fish, 17-2-14)
- All areas that provide or could potentially provide habitat for horned toads and bullfrogs as protected by the state of New Mexico statute (New Mexico Statute, 1978, Chapter 17, Game and Fish, 17-2-15 and 16, respectively)

2. Does the affected property contain land areas which were not listed in Question 1, but could be considered viable ecological habitat? The following are examples (but not a complete listing) of viable ecological habitats:

- Wooded areas
- Shrub/scrub vegetated areas
- Open fields (prairie)
- Other grassy areas
- Desert areas
- Any other areas which support wildlife and/or vegetation, excluding areas which support only opportunistic species (such as house mice, Norway rats, pigeons, etc.) that do not serve as prey to species in adjacent habitats.

The following features are <u>not</u> considered ecologically viable:

- Pavement
- Buildings
- Paved areas of roadways
- Paved/concrete equipment storage pads
- Paved manufacturing or process areas
- Other non-natural surface cover or structure

3. Does the affected property contain any perennial or ephemeral aquatic features which were not listed in Question 1?

II. Receptors

1. Is any part of the affected property used for habitat, foraging area, or refuge by any rare, threatened, or endangered species (plant *or* animal), or otherwise protected species (e.g., raptors, migratory birds)?

2. Is any part of the affected property used for habitat, foraging area, or refuge by any species used as a recreational (e.g., game animals) and/or commercial resource?

3. Is any part of the affected property used for habitat, foraging area, or refuge by any plant or animal species? This includes plants considered “weeds” and opportunistic insect and animal species (such as cockroaches and rats) if they are used as a food source for other species in the area.

III. Exposure Pathways

1. Could receptors be impacted by contaminants via direct contact?
   Is a receptor located in or using an area where it could contact contaminated air, soil[3], or surface water?

For Questions 2 and 3, note that one must answer “yes” to all three bullets in order to be directed to the “exclusion denied” box of the decision tree. This is because answering “no” to one of the questions in the bullet list indicates that a complete exposure pathway is not present. For example, in Question 2, if the chemical cannot leach or dissolve to groundwater (bullet 1), there is no chance of ecological receptors being exposed to the chemical through contact with contaminated groundwater. Similarly, the responses to the questions in Question 4 determine whether a complete pathway exists for exposure to NAPL.

2. Could receptors contact contaminants via groundwater?
   - Can the chemical leach or dissolve to groundwater[4]?
   - Can groundwater mobilize the chemical?
   - Could (does) contaminated groundwater discharge into known or potential receptor habitats?

3. Could receptors contact contaminants via runoff (i.e., surface water and/or suspended sediment) or erosion by water or wind?
   - Are chemicals present in surface soils?
   - Can the chemical be leached from or eroded with surface soils?
   - Is there a receptor habitat located downgradient of the leached/eroded surface soil?

4. Could receptors contact contaminants via migration of non-aqueous phase liquids (NAPL)?
   - Is NAPL present at the site?
   - Is NAPL migrating toward potential receptors or habitats?
   - Could NAPL discharge impact receptors or habitats?

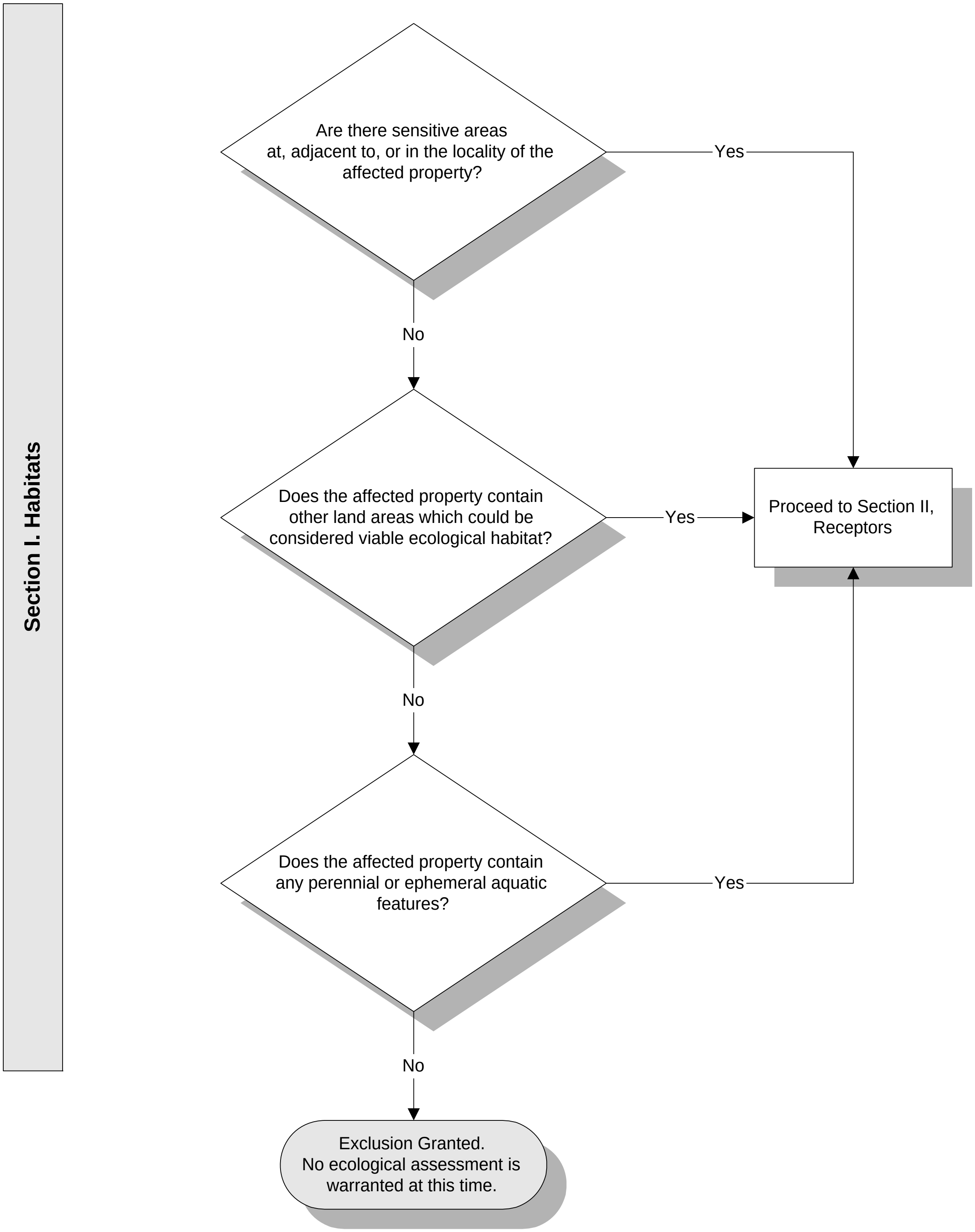
---

[3] For soil, this means contamination less than 5 feet below ground surface (bgs).

[4] Information on the environmental fate of specific chemicals can be found on the Internet at http://www.epa.gov/opptintr/chemfact/ or at a local library in published copies of the *Hazardous Substances Data Bank*.

Figure 1 -Ecological Exclusion Criteria Decision Tree
(Refer to corresponding checklist for the full text of each question)

Figure 1 - Exclusion Criteria Decision Tree (continued)



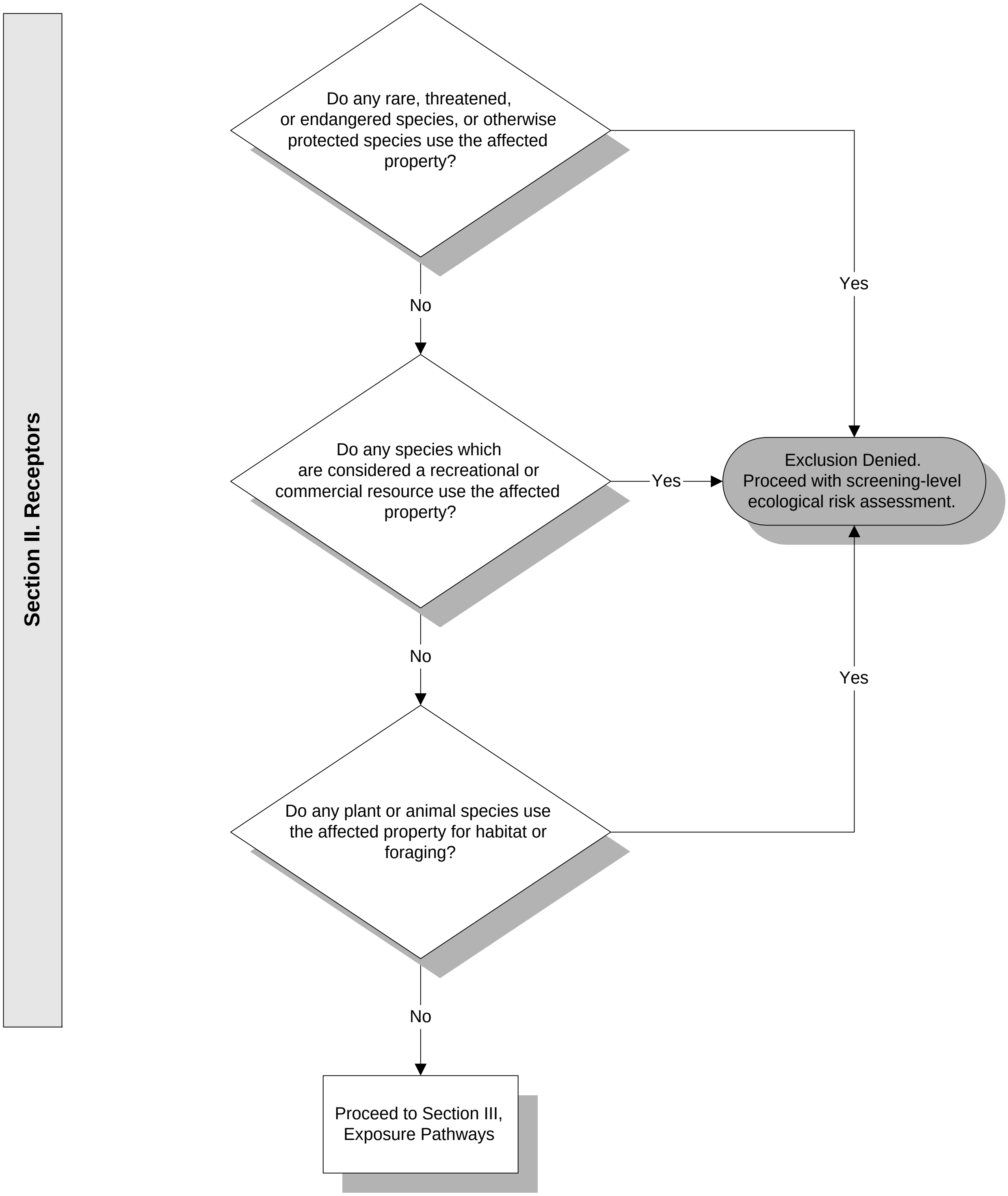
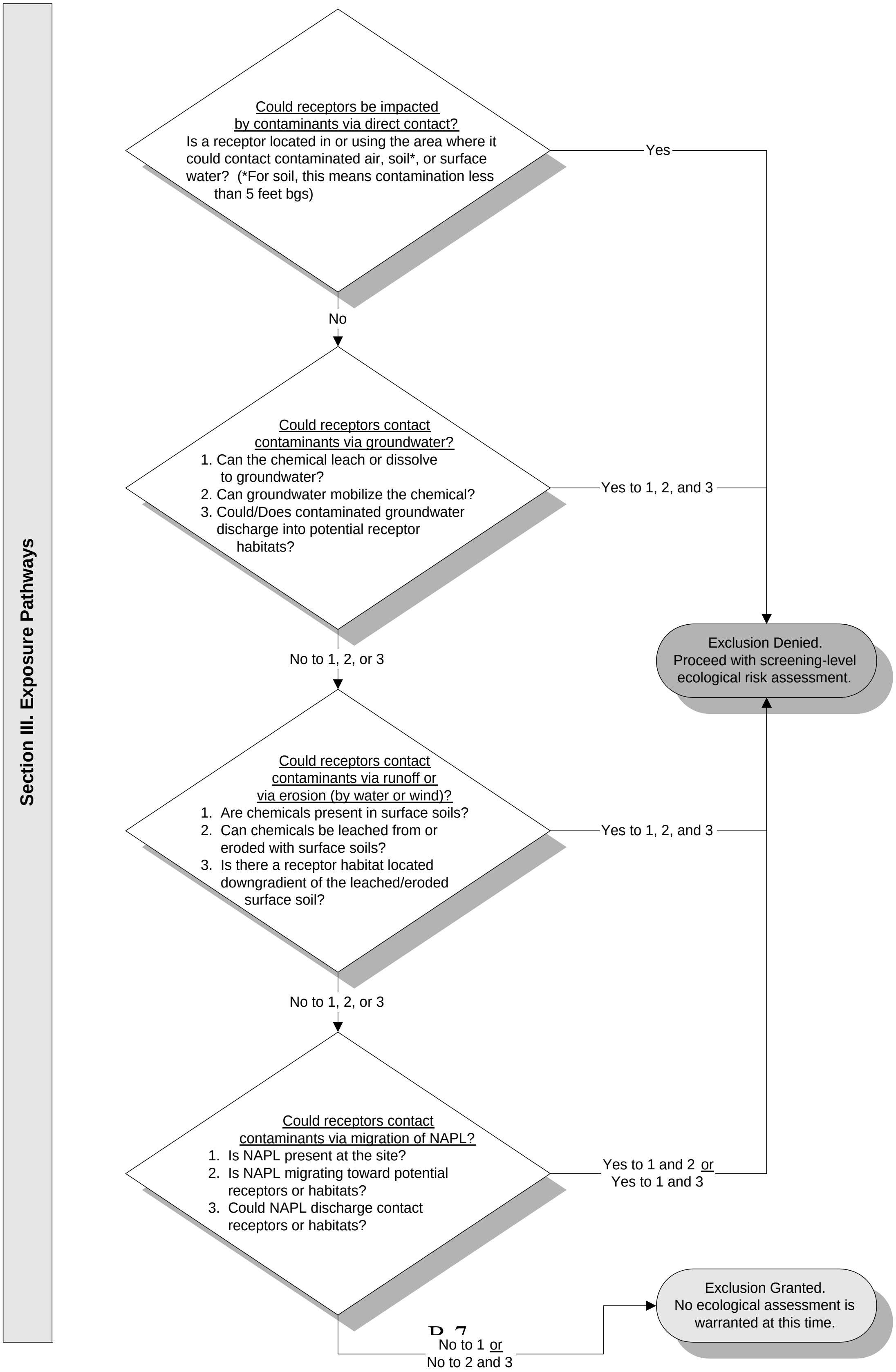

Section II. Receptors
Do any rare, threatened, or endangered species, or otherwise protected species use the affected property?
Yes
No
Do any species which are considered a recreational or commercial resource use the affected property?
Yes
Exclusion Denied. Proceed with screening-level ecological risk assessment.
No
Yes
Do any plant or animal species use the affected property for habitat or foraging?
No
Proceed to Section III, Exposure Pathways

Figure 1 - Exclusion Criteria Decision Tree (continued)



United States
Environmental Protection
Agency

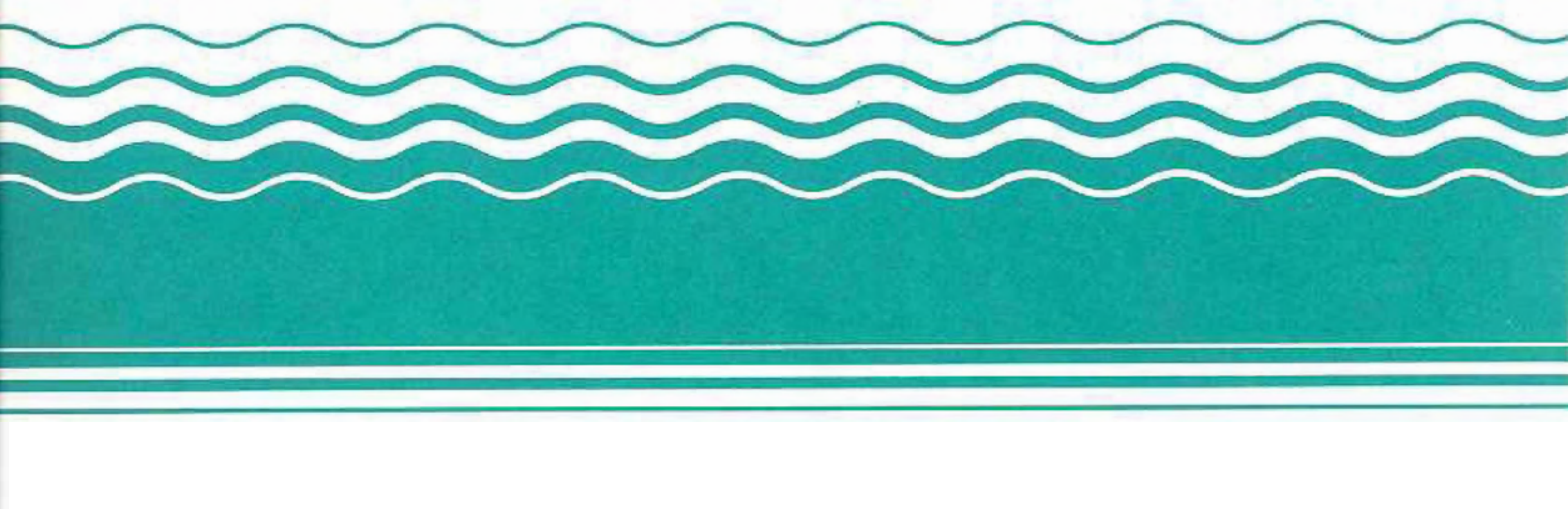
Office of
Solid Waste and
Emergency Response

Publication 9234.2-25
EPA/540-R-93-080
PB93-963507
September 1993

Superfund

EPA

Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration



Directive 9234.2-25
September 1993

Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration

Interim Final

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

1.0 Introduction

1.1 Background

Restoration[1] of contaminated ground waters is one of the primary objectives of both the Superfund and RCRA Corrective Action programs. Ground-water contamination problems are pervasive in both programs; over 85 percent of Superfund National Priorities List (NPL) sites and a substantial portion of RCRA facilities have some degree of ground-water contamination. The Superfund and RCRA Corrective Action programs share the common purposes of protecting human health and the environment from contaminated ground waters and restoring those waters to a quality consistent with their current, or reasonably expected future, uses.

The National Contingency Plan (NCP), which provides the regulatory framework for the Superfund program, states that:

> "EPA expects to return usable ground waters to their beneficial uses wherever practicable, within a timeframe that is reasonable given the particular circumstances of the site" (NCP §300.430(a)(1)(iii)(F)).

Generally, restoration cleanup levels in the Superfund program are established by applicable or relevant and appropriate requirements (ARARs), such as the use of Federal or State standards for drinking water quality. Cleanup levels protective of human health and the environment are identified by EPA where no ARARs for particular contaminants exist (see Section 4.1.1).

The RCRA Corrective Action program for releases from solid waste management facilities (see 40 CFR 264.101)[2] requires a facility owner/operator to:

> "...institute corrective action as necessary to protect human health and the environment for all releases of hazardous waste or constituents from any solid waste management unit..."

The goal of protectiveness is further clarified in the Preamble to the Proposed Subpart S to 40 CFR 264:

> "Potentially drinkable ground water would be cleaned up to levels safe for drinking throughout the contaminated plume, regardless of whether the water was in fact being consumed... Alternative levels protective of the environment and safe for other uses could be established for ground water that is not an actual or reasonably expected source of drinking water."[3]

While both programs have had a great deal of success reducing the immediate threats posed by contaminated ground waters, experience over the past decade has shown that restoration to drinking water quality (or more stringent levels where required) may not always be achievable due to the limitations of available remediation technologies (EPA 1989b, 1992d). EPA, therefore, must evaluate whether ground-water restoration at Superfund and RCRA ground-water cleanup sites is attainable from an engineering perspective. **This document outlines EPA's approach to evaluating the technical impracticability of attaining required ground-water cleanup levels and establishing alternative, protective remedial strategies where restoration is determined to be technically impracticable.**

Many factors can inhibit ground-water restoration. These factors may be grouped under three general categories:

- Hydrogeologic factors;
- Contaminant-related factors; and
- Remediation system design inadequacies.

Hydrogeologic limitations to aquifer remediation include conditions such as complex sedimentary deposits; aquifers of very low permeability; certain types of

---

[1] For this guidance, "restoration" refers to the reduction of contaminant concentrations to levels required under the Superfund or RCRA Corrective Action programs. For ground water currently or potentially used for drinking water purposes, these levels may be Maximum Contaminant Levels (MCLs) or non-zero Maximum Contaminant Levels Goals (MCLGs) established under the Safe Drinking Water Act; State MCLs or other cleanup requirements; or risk-based levels for compounds not covered by specific State or Federal MCLs or MCLGs. Other cleanup levels may be appropriate for ground waters used for non-drinking water purposes.

[2] At this time, this guidance is not applicable to corrective actions for releases from Subpart F regulated units that are subject to corrective actions under 40 CFR 264.91-264.100.

[3] "Corrective Action for Solid Waste Management Units (SWMUs) at Hazardous Waste Management Facilities," 55 FR 30798-30884, July 27, 1990, Proposed Rules, is currently used as guidance in the RCRA Corrective Action program. When final regulations under Subpart S are promulgated, certain aspects of this guidance pertaining to the RCRA program may need to be revised to reflect new regulatory requirements.

fractured bedrock; and other conditions that presently make extraction or *in situ* treatment of contaminated ground water extremely difficult (Figure 1).

Contaminant-related factors, while not independent of hydrogeologic constraints, are more directly related to contaminant properties that may limit the success of an extraction or *in situ* treatment process. These properties include a contaminant's potential to become either sorbed onto, or lodged within, the soil or rock comprising the aquifer. Nonaqueous phase liquids (NAPLs) are examples of contaminants that may pose such technical limitations to aquifer restoration efforts. NAPLs that are denser than water (DNAPLs) often are particularly difficult to locate and remove from the subsurface; their ability to sink through the water table and penetrate deeper portions of aquifers is one of the properties that makes them very difficult to remediate (Figure 1).

The widespread use of DNAPLs in manufacturing and many other sectors of the economy prior to the advent of safe waste-management practices has led to their similarly widespread occurrence at ground-water contamination sites. Most of the sites where EPA already has determined that ground-water restoration is technically impracticable have DNAPLs present. The potential impact of DNAPL contamination on attainment of remediation goals is so significant that EPA is developing specific recommendations for DNAPL site management; the key elements of this strategy are presented in Section 3.0 below.

The third factor that may limit ground-water restoration is inadequate remediation system design and implementation. Examples of design inadequacies in a ground-water extraction system include an insufficient number of extraction points (e.g., ground water or vapor extraction wells) or wells whose locations, screened intervals, or pumping rates lead to an inability to capture the plume. Design inadequacies may result from incomplete site characterization, such as inaccurate measurement of hydraulic conductivity of the affected aquifer or not considering the presence of NAPL contamination. Poor remediation system operation, such as excessive downtime or failure to modify or enhance the system to improve performance, also may limit the effectiveness of restoration efforts. **Failure to achieve desired cleanup standards resulting from inadequate system design or operation is not considered by EPA to be a sufficient justification for a determination of technical impracticability of ground-water cleanup.**

1.2 Purpose of the Guidance

This guidance clarifies how EPA will determine whether ground-water restoration is technically impracticable and what alternative measures or actions must be undertaken to ensure that the final remedy is protective of human health and the environment. Topics covered include the types of technical data and analyses needed to support EPA's evaluation of a particular site and the criteria used to make a determination. As technical impracticability (TI) decisions are part of the process of site investigation, remedy selection, remedial action, and evaluation of remedy performance, the guidance also briefly discusses the overall framework for decision making during these phases of site cleanup.

This guidance does not signal a scaling back of EPA's efforts to restore contaminated ground waters at Superfund sites and RCRA facilities. Rather, EPA is promoting the careful and realistic assessment of the technical capabilities at hand to manage risks posed by ground-water contamination. This guidance provides consistent guidelines for evaluating technical impracticability and for maintaining protectiveness at sites where ground water cannot be restored within a reasonable timeframe. EPA will continue to conduct, fund, and encourage research and development in the fields of subsurface assessment, remediation, and pollution prevention so that an ever decreasing number of sites will require the analysis described in this document.

2.0 Ground-Water Remedy Decision Framework

2.1 Use of the Phased Approach

At sites with very complex ground-water contamination problems, it may be difficult to determine whether required cleanup levels are achievable at the time a remedy selection decision must be made. This is especially true when such decisions must be based on site data collected prior to implementation and monitoring of pilot or full-scale remediation systems. EPA recognizes this limitation and has recommended several approaches to reduce uncertainty during the site characterization, remedy selection, and remedy implementation processes (EPA 1989a, 1992a).

Determining the restoration potential of a site may be aided by employing a **phased approach** to site characterization and remediation. Each phase of site

Figure 1. Examples of Factors Affecting Ground-Water Restoration

Certain site characteristics may limit the effectiveness of subsurface remediation. The examples listed below are highly generalized. The particular factor or combination of factors that may critically limit restoration potential will be site specific.

Generalized Remediation Difficulty Scale

Increasing difficulty →

	Contaminant Characteristics		
Site Use	Nature of Release	Small Volume Short Duration Slug Release →	Large Volume Long Duration Continual Release
Chemical Properties	Biotic/Abiotic Decay Potential	High →	Low
	Volatility	High →	Low
	Contaminant Retardation (Sorption) Potential	Low →	High
Contaminant Distribution	Contaminant Phase	Aqueous, Gaseous → Sorbed → LNAPLs →	DNAPLs
	Volume of Contaminated Media	Small →	Large
	Contaminant Depth	Shallow →	Deep

	Hydrogeologic Characteristics		
Geology	Stratigraphy	Simple Geology, e.g., Planar Bedding →	Complex Geology, e.g., Interbedded and Discontinuous Strata
	Texture of Unconsolidated Deposits	Sand →	Clay
	Degree of Heterogeneity	Homogeneous (e.g., well-sorted sand) →	Heterogeneous (e.g., interbedded sand and silts, clays, fractured media, karst)
Hydraulics/Flow	Hydraulic conductivity	High ($>10^{-2}$ cm/sec) →	Low ($< 10^{-4}$ cm/sec)
	Temporal Variation	Little/None →	High
	Vertical Flow	Little →	Large Downward Flow Component

characterization should be designed to provide information necessary for the next phase of characterization. Likewise, site remediation activities can be conducted in phases to achieve interim goals at the outset, while developing a more accurate understanding of the restoration potential of the contaminated aquifer. An example of how this approach might be applied at a site is provided below in Section 4.4.3.

The timing of phased cleanup actions (early, interim, final) should reflect the relative urgency of the action and the degree to which the site has been characterized. Early actions should focus on reducing the risk posed by site contamination (e.g., removal of contamination sources) and may be carried out before detailed site characterization studies have been completed. Interim remedial actions may abate the spread of contamination or limit exposure but do not fully address the final cleanup levels for the site. Interim actions generally will require a greater degree of site characterization than early actions. However, implementation of interim actions still may be appropriate prior to completion of site characterization studies, such as the Remedial Investigation/Feasibility Study (RI/FS) or RCRA Facility Investigation (RFI) and Corrective Measures Study (CMS). Final remedial actions must address the cleanup levels and other remediation requirements for the site and, therefore, must be based on completed characterization reports. Information from early and interim actions also should be factored into these reports and final remedy decisions.

Phasing of activities generally should not delay or prolong site characterization or remediation. In fact, such an approach may accelerate the implementation of interim risk reduction actions and lead more quickly to the development of achievable final remediation levels and strategies. A phased approach should be considered when there is uncertainty regarding the ultimate restoration potential of the site but also a need to quickly control risk of exposure to, or limit further migration of, the contamination.

It is critical that the performance of phased remedial actions (e.g., control of plume migration) be monitored carefully as part of the ongoing effort to characterize the site and assess its restoration potential. Data collection activities during such actions not only should be designed to evaluate performance with respect to the action's specific objectives but also contribute to the overall understanding of the site. In this manner, actions implemented early in the site remediation process can achieve significant risk reduction and lead to development of technically sound, final remedy decisions.

2.2 Documenting Ground-Water Remedy Decisions Under CERCLA

The phased approach to site characterization and remediation can be employed using the existing decision document options within the Superfund program.

2.2.1 Removal Actions

Removal authority can be used for early actions as part of a phased approach to ground-water cleanup and decision making and should be considered where early response to ground-water contamination is advantageous or necessary. Within the context of ground-water actions, removals are appropriate where contamination poses an actual or potential threat to drinking water supplies or threatens sensitive ecosystems. Examples of actions that might qualify for use of removal authority include removal of surface sources (e.g., drums or highly contaminated soils), removal of subsurface sources (e.g., NAPL accumulations, highly contaminated soils, or other buried waste), and containment of migrating ground-water contamination "hot spots" (zones of high contaminant concentration) or plumes to protect current or potential drinking water supplies.

Removals of subsurface sources most likely will be non-time-critical actions, although time-critical actions may be appropriate for removal of NAPL accumulations or other sources, depending on the urgency of the threat. Documentation requirements for removal actions include a Removal Action Memorandum and, for non-time critical actions, an Engineering Evaluation/Cost Analysis report.[4]

Removal actions must attain ARARs to the extent practicable, considering the exigencies of the situation. The urgency of the situation and the scope of the removal action may be considered when determining the practicability of attaining ARARs (NCP §300.415(i)). Standards or regulations typically used to establish ground-water cleanup levels for final actions (e.g., MCLs/MCLGs) may not be ARARs, depending on the scope of the removal. Further

---

[4] See "Guidance on Conducting Non-Time Critical Removal Actions under CERCLA," OSWER Publication 9360.0-32, August 1993 (EPA 1993b).

information on removal actions may be found in other EPA guidances (EPA 1990b, 1991d).

2.2.2 *Interim RODs*

Interim RODs may be appropriate where there is a moderate to high degree of uncertainty regarding attainment of ARARs or other protective cleanup levels. As mentioned before, an interim action may be used to minimize further contaminant migration and reduce the risk of exposure to contaminated ground water. Interim actions include containment of the leading edge of a plume to prevent further contamination of unaffected portions of an aquifer, removal of source material, remediation of ground-water hot spots, and in some cases, installation of physical barriers or caps to contain releases from source materials. Interim actions should be monitored carefully to collect detailed information regarding aquifer response to remediation, which should be used to augment and update previous site characterization efforts. This information then can be used at a later date to develop final remediation goals and cleanup levels that more accurately reflect the particular conditions of the site.

It is important to note that for interim actions, ARARs must be attained only if they are within the scope of that action. For example, where an interim action will manage or contain migration of an aqueous contaminant plume, MCLs and MCLGs would not be ARARs, since the objective of the action is containment, not cleanup (although requirements such as those related to discharge of the treated water still would be ARARs, since they address the disposition of treated waste).

Furthermore, a requirement that is an ARAR for an interim action may be waived under certain circumstances. An "interim action" ARAR waiver may be invoked where an interim action that does not attain an ARAR is part of, or will be followed by, a final action that does (NCP §300.430(f)(1)(ii)(C)). For example, where an interim action seeks to reduce contamination levels in a ground-water hot spot, MCLs/MCLGs may be ARARs since the action is cleaning up a portion of the contaminated ground water. If, however, this interim action is expected to be followed by a final, ARAR-compliant action that addresses the entire contaminated ground-water zone, an interim action ARAR waiver may be invoked.

2.2.3 *Final RODs*

Where site characterization is very thorough and there is a moderate to high degree of certainty that cleanup levels can be achieved, a final decision document should be developed that adopts those levels. Conversely, in cases where there is a high degree of certainty that cleanup levels cannot be achieved, a final ROD that invokes a TI ARAR waiver and establishes an alternative remedial strategy may be the most appropriate option.[5] Note that for ROD-stage waivers, site characterization generally should be sufficiently detailed to address the data and analysis requirements for TI determinations set forth in this guidance.

2.2.4 *ROD Contingency Remedies and Contingency Language*

Where a moderate degree of uncertainty exists regarding the ability to achieve cleanup levels, a final ARAR-compliant ROD generally still is appropriate. However, the ROD may include contingency language that addresses actions to be taken in the event the selected remedy is unable to achieve the required cleanup levels (EPA 1990a, 1991a). The contingency language may include requirements to enhance or augment the planned remediation system as well as an alternative remedial technology to be employed if modifications to the planned system fail to significantly improve its performance. Use of language in final remedy decision documents that addresses the uncertainty in achieving required cleanup levels also is appropriate in certain cases. **However, language that identifies a TI decision (e.g., an ARAR waiver) as a future contingency of the remedy should be avoided.** Such language is not necessary, as a TI evaluation may be performed (and a decision made) by EPA at any site regardless of whether such a contingency is provided in the decision document.

Note that in cases of existing RODs that already include a contingency for invoking a TI ARAR waiver, the conditions under which the ARAR may be waived should be consistent with, and as stringent as, those presented in this guidance or a future update.

Furthermore, the fact that such contingency language has been included in an existing ROD does not alter the need to enhance or augment a remedy to improve its ability to attain ARARs before concluding that a waiver can be granted. It also

---

[5] At sites where a TI ARAR waiver is invoked in the ROD, preparation of the pre-referral negotiation package ("mini-lit" package) must include analysis of the model Consent Degree language to ensure that appropriate consideration of the waiver's impact is incorporated.

should be noted that remediation must be conducted for a sufficient period of time before its ability to restore contaminated ground water can be evaluated. This minimum time period will be determined by EPA on a site-specific basis.

2.3 Documenting Ground-Water Remedy Decisions under RCRA

The instruments used for implementing the RCRA Corrective Action program (permits and orders) also are amenable to a phased approach to remedy selection and facility remediation. The RCRA program can use permits or orders to compel both interim measures and final remedies.

2.3.1. Permits/Orders Addressing Stabilization
RCRA permits or orders can require the stabilization of releases from solid waste management units (SWMUs) at the facility. The Stabilization Initiative focuses on taking interim actions to prevent the further spread of existing contamination and reduce risks. Examples of measures used for stabilization include capping, excavation, and plume containment. Since the long-term or final cleanup of the facility is not the objective of stabilization (although stabilization should be consistent with the final remedy), TI decisions are not applicable at this early stage. Information gained during stabilization should be used to help determine the restoration potential of the facility and the objectives of the final remedy.

2.3.2. Permits/Orders Addressing Final Remedies
Where achieving ground-water cleanup standards is determined by EPA to be technically impracticable, the permit or order addressing final remedies should include practicable and protective alternative remedial measures. EPA's decision to make a TI determination will be based on clear and convincing information provided by the owner/operator. EPA generally will seek public comment on TI determinations prior to implementation. EPA's preliminary TI determinations and justification for these determinations should be documented in a Statement of Basis. As discussed above, uncertainty in the ability to restore an aquifer should be reduced through phased characterization and the use of interim remedial measures, where appropriate.

Permits and orders that address "final" remedies should specify the remediation cleanup levels selected by the implementing Agency. Such permits and orders, however, generally should not incorporate contingency TI language. The permit or order will need to be modified to document the TI determination and to specify, as appropriate, alternative cleanup levels and alternative remedial measures that have been determined to be technically practicable and protective of human health and the environment.

3.0 Remedial Strategy for DNAPL Sites

Many of the subsurface contaminants present at Superfund sites and RCRA facilities are organic compounds that are either lighter-than-water NAPLs (LNAPLs) or DNAPLs. As mentioned in Section 1.1, the presence of NAPL contamination, and in particular DNAPL contamination, may have a significant impact on site investigations and the ability to restore contaminated portions of the subsurface to required cleanup levels. Furthermore, DNAPL contamination may be a relatively widespread problem. A recent EPA study (EPA 1993a) concluded that up to 60 percent of National Priorities List (NPL) sites may have DNAPL contamination in the subsurface; a significant percentage of RCRA Corrective Action facilities also are thought to be affected by DNAPLs. As proven technologies for the removal of certain types of DNAPL contamination do not exist yet, DNAPL sites are more likely to require TI evaluations than sites with other types of contamination. Although this guidance pertains to TI evaluations at all site types, EPA believes the significance of the DNAPL contamination problem warrants the following brief discussion of DNAPL contamination and recommended site management strategies.

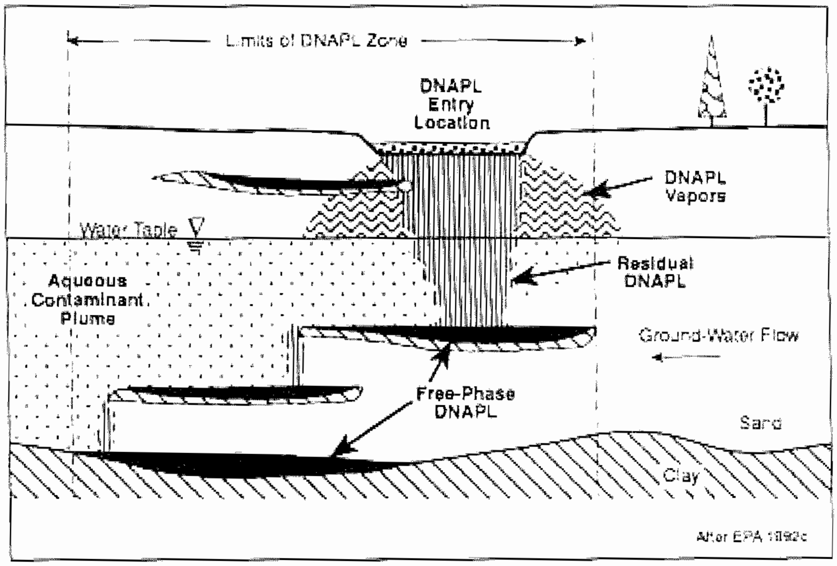
DNAPLs comprise a broad class of compounds, including creosote and coal tars, polychlorinated biphenyls (PCBs), certain pesticides, and chlorinated organic solvents such as trichloroethylene (TCE) and tetrachloroethylene (PCE). The term "DNAPL" refers only to liquids immiscible in, and denser than, water and not to chemicals that are dissolved in water that originally may have been derived from a DNAPL source. DNAPLs may occur as "free-phase" or "residual" contamination. **Free-phase** DNAPL is an immiscible liquid in the subsurface that is under positive pressure; that is, the DNAPL is capable of flowing into a well or migrating laterally or vertically through an aquifer. Where vertically migrating free-phase DNAPL encounters a rock or soil layer of relatively low permeability (e.g., clay or other fine-grained layer), a DNAPL accumulation or "pool" may form. **Residual** DNAPL is immiscible liquid held by capillary forces within the pores or fractures in soil or rock layers; residual DNAPL, therefore, generally is not capable of migrating or being displaced by normal ground-water flow. Both free-phase and residual DNAPL, however, can slowly dissolve in ground water and produce "plumes" of aqueous-phase contamination. DNAPLs also can produce subsurface vapors capable of migrating through the unsaturated zone and contaminating ground water (EPA 1992c). Figure 2 depicts the various types of contamination that may be encountered at a DNAPL site.

The three areas that should be delineated at a DNAPL site are the DNAPL entry location, the DNAPL zone, and the aqueous contaminant plume. The **entry locations** are those areas where DNAPL was released and likely is present in the subsurface. Entry locations include waste disposal lagoons, drum burial sites, or any other area where DNAPL was allowed to infiltrate into the subsurface. The **DNAPL zone** is defined by that portion of the subsurface containing free-phase or residual DNAPL. Thus, the DNAPL zone includes all portions of the subsurface where the immiscible-phase contamination has come to be located. The DNAPL zone may occur within both the saturated zone (below the water table) and the unsaturated zone (above the water table). The DNAPL zone also may contain vapor and aqueous-phase contamination derived from the DNAPL. The DNAPL zone may include areas at relatively great depths and lateral distances from the entry locations, depending on the subsurface geology and the volume of DNAPL released. The **aqueous contaminant plume** contains organic chemicals in the dissolved phase. The plume originates from the DNAPL zone and may extend hundreds or thousands of feet downgradient (in the direction of ground-water flow). Figure 3 illustrates the various components of a DNAPL site.

Since each DNAPL site component may require a different remediation strategy, it is important to characterize these components to the extent practicable. Thus, the properties and behavior of DNAPL contamination require consideration when planning and conducting both site investigation and remediation. The potential for DNAPL occurrence at the site should be evaluated as early as possible in the site investigation. Recent publications such as "Estimating Potential for DNAPL Occurrence at Superfund Sites" (EPA 1992c) and "DNAPL Site Evaluation" (Cohen and Mercer, 1993) provide detailed guidance on these topics. At sites where DNAPL disposal is known or suspected to have occurred, likely DNAPL entry locations should be identified from available historical waste-management information and subsurface chemistry data. This information can assist in the delineation of the DNAPL zone.

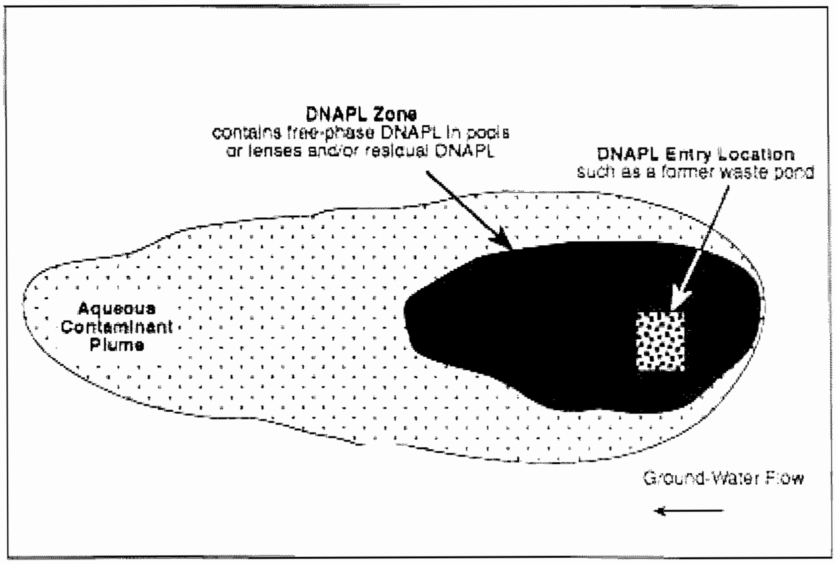
Characterization and delineation of the DNAPL zone is critical for remedy design and evaluation of the restoration potential of the site. At many sites, a subsurface investigation strategy that begins outside of the suspected DNAPL zone may be appropriate ("outside-in" strategy), in part to minimize the possibility of inadvertent mobilization of DNAPLs to

Figure 2. Types of Contamination and Contaminant Zones at DNAPL Sites (Cross-sectional view)



After EPA 1992c

Figure 3. Components of DNAPL Sites



lower aquifers. Delineation of the extent of the DNAPL zone may be difficult at certain sites due to complex geology or waste disposal practices. In such cases, the extent of the DNAPL zone may need to be inferred from geologic information (e.g., thickness, extent, structure, and permeability of soil or rock units) or from interpretation of the aqueous concentration of contaminants derived from DNAPL sources. At some sites, however, geologic complexity and inadequate information on waste disposal may make the delineation of the DNAPL zone difficult.

A phased approach, as discussed in Section 2.1, is recommended for DNAPL sites; such an approach may facilitate identification of appropriate short- and long-term site remediation objectives. Note also that technical approaches appropriate for the DNAPL zone (e.g., free-phase DNAPL removal, vapor extraction, excavation, and slurry walls aided by limited pump-and-treat) may differ significantly from those appropriate for the aqueous contaminant plume (typically pump-and-treat).

Short-term remediation objectives generally should include prevention of exposure to contaminated ground water and containment of the aqueous contaminant plume. Where sufficient information is available, early removal of DNAPL sources also is recommended. Information gathered during these actions should be used to help characterize the site and identify practicable options for further remediation.

The long-term remediation objectives for a DNAPL zone should be to remove the free-phase, residual, and vapor phase DNAPL to the extent practicable and contain DNAPL sources that cannot be removed. EPA recognizes that it may be difficult to locate and remove all of the subsurface DNAPL within a DNAPL zone. Removal of DNAPL mass should be pursued wherever practicable and, in general, where significant reduction of current or future risk will result.[6] Where it is technically impracticable to remove subsurface DNAPLs, EPA expects to contain the DNAPL zone to minimize further release of contaminants to the surrounding ground water, wherever practicable.[7]

Where it is technically practicable to contain the long-term sources of contamination, such as the DNAPL zone, EPA expects to restore the aqueous contaminant plume outside the DNAPL zone to required cleanup levels. Effective containment of the DNAPL zone generally will be required to achieve this long-term objective because ground-water extraction remedies (e.g., pump-and-treat) or *in situ* treatment technologies are effective for plume restoration only where source areas have been contained or removed.

---

[6] DNAPL mass removal also must satisfy the Superfund or RCRA Corrective Action remedy selection criteria, as appropriate.

[7] As DNAPLs may be remobilized during drilling or ground-water pumping, caution should be exercised where such activities are proposed for DNAPL zone characterization, remediation, or containment.

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

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

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

4.0 TI Decisions and Supporting Information

4.1 Regulatory Framework for TI Decisions

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

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

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

4.1.1 Superfund

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

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

Highlight 1.
CERCLA ARAR Waivers

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

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

---

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

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

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

4.1.2 RCRA

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

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

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

4.2 Timing of TI Decisions

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

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

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

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

---

[9] See NCP Preamble, 55 FR 8748, March 8, 1990.

[10] Technical impracticability is discussed in Sections 264.525(d)(2) and 264.531 of the Proposed Subpart S rule.

[11] Proposed Subpart S; 55 FR 30830, July 27, 1990.

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

4.3 TI Evaluation Components[12]

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

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

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

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

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

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

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

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

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

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

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

4.4 Supporting Information for TI Evaluations

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

---

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

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

4.4.1. Specific ARARs or Media Cleanup Standards

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

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

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

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

4.4.2 Spatial Extent of TI Decisions

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

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

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

---

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

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

4.4.3 Development and Purpose of the Site Conceptual Model

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

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

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

4.4.4 Evaluation of Restoration Potential

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

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

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

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

Figure 4. Elements of Site Conceptual Model

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

Background Information

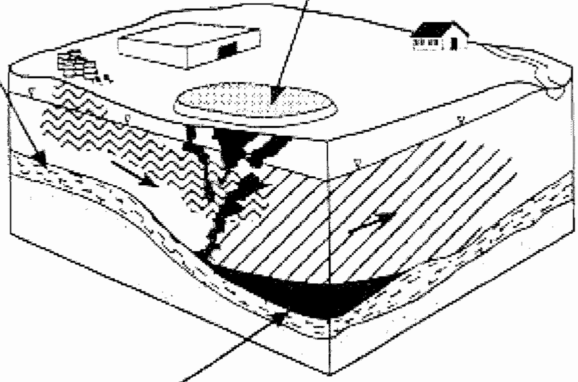
- Location of water supply wells.
- Ground-water Classification.
- Nearby wellhead protection areas or sole-source aquifers.
- Location of potential environmental receptors.

Geologic and Hydrologic Information

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

Contaminant Source and Release Information

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

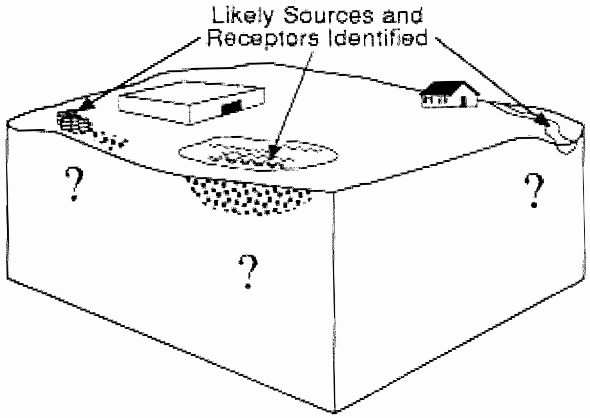


Contaminant Distribution, Transport, and Fate Parameters

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

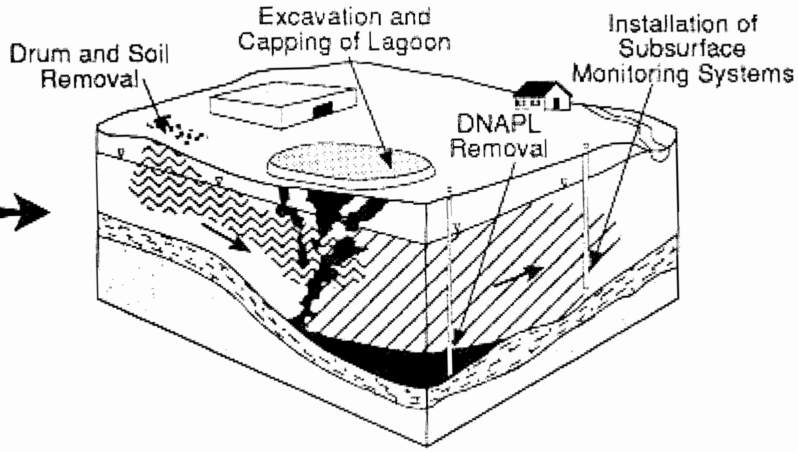
Figure 5. Evolution of the Site Conceptual Model

- Site Background and History
- Preliminary Site Investigations



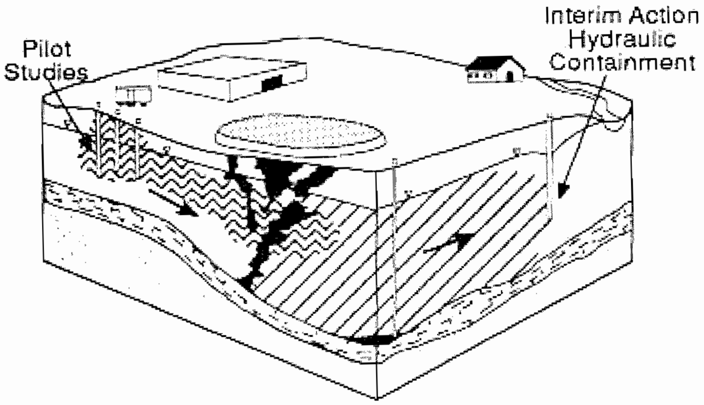
Conceptual Model Provides Basis for:

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



Conceptual Model Provides Basis for:

- Pilot Studies
- Interim Ground-Water Actions



Conceptual Model Provides Basis for:

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

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

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

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

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

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

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

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

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

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

---

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

Figure 6. Remedy Performance Analysis

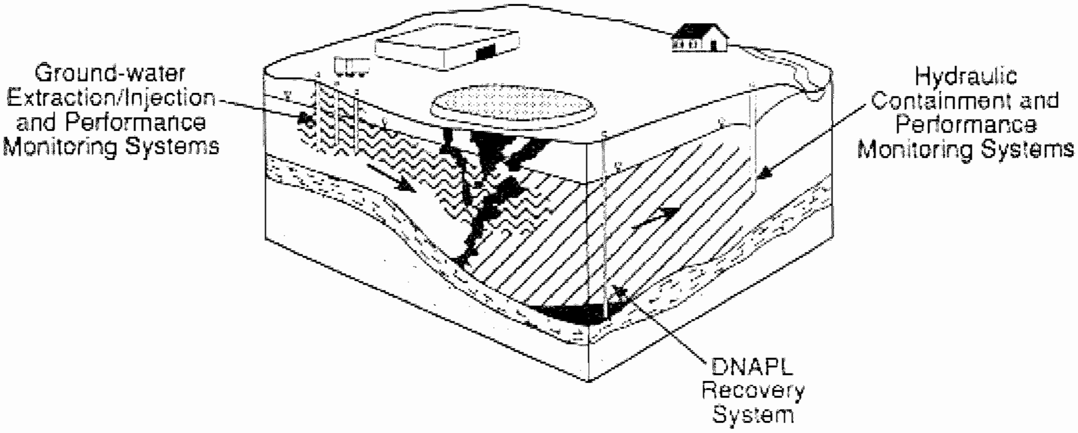
Remedy design and performance data requirements should be specific to technologies employed and site conditions. The categories of required information normally necessary to evaluate performance are provided below with some examples of specific data elements. These data should be reported to EPA in formats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

Remedy Design and Operational Information

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

Enhancements to Original Remedial Design

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



Source Removal or Control

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

Performance Monitoring Information

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

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

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

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

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

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

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

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

---

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

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

4.4.5 Cost Estimate

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

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

5.0 Alternative Remedial Strategies

5.1 Options and Objectives for Alternative Strategies[17]

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

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

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

5.1.1 Exposure Control

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

5.1.2 Source Control

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

---

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

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

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

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

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

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

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

5.1.3 Aqueous Plume Remediation

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

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

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

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

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

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

---

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

attainment of the desired cleanup levels, but may take longer to meet them than active remediation. This approach is most likely to be appropriate where the affected ground water is not a current or reasonably expected future source of drinking water, and ground-water discharge does not significantly impact surface water or ecologic resources. Sufficient technical information and supporting data must be presented to demonstrate the effectiveness of this strategy, along with assurances that any institutional controls required to prevent exposure will be reliable and enforceable. Contingencies for additional or more active remediation also should be incorporated into the remedy, to be triggered by specific contaminant concentration levels in the site ground-water monitoring network, or other criteria as appropriate.

5.2 Alternative Remedy Selection

The alternative remedial strategy options discussed above represent a range of responses for addressing the various aspects of a ground-water contamination site. Selection of the options appropriate for a particular site must not only consider the desired remediation objectives, as discussed above, but also the statutory and regulatory requirements applicable to the program under which the action is being taken. These requirements are discussed briefly below. Further information and guidance on these requirements can be obtained from publications referenced in this section.

5.2.1. Superfund

The selection of an alternative remedy at a Superfund site should follow the remedy selection process provided in NCP §300.430(f). Regardless of whether ARARs are waived at the site, the alternative remedy still must satisfy the two threshold remedy selection criteria (protect human health and the environment and comply with all ARARs that have not been waived); be cost effective; and utilize permanent solutions and treatment to the maximum extent practicable. This last finding is satisfied by identifying the alternative that best balances the trade-offs with respect to the remaining balancing and modifying criteria, taking into account the demonstrated technical limitations (see Highlight 2).[20]

Where ground-water ARARs are waived at a Superfund site due to technical impracticability, EPA's general expectations are to prevent further migration of the contaminated ground-water plume, prevent exposure to the contaminated ground water, and evaluate further risk reduction measures as appropriate. (NCP §300.430(a)(1)(iii)(F)). These expectations should be evaluated along with the nine remedy selection criteria to determine the most appropriate remedial strategy for the site.

Highlight 2.
Superfund Remedy Selection Criteria

Threshold Criteria
- Overall protection of human health and the environment
- Compliance with (or justification for a waiver of) ARARs

Balancing Criteria
- Long-term effectiveness and permanence
- Reduction of mobility, toxicity, or volume
- Short-term effectiveness
- Implementability
- Cost

Modifying Criteria
- State acceptance
- Community acceptance

5.2.2 RCRA

At RCRA facilities where ground-water restoration is technically impracticable, the permit or order schedule of compliance may be modified by establishing: 1) further measures that may be required of the permittee to control exposure to residual contamination, as necessary to protect human health and the environment; and 2) alternate levels or measures for cleaning up contaminated media.[21]

Criteria for establishing an alternative remedial strategy under RCRA are presented in Highlight 3. In addition to satisfying the general standards for remedies, the alternative remedial strategy at a RCRA facility also should provide the best balance of trade-offs among the five remedy selection decision factors.[22]

---

[20] For further guidance on the Superfund remedy selection process, see NCP §300.430(f) and "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA," (EPA 1988a).

[21] Proposed Subpart S Rule, §264.531(b).

[22] Further guidance on remedy selection at RCRA facilities is provided in the proposed Subpart S Rule (55 FR 30823-30824, July 27, 1990).

Highlight 3.
RCRA Remedy Standards and Selection Factors

General Standards for Remedies

1. Overall protection of human health and the environment
2. Attainment of media cleanup standards
3. Source control
4. Compliance with waste management standards

Remedy Selection Decision Factors

1. Long-term effectiveness
2. Reduction of waste toxicity, mobility, or volume
3. Short-term effectiveness
4. Implementability
5. Cost

5.2.3 Additional Remedy Selection Considerations

The choice among available remedial strategy options may involve a consideration of the aggressiveness of the remedy, a concept that includes both the choice of remedial technologies as well as the relative intensity of how that technology is applied at the site. For example, consider a site where source area restoration is technically impracticable but source containment is both feasible and practicable. With the contaminant source contained, restoration of the portion of the plume outside of the containment area may be feasible. However, as discussed earlier, there are several options for attaining cleanup levels within the aqueous plume: active pump-and-treat throughout the aqueous plume; natural gradient flushing of the plume towards a pump-and-treat capture system located at the leading edge of the plume; and natural attenuation (dilution, dispersion, and any natural degradation processes active within the affected aquifer). Each alternative will attain the required cleanup levels, but the choice involves a trade-off among several factors, including: 1) remediation timeframe (longer with less aggressive strategies); 2) cost (lower with less aggressive strategies); and 3) potential risk of exposure (may increase with less aggressive strategies).[23]

Conditions favoring more aggressive strategies (i.e., active pump-and-treat throughout the aqueous plume) include the following:

1) **The aggressive strategy clearly will result in a significantly shorter restoration timeframe than other available options.** This will depend on site hydrogeologic and contaminant-related factors, including the complexity of the aquifer system, natural rate of ground-water flow, quantity of sorbed contaminant mass in the aquifer (and its rate of desorption), and other factors.

2) **A shorter remediation timeframe is desired to reduce the potential for human exposure.** This generally is the case where there is current or reasonably expected near-term future use of the ground water. Factors that may be useful in evaluating the likelihood of exposure include the State (or Federal, as appropriate) classification of the ground water; availability of alternate supplies, such as municipal hookups or other water supply aquifers; interconnections of the contaminated aquifer with other surface or ground waters; and the ability of institutional controls to limit exposure.

3) **A shorter remediation timeframe is desired to reduce ongoing or potential impacts to environmental receptors.** Such impacts may be caused by discharges to surface waters, sensitive ecologic areas (e.g., wetlands), or sole-source aquifers.

EPA will evaluate and determine the objectives and relative aggressiveness of the alternative remedy on a site-specific basis, based on the applicable regulatory requirements and considering the factors discussed throughout this section. Where conditions favoring more aggressive strategies do not exist, EPA is more likely to choose a less aggressive strategy to achieve the desired remediation objectives. EPA recognizes that, at some sites, remedies may need to be in operation for very long time periods. Adequate monitoring and periodic evaluation of remedy performance should be conducted to ensure protectiveness and to evaluate the need for remedy enhancements or the use of new or different remediation technologies.

5.2.4 Relation to Alternate Concentration Limits

Site-specific cleanup levels established as part of an alternative remedial strategy at a Superfund site should not be confused with CERCLA Alternate Concentration Limits (ACLs). To qualify for use of a CERCLA ACL, the site must meet the following three requirements: 1) there are known points of entry of the contaminated ground water into surface water; 2) there

---

[23] The long-term reliability of a remedy also is an important consideration for alternative remedial strategy selection. In this example, long-term reliability is primarily a function of the design and integrity of the source containment system.

will be no statistically significant increases of the contaminant concentrations in the surface water or contaminant accumulations in downstream sediments; and 3) enforceable measures can be put into place to prevent exposure to the contaminated ground water (see CERCLA §121(d)(2)(B)(ii)). In addition, EPA generally considers ACLs appropriate only where cleanup to ARARs is impracticable, based on an analysis using the Superfund remedy selection "balancing" and "modifying" criteria shown in Highlight 2. Where an ACL is established, an ARAR waiver is not necessary. Conversely, where an ARAR is waived due to technical impracticability, there is no need to establish a CERCLA ACL. For further guidance on CERCLA ACLs, refer to the NCP Preamble (55 FR 8754, March 1990).

Site-specific cleanup levels established in response to a TI determination at a RCRA facility also should not be confused with ACLs established as part of the ground-water monitoring program for regulated units under 40 CFR 264.94. ACLs established under §264.94(a)(3) represent concentrations that EPA determines will not pose a substantial hazard to human or environmental receptors. (If the ACL is exceeded, then corrective action responsibilities for the regulated unit are triggered.) A TI determination generally will not satisfy the criteria for an ACL under this authority.

6.0 Administrative Issues

6.1 TI Review and Decision Process

A TI decision must be incorporated into a site decision document (Superfund ROD or RCRA permit or enforcement order) or be incorporated into a modification or amendment to an original document. Information and analyses supporting the TI decision must be incorporated into the site administrative record, either as part of a Feasibility Study or Corrective Measures Study (for a "front-end" TI determination) or remedy performance evaluation or other technical report or evaluation (for a post-remedy implementation determination).

The first step in EPA's review process for a TI determination will be to assess the completeness and adequacy of the TI evaluation. TI evaluations that do not adequately address the considerations identified in this guidance likely will have to be revised or augmented to address the inadequacies identified by EPA or the responsible agency. Early consultation with EPA by PRPs or owner/operators is encouraged to help identify appropriate data and analysis for the evaluation. While a TI evaluation is underway, remediation efforts underway at a site shall continue until the State or Federal official responsible for the decision determines that the existing remedy should be altered. Requirements specific to the Superfund and RCRA programs are discussed further below.

6.1.1 Superfund

As discussed in Section 4.2, TI decisions may be made either in the ROD (front-end decisions) or after the remedy has been implemented and monitored (post-implementation decisions), depending on the circumstances of the site.

TI decisions at Superfund sites generally will be made by the EPA Regional Administrator who, upon review of a TI evaluation, will determine whether ground-water restoration is technically impracticable and will identify further remedial actions to be taken at the site. TI determinations at Superfund sites may require consultation with headquarters program management. Regional personnel should refer to the most recent OERR Remedy Delegation Memorandum for current consultation requirements.[24]

Where a Superfund ROD will invoke a TI ARAR waiver (front-end decision), EPA (or the lead agency) must provide notice of its intent to waive the ARAR in the Proposed Plan for the site and respond to any State (or Federal) agency or public comments concerning the waiver. The requirements for State and community involvement are provided in NCP §300.500-515 and §300.430, respectively. In general, State and community involvement in the decision to waive an ARAR based on technical impracticability will be the same as for other site remedy decisions. Since TI decisions may affect the potential future uses of ground water, interest in TI ARAR waivers may be high. Therefore, it is EPA's intent to coordinate and consult with States and the public regarding TI ARAR waiver issues as early as possible in the remedy decision process.

---

[24] The types of Superfund site remedy decisions that require consultation with headquarters program management are identified in the periodically updated OERR Remedy Delegation Memorandum. The most recent version available at the time of publication of this guidance was the "Twenty Fourth Remedy Delegation Report - FY 1993," dated February 18, 1993.

State concurrence should be sought, but is not required, for all remedy decisions in which EPA invokes an ARAR waiver. Where the ARAR to be waived is a State ARAR, EPA must notify the State of this when submitting the RI/FS to the State or when responding to a State-lead RI/FS (NCP §300.515(d)(3)). EPA must provide the State with an explanation of any waiver of a State standard (CERCLA §121(f)(1)(G)).

For remedial actions under CERCLA §106 that will waive an ARAR, the State must be notified at least 30 days prior to the date on which any Consent Decree will be entered. If the State wishes the action to conform to (and not waive) those standards, the State may intervene in the action before the Consent Decree is entered (see §121(f)(2) and (f)(3)).

At certain State-lead sites, the State may make the final remedy decision, including a decision to invoke an ARAR waiver. This situation is restricted to sites where the State has been assigned the lead role for the response action, the action is being taken under State law, and the State is not receiving funding for the action from the Trust Fund. In such situations, the State may seek, but is not required to obtain, EPA concurrence on the remedy decision. For further guidance on this and other issues regarding the State role in remedy selection, see "Questions and Answers About the State Role in Remedy Selection at Non-Fund-Financed Enforcement Sites" (EPA 1991c).

Post-remedy-implementation TI decisions may be made in cases where an outside party or agency submits comments requesting a TI determination or EPA determines on its own initiative that a waiver is warranted. The information considered in making such decisions should include the same types of information and analyses discussed for front-end determinations, except that remedy performance data and analysis also should be provided. This information must be entered into the site administrative record before the TI decision can be made and an ARAR waiver invoked. There are limitations, however, to the requirement that EPA open the administrative record to new comments, such as an outside party's request for a TI determination. EPA is not required to consider comments on the selected remedy unless the comments contain "significant information not contained elsewhere in the administrative record file which substantially supports the need to significantly alter the response action" (see NCP §300.825). The type and amount of information necessary to meet this requirement (e.g., the length of time a remedy must be operated prior to a TI evaluation) will be determined by EPA on a site-specific basis.

A modification to a signed ROD invoking a TI ARAR waiver generally will require a ROD amendment, since a waiver usually will constitute a fundamental change in the remedy. A public comment period of 30 days is required for an amendment to a ROD; this period may be extended to 60 days upon request.[25] A public meeting also should be granted if requested. In the exceptional case where an ESD is used to invoke a TI ARAR waiver, public notice and opportunity for comment also should be provided. Further guidance on ROD amendments is provided in "Guide to Addressing Pre-ROD and Post-ROD Changes" (EPA 1991b) and upcoming revisions to "Guidance on Preparing Superfund Decision Documents" (expected Fall 1993).

6.1.2 RCRA

TI decisions at RCRA Corrective Action facilities will be made either by the EPA Regional Administrator or by the appropriate State agency, depending on the RCRA program authorization status of the State. EPA's goal in the RCRA corrective action program is to work cooperatively with individual States, regardless of their authorization status, to promote consistent TI decisions. As in the Superfund program, it is recommended that the State and EPA notify and consult each other as early as possible regarding sites where TI determinations may be made. This notification and consultation process may be outlined in the State/EPA Memorandum of Understanding.

For States authorized for Hazardous and Solid Waste Amendments (HSWA) Corrective Action, the State will have primary authority for remedy decisions, including TI decisions. EPA will retain authority for TI determinations in States that are not authorized for HSWA corrective action.

At RCRA permitted facilities, implementation of a TI determination generally would require a Class 3 permit modification for the purpose of specifying (alternative) corrective measures. This process requires a 45-day notice and comment period, response to comments, and

---

[25] Public notice and opportunity for comment should be provided before an ARAR waiver is granted, regardless of whether an Explanation of Significant Differences (ESD) or ROD amendment is used to invoke the waiver.

public hearing, if requested. At RCRA facilities conducting corrective action under an order, TI determinations generally are implemented through the negotiation of a new order or an amendment to an existing order. This process generally includes a 30- to 45-day pubic comment period and public hearing, if requested.

6.1.3 Technical Review and Support

Technical support for the TI evaluation should be sought as early in the process as possible, preferably during the initial scoping of the content of the TI evaluation. TI determinations usually will require expertise from several disciplines, including hydrogeology, engineering, and risk assessment. Technical staff within the Regions representing these disciplines should be part of the TI review team. EPA's Office of Research and Development (ORD) technical liaisons and scientists based in the Regions also may provide assistance to program staff. Further assistance and review may be obtained from the ORD laboratories involved in the Technical Support Project, including the R.S. Kerr Environmental Research Laboratory (Ada, OK), the Risk Reduction and Engineering Laboratory (Cincinnati, OH), the Environmental Research Laboratory (Athens, GA), and the Environmental Monitoring Systems Laboratory (Las Vegas, NV). The directory of ORD technical services may be consulted for further information (EPA 1993c).

General assistance and site-specific consultation on technical impracticability issues also is available from EPA headquarters staff. Inquiries should be directed to the appropriate OSWER program office.

6.2 Duration of TI Decisions

A determination that ground-water restoration is technically impracticable and the subsequent selection of an alternative remedial strategy will be subject to future review by EPA.

At Superfund sites, an alternative remedial strategy implemented under a CERCLA TI waiver remains in effect so long as that strategy remains protective of human health and the environment. Protectiveness in this context encompasses long-term reliability of the remedy. If the conditions of protectiveness or reliability conditions cease to be met, EPA will determine what additional remedial actions must be implemented to enhance or augment the existing remedy. EPA shall conduct a full assessment of the protectiveness of the alternative remedy at least every five years at any site where contamination remains above levels that allow for unrestricted use, as required under NCP §300.430(f)(4)(ii).

RCRA TI decisions will be incorporated into facility permits or enforcement orders and therefore will be subject to continual oversight and review. Conditions of the permit or order involving the TI decision or the alternative strategy may be revisited on a periodic basis to ensure protectiveness. It may be necessary to modify permits or orders to reflect new information that becomes available during the remedy implementation and monitoring period.[26] Additional measures may be required by EPA to ensure the ongoing protectiveness and reliability of the remedy. Further, owner/operators of RCRA facilities may be required by EPA to undertake additional remedial measures in the future if subsequent advances in remediation technology make attainment of media cleanup standards technically practicable.

The protectiveness of an alternative remedial strategy at a Superfund site or RCRA facility must be ensured through a monitoring program designed to detect releases from containment areas, migration of contaminants to water supply wells, or other releases that would indicate a possible failure of one of the remedy components. EPA may decide to take any further response actions necessary to ensure protectiveness at any time based upon whether the alternative remedy is achieving its required performance standards. Monitoring data, therefore, must be provided to EPA on a regular basis to ensure adequate performance of the alternative remedy. The format, content, and reporting schedule of the monitoring program will be determined by EPA as part of the TI determination and alternative remedy selection process.

---

[26] RCRA Corrective Action Orders that incorporate TI decisions should contain language that retains EPA's authority to review these decisions and complete additional site remediation, as necessary.

7.0 References

Anderson, M.P. and W.W. Woessner, 1992. Applied Groundwater Modeling, Academic Press, San Diego.

Cohen, R.M. and J.W. Mercer, 1993. DNAPL Site Evaluation, C.K. Smoley, Boca Raton, FL.

EPA, 1988a. "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final," OSWER Directive 9355.3-01, EPA/540/G-89/004.

EPA, 1988b. "Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites," EPA/540/G-88/003.

EPA, 1989a. "Considerations in Ground Water Remediation at Superfund Sites," OSWER Directive 9355.4-03.

EPA, 1989b. "Evaluation of Ground-Water Extraction Remedies," EPA/540/2-89/054, Vols. 1-3.

EPA, 1989c. "Overview of ARARs, Focus on ARAR Waivers," OSWER Publication 9234.2-03/FS.

EPA, 1990a. "Suggested ROD Language for Various Ground Water Remediation Options," OSWER Directive 9283.1-03.

EPA, 1990b. "Superfund Removal Procedures - Action Memorandum Guidance," OSWER Directive 9360.3-01, EPA/540/P-90/004.

EPA, 1991a. "ARARs Q's & A's: General Policy, RCRA, CWA, SDWA, Post-ROD Information, and Contingent Waivers," OSWER Publication 9234.2-01/FS-A.

EPA, 1991b. "Guide to Addressing Pre-ROD and Post-ROD Changes," OSWER Publication 9355.3-02/FS-4.

EPA, 1991c. "Questions and Answers About the State Role in Remedy Selection at Non-Fund-Financed Enforcement Sites," OSWER Directive 9831.9.

EPA, 1991d. "Superfund Removal Procedures - Guidance on the Consideration of ARARs During Removal Actions," OSWER Publication 9380.3-02.

EPA, 1992a. "Considerations in Ground-Water Remediation at Superfund Sites and RCRA Facilities - Update," OSWER Directive 9283.1-06.

EPA, 1992b. "Dense Nonaqueous Phase Liquids - A Workshop Summary, Dallas, Texas, April 16-18, 1991," Office of Research and Development, EPA/600/R-92/030.

EPA, 1992c. "Estimating Potential for Occurrence of DNAPL at Superfund Sites," OSWER Publication 9355.4-07/FS.

EPA, 1992d. "Evaluation of Ground-Water Extraction Remedies, Phase II," OSWER Publication 9355.4-05, Vols. 1-2.

EPA, 1992e. "General Methods for Remedial Operations Performance Evaluations," Office of Research and Development, EPA/600/R-92/002.

EPA, 1992f. "Ground Water Issue: Fundamentals of Ground-Water Modeling," EPA/540/S-92/005.

EPA, 1992g. "Ground-Water Modeling Compendium," EPA/500/B-92/006.

EPA, 1993a. "Evaluation of the Likelihood of DNAPL Presence at NPL Sites," OSWER Publication 9355.4-13, EPA/540/R-93/073.

EPA, 1993b. "Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA," OSWER Directive 9360.0-32, EPA/540/R-93/057.

EPA, 1993c. "Technical Assistance Directory," Center for Environmental Research Information, Office of Research and Development," EPA/600/K-93/006.

Federal Register, Volume 55, No. 46, March 8, 1990. "National Oil and Hazardous Substances Pollution Contingency Plan; Final Rule."

Federal Register, Volume 55, No.145, July 27, 1990. "Corrective Action for Solid Waste Management Units at Hazardous Waste Management Facilities; Proposed Rule."

*U.S. G.P.O.:1993-500-574:82091

42 USC **§ 9601. Definitions** **[CERCLA Section 101]**

For purpose of this subchapter--

(1) The term “act of God” means an unanticipated grave natural disaster or other natural phenomenon of an exceptional, inevitable, and irresistible character, the effects of which could not have been prevented or avoided by the exercise of due care or foresight.

(2) The term “Administrator” means the Administrator of the United States Environmental Protection Agency.

(3) The term “barrel” means forty-two United States gallons at sixty degrees Fahrenheit.

(4) The term “claim” means a demand in writing for a sum certain.

(5) The term “claimant” means any person who presents a claim for compensation under this chapter.

(6) The term “damages” means damages for injury or loss of natural resources as set forth in section 9607(a) or 9611(b) of this title.

(7) The term “drinking water supply” means any raw or finished water source that is or may be used by a public water system (as defined in the Safe Drinking Water Act [42 U.S.C.A. § 300f et seq.]) or as drinking water by one or more individuals.

(8) The term “environment” means (A) the navigable waters, the waters of the contiguous zone, and the ocean waters of which the natural resources are under the exclusive management authority of the United States under the Magnuson-Stevens Fishery Conservation and Management Act [16 U.S.C.A. § 1801 et seq.], and (B) any other surface water, ground water, drinking water supply, land surface or subsurface strata, or ambient air within the United States or under the jurisdiction of the United States.

(9) The term “facility” means (A) any building, structure, installation, equipment, pipe or pipeline (including any pipe into a sewer or publicly owned treatment works), well, pit, pond, lagoon, impoundment, ditch, landfill, storage container, motor vehicle, rolling stock, or aircraft, or (B) any site or area where a hazardous substance has been deposited, stored, disposed of, or placed, or otherwise come to be located; but does not include any consumer product in consumer use or any vessel.

(10) The term “federally permitted release” means (A) discharges in compliance with a permit under section 1342 of Title 33, (B) discharges resulting from circumstances identified and reviewed and made part of the public record with respect to a permit issued or modified under section 1342 of Title 33 and subject to a condition of such permit, (C) continuous or anticipated intermittent discharges from a point source, identified in a permit or permit application under section 1342 of Title 33, which are caused by events occurring within the scope of relevant operating or treatment systems, (D) discharges in compliance with a legally enforceable permit under section 1344 of Title 33, (E) releases in compliance with a legally enforceable final permit issued pursuant to section 3005(a) through (d) of the Solid Waste Disposal Act [42 U.S.C.A. § 6925(a) to (d)] from a hazardous waste treatment, storage, or disposal facility when such permit specifically identifies the hazardous substances and makes such substances subject to a standard of practice, control procedure or bioassay limitation or condition, or other control on the hazardous substances in such releases, (F) any release in compliance with a legally enforceable permit issued under section 1412 of Title 33 of [FN1] section 1413 of Title 33, (G) any injection of fluids authorized under Federal underground injection control programs or State programs submitted for Federal approval (and not disapproved by the Administrator of the Environmental Protection Agency) pursuant to part C of the Safe Drinking Water Act [42 U.S.C.A. § 300h et seq.], (H) any emission into the air subject to a permit or control regulation under section 111 [42 U.S.C.A. § 7411], section 112 [42 U.S.C.A. § 7412], Title I part C [42 U.S.C.A. § 7470 et seq.], Title I part D [42 U.S.C.A. § 7501 et seq.], or State implementation plans submitted in accordance with section 110 of the Clean Air Act [42 U.S.C.A. § 7410] (and not disapproved by the Administrator of the Environmental Protection Agency), including any schedule or waiver granted, promulgated, or approved under these sections, (I) any injection of fluids or other materials authorized under applicable State law (i) for the purpose of stimulating or treating wells for the production of crude oil, natural gas, or water, (ii) for the purpose of secondary, tertiary, or other enhanced recovery of crude oil or natural gas, or (iii) which are brought to the surface in conjunction with the production of crude oil or natural gas and which are reinjected, (J) the introduction of any pollutant into a publicly owned treatment works when such pollutant is specified in and in compliance with applicable pretreatment standards of section 1317(b) or (c) of Title 33 and enforceable requirements in a pretreatment program submitted by a State or municipality for Federal approval under section 1342 of Title 33, and (K) any release of source, special nuclear, or byproduct material, as those terms are defined in the Atomic Energy Act of 1954 [42 U.S.C.A. § 2011 et seq.], in compliance with a legally enforceable license, permit, regulation, or order issued pursuant to the Atomic Energy Act of 1954.

(11) The term “Fund” or “Trust Fund” means the Hazardous Substance Superfund established by section 9507 of Title 26.

(12) The term “ground water” means water in a saturated zone or stratum beneath the surface of land or water.

(13) The term “guarantor” means any person, other than the owner or operator, who provides evidence of financial responsibility for an owner or operator under this chapter.

(14) The term “hazardous substance” means (A) any substance designated pursuant to section 1321(b)(2)(A) of Title 33, (B) any element, compound, mixture, solution, or substance designated pursuant to section 9602 of this title, (C) any hazardous waste having the characteristics identified under or listed pursuant to section 3001 of the Solid Waste Disposal Act [42 U.S.C.A. § 6921] (but not including any waste the regulation of which under the Solid Waste Disposal Act [42 U.S.C.A. § 6901 et seq.] has been suspended by Act of Congress), (D) any toxic pollutant listed under section 1317(a) of Title 33, (E) any hazardous air pollutant listed under section 112 of the Clean Air Act [42 U.S.C.A. § 7412], and (F) any imminently hazardous chemical substance or mixture with respect to which the Administrator has taken action pursuant to section 2606 of Title 15. The term does not include petroleum, including crude oil or any fraction thereof which is not otherwise specifically listed or designated as a hazardous substance under subparagraphs (A) through (F) of this paragraph, and the term does not include natural gas, natural gas liquids, liquefied natural gas, or synthetic gas usable for fuel (or mixtures of natural gas and such synthetic gas).

(15) The term “navigable waters” or “navigable waters of the United States” means the waters of the United States, including the territorial seas.

(16) The term “natural resources” means land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States (including the resources of the fishery conservation zone established by the Magnuson-Stevens Fishery Conservation and Management Act [16 U.S.C.A. § 1801 et seq.]) any State or local government, any foreign government, any Indian tribe, or, if such resources are subject to a trust restriction on alienation, any member of an Indian tribe.

(17) The term “offshore facility” means any facility of any kind located in, on, or under, any of the navigable waters of the United States, and any facility of any kind which is subject to the jurisdiction of the United States and is located in, on, or under any other waters, other than a vessel or a public vessel.

(18) The term “onshore facility” means any facility (including, but not limited to, motor vehicles and rolling stock) of any kind located in, on, or under, any land or nonnavigable waters within the United States.

(19) The term “otherwise subject to the jurisdiction of the United States” means subject to the jurisdiction of the United States by virtue of United States citizenship, United States vessel documentation or numbering, or as provided by international agreement to which the United States is a party.

(20)(A) The term “owner or operator” means (i) in the case of a vessel, any person owning, operating, or chartering by demise, such vessel, (ii) in the case of an onshore facility or an offshore facility, any person owning or operating such facility, and (iii) in the case of any facility, title or control of which was conveyed due to bankruptcy, foreclosure, tax delinquency, abandonment, or similar means to a unit of State or local government, any person who owned, operated, or otherwise controlled activities at such facility immediately beforehand. Such term does not include a person, who, without participating in the management of a vessel or facility, holds indicia of ownership primarily to protect his security interest in the vessel or facility.

(B) In the case of a hazardous substance which has been accepted for transportation by a common or contract carrier and except as provided in section 9607(a)(3) or (4) of this title, (i) the term “owner or operator” shall mean such common carrier or other bona fide for hire carrier acting as an independent contractor during such transportation, (ii) the shipper of such hazardous substance shall not be considered to have caused or contributed to any release during such transportation which resulted solely from circumstances or conditions beyond his control.

(C) In the case of a hazardous substance which has been delivered by a common or contract carrier to a disposal or treatment facility and except as provided in section 9607(a)(3) or (4) of this title, (i) the term “owner or operator” shall not include such common or contract carrier, and (ii) such common or contract carrier shall not be considered to have caused or contributed to any release at such disposal or treatment facility resulting from circumstances or conditions beyond its control.

(D) The term “owner or operator” does not include a unit of State or local government which acquired ownership or control involuntarily through bankruptcy, tax delinquency, abandonment, or other circumstances in which the government involuntarily acquires title by virtue of its function as sovereign. The exclusion provided under this paragraph shall not apply to any State or local government which has caused or contributed to the release or threatened release of a hazardous substance from the facility, and such a State or local government shall be subject to the provisions of this chapter in the same manner and to the same extent, both procedurally and substantively, as any nongovernmental entity, including liability under section 9607 of this title.

(E) Exclusion of lenders not participants in management

(i) Indicia of ownership to protect security

The term “owner or operator” does not include a person that is a lender that, without participating in the management of a vessel or facility, holds indicia of ownership primarily to protect the security interest of the person in the vessel or facility.

(ii) Foreclosure

The term “owner or operator” does not include a person that is a lender that did not participate in management of a vessel or facility prior to foreclosure, notwithstanding that the person--

(I) forecloses on the vessel or facility; and

(II) after foreclosure, sells, re-leases (in the case of a lease finance transaction), or liquidates the vessel or facility, maintains business activities, winds up operations, undertakes a response action under section 9607(d)(1) of this title or under the direction of an on-scene coordinator appointed under the National Contingency Plan, with respect to the vessel or facility, or takes any other measure to preserve, protect, or prepare the vessel or facility prior to sale or disposition,

if the person seeks to sell, re-lease (in the case of a lease finance transaction), or otherwise divest the person of the vessel or facility at the earliest practicable, commercially reasonable time, on commercially reasonable terms, taking into account market conditions and legal and regulatory requirements.

(F) Participation in management

For purposes of subparagraph (E)--

(i) the term “participate in management”--

(I) means actually participating in the management or operational affairs of a vessel or facility; and

(II) does not include merely having the capacity to influence, or the unexercised right to control, vessel or facility operations;

(ii) a person that is a lender and that holds indicia of ownership primarily to protect a security interest in a vessel or facility shall be considered to participate in management only if, while the borrower is still in possession of the vessel or facility encumbered by the security interest, the person--

(I) exercises decisionmaking control over the environmental compliance related to the vessel or facility, such that the person has undertaken responsibility for the hazardous substance handling or disposal practices related to the vessel or facility; or

(II) exercises control at a level comparable to that of a manager of the vessel or facility, such that the person has assumed or manifested responsibility--

(aa) for the overall management of the vessel or facility encompassing day-to-day decisionmaking with respect to environmental compliance; or

(bb) over all or substantially all of the operational functions (as distinguished from financial or administrative functions) of the vessel or facility other than the function of environmental compliance;

(iii) the term “participate in management” does not include performing an act or failing to act prior to the time at which a security interest is created in a vessel or facility; and

(iv) the term “participate in management” does not include--

(I) holding a security interest or abandoning or releasing a security interest;

(II) including in the terms of an extension of credit, or in a contract or security agreement relating to the extension, a covenant, warranty, or other term or condition that relates to environmental compliance;

(III) monitoring or enforcing the terms and conditions of the extension of credit or security interest;

(IV) monitoring or undertaking 1 or more inspections of the vessel or facility;

(V) requiring a response action or other lawful means of addressing the release or threatened release of a hazardous substance in connection with the vessel or facility prior to, during, or on the expiration of the term of the extension of credit;

(VI) providing financial or other advice or counseling in an effort to mitigate, prevent, or cure default or diminution in the value of the vessel or facility;

(VII) restructuring, renegotiating, or otherwise agreeing to alter the terms and conditions of the extension of credit or security interest, exercising forbearance;

(VIII) exercising other remedies that may be available under applicable law for the breach of a term or condition of the extension of credit or security agreement; or

(IX) conducting a response action under section 9607(d) of this title or under the direction of an on-scene coordinator appointed under the National Contingency Plan,

if the actions do not rise to the level of participating in management (within the meaning of clauses (i) and (ii)).

(G) Other terms

As used in this chapter:

(i) Extension of credit

The term “extension of credit” includes a lease finance transaction--

(I) in which the lessor does not initially select the leased vessel or facility and does not during the lease term control the daily operations or maintenance of the vessel or facility; or

(II) that conforms with regulations issued by the appropriate Federal banking agency or the appropriate State bank supervisor (as those terms are defined in section 1813 of Title 12 [FN2] or with regulations issued by the National Credit Union Administration Board, as appropriate.

(ii) Financial or administrative function

The term “financial or administrative function” includes a function such as that of a credit manager, accounts payable officer, accounts receivable officer, personnel manager, comptroller, or chief financial officer, or a similar function.

(iii) Foreclosure; foreclose

The terms “foreclosure” and “foreclose” mean, respectively, acquiring, and to acquire, a vessel or facility through--

(I)(aa) purchase at sale under a judgment or decree, power of sale, or nonjudicial foreclosure sale;

(bb) a deed in lieu of foreclosure, or similar conveyance from a trustee; or

(cc) repossession,

if the vessel or facility was security for an extension of credit previously contracted;

(II) conveyance pursuant to an extension of credit previously contracted, including the termination of a lease agreement; or

(III) any other formal or informal manner by which the person acquires, for subsequent disposition, title to or possession of a vessel or facility in order to protect the security interest of the person.

(iv) Lender

The term “lender” means--

(I) an insured depository institution (as defined in section 1813 of Title 12);

(II) an insured credit union (as defined in section 1752 of Title 12);

(III) a bank or association chartered under the Farm Credit Act of 1971 (12 U.S.C. 2001 et seq.);

(IV) a leasing or trust company that is an affiliate of an insured depository institution;

(V) any person (including a successor or assignee of any such person) that makes a bona fide extension of credit to or takes or acquires a security interest from a nonaffiliated person;

(VI) the Federal National Mortgage Association, the Federal Home Loan Mortgage Corporation, the Federal Agricultural Mortgage Corporation, or any other entity that in a bona fide manner buys or sells loans or interests in loans;

(VII) a person that insures or guarantees against a default in the repayment of an extension of credit, or acts as a surety with respect to an extension of credit, to a nonaffiliated person; and

(VIII) a person that provides title insurance and that acquires a vessel or facility as a result of assignment or conveyance in the course of underwriting claims and claims settlement.

(v) Operational function

The term “operational function” includes a function such as that of a facility or plant manager, operations manager, chief operating officer, or chief executive officer.

(vi) Security interest

The term “security interest” includes a right under a mortgage, deed of trust, assignment, judgment lien, pledge, security agreement, factoring agreement, or lease and any other right accruing to a person to secure the repayment of money, the performance of a duty, or any other obligation by a nonaffiliated person.

(21) The term “person” means an individual, firm, corporation, association, partnership, consortium, joint venture, commercial entity, United States Government, State, municipality, commission, political subdivision of a State, or any interstate body.

(22) The term “release” means any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment (including the abandonment or discarding of barrels, containers, and other closed receptacles containing any hazardous substance or pollutant or contaminant), but excludes (A) any release which results in exposure to persons solely within a workplace, with respect to a claim which such persons may assert against the employer of such persons, (B) emissions from the engine exhaust of a motor vehicle, rolling stock, aircraft, vessel, or pipeline pumping station engine, (C) release of source, byproduct, or special nuclear material from a nuclear incident, as those terms are defined in the Atomic Energy Act of 1954 [42 U.S.C.A. § 2011 et seq.], if such release is subject to requirements with respect to financial protection established by the Nuclear Regulatory Commission under section 170 of such Act [42 U.S.C.A. § 2210], or, for the purposes of section 9604 of this title or any other response action, any release of source byproduct, or special nuclear material from any processing site designated under section 7912(a)(1) or 7942(a) of this title, and (D) the normal application of fertilizer.

(23) The terms “remove” or “removal” means [FN3] the cleanup or removal of released hazardous substances from the environment, such actions as may be necessary taken in the event of the threat of release of hazardous substances into the environment, such actions as may be necessary to monitor, assess, and evaluate the release or threat of release of hazardous substances, the disposal of removed material, or the taking of such other actions as may be necessary to prevent, minimize, or mitigate damage to the public health or welfare or to the environment, which may otherwise result from a release or threat of release. The term includes, in addition, without being limited to, security fencing or other measures to limit access, provision of alternative water supplies, temporary evacuation and housing of threatened individuals not otherwise provided for, action taken under section 9604(b) of this title, and any emergency assistance which may be provided under the Disaster Relief and Emergency Assistance Act [42 U.S.C.A. § 5121 et seq.].

(24) The terms “remedy” or “remedial action” means [FN3] those actions consistent with permanent remedy taken instead of or in addition to removal actions in the event of a release or threatened release of a hazardous substance into the environment, to prevent or minimize the release of hazardous substances so that they do not migrate to cause substantial danger to present or future public health or welfare or the environment. The term includes, but is not limited to, such actions at the location of the release as storage, confinement, perimeter protection using dikes, trenches, or ditches, clay cover, neutralization, cleanup of released hazardous substances and associated contaminated materials, recycling or reuse, diversion, destruction, segregation of reactive wastes, dredging or excavations, repair or replacement of leaking containers, collection of leachate and runoff, onsite treatment or incineration, provision of alternative water supplies, and any monitoring reasonably required to assure that such actions protect the public health and welfare and the environment. The term includes the costs of permanent relocation of residents and businesses and community facilities where the President determines that, alone or in combination with other measures, such relocation is more cost-effective than and environmentally preferable to the transportation, storage, treatment, destruction, or secure disposition offsite of hazardous substances, or may otherwise be necessary to protect the public health or welfare; the term includes offsite transport and offsite storage, treatment, destruction, or secure disposition of hazardous substances and associated contaminated materials.

(25) The terms “respond” or “response” means [FN3] remove, removal, remedy, and remedial action;, [FN4] all such terms (including the terms “removal” and “remedial action”) include enforcement activities related thereto.

(26) The terms “transport” or “transportation” means [FN3] the movement of a hazardous substance by any mode, including a hazardous liquid pipeline facility (as defined in section 60101(a) of Title 49), and in the case of a hazardous substance which has been accepted for transportation by a common or contract carrier, the term “transport” or “transportation” shall include any stoppage in transit which is temporary, incidental to the transportation movement, and at the ordinary operating convenience of a common or contract carrier, and any such stoppage shall be considered as a continuity of movement and not as the storage of a hazardous substance.

(27) The terms “United States” and “State” include the several States of the United States, the District of Columbia, the Commonwealth of Puerto Rico, Guam, American Samoa, the United States Virgin Islands, the Commonwealth of the Northern Marianas, and any other territory or possession over which the United States has jurisdiction.

(28) The term “vessel” means every description of watercraft or other artificial contrivance used, or capable of being used, as a means of transportation on water.

(29) The terms “disposal”, “hazardous waste”, and “treatment” shall have the meaning provided in section 1004 of the Solid Waste Disposal Act [42 U.S.C.A. § 6903].

(30) The terms “territorial sea” and “contiguous zone” shall have the meaning provided in section 1362 of Title 33.

(31) The term “national contingency plan” means the national contingency plan published under section 1321(c) of Title 33 or revised pursuant to section 9605 of this title.

(32) The terms “liable” or “liability” under this subchapter shall be construed to be the standard of liability which obtains under section 1321 of Title 33.

(33) The term “pollutant or contaminant” shall include, but not be limited to, any element, substance, compound, or mixture, including disease-causing agents, which after release into the environment and upon exposure, ingestion, inhalation, or assimilation into any organism, either directly from the environment or indirectly by ingestion through food chains, will or may reasonably be anticipated to cause death, disease, behavioral abnormalities, cancer, genetic mutation, physiological malfunctions (including malfunctions in reproduction) or physical deformations, in such organisms or their offspring; except that the term “pollutant or contaminant” shall not include petroleum, including crude oil or any fraction thereof which is not otherwise specifically listed or designated as a hazardous substance under subparagraphs (A) through (F) of paragraph (14) and shall not include natural gas, liquefied natural gas, or synthetic gas of pipeline quality (or mixtures of natural gas and such synthetic gas).

(34) The term “alternative water supplies” includes, but is not limited to, drinking water and household water supplies.

(35)(A) The term “contractual relationship”, for the purpose of section 9607(b)(3) of this title, includes, but is not limited to, land contracts, deeds, easements, leases, or other instruments transferring title or possession, unless the real property on which the facility concerned is located was acquired by the defendant after the disposal or placement of the hazardous substance on, in, or at the facility, and one or more of the circumstances described in clause (i), (ii), or (iii) is also established by the defendant by a preponderance of the evidence:

(i) At the time the defendant acquired the facility the defendant did not know and had no reason to know that any hazardous substance which is the subject of the release or threatened release was disposed of on, in, or at the facility.

(ii) The defendant is a government entity which acquired the facility by escheat, or through any other involuntary transfer or acquisition, or through the exercise of eminent domain authority by purchase or condemnation.

(iii) The defendant acquired the facility by inheritance or bequest.

In addition to establishing the foregoing, the defendant must establish that the defendant has satisfied the requirements of section 9607(b)(3)(a) and (b) of this title, provides full cooperation, assistance, and facility access to the persons that are authorized to conduct response actions at the facility (including the cooperation and access necessary for the installation, integrity, operation, and maintenance of any complete or partial response action at the facility), is in compliance with any land use restrictions established or relied on in connection with the response action at a facility, and does not impede the effectiveness or integrity of any institutional control employed at the facility in connection with a response action.

(B) Reason to know

(i) All appropriate inquiries

To establish that the defendant had no reason to know of the matter described in subparagraph (A)(i), the defendant must demonstrate to a court that--

(I) on or before the date on which the defendant acquired the facility, the defendant carried out all appropriate inquiries, as provided in clauses (ii) and (iv), into the previous ownership and uses of the facility in accordance with generally accepted good commercial and customary standards and practices; and

(II) the defendant took reasonable steps to--

(aa) stop any continuing release;

(bb) prevent any threatened future release; and

(cc) prevent or limit any human, environmental, or natural resource exposure to any previously released hazardous substance.

(ii) Standards and practices

Not later than 2 years after January 11, 2002, the Administrator shall by regulation establish standards and practices for the purpose of satisfying the requirement to carry out all appropriate inquiries under clause (i).

(iii) Criteria

In promulgating regulations that establish the standards and practices referred to in clause (ii), the Administrator shall include each of the following:

(I) The results of an inquiry by an environmental professional.

(II) Interviews with past and present owners, operators, and occupants of the facility for the purpose of gathering information regarding the potential for contamination at the facility.

(III) Reviews of historical sources, such as chain of title documents, aerial photographs, building department records, and land use records, to determine previous uses and occupancies of the real property since the property was first developed.

(IV) Searches for recorded environmental cleanup liens against the facility that are filed under Federal, State, or local law.

(V) Reviews of Federal, State, and local government records, waste disposal records, underground storage tank records, and hazardous waste handling, generation, treatment, disposal, and spill records, concerning contamination at or near the facility.

(VI) Visual inspections of the facility and of adjoining properties.

(VII) Specialized knowledge or experience on the part of the defendant.

(VIII) The relationship of the purchase price to the value of the property, if the property was not contaminated.

(IX) Commonly known or reasonably ascertainable information about the property.

(X) The degree of obviousness of the presence or likely presence of contamination at the property, and the ability to detect the contamination by appropriate investigation.

(iv) Interim standards and practices

(I) Property purchased before May 31, 1997

With respect to property purchased before May 31, 1997, in making a determination with respect to a defendant described in clause (i), a court shall take into account--

(aa) any specialized knowledge or experience on the part of the defendant;

(bb) the relationship of the purchase price to the value of the property, if the property was not contaminated;

(cc) commonly known or reasonably ascertainable information about the property;

(dd) the obviousness of the presence or likely presence of contamination at the property; and

(ee) the ability of the defendant to detect the contamination by appropriate inspection.

(II) Property purchased on or after May 31, 1997

With respect to property purchased on or after May 31, 1997, and until the Administrator promulgates the regulations described in clause (ii), the procedures of the American Society for Testing and Materials, including the document known as ‘Standard E1527-97’, entitled ‘Standard Practice for Environmental Site Assessment: Phase 1 Environmental Site Assessment Process', shall satisfy the requirements in clause (i).

(v) Site inspection and title search

In the case of property for residential use or other similar use purchased by a nongovernmental or noncommercial entity, a facility inspection and title search that reveal no basis for further investigation shall be considered to satisfy the requirements of this subparagraph.

(C) Nothing in this paragraph or in section 9607(b)(3) of this title shall diminish the liability of any previous owner or operator of such facility who would otherwise be liable under this chapter. Notwithstanding this paragraph, if the defendant obtained actual knowledge of the release or threatened release of a hazardous substance at such facility when the defendant owned the real property and then subsequently transferred ownership of the property to another person without disclosing such knowledge, such defendant shall be treated as liable under section 9607(a)(1) of this title and no defense under section 9607(b)(3) of this title shall be available to such defendant.

(D) Nothing in this paragraph shall affect the liability under this chapter of a defendant who, by any act or omission, caused or contributed to the release or threatened release of a hazardous substance which is the subject of the action relating to the facility.

(36) The term “Indian tribe” means any Indian tribe, band, nation, or other organized group or community, including any Alaska Native village but not including any Alaska Native regional or village corporation, which is recognized as eligible for the special programs and services provided by the United States to Indians because of their status as Indians.

(37)(A) The term “service station dealer” means any person--

(i) who owns or operates a motor vehicle service station, filling station, garage, or similar retail establishment engaged in the business of selling, repairing, or servicing motor vehicles, where a significant percentage of the gross revenue of the establishment is derived from the fueling, repairing, or servicing of motor vehicles, and

(ii) who accepts for collection, accumulation, and delivery to an oil recycling facility, recycled oil that (I) has been removed from the engine of a light duty motor vehicle or household appliances by the owner of such vehicle or appliances, and (II) is presented, by such owner, to such person for collection, accumulation, and delivery to an oil recycling facility.

(B) For purposes of section 9614(c) of this title, the term “service station dealer” shall, notwithstanding the provisions of subparagraph (A), include any government agency that establishes a facility solely for the purpose of accepting recycled oil that satisfies the criteria set forth in subclauses (I) and (II) of subparagraph (A)(ii), and, with respect to recycled oil that satisfies the criteria set forth in subclauses (I) and (II), owners or operators of refuse collection services who are compelled by State law to collect, accumulate, and deliver such oil to an oil recycling facility.

(C) The President shall promulgate regulations regarding the determination of what constitutes a significant percentage of the gross revenues of an establishment for purposes of this paragraph.

(38) The term “incineration vessel” means any vessel which carries hazardous substances for the purpose of incineration of such substances, so long as such substances or residues of such substances are on board.

(39) Brownfield site

(A) In general

The term “brownfield site” means real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant.

(B) Exclusions

The term “brownfield site” does not include--

(i) a facility that is the subject of a planned or ongoing removal action under this subchapter;

(ii) a facility that is listed on the National Priorities List or is proposed for listing;

(iii) a facility that is the subject of a unilateral administrative order, a court order, an administrative order on consent or judicial consent decree that has been issued to or entered into by the parties under this chapter;

(iv) a facility that is the subject of a unilateral administrative order, a court order, an administrative order on consent or judicial consent decree that has been issued to or entered into by the parties, or a facility to which a permit has been issued by the United States or an authorized State under the Solid Waste Disposal Act (42 U.S.C. 6901 et seq.), the Federal Water Pollution Control Act (33 U.S.C. 1321), the Toxic Substances Control Act (15 U.S.C. 2601 et seq.), or the Safe Drinking Water Act (42 U.S.C. 300f et seq.);

(v) a facility that--

(I) is subject to corrective action under section 3004(u) or 3008(h) of the Solid Waste Disposal Act (42 U.S.C. 6924(u), 6928(h)); and

(II) to which a corrective action permit or order has been issued or modified to require the implementation of corrective measures;

(vi) a land disposal unit with respect to which--

(I) a closure notification under subtitle C of the Solid Waste Disposal Act (42 U.S.C. 6921 et seq.) has been submitted; and

(II) closure requirements have been specified in a closure plan or permit;

(vii) a facility that is subject to the jurisdiction, custody, or control of a department, agency, or instrumentality of the United States, except for land held in trust by the United States for an Indian tribe;

(viii) a portion of a facility--

(I) at which there has been a release of polychlorinated biphenyls; and

(II) that is subject to remediation under the Toxic Substances Control Act (15 U.S.C. 2601 et seq.); or

(ix) a portion of a facility, for which portion, assistance for response activity has been obtained under subtitle I of the Solid Waste Disposal Act (42 U.S.C. 6991 et seq.) from the Leaking Underground Storage Tank Trust Fund established under section 9508 of Title 26.

(C) Site-by-site determinations

Notwithstanding subparagraph (B) and on a site-by-site basis, the President may authorize financial assistance under section 9604(k) of this title to an eligible entity at a site included in clause (i), (iv), (v), (vi), (viii), or (ix) of subparagraph (B) if the President finds that financial assistance will protect human health and the environment, and either promote economic development or enable the creation of, preservation of, or addition to parks, greenways, undeveloped property, other recreational property, or other property used for nonprofit purposes.

(D) Additional areas

For the purposes of section 9604(k) of this title, the term “brownfield site” includes a site that--

(i) meets the definition of “brownfield site” under subparagraphs (A) through (C); and

(ii)(I) is contaminated by a controlled substance (as defined in section 802 of Title 21);

(II)(aa) is contaminated by petroleum or a petroleum product excluded from the definition of “hazardous substance” under this section; and

(bb) is a site determined by the Administrator or the State, as appropriate, to be--

(AA) of relatively low risk, as compared with other petroleum-only sites in the State; and

(BB) a site for which there is no viable responsible party and which will be assessed, investigated, or cleaned up by a person that is not potentially liable for cleaning up the site; and

(cc) is not subject to any order issued under section 6991b(h) of this title; or

(III) is mine-scarred land.

(40) Bona fide prospective purchaser

The term “bona fide prospective purchaser” means a person (or a tenant of a person) that acquires ownership of a facility after the date of the enactment of this paragraph and that establishes each of the following by a preponderance of the evidence:

(A) Disposal prior to acquisition

All disposal of hazardous substances at the facility occurred before the person acquired the facility.

(B) Inquiries

(i) In general

The person made all appropriate inquiries into the previous ownership and uses of the facility in accordance with generally accepted good commercial and customary standards and practices in accordance with clauses (ii) and (iii).

(ii) Standards and practices

The standards and practices referred to in clauses (ii) and (iv) of paragraph (35)(B) of this section shall be considered to satisfy the requirements of this subparagraph.

(iii) Residential use

In the case of property in residential or other similar use at the time of purchase by a nongovernmental or noncommercial entity, a facility inspection and title search that reveal no basis for further investigation shall be considered to satisfy the requirements of this subparagraph.

(C) Notices

The person provides all legally required notices with respect to the discovery or release of any hazardous substances at the facility.

(D) Care

The person exercises appropriate care with respect to hazardous substances found at the facility by taking reasonable steps to--

(i) stop any continuing release;

(ii) prevent any threatened future release; and

(iii) prevent or limit human, environmental, or natural resource exposure to any previously released hazardous substance.

(E) Cooperation, assistance, and access

The person provides full cooperation, assistance, and access to persons that are authorized to conduct response actions or natural resource restoration at a vessel or facility (including the cooperation and access necessary for the installation, integrity, operation, and maintenance of any complete or partial response actions or natural resource restoration at the vessel or facility).

(F) Institutional control

The person--

(i) is in compliance with any land use restrictions established or relied on in connection with the response action at a vessel or facility; and

(ii) does not impede the effectiveness or integrity of any institutional control employed at the vessel or facility in connection with a response action.

(G) Requests; subpoenas

The person complies with any request for information or administrative subpoena issued by the President under this chapter.

(H) No affiliation

The person is not--

(i) potentially liable, or affiliated with any other person that is potentially liable, for response costs at a facility through--

(I) any direct or indirect familial relationship; or

(II) any contractual, corporate, or financial relationship (other than a contractual, corporate, or financial relationship that is created by the instruments by which title to the facility is conveyed or financed or by a contract for the sale of goods or services); or

(ii) the result of a reorganization of a business entity that was potentially liable.

(41) Eligible response site

(A) In general

The term “eligible response site” means a site that meets the definition of a brownfield site in subparagraphs (A) and (B) of paragraph (39) of this section, as modified by subparagraphs (B) and (C) of this paragraph.

(B) Inclusions

The term “eligible response site” includes--

(i) notwithstanding paragraph (39)(B)(ix) of this section, a portion of a facility, for which portion assistance for response activity has been obtained under subtitle I of the Solid Waste Disposal Act (42 U.S.C. 6991 et seq.) from the Leaking Underground Storage Tank Trust Fund established under section 9508 of Title 26; or

(ii) a site for which, notwithstanding the exclusions provided in subparagraph (C) or paragraph (39)(B) of this section, the President determines, on a site-by-site basis and after consultation with the State, that limitations on enforcement under section 9628 of this title at sites specified in clause (iv), (v), (vi) or (viii) of paragraph (39)(B) of this section would be appropriate and will--

(I) protect human health and the environment; and

(II) promote economic development or facilitate the creation of, preservation of, or addition to a park, a greenway, undeveloped property, recreational property, or other property used for nonprofit purposes.

(C) Exclusions

The term “eligible response site” does not include--

(i) a facility for which the President--

(I) conducts or has conducted a preliminary assessment or site inspection; and

(II) after consultation with the State, determines or has determined that the site obtains a preliminary score sufficient for possible listing on the National Priorities List, or that the site otherwise qualifies for listing on the National Priorities List; unless the President has made a determination that no further Federal action will be taken; or

(ii) facilities that the President determines warrant particular consideration as identified by regulation, such as sites posing a threat to a sole-source drinking water aquifer or a sensitive ecosystem.

[FN1] So in original. Probably should be “or”.

[FN2] So in original. Probably should be followed by a closing parenthesis.

[FN3] So in original. Probably should be “mean”.

[FN4] So in original.

§ 9603. Notification requirements respecting released substances **[CERCLA Section 103]**

(a) Notice to National Response Center upon release from vessel or offshore or onshore facility by person in charge; conveyance of notice by Center

Any person in charge of a vessel or an offshore or an onshore facility shall, as soon as he has knowledge of any release (other than a federally permitted release) of a hazardous substance from such vessel or facility in quantities equal to or greater than those determined pursuant to section 9602 of this title, immediately notify the National Response Center established under the Clean Water Act [33 U.S.C.A. § 1251 et seq.] of such release. The National Response Center shall convey the notification expeditiously to all appropriate Government agencies, including the Governor of any affected State.

(b) Penalties for failure to notify; use of notice or information pursuant to notice in criminal case

Any person--

(1) in charge of a vessel from which a hazardous substance is released, other than a federally permitted release, into or upon the navigable waters of the United States, adjoining shorelines, or into or upon the waters of the contiguous zone, or

(2) in charge of a vessel from which a hazardous substance is released, other than a federally permitted release, which may affect natural resources belonging to, appertaining to, or under the exclusive management authority of the United States (including resources under the Magnuson-Stevens Fishery Conservation and Management Act [16 U.S.C.A. § 1801 et seq.]), and who is otherwise subject to the jurisdiction of the United States at the time of the release, or

(3) in charge of a facility from which a hazardous substance is released, other than a federally permitted release,

in a quantity equal to or greater than that determined pursuant to section 9602 of this title who fails to notify immediately the appropriate agency of the United States Government as soon as he has knowledge of such release or who submits in such a notification any information which he knows to be false or misleading shall, upon conviction, be fined in accordance with the applicable provisions of Title 18 or imprisoned for not more than 3 years (or not more than 5 years in the case of a second or subsequent conviction), or both. Notification received pursuant to this subsection or information obtained by the exploitation of such notification shall not be used against any such person in any criminal case, except a prosecution for perjury or for giving a false statement.

(c) Notice to Administrator of EPA of existence of storage, etc., facility by owner or operator; exception; time, manner, and form of notice; penalties for failure to notify; use of notice or information pursuant to notice in criminal case

Within one hundred and eighty days after December 11, 1980, any person who owns or operates or who at the time of disposal owned or operated, or who accepted hazardous substances for transport and selected, a facility at which hazardous substances (as defined in section 9601(14)(C) of this title) are or have been stored, treated, or disposed of shall, unless such facility has a permit issued under, or has been accorded interim status under, subtitle C of the Solid Waste Disposal Act [42 U.S.C.A. § 6921 et seq.], notify the Administrator of the Environmental Protection Agency of the existence of such facility, specifying the amount and type of any hazardous substance to be found there, and any known, suspected, or likely releases of such substances from such facility. The Administrator may prescribe in greater detail the manner and form of the notice and the information included. The Administrator shall notify the affected State agency, or any department designated by the Governor to receive such notice, of the existence of such facility. Any person who knowingly fails to notify the Administrator of the existence of any such facility shall, upon conviction, be fined not more than $10,000, or imprisoned for not more than one year, or both. In addition, any such person who knowingly fails to provide the notice required by this subsection shall not be entitled to any limitation of liability or to any defenses to liability set out in section 9607 of this title: *Provided, however*, That notification under this subsection is not required for any facility which would be reportable hereunder solely as a result of any stoppage in transit which is temporary, incidental to the transportation movement, or at the ordinary operating convenience of a common or contract carrier, and such stoppage shall be considered as a continuity of movement and not as the storage of a hazardous substance. Notification received pursuant to this subsection or information obtained by the exploitation of such notification shall not be used against any such person in any criminal case, except a prosecution for perjury or for giving a false statement.

(d) Recordkeeping requirements; promulgation of rules and regulations by Administrator of EPA; penalties for violations; waiver of retention requirements

(1) The Administrator of the Environmental Protection Agency is authorized to promulgate rules and regulations specifying, with respect to--

(A) the location, title, or condition of a facility, and

(B) the identity, characteristics, quantity, origin, or condition (including containerization and previous treatment) of any hazardous substances contained or deposited in a facility;

the records which shall be retained by any person required to provide the notification of a facility set out in subsection (c) of this section. Such specification shall be in accordance with the provisions of this subsection.

(2) Beginning with December 11, 1980, for fifty years thereafter or for fifty years after the date of establishment of a record (whichever is later), or at any such earlier time as a waiver if obtained under paragraph (3) of this subsection, it shall be unlawful for any such person knowingly to destroy, mutilate, erase, dispose of, conceal, or otherwise render unavailable or unreadable or falsify any records identified in paragraph (1) of this subsection. Any person who violates this paragraph shall, upon conviction, be fined in accordance with the applicable provisions of Title 18 or imprisoned for not more than 3 years (or not more than 5 years in the case of a second or subsequent conviction), or both.

(3) At any time prior to the date which occurs fifty years after December 11, 1980, any person identified under paragraph (1) of this subsection may apply to the Administrator of the Environmental Protection Agency for a waiver of the provisions of the first sentence of paragraph (2) of this subsection. The Administrator is authorized to grant such waiver if, in his discretion, such waiver would not unreasonably interfere with the attainment of the purposes and provisions of this chapter. The Administrator shall promulgate rules and regulations regarding such a waiver so as to inform parties of the proper application procedure and conditions for approval of such a waiver.

(4) Notwithstanding the provisions of this subsection, the Administrator of the Environmental Protection Agency may in his discretion require any such person to retain any record identified pursuant to paragraph (1) of this subsection for such a time period in excess of the period specified in paragraph (2) of this subsection as the Administrator determines to be necessary to protect the public health or welfare.

(e) Applicability to registered pesticide product

This section shall not apply to the application of a pesticide product registered under the Federal Insecticide, Fungicide, and Rodenticide Act [7 U.S.C.A. § 136 et seq.] or to the handling and storage of such a pesticide product by an agricultural producer.

(f) Exemptions from notice and penalty provisions for substances reported under other Federal law or is in continuous release, etc.

No notification shall be required under subsection (a) or (b) of this section for any release of a hazardous substance--

(1) which is required to be reported (or specifically exempted from a requirement for reporting) under subtitle C of the Solid Waste Disposal Act [42 U.S.C.A. § 6921 et seq.] or regulations thereunder and which has been reported to the National Response Center, or

(2) which is a continuous release, stable in quantity and rate, and is--

(A) from a facility for which notification has been given under subsection (c) of this section, or

(B) a release of which notification has been given under subsections (a) and (b) of this section for a period sufficient to establish the continuity, quantity, and regularity of such release:

Provided, That notification in accordance with subsections (a) and (b) of this paragraph shall be given for releases subject to this paragraph annually, or at such time as there is any statistically significant increase in the quantity of any hazardous substance or constituent thereof released, above that previously reported or occurring.

§ 9604. Response authorities [CERCLA Section 104]

(a) Removal and other remedial action by President; applicability of national contingency plan; response by potentially responsible parties; public health threats; limitations on response; exception

(1) Whenever (A) any hazardous substance is released or there is a substantial threat of such a release into the environment, or (B) there is a release or substantial threat of release into the environment of any pollutant or contaminant which may present an imminent and substantial danger to the public health or welfare, the President is authorized to act, consistent with the national contingency plan, to remove or arrange for the removal of, and provide for remedial action relating to such hazardous substance, pollutant, or contaminant at any time (including its removal from any contaminated natural resource), or take any other response measure consistent with the national contingency plan which the President deems necessary to protect the public health or welfare or the environment. When the President determines that such action will be done properly and promptly by the owner or operator of the facility or vessel or by any other responsible party, the President may allow such person to carry out the action, conduct the remedial investigation, or conduct the feasibility study in accordance with section 9622 of this title. No remedial investigation or feasibility study (RI/FS) shall be authorized except on a determination by the President that the party is qualified to conduct the RI/FS and only if the President contracts with or arranges for a qualified person to assist the President in overseeing and reviewing the conduct of such RI/FS and if the responsible party agrees to reimburse the Fund for any cost incurred by the President under, or in connection with, the oversight contract or arrangement. In no event shall a potentially responsible party be subject to a lesser standard of liability, receive preferential treatment, or in any other way, whether direct or indirect, benefit from any such arrangements as a response action contractor, or as a person hired or retained by such a response action contractor, with respect to the release or facility in question. The President shall give primary attention to those releases which the President deems may present a public health threat.

(2) Removal action

Any removal action undertaken by the President under this subsection (or by any other person referred to in section 9622 of this title) should, to the extent the President deems practicable, contribute to the efficient performance of any long term remedial action with respect to the release or threatened release concerned.

(3) Limitations on response

The President shall not provide for a removal or remedial action under this section in response to a release or threat of release--

(A) of 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;

(B) from products which are part of the structure of, and result in exposure within, residential buildings or business or community structures; or

(C) into public or private drinking water supplies due to deterioration of the system through ordinary use.

(4) Exception to limitations

Notwithstanding paragraph (3) of this subsection, 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.

(b) Investigations, monitoring, coordination, etc., by President

(1) Information; studies and investigations

Whenever the President is authorized to act pursuant to subsection (a) of this section, or whenever the President has reason to believe that a release has occurred or is about to occur, or that illness, disease, or complaints thereof may be attributable to exposure to a hazardous substance, pollutant, or contaminant and that a release may have occurred or be occurring, he may undertake such investigations, monitoring, surveys, testing, and other information gathering as he may deem necessary or appropriate to identify the existence and extent of the release or threat thereof, the source and nature of the hazardous substances, pollutants or contaminants involved, and the extent of danger to the public health or welfare or to the environment. In addition, the President may undertake such planning, legal, fiscal, economic, engineering, architectural, and other studies or investigations as he may deem necessary or appropriate to plan and direct response actions, to recover the costs thereof, and to enforce the provisions of this chapter.

(2) Coordination of investigations

The President shall promptly notify the appropriate Federal and State natural resource trustees of potential damages to natural resources resulting from releases under investigation pursuant to this section and shall seek to coordinate the assessments, investigations, and planning under this section with such Federal and State trustees.

(c) Criteria for continuance of obligations from Fund over specified amount for response actions; consultation by President with affected States; contracts or cooperative agreements by States with President prior to remedial actions; cost-sharing agreements; selection by President of remedial actions; State credits: granting of credit, expenses before listing or agreement, response actions between 1978 and 1980, State expenses after December 11, 1980, in excess of 10 percent of costs, item-by-item approval, use of credits; operation and maintenance; limitation on source of funds for O & M; recontracting; siting

(1) Unless (A) the President finds that (i) continued response actions are immediately required to prevent, limit, or mitigate an emergency, (ii) there is an immediate risk to public health or welfare or the environment, and (iii) such assistance will not otherwise be provided on a timely basis, or (B) the President has determined the appropriate remedial actions pursuant to paragraph (2) of this subsection and the State or States in which the source of the release is located have complied with the requirements of paragraph (3) of this subsection, or (C) continued response action is otherwise appropriate and consistent with the remedial action to be taken [FN1] obligations from the Fund, other than those authorized by subsection (b) of this section, shall not continue after $2,000,000 has been obligated for response actions or 12 months has elapsed from the date of initial response to a release or threatened release of hazardous substances.

(2) The President shall consult with the affected State or States before determining any appropriate remedial action to be taken pursuant to the authority granted under subsection (a) of this section.

(3) The President shall not provide any remedial actions pursuant to this section unless the State in which the release occurs first enters into a contract or cooperative agreement with the President providing assurances deemed adequate by the President that (A) the State will assure all future maintenance of the removal and remedial actions provided for the expected life of such actions as determined by the President; (B) the State will assure the availability of a hazardous waste disposal facility acceptable to the President and in compliance with the requirements of subtitle C of the Solid Waste Disposal Act [42 U.S.C.A. § 6921 et seq.] for any necessary offsite storage, destruction, treatment, or secure disposition of the hazardous substances; and (C) the State will pay or assure payment of (i) 10 per centum of the costs of the remedial action, including all future maintenance, or (ii) 50 percent (or such greater amount as the President may determine appropriate, taking into account the degree of responsibility of the State or political subdivision for the release) of any sums expended in response to a release at a facility, that was operated by the State or a political subdivision thereof, either directly or through a contractual relationship or otherwise, at the time of any disposal of hazardous substances therein. For the purpose of clause (ii) of this subparagraph, the term “facility” does not include navigable waters or the beds underlying those waters. In the case of remedial action to be taken on land or water held by an Indian tribe, held by the United States in trust for Indians, held by a member of an Indian tribe (if such land or water is subject to a trust restriction on alienation), or otherwise within the borders of an Indian reservation, the requirements of this paragraph for assurances regarding future maintenance and cost-sharing shall not apply, and the President shall provide the assurance required by this paragraph regarding the availability of a hazardous waste disposal facility.

(4) Selection of remedial action

The President shall select remedial actions to carry out this section in accordance with section 9621 of this title (relating to cleanup standards).

(5) State credits

(A) Granting of credit

The President shall grant a State a credit against the share of the costs, for which it is responsible under paragraph (3) with respect to a facility listed on the National Priorities List under the National Contingency Plan, for amounts expended by a State for remedial action at such facility pursuant to a contract or cooperative agreement with the President. The credit under this paragraph shall be limited to those State expenses which the President determines to be reasonable, documented, direct out-of-pocket expenditures of non-Federal funds.

(B) Expenses before listing or agreement

The credit under this paragraph shall include expenses for remedial action at a facility incurred before the listing of the facility on the National Priorities List or before a contract or cooperative agreement is entered into under subsection (d) of this section for the facility if--

(i) after such expenses are incurred the facility is listed on such list and a contract or cooperative agreement is entered into for the facility, and

(ii) the President determines that such expenses would have been credited to the State under subparagraph (A) had the expenditures been made after listing of the facility on such list and after the date on which such contract or cooperative agreement is entered into.

(C) Response actions between 1978 and 1980

The credit under this paragraph shall include funds expended or obligated by the State or a political subdivision thereof after January 1, 1978, and before December 11, 1980, for cost-eligible response actions and claims for damages compensable under section 9611 of this title.

(D) State expenses after December 11, 1980, in excess of 10 percent of costs

The credit under this paragraph shall include 90 percent of State expenses incurred at a facility owned, but not operated, by such State or by a political subdivision thereof. Such credit applies only to expenses incurred pursuant to a contract or cooperative agreement under subsection (d) of this section and only to expenses incurred after December 11, 1980, but before October 17, 1986.

(E) Item-by-item approval

In the case of expenditures made after October 17, 1986, the President may require prior approval of each item of expenditure as a condition of granting a credit under this paragraph.

(F) Use of credits

Credits granted under this paragraph for funds expended with respect to a facility may be used by the State to reduce all or part of the share of costs otherwise required to be paid by the State under paragraph (3) in connection with remedial actions at such facility. If the amount of funds for which credit is allowed under this paragraph exceeds such share of costs for such facility, the State may use the amount of such excess to reduce all or part of the share of such costs at other facilities in that State. A credit shall not entitle the State to any direct payment.

(6) Operation and maintenance

For the purposes of paragraph (3) of this subsection, in the case of ground or surface water contamination, completed remedial action includes the completion of treatment or other measures, whether taken onsite or offsite, necessary to restore ground and surface water quality to a level that assures protection of human health and the environment. With respect to such measures, the operation of such measures for a period of up to 10 years after the construction or installation and commencement of operation shall be considered remedial action. Activities required to maintain the effectiveness of such measures following such period or the completion of remedial action, whichever is earlier, shall be considered operation or maintenance.

(7) Limitation on source of funds for O&M

During any period after the availability of funds received by the Hazardous Substance Superfund established under subchapter A of chapter 98 of Title 26 from tax revenues or appropriations from general revenues, the Federal share of the payment of the cost of operation or maintenance pursuant to paragraph (3)(C)(i) or paragraph (6) of this subsection (relating to operation and maintenance) shall be from funds received by the Hazardous Substance Superfund from amounts recovered on behalf of such fund under this chapter.

(8) Recontracting

The President is authorized to undertake or continue whatever interim remedial actions the President determines to be appropriate to reduce risks to public health or the environment where the performance of a complete remedial action requires recontracting because of the discovery of sources, types, or quantities of hazardous substances not known at the time of entry into the original contract. The total cost of interim actions undertaken at a facility pursuant to this paragraph shall not exceed $2,000,000.

(9) Siting

Effective 3 years after October 17, 1986, the President shall not provide any remedial actions pursuant to this section unless the State in which the release occurs first enters into a contract or cooperative agreement with the President providing assurances deemed adequate by the President that the State will assure the availability of hazardous waste treatment or disposal facilities which--

(A) have adequate capacity for the destruction, treatment, or secure disposition of all hazardous wastes that are reasonably expected to be generated within the State during the 20-year period following the date of such contract or cooperative agreement and to be disposed of, treated, or destroyed,

(B) are within the State or outside the State in accordance with an interstate agreement or regional agreement or authority,

(C) are acceptable to the President, and

(D) are in compliance with the requirements of subtitle C of the Solid Waste Disposal Act [42 U.S.C.A. § 6921 et seq.]

(d) Contracts or cooperative agreements by President with States or political subdivisions or Indian tribes; State applications, terms and conditions; reimbursements; cost-sharing provisions; enforcement requirements and procedures

(1) Cooperative agreements

(A) State applications

A State or political subdivision thereof or Indian tribe may apply to the President to carry out actions authorized in this section. If the President determines that the State or political subdivision or Indian tribe has the capability to carry out any or all of such actions in accordance with the criteria and priorities established pursuant to section 9605(a)(8) of this title and to carry out related enforcement actions, the President may enter into a contract or cooperative agreement with the State or political subdivision or

Indian tribe to carry out such actions. The President shall make a determination regarding such an application within 90 days after the President receives the application.

(B) Terms and conditions

A contract or cooperative agreement under this paragraph shall be subject to such terms and conditions as the President may prescribe. The contract or cooperative agreement may cover a specific facility or specific facilities.

(C) Reimbursements

Any State which expended funds during the period beginning September 30, 1985, and ending on October 17, 1986, for response actions at any site included on the National Priorities List and subject to a cooperative agreement under this chapter shall be reimbursed for the share of costs of such actions for which the Federal Government is responsible under this chapter.

(2) If the President enters into a cost-sharing agreement pursuant to subsection (c) of this section or a contract or cooperative agreement pursuant to this subsection, and the State or political subdivision thereof fails to comply with any requirements of the contract, the President may, after providing sixty days notice, seek in the appropriate Federal district court to enforce the contract or to recover any funds advanced or any costs incurred because of the breach of the contract by the State or political subdivision.

(3) Where a State or a political subdivision thereof is acting in behalf of the President, the President is authorized to provide technical and legal assistance in the administration and enforcement of any contract or subcontract in connection with response actions assisted under this subchapter, and to intervene in any civil action involving the enforcement of such contract or subcontract.

(4) Where two or more noncontiguous facilities are reasonably related on the basis of geography, or on the basis of the threat, or potential threat to the public health or welfare or the environment, the President may, in his discretion, treat these related facilities as one for purposes of this section.

(e) Information gathering and access

(1) Action authorized

Any officer, employee, or representative of the President, duly designated by the President, is authorized to take action under paragraph (2), (3), or (4) (or any combination thereof) at a vessel, facility, establishment, place, property, or location or, in the case of paragraph (3) or (4), at any vessel, facility, establishment, place, property, or location which is adjacent to the vessel, facility, establishment, place, property, or location referred to in such paragraph (3) or (4). Any duly designated officer, employee, or representative of a State or political subdivision under a contract or cooperative agreement under subsection (d)(1) of this section is also authorized to take such action. The authority of paragraphs (3) and (4) may be exercised only if there is a reasonable basis to believe there may be a release or threat of release of a hazardous substance or pollutant or contaminant. The authority of this subsection may be exercised only for the purposes of determining the need for response, or choosing or taking any response action under this subchapter, or otherwise enforcing the provisions of this subchapter.

(2) Access to information

Any officer, employee, or representative described in paragraph (1) may require any person who has or may have information relevant to any of the following to furnish, upon reasonable notice, information or documents relating to such matter:

(A) The identification, nature, and quantity of materials which have been or are generated, treated, stored, or disposed of at a vessel or facility or transported to a vessel or facility.

(B) The nature or extent of a release or threatened release of a hazardous substance or pollutant or contaminant at or from a vessel or facility.

(C) Information relating to the ability of a person to pay for or to perform a cleanup.

In addition, upon reasonable notice, such person either (i) shall grant any such officer, employee, or representative access at all reasonable times to any vessel, facility, establishment, place, property, or location to inspect and copy all documents or records relating to such matters or (ii) shall copy and furnish to the officer, employee, or representative all such documents or records, at the option and expense of such person.

(3) Entry

Any officer, employee, or representative described in paragraph (1) is authorized to enter at reasonable times any of the following:

(A) Any vessel, facility, establishment, or other place or property where any hazardous substance or pollutant or contaminant may be or has been generated, stored, treated, disposed of, or transported from.

(B) Any vessel, facility, establishment, or other place or property from which or to which a hazardous substance or pollutant or contaminant has been or may have been released.

(C) Any vessel, facility, establishment, or other place or property where such release is or may be threatened.

(D) Any vessel, facility, establishment, or other place or property where entry is needed to determine the need for response or the appropriate response or to effectuate a response action under this subchapter.

(4) Inspection and samples

(A) Authority

Any officer, employee or representative described in paragraph (1) is authorized to inspect and obtain samples from any vessel, facility, establishment, or other place or property referred to in paragraph (3) or from any location of any suspected hazardous substance or pollutant or contaminant. Any such officer, employee, or representative is authorized to inspect and obtain samples of any containers or labeling for suspected hazardous substances or pollutants or contaminants. Each such inspection shall be completed with reasonable promptness.

(B) Samples

If the officer, employee, or representative obtains any samples, before leaving the premises he shall give to the owner, operator, tenant, or other person in charge of the place from which the samples were obtained a receipt describing the sample obtained and, if requested, a portion of each such sample. A copy of the results of any analysis made of such samples shall be furnished promptly to the owner, operator, tenant, or other person in charge, if such person can be located.

(5) Compliance orders

(A) Issuance

If consent is not granted regarding any request made by an officer, employee, or representative under paragraph (2), (3), or (4), the President may issue an order directing compliance with the request. The order may be issued after such notice and opportunity for consultation as is reasonably appropriate under the circumstances.

(B) Compliance

The President may ask the Attorney General to commence a civil action to compel compliance with a request or order referred to in subparagraph (A). Where there is a reasonable basis to believe there may be a release or threat of a release of a hazardous substance or pollutant or contaminant, the court shall take the following actions:

(i) In the case of interference with entry or inspection, the court shall enjoin such interference or direct compliance with orders to prohibit interference with entry or inspection unless under the circumstances of the case the demand for entry or inspection is arbitrary and capricious, an abuse of discretion, or otherwise not in accordance with law.

(ii) In the case of information or document requests or orders, the court shall enjoin interference with such information or document requests or orders or direct compliance with the requests or orders to provide such information or documents unless under the circumstances of the case the demand for information or documents is arbitrary and capricious, an abuse of discretion, or otherwise not in accordance with law.

The court may assess a civil penalty not to exceed $25,000 for each day of noncompliance against any person who unreasonably fails to comply with the provisions of paragraph (2), (3), or (4) or an order issued pursuant to subparagraph (A) of this paragraph.

(6) Other authority

Nothing in this subsection shall preclude the President from securing access or obtaining information in any other lawful manner.

(7) Confidentiality of information

(A) Any records, reports, or information obtained from any person under this section (including records, reports, or information obtained by representatives of the President) shall be available to the public, except that upon a showing satisfactory to the President (or the State, as the case may be) by any person that records, reports, or information, or particular part thereof (other than health or safety effects data), to which the President (or the State, as the case may be) or any officer, employee, or representative has access under this section if made public would divulge information entitled to protection under section 1905 of Title 18, such information or particular portion thereof shall be considered confidential in accordance with the purposes of that section, except that such record, report, document or information may be disclosed to other officers, employees, or authorized representatives of the United States concerned with carrying out this chapter, or when relevant in any proceeding under this chapter.

(B) Any person not subject to the provisions of section 1905 of Title 18 who knowingly and willfully divulges or discloses any information entitled to protection under this subsection shall, upon conviction, be subject to a fine of not more than $5,000 or to imprisonment not to exceed one year, or both.

(C) In submitting data under this chapter, a person required to provide such data may (i) designate the data which such person believes is entitled to protection under this subsection and (ii) submit such designated data separately from other data submitted under this chapter. A designation under this paragraph shall be made in writing and in such manner as the President may prescribe by regulation.

(D) Notwithstanding any limitation contained in this section or any other provision of law, all information reported to or otherwise obtained by the President (or any representative of the President) under this chapter shall be made available, upon written request of any duly authorized committee of the Congress, to such committee.

(E) No person required to provide information under this chapter may claim that the information is entitled to protection under this paragraph unless such person shows each of the following:

(i) Such person has not disclosed the information to any other person, other than a member of a local emergency planning committee established under title III of the Amendments and Reauthorization Act of 1986 [42 U.S.C.A. § 11001 et seq.], an officer or employee of the United States or a State or local government, an employee of such person, or a person who is bound by a confidentiality agreement, and such person has taken reasonable measures to protect the confidentiality of such information and intends to continue to take such measures.

(ii) The information is not required to be disclosed, or otherwise made available, to the public under any other Federal or State law.

(iii) Disclosure of the information is likely to cause substantial harm to the competitive position of such person.

(iv) The specific chemical identity, if sought to be protected, is not readily discoverable through reverse engineering.

(F) The following information with respect to any hazardous substance at the facility or vessel shall not be entitled to protection under this paragraph:

(i) The trade name, common name, or generic class or category of the hazardous substance.

(ii) The physical properties of the substance, including its boiling point, melting point, flash point, specific gravity, vapor density, solubility in water, and vapor pressure at 20 degrees celsius.

(iii) The hazards to health and the environment posed by the substance, including physical hazards (such as explosion) and potential acute and chronic health hazards.

(iv) The potential routes of human exposure to the substance at the facility, establishment, place, or property being investigated, entered, or inspected under this subsection.

(v) The location of disposal of any waste stream.

(vi) Any monitoring data or analysis of monitoring data pertaining to disposal activities.

(vii) Any hydrogeologic or geologic data.

(viii) Any groundwater monitoring data.

(f) Contracts for response actions; compliance with Federal health and safety standards

In awarding contracts to any person engaged in response actions, the President or the State, in any case where it is awarding contracts pursuant to a contract entered into under subsection (d) of this section, shall require compliance with Federal health and safety standards established under section 9651(f) of this title by contractors and subcontractors as a condition of such contracts.

(g) Rates for wages and labor standards applicable to covered work

(1) All laborers and mechanics employed by contractors or subcontractors in the performance of construction, repair, or alteration work funded in whole or in part under this section shall be paid wages at rates not less than those prevailing on projects of a character similar in the locality as determined by the Secretary of Labor in accordance with sections 3141-3144, 3146, 3147 of Title 40. The President shall not approve any such funding without first obtaining adequate assurance that required labor standards will be maintained upon the construction work.

(2) The Secretary of Labor shall have, with respect to the labor standards specified in paragraph (1), the authority and functions set forth in Reorganization Plan Numbered 14 of 1950 (15 F.R. 3176; 64 Stat. 1267) and section 3145 of Title 40.

(h) Emergency procurement powers; exercise by President

Notwithstanding any other provision of law, subject to the provisions of section 9611 of this title, the President may authorize the use of such emergency procurement powers as he deems necessary to effect the purpose of this chapter. Upon determination that such procedures are necessary, the President shall promulgate regulations prescribing the circumstances under which such authority shall be used and the procedures governing the use of such authority.

(i) Agency for Toxic Substances and Disease Registry; establishment, functions, etc.

(1) There is hereby established within the Public Health Service an agency, to be known as the Agency for Toxic Substances and Disease Registry, which shall report directly to the Surgeon General of the United States. The Administrator of said Agency shall, with the cooperation of the Administrator of the Environmental Protection Agency, the Commissioner of the Food and Drug Administration, the Directors of the National Institute of Medicine, National Institute of Environmental Health Sciences, National Institute of Occupational Safety and Health, Centers for Disease Control and Prevention, the Administrator of the Occupational Safety and Health Administration, the Administrator of the Social Security Administration, the Secretary of Transportation, and appropriate State and local health officials, effectuate and implement the health related authorities of this chapter. In addition, said Administrator shall--

(A) in cooperation with the States, establish and maintain a national registry of serious diseases and illnesses and a national registry of persons exposed to toxic substances;

(B) establish and maintain inventory of literature, research, and studies on the health effects of toxic substances;

(C) in cooperation with the States, and other agencies of the Federal Government, establish and maintain a complete listing of areas closed to the public or otherwise restricted in use because of toxic substance contamination;

(D) in cases of public health emergencies caused or believed to be caused by exposure to toxic substances, provide medical care and testing to exposed individuals, including but not limited to tissue sampling, chromosomal testing where appropriate, epidemiological studies, or any other assistance appropriate under the circumstances; and

(E) either independently or as part of other health status survey, conduct periodic survey and screening programs to determine relationships between exposure to toxic substances and illness. In cases of public health emergencies, exposed persons shall be eligible for admission to hospitals and other facilities and services operated or provided by the Public Health Service.

(2)(A) Within 6 months after October 17, 1986, the Administrator of the Agency for Toxic Substances and Disease Registry (ATSDR) and the Administrator of the Environmental Protection Agency (EPA) shall prepare a list, in order of priority, of at least 100 hazardous substances which are most commonly found at facilities on the National Priorities List and which, in their sole discretion, they determine are posing the most significant potential threat to human health due to their known or suspected toxicity to humans and the potential for human exposure to such substances at facilities on the National Priorities List or at facilities to which a response to a release or a threatened release under this section is under consideration.

(B) Within 24 months after October 17, 1986, the Administrator of ATSDR and the Administrator of EPA shall revise the list prepared under subparagraph (A). Such revision shall include, in order of priority, the addition of 100 or more such hazardous substances. In each of the 3 consecutive 12-month periods that follow, the Administrator of ATSDR and the Administrator of EPA shall revise, in the same manner as provided in the 2 preceding sentences, such list to include not fewer than 25 additional hazardous substances per revision. The Administrator of ATSDR and the Administrator of EPA shall not less often than once every year thereafter revise such list to include additional hazardous substances in accordance with the criteria in subparagraph (A).

(3) Based on all available information, including information maintained under paragraph (1)(B) and data developed and collected on the health effects of hazardous substances under this paragraph, the Administrator of ATSDR shall prepare toxicological profiles of each of the substances listed pursuant to paragraph (2). The toxicological profiles shall be prepared in accordance with guidelines developed by the Administrator of ATSDR and the Administrator of EPA. Such profiles shall include, but not be limited to each of the following:

(A) An examination, summary, and interpretation of available toxicological information and epidemiologic evaluations on a hazardous substance in order to ascertain the levels of significant human exposure for the substance and the associated acute, subacute, and chronic health effects.

(B) A determination of whether adequate information on the health effects of each substance is available or in the process of development to determine levels of exposure which present a significant risk to human health of acute, subacute, and chronic health effects.

(C) Where appropriate, an identification of toxicological testing needed to identify the types or levels of exposure that may present significant risk of adverse health effects in humans.

Any toxicological profile or revision thereof shall reflect the Administrator of ATSDR's assessment of all relevant toxicological testing which has been peer reviewed. The profiles required to be prepared under this paragraph for those hazardous substances listed under subparagraph (A) of paragraph (2) shall be completed, at a rate of no fewer than 25 per year, within 4 years after October 17, 1986. A profile required on a substance listed pursuant to subparagraph (B) of paragraph (2) shall be completed within 3 years after addition to the list. The profiles prepared under this paragraph shall be of those substances highest on the list of priorities under paragraph (2) for which profiles have not previously been prepared. Profiles required under this paragraph shall be revised and republished as necessary, but no less often than once every 3 years. Such profiles shall be provided to the States and made available to other interested parties.

(4) The Administrator of the ATSDR shall provide consultations upon request on health issues relating to exposure to hazardous or toxic substances, on the basis of available information, to the Administrator of EPA, State officials, and local officials. Such consultations to individuals may be provided by States under cooperative agreements established under this chapter.

(5)(A) For each hazardous substance listed pursuant to paragraph (2), the Administrator of ATSDR (in consultation with the Administrator of EPA and other agencies and programs of the Public Health Service) shall assess whether adequate information on the health effects of such substance is available. For any such substance for which adequate information is not available (or under development), the Administrator of ATSDR, in cooperation with the Director of the National Toxicology Program, shall assure the initiation of a program of research designed to determine the health effects (and techniques for development of methods to determine such health effects) of such substance. Where feasible, such program shall seek to develop methods to determine the health effects of such substance in combination with other substances with which it is commonly found. Before assuring the initiation of such program, the Administrator of ATSDR shall consider recommendations of the Interagency Testing Committee established under section 4(e) of the Toxic Substances Control Act [15 U.S.C.A. § 2603(e)] on the types of research that should be done. Such program shall include, to the extent necessary to supplement existing information, but shall not be limited to--

(i) laboratory and other studies to determine short, intermediate, and long-term health effects;

(ii) laboratory and other studies to determine organ-specific, site-specific, and system-specific acute and chronic toxicity;

(iii) laboratory and other studies to determine the manner in which such substances are metabolized or to otherwise develop an understanding of the biokinetics of such substances; and

(iv) where there is a possibility of obtaining human data, the collection of such information.

(B) In assessing the need to perform laboratory and other studies, as required by subparagraph (A), the Administrator of ATSDR shall consider--

(i) the availability and quality of existing test data concerning the substance on the suspected health effect in question;

(ii) the extent to which testing already in progress will, in a timely fashion, provide data that will be adequate to support the preparation of toxicological profiles as required by paragraph (3); and

(iii) such other scientific and technical factors as the Administrator of ATSDR may determine are necessary for the effective implementation of this subsection.

(C) In the development and implementation of any research program under this paragraph, the Administrator of ATSDR and the Administrator of EPA shall coordinate such research program implemented under this paragraph with the National Toxicology Program and with programs of toxicological testing established under the Toxic Substances Control Act [15 U.S.C.A. § 2601 et seq.] and the Federal Insecticide, Fungicide and Rodenticide Act [7 U.S.C.A. § 136 et seq.]. The purpose of such coordination shall be to avoid duplication of effort and to assure that the hazardous substances listed pursuant to this subsection are tested thoroughly at the earliest practicable date. Where appropriate, consistent with such purpose, a research program under this paragraph may be carried out using such programs of toxicological testing.

(D) It is the sense of the Congress that the costs of research programs under this paragraph be borne by the manufacturers and processors of the hazardous substance in question, as required in programs of toxicological testing under the Toxic Substances Control Act [15 U.S.C.A. § 2601 et seq.]. Within 1 year after October 17, 1986, the Administrator of EPA shall promulgate regulations which provide, where appropriate, for payment of such costs by manufacturers and processors under the Toxic Substances Control Act, and registrants under the Federal Insecticide, Fungicide, and Rodenticide Act [7 U.S.C.A. § 136 et seq.], and recovery of such costs from responsible parties under this chapter.

(6)(A) The Administrator of ATSDR shall perform a health assessment for each facility on the National Priorities List established under section 9605 of this title. Such health assessment shall be completed not later than December 10, 1988, for each facility proposed for inclusion on such list prior to October 17, 1986, or not later than one year after the date of proposal for inclusion on such list for each facility proposed for inclusion on such list after October 17, 1986.

(B) The Administrator of ATSDR may perform health assessments for releases or facilities where individual persons or licensed physicians provide information that individuals have been exposed to a hazardous substance, for which the probable source of such exposure is a release. In addition to other methods (formal or informal) of providing such information, such individual persons or licensed physicians may submit a petition to the Administrator of ATSDR providing such information and requesting a health assessment. If such a petition is submitted and the Administrator of ATSDR does not initiate a health assessment, the Administrator of ATSDR shall provide a written explanation of why a health assessment is not appropriate.

(C) In determining the priority in which to conduct health assessments under this subsection, the Administrator of ATSDR, in consultation with the Administrator of EPA, shall give priority to those facilities at which there is documented evidence of the release of hazardous substances, at which the potential risk to human health appears highest, and for which in the judgment of the Administrator of ATSDR existing health assessment data are inadequate to assess the potential risk to human health as provided in subparagraph (F). In determining the priorities for conducting health assessments under this subsection, the Administrator of ATSDR shall consider the National Priorities List schedules and the needs of the Environmental Protection Agency and other Federal agencies pursuant to schedules for remedial investigation and feasibility studies.

(D) Where a health assessment is done at a site on the National Priorities List, the Administrator of ATSDR shall complete such assessment promptly and, to the maximum extent practicable, before the completion of the remedial investigation and feasibility study at the facility concerned.

(E) Any State or political subdivision carrying out a health assessment for a facility shall report the results of the assessment to the Administrator of ATSDR and the Administrator of EPA and shall include recommendations with respect to further activities which need to be carried out under this section. The Administrator of ATSDR shall state such recommendation in any report on the results of any assessment carried out directly by the Administrator of ATSDR for such facility and shall issue periodic reports which include the results of all the assessments carried out under this subsection.

(F) For the purposes of this subsection and section 9611(c)(4) of this title, the term “health assessments” shall include preliminary assessments of the potential risk to human health posed by individual sites and facilities, based on such factors as the nature and extent of contamination, the existence of potential pathways of human exposure (including ground or surface water contamination, air emissions, and food chain contamination), the size and potential susceptibility of the community within the likely pathways of exposure, the comparison of expected human exposure levels to the short-term and long-term health effects associated with identified hazardous substances and any available recommended exposure or tolerance limits for such hazardous substances, and the comparison of existing morbidity and mortality data on diseases that may be associated with the observed levels of exposure. The Administrator of ATSDR shall use appropriate data, risk assessments, risk evaluations and studies available from the Administrator of EPA.

(G) The purpose of health assessments under this subsection shall be to assist in determining whether actions under paragraph (11) of this subsection should be taken to reduce human exposure to hazardous substances from a facility and whether additional information on human exposure and associated health risks is needed and should be acquired by conducting epidemiological studies under paragraph (7), establishing a registry under paragraph (8), establishing a health surveillance program under paragraph (9), or through other means. In using the results of health assessments for determining additional actions to be taken under this section, the Administrator of ATSDR may consider additional information on the risks to the potentially affected population from all sources of such hazardous substances including known point or nonpoint sources other than those from the facility in question.

(H) At the completion of each health assessment, the Administrator of ATSDR shall provide the Administrator of EPA and each affected State with the results of such assessment, together with any recommendations for further actions under this subsection or otherwise under this chapter. In addition, if the health assessment indicates that the release or threatened release concerned may pose a serious threat to human health or the environment, the Administrator of ATSDR shall so notify the Administrator of EPA who shall promptly evaluate such release or threatened release in accordance with the hazard ranking system referred to in section 9605(a)(8)(A) of this title to determine whether the site shall be placed on the National Priorities List or, if the site is already on the list, the Administrator of ATSDR may recommend to the Administrator of EPA that the site be accorded a higher priority.

(7)(A) Whenever in the judgment of the Administrator of ATSDR it is appropriate on the basis of the results of a health assessment, the Administrator of ATSDR shall conduct a pilot study of health effects for selected groups of exposed individuals in order to determine the desirability of conducting full scale epidemiological or other health studies of the entire exposed population.

(B) Whenever in the judgment of the Administrator of ATSDR it is appropriate on the basis of the results of such pilot study or other study or health assessment, the Administrator of ATSDR shall conduct such full scale epidemiological or other health studies as may be necessary to determine the health effects on the population exposed to hazardous substances from a release or threatened release. If a significant excess of disease in a population is identified, the letter of transmittal of such study shall include an assessment of other risk factors, other than a release, that may, in the judgment of the peer review group, be associated with such disease, if such risk factors were not taken into account in the design or conduct of the study.

(8) In any case in which the results of a health assessment indicate a potential significant risk to human health, the Administrator of ATSDR shall consider whether the establishment of a registry of exposed persons would contribute to accomplishing the purposes of this subsection, taking into account circumstances bearing on the usefulness of such a registry, including the seriousness or unique character of identified diseases or the likelihood of population migration from the affected area.

(9) Where the Administrator of ATSDR has determined that there is a significant increased risk of adverse health effects in humans from exposure to hazardous substances based on the results of a health assessment conducted under paragraph (6), an epidemiologic study conducted under paragraph (7), or an exposure registry that has been established under paragraph (8), and the Administrator of ATSDR has determined that such exposure is the result of a release from a facility, the Administrator of ATSDR shall initiate a health surveillance program for such population. This program shall include but not be limited to--

(A) periodic medical testing where appropriate of population subgroups to screen for diseases for which the population or subgroup is at significant increased risk; and

(B) a mechanism to refer for treatment those individuals within such population who are screened positive for such diseases.

(10) Two years after October 17, 1986, and every 2 years thereafter, the Administrator of ATSDR shall prepare and submit to the Administrator of EPA and to the Congress a report on the results of the activities of ATSDR regarding--

(A) health assessments and pilot health effects studies conducted;

(B) epidemiologic studies conducted;

(C) hazardous substances which have been listed under paragraph (2), toxicological profiles which have been developed, and toxicologic testing which has been conducted or which is being conducted under this subsection;

(D) registries established under paragraph (8); and

(E) an overall assessment, based on the results of activities conducted by the Administrator of ATSDR, of the linkage between human exposure to individual or combinations of hazardous substances due to releases from facilities covered by this chapter or the Solid Waste Disposal Act [42 U.S.C.A. § 6901 et seq.] and any increased incidence or prevalence of adverse health effects in humans.

(11) If a health assessment or other study carried out under this subsection contains a finding that the exposure concerned presents a significant risk to human health, the President shall take such steps as may be necessary to reduce such exposure and eliminate or substantially mitigate the significant risk to human health. Such steps may include the use of any authority under this chapter, including, but not limited to--

(A) provision of alternative water supplies, and

(B) permanent or temporary relocation of individuals.

In any case in which information is insufficient, in the judgment of the Administrator of ATSDR or the President to determine a significant human exposure level with respect to a hazardous substance, the President may take such steps as may be necessary to reduce the exposure of any person to such hazardous substance to such level as the President deems necessary to protect human health.

(12) In any case which is the subject of a petition, a health assessment or study, or a research program under this subsection, nothing in this subsection shall be construed to delay or otherwise affect or impair the authority of the President, the Administrator of ATSDR, or the Administrator of EPA to exercise any authority vested in the President, the Administrator of ATSDR or the Administrator of EPA under any other provision of law (including, but not limited to, the imminent hazard authority of section 7003 of the Solid Waste Disposal Act [42 U.S.C.A. § 6973]) or the response and abatement authorities of this chapter.

(13) All studies and results of research conducted under this subsection (other than health assessments) shall be reported or adopted only after appropriate peer review. Such peer review shall be completed, to the maximum extent practicable, within a period of 60 days. In the case of research conducted under the National Toxicology Program, such peer review may be conducted by the Board of Scientific Counselors. In the case of other research, such peer review shall be conducted by panels consisting of no less than three nor more than seven members, who shall be disinterested scientific experts selected for such purpose by the Administrator of ATSDR or the Administrator of EPA, as appropriate, on the basis of their reputation for scientific objectivity and the lack of institutional ties with any person involved in the conduct of the study or research under review. Support services for such panels shall be provided by the Agency for Toxic Substances and Disease Registry, or by the Environmental Protection Agency, as appropriate.

(14) In the implementation of this subsection and other health-related authorities of this chapter, the Administrator of ATSDR shall assemble, develop as necessary, and distribute to the States, and upon request to medical colleges, physicians, and other health professionals, appropriate educational materials (including short courses) on the medical surveillance, screening, and methods of diagnosis and treatment of injury or disease related to exposure to hazardous substances (giving priority to those listed in paragraph (2)), through such means as the Administrator of ATSDR deems appropriate.

(15) The activities of the Administrator of ATSDR described in this subsection and section 9611(c)(4) of this title shall be carried out by the Administrator of ATSDR, either directly or through cooperative agreements with States (or political subdivisions thereof) which the Administrator of ATSDR determines are capable of carrying out such activities. Such activities shall include provision of consultations on health information, the conduct of health assessments, including those required under section 3019(b) of the Solid Waste Disposal Act [42 U.S.C.A. § 6939a(b)], health studies, registries, and health surveillance.

(16) The President shall provide adequate personnel for ATSDR, which shall not be fewer than 100 employees. For purposes of determining the number of employees under this subsection, an employee employed by ATSDR on a part-time career employment basis shall be counted as a fraction which is determined by dividing 40 hours into the average number of hours of such employee's regularly scheduled workweek.

(17) In accordance with section 9620 of this title (relating to Federal facilities), the Administrator of ATSDR shall have the same authorities under this section with respect to facilities owned or operated by a department, agency, or instrumentality of the United States as the Administrator of ATSDR has with respect to any nongovernmental entity.

(18) If the Administrator of ATSDR determines that it is appropriate for purposes of this section to treat a pollutant or contaminant as a hazardous substance, such pollutant or contaminant shall be treated as a hazardous substance for such purpose.

(j) Acquisition of property

(1) Authority

The President is authorized to acquire, by purchase, lease, condemnation, donation, or otherwise, any real property or any interest in real property that the President in his discretion determines is needed to conduct a remedial action under this chapter. There shall be no cause of action to compel the President to acquire any interest in real property under this chapter.

(2) State assurance

The President may use the authority of paragraph (1) for a remedial action only if, before an interest in real estate is acquired under this subsection, the State in which the interest to be acquired is located assures the President, through a contract or cooperative agreement or otherwise, that the State will accept transfer of the interest following completion of the remedial action.

(3) Exemption

No Federal, State, or local government agency shall be liable under this chapter solely as a result of acquiring an interest in real estate under this subsection.

(k) Brownfields revitalization funding

(1) Definition of eligible entity

In this subsection, the term “eligible entity” means--

(A) a general purpose unit of local government;

(B) a land clearance authority or other quasi-governmental entity that operates under the supervision and control of or as an agent of a general purpose unit of local government;

(C) a government entity created by a State legislature;

(D) a regional council or group of general purpose units of local government;

(E) a redevelopment agency that is chartered or otherwise sanctioned by a State;

(F) a State;

(G) an Indian Tribe other than in Alaska; or

(H) an Alaska Native Regional Corporation and an Alaska Native Village Corporation as those terms are defined in the Alaska Native Claims Settlement Act (43 U.S.C. 1601 and following) and the Metlakatla Indian community.

(2) Brownfield site characterization and assessment grant program

(A) Establishment of program

The Administrator shall establish a program to--

(i) provide grants to inventory, characterize, assess, and conduct planning related to brownfield sites under subparagraph (B); and

(ii) perform targeted site assessments at brownfield sites.

(B) Assistance for site characterization and assessment

(i) In general

On approval of an application made by an eligible entity, the Administrator may make a grant to the eligible entity to be used for programs to inventory, characterize, assess, and conduct planning related to one or more brownfield sites.

(ii) Site characterization and assessment

A site characterization and assessment carried out with the use of a grant under clause (i) shall be performed in accordance with section 9601(35)(B) of this title.

(3) Grants and loans for brownfield remediation

(A) Grants provided by the President

Subject to paragraphs (4) and (5), the President shall establish a program to provide grants to--

(i) eligible entities, to be used for capitalization of revolving loan funds; and

(ii) eligible entities or nonprofit organizations, where warranted, as determined by the President based on considerations under subparagraph (C), to be used directly for remediation of one or more brownfield sites owned by the entity or organization that receives the grant and in amounts not to exceed $200,000 for each site to be remediated.

(B) Loans and grants provided by eligible entities

An eligible entity that receives a grant under subparagraph (A)(i) shall use the grant funds to provide assistance for the remediation of brownfield sites in the form of--

(i) one or more loans to an eligible entity, a site owner, a site developer, or another person; or

(ii) one or more grants to an eligible entity or other nonprofit organization, where warranted, as determined by the eligible entity that is providing the assistance, based on considerations under subparagraph (C), to remediate sites owned by the eligible entity or nonprofit organization that receives the grant.

(C) Considerations

In determining whether a grant under subparagraph (A)(ii) or (B)(ii) is warranted, the President or the eligible entity, as the case may be, shall take into consideration--

(i) the extent to which a grant will facilitate the creation of, preservation of, or addition to a park, a greenway, undeveloped property, recreational property, or other property used for nonprofit purposes;

(ii) the extent to which a grant will meet the needs of a community that has an inability to draw on other sources of funding for environmental remediation and subsequent redevelopment of the area in which a brownfield site is located because of the small population or low income of the community;

(iii) the extent to which a grant will facilitate the use or reuse of existing infrastructure;

(iv) the benefit of promoting the long-term availability of funds from a revolving loan fund for brownfield remediation; and

(v) such other similar factors as the Administrator considers appropriate to consider for the purposes of this subsection.

(D) Transition

Revolving loan funds that have been established before the date of the enactment of this subsection may be used in accordance with this paragraph.

(4) General provisions

(A) Maximum grant amount

(i) Brownfield site characterization and assessment

(I) In general

A grant under paragraph (2) may be awarded to an eligible entity on a community-wide or site-by-site basis, and shall not exceed, for any individual brownfield site covered by the grant, $200,000.

(II) Waiver

The Administrator may waive the $200,000 limitation under subclause (I) to permit the brownfield site to receive a grant of not to exceed $350,000, based on the anticipated level of contamination, size, or status of ownership of the site.

(ii) Brownfield remediation

A grant under paragraph (3)(A)(i) may be awarded to an eligible entity on a community-wide or site-by-site basis, not to exceed $1,000,000 per eligible entity. The Administrator may make an additional grant to an eligible entity described in the previous sentence for any year after the year for which the initial grant is made, taking into consideration--

(I) the number of sites and number of communities that are addressed by the revolving loan fund;

(II) the demand for funding by eligible entities that have not previously received a grant under this subsection;

(III) the demonstrated ability of the eligible entity to use the revolving loan fund to enhance remediation and provide funds on a continuing basis; and

(IV) such other similar factors as the Administrator considers appropriate to carry out this subsection.

(B) Prohibition

(i) In general

No part of a grant or loan under this subsection may be used for the payment of--

(I) a penalty or fine;

(II) a Federal cost-share requirement;

(III) an administrative cost;

(IV) a response cost at a brownfield site for which the recipient of the grant or loan is potentially liable under section 9607 of this title; or

(V) a cost of compliance with any Federal law (including a Federal law specified in section 9601(39)(B) of this title), excluding the cost of compliance with laws applicable to the cleanup.

(ii) Exclusions

For the purposes of clause (i)(III), the term ‘administrative cost’ does not include the cost of--

(I) investigation and identification of the extent of contamination;

(II) design and performance of a response action; or

(III) monitoring of a natural resource.

(iii) Exception

Notwithstanding clause (i)(IV), the Administrator may use up to 25 percent of the funds made available to carry out this subsection to make a grant or loan under this subsection to eligible entities that satisfy all of the elements set forth in section 9601(40) of this title to qualify as a bona fide prospective purchaser, except that the date of acquisition of the property was on or before January 11, 2002.

(C) Assistance for development of local government site remediation programs

A local government that receives a grant under this subsection may use not to exceed 10 percent of the grant funds to develop and implement a brownfields program that may include--

(i) monitoring the health of populations exposed to one or more hazardous substances from a brownfield site; and

(ii) monitoring and enforcement of any institutional control used to prevent human exposure to any hazardous substance from a brownfield site.

(D) Insurance

A recipient of a grant or loan awarded under paragraph (2) or (3) that performs a characterization, assessment, or remediation of a brownfield site may use a portion of the grant or loan to purchase insurance for the characterization, assessment, or remediation of that site.

(5) Grant applications

(A) Submission

(i) In general

(I) Application

An eligible entity may submit to the Administrator, through a regional office of the Environmental Protection Agency and in such form as the Administrator may require, an application for a grant under this subsection for one or more brownfield sites (including information on the criteria used by the Administrator to rank applications under subparagraph (C), to the extent that the information is available).

(II) NCP requirements

The Administrator may include in any requirement for submission of an application under subclause (I) a requirement of the National Contingency Plan only to the extent that the requirement is relevant and appropriate to the program under this subsection.

(ii) Coordination

The Administrator shall coordinate with other Federal agencies to assist in making eligible entities aware of other available Federal resources.

(iii) Guidance

The Administrator shall publish guidance to assist eligible entities in applying for grants under this subsection.

(B) Approval

The Administrator shall--

(i) at least annually, complete a review of applications for grants that are received from eligible entities under this subsection; and

(ii) award grants under this subsection to eligible entities that the Administrator determines have the highest rankings under the ranking criteria established under subparagraph (C).

(C) Ranking criteria

The Administrator shall establish a system for ranking grant applications received under this paragraph that includes the following criteria:

(i) The extent to which a grant will stimulate the availability of other funds for environmental assessment or remediation, and subsequent reuse, of an area in which one or more brownfield sites are located.

(ii) The potential of the proposed project or the development plan for an area in which one or more brownfield sites are located to stimulate economic development of the area on completion of the cleanup.

(iii) The extent to which a grant would address or facilitate the identification and reduction of threats to human health and the environment, including threats in areas in which there is a greater-than-normal incidence of diseases or conditions (including cancer, asthma, or birth defects) that may be associated with exposure to hazardous substances, pollutants, or contaminants.

(iv) The extent to which a grant would facilitate the use or reuse of existing infrastructure.

(v) The extent to which a grant would facilitate the creation of, preservation of, or addition to a park, a greenway, undeveloped property, recreational property, or other property used for nonprofit purposes.

(vi) The extent to which a grant would meet the needs of a community that has an inability to draw on other sources of funding for environmental remediation and subsequent redevelopment of the area in which a brownfield site is located because of the small population or low income of the community.

(vii) The extent to which the applicant is eligible for funding from other sources.

(viii) The extent to which a grant will further the fair distribution of funding between urban and nonurban areas.

(ix) The extent to which the grant provides for involvement of the local community in the process of making decisions relating to cleanup and future use of a brownfield site.

(x) The extent to which a grant would address or facilitate the identification and reduction of threats to the health or welfare of children, pregnant women, minority or low-income communities, or other sensitive populations.

(6) Implementation of brownfields programs

(A) Establishment of program

The Administrator may provide, or fund eligible entities or nonprofit organizations to provide, training, research, and technical assistance to individuals and organizations, as appropriate, to facilitate the inventory of brownfield sites, site assessments, remediation of brownfield sites, community involvement, or site preparation.

(B) Funding restrictions

The total Federal funds to be expended by the Administrator under this paragraph shall not exceed 15 percent of the total amount appropriated to carry out this subsection in any fiscal year.

(7) Audits

(A) In general

The Inspector General of the Environmental Protection Agency shall conduct such reviews or audits of grants and loans under this subsection as the Inspector General considers necessary to carry out this subsection.

(B) Procedure

An audit under this subparagraph shall be conducted in accordance with the auditing procedures of the Government Accountability Office, including chapter 75 of Title 31, United States Code.

(C) Violations

If the Administrator determines that a person that receives a grant or loan under this subsection has violated or is in violation of a condition of the grant, loan, or applicable Federal law, the Administrator may--

(i) terminate the grant or loan;

(ii) require the person to repay any funds received; and

(iii) seek any other legal remedies available to the Administrator.

(D) Report to Congress

Not later than 3 years after the date of the enactment of this subsection, the Inspector General of the Environmental Protection Agency shall submit to Congress a report that provides a description of the management of the program (including a description of the allocation of funds under this subsection).

(8) Leveraging

An eligible entity that receives a grant under this subsection may use the grant funds for a portion of a project at a brownfield site for which funding is received from other sources if the grant funds are used only for the purposes described in paragraph (2) or (3).

(9) Agreements

Each grant or loan made under this subsection shall--

(A) include a requirement of the National Contingency Plan only to the extent that the requirement is relevant and appropriate to the program under this subsection, as determined by the Administrator; and

(B) be subject to an agreement that--

(i) requires the recipient to--

(I) comply with all applicable Federal and State laws; and

(II) ensure that the cleanup protects human health and the environment;

(ii) requires that the recipient use the grant or loan exclusively for purposes specified in paragraph (2) or (3), as applicable;

(iii) in the case of an application by an eligible entity under paragraph (3)(A), requires the eligible entity to pay a matching share (which may be in the form of a contribution of labor, material, or services) of at least 20 percent, from non-Federal sources of funding, unless the Administrator determines that the matching share would place an undue hardship on the eligible entity; and

(iv) contains such other terms and conditions as the Administrator determines to be necessary to carry out this subsection.

(10) Facility other than brownfield site

The fact that a facility may not be a brownfield site within the meaning of section 9601(39)(A) of this title has no effect on the eligibility of the facility for assistance under any other provision of Federal law.

(11) Effect on Federal laws

Nothing in this subsection affects any liability or response authority under any Federal law, including--

(A) this chapter (including the last sentence of section 9601(14) of this title);

(B) the Solid Waste Disposal Act (42 U.S.C. 6901 et seq.);

(C) the Federal Water Pollution Control Act (33 U.S.C. 1251 et seq.);

(D) the Toxic Substances Control Act (15 U.S.C. 2601 et seq.); and

(E) the Safe Drinking Water Act (42 U.S.C. 300f et seq.).

(12) Funding

(A) Authorization of appropriations

There is authorized to be appropriated to carry out this subsection $200,000,000 for each of fiscal years 2002 through 2006.

(B) Use of certain funds

Of the amount made available under subparagraph (A), $50,000,000, or, if the amount made available is less than $200,000,000, 25 percent of the amount made available, shall be used for site characterization, assessment, and remediation of facilities described in section 9601(39)(D)(ii)(II) of this title.

[FN1] So in original. Probably should be followed by a comma.

§ 9605. National contingency plan **[CERCLA Section 105]**

(a) Revision and republication

Within one hundred and eighty days after December 11, 1980, the President shall, after notice and opportunity for public comments, revise and republish the national contingency plan for the removal of oil and hazardous substances, originally prepared and published pursuant to section 1321 of Title 33, to reflect and effectuate the responsibilities and powers created by this chapter, in addition to those matters specified in section 1321(c)(2) of Title 33. Such revision shall include a section of the plan to be known as the national hazardous substance response plan which shall establish procedures and standards for responding to releases of hazardous substances, pollutants, and contaminants, which shall include at a minimum:

(1) methods for discovering and investigating facilities at which hazardous substances have been disposed of or otherwise come to be located;

(2) methods for evaluating, including analyses of relative cost, and remedying any releases or threats of releases from facilities which pose substantial danger to the public health or the environment;

(3) methods and criteria for determining the appropriate extent of removal, remedy, and other measures authorized by this chapter;

(4) appropriate roles and responsibilities for the Federal, State, and local governments and for interstate and nongovernmental entities in effectuating the plan;

(5) provision for identification, procurement, maintenance, and storage of response equipment and supplies;

(6) a method for and assignment of responsibility for reporting the existence of such facilities which may be located on federally owned or controlled properties and any releases of hazardous substances from such facilities;

(7) means of assuring that remedial action measures are cost-effective over the period of potential exposure to the hazardous substances or contaminated materials;

(8)(A) criteria for determining priorities among releases or threatened releases throughout the United States for the purpose of taking remedial action and, to the extent practicable taking into account the potential urgency of such action, for the purpose of taking removal action. Criteria and priorities under this paragraph shall be based upon relative risk or danger to public health or welfare or the environment, in the judgment of the President, taking into account to the extent possible the population at risk, the hazard potential of the hazardous substances at such facilities, the potential for contamination of drinking water supplies, the potential for direct human contact, the potential for destruction of sensitive ecosystems, the damage to natural resources which may affect the human food chain and which is associated with any release or threatened release, the contamination or potential contamination of the ambient air which is associated with the release or threatened release, State preparedness to assume State costs and responsibilities, and other appropriate factors;

(B) based upon the criteria set forth in subparagraph (A) of this paragraph, the President shall list as part of the plan national priorities among the known releases or threatened releases throughout the United States and shall revise the list no less often than annually. Within one year after December 11, 1980, and annually thereafter, each State shall establish and submit for consideration by the President priorities for remedial action among known releases and potential releases in that State based upon the criteria set forth in subparagraph (A) of this paragraph. In assembling or revising the national list, the President shall consider any priorities established by the States. To the extent practicable, the highest priority facilities shall be designated individually and shall be referred to as the “top priority among known response targets”, and, to the extent practicable, shall include among the one hundred highest priority facilities one such facility from each State which shall be the facility designated by the State as presenting the greatest danger to public health or welfare or the environment among the known facilities in such State. A State shall be allowed to designate its highest priority facility only once. Other priority facilities or incidents may be listed singly or grouped for response priority purposes;

(9) specified roles for private organizations and entities in preparation for response and in responding to releases of hazardous substances, including identification of appropriate qualifications and capacity therefor and including consideration of minority firms in accordance with subsection (f) of this section; and

(10) standards and testing procedures by which alternative or innovative treatment technologies can be determined to be appropriate for utilization in response actions authorized by this chapter.

The plan shall specify procedures, techniques, materials, equipment, and methods to be employed in identifying, removing, or remedying releases of hazardous substances comparable to those required under section 1321(c)(2)(F) and (G) and (j)(1) of Title 33. Following publication of the revised national contingency plan, the response to and actions to minimize damage from hazardous substances releases shall, to the greatest extent possible, be in accordance with the provisions of the plan. The President may, from time to time, revise and republish the national contingency plan.

(b) Revision of plan

Not later than 18 months after the enactment of the Superfund Amendments and Reauthorization Act of 1986 [October 17, 1986], the President shall revise the National Contingency Plan to reflect the requirements of such amendments. The portion of such Plan known as “the National Hazardous Substance Response Plan” shall be revised to provide procedures and standards for remedial actions undertaken pursuant to this chapter which are consistent with amendments made by the Superfund Amendments and Reauthorization Act of 1986 relating to the selection of remedial action.

(c) Hazard ranking system

(1) Revision

Not later than 18 months after October 17, 1986, and after publication of notice and opportunity for submission of comments in accordance with section 553 of Title 5, the President shall by rule promulgate amendments to the hazard ranking system in effect on September 1, 1984. Such amendments shall assure, to the maximum extent feasible, that the hazard ranking system accurately assesses the relative degree of risk to human health and the environment posed by sites and facilities subject to review. The President shall establish an effective date for the amended hazard ranking system which is not later than 24 months after October 17, 1986. Such amended hazard ranking system shall be applied to any site or facility to be newly listed on the National Priorities List after the effective date established by the President. Until such effective date of the regulations, the hazard ranking system in effect on September 1, 1984, shall continue in full force and effect.

(2) Health assessment of water contamination risks

In carrying out this subsection, the President shall ensure that the human health risks associated with the contamination or potential contamination (either directly or as a result of the runoff of any hazardous substance or pollutant or contaminant from sites or facilities) of surface water are appropriately assessed where such surface water is, or can be, used for recreation or potable water consumption. In making the assessment required pursuant to the preceding sentence, the President shall take into account the potential migration of any hazardous substance or pollutant or contaminant through such surface water to downstream sources of drinking water.

(3) Reevaluation not required

The President shall not be required to reevaluate, after October 17, 1986, the hazard ranking of any facility which was evaluated in accordance with the criteria under this section before the effective date of the amendments to the hazard ranking system under this subsection and which was assigned a national priority under the National Contingency Plan.

(4) New information

Nothing in paragraph (3) shall preclude the President from taking new information into account in undertaking response actions under this chapter.

(d) Petition for assessment of release

Any person who is, or may be, affected by a release or threatened release of a hazardous substance or pollutant or contaminant, may petition the President to conduct a preliminary assessment of the hazards to public health and the environment which are associated with such release or threatened release. If the President has not previously conducted a preliminary assessment of such release, the President shall, within 12 months after the receipt of any such petition, complete such assessment or provide an explanation of why the assessment is not appropriate. If the preliminary assessment indicates that the release or threatened release concerned may pose a threat to human health or the environment, the President shall promptly evaluate such release or threatened release in accordance with the hazard ranking system referred to in paragraph (8)(A) of subsection (a) of this section to determine the national priority of such release or threatened release.

(e) Releases from earlier sites

Whenever there has been, after January 1, 1985, a significant release of hazardous substances or pollutants or contaminants from a site which is listed by the President as a “Site Cleaned Up To Date” on the National Priorities List (revised edition, December 1984) the site shall be restored to the National Priorities List, without application of the hazard ranking system.

(f) Minority contractors

In awarding contracts under this chapter, the President shall consider the availability of qualified minority firms. The President shall describe, as part of any annual report submitted to the Congress under this chapter, the participation of minority firms in contracts carried out under this chapter. Such report shall contain a brief description of the contracts which have been awarded to minority firms under this chapter and of the efforts made by the President to encourage the participation of such firms in programs carried out under this chapter.

(g) Special study wastes

(1) Application

This subsection applies to facilities--

(A) which as of October 17, 1986, were not included on, or proposed for inclusion on, the National Priorities List; and

(B) at which special study wastes described in paragraph (2), (3)(A)(ii) or (3)(A)(iii) of section 6921(b) of this title are present in significant quantities, including any such facility from which there has been a release of a special study waste.

(2) Considerations in adding facilities to NPL

Pending revision of the hazard ranking system under subsection (c) of this section, the President shall consider each of the following factors in adding facilities covered by this section to the National Priorities List:

(A) The extent to which hazard ranking system score for the facility is affected by the presence of any special study waste at, or any release from, such facility.

(B) Available information as to the quantity, toxicity, and concentration of hazardous substances that are constituents of any special study waste at, or released from such facility, the extent of or potential for release of such hazardous constituents, the exposure or potential exposure to human population and the environment, and the degree of hazard to human health or the environment posed by the release of such hazardous constituents at such facility. This subparagraph refers only to available information on actual concentrations of hazardous substances and not on the total quantity of special study waste at such facility.

(3) Savings provisions

Nothing in this subsection shall be construed to limit the authority of the President to remove any facility which as of October 17, 1986, is included on the National Priorities

List from such List, or not to list any facility which as of such date is proposed for inclusion on such list.

(4) Information gathering and analysis

Nothing in this chapter shall be construed to preclude the expenditure of monies from the Fund for gathering and analysis of information which will enable the President to consider the specific factors required by paragraph (2).

(h) NPL deferral

(1) Deferral to State voluntary cleanups

At the request of a State and subject to paragraphs (2) and (3), the President generally shall defer final listing of an eligible response site on the National Priorities List if the President determines that--

(A) the State, or another party under an agreement with or order from the State, is conducting a response action at the eligible response site--

(i) in compliance with a State program that specifically governs response actions for the protection of public health and the environment; and

(ii) that will provide long-term protection of human health and the environment; or

(B) the State is actively pursuing an agreement to perform a response action described in subparagraph (A) at the site with a person that the State has reason to believe is capable of conducting a response action that meets the requirements of subparagraph (A).

(2) Progress toward cleanup

If, after the last day of the 1-year period beginning on the date on which the President proposes to list an eligible response site on the National Priorities List, the President determines that the State or other party is not making reasonable progress toward completing a response action at the eligible response site, the President may list the eligible response site on the National Priorities List.

(3) Cleanup agreements

With respect to an eligible response site under paragraph (1)(B), if, after the last day of the 1-year period beginning on the date on which the President proposes to list the eligible response site on the National Priorities List, an agreement described in paragraph (1)(B) has not been reached, the President may defer the listing of the eligible response site on the National Priorities List for an additional period of not to exceed 180 days if the President determines deferring the listing would be appropriate based on--

(A) the complexity of the site;

(B) substantial progress made in negotiations; and

(C) other appropriate factors, as determined by the President.

(4) Exceptions

The President may decline to defer, or elect to discontinue a deferral of, a listing of an eligible response site on the National Priorities List if the President determines that--

(A) deferral would not be appropriate because the State, as an owner or operator or a significant contributor of hazardous substances to the facility, is a potentially responsible party;

(B) the criteria under the National Contingency Plan for issuance of a health advisory have been met; or

(C) the conditions in paragraphs (1) through (3), as applicable, are no longer being met.

§ 9606. Abatement actions [CERCLA Section 106]

(a) Maintenance, jurisdiction, etc.

In addition to any other action taken by a State or local government, when the President determines that there may be an imminent and substantial endangerment to the public health or welfare or the environment because of an actual or threatened release of a hazardous substance from a facility, he may require the Attorney General of the United States to secure such relief as may be necessary to abate such danger or threat, and the district court of the United States in the district in which the threat occurs shall have jurisdiction to grant such relief as the public interest and the equities of the case may require. The President may also, after notice to the affected State, take other action under this section including, but not limited to, issuing such orders as may be necessary to protect public health and welfare and the environment.

(b) Fines; reimbursement

(1) Any person who, without sufficient cause, willfully violates, or fails or refuses to comply with, any order of the President under subsection (a) of this section may, in an action brought in the appropriate United States district court to enforce such order, be fined not more than $25,000 for each day in which such violation occurs or such failure to comply continues.

(2)(A) Any person who receives and complies with the terms of any order issued under subsection (a) of this section may, within 60 days after completion of the required action, petition the President for reimbursement from the Fund for the reasonable costs of such action, plus interest. Any interest payable under this paragraph shall accrue on the amounts expended from the date of expenditure at the same rate as specified for interest on investments of the Hazardous Substance Superfund established under subchapter A of chapter 98 of Title 26.

(B) If the President refuses to grant all or part of a petition made under this paragraph, the petitioner may within 30 days of receipt of such refusal file an action against the President in the appropriate United States district court seeking reimbursement from the Fund.

(C) Except as provided in subparagraph (D), to obtain reimbursement, the petitioner shall establish by a preponderance of the evidence that it is not liable for response costs under section 9607(a) of this title and that costs for which it seeks reimbursement are reasonable in light of the action required by the relevant order.

(D) A petitioner who is liable for response costs under section 9607(a) of this title may also recover its reasonable costs of response to the extent that it can demonstrate, on the administrative record, that the President's decision in selecting the response action ordered was arbitrary and capricious or was otherwise not in accordance with law. Reimbursement awarded under this subparagraph shall include all reasonable response costs incurred by the petitioner pursuant to the portions of the order found to be arbitrary and capricious or otherwise not in accordance with law.

(E) Reimbursement awarded by a court under subparagraph (C) or (D) may include appropriate costs, fees, and other expenses in accordance with subsections (a) and (d) of section 2412 of Title 28.

(c) Guidelines for using imminent hazard, enforcement, and emergency response authorities; promulgation by Administrator of EPA, scope, etc.

Within one hundred and eighty days after December 11, 1980, the Administrator of the Environmental Protection Agency shall, after consultation with the Attorney General, establish and publish guidelines for using the imminent hazard, enforcement, and emergency response authorities of this section and other existing statutes administered by the Administrator of the Environmental Protection Agency to effectuate the responsibilities and powers created by this chapter. Such guidelines shall to the extent practicable be consistent with the national hazardous substance response plan, and shall include, at a minimum, the assignment of responsibility for coordinating response actions with the issuance of administrative orders, enforcement of standards and permits, the gathering of information, and other imminent hazard and emergency powers authorized by (1) sections 1321(c)(2), 1318, 1319, and 1364(a) of Title 33, (2) sections 6927, 6928, 6934, and 6973 of this title, (3) sections 300j-4 and 300i of this title, (4) sections 7413, 7414, and 7603 of this title, and (5) section 2606 of Title 15.

§ 9607. Liability **[CERCLA Section 107]**

(a) Covered persons; scope; recoverable costs and damages; interest rate; “comparable maturity” date

Notwithstanding any other provision or rule of law, and subject only to the defenses set forth in subsection (b) of this section--

(1) the owner and operator of a vessel or a facility,

(2) any person who at the time of disposal of any hazardous substance owned or operated any facility at which such hazardous substances were disposed of,

(3) any person who by contract, agreement, or otherwise arranged for disposal or treatment, or arranged with a transporter for transport for disposal or treatment, of hazardous substances owned or possessed by such person, by any other party or entity, at any facility or incineration vessel owned or operated by another party or entity and containing such hazardous substances, and

(4) any person who accepts or accepted any hazardous substances for transport to disposal or treatment facilities, incineration vessels or sites selected by such person, from which there is a release, or a threatened release which causes the incurrence of response costs, of a hazardous substance, shall be liable for--

(A) all costs of removal or remedial action incurred by the United States Government or a State or an Indian tribe not inconsistent with the national contingency plan;

(B) any other necessary costs of response incurred by any other person consistent with the national contingency plan;

(C) damages for injury to, destruction of, or loss of natural resources, including the reasonable costs of assessing such injury, destruction, or loss resulting from such a release; and

(D) the costs of any health assessment or health effects study carried out under section 9604(i) of this title.

The amounts recoverable in an action under this section shall include interest on the amounts recoverable under subparagraphs (A) through (D). Such interest shall accrue from the later of (i) the date payment of a specified amount is demanded in writing, or (ii) the date of the expenditure concerned. The rate of interest on the outstanding unpaid balance of the amounts recoverable under this section shall be the same rate as is specified for interest on investments of the Hazardous Substance Superfund established under subchapter A of chapter 98 of Title 26. For purposes of applying such amendments to interest under this subsection, the term “comparable maturity” shall be determined with reference to the date on which interest accruing under this subsection commences.

(b) Defenses

There shall be no liability under subsection (a) of this section for a person otherwise liable who can establish by a preponderance of the evidence that the release or threat of release of a hazardous substance and the damages resulting therefrom were caused solely by--

(1) an act of God;

(2) an act of war;

(3) an act or omission of a third party other than an employee or agent of the defendant, or than one whose act or omission occurs in connection with a contractual relationship, existing directly or indirectly, with the defendant (except where the sole contractual arrangement arises from a published tariff and acceptance for carriage by a common carrier by rail), if the defendant establishes by a preponderance of the evidence that (a) he exercised due care with respect to the hazardous substance concerned, taking into consideration the characteristics of such hazardous substance, in light of all relevant facts and circumstances, and (b) he took precautions against foreseeable acts or omissions of any such third party and the consequences that could foreseeably result from such acts or omissions; or

(4) any combination of the foregoing paragraphs.

(c) Determination of amounts

(1) Except as provided in paragraph (2) of this subsection, the liability under this section of an owner or operator or other responsible person for each release of a hazardous substance or incident involving release of a hazardous substance shall not exceed--

(A) for any vessel, other than an incineration vessel, which carries any hazardous substance as cargo or residue, $300 per gross ton, or $5,000,000, whichever is greater;

(B) for any other vessel, other than an incineration vessel, $300 per gross ton, or $500,000, whichever is greater;

(C) for any motor vehicle, aircraft, hazardous liquid pipeline facility (as defined in section 60101(a) of Title 49), or rolling stock, $50,000,000 or such lesser amount as the President shall establish by regulation, but in no event less than $5,000,000 (or, for releases of hazardous substances as defined in section 9601(14)(A) of this title into the navigable waters, $8,000,000). Such regulations shall take into account the size, type, location, storage, and handling capacity and other matters relating to the likelihood of release in each such class and to the economic impact of such limits on each such class; or

(D) for any incineration vessel or any facility other than those specified in subparagraph (C) of this paragraph, the total of all costs of response plus $50,000,000 for any damages under this subchapter.

(2) Notwithstanding the limitations in paragraph (1) of this subsection, the liability of an owner or operator or other responsible person under this section shall be the full and total costs of response and damages, if (A)(i) the release or threat of release of a hazardous substance was the result of willful misconduct or willful negligence within the privity or knowledge of such person, or (ii) the primary cause of the release was a violation (within the privity or knowledge of such person) of applicable safety, construction, or operating standards or regulations; or (B) such person fails or refuses to provide all reasonable cooperation and assistance requested by a responsible public official in connection with response activities under the national contingency plan with respect to regulated carriers subject to the provisions of Title 49 or vessels subject to the provisions of Title 33, 46, or 46 Appendix, subparagraph (A)(ii) of this paragraph shall be deemed to refer to Federal standards or regulations.

(3) If any person who is liable for a release or threat of release of a hazardous substance fails without sufficient cause to properly provide removal or remedial action upon order of the President pursuant to section 9604 or 9606 of this title, such person may be liable to the United States for punitive damages in an amount at least equal to, and not more than three times, the amount of any costs incurred by the Fund as a result of such failure to take proper action. The President is authorized to commence a civil action against any such person to recover the punitive damages, which shall be in addition to any costs recovered from such person pursuant to section 9612(c) of this title. Any moneys received by the United States pursuant to this subsection shall be deposited in the Fund.

(d) Rendering care or advice

(1) In general

Except as provided in paragraph (2), no person shall be liable under this subchapter for costs or damages as a result of actions taken or omitted in the course of rendering care, assistance, or advice in accordance with the National Contingency Plan (“NCP”) or at the direction of an onscene coordinator appointed under such plan, with respect to an incident creating a danger to public health or welfare or the environment as a result of any releases of a hazardous substance or the threat thereof. This paragraph shall not preclude liability for costs or damages as the result of negligence on the part of such person.

(2) State and local governments

No State or local government shall be liable under this subchapter for costs or damages as a result of actions taken in response to an emergency created by the release or threatened release of a hazardous substance generated by or from a facility owned by another person. This paragraph shall not preclude liability for costs or damages as a result of gross negligence or intentional misconduct by the State or local government. For the purpose of the preceding sentence, reckless, willful, or wanton misconduct shall constitute gross negligence.

(3) Savings provision

This subsection shall not alter the liability of any person covered by the provisions of paragraph (1), (2), (3), or (4) of subsection (a) of this section with respect to the release or threatened release concerned.

(e) Indemnification, hold harmless, etc., agreements or conveyances; subrogation rights

(1) No indemnification, hold harmless, or similar agreement or conveyance shall be effective to transfer from the owner or operator of any vessel or facility or from any person who may be liable for a release or threat of release under this section, to any other person the liability imposed under this section. Nothing in this subsection shall bar any agreement to insure, hold harmless, or indemnify a party to such agreement for any liability under this section.

(2) Nothing in this subchapter, including the provisions of paragraph (1) of this subsection, shall bar a cause of action that an owner or operator or any other person subject to liability under this section, or a guarantor, has or would have, by reason of subrogation or otherwise against any person.

(f) Natural resources liability; designation of public trustees of natural resources

(1) Natural resources liability

In the case of an injury to, destruction of, or loss of natural resources under subparagraph (C) of subsection (a) of this section liability shall be to the United States Government and to any State for natural resources within the State or belonging to, managed by, controlled by, or appertaining to such State and to any Indian tribe for natural resources belonging to, managed by, controlled by, or appertaining to such tribe, or held in trust for the benefit of such tribe, or belonging to a member of such tribe if such resources are subject to a trust restriction on alienation: *Provided, however,* That no liability to the United States or State or Indian tribe shall be imposed under subparagraph (C) of subsection (a) of this section, where the party sought to be charged has demonstrated that the damages to natural resources complained of were specifically identified as an irreversible and irretrievable commitment of natural resources in an environmental impact statement, or other comparable environment analysis, and the decision to grant a permit or license authorizes such commitment of natural resources, and the facility or project was otherwise operating within the terms of its permit or license, so long as, in the case of damages to an Indian tribe occurring pursuant to a Federal permit or license, the issuance of that permit or license was not inconsistent with the fiduciary duty of the United States with respect to such Indian tribe. The President, or the authorized representative of any State, shall act on behalf of the public as trustee of such natural resources to recover for such damages. Sums recovered by the United States Government as trustee under this subsection shall be retained by the trustee, without further appropriation, for use only to restore, replace, or acquire the equivalent of such natural resources. Sums recovered by a State as trustee under this subsection shall be available for use only to restore, replace, or acquire the equivalent of such natural resources by the State. The measure of damages in any action under subparagraph (C) of subsection (a) of this section shall not be limited by the sums which can be used to restore or replace such resources. There shall be no double recovery under this chapter for natural resource damages, including the costs of damage assessment or restoration, rehabilitation, or acquisition for the same release and natural resource. There shall be no recovery under the authority of subparagraph (C) of subsection (a) of this section where such damages and the release of a hazardous substance from which such damages resulted have occurred wholly before December 11, 1980.

(2) Designation of Federal and State officials

(A) Federal

The President shall designate in the National Contingency Plan published under section 9605 of this title the Federal officials who shall act on behalf of the public as trustees for natural resources under this chapter and section 1321 of Title 33. Such officials shall assess damages for injury to, destruction of, or loss of natural resources for purposes of this chapter and such section 1321 of Title 33 for those resources under their trusteeship and may, upon request of and reimbursement from a State and at the Federal officials' discretion, assess damages for those natural resources under the State's trusteeship.

(B) State

The Governor of each State shall designate State officials who may act on behalf of the public as trustees for natural resources under this chapter and section 1321 of Title 33 and shall notify the President of such designations. Such State officials shall assess damages to natural resources for the purposes of this chapter and such section 1321 of Title 33 for those natural resources under their trusteeship.

(C) Rebuttable presumption

Any determination or assessment of damages to natural resources for the purposes of this chapter and section 1321 of Title 33 made by a Federal or State trustee in accordance with the regulations promulgated under section 9651(c) of this title shall have the force and effect of a rebuttable presumption on behalf of the trustee in any administrative or judicial proceeding under this chapter or section 1321 of Title 33.

(g) Federal agencies

For provisions relating to Federal agencies, see section 9620 of this title.

(h) Owner or operator of vessel

The owner or operator of a vessel shall be liable in accordance with this section, under maritime tort law, and as provided under section 9614 of this title notwithstanding any provision of the Act of March 3, 1851 (46 U.S.C. 183ff) or the absence of any physical damage to the proprietary interest of the claimant.

(i) Application of a registered pesticide product

No person (including the United States or any State or Indian tribe) may recover under the authority of this section for any response costs or damages resulting from the application of a pesticide product registered under the Federal Insecticide, Fungicide, and Rodenticide Act [7 U.S.C.A. § 136 et seq.]. Nothing in this paragraph shall affect or modify in any way the obligations or liability of any person under any other provision of State or Federal law, including common law, for damages, injury, or loss resulting from a release of any hazardous substance or for removal or remedial action or the costs of removal or remedial action of such hazardous substance.

(j) Obligations or liability pursuant to federally permitted release

Recovery by any person (including the United States or any State or Indian tribe) for response costs or damages resulting from a federally permitted release shall be pursuant to existing law in lieu of this section. Nothing in this paragraph shall affect or modify in any way the obligations or liability of any person under any other provision of State or Federal law, including common law, for damages, injury, or loss resulting from a release of any hazardous substance or for removal or remedial action or the costs of removal or remedial action of such hazardous substance. In addition, costs of response incurred by the Federal Government in connection with a discharge specified in section 9601(10)(B) or (C) of this title shall be recoverable in an action brought under section 1319(b) of Title 33.

(k) Transfer to, and assumption by, Post-Closure Liability Fund of liability of owner or operator of hazardous waste disposal facility in receipt of permit under applicable solid waste disposal law; time, criteria applicable, procedures, etc.; monitoring costs; reports

(1) The liability established by this section or any other law for the owner or operator of a hazardous waste disposal facility which has received a permit under subtitle C of the Solid Waste Disposal Act [42 U.S.C.A. § 6921 et seq.], shall be transferred to and assumed by the Post-closure Liability Fund established by section 9641 of this title when--

(A) such facility and the owner and operator thereof has complied with the requirements of subtitle C of the Solid Waste Disposal Act [42 U.S.C.A. § 6921 et seq.] and regulations issued thereunder, which may affect the performance of such facility after closure; and

(B) such facility has been closed in accordance with such regulations and the conditions of such permit, and such facility and the surrounding area have been monitored as required by such regulations and permit conditions for a period not to exceed five years after closure to demonstrate that there is no substantial likelihood that any migration offsite or release from confinement of any hazardous substance or other risk to public health or welfare will occur.

(2) Such transfer of liability shall be effective ninety days after the owner or operator of such facility notifies the Administrator of the Environmental Protection Agency (and the State where it has an authorized program under section 3006(b) of the Solid Waste Disposal Act [42 U.S.C.A. § 6926(b)]) that the conditions imposed by this subsection have been satisfied. If within such ninety-day period the Administrator of the Environmental Protection Agency or such State determines that any such facility has not complied with all the conditions imposed by this subsection or that insufficient information has been provided to demonstrate such compliance, the Administrator or such State shall so notify the owner and operator of such facility and the administrator of the Fund established by section 9641 of this title, and the owner and operator of such facility shall continue to be liable with respect to such facility under this section and other law until such time as the Administrator and such State determines that such facility has complied with all conditions imposed by this subsection. A determination by the Administrator or such State that a facility has not complied with all conditions imposed by this subsection or that insufficient information has been supplied to demonstrate compliance, shall be a final administrative action for purposes of judicial review. A request for additional information shall state in specific terms the data required.

(3) In addition to the assumption of liability of owners and operators under paragraph (1) of this subsection, the Post-closure Liability Fund established by section 9641 of this title may be used to pay costs of monitoring and care and maintenance of a site incurred by other persons after the period of monitoring required by regulations under subtitle C of the Solid Waste Disposal Act [42 U.S.C.A. § 6921 et seq.] for hazardous waste disposal facilities meeting the conditions of paragraph (1) of this subsection.

(4)(A) Not later than one year after December 11, 1980, the Secretary of the Treasury shall conduct a study and shall submit a report thereon to the Congress on the feasibility of establishing or qualifying an optional system of private insurance for postclosure financial responsibility for hazardous waste disposal facilities to which this subsection applies. Such study shall include a specification of adequate and realistic minimum standards to assure that any such privately placed insurance will carry out the purposes of this subsection in a reliable, enforceable, and practical manner. Such a study shall include an examination of the public and private incentives, programs, and actions necessary to make privately placed insurance a practical and effective option to the financing system for the Post-closure Liability Fund provided in subchapter II of this chapter.

(B) Not later than eighteen months after December 11, 1980, and after a public hearing, the President shall by rule determine whether or not it is feasible to establish or qualify an optional system of private insurance for postclosure financial responsibility for hazardous waste disposal facilities to which this subsection applies. If the President determines the establishment or qualification of such a system would be infeasible, he shall promptly publish an explanation of the reasons for such a determination. If the President determines the establishment or qualification of such a system would be feasible, he shall promptly publish notice of such determination. Not later than six months after an affirmative determination under the preceding sentence and after a public hearing, the President shall by rule promulgate adequate and realistic minimum standards which must be met by any such privately placed insurance, taking into account the purposes of this chapter and this subsection. Such rules shall also specify reasonably expeditious procedures by which privately placed insurance plans can qualify as meeting such minimum standards.

(C) In the event any privately placed insurance plan qualifies under subparagraph (B), any person enrolled in, and complying with the terms of, such plan shall be excluded from the provisions of paragraphs (1), (2), and (3) of this subsection and exempt from the requirements to pay any tax or fee to the Post-closure Liability Fund under subchapter II of this chapter.

(D) The President may issue such rules and take such other actions as are necessary to effectuate the purposes of this paragraph.

(5) Suspension of liability transfer

Notwithstanding paragraphs (1), (2), (3), and (4) of this subsection and subsection (j) of section 9611 of this title, no liability shall be transferred to or assumed by the Post-Closure Liability Trust Fund established by section 9641 of this title prior to completion of the study required under paragraph (6) of this subsection, transmission of a report of such study to both Houses of Congress, and authorization of such a transfer or assumption by Act of Congress following receipt of such study and report.

(6) Study of options for post-closure program

(A) Study

The Comptroller General shall conduct a study of options for a program for the management of the liabilities associated with hazardous waste treatment, storage, and disposal sites after their closure which complements the policies set forth in the Hazardous and Solid Waste Amendments of 1984 and assures the protection of human health and the environment.

(B) Program elements

The program referred to in subparagraph (A) shall be designed to assure each of the following:

(i) Incentives are created and maintained for the safe management and disposal of hazardous wastes so as to assure protection of human health and the environment.

(ii) Members of the public will have reasonable confidence that hazardous wastes will be managed and disposed of safely and that resources will be available to address any problems that may arise and to cover costs of long-term monitoring, care, and maintenance of such sites.

(iii) Persons who are or seek to become owners and operators of hazardous waste disposal facilities will be able to manage their potential future liabilities and to attract the investment capital necessary to build, operate, and close such facilities in a manner which assures protection of human health and the environment.

(C) Assessments

The study under this paragraph shall include assessments of treatment, storage, and disposal facilities which have been or are likely to be issued a permit under section 3005 of the Solid Waste Disposal Act [42 U.S.C.A. § 6925] and the likelihood of future insolvency on the part of owners and operators of such facilities. Separate assessments shall be made for different classes of facilities and for different classes of land disposal facilities and shall include but not be limited to--

(i) the current and future financial capabilities of facility owners and operators;

(ii) the current and future costs associated with facilities, including the costs of routine monitoring and maintenance, compliance monitoring, corrective action, natural resource damages, and liability for damages to third parties; and

(iii) the availability of mechanisms by which owners and operators of such facilities can assure that current and future costs, including post-closure costs, will be financed.

(D) Procedures

In carrying out the responsibilities of this paragraph, the Comptroller General shall consult with the Administrator, the Secretary of Commerce, the Secretary of the Treasury, and the heads of other appropriate Federal agencies.

(E) Consideration of options

In conducting the study under this paragraph, the Comptroller General shall consider various mechanisms and combinations of mechanisms to complement the policies set forth in the Hazardous and Solid Waste Amendments of 1984 to serve the purposes set forth in subparagraph (B) and to assure that the current and future costs associated with hazardous waste facilities, including post-closure costs, will be adequately financed and, to the greatest extent possible, borne by the owners and operators of such facilities. Mechanisms to be considered include, but are not limited to--

(i) revisions to closure, post-closure, and financial responsibility requirements under subtitles C and I of the Solid Waste Disposal Act [42 U.S.C.A. §§ 6921 et seq. and 6991 et seq.];

(ii) voluntary risk pooling by owners and operators;

(iii) legislation to require risk pooling by owners and operators;

(iv) modification of the Post-Closure Liability Trust Fund previously established by section 9641 of this title, and the conditions for transfer of liability under this subsection, including limiting the transfer of some or all liability under this subsection only in the case of insolvency of owners and operators;

(v) private insurance;

(vi) insurance provided by the Federal Government;

(vii) coinsurance, reinsurance, or pooled-risk insurance, whether provided by the private sector or provided or assisted by the Federal Government; and

(viii) creation of a new program to be administered by a new or existing Federal agency or by a federally chartered corporation.

(F) Recommendations

The Comptroller General shall consider options for funding any program under this section and shall, to the extent necessary, make recommendations to the appropriate committees of Congress for additional authority to implement such program.

(*l*) Federal lien

(1) In general

All costs and damages for which a person is liable to the United States under subsection (a) of this section (other than the owner or operator of a vessel under paragraph (1) of subsection (a) of this section) shall constitute a lien in favor of the United States upon all real property and rights to such property which--

(A) belong to such person; and

(B) are subject to or affected by a removal or remedial action.

(2) Duration

The lien imposed by this subsection shall arise at the later of the following:

(A) The time costs are first incurred by the United States with respect to a response action under this chapter.

(B) The time that the person referred to in paragraph (1) is provided (by certified or registered mail) written notice of potential liability.

Such lien shall continue until the liability for the costs (or a judgment against the person arising out of such liability) is satisfied or becomes unenforceable through operation of the statute of limitations provided in section 9613 of this title.

(3) Notice and validity

The lien imposed by this subsection shall be subject to the rights of any purchaser, holder of a security interest, or judgment lien creditor whose interest is perfected under applicable State law before notice of the lien has been filed in the appropriate office within the State (or county or other governmental subdivision), as designated by State law, in which the real property subject to the lien is located. Any such purchaser, holder of a security interest, or judgment lien creditor shall be afforded the same protections against the lien imposed by this subsection as are afforded under State law against a judgment lien which arises out of an unsecured obligation and which arises as of the time of the filing of the notice of the lien imposed by this subsection. If the State has not by law designated one office for the receipt of such notices of liens, the notice shall be filed in the office of the clerk of the United States district court for the district in which the real property is located. For purposes of this subsection, the terms “purchaser” and “security interest” shall have the definitions provided under section 6323(h) of Title 26.

(4) Action in rem

The costs constituting the lien may be recovered in an action in rem in the United States district court for the district in which the removal or remedial action is occurring or has occurred. Nothing in this subsection shall affect the right of the United States to bring an action against any person to recover all costs and damages for which such person is liable under subsection (a) of this section.

(m) Maritime lien

All costs and damages for which the owner or operator of a vessel is liable under subsection (a)(1) of this section with respect to a release or threatened release from such vessel shall constitute a maritime lien in favor of the United States on such vessel. Such costs may be recovered in an action in rem in the district court of the United States for the district in which the vessel may be found. Nothing in this subsection shall affect the right of the United States to bring an action against the owner or operator of such vessel in any court of competent jurisdiction to recover such costs.

(n) Liability of fiduciaries

(1) In general

The liability of a fiduciary under any provision of this chapter for the release or threatened release of a hazardous substance at, from, or in connection with a vessel or facility held in a fiduciary capacity shall not exceed the assets held in the fiduciary capacity.

(2) Exclusion

Paragraph (1) does not apply to the extent that a person is liable under this chapter independently of the person's ownership of a vessel or facility as a fiduciary or actions taken in a fiduciary capacity.

(3) Limitation

Paragraphs (1) and (4) do not limit the liability pertaining to a release or threatened release of a hazardous substance if negligence of a fiduciary causes or contributes to the release or threatened release.

(4) Safe harbor

A fiduciary shall not be liable in its personal capacity under this chapter for--

(A) undertaking or directing another person to undertake a response action under subsection (d)(1) of this section or under the direction of an on scene coordinator designated under the National Contingency Plan;

(B) undertaking or directing another person to undertake any other lawful means of addressing a hazardous substance in connection with the vessel or facility;

(C) terminating the fiduciary relationship;

(D) including in the terms of the fiduciary agreement a covenant, warranty, or other term or condition that relates to compliance with an environmental law, or monitoring, modifying or enforcing the term or condition;

(E) monitoring or undertaking 1 or more inspections of the vessel or facility;

(F) providing financial or other advice or counseling to other parties to the fiduciary relationship, including the settlor or beneficiary;

(G) restructuring, renegotiating, or otherwise altering the terms and conditions of the fiduciary relationship;

(H) administering, as a fiduciary, a vessel or facility that was contaminated before the fiduciary relationship began; or

(I) declining to take any of the actions described in subparagraphs (B) through (H).

(5) Definitions

As used in this chapter:

(A) Fiduciary

The term “fiduciary”--

(i) means a person acting for the benefit of another party as a bona fide--

(I) trustee;

(II) executor;

(III) administrator;

(IV) custodian;

(V) guardian of estates or guardian ad litem;

(VI) receiver;

(VII) conservator;

(VIII) committee of estates of incapacitated persons;

(IX) personal representative;

(X) trustee (including a successor to a trustee) under an indenture agreement, trust agreement, lease, or similar financing agreement, for debt securities, certificates of interest or certificates of participation in debt securities, or other forms of indebtedness as to which the trustee is not, in the capacity of trustee, the lender; or

(XI) representative in any other capacity that the Administrator, after providing public notice, determines to be similar to the capacities described in subclauses (I) through (X); and

(ii) does not include--

(I) a person that is acting as a fiduciary with respect to a trust or other fiduciary estate that was organized for the primary purpose of, or is engaged in, actively carrying on a trade or business for profit, unless the trust or other fiduciary estate was created as part of, or to facilitate, 1 or more estate plans or because of the incapacity of a natural person; or

(II) a person that acquires ownership or control of a vessel or facility with the objective purpose of avoiding liability of the person or of any other person.

(B) Fiduciary capacity

The term “fiduciary capacity” means the capacity of a person in holding title to a vessel or facility, or otherwise having control of or an interest in the vessel or facility, pursuant to the exercise of the responsibilities of the person as a fiduciary.

(6) Savings clause

Nothing in this subsection--

(A) affects the rights or immunities or other defenses that are available under this chapter or other law that is applicable to a person subject to this subsection; or

(B) creates any liability for a person or a private right of action against a fiduciary or any other person.

(7) No effect on certain persons

Nothing in this subsection applies to a person if the person--

(A)(i) acts in a capacity other than that of a fiduciary or in a beneficiary capacity; and

(ii) in that capacity, directly or indirectly benefits from a trust or fiduciary relationship; or

(B)(i) is a beneficiary and a fiduciary with respect to the same fiduciary estate; and

(ii) as a fiduciary, receives benefits that exceed customary or reasonable compensation, and incidental benefits, permitted under other applicable law.

(8) Limitation

This subsection does not preclude a claim under this chapter against--

(A) the assets of the estate or trust administered by the fiduciary; or

(B) a nonemployee agent or independent contractor retained by a fiduciary.

(o) De micromis exemption

(1) In general

Except as provided in paragraph (2), a person shall not be liable, with respect to response costs at a facility on the National Priorities List, under this chapter if liability is based solely on paragraph (3) or (4) of subsection (a), and the person, except as provided in paragraph (4) of this subsection, can demonstrate that--

(A) the total amount of the material containing hazardous substances that the person arranged for disposal or treatment of, arranged with a transporter for transport for disposal or treatment of, or accepted for transport for disposal or treatment, at the facility was less than 110 gallons of liquid materials or less than 200 pounds of solid materials (or such greater or lesser amounts as the Administrator may determine by regulation); and

(B) all or part of the disposal, treatment, or transport concerned occurred before April 1, 2001.

(2) Exceptions

Paragraph (1) shall not apply in a case in which--

(A) the President determines that--

(i) the materials containing hazardous substances referred to in paragraph (1) have contributed significantly or could contribute significantly, either individually or in the aggregate, to the cost of the response action or natural resource restoration with respect to the facility; or

(ii) the person has failed to comply with an information request or administrative subpoena issued by the President under this chapter or has impeded or is impeding, through action or inaction, the performance of a response action or natural resource restoration with respect to the facility; or

(B) a person has been convicted of a criminal violation for the conduct to which the exemption would apply, and that conviction has not been vitiated on appeal or otherwise.

(3) No judicial review

A determination by the President under paragraph (2)(A) shall not be subject to judicial review.

(4) NonGovernmental third-party contribution actions

In the case of a contribution action, with respect to response costs at a facility on the National Priorities List, brought by a party, other than a Federal, State, or local government, under this chapter, the burden of proof shall be on the party bringing the action to demonstrate that the conditions described in paragraph (1)(A) and (B) of this subsection are not met.

(p) Municipal solid waste exemption

(1) In general

Except as provided in paragraph (2) of this subsection, a person shall not be liable, with respect to response costs at a facility on the National Priorities List, under paragraph (3) of subsection (a) of this section for municipal solid waste disposed of at a facility if the person, except as provided in paragraph (5) of this subsection, can demonstrate that the person is--

(A) an owner, operator, or lessee of residential property from which all of the person's municipal solid waste was generated with respect to the facility;

(B) a business entity (including a parent, subsidiary, or affiliate of the entity) that, during its 3 taxable years preceding the date of transmittal of written notification from the President of its potential liability under this section, employed on average not more than 100 full-time individuals, or the equivalent thereof, and that is a small business concern (within the meaning of the Small Business Act (15 U.S.C. 631 et seq.)) from which was generated all of the municipal solid waste attributable to the entity with respect to the facility; or

(C) an organization described in section 501(c)(3) of Title 26 and exempt from tax under section 501(a) of Title 26 that, during its taxable year preceding the date of transmittal of written notification from the President of its potential liability under this section, employed not more than 100 paid individuals at the location from which was generated all of the municipal solid waste attributable to the organization with respect to the facility.

For purposes of this subsection, the term “affiliate” has the meaning of that term provided in the definition of “small business concern” in regulations promulgated by the Small Business Administration in accordance with the Small Business Act (15 U.S.C. 631 et seq.).

(2) Exception

Paragraph (1) shall not apply in a case in which the President determines that--

(A) the municipal solid waste referred to in paragraph (1) has contributed significantly or could contribute significantly, either individually or in the aggregate, to the cost of the response action or natural resource restoration with respect to the facility;

(B) the person has failed to comply with an information request or administrative subpoena issued by the President under this chapter; or

(C) the person has impeded or is impeding, through action or inaction, the performance of a response action or natural resource restoration with respect to the facility.

(3) No judicial review

A determination by the President under paragraph (2) shall not be subject to judicial review.

(4) Definition of municipal solid waste

(A) In general

For purposes of this subsection, the term “municipal solid waste” means waste material--

(i) generated by a household (including a single or multifamily residence); and

(ii) generated by a commercial, industrial, or institutional entity, to the extent that the waste material--

(I) is essentially the same as waste normally generated by a household;

(II) is collected and disposed of with other municipal solid waste as part of normal municipal solid waste collection services; and

(III) contains a relative quantity of hazardous substances no greater than the relative quantity of hazardous substances contained in waste material generated by a typical single-family household.

(B) Examples

Examples of municipal solid waste under subparagraph (A) include food and yard waste, paper, clothing, appliances, consumer product packaging, disposable diapers, office supplies, cosmetics, glass and metal food containers, elementary or secondary school science laboratory waste, and household hazardous waste.

(C) Exclusions

The term “municipal solid waste” does not include--

(i) combustion ash generated by resource recovery facilities or municipal incinerators; or

(ii) waste material from manufacturing or processing operations (including pollution control operations) that is not essentially the same as waste normally generated by households.

(5) Burden of proof

In the case of an action, with respect to response costs at a facility on the National Priorities List, brought under this section or section 9613 of this title by--

(A) a party, other than a Federal, State, or local government, with respect to municipal solid waste disposed of on or after April 1, 2001; or

(B) any party with respect to municipal solid waste disposed of before April 1, 2001, the burden of proof shall be on the party bringing the action to demonstrate that the conditions described in paragraphs (1) and (4) for exemption for entities and organizations described in paragraph (1)(B) and (C) are not met.

(6) Certain actions not permitted

No contribution action may be brought by a party, other than a Federal, State, or local government, under this chapter with respect to circumstances described in paragraph (1)(A).

(7) Costs and fees

A nongovernmental entity that commences, after the date of the enactment of this subsection, a contribution action under this chapter shall be liable to the defendant for all reasonable costs of defending the action, including all reasonable attorney's fees and expert witness fees, if the defendant is not liable for contribution based on an exemption under this subsection or subsection (o) of this section.

(q) Contiguous properties

(1) Not considered to be an owner or operator

(A) In general

A person that owns real property that is contiguous to or otherwise similarly situated with respect to, and that is or may be contaminated by a release or threatened release of a hazardous substance from, real property that is not owned by that person shall not be considered to be an owner or operator of a vessel or facility under paragraph (1) or (2) of subsection (a) solely by reason of the contamination if--

(i) the person did not cause, contribute, or consent to the release or threatened release;

(ii) the person is not--

(I) potentially liable, or affiliated with any other person that is potentially liable, for response costs at a facility through any direct or indirect familial relationship or any contractual, corporate, or financial relationship (other than a contractual, corporate, or financial relationship that is created by a contract for the sale of goods or services); or

(II) the result of a reorganization of a business entity that was potentially liable;

(iii) the person takes reasonable steps to--

(I) stop any continuing release;

(II) prevent any threatened future release; and

(III) prevent or limit human, environmental, or natural resource exposure to any hazardous substance released on or from property owned by that person;

(iv) the person provides full cooperation, assistance, and access to persons that are authorized to conduct response actions or natural resource restoration at the vessel or facility from which there has been a release or threatened release (including the cooperation and access necessary for the installation, integrity, operation, and maintenance of any complete or partial response action or natural resource restoration at the vessel or facility);

(v) the person--

(I) is in compliance with any land use restrictions established or relied on in connection with the response action at the facility; and

(II) does not impede the effectiveness or integrity of any institutional control employed in connection with a response action;

(vi) the person is in compliance with any request for information or administrative subpoena issued by the President under this chapter;

(vii) the person provides all legally required notices with respect to the discovery or release of any hazardous substances at the facility; and

(viii) At the time at which the person acquired the property, the person

(I) conducted all appropriate inquiry within the meaning of section 9601(35)(B) of this title with respect to the property; and

(II) did not know or have reason to know that the property was or could be contaminated by a release or threatened release of one or more hazardous substances from other real property not owned or operated by the person.

(B) Demonstration

To qualify as a person described in subparagraph (A), a person must establish by a preponderance of the evidence that the conditions in clauses (i) through (viii) of subparagraph (A) have been met.

(C) Bona fide prospective purchaser

Any person that does not qualify as a person described in this paragraph because the person had, or had reason to have, knowledge specified in subparagraph (A)(viii) at the time of acquisition of the real property may qualify as a bona fide prospective purchaser under section 9601(40) of this title if the person is otherwise described in that section.

(D) Ground water

With respect to a hazardous substance from one or more sources that are not on the property of a person that is a contiguous property owner that enters ground water beneath the property of the person solely as a result of subsurface migration in an aquifer, subparagraph (A)(iii) shall not require the person to conduct ground water investigations or to install ground water remediation systems, except in accordance with the policy of the Environmental Protection Agency concerning owners of property containing contaminated aquifers, dated May 24, 1995.

(2) Effect of law

With respect to a person described in this subsection, nothing in this subsection--

(A) limits any defense to liability that may be available to the person under any other provision of law; or

(B) imposes liability on the person that is not otherwise imposed by subsection (a) of this section.

(3) Assurances

The Administrator may--

(A) issue an assurance that no enforcement action under this chapter will be initiated against a person described in paragraph (1); and

(B) grant a person described in paragraph (1) protection against a cost recovery or contribution action under section 9613(f) of this title.

(r) Prospective purchaser and windfall lien

(1) Limitation on liability

Notwithstanding subsection (a)(1) of this section, a bona fide prospective purchaser whose potential liability for a release or threatened release is based solely on the purchaser's being considered to be an owner or operator of a facility shall not be liable as long as the bona fide prospective purchaser does not impede the performance of a response action or natural resource restoration.

(2) Lien

If there are unrecovered response costs incurred by the United States at a facility for which an owner of the facility is not liable by reason of paragraph (1), and if each of the conditions described in paragraph (3) is met, the United States shall have a lien on the facility, or may by agreement with the owner, obtain from the owner a lien on any other property or other assurance of payment satisfactory to the Administrator, for the unrecovered response costs.

(3) Conditions

The conditions referred to in paragraph (2) are the following:

(A) Response action

A response action for which there are unrecovered costs of the United States is carried out at the facility.

(B) Fair market value

The response action increases the fair market value of the facility above the fair market value of the facility that existed before the response action was initiated.

(4) Amount; duration

A lien under paragraph (2)--

(A) shall be in an amount not to exceed the increase in fair market value of the property attributable to the response action at the time of a sale or other disposition of the property;

(B) shall arise at the time at which costs are first incurred by the United States with respect to a response action at the facility;

(C) shall be subject to the requirements of subsection (l)(3); and

(D) shall continue until the earlier of--

(i) satisfaction of the lien by sale or other means; or

(ii) notwithstanding any statute of limitations under section 9613 of this tile, recovery of all response costs incurred at the facility.

§ 9613. Civil proceedings [CERCLA Section 113]

(a) Review of regulations in Circuit Court of Appeals of the United States for the District of Columbia

Review of any regulation promulgated under this chapter may be had upon application by any interested person only in the Circuit Court of Appeals of the United States for the District of Columbia. Any such application shall be made within ninety days from the date of promulgation of such regulations. Any matter with respect to which review could have been obtained under this subsection shall not be subject to judicial review in any civil or criminal proceeding for enforcement or to obtain damages or recovery of response costs.

(b) Jurisdiction; venue

Except as provided in subsections (a) and (h) of this section, the United States district courts shall have exclusive original jurisdiction over all controversies arising under this chapter, without regard to the citizenship of the parties or the amount in controversy. Venue shall lie in any district in which the release or damages occurred, or in which the defendant resides, may be found, or has his principal office. For the purposes of this section, the Fund shall reside in the District of Columbia.

(c) Controversies or other matters resulting from tax collection or tax regulation review

The provisions of subsections (a) and (b) of this section shall not apply to any controversy or other matter resulting from the assessment of collection of any tax, as provided by subchapter II of this chapter, or to the review of any regulation promulgated under Title 26.

(d) Litigation commenced prior to December 11, 1980

No provision of this chapter shall be deemed or held to moot any litigation concerning any release of any hazardous substance, or any damages associated therewith, commenced prior to December 11, 1980.

(e) Nationwide service of process

In any action by the United States under this chapter, process may be served in any district where the defendant is found, resides, transacts business, or has appointed an agent for the service of process.

(f) Contribution

(1) Contribution

Any person may seek contribution from any other person who is liable or potentially liable under section 9607(a) of this title, during or following any civil action under section 9606 of this title or under section 9607(a) of this title. Such claims shall be brought in accordance with this section and the Federal Rules of Civil Procedure, and shall be governed by Federal law. In resolving contribution claims, the court may allocate response costs among liable parties using such equitable factors as the court determines are appropriate. Nothing in this subsection shall diminish the right of any person to bring an action for contribution in the absence of a civil action under section 9606 of this title or section 9607 of this title.

(2) Settlement

A person who has resolved its liability to the United States or a State in an administrative or judicially approved settlement shall not be liable for claims for contribution regarding matters addressed in the settlement. Such settlement does not discharge any of the other potentially liable persons unless its terms so provide, but it reduces the potential liability of the others by the amount of the settlement.

(3) Persons not party to settlement

(A) If the United States or a State has obtained less than complete relief from a person who has resolved its liability to the United States or the State in an administrative or judicially approved settlement, the United States or the State may bring an action against any person who has not so resolved its liability.

(B) A person who has resolved its liability to the United States or a State for some or all of a response action or for some or all of the costs of such action in an administrative or judicially approved settlement may seek contribution from any person who is not party to a settlement referred to in paragraph (2).

(C) In any action under this paragraph, the rights of any person who has resolved its liability to the United States or a State shall be subordinate to the rights of the United States or the State. Any contribution action brought under this paragraph shall be governed by Federal law.

(g) Period in which action may be brought

(1) Actions for natural resource damages

Except as provided in paragraphs (3) and (4), no action may be commenced for damages (as defined in section 9601(6) of this title) under this chapter, unless that action is commenced within 3 years after the later of the following:

(A) The date of the discovery of the loss and its connection with the release in question.

(B) The date on which regulations are promulgated under section 9651(c) of this title.

With respect to any facility listed on the National Priorities List (NPL), any Federal facility identified under section 9620 of this title (relating to Federal facilities), or any vessel or facility at which a remedial action under this chapter is otherwise scheduled, an action for damages under this chapter must be commenced within 3 years after the completion of the remedial action (excluding operation and maintenance activities) in lieu of the dates referred to in subparagraph (A) or (B). In no event may an action for damages under this chapter with respect to such a vessel or facility be commenced (i) prior to 60 days after the Federal or State natural resource trustee provides to the President and the potentially responsible party a notice of intent to file suit, or (ii) before selection of the remedial action if the President is diligently proceeding with a remedial investigation and feasibility study under section 9604(b) of this title or section 9620 of this title (relating to Federal facilities). The limitation in the preceding sentence on commencing an action before giving notice or before selection of the remedial action does not apply to actions filed on or before October 17, 1986.

(2) Actions for recovery of costs

An initial action for recovery of the costs referred to in section 9607 of this title must be commenced--

(A) for a removal action, within 3 years after completion of the removal action, except that such cost recovery action must be brought within 6 years after a determination to grant a waiver under section 9604(c)(1)(C) of this title for continued response action; and

(B) for a remedial action, within 6 years after initiation of physical on-site construction of the remedial action, except that, if the remedial action is initiated within 3 years after the completion of the removal action, costs incurred in the removal action may be recovered in the cost recovery action brought under this subparagraph.

In any such action described in this subsection, the court shall enter a declaratory judgment on liability for response costs or damages that will be binding on any subsequent action or actions to recover further response costs or damages. A subsequent action or actions under section 9607 of this title for further response costs at the vessel or facility may be maintained at any time during the response action, but must be commenced no later than 3 years after the date of completion of all response action. Except as otherwise provided in this paragraph, an action may be commenced under section 9607 of this title for recovery of costs at any time after such costs have been incurred.

(3) Contribution

No action for contribution for any response costs or damages may be commenced more than 3 years after--

(A) the date of judgment in any action under this chapter for recovery of such costs or damages, or

(B) the date of an administrative order under section 9622(g) of this title (relating to de minimis settlements) or 9622(h) of this title (relating to cost recovery settlements) or entry of a judicially approved settlement with respect to such costs or damages.

(4) Subrogation

No action based on rights subrogated pursuant to this section by reason of payment of a claim may be commenced under this subchapter more than 3 years after the date of payment of such claim.

(5) Actions to recover indemnification payments

Notwithstanding any other provision of this subsection, where a payment pursuant to an indemnification agreement with a response action contractor is made under section 9619 of this title, an action under section 9607 of this title for recovery of such indemnification payment from a potentially responsible party may be brought at any time before the expiration of 3 years from the date on which such payment is made.

(6) Minors and incompetents

The time limitations contained herein shall not begin to run--

(A) against a minor until the earlier of the date when such minor reaches 18 years of age or the date on which a legal representative is duly appointed for such minor, or

(B) against an incompetent person until the earlier of the date on which such incompetent's incompetency ends or the date on which a legal representative is duly appointed for such incompetent.

(h) Timing of review

No Federal court shall have jurisdiction under Federal law other than under section 1332 of Title 28 (relating to diversity of citizenship jurisdiction) or under State law which is applicable or relevant and appropriate under section 9621 of this title (relating to cleanup standards) to review any challenges to removal or remedial action selected under section 9604 of this title, or to review any order issued under section 9606(a) of this title, in any action except one of the following:

(1) An action under section 9607 of this title to recover response costs or damages or for contribution.

(2) An action to enforce an order issued under section 9606(a) of this title or to recover a penalty for violation of such order.

(3) An action for reimbursement under section 9606(b)(2) of this title.

(4) An action under section 9659 of this title (relating to citizens suits) alleging that the removal or remedial action taken under section 9604 of this title or secured under section 9606 of this title was in violation of any requirement of this chapter. Such an action may not be brought with regard to a removal where a remedial action is to be undertaken at the site.

(5) An action under section 9606 of this title in which the United States has moved to compel a remedial action.

(i) Intervention

In any action commenced under this chapter or under the Solid Waste Disposal Act [42 U.S.C.A. § 6901 et seq.] in a court of the United States, any person may intervene as a matter of right when such person claims an interest relating to the subject of the action and is so situated that the disposition of the action may, as a practical matter, impair or impede the person's ability to protect that interest, unless the President or the State shows that the person's interest is adequately represented by existing parties.

(j) Judicial review

(1) Limitation

In any judicial action under this chapter, judicial review of any issues concerning the adequacy of any response action taken or ordered by the President shall be limited to the administrative record. Otherwise applicable principles of administrative law shall govern whether any supplemental materials may be considered by the court.

(2) Standard

In considering objections raised in any judicial action under this chapter, the court shall uphold the President's decision in selecting the response action unless the objecting party can demonstrate, on the administrative record, that the decision was arbitrary and capricious or otherwise not in accordance with law.

(3) Remedy

If the court finds that the selection of the response action was arbitrary and capricious or otherwise not in accordance with law, the court shall award (A) only the response costs or damages that are not inconsistent with the national contingency plan, and (B) such other relief as is consistent with the National Contingency Plan.

(4) Procedural errors

In reviewing alleged procedural errors, the court may disallow costs or damages only if the errors were so serious and related to matters of such central relevance to the action that the action would have been significantly changed had such errors not been made.

(k) Administrative record and participation procedures

(1) Administrative record

The President shall establish an administrative record upon which the President shall base the selection of a response action. The administrative record shall be available to the public at or near the facility at issue. The President also may place duplicates of the administrative record at any other location.

(2) Participation procedures

(A) Removal action

The President shall promulgate regulations in accordance with chapter 5 of Title 5 establishing procedures for the appropriate participation of interested persons in the development of the administrative record on which the President will base the selection of removal actions and on which judicial review of removal actions will be based.

(B) Remedial action

The President shall provide for the participation of interested persons, including potentially responsible parties, in the development of the administrative record on which the President will base the selection of remedial actions and on which judicial review of remedial actions will be based. The procedures developed under this subparagraph shall include, at a minimum, each of the following:

(i) Notice to potentially affected persons and the public, which shall be accompanied by a brief analysis of the plan and alternative plans that were considered.

(ii) A reasonable opportunity to comment and provide information regarding the plan.

(iii) An opportunity for a public meeting in the affected area, in accordance with section 9617(a)(2) of this title (relating to public participation).

(iv) A response to each of the significant comments, criticisms, and new data submitted in written or oral presentations.

(v) A statement of the basis and purpose of the selected action.

For purposes of this subparagraph, the administrative record shall include all items developed and received under this subparagraph and all items described in the second sentence of section 9617(d) of this title. The President shall promulgate regulations in accordance with chapter 5 of Title 5 to carry out the requirements of this subparagraph.

(C) Interim record

Until such regulations under subparagraphs (A) and (B) are promulgated, the administrative record shall consist of all items developed and received pursuant to current procedures for selection of the response action, including procedures for the participation of interested parties and the public. The development of an administrative record and the selection of response action under this chapter shall not include an adjudicatory hearing.

(D) Potentially responsible parties

The President shall make reasonable efforts to identify and notify potentially responsible parties as early as possible before selection of a response action. Nothing in this paragraph shall be construed to be a defense to liability.

(l) Notice of actions

Whenever any action is brought under this chapter in a court of the United States by a plaintiff other than the United States, the plaintiff shall provide a copy of the complaint to the Attorney General of the United States and to the Administrator of the Environmental Protection Agency.

§ 9620. Federal facilities

(a) Application of chapter to Federal Government

(1) In general

Each department, agency, and instrumentality of the United States (including the executive, legislative, and judicial branches of government) shall be subject to, and comply with, this chapter in the same manner and to the same extent, both procedurally and substantively, as any nongovernmental entity, including liability under section 9607 of this title. Nothing in this section shall be construed to affect the liability of any person or entity under sections 9606 and 9607 of this title.

(2) Application of requirements to Federal facilities

All guidelines, rules, regulations, and criteria which are applicable to preliminary assessments carried out under this chapter for facilities at which hazardous substances are located, applicable to evaluations of such facilities under the National Contingency Plan, applicable to inclusion on the National Priorities List, or applicable to remedial actions at such facilities shall also be applicable to facilities which are owned or operated by a department, agency, or instrumentality of the United States in the same manner and to the extent as such guidelines, rules, regulations, and criteria are applicable to other facilities. No department, agency, or instrumentality of the United States may adopt or utilize any such guidelines, rules, regulations, or criteria which are inconsistent with the guidelines, rules, regulations, and criteria established by the Administrator under this chapter.

(3) Exceptions

This subsection shall not apply to the extent otherwise provided in this section with respect to applicable time periods. This subsection shall also not apply to any requirements relating to bonding, insurance, or financial responsibility. Nothing in this chapter shall be construed to require a State to comply with section 9604(c)(3) of this title in the case of a facility which is owned or operated by any department, agency, or instrumentality of the United States.

(4) State laws

State laws concerning removal and remedial action, including State laws regarding enforcement, shall apply to removal and remedial action at facilities owned or operated by a department, agency, or instrumentality of the United States or facilities that are the subject of a deferral under subsection (h)(3)(C) of this section when such facilities are not included on the National Priorities List. The preceding sentence shall not apply to the extent a State law would apply any standard or requirement to such facilities which is more stringent than the standards and requirements applicable to facilities which are not owned or operated by any such department, agency, or instrumentality.

(b) Notice

Each department, agency, and instrumentality of the United States shall add to the inventory of Federal agency hazardous waste facilities required to be submitted under section 3016 of the Solid Waste Disposal Act [42 U.S.C.A. § 6937] (in addition to the information required under section 3016(a)(3) of such Act [42 U.S.C.A. § 6937(a)(3)]) information on contamination from each facility owned or operated by the department, agency, or instrumentality if such contamination affects contiguous or adjacent property owned by the department, agency, or instrumentality or by any other person, including a description of the monitoring data obtained.

(c) Federal Agency Hazardous Waste Compliance Docket

The Administrator shall establish a special Federal Agency Hazardous Waste Compliance Docket (hereinafter in this section referred to as the “docket”) which shall contain each of the following:

(1) All information submitted under section 3016 of the Solid Waste Disposal Act [42 U.S.C.A. § 6937] and subsection (b) of this section regarding any Federal facility and notice of each subsequent action taken under this chapter with respect to the facility.

(2) Information submitted by each department, agency, or instrumentality of the United States under section 3005 or 3010 of such Act [42 U.S.C.A. § 6925 or 6930].

(3) Information submitted by the department, agency, or instrumentality under section 9603 of this title.

The docket shall be available for public inspection at reasonable times. Six months after establishment of the docket and every 6 months thereafter, the Administrator shall publish in the Federal Register a list of the Federal facilities which have been included in the docket during the immediately preceding 6-month period. Such publication shall also indicate where in the appropriate regional office of the Environmental Protection Agency additional information may be obtained with respect to any facility on the docket. The Administrator shall establish a program to provide information to the public with respect to facilities which are included in the docket under this subsection.

(d) Assessment and evaluation

(1) In general

The Administrator shall take steps to assure that a preliminary assessment is conducted for each facility on the docket. Following such preliminary assessment, the Administrator shall, where appropriate--

(A) evaluate such facilities in accordance with the criteria established in accordance with section 9605 of this title under the National Contingency Plan for determining priorities among releases; and

(B) include such facilities on the National Priorities List maintained under such plan if the facility meets such criteria.

(2) Application of criteria

(A) In general

Subject to subparagraph (B), the criteria referred to in paragraph (1) shall be applied in the same manner as the criteria are applied to facilities that are owned or operated by persons other than the United States.

(B) Response under other law

It shall be an appropriate factor to be taken into consideration for the purposes of section 9605(a)(8)(A) of this title that the head of the department, agency, or instrumentality that owns or operates a facility has arranged with the Administrator or appropriate State authorities to respond appropriately, under authority of a law other than this chapter, to a release or threatened release of a hazardous substance.

(3) Completion

Evaluation and listing under this subsection shall be completed in accordance with a reasonable schedule established by the Administrator.

(e) Required action by department

(1) RI/FS

Not later than 6 months after the inclusion of any facility on the National Priorities List, the department, agency, or instrumentality which owns or operates such facility shall, in consultation with the Administrator and appropriate State authorities, commence a remedial investigation and feasibility study for such facility. In the case of any facility which is listed on such list before October 17, 1986, the department, agency, or instrumentality which owns or operates such facility shall, in consultation with the Administrator and appropriate State authorities, commence such an investigation and study for such facility within one year after October 17, 1986. The Administrator and appropriate State authorities shall publish a timetable and deadlines for expeditious completion of such investigation and study.

(2) Commencement of remedial action; interagency agreement

The Administrator shall review the results of each investigation and study conducted as provided in paragraph (1). Within 180 days thereafter, the head of the department, agency, or instrumentality concerned shall enter into an interagency agreement with the Administrator for the expeditious completion by such department, agency, or instrumentality of all necessary remedial action at such facility. Substantial continuous physical onsite remedial action shall be commenced at each facility not later than 15 months after completion of the investigation and study. All such interagency agreements, including review of alternative remedial action plans and selection of remedial action, shall comply with the public participation requirements of section 9617 of this title.

(3) Completion of remedial actions

Remedial actions at facilities subject to interagency agreements under this section shall be completed as expeditiously as practicable. Each agency shall include in its annual budget submissions to the Congress a review of alternative agency funding which could be used to provide for the costs of remedial action. The budget submission shall also include a statement of the hazard posed by the facility to human health, welfare, and the environment and identify the specific consequences of failure to begin and complete remedial action.

(4) Contents of agreement

Each interagency agreement under this subsection shall include, but shall not be limited to, each of the following:

(A) A review of alternative remedial actions and selection of a remedial action by the head of the relevant department, agency, or instrumentality and the Administrator or, if unable to reach agreement on selection of a remedial action, selection by the Administrator.

(B) A schedule for the completion of each such remedial action.

(C) Arrangements for long-term operation and maintenance of the facility.

(5) Annual report

Each department, agency, or instrumentality responsible for compliance with this section shall furnish an annual report to the Congress concerning its progress in implementing the requirements of this section. Such reports shall include, but shall not be limited to, each of the following items:

(A) A report on the progress in reaching interagency agreements under this section.

(B) The specific cost estimates and budgetary proposals involved in each interagency agreement.

(C) A brief summary of the public comments regarding each proposed interagency agreement.

(D) A description of the instances in which no agreement was reached.

(E) A report on progress in conducting investigations and studies under paragraph (1).

(F) A report on progress in conducting remedial actions.

(G) A report on progress in conducting remedial action at facilities which are not listed on the National Priorities List.

With respect to instances in which no agreement was reached within the required time period, the department, agency, or instrumentality filing the report under this paragraph shall include in such report an explanation of the reasons why no agreement was reached. The annual report required by this paragraph shall also contain a detailed description on a State-by-State basis of the status of each facility subject to this section, including a description of the hazard presented by each facility, plans and schedules for initiating and completing response action, enforcement status (where appropriate), and an explanation of any postponements or failure to complete response action. Such reports shall also be submitted to the affected States.

(6) Settlements with other parties

If the Administrator, in consultation with the head of the relevant department, agency, or instrumentality of the United States, determines that remedial investigations and feasibility studies or remedial action will be done properly at the Federal facility by another potentially responsible party within the deadlines provided in paragraphs (1), (2), and (3) of this subsection, the Administrator may enter into an agreement with such party under section 9622 of this title (relating to settlements). Following approval by the Attorney General of any such agreement relating to a remedial action, the agreement shall be entered in the appropriate United States district court as a consent decree under section 9606 of this title.

(f) State and local participation

The Administrator and each department, agency, or instrumentality responsible for compliance with this section shall afford to relevant State and local officials the opportunity to participate in the planning and selection of the remedial action, including but not limited to the review of all applicable data as it becomes available and the development of studies, reports, and action plans. In the case of State officials, the opportunity to participate shall be provided in accordance with section 9621 of this title.

(g) Transfer of authorities

Except for authorities which are delegated by the Administrator to an officer or employee of the Environmental Protection Agency, no authority vested in the Administrator under this section may be transferred, by executive order of the President or otherwise, to any other officer or employee of the United States or to any other person.

(h) Property transferred by Federal agencies

(1) Notice

After the last day of the 6-month period beginning on the effective date of regulations under paragraph (2) of this subsection, whenever any department, agency, or instrumentality of the United States enters into any contract for the sale or other transfer of real property which is owned by the United States and on which any hazardous substance was stored for one year or more, known to have been released, or disposed of, the head of such department, agency, or instrumentality shall include in such contract notice of the type and quantity of such hazardous substance and notice of the time at which such storage, release, or disposal took place, to the extent such information is available on the basis of a complete search of agency files.

(2) Form of notice; regulations

Notice under this subsection shall be provided in such form and manner as may be provided in regulations promulgated by the Administrator. As promptly as practicable after October 17, 1986, but not later than 18 months after October 17, 1986, and after consultation with the Administrator of the General Services Administration, the Administrator shall promulgate regulations regarding the notice required to be provided under this subsection.

(3) Contents of certain deeds

(A) In general

After the last day of the 6-month period beginning on the effective date of regulations under paragraph (2) of this subsection, in the case of any real property owned by the United States on which any hazardous substance was stored for one year or more, known to have been released, or disposed of, each deed entered into for the transfer of such property by the United States to any other person or entity shall contain--

(i) to the extent such information is available on the basis of a complete search of agency files--

(I) a notice of the type and quantity of such hazardous substances,

(II) notice of the time at which such storage, release, or disposal took place, and

(III) a description of the remedial action taken, if any;

(ii) a covenant warranting that--

(I) all remedial action necessary to protect human health and the environment with respect to any such substance remaining on the property has been taken before the date of such transfer, and

(II) any additional remedial action found to be necessary after the date of such transfer shall be conducted by the United States; and

(iii) a clause granting the United States access to the property in any case in which remedial action or corrective action is found to be necessary after the date of such transfer.

(B) Covenant requirements

For purposes of subparagraphs (A)(ii)(I) and (C)(iii), all remedial action described in such subparagraph has been taken if the construction and installation of an approved remedial design has been completed, and the remedy has been demonstrated to the Administrator to be operating properly and successfully. The carrying out of long-term pumping and treating, or operation and maintenance, after the remedy has been demonstrated to the Administrator to be operating properly and successfully does not preclude the transfer of the property.

The requirements of subparagraph (A)(ii) shall not apply in any case in which the person or entity to whom the real property is transferred is a potentially responsible party with respect to such property. The requirements of subparagraph (A)(ii) shall not apply in any case in which the transfer of the property occurs or has occurred by means of a lease, without regard to whether the lessee has agreed to purchase the property or whether the duration of the lease is longer than 55 years. In the case of a lease entered into after September 30, 1995, with respect to real property located at an installation approved for closure or realignment under a base closure law, the agency leasing the property, in consultation with the Administrator, shall determine before leasing the property that the property is suitable for lease, that the uses contemplated for the lease are consistent with protection of human health and the environment, and that there are adequate assurances that the United States will take all remedial action referred to in subparagraph (A)(ii) that has not been taken on the date of the lease.

(C) Deferral

(i) In general

The Administrator, with the concurrence of the Governor of the State in which the facility is located (in the case of real property at a Federal facility that is listed on the National Priorities List), or the Governor of the State in which the facility is located (in the case of real property at a Federal facility not listed on the National Priorities List) may defer the requirement of subparagraph (A)(ii)(I) with respect to the property if the Administrator or the Governor, as the case may be, determines that the property is suitable for transfer, based on a finding that--

(I) the property is suitable for transfer for the use intended by the transferee, and the intended use is consistent with protection of human health and the environment;

(II) the deed or other agreement proposed to govern the transfer between the United States and the transferee of the property contains the assurances set forth in clause (ii);

(III) the Federal agency requesting deferral has provided notice, by publication in a newspaper of general circulation in the vicinity of the property, of the proposed transfer and of the opportunity for the public to submit, within a period of not less than 30 days after the date of the notice, written comments on the suitability of the property for transfer; and

(IV) the deferral and the transfer of the property will not substantially delay any necessary response action at the property.

(ii) Response action assurances

With regard to a release or threatened release of a hazardous substance for which a Federal agency is potentially responsible under this section, the deed or other agreement proposed to govern the transfer shall contain assurances that--

(I) provide for any necessary restrictions on the use of the property to ensure the protection of human health and the environment;

(II) provide that there will be restrictions on use necessary to ensure that required remedial investigations, response action, and oversight activities will not be disrupted;

(III) provide that all necessary response action will be taken and identify the schedules for investigation and completion of all necessary response action as approved by the appropriate regulatory agency; and

(IV) provide that the Federal agency responsible for the property subject to transfer will submit a budget request to the Director of the Office of Management and Budget that adequately addresses schedules for investigation and completion of all necessary response action, subject to congressional authorizations and appropriations.

(iii) Warranty

When all response action necessary to protect human health and the environment with respect to any substance remaining on the property on the date of transfer has been taken, the United States shall execute and deliver to the transferee an appropriate document containing a warranty that all such response action has been taken, and the making of the warranty shall be considered to satisfy the requirement of subparagraph (A)(ii)(I).

(iv) Federal responsibility

A deferral under this subparagraph shall not increase, diminish, or affect in any manner any rights or obligations of a Federal agency (including any rights or obligations under sections 9606, 9607 of this title, and this section existing prior to transfer) with respect to a property transferred under this subparagraph.

(4) Identification of uncontaminated property

(A) In the case of real property to which this paragraph applies (as set forth in subparagraph (E)), the head of the department, agency, or instrumentality of the United States with jurisdiction over the property shall identify the real property on which no hazardous substances and no petroleum products or their derivatives were known to have been released or disposed of. Such identification shall be based on an investigation of the real property to determine or discover the obviousness of the presence or likely presence of a release or threatened release of any hazardous substance or any petroleum product or its derivatives, including aviation fuel and motor oil, on the real property. The identification shall consist, at a minimum, of a review of each of the following sources of information concerning the current and previous uses of the real property:

(i) A detailed search of Federal Government records pertaining to the property.

(ii) Recorded chain of title documents regarding the real property.

(iii) Aerial photographs that may reflect prior uses of the real property and that are reasonably obtainable through State or local government agencies.

(iv) A visual inspection of the real property and any buildings, structures, equipment, pipe, pipeline, or other improvements on the real property, and a visual inspection of properties immediately adjacent to the real property.

(v) A physical inspection of property adjacent to the real property, to the extent permitted by owners or operators of such property.

(vi) Reasonably obtainable Federal, State, and local government records of each adjacent facility where there has been a release of any hazardous substance or any petroleum product or its derivatives, including aviation fuel and motor oil, and which is likely to cause or contribute to a release or threatened release of any hazardous substance or any petroleum product or its derivatives, including aviation fuel and motor oil, on the real property.

(vii) Interviews with current or former employees involved in operations on the real property.

Such identification shall also be based on sampling, if appropriate under the circumstances. The results of the identification shall be provided immediately to the Administrator and State and local government officials and made available to the public.

(B) The identification required under subparagraph (A) is not complete until concurrence in the results of the identification is obtained, in the case of real property that is part of a facility on the National Priorities List, from the Administrator, or, in the case of real property that is not part of a facility on the National Priorities List, from the appropriate State official. In the case of a concurrence which is required from a State official, the concurrence is deemed to be obtained if, within 90 days after receiving a request for the concurrence, the State official has not acted (by either concurring or declining to concur) on the request for concurrence.

(C)(i) Except as provided in clauses (ii), (iii), and (iv), the identification and concurrence required under subparagraphs (A) and (B), respectively, shall be made at least 6 months before the termination of operations on the real property.

(ii) In the case of real property described in subparagraph (E)(i)(II) on which operations have been closed or realigned or scheduled for closure or realignment pursuant to a base closure law described in subparagraph (E)(ii)(I) or (E)(ii)(II) by October 19, 1992, the identification and concurrence required under subparagraphs (A) and (B), respectively, shall be made not later than 18 months after October 19, 1992.

(iii) In the case of real property described in subparagraph (E)(i)(II) on which operations are closed or realigned or become scheduled for closure or realignment pursuant to the base closure law described in subparagraph (E)(ii)(II) after October 19, 1992, the identification and concurrence required under subparagraphs (A) and (B), respectively, shall be made not later than 18 months after the date by which a joint resolution disapproving the closure or realignment of the real property under section 2904(b) of such base closure law must be enacted, and such a joint resolution has not been enacted.

(iv) In the case of real property described in subparagraphs (E)(i)(II) on which operations are closed or realigned pursuant to a base closure law described in subparagraph (E)(ii)(III) or (E)(ii)(IV), the identification and concurrence required under subparagraphs (A) and (B), respectively, shall be made not later than 18 months after the date on which the real property is selected for closure or realignment pursuant to such a base closure law.

(D) In the case of the sale or other transfer of any parcel of real property identified under subparagraph (A), the deed entered into for the sale or transfer of such property by the United States to any other person or entity shall contain--

(i) a covenant warranting that any response action or corrective action found to be necessary after the date of such sale or transfer shall be conducted by the United States; and

(ii) a clause granting the United States access to the property in any case in which a response action or corrective action is found to be necessary after such date at such property, or such access is necessary to carry out a response action or corrective action on adjoining property.

(E)(i) This paragraph applies to--

(I) real property owned by the United States and on which the United States plans to terminate Federal Government operations, other than real property described in subclause (II); and

(II) real property that is or has been used as a military installation and on which the United States plans to close or realign military operations pursuant to a base closure law.

(ii) For purposes of this paragraph, the term “base closure law” includes the following:

(I) Title II of the Defense Authorization Amendments and Base Closure and Realignment Act (Public Law 100-526; 10 U.S.C. 2687 note).

(II) The Defense Base Closure and Realignment Act of 1990 (part A of title XXIX of Public Law 101-510; 10 U.S.C. 2687 note).

(III) Section 2687 of Title 10.

(IV) Any provision of law authorizing the closure or realignment of a military installation enacted on or after October 19, 1992.

(F) Nothing in this paragraph shall affect, preclude, or otherwise impair the termination of Federal Government operations on real property owned by the United States.

(5) Notification of States regarding certain leases

In the case of real property owned by the United States, on which any hazardous substance or any petroleum product or its derivatives (including aviation fuel and motor oil) was stored for one year or more, known to have been released, or disposed of, and on which the United States plans to terminate Federal Government operations, the head of the department, agency, or instrumentality of the United States with jurisdiction over the property shall notify the State in which the property is located of any lease entered into by the United States that will encumber the property beyond the date of termination of operations on the property. Such notification shall be made before entering into the lease and shall include the length of the lease, the name of person to whom the property is leased, and a description of the uses that will be allowed under the lease of the property and buildings and other structures on the property.

(i) Obligations under Solid Waste Disposal Act

Nothing in this section shall affect or impair the obligation of any department, agency, or instrumentality of the United States to comply with any requirement of the Solid Waste Disposal Act [42 U.S.C.A. § 6901 et seq.] (including corrective action requirements).

(j) National security

(1) Site specific Presidential orders

The President may issue such orders regarding response actions at any specified site or facility of the Department of Energy or the Department of Defense as may be necessary to protect the national security interests of the United States at that site or facility. Such orders may include, where necessary to protect such interests, an exemption from any requirement contained in this subchapter or under title III of the Superfund Amendments and Reauthorization Act of 1986 [42 U.S.C.A. § 11001 et seq.] with respect to the site or facility concerned. The President shall notify the Congress within 30 days of the issuance of an order under this paragraph providing for any such exemption. Such notification shall include a statement of the reasons for the granting of the exemption. An exemption under this paragraph shall be for a specified period which may not exceed one year. Additional exemptions may be granted, each upon the President's issuance of a new order under this paragraph for the site or facility concerned. Each such additional exemption shall be for a specified period which may not exceed one year. It is the intention of the Congress that whenever an exemption is issued under this paragraph the response action shall proceed as expeditiously as practicable. The Congress shall be notified periodically of the progress of any response action with respect to which an exemption has been issued under this paragraph. No exemption shall be granted under this paragraph due to lack of appropriation unless the President shall have specifically requested such appropriation as a part of the budgetary process and the Congress shall have failed to make available such requested appropriation.

(2) Classified information

Notwithstanding any other provision of law, all requirements of the Atomic Energy Act [42 U.S.C.A. § 2011 et seq.] and all Executive orders concerning the handling of restricted data and national security information, including “need to know” requirements, shall be applicable to any grant of access to classified information under the provisions of this chapter or under title III of the Superfund Amendments and Reauthorization Act of 1986 [42 U.S.C.A. § 11001 et seq.].

§ 9621. Cleanup standards [CERCLA Section 121]

(a) Selection of remedial action

The President shall select appropriate remedial actions determined to be necessary to be carried out under section 9604 of this title or secured under section 9606 of this title which are in accordance with this section and, to the extent practicable, the national contingency plan, and which provide for cost-effective response. In evaluating the cost effectiveness of proposed alternative remedial actions, the President shall take into account the total short- and long-term costs of such actions, including the costs of operation and maintenance for the entire period during which such activities will be required.

(b) General rules

(1) Remedial actions in which treatment which permanently and significantly reduces the volume, toxicity or mobility of the hazardous substances, pollutants, and contaminants is a principal element, are to be preferred over remedial actions not involving such treatment. The offsite transport and disposal of hazardous substances or contaminated materials without such treatment should be the least favored alternative remedial action where practicable treatment technologies are available. The President shall conduct an assessment of permanent solutions and alternative treatment technologies or resource recovery technologies that, in whole or in part, will result in a permanent and significant decrease in the toxicity, mobility, or volume of the hazardous substance, pollutant, or contaminant. In making such assessment, the President shall specifically address the long-term effectiveness of various alternatives. In assessing alternative remedial actions, the President shall, at a minimum, take into account:

(A) the long-term uncertainties associated with land disposal;

(B) the goals, objectives, and requirements of the Solid Waste Disposal Act [42 U.S.C.A. § 6901 et seq.];

(C) the persistence, toxicity, mobility, and propensity to bioaccumulate of such hazardous substances and their constituents;

(D) short- and long-term potential for adverse health effects from human exposure;

(E) long-term maintenance costs;

(F) the potential for future remedial action costs if the alternative remedial action in question were to fail; and

(G) the potential threat to human health and the environment associated with excavation, transportation, and redisposal, or containment.

The President shall select a remedial action that is protective of human health and the environment, that is cost effective, and that utilizes permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. If the President selects a remedial action not appropriate for a preference under this subsection, the President shall publish an explanation as to why a remedial action involving such reductions was not selected.

(2) The President may select an alternative remedial action meeting the objectives of this subsection whether or not such action has been achieved in practice at any other facility or site that has similar characteristics. In making such a selection, the President may take into account the degree of support for such remedial action by parties interested in such site.

(c) Review

If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each 5 years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented. In addition, if upon such review it is the judgment of the President that action is appropriate at such site in accordance with section 9604 or 9606 of this title, the President shall take or require such action. The President shall report to the Congress a list of facilities for which such review is required, the results of all such reviews, and any actions taken as a result of such reviews.

(d) Degree of cleanup

(1) Remedial actions selected under this section or otherwise required or agreed to by the President under this chapter shall attain a degree of cleanup of hazardous substances, pollutants, and contaminants released into the environment and of control of further release at a minimum which assures protection of human health and the environment. Such remedial actions shall be relevant and appropriate under the circumstances presented by the release or threatened release of such substance, pollutant, or contaminant.

(2)(A) With respect to any hazardous substance, pollutant or contaminant that will remain onsite, if--

(i) any standard, requirement, criteria, or limitation under any Federal environmental law, including, but not limited to, the Toxic Substances Control Act [15 U.S.C.A. § 2601 et seq.], the Safe Drinking Water Act [42 U.S.C.A. § 300f et seq.], the Clean Air Act [42 U.S.C.A. § 7401 et seq.], the Clean Water Act [33 U.S.C.A. § 1251 et seq.], the Marine Protection, Research and Sanctuaries Act [16 U.S.C.A. § 1431 et seq., § 1447 et seq., 33 U.S.C.A. § 1401 et seq., § 2801 et seq.], or the Solid Waste Disposal Act [42 U.S.C.A. § 6901 et seq.]; or

(ii) any promulgated standard, requirement, criteria, or limitation under a State environmental or facility siting law that is more stringent than any Federal standard, requirement, criteria, or limitation, including each such State standard, requirement, criteria, or limitation contained in a program approved, authorized or delegated by the Administrator under a statute cited in subparagraph (A), and that has been identified to the President by the State in a timely manner,

is legally applicable to the hazardous substance or pollutant or contaminant concerned or is relevant and appropriate under the circumstances of the release or threatened release of such hazardous substance or pollutant or contaminant, the remedial action selected under section 9604 of this title or secured under section 9606 of this title shall require, at the completion of the remedial action, a level or standard of control for such hazardous substance or pollutant or contaminant which at least attains such legally applicable or relevant and appropriate standard, requirement, criteria, or limitation. Such remedial action shall require a level or standard of control which at least attains Maximum Contaminant Level Goals established under the Safe Drinking Water Act [42 U.S.C.A. § 300f et seq.] and water quality criteria established under section 304 or 303 of the Clean Water Act [33 U.S.C.A. § 1314 or 1313], where such goals or criteria are relevant and appropriate under the circumstances of the release or threatened release.

(B)(i) In determining whether or not any water quality criteria under the Clean Water Act [33 U.S.C.A. § 1251 et seq.] is relevant and appropriate under the circumstances of the release or threatened release, the President shall consider the designated or potential use of the surface or groundwater, the environmental media affected, the purposes for which such criteria were developed, and the latest information available.

(ii) For the purposes of this section, a process for establishing alternate concentration limits to those otherwise applicable for hazardous constituents in groundwater under subparagraph (A) may not be used to establish applicable standards under this paragraph if the process assumes a point of human exposure beyond the boundary of the facility, as defined at the conclusion of the remedial investigation and feasibility study, except where--

(I) there are known and projected points of entry of such groundwater into surface water; and

(II) on the basis of measurements or projections, there is or will be no statistically significant increase of such constituents from such groundwater in such surface water at the point of entry or at any point where there is reason to believe accumulation of constituents may occur downstream; and

(III) the remedial action includes enforceable measures that will preclude human exposure to the contaminated groundwater at any point between the facility boundary and all known and projected points of entry of such groundwater into surface water

then the assumed point of human exposure may be at such known and projected points of entry.

(C)(i) Clause (ii) of this subparagraph shall be applicable only in cases where, due to the President's selection, in compliance with subsection (b)(1) of this section, of a proposed remedial action which does not permanently and significantly reduce the volume, toxicity, or mobility of hazardous substances, pollutants, or contaminants, the proposed disposition of waste generated by or associated with the remedial action selected by the President is land disposal in a State referred to in clause (ii).

(ii) Except as provided in clauses (iii) and (iv), a State standard, requirement, criteria, or limitation (including any State siting standard or requirement) which could effectively result in the statewide prohibition of land disposal of hazardous substances, pollutants, or contaminants shall not apply.

(iii) Any State standard, requirement, criteria, or limitation referred to in clause (ii) shall apply where each of the following conditions is met:

(I) The State standard, requirement, criteria, or limitation is of general applicability and was adopted by formal means.

(II) The State standard, requirement, criteria, or limitation was adopted on the basis of hydrologic, geologic, or other relevant considerations and was not adopted for the purpose of precluding onsite remedial actions or other land disposal for reasons unrelated to protection of human health and the environment.

(III) The State arranges for, and assures payment of the incremental costs of utilizing, a facility for disposition of the hazardous substances, pollutants, or contaminants concerned.

(iv) Where the remedial action selected by the President does not conform to a State standard and the State has initiated a law suit against the Environmental Protection Agency prior to May 1, 1986, to seek to have the remedial action conform to such standard, the President shall conform the remedial action to the State standard. The State shall assure the availability of an offsite facility for such remedial action.

(3) In the case of any removal or remedial action involving the transfer of any hazardous substance or pollutant or contaminant offsite, such hazardous substance or pollutant or contaminant shall only be transferred to a facility which is operating in compliance with section 3004 and 3005 of the Solid Waste Disposal Act [42 U.S.C.A. §§ 6924 and 6925] (or, where applicable, in compliance with the Toxic Substances Control Act [15 U.S.C.A. § 2601 et seq.] or other applicable Federal law) and all applicable State requirements. Such substance or pollutant or contaminant may be transferred to a land disposal facility only if the President determines that both of the following requirements are met:

(A) The unit to which the hazardous substance or pollutant or contaminant is transferred is not releasing any hazardous waste, or constituent thereof, into the groundwater or surface water or soil.

(B) All such releases from other units at the facility are being controlled by a corrective action program approved by the Administrator under subtitle C of the Solid Waste Disposal Act [42 U.S.C.A. § 6921 et seq.].

The President shall notify the owner or operator of such facility of determinations under this paragraph.

(4) The President may select a remedial action meeting the requirements of paragraph

(1) that does not attain a level or standard of control at least equivalent to a legally applicable or relevant and appropriate standard, requirement, criteria, or limitation as required by paragraph (2) (including subparagraph (B) thereof), if the President finds that--

(A) the remedial action selected is only part of a total remedial action that will attain such level or standard of control when completed;

(B) compliance with such requirement at that facility will result in greater risk to human health and the environment than alternative options;

(C) compliance with such requirements is technically impracticable from an engineering perspective;

(D) the remedial action selected will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, criteria, or limitation, through use of another method or approach;

(E) with respect to a State standard, requirement, criteria, or limitation, the State has not consistently applied (or demonstrated the intention to consistently apply) the standard, requirement, criteria, or limitation in similar circumstances at other remedial actions within the State; or

(F) in the case of a remedial action to be undertaken solely under section 9604 of this title using the Fund, selection of a remedial action that attains such level or standard of control will not provide a balance between the need for protection of public health and welfare and the environment at the facility under consideration, and the availability of amounts from the Fund to respond to other sites which present or may present a threat to public health or welfare or the environment, taking into consideration the relative immediacy of such threats.

The President shall publish such findings, together with an explanation and appropriate documentation.

(e) Permits and enforcement

(1) No Federal, State, or local permit shall be required for the portion of any removal or remedial action conducted entirely onsite, where such remedial action is selected and carried out in compliance with this section.

(2) A State may enforce any Federal or State standard, requirement, criteria, or limitation to which the remedial action is required to conform under this chapter in the United States district court for the district in which the facility is located. Any consent decree shall require the parties to attempt expeditiously to resolve disagreements concerning implementation of the remedial action informally with the appropriate Federal and State agencies. Where the parties agree, the consent decree may provide for administrative enforcement. Each consent decree shall also contain stipulated penalties for violations of the decree in an amount not to exceed $25,000 per day, which may be enforced by either the President or the State. Such stipulated penalties shall not be construed to impair or affect the authority of the court to order compliance with the specific terms of any such decree.

(f) State involvement

(1) The President shall promulgate regulations providing for substantial and meaningful involvement by each State in initiation, development, and selection of remedial actions to be undertaken in that State. The regulations, at a minimum, shall include each of the following:

(A) State involvement in decisions whether to perform a preliminary assessment and site inspection.

(B) Allocation of responsibility for hazard ranking system scoring.

(C) State concurrence in deleting sites from the National Priorities List.

(D) State participation in the long-term planning process for all remedial sites within the State.

(E) A reasonable opportunity for States to review and comment on each of the following:

(i) The remedial investigation and feasibility study and all data and technical documents leading to its issuance.

(ii) The planned remedial action identified in the remedial investigation and feasibility study.

(iii) The engineering design following selection of the final remedial action.

(iv) Other technical data and reports relating to implementation of the remedy.

(v) Any proposed finding or decision by the President to exercise the authority of subsection (d)(4) of this section.

(F) Notice to the State of negotiations with potentially responsible parties regarding the scope of any response action at a facility in the State and an opportunity to participate in such negotiations and, subject to paragraph (2), be a party to any settlement.

(G) Notice to the State and an opportunity to comment on the President's proposed plan for remedial action as well as on alternative plans under consideration. The President's proposed decision regarding the selection of remedial action shall be accompanied by a response to the comments submitted by the State, including an explanation regarding any decision under subsection (d)(4) of this section on compliance with promulgated State standards. A copy of such response shall also be provided to the State.

(H) Prompt notice and explanation of each proposed action to the State in which the facility is located.

Prior to the promulgation of such regulations, the President shall provide notice to the State of negotiations with potentially responsible parties regarding the scope of any response action at a facility in the State, and such State may participate in such negotiations and, subject to paragraph (2), any settlements.

(2)(A) This paragraph shall apply to remedial actions secured under section 9606 of this title. At least 30 days prior to the entering of any consent decree, if the President proposes to select a remedial action that does not attain a legally applicable or relevant and appropriate standard, requirement, criteria, or limitation, under the authority of subsection (d)(4) of this section, the President shall provide an opportunity for the State to concur or not concur in such selection. If the State concurs, the State may become a signatory to the consent decree.

(B) If the State does not concur in such selection, and the State desires to have the remedial action conform to such standard, requirement, criteria, or limitation, the State shall intervene in the action under section 9606 of this title before entry of the consent decree, to seek to have the remedial action so conform. Such intervention shall be a matter of right. The remedial action shall conform to such standard, requirement, criteria, or limitation if the State establishes, on the administrative record, that the finding of the President was not supported by substantial evidence. If the court determines that the remedial action shall conform to such standard, requirement, criteria, or limitation, the remedial action shall be so modified and the State may become a signatory to the decree. If the court determines that the remedial action need not conform to such standard, requirement, criteria, or limitation, and the State pays or assures the payment of the additional costs attributable to meeting such standard, requirement, criteria, or limitation, the remedial action shall be so modified and the State shall become a signatory to the decree.

(C) The President may conclude settlement negotiations with potentially responsible parties without State concurrence.

(3)(A) This paragraph shall apply to remedial actions at facilities owned or operated by a department, agency, or instrumentality of the United States. At least 30 days prior to the publication of the President's final remedial action plan, if the President proposes to select a remedial action that does not attain a legally applicable or relevant and appropriate standard, requirement, criteria, or limitation, under the authority of subsection (d)(4) of this section, the President shall provide an opportunity for the State to concur or not concur in such selection. If the State concurs, or does not act within 30 days, the remedial action may proceed.

(B) If the State does not concur in such selection as provided in subparagraph (A), and desires to have the remedial action conform to such standard, requirement, criteria, or limitation, the State may maintain an action as follows:

(i) If the President has notified the State of selection of such a remedial action, the State may bring an action within 30 days of such notification for the sole purpose of determining whether the finding of the President is supported by substantial evidence. Such action shall be brought in the United States district court for the district in which the facility is located.

(ii) If the State establishes, on the administrative record, that the President's finding is not supported by substantial evidence, the remedial action shall be modified to conform to such standard, requirement, criteria, or limitation.

(iii) If the State fails to establish that the President's finding was not supported by substantial evidence and if the State pays, within 60 days of judgment, the additional costs attributable to meeting such standard, requirement, criteria, or limitation, the remedial action shall be selected to meet such standard, requirement, criteria, or limitation. If the State fails to pay within 60 days, the remedial action selected by the President shall proceed through completion.

(C) Nothing in this section precludes, and the court shall not enjoin, the Federal agency from taking any remedial action unrelated to or not inconsistent with such standard, requirement, criteria, or limitation.

§ 9659. Citizens suits [CERCLA Section 310]

(a) Authority to bring civil actions

Except as provided in subsections (d) and (e) of this section and in section 9613(h) of this title (relating to timing of judicial review), any person may commence a civil action on his own behalf--

(1) against any person (including the United States and any other governmental instrumentality or agency, to the extent permitted by the eleventh amendment to the Constitution) who is alleged to be in violation of any standard, regulation, condition, requirement, or order which has become effective pursuant to this chapter (including any provision of an agreement under section 9620 of this title, relating to Federal facilities); or

(2) against the President or any other officer of the United States (including the Administrator of the Environmental Protection Agency and the Administrator of the ATSDR) where there is alleged a failure of the President or of such other officer to perform any act or duty under this chapter, including an act or duty under section 9620 of this title (relating to Federal facilities), which is not discretionary with the President or such other officer.

Paragraph (2) shall not apply to any act or duty under the provisions of section 9660 of this title (relating to research, development, and demonstration).

(b) Venue

(1) Actions under subsection (a)(1)

Any action under subsection (a)(1) of this section shall be brought in the district court for the district in which the alleged violation occurred.

(2) Actions under subsection (a)(2)

Any action brought under subsection (a)(2) of this section may be brought in the United States District Court for the District of Columbia.

(c) Relief

The district court shall have jurisdiction in actions brought under subsection (a)(1) of this section to enforce the standard, regulation, condition, requirement, or order concerned (including any provision of an agreement under section 9620 of this title), to order such action as may be necessary to correct the violation, and to impose any civil penalty provided for the violation. The district court shall have jurisdiction in actions brought under subsection (a)(2) of this section to order the President or other officer to perform the act or duty concerned.

(d) Rules applicable to subsection (a)(1) actions

(1) Notice

No action may be commenced under subsection (a)(1) of this section before 60 days after the plaintiff has given notice of the violation to each of the following:

(A) The President.

(B) The State in which the alleged violation occurs.

(C) Any alleged violator of the standard, regulation, condition, requirement, or order concerned (including any provision of an agreement under section 9620 of this title).

Notice under this paragraph shall be given in such manner as the President shall prescribe by regulation.

(2) Diligent prosecution

No action may be commenced under paragraph (1) of subsection (a) of this section if the President has commenced and is diligently prosecuting an action under this chapter, or under the Solid Waste Disposal Act [42 U.S.C.A. § 6901 et seq.] to require compliance with the standard, regulation, condition, requirement, or order concerned (including any provision of an agreement under section 9620 of this title).

(e) Rules applicable to subsection (a)(2) actions

No action may be commenced under paragraph (2) of subsection (a) of this section before the 60th day following the date on which the plaintiff gives notice to the Administrator or other department, agency, or instrumentality that the plaintiff will commence such action. Notice under this subsection shall be given in such manner as the President shall prescribe by regulation.

(f) Costs

The court, in issuing any final order in any action brought pursuant to this section, may award costs of litigation (including reasonable attorney and expert witness fees) to the prevailing or the substantially prevailing party whenever the court determines such an award is appropriate. The court may, if a temporary restraining order or preliminary injunction is sought, require the filing of a bond or equivalent security in accordance with the Federal Rules of Civil Procedure.

(g) Intervention

In any action under this section, the United States or the State, or both, if not a party may intervene as a matter of right. For other provisions regarding intervention, see section 9613 of this title.

(h) Other rights

This chapter does not affect or otherwise impair the rights of any person under Federal, State, or common law, except with respect to the timing of review as provided in section 9613(h) of this title or as otherwise provided in section 9658 of this title (relating to actions under State law).

(i) Definitions

The terms used in this section shall have the same meanings as when used in subchapter I of this chapter.