CHAPTER 6
EXPOSURE ASSESSMENT

FROM:
- Site discovery
- Preliminary assessment
- Site Inspection
- NPL listing

DATA COLLECTION
- Data Evaluation

RISK CHARACTERIZATION
- Selection of remedy
- Remedial design
- Remedial action

TOXICITY ASSESSMENT

EXPOSURE ASSESSMENT
- Characterize physical setting
- Identify potentially exposed populations
- Identify potential exposure pathways
- Estimate exposure concentrations
- Estimate chemical intakes
EXHIBIT 6-1
THE EXPOSURE ASSESSMENT PROCESS

STEP 1
Characterize Exposure Setting
- Physical Environment
- Potentially Exposed Populations

STEP 2
Identify Exposure Pathways
- Chemical Source/Release
- Exposure Point
- Exposure Route

STEP 3
Quantify Exposure
- Exposure Concentration
- Intake Variables
- Pathway-Specific Exposure
EXHIBIT 6-2
ILLUSTRATION OF EXPOSURE PATHWAYS
## EXHIBIT 6-3

**COMMON CHEMICAL RELEASE SOURCES AT SITES IN THE ABSENCE OF REMEDIAL ACTION**

<table>
<thead>
<tr>
<th>Receiving Medium</th>
<th>Release Mechanism</th>
<th>Release Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air</td>
<td>Volatilization</td>
<td>Surface wastes -- lagoons, ponds, plt, spills</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Contaminated surface water</td>
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<tr>
<td></td>
<td></td>
<td>Contaminated surface soil</td>
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<tr>
<td></td>
<td></td>
<td>Contaminated wetlands</td>
</tr>
<tr>
<td></td>
<td>Fugitive dust</td>
<td>Leaking drums</td>
</tr>
<tr>
<td></td>
<td>generation</td>
<td></td>
</tr>
<tr>
<td>Surface water</td>
<td>Surface runoff</td>
<td>Contaminated surface soil</td>
</tr>
<tr>
<td></td>
<td>Episodic overland</td>
<td>Lagoon overflow</td>
</tr>
<tr>
<td></td>
<td>flow</td>
<td>Spills, leaking containers</td>
</tr>
<tr>
<td></td>
<td>Ground-water</td>
<td>Contaminated ground water</td>
</tr>
<tr>
<td></td>
<td>seepage</td>
<td></td>
</tr>
<tr>
<td>Ground water</td>
<td>Leaching</td>
<td>Surface or buried wastes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Contaminated soil</td>
</tr>
<tr>
<td>Soil</td>
<td>Leaching</td>
<td>Surface or buried wastes</td>
</tr>
<tr>
<td></td>
<td>Surface runoff</td>
<td>Contaminated surface soil</td>
</tr>
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<td>Spills, leaking containers</td>
</tr>
<tr>
<td></td>
<td>Fugitive dust</td>
<td>Contaminated surface soil</td>
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<tr>
<td></td>
<td>generation/</td>
<td>Waste piles</td>
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<tr>
<td></td>
<td>deposition</td>
<td></td>
</tr>
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<td></td>
<td>Tracking</td>
<td>Contaminated surface soil</td>
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<tr>
<td>Sediment</td>
<td>Surface runoff,</td>
<td>Surface wastes -- lagoons, ponds, plt, spills</td>
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<tr>
<td></td>
<td>Episodic overland</td>
<td>Contaminated surface soil</td>
</tr>
<tr>
<td></td>
<td>flow</td>
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<td>Leaching</td>
<td>Surface or buried wastes</td>
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<tr>
<td></td>
<td></td>
<td>Contaminated soil</td>
</tr>
<tr>
<td>Biota</td>
<td>Uptake (direct</td>
<td>Contaminated soil, surface</td>
</tr>
<tr>
<td></td>
<td>contact, Ingestion</td>
<td>water, sediments, ground</td>
</tr>
<tr>
<td></td>
<td></td>
<td>water or air</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other biota</td>
</tr>
</tbody>
</table>
EXHIBIT 6-4

IMPORTANT PHYSICAL/CHEMICAL AND ENVIRONMENTAL FATE PARAMETERS

$K_{oc}$ provides a measure of the extent of chemical partitioning between organic carbon and water at equilibrium. The higher the $K_{oc}$, the more likely a chemical is to bind to soil or sediment than to remain in water.

$K_d$ provides a soil or sediment-specific measure of the extent of chemical partitioning between soil or sediment and water, unadjusted for dependence upon organic carbon. To adjust for the fraction of organic carbon present in soil or sediment ($f_{oc}$), use $K_d = K_{oc} \times f_{oc}$. The higher the $K_d$, the more likely a chemical is to bind to soil or sediment than to remain in water.

$K_{ow}$ provides a measure of the extent of chemical partitioning between water and octanol at equilibrium. The greater the $K_{ow}$, the more likely a chemical is to partition to octanol than to remain in water. Octanol is used as a surrogate for lipids (fat), and $K_{ow}$ can be used to predict bioconcentration in aquatic organisms.

Solubility is an upper limit on a chemical’s dissolved concentration in water at a specified temperature. Aqueous concentrations in excess of solubility may indicate sorption onto sediments, the presence of solubilizing chemicals such as solvents, or the presence of a non-aqueous phase liquid.

Henry’s Law Constant provides a measure of the extent of chemical partitioning between air and water at equilibrium. The higher the Henry’s Law constant, the more likely a chemical is to volatilize than to remain in water.

Vapor Pressure is the pressure exerted by a chemical vapor in equilibrium with its solid or liquid form at any given temperature. It is used to calculate the rate of volatilization of a pure substance from a surface or in estimating a Henry’s Law constant for chemicals with low water solubility. The higher the vapor pressure, the more likely a chemical is to exist in a gaseous state.

Diffusivity describes the movement of a molecule in a liquid or gas medium as a result of differences in concentration. It is used to calculate the dispersive component of chemical transport. The higher the diffusivity, the more likely a chemical is to move in response to concentration gradients.

Bioconcentration Factor (BCF) provides a measure of the extent of chemical partitioning at equilibrium between a biological medium such as fish tissue or plant tissue and an external medium such as water. The higher the BCF, the greater the accumulation in living tissue is likely to be.

Media-specific Half-life provides a relative measure of the persistence of a chemical in a given medium, although actual values can vary greatly depending on site-specific conditions. The greater the half-life, the more persistent a chemical is likely to be.
EXHIBIT 6-5

IMPORTANT CONSIDERATIONS FOR DETERMINING THE ENVIRONMENTAL FATE AND TRANSPORT OF THE CHEMICALS OF POTENTIAL CONCERN AT A SUPERFUND SITE

- What are the principal mechanisms for change or removal in each of the environmental media?

- How does the chemical behave in air, water, soil, and biological media? Does it bioaccumulate or biodegrade? Is it absorbed or taken up by plants?

- Does the agent react with other compounds in the environment?

- Is there intermedia transfer? What are the mechanisms for intermedia transfer? What are the rates of the intermedia transfer or reaction mechanism?

- How long might the chemical remain in each environmental medium? How does its concentration change with time in each medium?

- What are the products into which the agent might degrade or change in the environment? Are these products potentially of concern?

- Is a steady-state concentration distribution in the environment or in specific segments of the environment achieved?
EXHIBIT 6-6
FLOW CHART FOR FATE AND TRANSPORT ASSESSMENTS

Environmental fate and transport assessment: atmosphere

Contaminant Release

- Potential Volatilization of Contaminants from Site
- Potential Release of Fugitive Dust/Contaminated Particles from Site

Consider Direction and Rate of Contaminant Movement within Air; Major Mechanisms Wind Currents, Dispersion

Could Sediment and Runoff Potentially Result in Sufficient Soil Contamination to Bring About Leaching to Ground Water?
- No
- Yes
  - Consider Contaminant Transfer to Ground Water; Assess Fate in this Medium

Could Contaminants Potentially Reach Agricultural, Hunting, or Fishing Areas?
- No
- Yes
  - Consider Transfer of Contaminants to Plants or Animals Consumed by Humans; Assess Fate in these Media

Determine Probable Boundaries of Elevated Concentrations

Could Contaminants Potentially Reach Surface Water?
- No
- Yes
  - Identify Populations Directly Exposed to Atmospheric Contaminants
  - Consider Transfer Contaminants to Surface Water; Assess Fate in this Medium

Source: Adapted from EPA 1988b

(continued)
EXHIBIT 6-6 (continued)
FLOW CHART FOR 
FATE AND TRANSPORT ASSESSMENTS

Contaminant Release

Release to Surface Water

Consider Direction and Rate of Contaminant Migration Within Waterbody
Assess Distance Downstream, or Areas of Lakes and Estuaries
Major Mechanisms: Currents in Affected Rivers or Streams
Dispersion to Impoundments; Tidal Currents and Flooding in Estuaries; Partitioning to Sediment

Estimate Concentration in Sediment

Consider Sediment as a Source of Surface Water Contaminants

Estimate Surface Water Contaminant Concentrations
Major Factors: Source Release Strength, Dilution Volume

Could Exchange of Water Between Surface Water and Ground Water be Significant?

No Yes

Could Water be Used for Irrigation or Watering Livestock, or Does Waterbody Support Commercial or Sport Fish Population?

No Yes

In Contaminant Vapor?

No Yes

Identify Human Populations Directly Exposed to Surface Water

Consider Transfer of Contaminants to Plants or Animals Consumed by Humans; Assess Fate in these Media

Consider Transfer of Contaminants to Ground Water Assess Fate in this Medium

Identify Human Populations Directly Exposed to Sediment

Source: Adapted from EPA 1988b.

(continued)
EXHIBIT 6-6 (continued)
FLOW CHART FOR
FATE AND TRANSPORT ASSESSMENTS

Environmental fate and transport assessment: soils and ground water

Contaminant Release

Release to Soil at or Surrounding the Site

Consider Rate of Contaminant Percolation Through Unsaturated Soils Based on Soil Permeabilities, Water or Liquid Recharge Rates

Release to Ground Water Beneath Site

Could Contaminants Potentially Reach Ground Water?

No

Consider Direction and Rate of Ground Water Flow Using Available Hydrogeologic Data, or by Assuming These Will Approximate Surface Topography

Yes

Does Contaminated Soil Support Edible Species?

No

No

Are Contaminants Volatile? Are Contaminants in Fugitive Form or Sorbed to Particulates?

Yes

No

Could Contaminants Reach a Surface Waterbody?

No

Yes

Could Contaminants Reach any Wells Located Downgradient?

No

Yes

Is Plume Sufficiently Near Ground Surface to Allow Direct Uptake of Contaminated Ground Water by Plants or Animals?

No

Yes

Is Well Water Used for Irrigation or for Watering Livestock, or Could it be?

No

Yes

Consider Transfer of Contaminants to Surface Waters and Assess Fate in this Medium

Identify Human Populations Directly Exposed to Well Water

Consider Transfer of Contaminants to Plants or Animals Consumed by Humans, Assess Fate in these Media

Consider Transfer of Contaminants to Atmosphere, Assess Fate in this Medium

Identify Human Populations Directly Exposed to Soils

Sources: Adapted from EPA 1988b