GUIDANCE FOR ECOLOGICAL RISK ASSESSMENT: LEVELS I, II, III, IV

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FINAL

April 1998

SECTION	Last Update
LEVEL I Scoping	11 / 98
LEVEL II Screening	12 / 01
LEVEL II Screening Benchmark Values	12 / 01
LEVEL III Baseline	03 / 00
LEVEL IV Field Baseline	11 / 98

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INTRODUCTION

The DEQ ecological risk assessment process consists of four distinct levels, as follows (and as shown in Figure 1):

- Level I Scoping
- Level II Screening
- Level III Baseline
- Level IV Field Baseline

Within and between these levels are a number of Technical/Management Decision Points (TMDP). Based on the information developed and presented within a given level, these TMDPs determine one of three recommendations:

- No further ecological investigations at the site, or
- Continuation of the risk assessment process at the next level, or
- Undertake (beyond Level I only) a removal or remedial action.

The outcome of each level of the assessment should be documented in writing. Thorough documentation will provide a future reference for any other site-related activities involving a hazardous substance release, future site remedial actions, or onsite monitoring.

Prior to undertaking any ecological risk assessment pursuant to OAR 340-122-084, risk assessors should have read and be familiar with the terms, concepts, and approaches discussed in the following documents:

- USEPA Proposed Guidelines for Ecological Risk Assessment (61 FR 47552, 9/9/96)
- USEPA Region X Supplemental Ecological Risk Assessment Guidance for Superfund (EPA 910-R-97-005, June 1997)
- ORS 465.315
- OAR 340-122-010 through -115
- State of Oregon Level I, II, III, and IV Ecological Risk Assessment Guidance

OBJECTIVE

Level I is a conservative qualitative determination of whether there is any reason to believe that ecological receptors and/or exposure pathways are present or potentially present at or in the locality of the facility. Scoping is intended to identify sites that are obviously devoid of ecological important species or habitats and/or where exposure pathways are obviously incomplete.

PREREQUISITES

A release or suspected release of a hazardous substance.

TASKS (see Figure 2)

(1) **Assess existing data** Prior to visiting the site, obtain as much information regarding the following as possible:

- (a) Surface area of the site;
- (b) Present and historical uses of the site and nearby properties;
- (c) Current and reasonably likely future land and/or water use(s);
- (d) Sensitive environments (as defined by OAR 340-122-115(49)) at, adjacent to, or in the locality of the site;
- (e) Known or suspected presence of threatened and/or endangered species or their habitat in the locality of the facility (as evidenced by response letters from the U.S. Fish & Wildlife Service (USFWS) and the Oregon Department of Fish and Wildlife (ODFW). For coastal sites, contact with the National Marine Fisheries Service (NMFS) may also be required;
- (f) Accurate site and regional maps showing structures, sampling locations, land use, wetlands, surface water bodies, sensitive environments, etc.;
- (g) Types of hazardous substances reportedly released at the site;
- (h) Magnitude and extent of migration of any hazardous substances reportedly released at the site.

(2) **Initial site visit** A visit to the site to directly assess ecological features and conditions is mandatory. Involvement of an ecologist or biologist with risk assessment experience is preferred. The site visit should be conducted at a time of the year when ecological features are most apparent, i.e., spring, summer, early fall. Visits during the winter months or periods of severe weather are unlikely to produce convincing evidence of the presence/absence of receptors and exposure pathways. The site itself, areas adjacent to the site, and areas in the locality of the site (as defined by OAR 340-122-115(34)) should all be visited. The size and complexity of the site will determine the time needed for this initial visit. While at the site, the following activities should be performed:

- (a) Look for any signs (e.g. visual, olfactory, etc.) of a chemical release;
- (b) Sketch the site topography, with special emphasis to surface water drainages and other potential hazardous substance migration pathways;
- (c) Note any evident (e.g. visual, olfactory, etc.) signs of hazardous substance migration within the site or offsite;
- (d) Look for signs of threatened and/or endangered species or their habitat within or adjacent to the site;

(e) As appropriate, note any evident signs (seeps, springs, cutbanks, etc.) for groundwater discharge to the surface;

(f) Note any natural or anthropogenic disturbances onsite;

(g) Make a photographic record of the site, with emphasis on ecological features and potential exposure pathways;

(h) Complete the Ecological Scoping Checklist (Attachment 1).

(3) **Identify contaminants of interest (COIs)** Identification of contaminants of interest for ecological receptors may necessitate a separate identification process than that used for any human health evaluation, since a contaminant not generally considered a threat to human health may be a threat to biota. The list of COIs may be developed using either site-specific historical information or the results of chemical analyses of suspected source media. For Level I, the site-specific history of hazardous substance uses and releases is more typically the source of potential contaminant information. Although the focus is generally on hazardous substances alone, the assessment should consider whether other stressors, such as mechanical disturbance or unusual water quality parameters, are potentially contributing to adverse effects. These other stressors should be identified to provide an insight into the broader ecological situation. The results of this evaluation are summarized by completing Attachment 1, Parts ❶ and ❷.

(4) **Evaluate receptor-pathway interactions** Make an estimate, based on the site-specific information gathered in the previous three tasks and professional judgment, as to whether complete exposure pathways exist between COIs in a specific environmental media and ecologically important receptors associated with that media (e.g., between hazardous substances in surface water and fish). The results of this evaluation are summarized by completing Attachment 2.

(a) For the purpose of completing Attachment 2, complete exposure pathways are those that have: a source and mechanism for hazardous substance release to the environment, an environmental transport medium for the hazardous substance, a point of receptor contact (exposure point) with the contaminated media, and an exposure route to the receptor at the exposure point.

(b) For the purpose of completing Attachment 2, any of the following are considered "ecologically important" species:

(i) Individual listed threatened and endangered species;

(ii) Local populations of species that are recreational and/or commercial resources;

(iii) Local populations of any species with a known or suspected susceptibility to the hazardous substance(s);

(iv) Local populations of vertebrate species;

(v) Local populations of invertebrate species that:

- 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 function would not be replaced by other species; or
- Can be used as a surrogate measure of adverse effects for individuals or populations of other species.

(c) For the purpose of completing Attachment 2, "ecologically important" plants are those that form the habitat for an ecologically important species as defined above or are themselves listed as threatened and endangered species.

(d) Because they are not members of natural communities, any of the following should not be considered "ecologically important" species for the purpose of completing Attachment 2:

(i) Pest and opportunistic species that populate an area <u>entirely because</u> of artificial or anthropogenic conditions;

(ii) Domestic animals (e.g., pets and livestock);

(iii) Plants or animals whose existence is maintained by continuous human intervention (e.g., fish hatcheries, agricultural crops).

(5) **Submit Level I deliverable** This deliverable is a brief memorandum (see Attachment 3, Site Ecology Scoping Report, for suggested format and contents) detailing the results of the data review, site visit, and evaluation of receptors and pathways. It should present information in sufficient depth to give risk managers confidence in determining whether receptors and exposure pathways are or are not likely to exist at the site.

(a) Attachment 3, Items 1a through 1g are 1-2 paragraph summaries of site conditions, making reference to Items 4a through 4f as appropriate.

(b) Attachment 3, Item 2a is Part ❶ of Attachment 1.

(c) Attachment 3, Item 2b includes, at a minimum, Part ❷ of Attachment 1, as well as any other site-specific observations that the responsible party wishes to include.

(d) Attachment 3, Item 2c includes, at a minimum, Part ❸ of Attachment 1, as well as any other site-specific observations that the responsible party wishes to include.

(e) Attachment 3, Item 2d discusses efforts to observe ecologically important species and/or habitats, particularly listed threatened or endangered species (or their habitat) at or adjacent to the site. Any such species or habitats should be noted on Part ❹ of Attachment 1.

(f) Attachment 3, Item 2e includes, at a minimum, Attachment 2, as well as any other site-specific observations that the responsible party wishes to include.

(g) Attachment 3, Item 3 describes recommendations made on the basis of specific criteria associated with TMDP 1.

(6) **TMDP 1: Ecological Risk Suspected?** Based on information presented in the Level I deliverable, do potential ecological receptors and potentially complete exposure pathways exist at or in the locality of the site? Specific criteria are as follows:

(a) If any of the "**Y**" or "**U**" boxes in Attachment 2 are checked, then a recommendation to move to Level II should be made. In completing this Attachment, a lack of knowledge, presence of high uncertainty, or any "unknown" circumstances should be tabulated as a "**U**".

(i) Note that a "**Y**" answer for any section requires that all three questions within that section be answered "**Y**" or "**U**".

(b) If all of the "**No**" boxes in Attachment 2 are checked, then the site is highly unlikely to present significant risks to ecological receptors and a recommendation for no further ecological investigations should be made.

ADDITIONAL INFORMATION

USEPA. 1992. **Briefing the BTAG: Initial Description of Setting, History, and Ecology of a Site**. Publication 9345.0-05I, Eco Update Intermittent Bulletin 1(5). Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, DC.

USEPA. 1994. **Selecting and Using Reference Information in Superfund Ecological Risk Assessments**. Publication 9345.0-10I, Eco Update Intermittent Bulletin 2(4). EPA 540-F-94-050. Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, DC.

ATTACHMENT 1
Ecological Scoping Checklist

Site Name	
Date of Site Visit	
Site Location	
Site Visit Conducted by	

Part ❶

CONTAMINANTS OF INTEREST Types, Classes, Or Specific Hazardous Substances ‡ Known Or Suspected	Onsite	Adjacent to or in locality of the facility †

‡ As defined by OAR 340-122-115(30) † As defined by OAR 340-122-115(34)

Part ❷

OBSERVED IMPACTS ASSOCIATED WITH THE SITE	Finding
Onsite vegetation (**N**one, **L**imited, **E**xtensive)	
Vegetation in the locality of the site (**N**one, **L**imited, **E**xtensive)	
Onsite wildlife such as macroinvertebrates, reptiles, amphibians, birds, mammals, other (**N**one, **L**imited, **E**xtensive)	
Wildlife such as macroinvertebrates, reptiles, amphibians, birds, mammals, other in the locality of the site (**N**one, **L**imited, **E**xtensive)	
Other readily observable impacts (**N**one, **D**iscuss below)	
Discussion:	

ATTACHMENT 1
Ecological Scoping Checklist (cont'd)

Part ❸

SPECIFIC EVALUATION OF ECOLOGICAL RECEPTORS / HABITAT	Finding

SPECIFIC EVALUATION OF ECOLOGICAL RECEPTORS / HABITAT	Finding
Terrestrial - Wooded	
Percentage of site that is wooded	
Dominant vegetation type (**E**vergreen, **D**eciduous, **M**ixed)	**P ***
Prominent tree size at breast height, i.e., four feet (<6”, 6” to 12”, >12”)	
Evidence / observation of wildlife (**M**acroinvertebrates, **R**eptiles, **A**mphibians, **B**irds, **M**ammals, **O**ther)	
Terrestrial - Scrub/Shrub/Grasses	
Percentage of site that is scrub/shrub	
Dominant vegetation type (**Sc**rub, **Sh**rub, **G**rasses, **O**ther)	**P**
Prominent height of vegetation (<2’, 2’ to 5’, >5’)	
Density of vegetation (**D**ense, **P**atchy, **S**parse)	**P**
Evidence / observation of wildlife (**M**acroinvertebrates, **R**eptiles, **A**mphibians, **B**irds, **M**ammals, **O**ther)	
Terrestrial - Ruderal	
Percentage of site that is ruderal	
Dominant vegetation type (**L**andscaped, **A**griculture, **B**are ground)	**P**
Prominent height of vegetation (0’, >0’ to <2’, 2’ to 5’, >5’)	
Density of vegetation (**D**ense, **P**atchy, **S**parse)	**P**
Evidence / observation of wildlife (**M**acroinvertebrates, **R**eptiles, **A**mphibians, **B**irds, **M**ammals, **O**ther)	
Aquatic - Non-flowing (lentic)	
Percentage of site that is covered by lakes or ponds	
Type of water bodies (**L**akes, **P**onds, **V**ernal pools, **I**mpoundments, **Lag**oon, **R**eservoir, **C**anal)	
Size (acres), average depth (feet), trophic status of water bodies	
Source water (**R**iver, **St**ream, **G**roundwater, **I**ndustrial discharge, **Su**rface water runoff)	
Water discharge point (**N**one, **R**iver, **St**ream, **G**roundwater, **W**etlands impoundment)	
Nature of bottom (**M**uddy, **R**ocky, **S**and, **C**oncrete, **O**ther)	**P**
Vegetation present (**S**ubmerged, **E**mergent, **F**loating)	**P**
Obvious wetlands present (**Y**es / **N**o)	
Evidence / observation of wildlife (**M**acroinvertebrates, **R**eptiles, **A**mphibians, **B**irds, **M**ammals, **O**ther)	
Aquatic - Flowing (lotic)	
Percentage of site that is covered by rivers, streams (brooks, creeks), intermittent streams, dry wash, arroyo, ditches, or channel waterway	
Type of water bodies (**R**ivers, **S**treams, **I**ntermittent Streams, **D**ry wash, **A**rroyo, **D**itches, **C**hannel waterway)	
Size (acres), average depth (feet), approximate flow rate (cfs) of water bodies	**P**
Bank environment (cover: **V**egetated, **B**are / slope: **S**teep, **G**radual / height (in feet))	
Source water (**R**iver, **St**ream, **G**roundwater, **I**ndustrial discharge, **Su**rface water runoff)	
Tidal influence (**Y**es / **N**o)	
Water discharge point (**N**one, **R**iver, **St**ream, **G**roundwater, **W**etlands impoundment)	
Nature of bottom (**M**uddy, **R**ocky, **S**and, **C**oncrete, **O**ther)	
Vegetation present (**S**ubmerged, **E**mergent, **F**loating)	**P**
Obvious wetlands present (**Y**es / **N**o)	
Evidence / observation of wildlife (**M**acroinvertebrates, **R**eptiles, **A**mphibians, **B**irds,	

SPECIFIC EVALUATION OF ECOLOGICAL RECEPTORS / HABITAT	Finding
Mammals, **O**ther)	
Aquatic - Wetlands	
Obvious or designated wetlands present (**Y**es / **N**o)	
Wetlands suspected as site is/has (**A**djacent to water body, in **F**loodplain, **S**tanding water, **D**ark wet soils, **M**ud cracks, **D**ebris line, **W**ater marks)	
Vegetation present (**S**ubmerged, **E**mergent, **S**crub/shrub, **W**ooded)	**P**
Size (acres) and depth (feet) of suspected wetlands	
Source water (**R**iver, **St**ream, **G**roundwater, **I**ndustrial discharge, **Su**rface water runoff)	
Water discharge point (**N**one, **R**iver, **St**ream, **G**roundwater, **I**mpoundment)	
Tidal influence (**Y**es / **N**o)	
Evidence / observation of wildlife (**M**acroinvertebrates, **R**eptiles, **A**mphibians, **B**irds, **M**ammals, **O**ther)	

*** P**: Photographic documentation of these features is highly recommended.

Part ❹

ECOLOGICALLY IMPORTANT SPECIES / HABITATS OBSERVED

ATTACHMENT 2
Evaluation of Receptor-Pathway Interactions

EVALUATION OF RECEPTOR-PATHWAY INTERACTIONS	Y	N	U
Are hazardous substances present or potentially present in surface waters? **AND** **Are ecologically important species or habitats present?** **AND** **Could hazardous substances reach these receptors via surface water?**			
When answering the above questions, consider the following: • Known or suspected presence of hazardous substances in surface waters. • Ability of hazardous substances to migrate to surface waters. • Terrestrial organisms may be dermally exposed to water-borne contaminants as a result of wading or swimming in contaminated waters. Aquatic receptors may be exposed through osmotic exchange, respiration or ventilation of surface waters. • Contaminants may be taken-up by terrestrial plants whose roots are in contact with surface waters. • Terrestrial receptors may ingest water-borne contaminants if contaminated surface waters are used as a drinking water source.			
Are hazardous substances present or potentially present in groundwater? **AND** **Are ecologically important species or habitats present?** **AND** **Could hazardous substances reach these receptors via groundwater?**			
When answering the above questions, consider the following: • Known or suspected presence of hazardous substances in groundwater. • Ability of hazardous substances to migrate to groundwater. • Potential for hazardous substances to migrate via groundwater and discharge into habitats and/or surface waters. • Contaminants may be taken-up by terrestrial and rooted aquatic plants whose roots are in contact with groundwater present within the root zone (~1m depth). • Terrestrial wildlife receptors generally will not contact groundwater unless it is discharged to the surface.			

"Y" = yes; "N" = No, "U" = Unknown (counts as a "Y")

ATTACHMENT 2
Evaluation of Receptor-Pathway Interactions (cont'd)

EVALUATION OF RECEPTOR-PATHWAY INTERACTIONS	Y	N	U
Are hazardous substances present or potentially present in sediments? **AND** **Are ecologically important species or habitats present?** **AND** **Could hazardous substances reach these receptors via contact with sediments?**			
When answering the above questions, consider the following: • Known or suspected presence of hazardous substances in sediment. • Ability of hazardous substances to leach or erode from surface soils and be carried into sediment via surface runoff. • Potential for contaminated groundwater to upwell through, and deposit contaminants in, sediments. • If sediments are present in an area that is only periodically inundated with water, terrestrial species may be dermally exposed during dry periods. Aquatic receptors may be directly exposed to sediments or may be exposed through osmotic exchange, respiration or ventilation of sediment pore waters. • Terrestrial plants may be exposed to sediment in an area that is only periodically inundated with water. • If sediments are present in an area that is only periodically inundated with water, terrestrial species may have direct access to sediments for the purposes of incidental ingestion. Aquatic receptors may regularly or incidentally ingest sediment while foraging.			
Are hazardous substances present or potentially present in prey or food items of ecologically important receptors? **AND** **Are ecologically important species or habitats present?** **AND** **Could hazardous substances reach these receptors via consumption of food items?**			
When answering the above questions, consider the following: • Higher trophic level terrestrial and aquatic consumers and predators may be exposed through consumption of contaminated food sources. • In general, organic contaminants with log K_{ow} > 3.5 may accumulate in terrestrial mammals and those with a log K_{ow} > 5 may accumulate in aquatic vertebrates.			

"Y" = yes; "N" = No, "U" = Unknown (counts as a "Y")

ATTACHMENT 2
Evaluation of Receptor-Pathway Interactions (cont'd)

EVALUATION OF RECEPTOR-PATHWAY INTERACTIONS	Y	N	U
Are hazardous substances present or potentially present in surficial soils? **AND** **Are ecologically important species or habitats present?** **AND** **Could hazardous substances reach these receptors via incidental ingestion of or dermal contact with surficial soils?**			
When answering the above questions, consider the following: • Known or suspected presence of hazardous substances in surficial (~1m depth) soils. • Ability of hazardous substances to migrate to surficial soils. • Significant exposure via dermal contact would generally be limited to organic contaminants which are lipophilic and can cross epidermal barriers. • Exposure of terrestrial plants to contaminants present in particulates deposited on leaf and stem surfaces by rain striking contaminated soils (i.e., rain splash). • Contaminants in bulk soil may partition into soil solution, making them available to roots. • Incidental ingestion of contaminated soil could occur while animals grub for food resident in the soil, feed on plant matter covered with contaminated soil or while grooming themselves clean of soil.			
Are hazardous substances present or potentially present in soils? **AND** **Are ecologically important species or habitats present?** **AND** **Could hazardous substances reach these receptors via vapors or fugitive dust carried in surface air or confined in burrows?**			
When answering the above questions, consider the following: • Volatility of the hazardous substance (volatile chemicals generally have Henry's Law constant > 10^{-5} atm-m^3/mol and molecular weight < 200 g/mol). • Exposure via inhalation is most important to organisms that burrow in contaminated soils, given the limited amounts of air present to dilute vapors and an absence of air movement to disperse gases. • Exposure via inhalation of fugitive dust is particularly applicable to ground-dwelling species that could be exposed to dust disturbed by their foraging or burrowing activities or by wind movement. • Foliar uptake of organic vapors would be limited to those contaminants with relatively high vapor pressures. • Exposure of terrestrial plants to contaminants present in particulates deposited on leaf and stem surfaces.			

"Y" = yes; "N" = No, "U" = Unknown (counts as a "Y")

ATTACHMENT 3
Level I Deliverable - Site Ecology Scoping Report
Outline

(1) **EXISTING DATA SUMMARY**
- (a) Site location
- (b) Site history
- (c) Site land and/or water use(s)
  - (i) Current
  - (ii) Future
- (d) Known or suspected hazardous substance releases
- (e) Sensitive environments
- (f) Threatened and/or endangered species (USFWS/ODFW/NMFS data)

(2) **SITE VISIT SUMMARY**
- (a) Contaminants of Interest (Part ❶, Attachment 1)
- (b) Observed impacts (Part ❷, Attachment 1)
- (c) Ecological features (Part ❸, Attachment 1)
- (d) Ecologically important species/habitats (Part ❹, Attachment 1)
  - (i) Threatened and/or endangered species
  - (ii) Threatened and/or endangered species habitat
- (e) Exposure pathways (Attachment 2)

(3) **RECOMMENDATIONS**

(4) **ATTACHMENTS**
- (a) Regional map showing location of site
- (b) Local map showing site in relation to adjacent property
- (c) Site map
- (d) Sketch map of ecological features as overlay to site map
- (e) Sketch map of known or suspected extent of hazardous substances as overlay to site map
- (f) Site photograph(s)
- (g) Copies of letters from USFWS and ODFW, responding to queries about threatened and endangered species (also NMFS if appropriate)

(5) **REFERENCES / DATA SOURCES**

FIGURE 1. Ecological Risk Assessment Process Flowchart

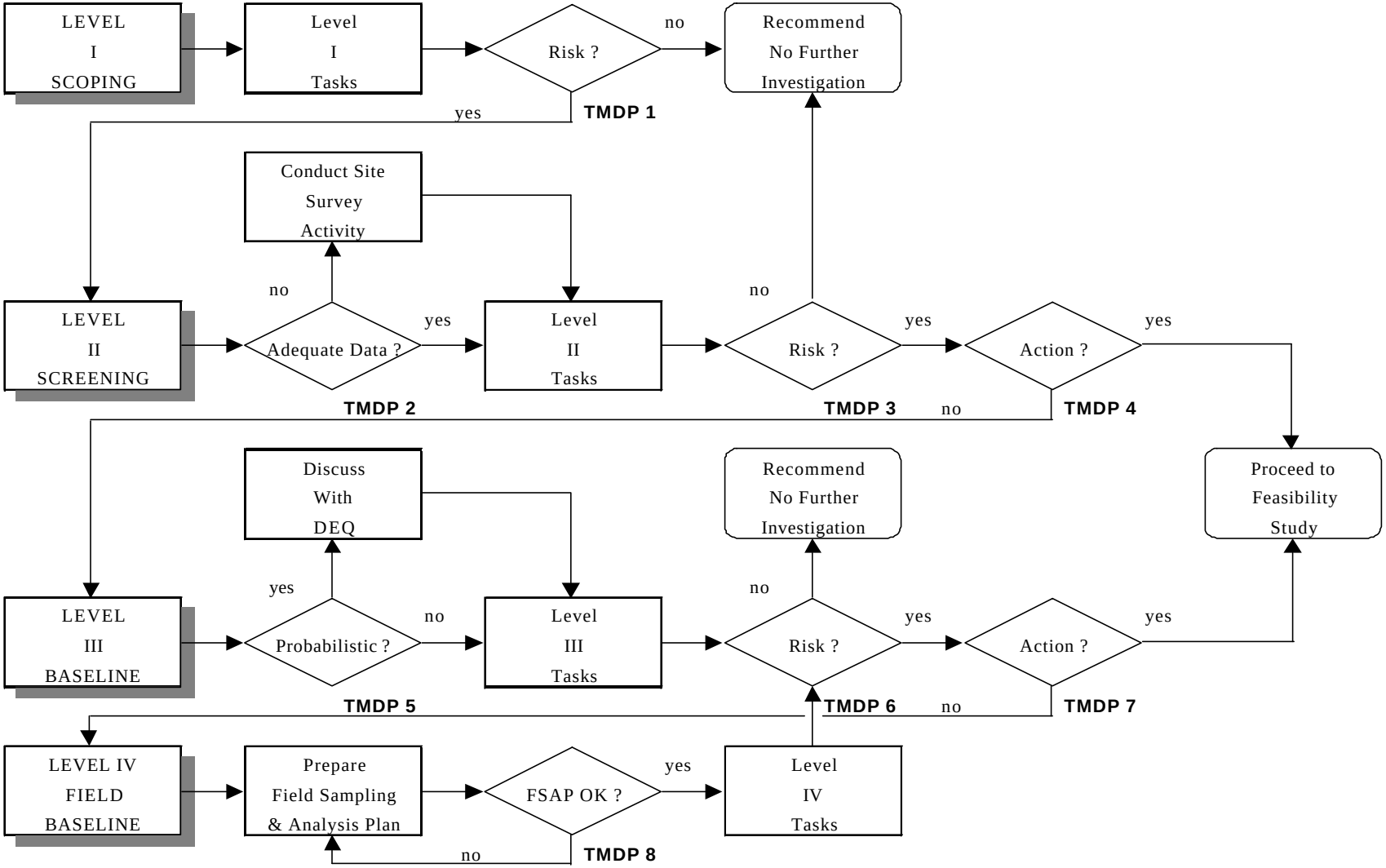
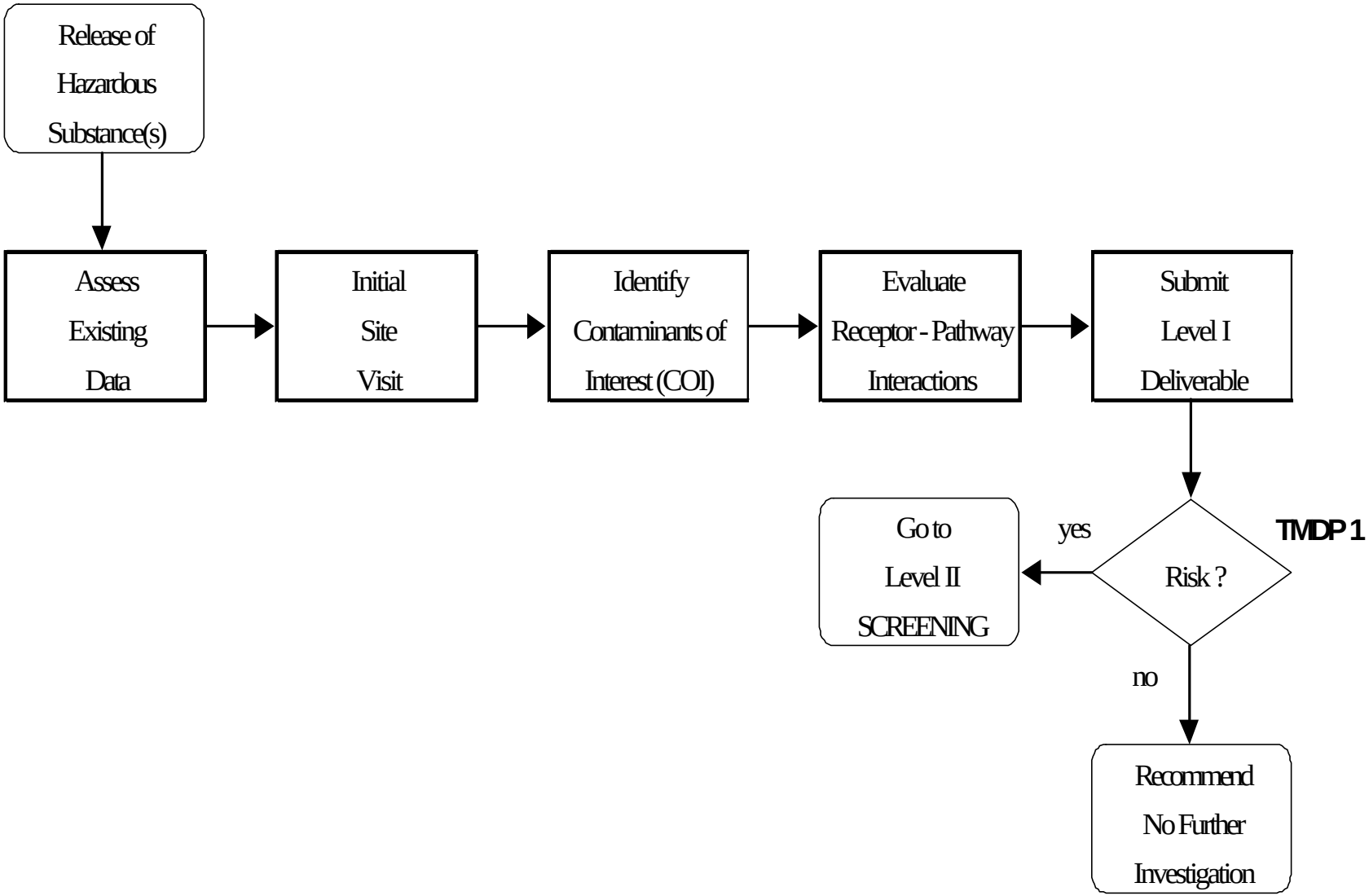


FIGURE 2. Level I (Scoping) Ecological Risk Assessment Flowchart



Note:

In Task 9(c), page II-8 of the Level II Ecological Risk Assessment Guidance, please note that the Q = 5 guidance applies only to soil, and **does not apply to water and sediment**. Until other screening level values become available, water and sediment screening should be done using the SLVs provided in Tables 1 and 2.

(February 2005)

INTRODUCTION

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- Level I Scoping
- Level II Screening
- Level III Baseline
- Level IV Field Baseline

Within and between these levels are a number of Technical/Management Decision Points (TMDP). Based on the information developed and presented within a given level, these TMDPs determine one of three recommendations:

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- Continuation of the risk assessment process at the next level, or
- Undertake (beyond Level I only) a removal or remedial action.

The outcome of each level of the assessment should be documented in writing. Thorough documentation will provide a future reference for any other site-related activities involving a hazardous substance release, future site remedial actions, or onsite monitoring.

Prior to undertaking any ecological risk assessment pursuant to OAR 340-122-084, risk assessors should have read and be familiar with the terms, concepts, and approaches discussed in the following documents:

- *Guidelines for Ecological Risk Assessment (Final).* EPA/630/R-95/002F. U.S. Environmental Protection Agency, 1998;
- *Ecological Risk Assessment Guidance for Superfund, Process for Designing and Conducting Ecological Risk Assessments (Interim Final).* EPA 540-R-97-006. U.S. Environmental Protection Agency, 1997;
- State of Oregon regulations (ORS 465.315 & OAR 340-122-010 to –115);
- State of Oregon ecological risk assessment guidance (Levels I, II, III, & IV).

OBJECTIVE

A Level II assessment, building on the results of Level I, initiates the process of problem formulation for the site. The objective of Level II is to: (a) construct a site description based on information from site visits and/or surveys, the existing literature, any prior preliminary assessments, and site history (including past and present uses), (b) identify site-specific ecologically important receptors, relevant and complete exposure pathways between each

source medium of concern and these receptors, contaminants of potential ecological concern (CPECs) from among the contaminants of interest (COIs) associated with the site, (c) discuss how the physicochemical and toxicological properties of each CPEC may influence exposure pathways and adverse effects, (d) define ecologically appropriate assessment endpoints, (e) establish potential links between CPECs and responses in site-specific receptors by means of a preliminary conceptual site model, and (f) make an initial evaluation of the potential for site-related risk.

PREREQUISITES

A release or suspected release of a hazardous substance and completion of a Level I assessment.

TASKS (see Figure 2)

(1) **TMDP 2: Existing Data Sufficient?** Scoping results presented in the Level I deliverable, professional judgment, and concurrence of the DEQ project manager are used to determine whether existing data (including those developed during the initial site visit) are sufficient for Level II problem formulation. If "Yes", skip to Task (3); if "No", perform Task (2).

(2) **Conduct site survey activity** A site survey goes beyond the Level I site visit to gather the site-specific qualitative and semi-quantitative data necessary for identifying relevant and complete contaminant-pathway-receptor relationships. Techniques that may be employed to accomplish the survey may include, but are not limited to, any or all of the following:

- (a) Habitat / vegetation inventory (observation, line transects, quadrats, habitat evaluation procedures (HEP), etc.);
- (b) Terrestrial receptor inventory (observation, night-lighting, live and snap traps, nets, Emlen line transects, etc.);
- (c) Aquatic receptor inventory (observation, dip nets, Surber samplers, grab samplers, traps, USEPA Rapid Bioassessment Protocols, etc.);
- (d) Geographic information system (GIS) mapping and analysis of survey data.

(3) **Update site description** A narrative description and analysis of ecological conditions at, adjacent to, and in the locality of the site. This narrative should provide greater depth and detail than that allowed for in the Level I checklists and should consider:

- (a) Known or historical nature, sources, and extent of contamination;
- (b) Recorded or observed environmental problems, e.g., observed toxicity; mortality, chlorosis in plants, etc.;
- (c) Available results from any previous biological testing, such as data on acute or

chronic toxicity or bioaccumulation phenomena;

(d) Physical and chemical characteristics of abiotic media in the area or climatic, physiographic, oceanographic, and/or geohydrologic features that could create contaminant pathways linking biota with contaminants;

(e) Location of any threatened or endangered species, or their preferred habitats, or sensitive environmental areas, on or near the site;

(f) Common flora and fauna of the site and surrounding areas, i.e., the most common species likely to be exposed to contaminants;

(g) Ecological information on biological assemblages or species important to site ecosystems;

(h) Specific mapping of site to identify site-specific microhabitats (areas of use);

(i) Results from any previous ecosystem modeling or geographic information system (GIS)-based analyses.

(4) **Identify ecological receptors** Site-specific ecologically important receptors are identified, using the criteria established for Level I, as follows:

(a) Identify all habitat types at and within the locality of the facility (as defined by OAR 340-122-115(34)).

(b) Identify, using results of the initial site visit, the Level II site survey (if any), a review of the available published literature, published government or scientific studies of the area, or information maintained by government agencies or academic institutions, the plant and animal species most likely to be associated with each habitat type identified in (a) above.

(c) Identify <u>site-specific receptors</u> for each habitat type. To the extent practicable, these receptors should be organisms that spend a significant portion of their life or derive a significant portion of their diet or physiological needs from that habitat type. Bear in mind that presentation of long lists of species copied from regional or state-wide guidebooks, without reference to observations made during the site visit or site survey (if any), is rarely useful.

(d) Summarize the results of steps (a-c) above in the form of a table.

(5) **Identify complete exposure pathways** This is a through identification of relevant and complete exposure pathways, taking into consideration the physicochemical and transport and fate characteristics of the CPECs. An exposure route is the way a chemical or physical agent comes in contact with a receptor (i.e., by ingestion, inhalation, dermal contact, etc.). Ecological receptors may be exposed to chemical contaminants either through direct (primary) and/or indirect (secondary) exposure routes. Only those pathways that are complete, and are expected to contribute substantially to exposures by ecologically important receptors should be addressed.

(a) For an exposure to a contaminant to occur, complete exposure pathways must exist, which requires:
   (i) A source and mechanism for contaminant release;
   (ii) A transport medium;
   (iii) A point of environmental contact; and
   (iv) An exposure route at the exposure point.
   (v) If any of these four components is absent, a pathway is generally considered incomplete. However, the transport medium may be missing and the pathway still be complete if the contact point is directly at the contaminant release point. A pathway may also be complete if a source and mechanism for contaminant release appear to be absent but (ii), (iii), and (iv) exist, i.e., direct ingestion of a contaminated transport medium.

(b) Identify those pathways that have the greatest potential to bring receptors into contact with toxicologically significant quantities of a given contaminant. Select from one or more of the following eight distinct exposure pathways:
   (i) Volatile contaminants may be released to air and transported by wind.
   (ii) Non-volatile contaminants with a moderate to strong affinity for adsorption to soils may be transported via fugitive dust released by aeolian (wind-blown) erosion.
   (iii) Contaminants that are soluble in water and have a low affinity for adsorption to soil particles may leach, infiltrate, or percolate into groundwater.
   (iv) Contaminants that are soluble in water and have a low affinity for adsorption to soil particles may become dissolved in stormwater runoff from the site or may be discharged directly to surface waters.
   (v) Contaminants with a strong affinity for soils may be resuspended as sediment load and transported in surface runoff.
   (vi) Contaminants that reach groundwater may be transported to surface waters if the groundwater has a surface discharge point (e.g., a seep, spring, or surface water recharge area).
   (vii) Contaminants in sediments may be directly ingested by benthic invertebrates or bottom-dwelling fish or may become available by partitioning (based on their adsorption characteristics and sediment organic carbon levels) into the water column.
   (viii) Receptors may be exposed (through ingestion) to contaminants that are capable of bioaccumulation and/or biomagnification within the food chain. This is an indirect (secondary) exposure pathway that may involve contaminants initially contained in any media.

(c) Typical exposure routes are summarized (by environmental media) in Table 1.

Identification of typical exposure routes does not rule out the possibility that at certain sites, highly unique exposure routes could bring receptors into contact with significant quantities of contaminants. However, unless demanded by unique site characteristics, it is usually unproductive to identify particularly obscure exposure pathways and/or routes as these will ultimately be difficult or impossible to quantify.

(6) **Identify candidate assessment endpoints** Per OAR 340-122-115(7), an assessment endpoint is "…an explicit expression of a value deemed important to protect, operationally defined by an entity (hereafter, "endpoint receptor") and one or more of that entity's measurable attributes…" Well-crafted assessment endpoints establish a clear logical connection between regulatory goals for a site, values to be protected, and how the risk assessment is to be conducted.

(a) The process of assessment endpoint definition begins here and, if necessary, is completed during Task (1) of the Level III assessment. This identification is intended to begin focusing the risk assessment on site-specific ecological features or resources of particular interest to risk managers and stakeholders. This is an opportunity for the risk manager and the risk assessor to begin a dialogue to translate the risk manager's higher-level decision criteria into a statement of assessment objectives.

(b) Per OAR 340-122-084(3)(c), assessment endpoints are a required component of an ecological risk assessment; so the issue is not whether to pick one but rather which one to pick. If the results of an ecological risk assessment are to play a meaningful role in the remedial action process, care must be exercised when identifying assessment endpoints (and their associated endpoint receptors). When identifying assessment endpoints, consider whether if risk is demonstrated for that endpoint there would be a willingness on the part of the risk managers to undertake a potentially costly and/or time-consuming remedial action to alleviate that risk. Identifying useful endpoints usually requires input from risk managers, stakeholders, and risk assessors.

(c) An example of a candidate assessment endpoint may be: *Great blue heron {entity, endpoint receptor} breeding success {measurable attribute}*. This measurable attribute can be directly related to the condition of an individual heron, as well as to that of the local population of herons.

(d) Groups (guilds) of receptors that are candidates for consideration as endpoint receptors include, but are not limited to: benthic or epibenthic aquatic invertebrates; small mammalian predators whose diets include invertebrates living in close contact with soil; small mammalian herbivores; ground-feeding avian predators whose diet includes invertebrates living in close contact with soil;

piscivorous avian predators whose diet includes pelagic or bottom-feeding fish; omnivorous waterfowl whose diet includes aquatic macrophytes and invertebrates.

(e) Of the set of ecologically important ecological receptors identified during Level I, in Task (4) above, or in section (d) above, those that have substantial aesthetic, social, or economic value to risk managers or stakeholders or are important in the biological functions or biodiversity of the system, may be selected as endpoint receptors. These receptors are either themselves the object of protection or serve as surrogates for all other ecological receptors requiring protection (see OAR 340-122-115(7)). This identification of endpoint receptors at Level II may be further refined or modified during Task (1) of a Level III assessment.

(7) **Identify known ecological effects** Factors, such as those listed below, that affect the toxicological behavior of a contaminant with respect to a given endpoint receptor (and not a universe of possible receptors) should be <u>briefly and qualitatively</u> discussed to the extent practicable. Note that development of any detailed, quantitative toxicity profiles will occur only in Level III.

(a) The physicochemical characteristics and toxic mechanism of a hazardous substance;

(b) Contaminant-specific effects that might be expected in potentially exposed endpoint receptors and whether any such receptors are particularly susceptible to any site-related CPEC;

(c) The potential for bioconcentration, bioaccumulation, or biomagnification of COIs within receptors at the site (based upon abiotic and biotic conditions and chemical data);

(d) Data gaps regarding the effects of a particular COI on a given endpoint receptors; and

(e) Those receptors that might be good indicators of habitat modifications or alterations that are potentially due to the presence of specific COIs.

(8) **Calculate COI Concentration(s)** Chemical sampling and analysis provides raw data concerning the presence and concentrations of COIs in abiotic (soil, surface water, groundwater, sediment, air) and biotic (plant and animal tissues) media within each habitat at or in the locality of the site. The risk assessor should ensure that sampling covers areas and media of ecological interest and that analytical detection levels are set low enough to be of ecological significance, as determined by the analysis plan (which includes DQOs and the QA/QC plan).

(a) <u>Estimate Environmental Concentration (EC)</u> Because ecological receptors do not experience their environment on a “point” basis, it is necessary to convert measured data from single sample points into an estimate of concentration over

some relevant spatial area, such as their habitat.

(i) For abiotic media (soil, water, sediment), the simplest approach is to assume that contaminants are evenly distributed within a habitat and that endpoint receptors forage randomly with respect to contamination within that habitat. In this case, the EC can be represented by either the one-sided 90th percentile upper confidence limit (90th percentile UCL) of the uncertainty in the arithmetic mean. Alternatively, EC may be set equal to the maximum detected concentration (MDC). If the data set contains any value classed as a positive detect, then include all non-detect samples in the EC computation with values of one-half their detection limits. For soil and sediment samples, include duplicate samples as additional single data points in the computation; for water samples, include the average concentration of the sample and its duplicate. Note, however, that data sets with greater than 15% non-detects will require use of special statistical methods (WDOE 1993).

(ii) Chemical analysis of biotic samples can be used to measure contaminant concentrations in biotic (tissues) media; however, cost and schedule considerations generally restrict such analyses to Levels III and/or IV.

(iii) It may be desirable to use a geographic information system (GIS) to overlay the spatial distribution of various habitat types with contaminant distributions to more accurately determine the degree to which habitat is contaminated. If information is available regarding the distribution or movements of plants and/or animals, these data may be combined with the habitat and contamination data to provide a more accurate visualization of exposure.

(b) The exposure concentration that will be compared to the screening level value (SLV) depends on the characteristics of the receptor. A concentration should be used that represents a reasonable maximum exposure given the characteristics of the medium and the site-related species as determined in Task (4) above. A fundamental distinction must be made between receptors that average their exposure over space and time and those that have essentially constant exposure, as follows:

(i) For terrestrial wildlife consuming soil, vegetation, or animal foods, the 90th percentile UCL on the mean is the appropriate media concentration for comparison with the SLV.

(ii) For fish and other mobile aquatic species in flowing waters, the 90th percentile UCL in either water or sediment is the appropriate value for comparison.

(iii) For wildlife that feed on aquatic biota, the 90th percentile UCL is the appropriate value for comparison.

(iv) For plants, aquatic, and soil invertebrates that are immobile or nearly immobile, the MDC in soil or sediment is the appropriate value for comparison.

(v) For groundwater, the receptor-appropriate concentration (90th percentile UCL or MDC) at (or nearest) the point of discharge should be used without allowance for a mixing or dilution zone.

(9) **Identify contaminants of potential ecological concern (CPECs)** Here COIs (identified in Level I and quantified in Task (8) above) for each media (soil, water, air, etc.) are screened on the basis of physicochemical properties and then their toxicity and bioaccumulation potential, using the criteria listed below.

(a) Frequency of Detection COIs that are infrequently detected may be artifacts in the data due to sampling, analytical, or other errors. Assuming that detection limits have been set low enough for ecological purposes and that adequate sampling has occurred, COIs detected in less than five percent of the samples site-wide for a given media need not be selected as CPECs.

(b) Background Concentration If the MDC of an otherwise naturally occurring COI is less than the concentration selected as a background value (derived either from the literature, from site-specific sampling, or **Table Q**), it need not be selected as a CPEC.

(c) Chemistry-Toxicity Screen Screening on the basis of toxicity alone must take into consideration the potential for risk to be posed by exposure to: (a) individual COIs, (b) multiple COIs simultaneously within a given medium (cumulative risk per OAR 340-122-084(1)(i)), and (c) individual or multiple COIs within different media (i.e., aggregate exposure). Note also that screening should involve SLVs for receptors or classes of receptors that are related to endpoint receptors, and which may actually exist at, or in the locality of, the site.

(i) Any individual COI in any given media with $T_{ij} > Q$, where $T_{ij} = C_{ij} / SLV_{ij}$ [C_{ij} is the concentration of COI *i* in medium *j*, SLV_{ij} is the screening level value for COI *i* in medium *j* under a site-appropriate exposure scenario, T_{ij} is the toxicity ratio for COI *i* in medium *j*, and *Q* is the receptor designator [*Q* = 1 for listed threatened and endangered (T&E) species, *Q* = 5 for non-T&E species] must be identified as a CPEC.

(ii) For multiple COIs in any given media, those with T_{ij}/T_j values $\geq (1/N_{ij}) \times Q$ (where N_{ij} is the total number of *i* COIs in medium *j* and $T_j = \sum_{i=1}^{i} T_{ij}$) must be retained as CPECs, provided $T_j > Q$.

(iii) If a COI is detected in multiple media (e.g., in both surface water and soil),

it must be retained as a CPEC if $\sum_{j=1}^{j} T_{ij} > Q$.

(iv) For sediment, detection of one or more CPECs may require a Sediment Level III (toxicity) evaluation (see DEQ's *Guidance for Evaluation of Contaminated Sediment*).

(d) Bioaccumulation Screen OAR 340-122-084(3)(d) requires that special attention be given to COIs that are, or are suspected of being, persistent bioaccumulative toxins (PBTs). These include, but are not limited to, all dioxins, PCB mixtures, PCB congeners, DDT, DDD, DDE, organochlorine pesticides, metals capable of biomethylation (e.g., mercury), and chlorinated dibenzofurans.

(i) If such COIs are detected (i.e., at any concentration above the detection limit) in soil, surface water, or groundwater samples, their potential to compromise food chains and induce adverse effects in higher trophic level species should be discussed in the Level II deliverable. Addressing their presence may require advancing to a Level III assessment.

(ii) If such COIs are detected in sediment at concentrations above their bioaccumulation SLVs (or are without SLVs), a sediment bioaccumulation evaluation is likely to be required (see *Guidance for Evaluation of Contaminated Sediment*).

(e) Screening Level Value Availability In some cases, no appropriate SLV will be available for a given COI-media-receptor combination. In these cases, while the toxicity or bioaccumulation potential of the COI cannot be addressed, neither should that COI be eliminated from further consideration. Such COIs should be retained in a separate category for purposes of determining the need for further toxicity or bioaccumulation testing (especially in the case of sediment) and to prevent elimination from further consideration of the media in which it occurs.

(f) The results of the CPEC selection process should be presented in tabular format, with the table clearly presenting all of the data used to determine whether a COIs qualifies as a CPEC.

(10) **Preliminary conceptual site model** Information on ecologically important receptors, assessment endpoints, CPECs, exposure routes, and potential effects is integrated to create a preliminary conceptual site model (CSM) involving both text and graphics. For Level II, the CSM should consist of:

(a) One or more "risk hypotheses" that describe predicted relationships between CPECs, exposure, and assessment endpoint response; i.e., a statement of how each CPEC might affect ecologically important components of the natural environment. For example:

- PCBs have been shown to cause reproductive impairment in birds; such impairment could lead to loss of individuals or populations. The risk

assessment will evaluate (as a risk hypothesis) whether the concentration of PCBs in prey (due to site-related exposures) of piscivorous Great Blue Herons exceeds levels known to impair reproduction in these birds.

(b) A simple box and arrow diagram exposure pathway model, showing the relationship between exposure pathways and ecological receptors.

(11) **Submit level II deliverable** This deliverable is a brief memorandum (see Attachment 1, Site Screening Report, for suggested format and contents) which identifies CPECs, site-specific ecological receptors, relevant and complete exposure pathways, and the known ecological effects of CPECs. The resulting CSM forms the factual basis for evaluating the following TMDPs.

(12) **TMDP 3: Ecological Risk Probable?** For a site to present a potential for risk, it must exhibit the following three criteria: (a) contain CPECs in abiotic media at detectable and biologically significant concentrations, (b) provide exposure pathways linking CPECs to ecological receptors, and (c) have these receptors either utilize the site, be present nearby, or be in the locality of CPECs migrating from the site. Based on information presented in the Level II deliverable, do CPECs, entities, and complete exposure pathways exist at or in the locality of the site?

(a) Specific criteria are as follows:

(i) Does the locality of the facility contain, or is it reasonably likely to contain, any individuals of a threatened or endangered species or their critical habitat or does it contain habitat of sufficient size and quality to support a local population of each non-T&E species?;

(ii) Were CPECs selected on the basis of exceedence of SLVs (Task 9d) or because they have a high potential to bioaccumulate (Task 9e)?;

(iii) Based on site-specific information gathered during the site visit and/or site survey, knowledge of CPEC characteristics, receptor behavior, and professional judgment, do there appear to be plausible links between CPEC sources and endpoint receptors?;

(b) If (i), (ii), or (iii) are **"No"**, then the site is highly unlikely to present ecological risks and a recommendation for no further ecological investigations should be made.

(c) If (i) and (ii) and (iii) are **"Yes"**, then the site could present ecological risks and a recommendation to move to TMDP 4 should be made.

(13) **TMDP 4: Remedial Action Decision Possible?** Are risk managers willing to make a response action decision with existing information and current levels of uncertainty? Key questions: Would cleanup be less costly than further investigation? Are data adequate to approve a removal action or to select or approve a remedy? If "**Yes**", then further

ecological investigation is deferred in favor of a response action. If "**No**", then the assessment process proceeds to Level III for further evaluation of the risk hypotheses posed in Task (10).

ADDITIONAL INFORMATION

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Table 1
Exposure Routes for Ecological Receptors By Environmental Media

Environmental Media	Exposure Route	Comments
Surface Water	Direct Contact	Terrestrial organisms may be dermally exposed to water-borne contaminants as a result of wading or swimming in contaminated waters. Aquatic receptors may be exposed through osmotic exchange, respiration of surface waters.
	Root Contact	Contaminants may be taken-up by terrestrial plants whose roots are in contact with surface waters.
	Ingestion	Terrestrial receptors may ingest water-borne contaminants if contaminated surface waters are used as a drinking water source
Ground Water	Root Contact	Contaminants may be taken-up by terrestrial plants whose roots are in contact with groundwater present within the root zone (~1 m depth).
	Ingestion	Receptors generally will not contact groundwater unless it is discharged to the surface, at which time it should be evaluated as surface water.
Sediment	Direct Contact	If sediments are present in an area that is only periodically inundated with water, terrestrial species may be dermally exposed during dry periods; such sediment exposure would be evaluated as soil exposure. Aquatic receptors may be directly exposed to sediments or may be exposed through osmotic exchange, respiration or ventilation of sediment pore waters.
	Root Contact	Exposure of terrestrial plants to contaminated sediment may be treated as exposure to soil.
	Ingestion	If sediments are present in an area that is only periodically inundated with water, terrestrial species may have direct access to sediments for the purposes of incidental ingestion. In this instance, sediment exposure would be evaluated as soil exposure. Aquatic receptors may regularly or incidentally ingest sediment while foraging.
Soil	Dermal Contact	Significant exposure via dermal contact would be limited to organic contaminants which are lipophilic and can cross epidermal barriers.

Table 1
Exposure Routes for Ecological Receptors By Environmental Media

Environmental Media	Exposure Route	Comments
	Foliar Deposition (rainsplash)	Exposure of terrestrial plants to contaminants present in particulates deposited on leaf and stem surfaces by rain striking contaminated soils.
	Root Contact	Contaminants in bulk soil may partition into soil solution, making them available to roots.
	Ingestion	Incidental ingestion of contaminated soil could occur while animals grub for food resident in the soil, feed on plant matter covered with contaminated soil or groom themselves.
Air	Inhalation (vapors)	Exposure via inhalation is most important to organisms that burrow in contaminated soils, given the limited amounts of air present to dilute vapors and an absence of air movement to disperse gases.
	Inhalation (dust)	Exposure via inhalation of fugitive dust is particularly applicable to ground-dwelling species that could be exposed to dust disturbed by their foraging or burrowing activities or by wind movement.
	Foliar Uptake (vapors)	Foliar uptake of organic vapors would be limited to those contaminants with relatively high vapor pressures.
	Foliar Deposition (dust)	Exposure of terrestrial plants to contaminants present in particulates deposited on leaf and stem surfaces.
Food Web	Ingestion	Higher trophic level terrestrial and aquatic consumers and predators, not necessarily in direct contact with any contaminated media, may be exposed through consumption of contaminated food sources.

Attachment 1
Level II Deliverable - Site Screening Report
Outline

(1) **INTRODUCTION**
- (a) Site History
- (b) Regulatory Status
- (c) Summary of Level I Results
  - (i) Contaminants of Interest
  - (ii) Potential Ecological Receptors
  - (iii) Potential Exposure Pathways

(2) **SITE SURVEY**
- (a) Objectives and Scope
- (b) Methodology
- (c) Results

(3) **SCREENING RESULTS**
- (a) Site Description
- (b) Site-specific Ecological Receptors
- (c) Contaminants of Potential Ecological Concern
- (d) Relevant and Complete Exposure Pathways
- (e) Known Ecological Effects
- (f) Candidate Assessment Endpoints
- (g) Preliminary Conceptual Site Model

(4) **RECOMMENDATIONS**

(5) **ATTACHMENTS**
- (a) Regional map showing location of site
- (b) Local map showing site in relation to adjacent property
- (c) Site map
- (d) Map of ecological habitats as overlay to site map
- (e) Map of known or suspected extent of CPECs as overlay to site map

(6) **REFERENCES**

FIGURE 1. Ecological Risk Assessment Process Flowchart

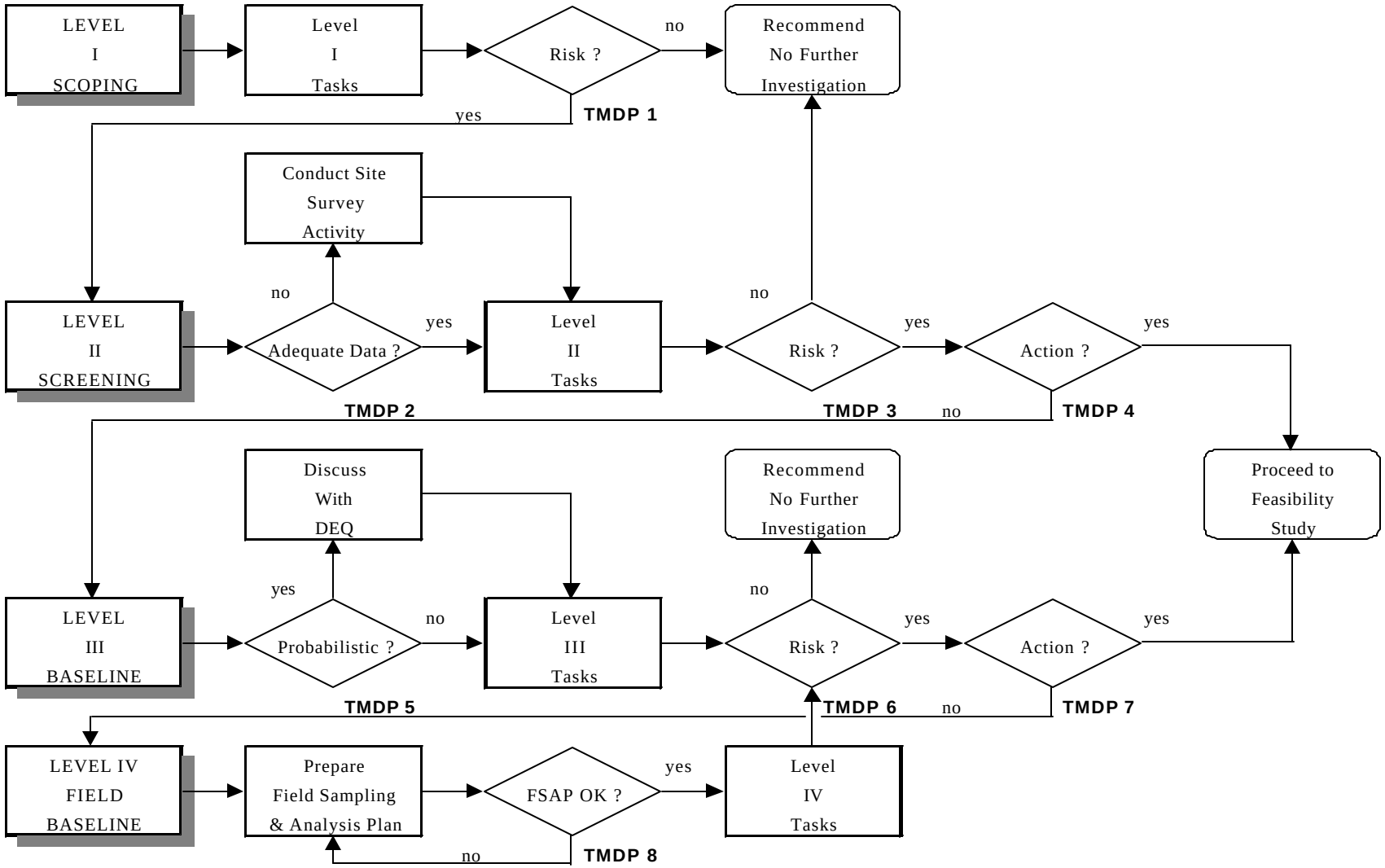
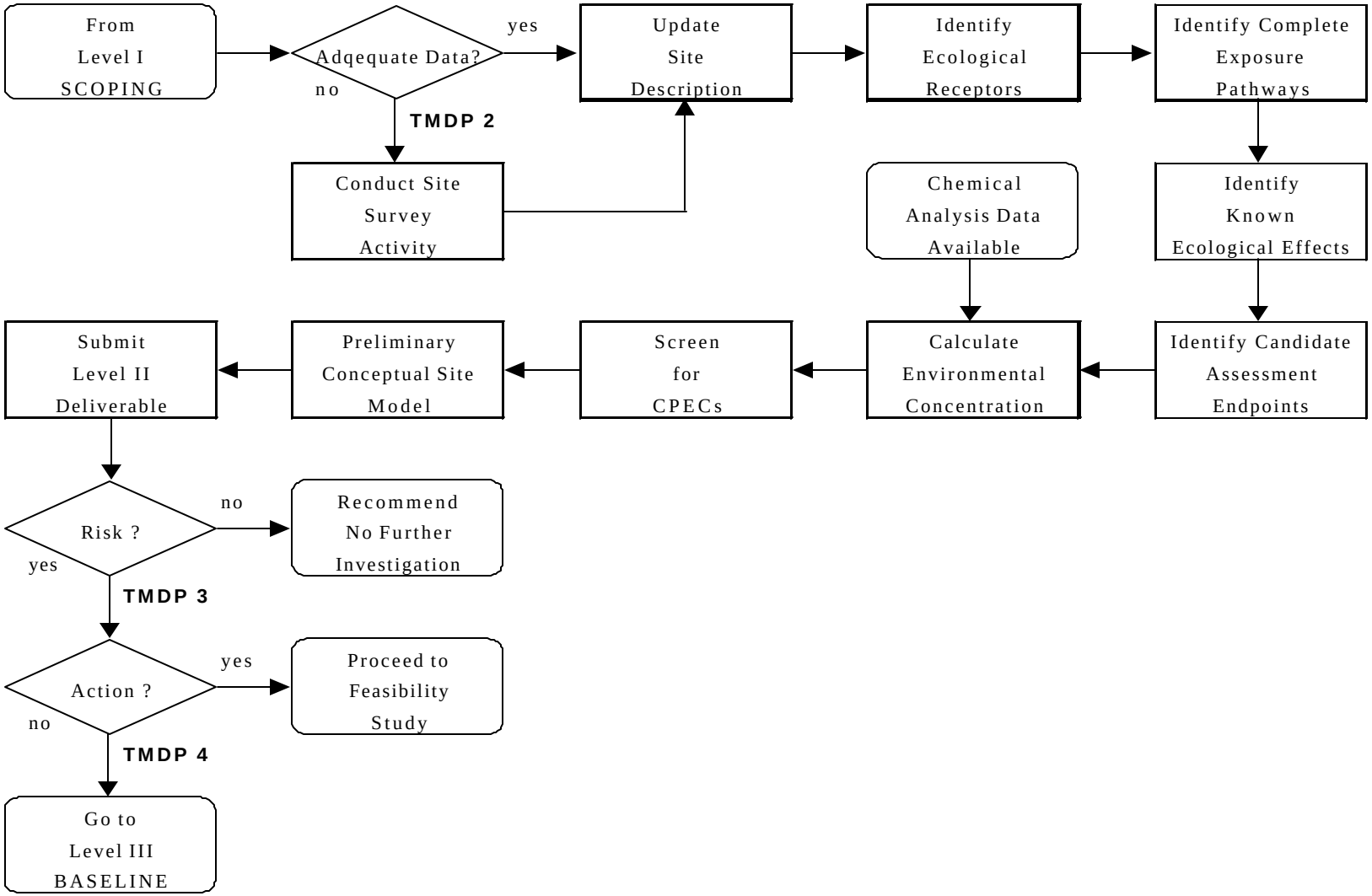


FIGURE 2. Level II (Screening) Ecological Risk Assessment Flowchart



LEVEL II SCREENING LEVEL VALUES

Per OAR 340-122-080(5), a screening activity is permitted as part of a remedial investigation at the discretion of the Department. A Level II screening ecological risk assessment attempts to narrow the scope of subsequent site investigation and assessment activities by focusing on those contaminants and media posing potential risks to ecological receptors. Only contaminants that occur at concentrations potentially hazardous ecological receptors are included as contaminants of potential ecological concern (CPECs). Exposure concentrations that are deemed acceptable for ecological receptors are herein referred to as "screening level values" (SLVs). These Level II SLVs are intended only for purposes of screening during ecological risk assessments performed in accordance with directions provided in the "Level II Screening" guidance document. These SLVs are generally not appropriate for use as site-specific cleanup levels. This guidance will be updated regularly in response to the addition of new chemicals, scientific and technical advances, and changes in regulatory policy.

For further considerations when screening COIs, see: *The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments*. EPA 540/F-01/014, Publication 9345.0-14. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, DC., 2001.

Table 1. Screening Level Values for Plants, Invertebrates, and Wildlife Exposed to Soil and Surface Water

CHEMICAL	CAS No.	Soils (mg/kg)				Surface Water (mg/L)		
		Terrestrial Receptors				Fresh		
		Plants	Inverts	Birds	Mammals	Aquatic	Birds	Mammals
INORGANICS								
Aluminum	7429-90-5	50 c	600 b	450 g	107 e	0.087 n,t	797 h	8 f
Antimony and compounds	7440-36-0	5 c			15 e	1.6 q		1 f
Arsenic III	7440-38-2	10 c	60 a	10 g	29 e,i	0.150 t	18 h	6 f,i
Arsenic V						0.150 t		
Barium and compounds	7440-39-3	500 c	3000 b	85 g	638 e	0.004 o	150 h	39 f
Beryllium and compounds	7440-41-7	10 c			83 e	0.0053 q		5 f
Bismuth		20 d						
Boron	7440-42-8	0.5 c	20 b	120 g	3500 e	0.0016 o	209 h	213 f
Bromine		10 c						
Cadmium and compounds	7440-43-9	4 c	20 a	6 g	125 e,i	0.0022 t	10 h	8 f,i
Calcium						116 p		
Chromium III		1 c	0.4 a	4 g	3.4×10^5 e	0.074 t	7.2 h	2.1×10^4 f
Chromium VI	7440-47-3				410 e	0.011 n,q,t		25 f
Cobalt	7440-48-4	20 c	1000 b		150 e,i	0.023 o		9 f,i
Copper and compounds	7440-50-8	100 c	50 a	190 g	390 e,i	0.009 t	341 h	53 f,i
Cyanides						0.0052 q,t		
Fluorine (soluble fluoride)	7782-41-4	200 c	30 b	32 g	2285 e		57 h	317 f
Iron		10 d	200 b			1.000 n,q,t		
Iodine		4 c						
Lanthanum			50 b					
Lead	7439-92-1	50 c	500 a	16 g	4000 e,i	0.0025 t	28 h	323 f,i
Lithium	7439-93-2	2 c	10 b		1175 e	0.014 o		72 f
Magnesium						82 p		
Manganese and compounds	7439-96-5	500 c	100 b	4125 g	11000 e,i	0.120 o	7242 h	676 f,i
Mercury (elemental, total)	7439-97-6	0.3 c	0.1 a	1.5 g	73 e	0.00077 t	3.3 h	10 f
Mercury (methyl)	22967-92-6	0.0002 d		0.025 g	4 e,i		0.05 h	0.25 f,i
Molybdenum	7439-98-7	2 c	200 b	15 g	14 e	0.370 o	25 h	1 f

Table 1. Screening Level Values for Plants, Invertebrates, and Wildlife Exposed to Soil and Surface Water

CHEMICAL	CAS No.	Soils (mg/kg)				Surface Water (mg/L)		
		Terrestrial Receptors				Fresh		
		Plants	Inverts	Birds	Mammals	Aquatic	Birds	Mammals
Nickel	7440-02-0	30 c	200 a	320 g	625 e,i	0.052 t	562 h	38 f,i
Niobium					9 e			0.6 f
Potassium						53 p		
Selenium	7782-49-2	1 c	70 a	2 g	25 e,i	0.005 t	3.6 h	1.5 f,i
Silver and compounds	7440-22-4	2 c	50 b			0.00012 q		
Sodium						680 p		
Strontium	7440-24-6				32875 e	1.500 o		2001 f
Technetium		0.2 c						
Tellurium		2 d						
Thallium		1 c			1 e,i	0.040 q		0.06 f,i
Tin (inorganic)		50 c	2000 b			0.073 o		
Titanium			1000 b					
Tungsten			400 b					
Uranium	7440-61-1	5 c		65 g	170 e	0.0026 o	116 h	12 f
Vanadium	7440-62-2	2 c		47 g	25 e	0.020 o	82 h	1.6 f
Zinc	7440-66-6	50 c	200 a	60 g	20000 e,i	0.120 t	105 h	1230 f,i
Zirconium					97 e	0.017 o		7 f
ORGANICS								
Acenaphthene	83-32-9	20 c				0.520 q		
Acetone	67-64-1				1250 e	1.500 o		76 f
Acrolein	107-02-8					0.021 q		
Acrylonitrile	107-13-1		1000 b			2.6 q		
Aldrin	309-00-2				25 e,i	0.00006 r		1.5 f,i
Ammonia	7664-41-7					0.017 p		
Aniline	62-53-3	200 d						
Anthracene	120-12-7					0.013 o		
Benzene	71-43-2				3300 e	0.13 o		200 f
Benzidine	92-87-5					0.0039 o		

Table 1. Screening Level Values for Plants, Invertebrates, and Wildlife Exposed to Soil and Surface Water

CHEMICAL	CAS No.	Soils (mg/kg)				Surface Water (mg/L)		
		Terrestrial Receptors				Fresh		
		Plants	Inverts	Birds	Mammals	Aquatic	Birds	Mammals
Benzo[a]anthracene	56-55-3					0.000027 o		
Benzo[a]pyrene	50-32-8				125 e,i	0.000014 o		8 f,i
Benzoic acid	65-85-0					0.042 o		
Benzyl alcohol	100-51-6					0.0086 o		
BHC (alpha)	319-84-6					0.0022 o		
BHC (beta)	319-85-7					0.0022 o		
BHC (gamma) Lindane	58-89-9			8 g	1000 e,i	0.00008 n,q	14.5 h	62 f,i
BHC-technical	58-89-9			2.5 g	200 e		4 h	12 f
1,1-Biphenyl	92-52-4	60 c				0.014 o		
Bis(2-ethylhexyl)phthalate (DEHP)	117-81-7			4.5 g	1020 e	0.003 o	8 h	73 f
4-Bromoaniline		100 d						
4-Bromophenyl phenyl ether	101-55-3					0.0015 o		
2-Butanone						14 o		
Butyl benzyl phthalate	85-68-7					0.019 o		
Carbon disulfide	75-15-0					0.00092 o		
Carbon tetrachloride	56-23-5		1000 b		2000 e	0.074 r		123 f
Chlordane	57-74-9			9 g	250 e	4.3×10^{-6} q,t	15.5 h	18 f
Chloroacetamide			2 a					
3-Chloraniline		20 c	30 a					
4-Chloroaniline	106-47-8	40 d						
Chlorobenzene	108-90-7		40 a			0.05 q		
2-Chloroethyl vinyl ether	110-75-8					4.76 r		
Chloroform	67-66-3				1875 e	1.24 q		115 f
beta-Chloronaphthalene	91-58-7					0.032 r		
2-Chlorophenol	95-57-8	60 d				2.0 q		
3-Chlorophenol		7 c	10 a					
4-Chlorophenol		50 d						
Chlorpyrifos	2921-88-2					0.000041 t		

Table 1. Screening Level Values for Plants, Invertebrates, and Wildlife Exposed to Soil and Surface Water

CHEMICAL	CAS No.	Soils (mg/kg)				Surface Water (mg/L)		
		Terrestrial Receptors				Fresh		
		Plants	Inverts	Birds	Mammals	Aquatic	Birds	Mammals
DDD	72-54-8			0.01 g	100 e	0.000001 t	0.02 h	6 f
DDE	72-55-9			0.01 g	100 e		0.02 h	6 f
DDT	50-29-3			0.01 g	100 e,i	0.000001 q	0.02 h	6 f,i
Decane						0.049 o		
Demeton	8065-48-3					0.0001 q,t		
Diazinon	333-41-5					0.000043 o		
Dibenzofuran	132-64-9				2.0×10^{-3} e	0.0037 o		
Di-n-butyl phthalate	84-74-2	200 c		0.45 g	30000 e	0.035 o	0.8 h	2200 f
2,4-Dichloroaniline			100 a					
3,4-Dichloroaniline		10 d	20 a					
1,2-Dichlorobenzene	95-50-1					0.014 o		
1,3-Dichlorobenzene	541-73-1					0.071 o		
1,4-Dichlorobenzene	106-46-7		20 a			0.015 o		
cis-1,4-Dichloro-2-butene	764-41-0		1000 b					
trans-1,4-Dichloro-2-butene			1000 b					
1,1-Dichloroethane	75-34-3					0.047 o		
1,2-Dichloroethane (EDC)	107-06-2			70 g	2780 e	20.0 q	125 h	200 f
1,1-Dichloroethylene	75-35-4				3750 e	0.025 o		230 f
1,2-Dichloroethylene (cis)	156-59-2				2500 e	0.590 o		180 f
1,2-Dichloroethylene (trans)	156-60-5				2500 e	0.590 o		180 f
1,2-Dichloroethylene (mixture)	540-59-0				2500 e	0.590 o		180 f
2,4-Dichlorophenol	120-83-2	20 d				3.65 q		
3,4-Dichlorophenol		20 c	20 a					
1,2-Dichloropropane	78-87-5		700 a			5.7 q		
1,3-Dichloropropene	542-75-6					0.244 q		
Dieldrin	60-57-1			0.3 g	3 e	0.000056 t	0.6 h	0.15 f
Diethyl phthalate	84-66-2	100 c			2.5×10^{5} e	0.210 o		1.8×10^{4} f
Di-n-hexylphthalate					3050 e			220 f

Table 1. Screening Level Values for Plants, Invertebrates, and Wildlife Exposed to Soil and Surface Water

CHEMICAL	CAS No.	Soils (mg/kg)				Surface Water (mg/L)		
		Terrestrial Receptors				Fresh		
		Plants	Inverts	Birds	Mammals	Aquatic	Birds	Mammals
2,4-Dimethylphenol	105-67-9	20 c				0.042 r		
Dimethyl phthalate	131-11-3		200 a			0.003 q		
Dimethyl terephthalate	120-61-6					0.003 q		
2,4-Dinitrophenol	51-28-5	20 c						
Dinitrotoluene mixture	25321-14-6					0.230 q		
2,4-Dinitrotoluene	121-14-2					0.230 q		
2,6-Dinitrotoluene	606-20-2					0.230 q		
Di-n-octyl phthalate	117-84-0					0.708 p		
1,4-Dioxane	123-91-1				63 e			4 f
1,2-Diphenylhydrazine	122-66-7					0.0054 r		
Endosulfan	115-29-7			42 g	20 e	0.000056 q,t	72 h	1 f
Endrin	72-20-8			0.04 g	5 e	0.000036 t	0.07 h	0.3 f
Ethanol					4000 e			245 f
Ethyl acetate	141-78-6				11250 e			690 f
Ethylbenzene	100-41-4					0.0073 o		
Fluoranthene	206-44-0					0.00616 n		
Fluorene	86-73-7		30 a			0.0039 p		
Formaldehyde	50-00-0				3900 e			184 f
Furan	110-00-9	600 c						
Guthion	86-50-0					0.00001 t		
Heptachlor	76-44-8				15 e,i	3.8×10^{-6} q,t		2 f,i
Heptachlor epoxide	102-45-73					3.8×10^{-6} t		
Heptane		1 d						
Hexachlorobenzene	118-74-1		1000 b					
Hexachlorobutadiene	87-68-3					0.0093 q		
Hexachlorocyclopentadiene	77-47-4	10 c				0.0052 q		
Hexachloroethane	67-72-1					0.540 q		
n-Hexane	110-54-3					0.00058 o		

Table 1. Screening Level Values for Plants, Invertebrates, and Wildlife Exposed to Soil and Surface Water

CHEMICAL	CAS No.	Soils (mg/kg)				Surface Water (mg/L)		
		Terrestrial Receptors				Fresh		
		Plants	Inverts	Birds	Mammals	Aquatic	Birds	Mammals
2-Hexanone						0.099 o		
Isophorone	78-59-1					2.34 r		
Kepone (Chlordecone)	143-50-0				10 e			0.6 f
Malathion	121-75-5					0.0001 q,t		
Methanol	67-56-1				6250 e			384 f
Methoxychlor	72-43-5				500 e,i	0.00003 q,t		30 f,i
Methylene chloride	75-09-2				730 e	2.200 o		45 f
Methyl ethyl ketone	78-93-3				2.0×10^{5} e			14000 f
1-Methylnaphthalene						0.0021 o		
4-Methyl-2-pentanone						0.170 o		
2-Methylphenol (o-Cresol)	95-48-7	50 d			16000 e	0.013 o		2200 f
Mirex	2385-85-5					0.000001 q,t		
Naphthalene	91-20-3	10 d			3900 e,i	0.620 q		284 f,i
3-Nitroaniline	99-09-2	70 d						
4-Nitroaniline	100-01-6	40 d						
Nitrobenzene	98-95-3	8 d	40 a			0.54 r		
4-Nitrophenol	100-02-7	10 d	7 a			0.150 q		
N-Nitrosodi-n-butylamine	924-16-3					0.117 r		
N-Nitrosodiethanolamine	1116-54-7					0.117 r		
N-Nitrosodiethylamine	55-18-5					0.117 r		
N-Nitrosodimethylamine	62-75-9					0.117 r		
N-Nitrosodiphenylamine	86-30-6		20 a			0.210 o		
N-Nitroso di-n-propylamine	621-64-7					0.117 r		
N-Nitroso-N-methylethylamine	10595-95-6					0.117 r		
2-Octanone						0.0083 o		
Parathion	56-38-2					0.000013 q,t		
Pentachlorobenzene	608-93-5		40 a			0.00047 o		
Pentachloronitrobenzene	82-68-8			30 g			51 h	

Table 1. Screening Level Values for Plants, Invertebrates, and Wildlife Exposed to Soil and Surface Water

CHEMICAL	CAS No.	Soils (mg/kg)				Surface Water (mg/L)		
		Terrestrial Receptors				Fresh		
		Plants	Inverts	Birds	Mammals	Aquatic	Birds	Mammals
Pentachlorophenol	87-86-5	3 c	4 a		30 e	0.015 t		1.8 f
1-Pentanol						0.110 o		
Phenanthrene						0.0063 n		
Phenol	108-95-2	70 c	30 a			0.110 n		
Polychlorinated biphenyls (Total)	1336-36-3	40 c			4 e,i	0.000014 q,t		0.27 e,i
Aroclor 1016	12674-11-2				100 e			13 f
Aroclor 1221						0.00028 o		
Aroclor 1232						0.00058 o		
Aroclor 1242				1.5 g	5 e	0.000053 o	3.0 h	0.7 f
Aroclor 1248						0.000081 o		
Aroclor 1254	11097-69-1			0.7 g	4 e	0.000033 o	1.3 h	0.3 f
Aroclor 1260						0.094 o		
2-Propanol						0.0075 o		
Styrene	100-42-5	300 c						
2,3,7,8-TCDD (dioxin)	1746-01-6			5.5×10^{-5} g	1.2×10^{-4} e		1.0×10^{-4} h	7.6×10^{-6} f
2,3,5,6-Tetrachloroaniline		20 c	20 a					
1,2,3,4-Tetrachlorobenzene			10 a					
1,1,1,2-Tetrachloroethane	630-20-6					0.186 r		
1,1,2,2-Tetrachloroethane	79-34-5					2.4 q		
Tetrachloroethylene (PCE)	127-18-4	10 d			80 e	0.840 q		6 f
Tetrachloromethane						0.240 o		
2,3,4,6-Tetrachlorophenol	58-90-2		20 a					
Toluene	108-88-3	200 c			1440 e	0.0098 o		104 f
p-Toluidine	106-49-0	100 d						
Toxaphene	8001-35-2				1000 e	2.0×10^{-7} q,t		60 f
Tribromomethane						0.320 o		
Tributyltin						0.000063 t		
Tributyltin oxide (TBTO)	56-35-9			28 g	1300 e,i	0.01 s	49 h	94 f,i

Table 1. Screening Level Values for Plants, Invertebrates, and Wildlife Exposed to Soil and Surface Water

CHEMICAL	CAS No.	Soils (mg/kg)				Surface Water (mg/L)		
		Terrestrial Receptors				Fresh		
		Plants	Inverts	Birds	Mammals	Aquatic	Birds	Mammals
2,4,5-Trichloroaniline		20 c	20 a					
1,2,3-Trichlorobenzene			20 a					
1,2,4-Trichlorobenzene	120-82-1		20 a			0.110 o		
1,1,1-Trichloroethane	71-55-6				55550 e	0.011 o		4000 f
1,1,2-Trichloroethane	79-00-5					9.4 q		
Trichloroethylene (TCE)	79-01-6				40 e	21.9 q		3 f
2,4,5-Trichlorophenol	95-95-4	4 c	9 a					
2,4,6-Trichlorophenol	88-06-2	10 d	10 a			0.970 q		
Vinyl acetate	108-05-4					0.016 o		
Vinyl chloride	75-01-4				20 e			1.3 f
m-Xylene	108-38-3					0.0018 o		
o-Xylene	95-47-6	1 d						
Xylene (mixed)	1330-20-7	100 d			120 e	0.013 o		8 f

Table 1 Notes

a) Oak Ridge National Laboratory (ORNL) TM-126 [1995] Table 1 (earthworms)

b) ORNL TM-126 [1995] Table 2 (microbial processes)

c) ORNL TM-85/R3 [1997] Table 1 (soil)

d) ORNL TM-85/R3 [1997] Table 1 (soil solution)

e) NOAEL equivalent concentration in food (i.e., the dietary level in food of a chemical that would result in a dose equivalent to the NOAEL, assuming no other exposures) for mammals. Calculated per Equation (10) in ORNL TM-86/R3 [1996], with NOAEL values from Appendix A of same reference. Assumes diet is 10% soil – approximately the 95th percentile of estimated percent soil in diet (dry weight) values for mammals given in Tables 4-4 and 4-5 of the *Wildlife Exposure Factors Handbook* (EPA/600/R-93/187, 1993).

f) NOAEL equivalent concentration in drinking water (i.e., the level of a chemical in the drinking water of an animal that would result in a dose equivalent to the NOAEL, assuming no other exposures) for mammals. Calculated per Equation (22) in ORNL TM-

86/R3 [1996], with NOAEL values from Appendix A of same reference. Assumes all drinking water is consumed from source contaminated with the given chemical.

g) NOAEL equivalent concentration in food for birds (represented by the American Robin) from ORNL TM-86/R3 [1996], Appendix D, Table 12. Assumes diet is 20% soil – approximately the 95th percentile of estimated percent soil in diet (dry weight) values for birds given in Table 4-4 of the *Wildlife Exposure Factors Handbook* (EPA/600/R-93/187, 1993).

h) NOAEL equivalent concentration in water for birds (represented by the American Robin) from ORNL TM-86/R3 [1996], Appendix D, Table 12.

i) Reflects limited re-assessment (based on new and/or different toxicology data) of values originally appearing in ORNL TM-86/R3. Further details available upon request.

j) reserved

k) Order of precedence for surface (fresh) water values is: (1) corrected NRWQC [t], (2) NAWQC chronic value [n], (3) Oregon chronic WQC [q], (4) Oregon acute WQC [r], (5) ORNL secondary chronic value [l], (6) ORNL Tier II secondary chronic value [o], and (7) ORNL lowest chronic value, other organisms [p].

l) ORNL TM-95/R4 [1997] Table 3 (secondary chronic value)

m) reserved

n) ORNL TM-96/R2 [1996] Table 1 (NAWQC chronic value)

o) ORNL TM-96/R2 [1996] Table 1 (Tier II secondary chronic value)

p) ORNL TM-96/R2 [1996] Table 1 (lowest chronic value, all other organisms)

q) Oregon Water Quality Criteria [1992] Freshwater chronic criteria (OAR 340-41)

r) Oregon Water Quality Criteria [1992] Freshwater acute criteria (OAR 340-41) divided by 50 for acute > chronic conversion.

s) USEPA [1991] *Draft Proposed Ambient Aquatic Life Water Quality Criteria for Tributyltin*

t) USEPA [EPA 822-Z-99-001; April 1999] *National Recommended Water Quality Criteria - Correction* (chronic values)

Table 2. Screening Level Values for Freshwater and Marine Sediment

CHEMICAL	CAS No.	SEDIMENT		
		Freshwater	Marine	Bioaccumulation
INORGANICS (mg/kg)				
Antimony and compounds	7440-36-0	3 g	9 f	10 k
Arsenic III	7440-38-2	6 c	7 c	4 k
Barium and compounds	7440-39-3		48 f	
Beryllium				122 k
Cadmium and compounds	7440-43-9	0.6 c	0.7 d	0.003 k
Chromium (total)		37 c	52 d	4200 k
Copper and compounds	7440-50-8	36 c	19 d	10 k
Lead	7439-92-1	35 c	30 d	128 k
Manganese and compounds	7439-96-5	1100 g		
Mercury (elemental, total)	7439-97-6	0.2 c, j	0.1 d	
Mercury (methyl)	22967-92-6			
Nickel	7440-02-0	18 c	16 d	316 k
Selenium	7782-49-2		1 f	0.1 k
Silver and compounds	7440-22-4	4.5 b, g	0.7 d	
Thallium				0.7 k
Vanadium	7440-62-2		57 f	
Zinc	7440-66-6	123 c	124 d	3 k
ORGANICS (µg/kg)				
Acetone				290 k
Acenaphthene	83-32-9	290 g	7 d	
Acenaphthylene	208-96-8	160 g	6 d	
Aldrin	309-00-2	40 g	10 f	40 k
Anthracene	120-12-7	57 j	47 d	
Benzene				3920 k
Benzo[a]anthracene	56-55-3	32 c	75 d	
Benzo[b]fluoranthene	205-99-2		1800 f	
Benzo[k]fluoranthene	207-08-9	27 c	1800 f	
Benzo[a]pyrene	50-32-8	32 c	89 d	100 k
Benzo[g,h,i]perylene	191-24-2	300 g	670 a, f	
Benzoic acid	65-85-0		65 f	
Benzyl alcohol	100-51-6		52~57 a, f	
BHC (beta)	319-85-7			220 k
BHC (gamma) Lindane	58-89-9	0.9 c	0.3 d	1160 k
BHC (technical)	608-73-1	100 g		4 k
Bis(2-ethylhexyl)phthalate (DEHP)	117-81-7	750 b, g	1300 f	330 k
Butyl benzyl phthalate	85-68-7		63 f	
Carbazole	86-74-8	140 b		
Carbon tetrachloride				6080 k
Chlordane	57-74-9	4.5 c	2 d	420 k
Chlordane (alpha)	12789-03-6		10 a	
Chloroform				3660 k

Table 2. Screening Level Values for Freshwater and Marine Sediment

CHEMICAL	CAS No.	SEDIMENT		
		Freshwater	Marine	Bioaccumulation
Chrysene	218-01-9	57 c	107 d	
DDD	72-54-8	4 c	1 d	0.3 k
DDE	72-55-9	1.5 c	2 d	0.3 k
DDT	50-29-3	4 j	1 d	0.3 k
DDT (Total)		7 c	4 d	0.3 k
Dibenz[a,h]anthracene	53-70-3	33 j	6 d	
Dibenzofuran	132-64-9	5100 g	110 f	
Di-n-butyl phthalate	84-74-2	110 g	58 f	60 k
1,2-Dichlorobenzene	95-50-1		13 f	
1,3-Dichlorobenzene	541-73-1		170 a	
1,4-Dichlorobenzene	106-46-7		110 a, f	
1,1-Dichloroethylene				1590 k
1,2-Dichloroethane				3430 k
1,2-Dichloroethylene				5760 k
Dieldrin	60-57-1	3 c	0.7 d	4 k
Diethyl phthalate	84-66-2		6 f	8.3×10^6 k
2,4-Dimethylphenol	105-67-9		18 f	
Dimethyl phthalate	131-11-3		6 f	
Di-n-octyl phthalate	117-84-0		61 f	
1,4-Dioxane				10 k
Endosulfan	115-29-7			110 k
Endrin	72-20-8	3 c		4 k
Ethanol				840 k
Ethyl acetate				8950 k
Ethylbenzene	100-41-4		4 f	
Fluoranthene	206-44-0	111 c	113 d	
Fluorene	86-73-7	77 j	21 d	
Formaldehyde				900 k
Heptachlor	76-44-8	10 g	0.3 f	24 k
Heptachlor epoxide	102-45-73	0.6 c		
Hexachlorobenzene (HCB)	118-74-1	100 g	6 f	
Hexachlorobutadiene	87-68-3		1 f	
Hexachloroethane	67-72-1		73 f	
Indeno[1,2,3-cd]pyrene	193-39-5	17 c	600 f	
Kepone (Chlordecone)	143-50-0			24 k
Methanol				630 k
Methoxychlor	72-43-5			990 k
Methyl ethyl ketone				1.1×10^6 k
Methylene chloride				930 k
2-Methylnaphthalene	91-57-6		20 d	
2-Methylphenol (o-cresol)	95-48-7		8 f	
4-Methylphenol (p-cresol)	106-44-5		100 f	

Table 2. Screening Level Values for Freshwater and Marine Sediment

CHEMICAL	CAS No.	SEDIMENT		
		Freshwater	Marine	Bioaccumulation
4-Methyl-2-pentanone				3810 k
Mirex	2385-85-5	800 g		
Naphthalene	91-20-3	176 j	35 d	
Nitrobenzene	98-95-3		21 f	
N-Nitrosodiphenylamine	86-30-6		28 a, f	
Pentachloronitrobenzene	82-68-8			3640 k
Pentachlorophenol	87-86-5		17 f	370 k
Phenanthrene	85-01-8	42 c	86 d	
Phenol	108-95-2	48 b, g	130 f	
Polychlorinated biphenyls (total)	1336-36-3	34 c	22 d	
Aroclor 1016	12674-11-2			420 k
Aroclor 1242				2 k
Aroclor 1248		21 b		4 k
Aroclor 1254	11097-69-1	7 b		10 k
Polycyclic aromatic hydrocarbons				
Total PAH		1610 j	1684 d	
Total LPAH		76 c	312 d	
Total HPAH		193 c	655 d	
Pyrene	129-00-0	53 c	152 d	
2,3,7,8-TCDD (dioxin)	1746-01-6	0.009 g	0.004 f	8.5×10^{-4} k
Tetrachloroethylene (PCE)	127-18-4		57 f	280 k
Toluene				5300 k
Toxaphene	8001-35-2			2550 k
Tributyltin	56573-85-4		3 f	190 k
1,2,4-Trichlorobenzene	120-82-1		5 f	
1,1,1-Trichloroethane				1.8×10^{6} k
Trichloroethylene (TCE)	79-01-6		41 f	140 k
2,4,5-Trichlorophenol	95-95-4		3 f	
2,4,6-Trichlorophenol	88-06-2		6 f	
Vinyl chloride				30 k
Xylene (mixed)	1330-20-7		4 f	

Table 2 Notes

a) Screening Level (SL), Table 8-1, *Dredged Material Evaluation Framework, Lower Columbia River Management Area*, U.S. Army Corps of Engineers, April 1998 Draft.

b) Lowest Apparent Effects Threshold (LAET), Table 11, *Creation and Analysis of Freshwater Sediment Quality Values in Washington State*, Washington Department of Ecology, Pub. No. 97-323a, July 1997.

c) Threshold Effects Level (TEL) or lowest ARCs *H. azteca* TEL, Freshwater Sediment, Screening Quick Reference Tables (SQuiRTs), NOAA, Coastal Resource Coordination Branch, Hazmat Report 99-1, 1999.

d) Threshold Effects Level (TEL), Marine Sediment, SquiRTs.

e) Apparent Effects Threshold (AET), Freshwater Sediment, SquiRTs.

f) Apparent Effects Threshold (AET), Marine Sediment, SquiRTs.

g) Upper Effects Threshold (UET), Freshwater Sediment, SquiRTs.

h) Upper Effects Threshold (UET), Marine Sediment, SquiRTs.

i) Freshwater Chronic Criteria, *Ambient Water Quality Criteria Document for Tributyltin*, U.S. Environmental Protection Agency, 62 FR 42554, August 7, 1997.

j) Threshold Effects Concentration (TEC). Smith, SL., MacDonald, DD, Keenleyside, KA, Ingersoll, CG, and Field, J. 1996. A preliminary evaluation of sediment quality assessment values for freshwater ecosystems. *Journal of Great Lakes Research* 22:624-638.

k) Allowable water concentrations (C_w) calculated per Equation (28), Section 3.5 of ORNL TM-86/R3 [1996]. Value is lowest for representative piscivorous bird (Great Blue Heron) or piscivorous mammal (mink) species. Conversion of water (C_w) to sediment concentrations assumes 1% organic carbon content and organic carbon partition coefficient (K_{oc}) estimated from the octanol water partition coefficient (K_{ow}; taken from ORNL TM-86/R3 [1996]) using the regression relationship: $\log K_{oc} = 0.00028 + 0.983(\log K_{ow})$ [Di Toro et al. 1991. Technical basis for establishing sediment quality criteria for nonionic organic chemicals using equilibrium partitioning. *Environmental Toxicology and Chemistry* 10: 1541 - 1583].

INTRODUCTION

The DEQ ecological risk assessment process consists of four distinct levels, as follows (and as shown in Figure 1):

- Level I Scoping
- Level II Screening
- Level III Baseline
- Level IV Field Baseline

Within and between these levels are a number of Technical/Management Decision Points (TMDP). Based on the information developed and presented within a given level, these TMDPs determine one of three recommendations:

- No further ecological investigations at the site, or
- Continuation of the risk assessment process at the next level, or
- Undertake (beyond Level I only) a removal or remedial action.

The outcome of each level of the assessment should be documented in writing. Thorough documentation will provide a future reference for any other site-related activities involving a hazardous substance release, future site remedial actions, or onsite monitoring.

Prior to undertaking any ecological risk assessment pursuant to OAR 340-122-084, risk assessors should have read and be familiar with the terms, concepts, and approaches discussed in the following documents:

- USEPA Proposed Guidelines for Ecological Risk Assessment (61 FR 47552, 9/9/96)
- USEPA Region X Supplemental Ecological Risk Assessment Guidance for Superfund (EPA 910-R-97-005, June 1997)
- ORS 465.315
- OAR 340-122-010 through -115
- State of Oregon Level I, II, III, and IV Ecological Risk Assessment Guidance

OBJECTIVE

The objective of a Level III baseline assessment is to determine whether a site, if left unremediated, would pose unacceptable current or reasonably likely future risks to endpoint species. The purposes of a baseline assessment are to determine: (a) if significant ecological effects are occurring at a site, (b) the probable causes of these effects, (c) the source of causal agents, and (d) the consequences of leaving the site unremediated. The Level III assessment

provides the basis for determining the need for remediation and provides information necessary for the development of protective remedial alternatives.

A Level III assessment would generally be performed during a remedial investigation (RI) to meet the baseline risk assessment requirements of OAR 340-122-080(5). Any ecological baseline risk assessment performed in support of an RI must meet the information requirements of OAR 340-122-084(3). Note also that a baseline risk assessment is a necessary precursor to a residual risk assessment, which in turn is a prerequisite to demonstrating that remedial actions are protective of human health and the environment as defined by OAR 340-122-040(2)(a). A Level IV field baseline assessment would be used only to refine, reduce uncertainties in, or validate the accuracy of the Level III assessment at the discretion of the risk manager / risk assessor.

PREREQUISITES

Initiation of Level III requires completion of a Level I and/or Level II assessment with a decision to proceed with further ecological investigation. U.S. EPA has concluded that the strengths and weaknesses of ecological risk assessments seem to originate from decisions made during the problem formulation stage. It is especially important at this stage to identify and contact any stakeholders with responsibilities for the resources being analyzed. If the affected parties do not participate in the early decisions about goals, endpoints, and measurements, the analysis is likely to fail to provide information useful for decisionmaking. Therefore, it is strongly recommended that problem formulation (Tasks 1, 2, and 3 below) be completed, with stakeholder involvement, before Level III commences.

Completion of problem formulation requires: (a) assessment endpoints that link the risk assessment to management concerns, (b) a Conceptual Site Model (CSM) that describes key relationships between a Contaminant of Potential Ecological Concern (CPEC) and assessment endpoint or among several CPECs and assessment endpoints, and (c) finally, an analysis plan. The assessment endpoints and their associated endpoint species, risk hypotheses, conceptual site model(s), and other information developed in Levels I and/or II should be reviewed and, if necessary, revised to reflect any new information or the results of further discussions among stakeholders.

TASKS (see Figure 2)

(1) **Complete problem formulation** Following the screening process described in the Level II guidance, there should now be fewer CPEC under consideration. This should make it possible to better "think through" the relationship between specific CPEC, their toxicological characteristics, their likely pathway to specific ecological receptors, and the effect(s) they may induce in these receptors. This process should substantially lessen the

chance of having inappropriate assessment endpoints and of having the assessment itself consider insignificant or implausible CPEC - pathway - receptor relationships.

(a) Review/revise assessment endpoints Definition of assessment endpoints for the baseline assessment should be derived from the valued components of the ecosystem, as determined by further discussions amongst risk managers, other stakeholders, and risk assessors. Even if assessment endpoints identified by risk managers and/or stakeholders have no possible relationship to CPECs, they should nonetheless be carried forward in the assessment process so that stakeholders do not feel that their concerns are being slighted. An explanation of why further detailed evaluation of an assessment endpoint is not needed in Level III should be provided, but the assessment endpoint must be retained.

(b) Review/revise risk hypotheses The preliminary risk hypotheses stated for Task (10) of the Level II assessment are reviewed and further focused prior to designing and performing any baseline investigations. This will limit generation of data that are of little use in assessing baseline risk.

(c) Establish measures There are three categories of measures, each of which may be evaluated either qualitatively and/or quantitatively:

(i) Measures of exposure describe how exposure may be occurring, including CPEC concentrations in abiotic and biotic media, how a CPEC moves through the environment, and how it may co-occur with the assessment endpoint.

(ii) Measures of effect evaluate the response of the assessment endpoint when exposed to a CPEC.

(iii) Measures of characteristics include site characteristics that influence the behavior and location of assessment endpoints and of CPEC distribution, as well as natural history characteristics of the assessment endpoint that may affect exposure or response to the CPEC.

(d) It can be useful to organize the chosen baseline assessment endpoints and measures into a table format (Table 1 provides examples) to more clearly illustrate their relation to one another. The preliminary conceptual site model (CSM) developed during Level II can now be completed and will include: (a) text describing the risk hypotheses and associated measures, (b) an exposure pathway model (EPM), and (c) a measures of exposure/effect model (MEEM) (see Attachment 1) that traces CPEC movement from the primary source to subsequent sources, and from there through the food chain to one or more points where exposures and effects, that can affect the assessment endpoint, will be measured to evaluate the risk hypotheses. Note that an EPM alone does not constitute a complete CSM.

(e) Establishing clear assessment endpoints, risk hypotheses, and associated measures

should enable all concerned parties to think through and agree upon a common basis for understanding what is at risk at a given site. They define the terms under which an assessment will be brought to closure. Definition of appropriate assessment endpoints avoids making remedial decisions on the basis of trivial or insignificant effects. Therefore, once these factors have been defined, all affected parties and stakeholders should agree as to their acceptability. The assessment endpoints, hypotheses, and measures should be manipulated and refined until such an agreement is achieved; at which point an analysis plan can be prepared.

(2) **Prepare analysis plan** This plan describes the assessment design, data needs, measures, and methods for conducting the exposure and effects analysis components of the risk assessment. It may be relatively brief or extensive depending on the nature of the assessment; however, it should be included as a component of the overall RI work plan for the site. The plan includes, but is not limited to, discussion of:

(a) Data Quality Objectives (DQOs) for the assessment.

(b) The data interpretation paradigm, i.e., how measures and associated data analyses will test or otherwise evaluate the risk hypotheses.

(c) The risk characterization options that will be used, including any probabilistic methods or weight-of evidence techniques involving a combination of qualitative and quantitative data.

(d) How uncertainties in the data and analyses will be addressed.

(e) How the results will be presented.

(f) If sampling and analysis of biotic material is required for Level III, or if a Level IV risk assessment is anticipated, Field Sampling and Analysis and Quality Assurance/Quality Control Project Plans will be required.

(3) **TMDP 5: Use Probabilistic Methods?** Per OAR 340-122-084(1)(b), risk assessments may be conducted using either deterministic or Probabilistic Risk Assessment (PRA) methodologies at the discretion of the party conducting the risk assessment. If a decision is made to proceed with a PRA, then specific issues must be addressed <u>prior to</u> commencement of the assessment or it will not be accepted by the Department. The issues that must be discussed with the Department prior to the PRA are described in OAR 340-122-084(5)(a)(A - D). Once these issues have been satisfactorily addressed, the PRA must then meet the information requirements described in OAR 340-122-084(5)(d).

(4) **Perform exposure analysis** Per OAR 340-122-115(25), the exposure point value (EPV) is the concentration or dose of a hazardous substance occurring at a location of potential contact between an ecological receptor and the hazardous substance. Determining the EPV

requires taking into consideration a number of factors including, but not limited to, the spatial distribution of endpoint species and their habitat relative to the spatial distribution of CPEC concentrations. Calculating EPVs for any given endpoint species population involves the following process:

(a) Identify Ecological Receptors Based on the results of Level I and II assessments, identify ecological receptors at and in the locality of the site.

(b) Identify Assessment Endpoints and Endpoint Species Performed during Level II, Task (5) and above in Task (1).

(c) Define Local Population Boundaries This is necessary for plants and animals other than threatened and endangered species. Refer to Appendix A for details.

(d) Determine Habitat Size and Quality This is necessary for plants and animals other than threatened and endangered species. Refer to Appendix A for details.

(e) Estimate Exposure Point Value (EPV) Measured abiotic and/or biotic (tissues) media environmental concentrations (ECs) for a given CPEC may be used within an appropriate site-specific exposure model(s) to estimate the EPV. A useful model generally requires inclusion of the following:

(i) Modeling is a cost-effective, but less uncertain, method for estimating contaminant concentrations (tissue residues) in endpoint species and/or their prey/forage items. Measurement of contaminant concentrations in tissues of endpoint or prey species collected at and in the locality of the site can greatly enhance the determination of actual exposure, bioaccumulation potential, and trophic transfer of contaminants. Tissue sampling should be used at sites where greater certainty in the risk assessment is required.

(ii) Information on endpoint species food webs is usually required to fully evaluate exposure pathways, particularly those leading to higher trophic level receptors. A simple illustration of the food web(s) being considered for exposure analysis should be included (see example in Attachment 2).

(iii) Data on endpoint species natural history parameters (dietary fraction, weight, home range, etc.) keyed to the food web may also be required to make quantitative exposure estimates for these receptors.

(iv) An understanding of a contaminant's physicochemical properties is necessary to: (a) evaluate potential exposure routes, (b) estimate bioconcentration and/or bioaccumulation factors, and (c) assess its mobility and bioavailability.

(v) Refer to Appendix A for a description of a population-level exposure estimation model.

(5) **Perform ecological response analysis** Chemical contaminants coming into contact with endpoint species can induce acute or chronic adverse effects in individual organisms, or may indirectly affect their ability to survive and reproduce. Ecological effects may also be expressed as some impairment of a biological function or condition which may potentially effect populations.

(a) Individual-level EBV Per OAR 340-122-084(1)(h)(B)(i), effects at the level of the individual are assessed only for threatened or endangered species pursuant to 16 USC. 1531 *et seq* or ORS 496.172. Per OAR 340-122-115(21), the EBV for individual receptors is defined as the highest no-observed-adverse-effect-level (NOAEL) considering effects on reproductive success.

(b) Population-level EBV Per OAR 340-122-084(1)(h)(B)(ii), effects on species other than those classified as threatened or endangered are made only at the population level. Per OAR 340-122-115(21), the EBV for populations is defined as the median lethal dose or concentration (LD_{50} or LC_{50}). Note that, **in addition to considering the EBV**, the risk assessment must also demonstrate that there are no other observed significant adverse effects on the health or viability of the local population.

(c) EBV derivation If a NOAEL, LD_{50} or LC_{50}, as applicable, is not available for endpoint species considered in the risk assessment, the EBV may be derived from other toxicological endpoints for those receptors or appropriate surrogates for those receptors, adjusted with uncertainty factors to equate to a NOAEL, LD_{50} or LC_{50}. Also, per OAR 340-122-115(21), the EBV shall be based, to the extent practicable, on studies whose routes of exposure and duration of exposure were commensurate with the expected routes and duration of exposure for endpoint species considered in the risk assessment, or appropriate surrogates for those receptors.

(d) Uncertainty factors A logical process (shown in Table 2) may be used to convert a variety of toxicological endpoints to a NOAEL suitable for evaluating risk to individual threatened and endangered species. See also EPA (1997).

(e) Toxicity profiles Single numerical values offered for either individual or population-level EBVs should be supported by detailed toxicity profiles for each CPEC with respect to each endpoint species associated with an assessment endpoint. These toxicity profiles should describe the mechanism of toxicity for a given CPEC for a range of endpoint species and, if data are available, for those receptors of specific interest to this assessment or their appropriate surrogates.

(6) **Perform risk characterization** Risk characterization quantitatively defines the magnitude of potential risks to endpoint species under a specific set of circumstances. It is the

process of applying numerical methods and professional judgment to determine whether acceptable risk levels for endpoint species are or could be exceeded as a result of exposure to site-related CPECs. Risk characterization involves two components: a quantitative risk estimate and a narrative risk description.

(a) Risk estimate

(i) For threatened and endangered species, a quotient methodology, which simply indicates whether the EPV is or is not greater than the EBV, is used to assess "risk". Thus, toxicity quotient (TQ) = EPV / EBV and toxicity index (TI) = ΣTQ. Use of a TI assumes simple additivity of toxic responses, however, other assumptions are possible - see OAR 340-122-084(1)(i).

(ii) For populations of endpoint species, risk estimation involves the following general process (See Appendix A for details):

- Estimate local population abundance
- Calculate probability of exposure exceeding the benchmark using one of two probability functions.
- Calculate the number of individuals affected.
- Compare results of above calculations with definition of acceptable risk levels i.e., determine whether 20% or more of the total local population has a ≥ 10% chance of EPV > EBV.

(b) Risk description This is a qualitative narrative discussion of risks presented by the site and must include a discussion of any toxicological and ecological factors beyond those embodied in the quantitative risk estimates. Risk must be described for each CPEC-pathway-receptor combination, i.e., for each assessment endpoint.

(i) Because no one piece of information can necessarily adequately define risks to complex ecological systems, a formal "weight-of-evidence" approach might be needed to compile and integrate various types of evidence indicating the degree of risk present for each CPEC and assessment endpoint. The four general types of evidence available to a baseline assessment consist of: (a) toxicity testing using abiotic media from the site, (b) ecological survey data from the site, (c) tissue residue analysis of biota collected from the site, and (d) comparison of CPEC exposure experienced by endpoint species at the site to EBVs.

(ii) At Level III, however, only one type of evidence, (d) comparison of CPEC exposure experienced by endpoint species at the site to EBVs, need be considered.

(iii) If required, a Level IV field baseline assessment would use field investigations to further refine the risk estimate through acquisition of the

additional types of evidence (a, b, c).

(7) **Perform uncertainty analysis** Estimates of the potential for adverse affects from exposure to CPECs must often be made despite the presence of uncertainty (i.e., lack of knowledge or data gaps) and variability (stochastic or natural variability). The uncertainty analysis summarizes assumptions made for each element of the assessment and evaluates their validity, the strengths and weaknesses of the analyses, and quantifies to the greatest extent possible the uncertainties associated with each identified risk. This analysis addresses uncertainty associated with each component of the baseline assessment, including but not limited to: CPEC selection and quantification, receptor selection, exposure estimation, effects estimation, and risk characterization. It is important that data gaps that may have hindered or prevented the full determination of potential risk, and which may be addressed with a Level IV assessment, be identified at this time.

(8) **Submit Level III deliverable** This deliverable is a document (see Attachment 3, Baseline Risk Assessment Report, for suggested format and contents) which will describe, in detail, all of the items listed in OAR 340-122-084(3)(a-g), as well as how the exposure and effects analyses were performed, any assumptions employed in these analyses, the results of the risk characterization, and a thorough discussion of uncertainties inherent in the risk analyses. The results presented in this report provide the factual basis for evaluating the following TMDPs.

(9) **TMDP 6: Ecological Acceptable Risk Level Exceeded?** Based on information presented in the Level III deliverable, are any of the following acceptable risk levels exceeded for individuals and/or populations of endpoint species associated with assessment endpoints?

(a) Individual Receptors (OAR 340-122-115(5)) The following criteria apply only to threatened or endangered species pursuant to 16 USC 1531 *et seq*. or ORS 465.172:

(i) For deterministic risk assessments, a toxicity index (TI) less than or equal to one for an individual endpoint species at an upper-bound exposure, where the toxicity index is the sum of the toxicity quotients attributable to systemic toxicants with similar endpoints for similarly-responding species and the toxicity quotient is the ratio of the exposure point value to the ecological benchmark value (see also OAR 340-122-084(1)(i)); or

(ii) For probabilistic risk assessments, a TI less than or equal to one at the 90th percentile and less than or equal to 10 at the 95th percentile, each based on the same distribution of toxicity index numbers for an exposed individual

endpoint species; or

(iii) The probability of important changes in such factors as growth, survival, fecundity, or reproduction related to the health and viability of an individual endpoint species that are reasonably likely to occur as a consequence of exposure to hazardous substances is *de minimus*.

(b) Populations of endpoint species (OAR 340-122-115(6) The following criteria apply only populations of plants and animals other than those listed as thretaened and endangered:

(i) A 10 percent chance, or less, that 20 percent or more of the total local population will be exposed to an exposure point value greater than the ecological benchmark value for each contaminant of concern, **and**

(ii) No other observed significant adverse effects on the health or viability of the local population are identified. See Appendix A for details and an example.

(c) No further investigation If all criteria (a - b above) are not exceeded, then the site is highly unlikely to present significant risks to endpoint species and a recommendation for no further ecological investigations should be made.

(d) Further action If any criteria (a - b above) are exceeded, then the site could present significant risks to endpoint species and a recommendation to move to the next TMDP should be made. In this instance, the Level III analyses should identify (1) CPECs that clearly pose risks below the acceptable risk level (ARL) and thus require no further action, (2) CPECs that currently constitute risks above the ARL and thus should be subject to remediation, and (3) CPECs that may or may not pose a significant ecological risk but, because of elevated uncertainty, should also be subject to remediation and/or monitoring. CPECs in category (2) or (3) are termed contaminants of ecological concern (CEC) and are the focus of either further investigations or remedial actions.

(10) **TMDP 7: Remedial Action Decision Possible?** Based on the results of the Level III risk assessment and possibly other factors, risk managers (and not risk assessors) must decide if they are willing to make a response action decision with existing information and current levels of uncertainty. Key questions: Would cleanup be less costly than further investigation? Are data adequate to approve a removal action or to select or approve a remedy? If "**Y**", then further ecological investigation is deferred in favor of a response action. If "**N**", then the assessment process proceeds to Level IV, after which it returns to TMDP 6.

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Table 1
Example Assessment Endpoints and Associated Measures

Assessment Endpoint	Specific Ecological Receptor (Entity)	Measures	
		Exposure	Effect
Acute and chronic toxic effects in benthic community	Freshwater benthic community	• Ecological community indices (abundance, diversity, etc.) • Contaminant levels in sediments, surface water, and upwelling groundwater • Bioassays	• Estimated exceedence of ecological benchmark values (EBVs) • Estimated exceedence of population-level effect thresholds • Reference vs. onsite differences in community indices • Bioassay results
Acute and chronic toxic effects in non-migratory (resident) fish	Largemouth bass Fathead minnow Sculpin	• Food chain exposure modeling • Contaminant levels in surface water and sediments • Contaminant levels in food items (plankton, invertebrates) • Contaminant tissue residue levels	• Estimated exceedence of EBVs • Estimated exceedence of population-level effect thresholds • Contaminant tissue residue levels
Protect raptors from acute and chronic toxic effects due to consumption of contaminated food items and incidental ingestion of surficial soils.	Red-tailed hawk American kestrel	• Food chain exposure modeling • Contaminant levels in surficial soils • Contaminant levels in food items (small mammals, insects, birds)	• Estimated exceedence of EBVs • Estimated exceedence of population-level effect thresholds
Acute and chronic toxic effects in small mammals	Deer mouse Meadow vole	• Food chain exposure modeling • Contaminant levels in surficial soils • Contaminant levels in food items (vegetation, insects, earthworms) • Contaminant tissue residue levels	• Estimated exceedence of EBVs • Estimated exceedence of population-level effect thresholds • Measurement of bone density & strength • Contaminant tissue residue levels

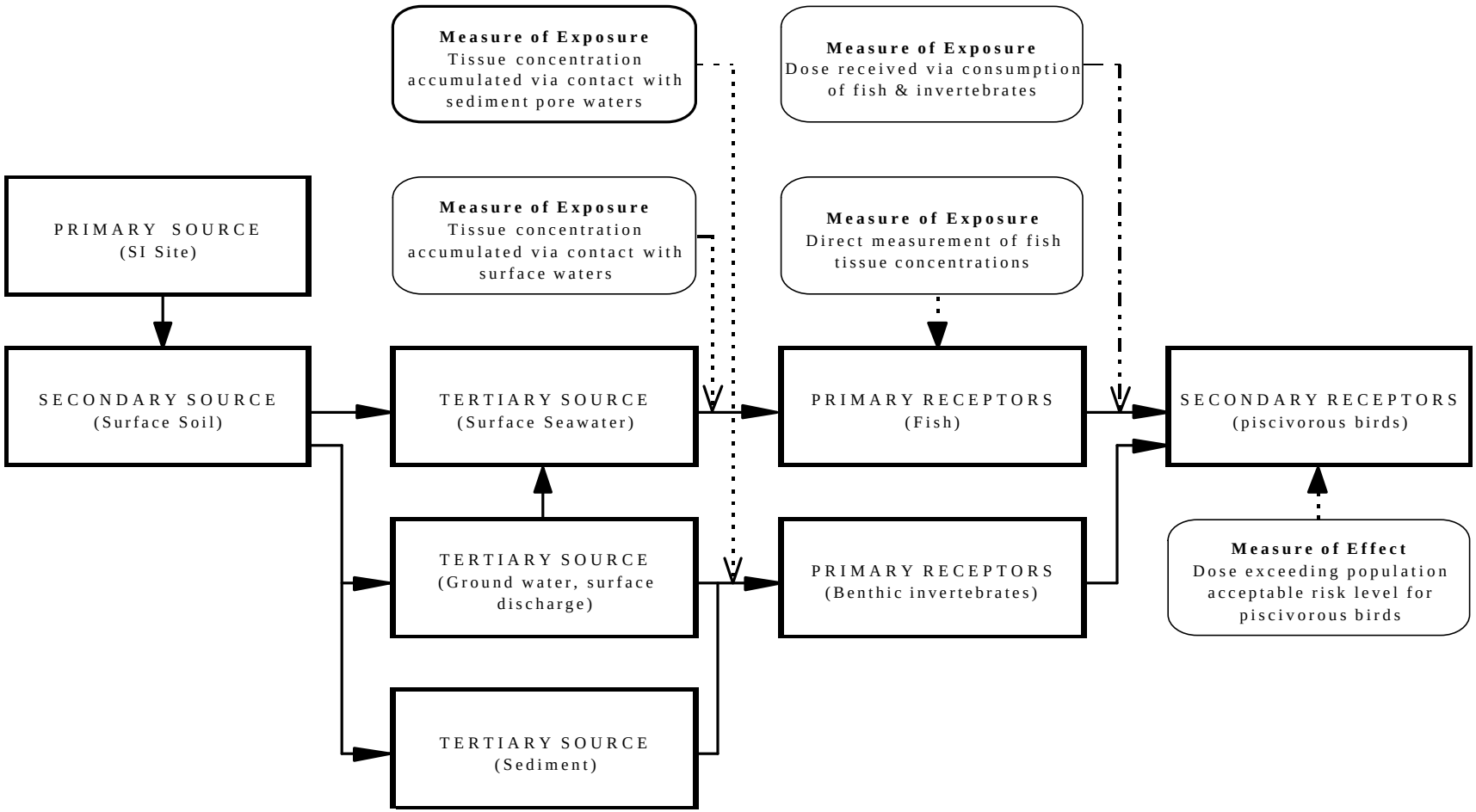
Table 2
Methodology to Derive Ecological Benchmark Values (EBVs)[a]

To Convert From	To NOAEL (EBV for Threatened & Endangered Species), Multiply by	To LD_{50} or LC_{50} (EBV for Populations), Multiply by
Chronic NOEL or NOAEL	1	100
Chronic LOAEL	0.2	20
Subchronic NOAEL	0.1	10
Subchronic LOAEL	0.05	5
Acute NOAEL	0.03	3
Acute LOAEL	0.02	2
LD_{50} or LC_{50}	0.01	1
Additional Modifiers		
Tested species in different family, same order as target species	0.5	0.5
Tested species in different order, same class as target species	0.5	0.5
Tested species a non-protected species related to target protected species	0.5	0.5

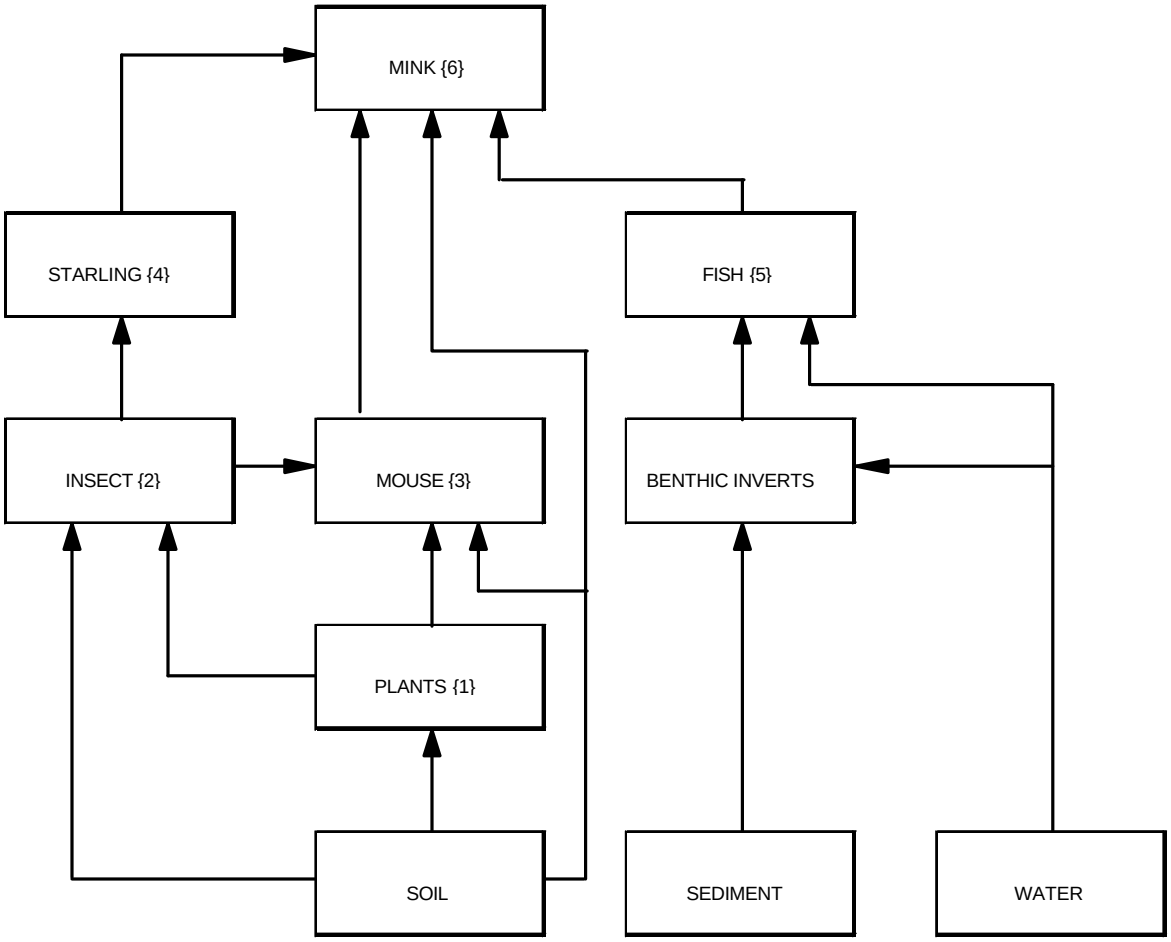
Notes:

(a) Process to convert a toxicological endpoint to a NOAEL suitable for evaluating risk to individual threatened & endangered species, or an LD_{50} or LC_{50} suitable for evaluating risk to populations of non-threatened species. Based on EPA 1997.

Attachment 1
Measures of Effect / Exposure Model (MEEM) - Piscivorous Birds



Attachment 2
Example of Food Web Model



{1}, {2}, ... {6} = receptor number

Attachment 3
Level III Deliverable - Baseline Risk Assessment Report Outline

(1) **INTRODUCTION**
- (a) Site History and Description
- (b) Summary of Level I/II Results
- (c) Assessment Objectives and Scope

(2) **PROBLEM FORMULATION**
- (a) Assessment Endpoints
- (b) Risk Hypotheses
- (c) Measures
  - (i) Exposure
  - (ii) Effect
  - (iii) Characteristics
- (d) Analysis Plan Summary

(3) **EXPOSURE ANALYSIS**
- (a) Habitats and Receptors Considered
- (b) CPEC Environmental Concentration
- (c) Exposure Estimation Model
- (d) Exposure Point Value (EPV) Estimates

(4) **ECOLOGICAL RESPONSE ANALYSIS**
- (a) Receptor Toxicity Profiles
- (b) Ecological Benchmark Value (EBV) Estimates

(5) **RISK CHARACTERIZATION**
- (a) Risk Estimation Methodology
- (b) Risk Description

(6) **UNCERTAINTY ANALYSIS**
- (a) CPEC Selection and Quantification
- (b) Receptor Selection
- (c) Exposure Estimation
- (d) Response Estimation
- (e) Risk Estimation

(7) **CONCLUSIONS**

(8) **ATTACHMENTS**
- (a) Regional map showing location of site
- (b) Local map showing site in relation to adjacent property
- (c) Site map
- (d) Map of ecological habitats as overlay to site map
- (e) Map of known or suspected extent of CPECs as overlay to site map

(9) **REFERENCES**

FIGURE 1. Ecological Risk Assessment Process Flowchart

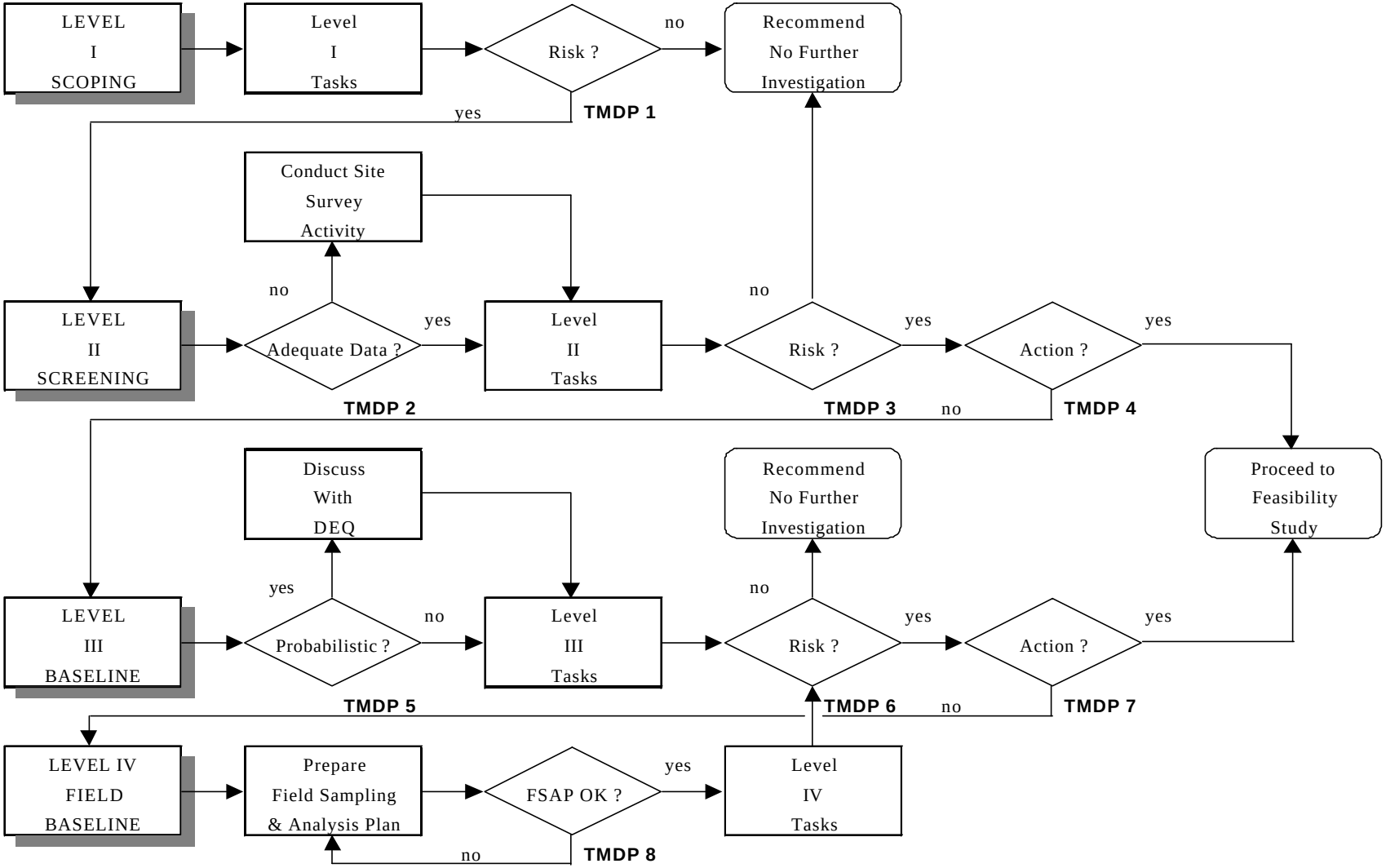
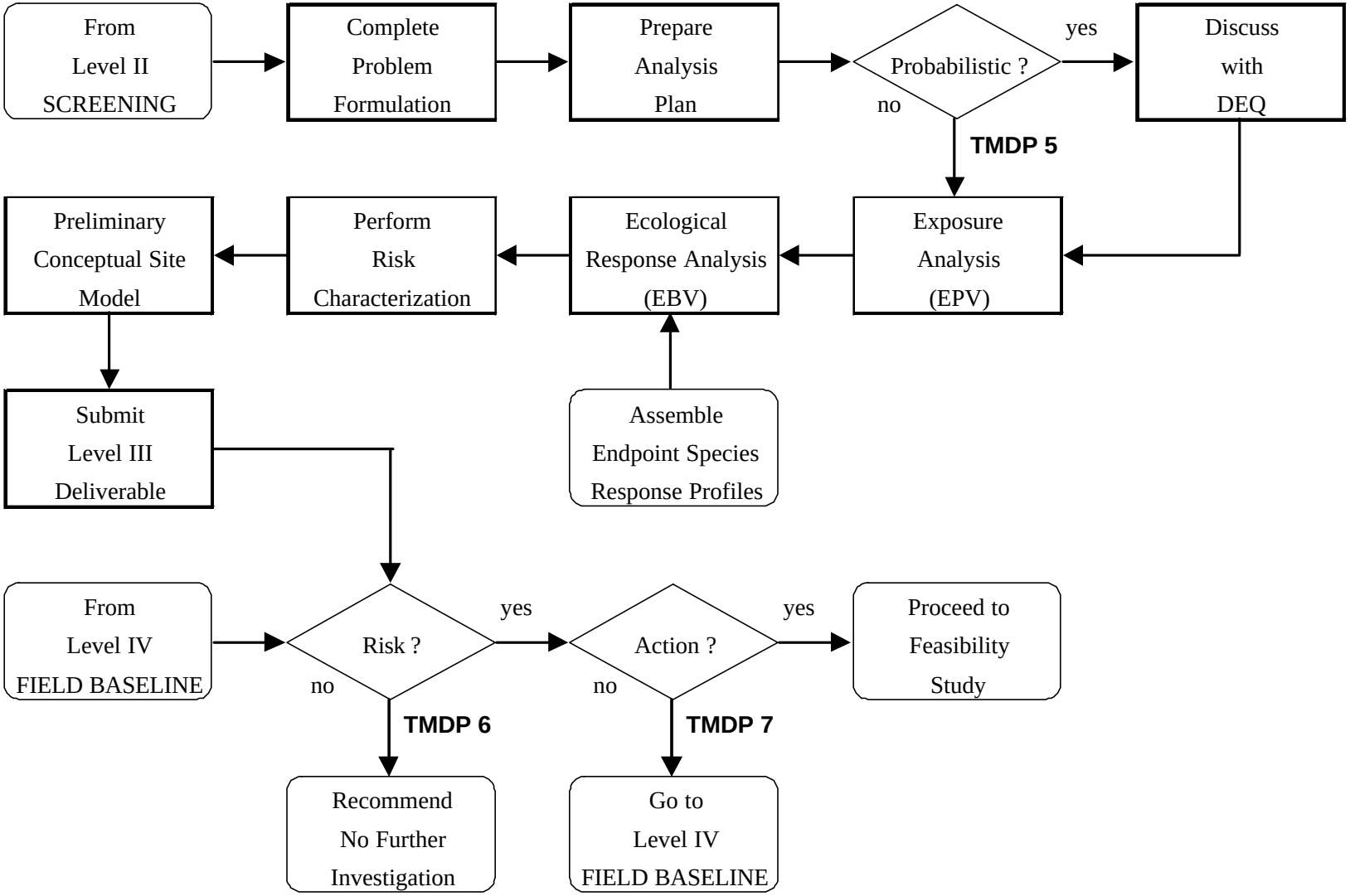


FIGURE 2. Level III (Baseline) Ecological Risk Assessment Process Flowchart



APPENDIX A

Procedure for Performing a Population-Level Ecological Risk Assessment

INTRODUCTION

In 1997, Oregon enacted amendments to its state superfund law which emphasize risk-based remedial action decisions. The amended statute and associated rules require that protection of ecological receptors be extended at the individual level for species listed as threatened and endangered species, but, in a departure from U.S. EPA practice, at the population-level for all other plants and animals. As defined by Oregon Administrative Rules, the acceptable risk level for populations of ecological receptors is a 10 percent chance, or less, that 20 percent or more of the total local population would receive an exposure greater than the toxicity reference value (EBV) for each hazardous substance. The spatial area within which site-related contaminants occur above detection limits is termed the "contaminated area" (CA). The nature and extent of contamination, and thus the size of the CA, is determined during the remedial investigation. Depending on the transport and fate characteristics of contaminants and the spatial distribution of receptors, the spatial boundaries of the CA may extend beyond the property boundaries of a site. In general, the local population is a group of individual plants, animals, or other organisms of the same species that live together and interbreed within habitat areas within or near the CA, including any portion of a population of a transient or migratory species that periodically occupy such habitats. The EBV for populations of ecological receptors is a median lethal dose or concentration (LD_{50} or LC_{50}) based on studies with routes and durations of exposure that simulate exposure conditions of ecological receptors in the field. This definition of acceptable risk level assumes that significant reductions in long-term population viability are unlikely if there is a low probability (<0.1) that a small fraction (<20%) of the population can be exposed to a dose or concentration equivalent to the EBV. In addition, however, there must be no other observed significant adverse effects on the health or viability of the local population.

This guidance describes a practical procedure for performing a population-level ecological risk assessment using a combination of relatively simple techniques within the regulatory context defined by Oregon statute and rules. Key elements of this procedure can be summarized as follows: (A) Problem Formulation, to include: identification of ecological receptors, identification of assessment endpoints and associated endpoint species, definition of local population boundaries, and determination of habitat size and quality, (B) Exposure Analysis or estimating receptor exposures (as dose or concentration), (C) Ecological Response Analysis or selecting contaminant-specific toxicity reference values, and (D) Risk Characterization, to include: estimating the abundance of local populations, estimating the probability of exposure exceeding toxicity reference values, estimating the number of individuals whose exposure exceeds these reference values, and evaluating acceptable risk levels.

PROBLEM FORMULATION

Identify Ecological Receptors

Site-specific ecological receptors, and their associated habitats, are generally identified during ecological field investigations performed at the site. To the extent practicable, these receptors should be organisms that spend a significant portion of their life or derive a significant portion of their diet or physiological needs from that habitat type. Note that defining habitat size and preferences for many species is usually not this straightforward and may be a source of significant uncertainty in the analysis.

Identify Assessment Endpoints and Endpoint Species

Assessment endpoints are an explicit expression of a specific ecological receptor and an associated function or quality that is to be maintained or protected (USEPA 1996). Because Oregon statute and rules require the protection of viable populations, assessment endpoints will typically involve demographic characteristics of populations such as population size, reproductive rates, or mortality rates. It is impractical to evaluate all potentially exposed populations, so a subset of potentially exposed ecological populations or surrogates for these ecological receptors must be selected for evaluation. This subset of species are called "endpoint species" and the factors that may be considered when choosing endpoints species include: aesthetic, social, economic, and ecological value (e.g., keystone species). Also, the availability of high quality information on population dynamics, food habits, ingestion rates, and other species characteristics that affect exposure and responses to contaminants may be considered when selecting endpoint species.

Define Local Population Boundaries

Establishing a species-specific local population boundary sets a limit on the number of individual members of an endpoint species population that will be considered in the risk assessment. Defining the size and boundaries of a local population can be difficult, especially for highly mobile and wide-ranging species. Natural resource managers often use political boundaries such as the size of a park or land management unit to delimit populations. A reasonable first approach for defining the boundaries of study populations is to review landscape conditions surrounding contaminated areas for topographic or anthropogenic features that are likely to represent important dispersal barriers for assessment endpoint species. If there are no clear and relevant geographic boundaries, alternative methods for defining populations must be used. While relating in some way to a biological feature of the species, this boundary should not be so large as to include individuals that will have little probability of contacting a site-related contaminant or be so small as to exclude individuals who might reasonably contact such a contaminant; its size will also necessarily have to vary in response to endpoint species characteristics.

Recognizing that the following approaches have important ecological limitations but practical advantages, populations for sessile, mobile, and migratory species may be estimated as follows:

(A) For sessile terrestrial species (e.g., plants), the local population comprises all individuals of the endpoint species within habitat patches within the CA. If there are no clearly defined habitat patches, the population comprises all individuals of the endpoint species within areas of contaminated soil within the CA. These are potentially conservative population boundary estimates because plants and other relatively sessile organisms have a variety of mechanisms to spread gametes, zygotes, or propagules over large distances. As a result, the interbreeding population can often be incorporate a number of habitat patches.

(B) For aquatic species in lakes or ponds (lentic habitats), the population comprises all individuals of the endpoint species within the water body receiving site-related contaminants. Again, many aquatic species have mechanisms that permit dispersal from the natal pond or lake. For example, the adult stage of most aquatic insects are volant and may fly to neighboring water bodies to breed. As a result, depending on the endpoint species and the water body, this definition of a population may be conservative.

(C) For aquatic species in moving water such as streams and rivers (lotic habitats), the local population comprises all individuals of the endpoint species within the stream segment within the CA.

(D) For terrestrial vertebrates, especially birds and mammals, the population may be defined using information about individual space use patterns. Terrestrial vertebrates travel varying distances on a daily and seasonal basis to find food, water, shelter, and mates. The area encompassed by these travels is termed an individual's home range (HR). For a variety of reasons, individuals of many bird and mammal species are philopatric. They tend to mate and rear young relatively close to the site where they were born or hatched. Studies of dispersal behavior in mammals suggest there is a low probability of an animal moving more than five HR diameters from its natal range (Waser 1987). In general, most individual mammals are likely to contact and mate with opposite-sexed individuals within five HR diameters of their natal site. For the purposes of defining the boundaries of study populations, it will be assumed that birds and other vertebrates behave in a manner similar to mammals. Then the local population comprises all individuals of the endpoint species within an area extending five HR diameters (D_{HR}) from the outer boundary of the CA. Given the typical HR of an individual endpoint species, the five home range diameters (i.e., D_{HR}) and the areal extent (A) of the study population can be approximated as follows:

$$D_{HR} = 10 \times \sqrt{\frac{HR}{p}} \qquad (1)$$

$$A = \frac{100 \times HR}{p} \qquad (2)$$

Potential sources of HR and population density information include published natural history studies, field guides, and the *Wildlife Exposure Factors Handbook* (USEPA, 1993). If species-specific information on HR is not available, scaling relationships may be used to estimate HR size based on species body mass (M). Several studies of both birds and mammals report that HR size scales as a power function of body mass and that the slope of the scaling exponent tends to be approximately 1.0 (Calder 1984; Harestad and Bunnell 1979; Peters 1983; Schoener 1968). Calder (1984) summarizes a variety of studies and lists the following relationships between mass (in kilograms) and HR size (in hectares) in mammals and birds: primary consumers (e.g., herbivores), HR = 4.7 $M^{1.02}$; secondary consumers (e.g., insectivores), HR = 66.8 $M^{1.22}$; omnivores, HR = 34 $M^{0.92}$; carnivores, HR = 13.2 $M^{1.36}$; passerines and nonpasserines, HR = 98.6 $M^{1.15}$.

(E) For transient and migratory species, the local population spatial boundary is assumed to be equal to the CA. Actual residency time for these non-resident species within this boundary is accounted for by means of the endpoint species temporal utilization factor (TUF).

Determine Habitat Size and Quality

Observation and mapping of habitats performed during ecological field investigations are used to estimate: (1) number (q), (2) approximate spatial extent (Ha_k), and (3) relative quality (Hq_k, based on relative expected residency) of each habitat (or habitat patch) within the local population boundary. It is assumed that habitat patches with greater relative quality will increase the probability of exposure by attracting and holding an endpoint species more strongly and for a longer duration (i.e., raising its expected residency time) than those with minimal habitat quality. In other words, habitat quality can serve as another temporal utilization factor that affects exposure on a smaller spatial scale than the TUF described previously. If a snap shot census of the population was performed, more individuals would be detected in high quality habitats at any given time than in low quality habitats. This result is consistent with the findings of many population-level studies that report higher densities of wildlife in high quality habitats, although the mechanisms responsible for this pattern in nature may be different than the one proposed here (i.e., individual foraging decisions). Quality of habitat, with respect to the needs of a given endpoint species relative to all other existing species-specific habitat within the local population boundary, should be rated as unsuitable (0), poor (0.25), average (0.5), good (0.75), or excellent (1.0). Justification for the quality determination should be made the basis of professional judgment, requirements of each endpoint species, and results of site visits/surveys.

EXPOSURE ANALYSIS

Exposure point value is, for terrestrial species, the contaminant dose (D) received by the receptor (applied dose) or, for aquatic species, the contaminant concentration (EC) in the media in which the receptor is immersed (surface water or sediment). The following tasks seek to estimate either D or EC, taking into consideration a number of factors including, but not limited to, the spatial distribution of contaminant concentrations relative to the spatial distribution of receptors.

Estimate Exposure

Typically, some type of exposure model, perhaps supplemented with tissue residue analyses, is used to estimate exposure. To the extent practicable, such a model must explicitly consider spatial relationships between endpoint species, their habitat, and the distribution of contaminants, as well as habitat quality and temporal utilization of habitat. Simple non-spatial exposure models generally assume an even distribution of contaminants over the site and random access by receptors to all portions of the site. However, because many sites are industrial or highly modified in nature, it is unlikely that all areas within their bounds will provide habitat suitable for endpoint species. For example, contaminant concentrations might be greatest near the center of a site, but the habitat quality might be highest near the edges. Thus, if contaminant levels are related to habitat quality, the assumptions of a simple model would not hold. A more reasonable model would account for the proportional contribution of each area with a distinct combination of contaminant level and habitat quality, as follows (modified from Sample and others 1997):

$$D_j = \sum_{k=1}^{q}\sum_{i=1}^{d}\left[\left(\frac{IR_i \times C_{ijk}}{BW}\right)\times\left(\frac{Ha_k Hq_k}{\sum_{k=1}^{q}(Ha_k Hq_k)}\right)\right]\times TUF \qquad (3)$$

where: D_j = Dose for a given endpoint species for j^{th} contaminant (mg/[kg·d]); q = Total number of kth habitat patches within local population boundary (unitless); d = Total number of ith media (e.g., food, water, soil); IR_i = Intake rate for i^{th} medium (kg/d or L/d); C_{ijk} = Concentration of jth contaminant in i^{th} medium in k^{th} habitat patch (mg/kg or mg/L); BW = Body weight of endpoint species (kg); Hq_k = Relative habitat quality (based on expected residency) of kth habitat patch for a given endpoint species (unitless); Ha_k = Area of kth habitat patch (m^2); TUF = Endpoint species temporal utilization factor (unitless).

Equation (3) assumes that individuals within the local population boundary use habitat in proportion to habitat area and quality. Here exposure is the applied dose (mg/[kg·d]) experienced by an individual of the endpoint species. For terrestrial species, Equation (3) can be modified to explicitly include an exposure route-specific estimate of contaminant absorption (gastrointestinal absorption, dermal absorption, etc.), so that exposure would then be expressed in terms of absorbed dose. If multiple food items are considered, Equation (3) may include a term

representing each item's contribution to IR_i, e.g., incidentally ingested soil may be only a small fraction (< 2%) of total food intake. For terrestrial species, Equation (3) considers doses received via ingestion exposure routes, e.g., consumption of contaminated prey, forage, or water and incidental ingestion of soil or sediment. It can be modified to quantify other exposure routes such as inhalation or dermal contact.

Field sampling and chemical analysis provide raw data concerning the presence and concentrations of CPECs in abiotic (soil, surface water, sediment) and biotic (plant and animal tissues) media at or in the locality of the facility. Chemical analysis of biotic samples can be used to measure C_{ijk} in the tissues of consumed prey and forage items, as well as to estimate site-specific intermedia transfer factors. In the absence of measured C_{ijk} values, they can be estimated using an abiotic media C_{ijk} value in conjunction with an appropriate intermedia transfer factor obtained from the literature. The risk assessor should ensure that sampling covers areas and media of ecological interest and that analytical detection levels are set low enough to be of ecological significance.

Because ecological receptors do not experience their environment on a "point" basis, it is necessary to convert measured data from single sample points into an estimate of concentration over some relevant spatial area, such as their habitat. For abiotic media (soil, water, sediment), the simplest approach is to assume that contaminants are evenly distributed within a habitat patch and that ecological receptors forage randomly with respect to contamination within that habitat patch. With these assumptions, and to allow for uncertainty, the abiotic media concentration (C_{ijk}) is represented by a distribution. Alternative methods, such as Bootstrap analysis, Voronoi diagrams or other methods involving explicit consideration of the potentially heterogeneous spatial distribution of contamination relative to receptor foraging patterns, may also be employed to provide an even more representative estimate of C_{ijk} for abiotic media (Burmaster and Thompson 1997; Freshman and Menzie 1996).

Some endpoint species have migration, hibernation, or other behavior patterns that result in less exposure throughout the year at a site. A temporal factor (TUF) quantifies the frequency of exposure to contaminated media as a function of such behavior patterns. For relatively long-lived species, this factor can be defined as the fraction of the number of days per year an endpoint species is active within a habitat, so that $1 \geq TUF > 0$. Non-hibernating, non-migratory species will have a unitless default temporal utilization factor of 1. For those species that use the habitat island only as a stop-over point duration their annual migration it will be necessary to estimate a TUF value < 1. This type of TUF is most appropriate when evaluating risks associated with chronic exposure to relatively low doses of contaminants.

For aquatic species, the IR_i and BW terms are dropped and exposure concentration (EPV = mg/L), rather than dose, is estimated, as follows (modified from Sample and others 1997):

$$EC_j = \sum_{k=1}^{q} \sum_{i=1}^{d} \left[C_{ijk} \times \left(\frac{Ha_k Hq_k}{\sum_{k=1}^{q} Ha_k Hq_k} \right) \right] \times TUF \qquad (4)$$

where: EC_j = Exposure concentration for a given endpoint species for j^{th} contaminant (mg/L); q = Total number of kth habitat patches within local population boundary (unitless); d = Total number of ith media (e.g., food, water, soil, sediment); IR_i = Intake rate for i^{th} medium (kg/d or L/d); C_{ijk} = Concentration of jth contaminant in i^{th} medium in k^{th} habitat patch (mg/kg or mg/L); Hq_k = Relative habitat quality (based on expected residency) of kth habitat patch for a given endpoint species (unitless); Ha_k = Area of kth habitat patch (m^2); TUF = Endpoint species temporal utilization factor (unitless).

It is also possible to use a geographic information system (GIS) to overlay the spatial distribution of various habitat types with contaminant distributions to more accurately determine the degree to which habitat is contaminated. If information is available regarding the distribution or movements of plants and/or animals, these data may be combined with the habitat and contamination data to provide a more accurate visualization of exposure and potential risks (Clifford and others 1995).

ECOLOGICAL RESPONSE ANALYSIS

Determine Toxicity Reference Value

By rule, the primary ecological benchmark value (EBV) for populations of ecological receptors is the median lethal dose or concentration (LD_{50} or LC_{50}). The EBV must be based, to the extent practicable, on studies whose routes of exposure and duration of exposure were commensurate with the expected routes and duration of exposure for ecological receptors considered in the risk assessment, or appropriate surrogates for those receptors; it may be expressed as either a point value or as a distribution. If a LD_{50} or LC_{50}, as applicable, is not available for ecological receptors considered in the risk assessment, the EBV may be derived from other toxicological endpoints for those receptors or appropriate surrogates for those receptors, adjusted with uncertainty factors to equate to a LD_{50} or LC_{50}. For example, most fish and wildlife toxicity studies reporting an LD_{50} or LC_{50} are conducted using acute or subchronic exposure durations, and as a result, extrapolation factors will be needed to estimate the median lethal dose or concentrations associated with chronic exposures.

RISK CHARACTERIZATION

By rule, the acceptable risk level (ARL) for populations of ecological receptors is a 10

percent chance, or less, that 20 percent or more of the total local population would have an exposure greater than the EBV for each contaminant of concern. Once an exposure distribution and a contaminant-specific EBV, either as a point value or a distribution, have been established for each endpoint species, computation of the ARL numerical criterion involves: (A) estimating the local population abundance of the endpoint species, (B) estimating the probability that an individual of an endpoint species will experience an exposure in excess of the EBV or p(exposure > EBV), (C) using a cumulative binomial distribution function to estimate the number of individuals likely to experience p(exposure > EBV) ≥ 10%, and (D) determining whether this number is > 20% of the total local population.

Estimate Local Population Abundance

Because definition of acceptable risk for a population is based on effects to a certain percentage of individuals, it is necessary to estimate the number of *n* individuals of each endpoint species within the local population boundary. For terrestrial (e.g., plants) and aquatic (e.g., benthic invertebrates) sessile and terrestrial and avian non-sessile species, the size (i.e., abundance) of the local population includes all individuals within the local population boundary, as previously defined. For seasonal migrants, local population abundance is defined as the number of individuals utilizing habitat within the CA over the course of a year. Methods for estimating population abundance include, but are not limited to: (A) observations, surveys, or sampling (e.g., transects, trapping, etc.) onsite and in the locality of the site; (B) game, fish, or other wildlife management records; (C) if appropriate, population density estimates compiled by the USEPA (1993), or (D) if there are no appropriate species-specific population density estimates available, scaling relationships may be used to estimate population abundance based on an animals body mass.

Numerous studies have reported that the local abundance of birds and mammals tends to decrease as average species body mass increases (Damuth 1991, 1993; Peters and Raelson 1984; Brown 1995). When plotted logarithmically, the slope of the relationship between abundance and body size is consistently about -0.75. There is considerable variability, especially for smaller birds and mammals, and factors such as phylogeny and diet may have significant effects on this relationship. The following equation, which is based on a regression of population density (#/km^2) on body mass (g) for 564 mammal populations (Damuth 1993), can be used to estimate abundance for non-volant mammals: log (density) = 3.98 - 0.77 × [log (body mass)]. Similarly, the following equation can be used to estimate abundance of bird populations (Juanes 1986): log (density) = 1.96 - 0.49·× [log (body mass)].

Probability of Exposure Exceeding the EBV

In general, risk is the probability associated with the occurrence of an unfavorable

consequence. For our purposes the "unfavorable consequence" is a decrease in the size or viability of a local population. An ecological response occurs when toxicological responses in individuals of an endpoint species, as a consequence of long-term (chronic) exposure to a hazardous substance, result in the actual or projected loss of a minimum viable local population of that species (Newton 1988). Here, aspects of individual health, viability, and performance are important only insofar as they might influence the sustainability of the local population.

Acceptable risk occurs when, for 20 percent of the individuals in a defined local population of size *n*, there is a ≤ 10 percent probability (*p*) that they will experience an exposure ≥ EBV; this probability (*p*) is assumed to apply equally to all individuals in the population (*n*) (it may be necessary to segment the population into relatively homogeneous subpopulations [adult vs. juvenile, breeding vs. non-breeding] in order to better meet this assumption). The probability (*p*) of any individual receptor experiencing an RAO ≥ TRV while moving at random over a site of finite dimension is determined by assuming that an exposed individual moves randomly across an exposure area, thus allowing the area-averaged media concentration to be used to estimate the true average concentration contacted over time. Estimation of p(exposure > EBV) may be accomplished through the use of a normal density function (Suter and others 1986). If EBV is a point value and exposure is defined by the mean and standard deviation of its natural logarithms, then the probability of exposure > EBV may be determined as follows:

$$p = f_Z\left(\frac{x_{EXP} - \ln(EBV)}{s_{EXP}}\right) \tag{5}$$

where: p = Probability of exposure > EBV (unitless); ϕ_Z = Cumulative distribution function of a standard normal random variable (NORMSDIST function in MS-Excel®); x_{EXP} = Mean of natural logarithms of exposure (mg/[kg·d] or mg/L); s_{EXP} = Standard deviation of natural logarithms of exposure (unitless); EBV = Point value of EBV (mg/[kg·d] or mg/L).

If both exposure and EBV are defined by the mean and variance of their natural logarithms, then the probability of exposure > EBV may be determined as follows (Suter and others 1986):

$$p = f_Z\left(\frac{x_{EXP} - x_{EBV}}{\sqrt{s_{EXP}^2 + s_{EBV}^2}}\right) \tag{6}$$

where: p = Probability of exposure > EBV (unitless); ϕ_Z = Cumulative distribution function of a standard normal random variable (MS-Excel® NORMSDIST function); x_{EXP} = Mean of natural logarithms of exposure (mg/[kg·d] or mg/L); x_{EBV} = Mean of natural logarithms of EBV (mg/[kg·d] or mg/L); s^2_{EXP} = Variance of natural logarithms of exposure (unitless); s^2_{EBV} = Variance of natural

logarithms of EBV (unitless).

Estimate Acceptability of Risk

Taking p from Equations (5) or (6), the probability (b) of 20 percent of the individuals (y) in a population (n) experiencing an RAO ≥ TRV is then determined using a binomial probability function (E. Crouch, *personal communication*; Sample and others 1997):

$$b(y,n,p) = \binom{n}{y} p^y (1-p)^{n-y} \tag{7}$$

where: y is 20 percent of the population ($y = 0.2n$); n is the size of the local population; p is the probability of exposure ≥ EBV as determined using Equations (5) or (6). For a given n, a value of p is selected for Equation (7) so that $b = 0.9$ (i.e., there is only a 10 percent chance that $0.2n$ individuals will experience an exposure ≥ EBV. The rationale is that each of the n individuals in the population is considered an independent exposure trial, that the probability of an individual's "success" (i.e., experiencing exposure ≥ EBV) during movement through the contaminated area (or volume in the case of aquatic exposures) is set by p, and that the number of "successes" (individuals encountering excessive exposure) must be ≤ 20 percent of n. In all cases, site-specific field and/or laboratory investigations may be necessary to verify or refute a finding of unacceptable risk.

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INTRODUCTION

The DEQ ecological risk assessment process consists of four distinct levels, as follows (and as shown in Figure 1):

- Level I Scoping
- Level II Screening
- Level III Baseline
- Level IV Field Baseline

Within and between these levels are a number of Technical/Management Decision Points (TMDP). Based on the information developed and presented within a given level, these TMDPs determine one of three recommendations:

- No further ecological investigations at the site, or
- Continuation of the risk assessment process at the next level, or
- Undertake (beyond Level I only) a removal or remedial action.

The outcome of each level of the assessment should be documented in writing. Thorough documentation will provide a future reference for any other site-related activities involving a hazardous substance release, future site remedial actions, or onsite monitoring.

Prior to undertaking any ecological risk assessment pursuant to OAR 340-122-084, risk assessors should have read and be familiar with the terms, concepts, and approaches discussed in the following documents:

- USEPA Proposed Guidelines for Ecological Risk Assessment (61 FR 47552, 9/9/96)
- USEPA Region X Supplemental Ecological Risk Assessment Guidance for Superfund (EPA 910-R-97-005, June 1997)
- ORS 465.315
- OAR 340-122-010 through -115
- State of Oregon Level I, II, III, and IV Ecological Risk Assessment Guidance

OBJECTIVE

A Level IV assessment attempts to reduce uncertainties in the Level III "desk top" risk estimates through analysis of site-specific empirical data obtained from site- and locality-specific ecological field surveys, tissue analysis, and/or toxicity tests (performed either in the laboratory or *in situ*). A Level IV field baseline assessment, unlike a Level III assessment, is intended to: (a) refine measures to focus on specific issues identified during the Level III assessment, (b) use actual, empirical data on exposure and potential effects to replace estimated and literature-derived

data; and (c) develop additional, specific lines of evidence to support a more robust weight-of-evidence-based conclusion regarding the potential risks identified during the Level III assessment.

PREREQUISITES

Moving to Level IV requires successful completion of a Level III baseline assessment with a decision on the part of risk managers to gather additional site-specific information for the purpose of reducing uncertainties in the Level III risk estimates.

TASKS (see Figure 2)

(1) **Refine problem formulation** Following the risk assessment process described in Level III guidance, there should now a limited number of contaminants of ecological concern (CECs) under consideration. Once again, the relationship between specific CEC, their toxicological characteristics, their likely pathway to specific ecological receptors, and the effect(s) they may induce in these receptors should be reexamined. This reexamination should substantially lessen the chance of engaging in field and/or laboratory investigations that do not provide information useful to risk managers.

(a) Select CECs Level III will have identified some contaminants as contaminants of ecological concern (CECs), on the basis of risk characterization or data gaps regarding their transport and fate behavior, toxicity, or potential for cumulative effects. Level IV may wish to consider all of these CECs or just a representative subset considered (on the basis of the Level III analysis) to be key risk drivers. New CEC may be added if additional chemical analysis data become available between the conclusion of Level III and the start of the Level IV planning activity.

(b) Review/Revise Established Measures For Level IV, measures are expected to be numerical expressions of observations (e.g., toxicity test results, community diversity measures, tissue analyses, etc.) that may be compared to reference locations or other controls to detect adverse responses in endpoint species resulting from exposure to a site-related CECs. When defining measures for field and laboratory investigations, select those with as strong an association as possible between site-related CECs and responses in the selected measures and those that represent the same exposure pathway and toxic mechanism of action as the assessment endpoint with which they are associated. Development of empirical exposure-response relationships is important for evaluating remedial options, so selection of measures that incorporate a CEC concentration gradient should be a goal wherever possible.

(2) **Select assessment tools** There are a limited number of demonstrated assessment tools currently available for conducting site-specific field investigations on ecological exposure and effects, as listed below. Which tool(s) to select for the assessment is highly dependent

on site-specific factors and will depend entirely on the risk hypotheses and measures chosen for the assessment.

(a) Tissue Analysis/Bioaccumulation Studies The tools listed below are particularly useful for measuring and quantifying exposure:

- (i) Chemical analysis of tissues (specific organs, muscle, whole body).
- (ii) Laboratory bioaccumulation studies (uptake measured in laboratory setting using contaminated media from site).
- (iii) Field bioaccumulation studies (receptor, animal or surrogate, placed onsite in proximity to contaminated media).
- (iv) Food web bioaccumulation models.
- (v) Gross morphology and/or histopathology.
- (vi) Biomarkers.
- (vii) Results obtained with one or more of the above methods may be used to support the following analyses:
  - Evaluating the degree to which CPECs are transferred through a food chain.
  - Measuring CPEC concentrations in foods consumed by endpoint species associated with an assessment endpoint.
  - Providing site-specific estimates of exposure to higher-trophic-level organisms. Techniques for exposure characterization could include, but are not limited to, any or all of the following:
  - Relating tissue residue levels to concentrations in environmental media;
  - Providing site-specific and CPEC-specific estimates of bioconcentration and/or bioaccumulation factors.

(b) Population/Community Evaluations The following methods are particularly useful for measuring and quantifying ecological responses to contaminants:

- (i) Community metrics (measurements of species composition, abundance, community structure, trophic dynamics, seasonal patterns, age classes, etc.) - study site vs. reference area or changes along a CPEC concentration gradient.
- (ii) Population metrics (measurements of density patterns, rates of recruitment, growth, and survival, etc.) - study site vs. reference area or changes along a CPEC concentration gradient.
- (iii) Physiological and behavioral measurements - respiration, photosynthesis reproduction, burrowing, predation, courtship, etc.
- (iv) Field experiments.

(c) Toxicity Tests (Bioassays) These are particularly useful for measuring and quantifying both exposure and ecological responses to contaminants. They are

appropriate measures for both lethal and/or sublethal responses and may be used to:

(i) Demonstrate whether contaminants are bioavailable.

(ii) Evaluate the aggregate toxic effects of all contaminants in a medium.

(iii) Evaluate the toxicity of substances whose biological effects may not have been well characterized.

(iv) Compare toxicity data generated at the site with that obtained in the laboratory.

(v) Characterize the nature of a toxic effect.

(vi) Characterize the distribution of toxicity at a site.

(vii) Develop remedial goals.

(viii) Support a monitoring program.

(ix) Determine a site's post-remediation potential to support a viable ecological community.

(x) There are numerous U.S. EPA methods manuals and American Society for Testing and Materials (ASTM) guides and procedures for conducting toxicity tests.

(3) **Prepare field sampling and analysis plan** The ecological sampling plan (FSAP) describes details of the site-specific field and/or laboratory investigation(s). It addresses only the field and/or laboratory collection of ecological data, but must be consistent with, and achievable within, the scope of the analysis plan prepared for Level III, as well as the overall remedial investigation work plan. Because field and/or laboratory investigations can be expensive and time-consuming, it is important to carefully consider the types of studies that will provide the most expeditious and defensible (i.e., supported by the scientific literature and peer-review) tests of the stated risk hypotheses. The plan may include, but is not limited to:

(a) A description of the study design, including its uncertainties and key assumptions. The design is guided by the conceptual site model, with appropriate modifications in response to any new data.

(b) A statement of data needs in terms of those needed to test the risk hypotheses (Is there or is there not a risk?) and, if risk is demonstrated, to inform the selection and implementation of a remedy. Basically, the discussion should focus on how each piece of data planned for collection will be used to answer the question of whether or not risk exists.

(c) A detailed description of the assessment tools (see Task (2) above) that will yield data of the type and quality required. If statistical analyses are desired, the study methodology and protocols should ensure that quantitative data will be collected.

(d) A statement of data quality objectives (DQOs) for all key components of the field and/or laboratory investigations, considering that DQOs should be used in conjunction with, and not as a substitute for, a scientifically defensible experimental design.

(4) **TMDP 8: Field Sampling Plan Approved?** Prior to initiating field and/or laboratory investigations, approval of the draft FSP must be obtained from the DEQ project manager. If some time has elapsed since site visits/surveys were conducted, an additional site visit may be required to verify that the study design specified in the FSAP is still implementable, i.e., whether sampling and testing specified by the FSAP can actually be collected at the site. It may be necessary to modify the FSAP in response to changes in site conditions before approval to proceed with field or laboratory investigations.

(5) **Conduct field/laboratory work** The site investigation involves implementation of the agreed upon FSAP and includes all of the field sampling and surveys that are conducted as part of the ecological risk assessment.

(6) **Measure/calculate exposure point values** Quantitative measurements of exposure are needed to evaluate the relative contributions from various contaminant sources or pathways when considering clean-up levels or remediation strategies. Endpoint species exposure profiles are determined preferably from tissue residue analyses and/or toxicity test results, although sophisticated food web models are a possibility.

(7) **Measure/calculate ecological benchmark values** This task describes and quantifies the responses of endpoint species when exposed to differing concentrations of site-related CPEC. A quantitative exposure-response profile for each endpoint species should be prepared based on the results of: (a) literature analysis, (b) toxicity testing, and/or (c) population/community evaluation methods. Note that this task will be simplified if effects data were collected along a CEC gradient.

(8) **Perform risk characterization** Risk characterization is designed to evaluate the likelihood of an adverse effect in an endpoint species (associated with an assessment endpoint) from exposure to a site-related CEC. This task typically contains two activities: estimation and description.

(a) <u>Risk estimation</u> This involves integrating exposure and exposure-response profiles to estimate a probability for adverse effects occurring in specific receptors as a result of exposure to a certain CEC.

(b) <u>Risk description</u> This combines any quantified risk estimate (obtained using either deterministic or probabilistic methods) with a "weight-of-evidence" approach to

present a broader picture of the degree of risk associated with each assessment endpoint.

(c) Lines of evidence that may be available in Level IV to construct a weight-of-evidence risk characterization include, but are not limited to:

(i) Detection of contaminant concentrations in soil, sediment, surface and ground water.

(ii) Presence of environmental transport mechanisms.

(iii) Geochemical factors that influence CEC bioavailability.

(iv) Observations of adverse effects in potentially exposed habitats compared to reference sites, including mortality and morbidity, vegetation stress, habitat degradation, presence or absence of key species.

(v) Presence of endangered species or sensitive habitat.

(vi) CEC concentrations in water, soil, sediment, and tissue exceed doses observed to cause chronic or acute toxicity in other areas, species, or media.

(vii) Detection of acute or chronic toxicity in waters, soil, or sediment.

(viii) Tissue and/or bioaccumulation analyses provide strong evidence of CEC availability in animals and plants.

(ix) Biomarkers which suggest that a receptor has been exposed to CEC.

(x) Observed changes in rates of physiological and behavioral processes (e.g., respiration, photosynthesis; burrowing, or predation) provide additional insight into exposure and effect.

(xi) Observations from ecological field studies of communities or population.

(9) **Perform uncertainty analysis** Uncertainty analysis involves summarizing assumptions made by the Level IV assessment, evaluating their validity and sensitivity, evaluating the strengths and weaknesses of the analyses (laboratory and field), and quantifying, to the extent possible, the uncertainties associated with each identified risk. This analysis addresses uncertainty associated with each component of the Level IV assessment. Given prior consultation with the Department (see Level III, TMDP 5), Monte Carlo or other probabilistic methods may be applied to exposure, toxicity extrapolation, or ecological models to quantify uncertainty.

(10) **Prepare Level IV deliverable** This deliverable is a document (see Attachment 1, Field Baseline Risk Assessment Report, for suggested format and contents) which will describe, in detail, all of the items listed in OAR 340-122-084(3)(a - g), as well as how the exposure and effects analyses were performed, any assumptions employed in these analyses, the results of the risk characterization, and a thorough discussion of uncertainties inherent in the risk analyses. The results presented in this report provide the factual basis

for re-evaluating TMDP 6.

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Attachment 1
Level IV Deliverable - Field Baseline Risk Assessment Report Outline

(1) **INTRODUCTION**
- (a) Site History and Description
- (b) Summary of Level III Results

(2) **STUDY DESIGN & METHODOLOGY**
- (a) Conceptual Site Model
  - (i) Exposure Pathway Model
  - (ii) Food Web Model
  - (iii) Assessment Endpoints
  - (iv) Risk Hypotheses
- (b) Selected Measures
  - (i) Exposure
  - (ii) Effect
  - (iii) Characteristics
- (c) Data Needs
  - (i) Data Quality Objectives
  - (ii) Data Analysis Procedures
  - (iii) Data Interpretation Paradigm
- (d) Assessment Tools Required
  - (i) Ecological Parameter Measurements
  - (ii) Toxicity Tests
  - (iii) Tissue Residue Analysis
  - (iv) Food Chain Models
  - (v) Other Methods
  - (vi) Risk Estimation Methodology
- (e) Sampling Location Selection
  - (i) Terrestrial
  - (ii) Aquatic
  - (iii) Reference Areas

(3) **EXPOSURE ANALYSIS**
- (a) Exposure Investigation Results
- (b) Endpoint Species Exposure Profiles
- (c) Exposure Point Value (EPV) Estimates

(4) **ECOLOGICAL RESPONSE ANALYSIS**
- (a) Response Investigation Results
- (b) Endpoint Species Exposure-Response Profiles
- (c) Ecological Benchmark Value (EBV) Estimates

(5) **RISK CHARACTERIZATION**
- (a) Risk Estimation Results
- (b) Risk Description {weight-of-evidence}

(6) **UNCERTAINTY ANALYSIS**
- (a) Exposure Estimation
- (b) Response Estimation
- (c) Risk Estimation

(7) **RECOMMENDATIONS**

(8) **REFERENCES**

FIGURE 1. Ecological Risk Assessment Process Flowchart

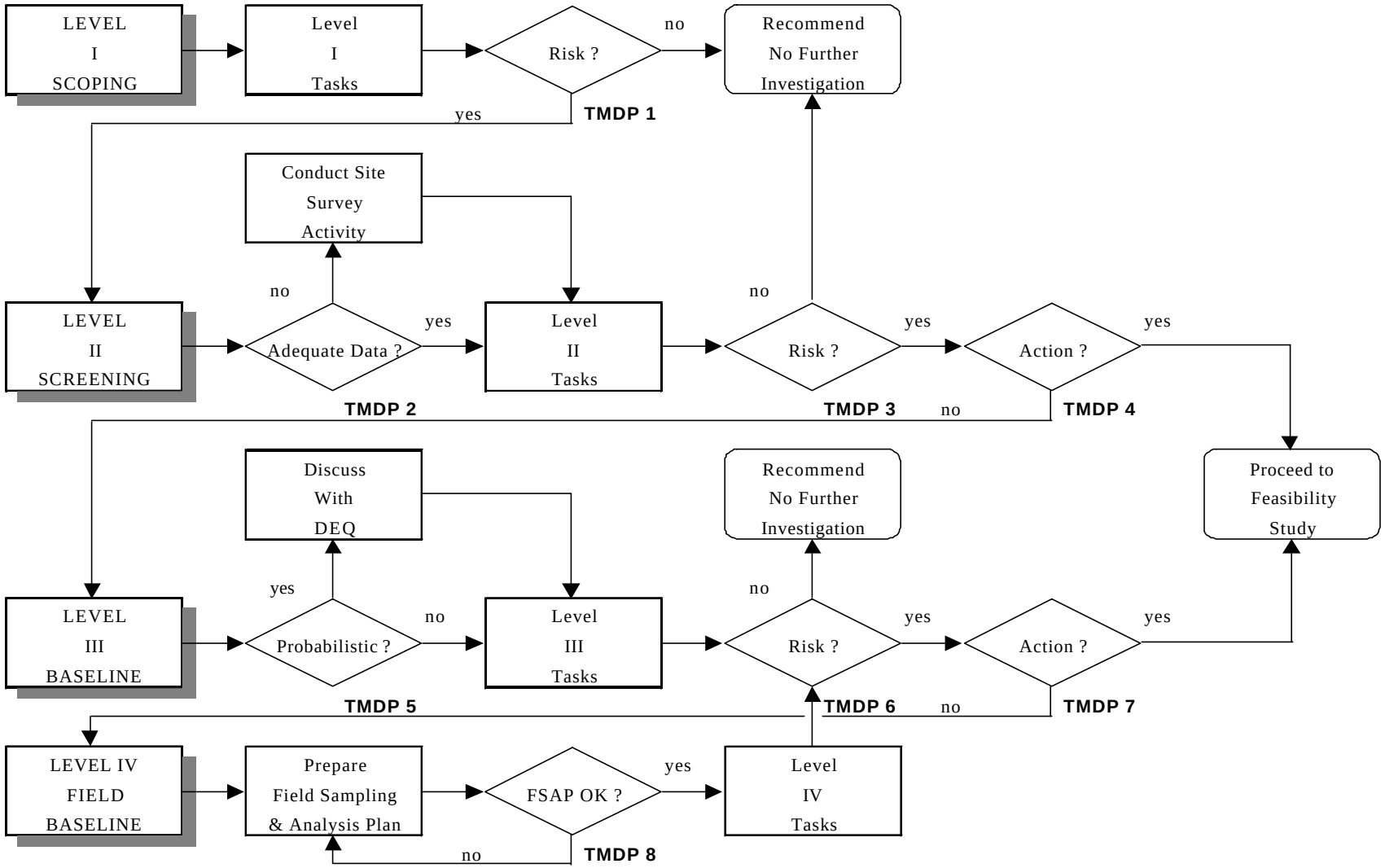
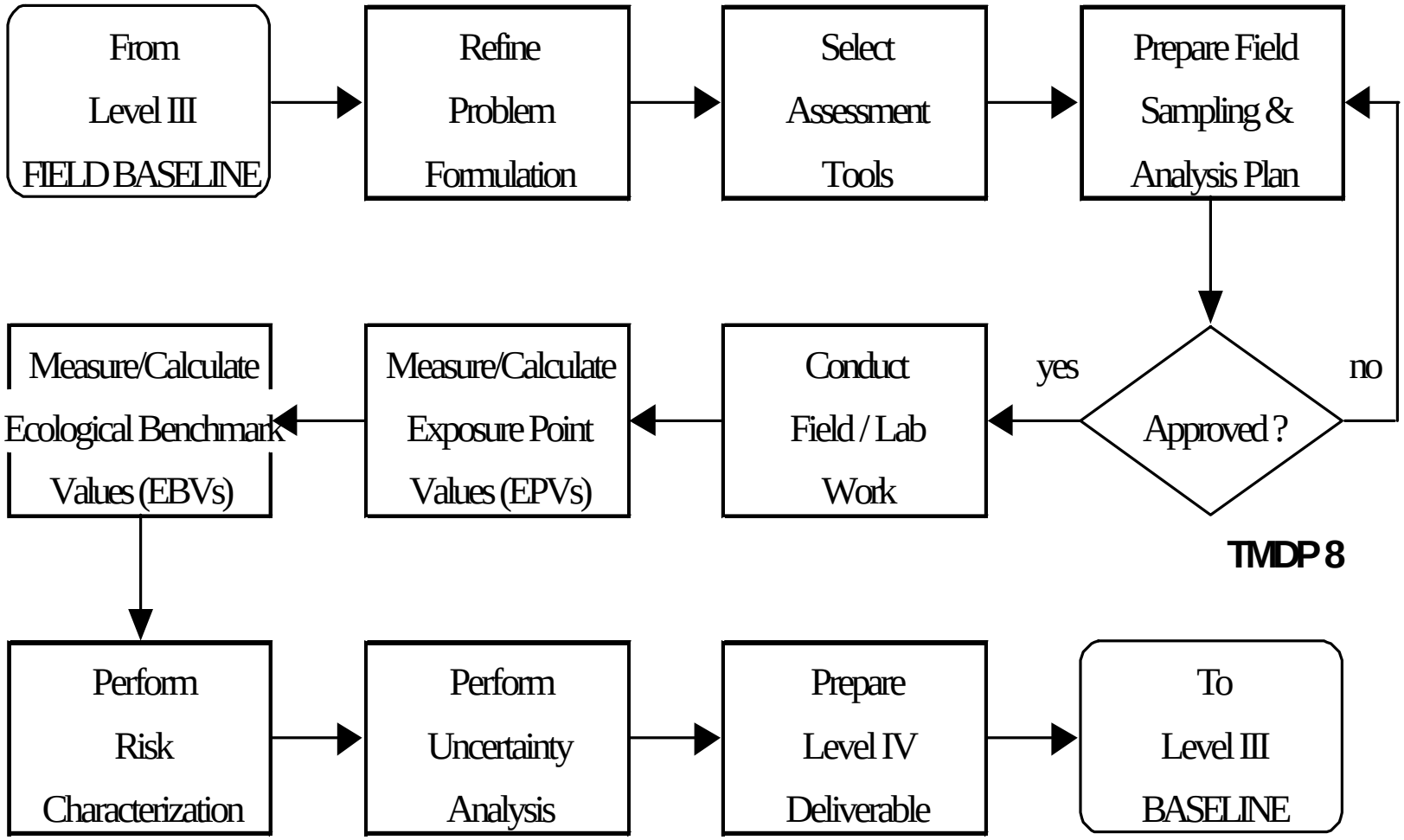
FIGURE 2. Level IV (Field Baseline) Ecological Risk Assessment Process Flowchart