Attachment A

Conceptual Site Model Summary

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Step 1 of the Soil Screening Guidance: User's Guide describes the development of a conceptual site model (CSM) to support the application of soil screening levels (SSLs) at a site. The CSM summary forms at the end of this attachment contain the information necessary to:

- Determine the applicability of SSLs to the site
- Calculate SSLs.

By identifying data gaps, these summary forms will help focus data collection and evaluation on the site-specific development and application of SSLs. The site investigator should use the summary forms during the SSL sampling effort to collect site-specific data and continually update the CSM with new information as appropriate.

The CSM summary forms indicate the information required for determining the applicability of the soil screening process to the site. Forms addressing source characteristics may be photocopied if more than one source is present at a site.

A site map showing contaminated soil sources and exposure areas (EAs) should be attached to the summary. If available, additional pages of other maps, summaries of analytical results, or more detailed descriptions of the site may be attached to the summary.

Form 1. General Site Information

The information included in this form is identical to the first page of the Site Inspection (SI) Data Summary form (page B-3 in *Guidance for Performing Site Inspections Under CERCLA*, U.S. EPA, 1992). However, the form should be updated to reflect any site activities conducted since the SI was completed.

Form 2. Site Characteristics

Form 2 indicates the information necessary to address the migration to ground water pathway and identify subsurface conditions that may limit the applicability of subsurface SSLs.

A hydrogeologic setting is defined as a unit with common hydrogeologic characteristics and therefore common vulnerability to contamination. Each setting provides a composite description of the hydrogeologic factors that control ground water movement and recharge. These factors can be used to make generalizations in the CSM about ground water conditions.

After placing the site into one of Heath's ground water regions (Heath, 1984), consider geologic and geomorphic features of the site and select a generic hydrogeologic setting from Aller et al. (1987) that is most similar to the site. If existing site information is not sufficient to definitively place the site in a setting, it should be possible to narrow the choice to two or three settings that will reduce the range of values necessary to develop SSLs. A copy of the setting diagram from Aller et al. (1987) should be attached to the CSM checklist to provide a general picture of subsurface site conditions.

Ground Water Flow Direction. The direction of ground water flow in the uppermost aquifer underlying each source is needed to determine source length parallel to that flow. If ground water flow direction is unknown or uncertain, assume it is parallel to the longest source dimension.

Aquifer Parameters. Aquifer parameters needed to estimate a site-specific dilution factor include hydraulic conductivity (K), hydraulic gradient (i), and aquifer thickness (d_a). Site-measured values for these parameters are the preferred alternative. Existing site documentation should be reviewed for in situ measurements of aquifer conductivity (i.e., from pump test data), water table maps that can be used to estimate hydraulic gradient, and boring logs that indicate the thickness of the uppermost aquifer. Detailed information on conducting and interpreting aquifer tests can be found in Nielsen (1991).

If site-measured values are not available, hydrogeologic knowledge of regional geologic conditions or measured values in the literature may be sources of reasonable estimates. Values from a similar site in the same region and hydrogeologic setting also may be used, but must be carefully reviewed to ensure that the subsurface conceptual models for the two sites show reasonable agreement. For all of these options, it is critical that the estimates and sources be reviewed by an experienced hydrogeologist knowledgeable of regional hydrogeologic conditions.

A third option is to obtain parameter estimates for the site's hydrogeologic setting from Aller et al. (1987) or from the American Petroleum Institute's (API's) hydrogeologic database (HGDB) (Newell et al., 1989, 1990). Aller et al. (1987) present ranges of values for K and i by hydrogeologic setting. The HGDB contains measured values for these parameters and aquifer depth for a number of sites in each hydrogeologic setting. If HGDB data are used, the median value presented for each setting should be used unless site-specific conditions indicate otherwise. Aquifer parameter values from these sources also can serve as a check of the validity of site-measured values or estimates obtained from other sources.

If outside sources such as Aller et al. (1987) are used to characterize site hydrogeologic conditions, the appropriate references and diagrams should be attached to the CSM checklist.

Infiltration Rate. Infiltration rate is used to calculate SSLs for subsurface soils (see Step 5). The simplest way to estimate infiltration rate (I) is to assume that infiltration is equal to recharge and obtain recharge estimates for the site's hydrogeologic setting from Aller et al. (1987). When using the Aller et al. (1987) estimates the user should recognize that these are estimates of average recharge conditions throughout the setting and site-specific values may differ to some extent. For example, areas within the setting with steeper than average slopes will tend to have lower infiltration rates and areas with flatter than average slopes will tend to have higher infiltration than average. An alternative is to use infiltration rates determined for a better-characterized site in the same hydrogeologic setting and with similar meteorological conditions as the site in question.

A third alternative is use the HELP model. Although HELP was originally written for hydrologic evaluation of landfills (Schroeder et al., 1984), inputs to the HELP program can be modified to estimate infiltration in undisturbed soils in natural settings. The most recent version of HELP and the most recent user's guide and documentation can be obtained by sending an address and two double-sided, high-density, DOS-formatted disks to:

attn. Eunice Burk
U.S. EPA
5995 Center Hill Ave.
Cincinnati, OH 45224
(513) 569-7871.

Meteorologic Parameters. Select a site-specific Q/C value from in the guidance for the volatilization factor (VF) equation or particulate emission factor (PEF) equation to place the site in a climatic zone (Figure A-1).

Several site-specific parameters are required to calculate a PEF if fugitive dusts are of concern at the site (see Step 5 for surface soils). The threshold windspeed at 7 meters above ground surface ($U_{t,7}$) is calculated from source area roughness height and the mode soil aggregate size as described in Cowherd et al. (1985). Mode soil aggregate size refers to the mode diameter of aggregated soil particles measured under field conditions.

Other site-specific variables necessary for calculating the PEF include fraction vegetative cover (V) and the mean annual windspeed (U_m). Fraction vegetative cover is estimated by visual observations of the surface of known or suspected source areas at the site. Mean annual windspeed can be obtained from the National Weather Service surface station nearest to the site.

Form 3. Exposure Pathways and Receptors

Form 3 includes information necessary to determine the applicability of the Soil Screening Guidance to a site (see Step 2 of the User's Guide). This form summarizes the site information necessary to identify and characterize potential exposure pathways and receptors at the site, such as site conditions, relevant exposure scenarios, and the properties of soil contaminants listed on Form 4. Table A-1 provides an example of exposure pathways that are not addressed by the guidance, but have relevance to CSM development.

Table A-1. Example Identification of Exposure Pathways Not Addressed by SSLs

Receptors/ Exposure Pathways	Contaminant Characteristics	Site Conditions
Human / Direct Pathways		
ingestion (acute exposure)	acute health effects (e.g., cyanide, phenol)	residential setting
inhalation - fugitive dusts (acute exposure)	acute health effects	high fugitive dusts (e.g., from soil tillage, heavy traffic on dirt roads; construction)
Human / Indirect Pathways		
consumption of meat or dairy products	bioaccumulation, biomagnification	nearby meat or dairy production
fish consumption	biomagnification	nearby surface waters with recreational or subsistence fishing
Ecological Pathways		
aquatic	aquatic toxicity	nearby surface waters or wetlands
terrestrial	toxicity to terrestrial organisms (e.g., DDT, Hg)	sensitive species on or near site

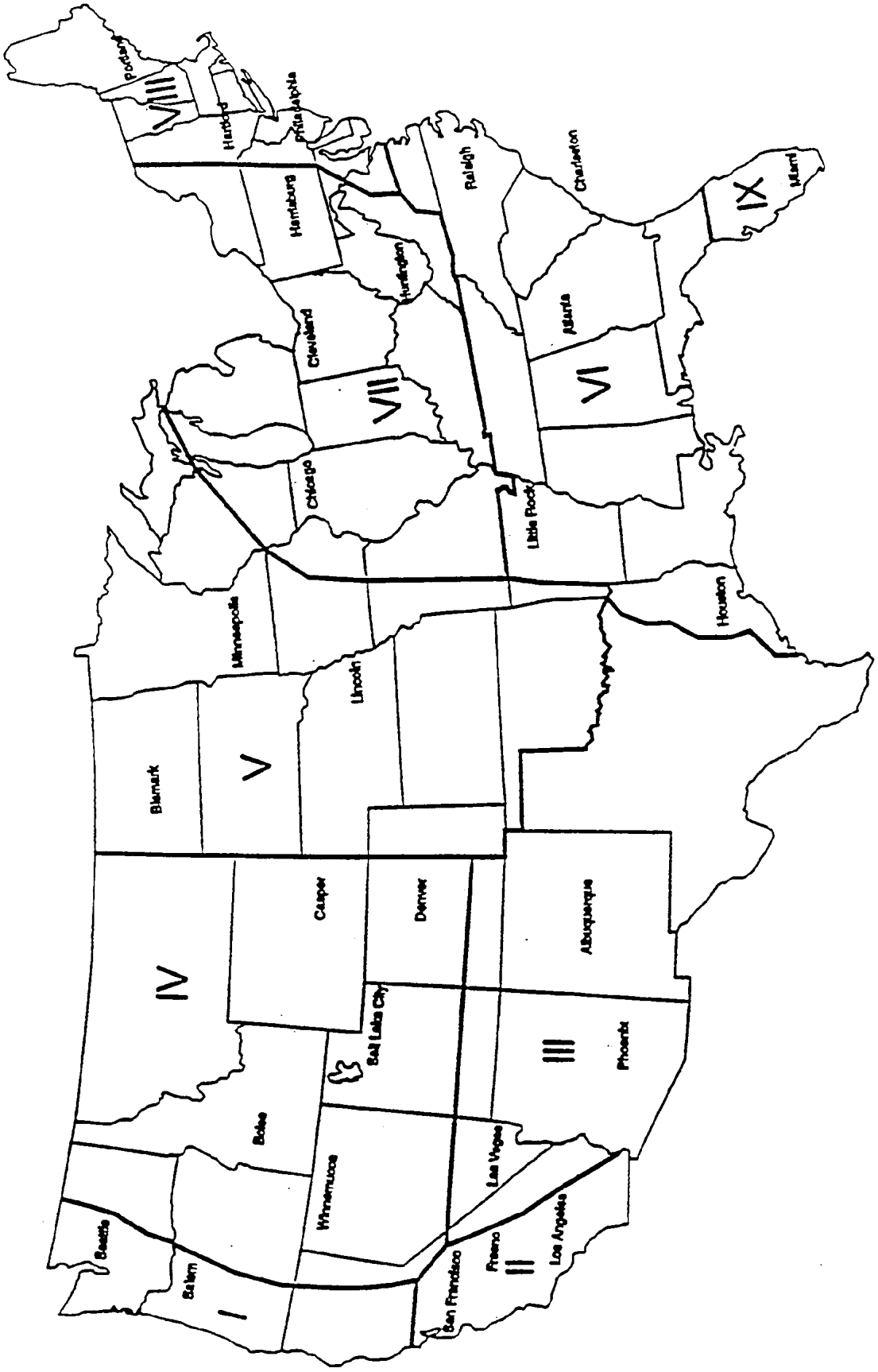

Figure A-1. U.S. climatic zones

Form 4. Soil Contaminant Source Characteristics

This form prompts the investigator to provide information on source characteristics, including soil contaminant levels and the physical and chemical parameters of site soils needed to calculate SSLs. One form should be completed for each contaminated soil source. Initially, the form should be filled out to the greatest extent possible with existing site information collected during CSM development (see Step 1 of the User's Guide). The forms should be updated after the SSL sampling effort is complete.

Measurement of contaminant levels and the soil parameters listed on this form is described in Step 3 of this guidance.

Average soil moisture content (θ_w) defines the fraction of total soil porosity that is filled by water and air. These parameters are necessary for determining the volatilization factor (VF) and the soil saturation limit (C_{sat}) and to apply the soil/water partition equation. It is important that the moisture content used to calculate these parameters represent the annual average soil moisture conditions. Moisture content measurements on discrete soil samples should not be used because they are affected by preceding rainfall events and thus may not represent average conditions. Volumetric average soil water content may be estimated by the following relationship developed by Clapp and Hornberger (1978) and presented in the *Superfund Exposure Assessment Manual* (U.S. EPA, 1988):

$$\theta_w = n\ (I/K_s)^{\ 1/(2b+3)}$$

where

n = total soil porosity (L_{pore}/L_{soil})
I = infiltration rate (m/yr)
K_s = saturated hydraulic conductivity (m/yr)
b = soil-specific exponential parameter (unitless).

Total soil porosity (n) is estimated from dry soil bulk density (ρ_b) as follows:

$$n = 1 - (\rho_b/\rho_s)$$

where

ρ_s = soil particle density = 2.65 kg/L.

Values for K_s and the exponential term 1/(2b+3) are shown in Table A-2 by soil texture class (soil class determination is discussed under Step 3).

Site-specific values for infiltration rate (I) may be estimated using the HELP model or may be assumed to be equivalent to recharge (see Form 2).

Table A-2. Parameter Estimates for Calculating Average Soil Moisture Content (θ_w)

Soil texture	K_s (m/yr)	1/(2b+3)
Sand	1,830	0.090
Loamy sand	540	0.085
Sandy loam	230	0.080
Silt loam	120	0.074
Loam	60	0.073
Sandy clay loam	40	0.058
Silt clay loam	13	0.054
Clay loam	20	0.050
Sandy clay	10	0.042
Silt clay	8	0.042
Clay	5	0.039

Source: U.S. EPA, 1988.

Worksheets

The worksheets following Forms 1 through 4 provide a convenient means of assembling chemical-specific parameters necessary to calculate SSLs for the contaminants of concern (Worksheet 1), existing site data on contaminant concentrations collected during CSM development or the SSL sampling effort (Worksheet 2), and SSLs calculated for EAs (Worksheet 3) or contaminant sources (Worksheet 4) of concern at the site.

CSM Diagram

The CSM diagram is a product of CSM development that represents the linkages among contaminant sources, release mechanisms, exposure pathways and routes, and receptors to summarize the current understanding of the soil contamination problem (see Step 1 of the guidance). An example SSL CSM diagram, Figure A-2 (U.S. EPA, 1989), and a site sketch, Figure A-3 (U.S. EPA, 1987) are provided following the Worksheets.

References

Aller, L., T. Bennett, J.H. Lehr, R.J. Petty, and G. Hackett. 1987. *DRASTIC: A Standardized System for Evaluating Ground Water Pollution Potential Using Hydrogeologic Settings.* Prepared for U.S. EPA Office of Research and Development, Ada, OK. National Water Well Association, Dublin, OH. EPA-600/2-87-035.

Clapp, R.B., and G.M. Hornberger. 1978. Empirical equations for some soil hydraulic properties. *Water Resources Research,* 14:601-604.

Cowherd, C., G. Muleski, P. Engelhart, and D. Gillette. 1985. *Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination*. Prepared for Office of Health and Environmental Assessment, U.S. EPA, Washington, DC. NTIS PB85-192219 7AS. EPA/600/8-85/002.

Heath, R.C. 1984. *Ground-Water Regions of the United States.* USGS Water Supply Paper 2242. U.S. Geological Survey, Reston, VA.

Newell, C.J., L.P. Hopkins, and P.B. Bedient. 1989. *Hydrogeologic Database for Ground Water Modeling.* API Publication No. 4476. American Petroleum Institute, Washington, DC.

Newell, C.J., L.P. Hopkins, and P.B. Bedient. 1990. A hydrogeologic database for ground water-modeling. *Ground Water,* 28(5):703-714.

Nielsen, D.M. (ed.). 1991. *Practical Handbook of Ground-Water Monitoring*. Lewis Publishers, Chelsea, MI.

Schroeder, P.R., A.C. Gibson, and M.D. Smolen. 1984. *Hydrological Evaluation of Landfill Performance (HELP) Model; Volume 2: Documentation for Version 1.* NTIS PB85-100832. Office of Research and Development, U.S. EPA, Cincinnati, OH. EPA/530-SW-84-010.

U.S. EPA. 1987. *Data Quality Objectives for Remedial Response Activities. Example Scenario: RI/FS Activities at a Site with Contaminated Soil and Groundwater.* Office of Emergency and Remedial Response, Washington, DC. NTIS PB88-13188.

U.S. EPA 1988. *Superfund Exposure Assessment Manual.* OSWER Directive 9285.5-1. Office of Emergency and Remedial Response, Washington, DC. EPA/540/1-88/001. NTIS PB89-135859.

U.S. EPA. 1989. *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA.* EPA/540/G-89/004. OSWER Directive 9355.3-01. Office of Emergency and Remedial Response, Washington, DC. NTIS PB89-184626.

U.S. EPA. 1992. *Guidance for Performing Site Inspections Under CERCLA*. EPA/540-R-92-0021. Office of Emergency and Remedial Response, Washington, DC. NTIS PB92-963375.

Soil Screening Guidance
Conceptual Site Model Summary Forms

Form 1: General Site Information **Site Name** _____

EPA Region_____ Date_____

Contractor Name and Address: _____

_____

_____

State Contact: _____

1. CERCLIS ID No. _____
   Address _____City _____
   County_____ State _____ Zip Code _____ Congressional District_____

2. Owner Name _____Operator Name _____
   Owner Address _____Operator Address_____
   City _____ State _____City _____ State _____

3. Type of ownership (check all that apply):
   ☐ Private ☐ Federal Agency _____ ☐ State ☐ County ☐ Municipal
   Other _____Ref. _____

4. Approximate size of property _____ acres Ref. _____

5. Latitude ___ o___|___ . ___" Longitude ___ o ___ |___ . ___" Ref. _____

6. Site status ☐ Active ☐ Inactive ☐ Unknown Ref. _____

7. Years of operation From_____ To _____ ☐ Unknown Ref. _____

8. Previous investigations

Type	Agency/State/Contractor	Date	
_____	_____	_____	Ref. _____
_____	_____	_____	Ref. _____
_____	_____	_____	Ref. _____
_____	_____	_____	Ref. _____
_____	_____	_____	Ref. _____
_____	_____	_____	Ref. _____

Ref. = reference(s) on information source

Figure A-1. U.S. climatic zones **Site Name** _____

Hydrogeologic Characteristics (migration to ground water pathway)

Is ground water of concern at the site? ☐ yes ☐ no (if no, move to Infiltration Rate below).

Heath region _____ **Hydrogeologic setting** _____

(attach setting diagram)

Check setting characteristics that apply: ☐ karst ☐ fractured rock ☐ solution limestone

Describe the stratigraphy and hydrogeologic characteristics of the site. (Attach available maps and cross-sections.)

_____

_____

_____

_____

Ref._____

Identify and describe nearby sites in similar settings that have already been characterized.

_____

_____

_____

_____

Ref._____

Aquifer Parameters	Unit	Typical	Min.	Max.	Reference or Source
hydraulic conductivity (K)	m/y				
hydraulic gradient (i)	m/m				
thickness (d_a)	m				

General direction of ground water flow across the site (e.g., NNE, SW): _____

(attach map.) Ref. _____

Infiltration rate (I) _____ m/yr Method _____

Meteorological Characteristics (inhalation pathway)

climatological zone: _____ (zone#, city) Q/C _____(g/m^2-s per kg/m^3)

fract. vegetative cover (V)_____ (unitless) Reference _____

mean annual windspeed (U_m)_____ m/s Reference _____

equivalent threshold value of windspeed at 7 m (U_t) _____m/s

fraction dependent on U_m/U_t _____(unitless)

Comments:_____

_____

_____

Form 3: Exposure Pathways and Receptors **Site Name** _____

Land Use Conditions

Current site use:	Surrounding land use:	Future land use:
__ residential	__ residential	__ residential
__ industrial	__ industrial	__ industrial
__ commercial	__ commercial	__ commercial
__ agricultural	__ agricultural	__ agricultural
__ recreational	__ recreational	__ recreational
__ other	__ other	__ other

Size of exposure areas (in acres) _____

Contaminant Release Mechanisms (check all that apply):

Source #___ ☐ leaching ☐ volatilization ☐ fugitive dusts ☐ erosion/runoff ☐ uptake by plants

Source #___ ☐ leaching ☐ volatilization ☐ fugitive dusts ☐ erosion/runoff ☐ uptake by plants

Source #___ ☐ leaching ☐ volatilization ☐ fugitive dusts ☐ erosion/runoff ☐ uptake by plants

(describe rationale for not including any of the above release mechanisms)

_____

_____

_____

Media affected (or potentially affected) by soil contamination.

Source #___ ☐ air ☐ ground water ☐ surface water ☐ sediments ☐ wetlands

Source #___ ☐ air ☐ ground water ☐ surface water ☐ sediments ☐ wetlands

Source #___ ☐ air ☐ ground water ☐ surface water ☐ sediments ☐ wetlands

Check if present on-site or on surrounding land (attach map showing locations)

☐ wetlands ☐ surface water ☐ subsistence fishing ☐ recreational fishing ☐ dairy/beef production

Check SSL exposure pathways applicable at site; describe basis for not including any pathway

☐ ingestion ☐ inhalation ☐ migration to ground water ☐ dermal ☐ soil-plant-human

Check Potential for:

☐ **Acute Effects (describe)**

☐ **Other Human Exposure Pathways (describe)**

☐ **Ecological concerns (describe)**

Form 4: Soil Contaminant Source Characteristics **Site Name**_____

Source No.: _____

Name: _____ (e.g., drum storage area)

Type: _____ (e.g., spill, dump, wood treater)

Location:_____ (site map)

Waste type: _____ (e.g., solvents, waste oil)

Description (describe history of contamination, other information)

_____

_____

_____

_____

_____

Describe past/current remedial or removal actions

_____

_____

_____

_____

_____

Source depth:_____ m (☐ measures ☐ estimated) Ref. _____

Source area: _____ acres _____ m^2 (☐ measures ☐ estimated) Ref. _____

Source length parallel to ground water flow: _____ m (if uncertain, use longest source dimension)

Contaminant types (check all that apply): ☐ volatile organics ☐ other organics ☐ metals ☐ other inorganics

Soil Contaminants Present (list): _____

_____

_____

(attach Worksheet #1)

Describe previous soil analyses. (attach available results and map showing sample locations)

_____

_____

_____

_____

(attach Worksheet #2)

Are NAPLs suspected? ☐ **Yes** ☐ **No** Reason_____

_____

Average Soil Characteristics

average water content (θ_w)_____(L_{water}/L_{soil}) Ref. _____

fraction organic carbon (f_{oc}) _____g/g Ref. _____

dry bulk density (ρ_b) _____(kg/L) Ref. _____

pH _____ Ref. _____

Worksheet 1. Contaminant-specific properties **Site Name** _____

Regulatory and Human Health Benchmarks[1]

Contaminant	CAS #	MCLG, MCL, or HBL (mg/L)	Sources (no.)	RfD (mg/kg/-d)	SF_o $(mg/kg/-d)^{-1}$	URF $(\mu g/m^3)^{-1}$	RfC (mg/m^3)

Chemical Properties[2]

Contaminant	CAS #	Sources (no.)	K_{oc}[3] (L/kg)	K_d[4] (L/kg)	H[5]	D_{ia}[5] (cm^2/s)	D_{iw}[5] (cm^2/s)	S[5] (mg/L)

1. Attachment D
2. Attachment C
3. For organic compounds
4. For metals and inorganic compounds
5. Not applicable to metals except mercury

Worksheet 2. Contaminant concentrations by source **Site Name**_____

Source #:_____

Contaminant	CAS #	average	standard deviation	number of samples	minimum	maximum	variance

Source #:_____

Contaminant	CAS #	average	standard deviation	number of samples	minimum	maximum	variance

Worksheet 3. Surface SSLs by Exposure Area (EA) **Site Name**_____

EA #:_____ **SSL type:** ☐ **site-specific** ☐ **generic (default)**

Contaminant	CAS #	Soil Screening Level	
		ingestion	other (plant uptake; fugitive dust)

EA #:_____ **SSL type:** ☐ **site-specific** ☐ **generic (default)**

Contaminant	CAS #	Soil Screening Level	
		ingestion	other (plant uptake; fugitive dust)

Worksheet 4. Subsurface SSLs by source **Site Name** _____

Source #:_____ **SSL type:** ☐ **site-specific** ☐ **generic (default)**

Contaminant	CAS #	Soil Screening Level	
		inhalation of volatiles	migration to ground water

Source #:_____ **SSL type:** ☐ **site-specific** ☐ **generic (default)**

Contaminant	CAS #	Soil Screening Level	
		inhalation of volatiles	migration to ground water

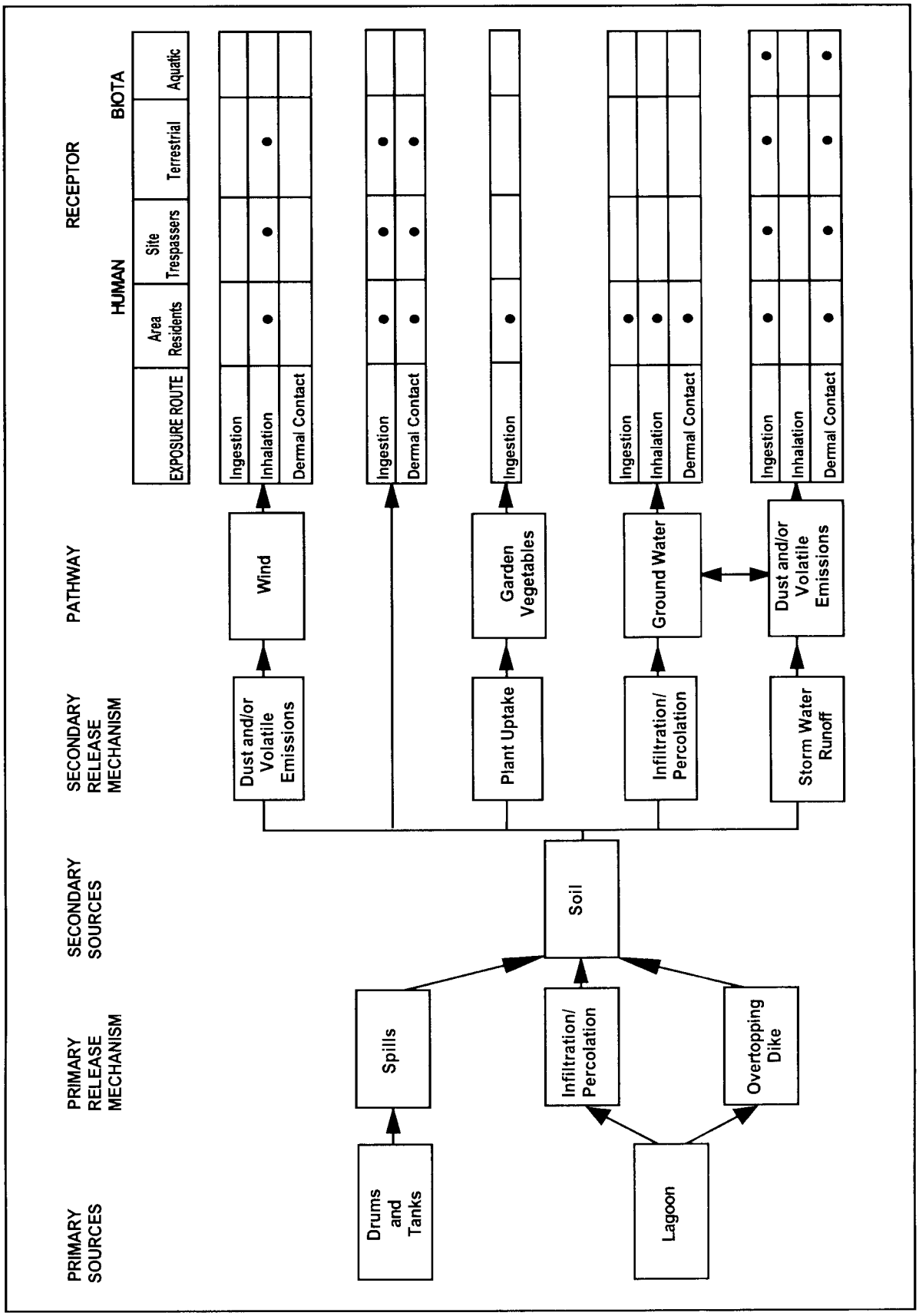

Figure A-2. Example conceptual site model diagram for contaminated soil (adapted from U.S. EPA, 1989).

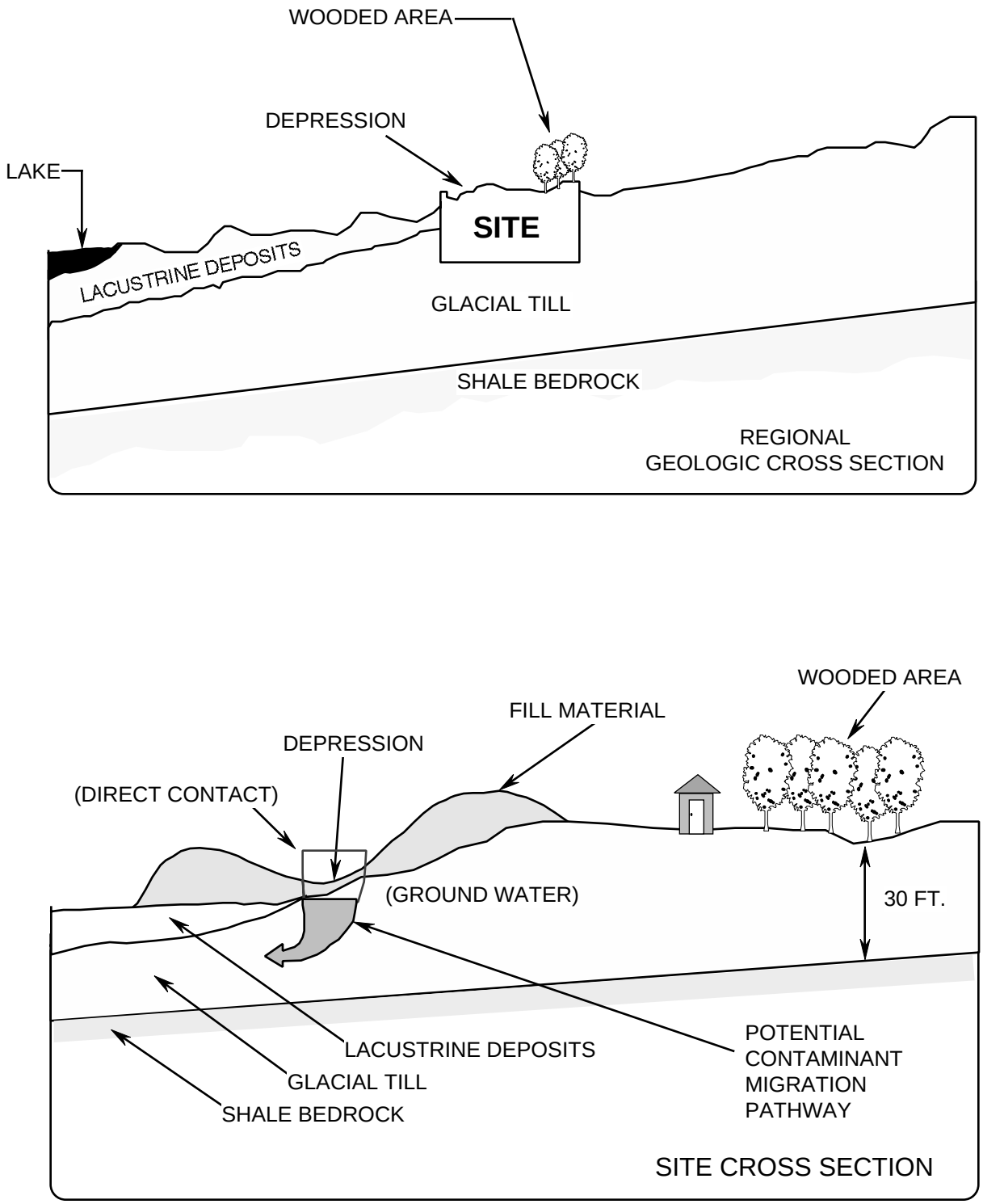

Figure A-3. Example Site Sketch (adapted from U.S. EPA, 1987)