3.0 Spatial Aspects of Environmental Settings and Receptors

The 3MRA modeling system uses site-based modeling to provide the spatial distribution of contaminants and receptors in a specified area of interest (AOI) around each of the sources being modeled. To support this site-based strategy, a geographic information system (GIS) is used to provide a spatial frame of reference and associated attributes around each site or facility within the AOI. This section describes the spatial layout and the methods and data used to characterize the various spatial attributes of an AOI in the 3MRA modeling system. The spatial aspects of an AOI and the associated data collection process are discussed in greater detail in Volume II of this report, *Data Collection for the 3MRA Modeling System* (U.S. EPA, 2003).

3.1 Overview of Spatial Layout for Environmental Settings and Receptors

The spatial layout of an AOI used in the 3MRA modeling system consists of the source of constituent releases, the surrounding environment, and the location of receptors. The sources, such as a landfill, surface impoundment, industrial facility, or abandoned site, are stationary, and the AOI is defined by a distance from the source. This distance could be a few hundred meters up to 50 km. The 50 km limit is imposed by the limits of the air dispersion model (ISCST3) used in the 3MRA modeling system. The distance defining the AOI is wholly dependent on the areal extent needed for a specific analysis. For the sites and environmental settings currently in the 3MRA representative national data set, the AOI distance is set at 2 km from the boundary of the source.

3.1.1 Settings and Areas of Interests

The 3MRA modeling system incorporates a number of attributes that characterize the environmental setting of the AOI. A setting is defined as the source or sources of pollutant releases being modeled plus the characteristics of the environment in the AOI. The 3MRA modeling system uses more than 700 total variables to describe a site's environmental setting. The values for many of these variables are based on site-specific information. Others are based on regional or national data sets, when site-specific data are not available. A GIS was used to overlay layers of spatial data to construct a complete description of the environmental setting within the AOI.

3.1.2 Site Layout and Spatial Data Layers

Several key spatial data layers for each setting are shown in Figure 3-1. The layers are defined as follows:

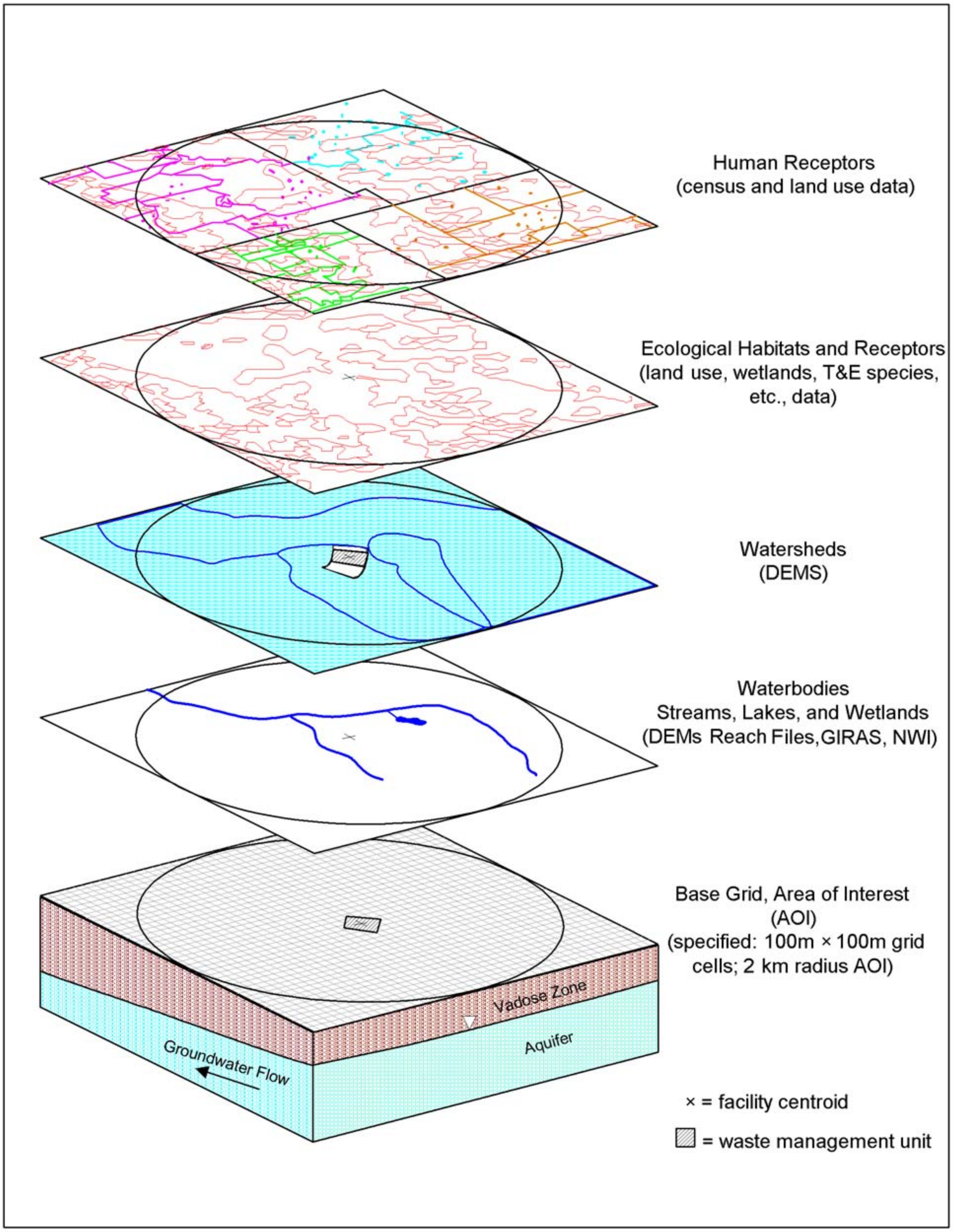


Figure 3-1. Site-based spatial overlays for 3MRA modeling system spatial framework (GIS analysis).

- **Human receptor points** are defined by U.S. Census block centroids for residents, and by randomly placed farms based on Census block group, agricultural census, and land use data for farmers (U.S. EPA, 2000b). These locations are used to calculate exposure concentrations in various media and to estimate risks to human receptors. A detailed explanation of how these data are used is provided in Volume II (U.S. EPA, 2003).

- **Ecological habitats and receptors** are defined by land use and other ecologically relevant data (U.S. EPA, 2002). These locations are used to calculate exposure concentrations in various media and to estimate risks to ecological receptors. A detailed explanation of how these data are used is provided in Volume II (U.S. EPA, 2000a).

- **Watersheds and watershed subbasins** are delineated either electronically, using digital elevation models (DEMs) of topography, or manually, based on Reach File 3 (RF3) stream networks (U.S. EPA, 2002). Watershed subbasins provide the spatial context and connectivity necessary to model chemical deposition, erosion, overland transport, and resultant soil concentrations in the Waste Pile, Land Application Unit (LAU), and Watershed Modules. Typically, a watershed is the entire drainage area for a particular stream network in the AOI, and is subdivided into subbasins. A watershed subbasin can vary in size from a portion of a hillside to much larger areas encompassing regional stream or river networks. In all cases, a subbasin is treated as a single, homogeneous area with respect to soil characteristics, runoff and erosion characteristics, and constituent concentrations in soil.

- **Waterbodies** (lakes, streams, and wetlands) are defined by DEMs, RF3 data, land use data contained in the Geographic Information Retrieval and Analysis System (GIRAS), and/or National Wetlands Inventory (NWI) (see U.S. EPA, 2002). Waterbodies provide the spatial context and connectivity necessary to model contaminant deposition, fate, transport, and the resulting water column and sediment concentrations in streams, lakes, and wetlands.

- **Subsurface features** include the surficial aquifer (the unconfined ground water source nearest the surface) and the vadose zone (the soil zone between the ground surface and the surficial aquifer). The vadose zone and surficial aquifer are assumed to directly underlie the source. The State Soil Geographic Data Base (STATSGO) provides vadose zone characteristics. Aquifer properties are obtained from regional data sets. Ground water flow is assumed to follow the topography of the land surface, as determined from the DEMs.

In the GIS, each of these spatial data layers is composed of 2-D polygons, except for streams, which are defined by 1-D vectors (stream reaches), and human receptor locations (residences and drinking water wells), which are defined as points. Because these polygon coverages could not be exported directly to the 3MRA modeling system, each spatial data layer was defined in terms of a base grid composed of 100 × 100 m cells, which roughly correspond to the minimum resolution of several site-specific data types (i.e., land use, topographic, and soil). This base grid (or *x*,*y* coordinate system) serves as the basis for defining receptor points at which the Air, Vadose Zone, and Aquifer Modules in the 3MRA modeling system produce constituent concentrations (and deposition rates for the Air Module) in terms of distance and direction from the constituent source. To provide the 3MRA modeling system with the data necessary to specify air points and well locations, spatial data are passed to the model using this site coordinate system for the following data layers:

- Watersheds,
- Waterbodies,
- Farms,
- Human receptor points,
- Wells (human receptor points with drinking water wells), and
- Ecological habitats.

The site coordinate system is described using metric *x*,*y* coordinates relative to the ground surface at the facility or site centroid (the georeference point). The 3MRA modeling system requires that the georeference point be specified using a latitude and longitude in the Universal Transverse Mercator (UTM) coordinate system. Using GIS, a coverage of spatial data (e.g., watersheds) is overlaid on the standard grid. If the centroid of a grid cell intersects a polygon, it receives the identifier for that polygon (see Figure 3-2).

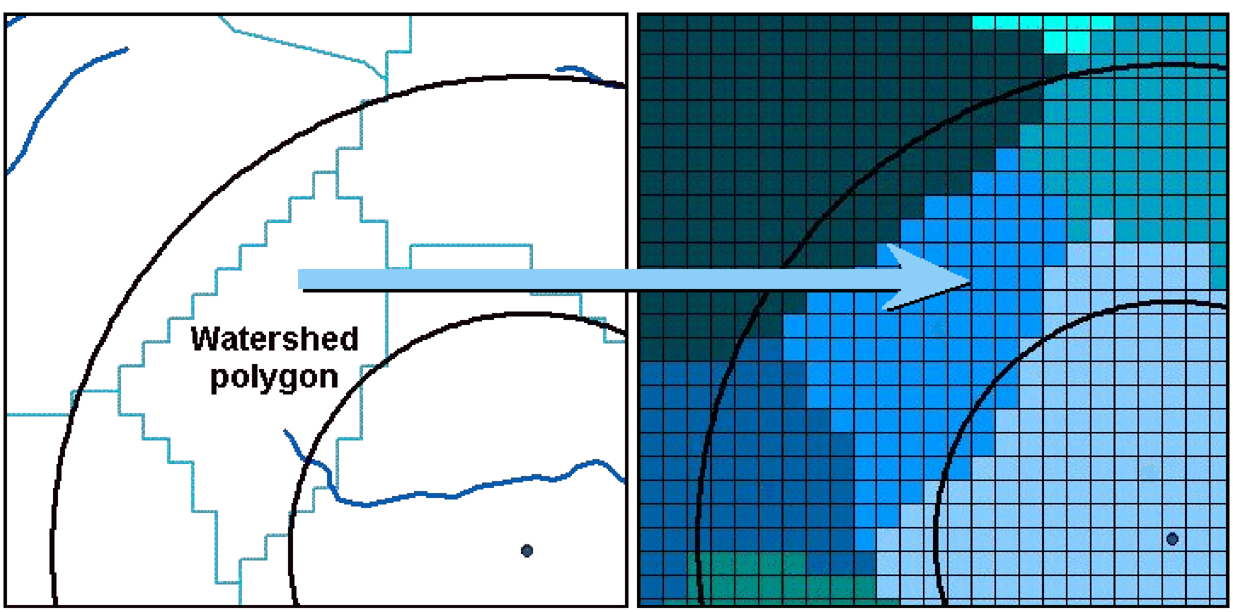


Figure 3-2. Example of transfer of polygons to 100 × 100 m template grid.

3.2 Watersheds and Waterbodies

To develop the watershed/waterbody layout, GIS programs were used to

- Compile available hydrologic, DEM land use, and wetlands data sets (see Figure 3-3);

- Extract site-specific data from these data sets; and

- Delineate the watershed subbasins, waterbodies, and local watersheds.

The watershed layout includes the watersheds that contribute flow to waterbodies within the AOI. Although the waterbody/watershed layout is important for several modules in the 3MRA modeling system, the layout primarily supports the surface water, regional watershed, and local watershed components. These components serve the following purposes:

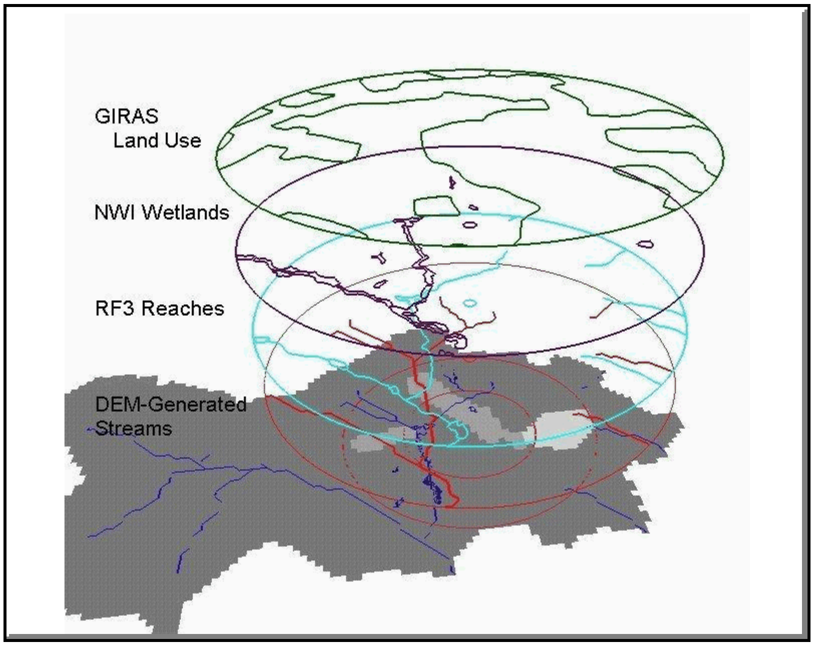


Figure 3-3. GIS data coverages for waterbody and watershed delineation.

- The Surface Water Module estimates water column and sediment chemical concentrations for use in the Aquatic Food Web and Ecological Exposure Modules.

- The Watershed Module estimates surficial (top 1 cm) and depth-averaged soil concentrations within the AOI for the Terrestrial Food Web, Farm Food Chain, and Human and Ecological Exposure Modules; generates hydrologic inputs (runoff, baseflow, soil loads) for the Surface Water Module; and generates annual average infiltration estimates for use as recharge for the Aquifer Module.

- The Waste Pile and LAU Modules estimate runoff, soil loads, and contaminant loadings for upgradient and downgradient subbasins. The modules simulate contaminant movement due to water erosion and overland transport from the LAU or waste pile to the nearest downslope waterbody.

Within the context of the 3MRA modeling system, certain assumptions and definitions were required to develop the procedures for delineating the watersheds, subbasins, and waterbodies to be modeled. Figure 3-4 illustrates the conceptual framework for the waterbody and watershed layout, which is detailed below.

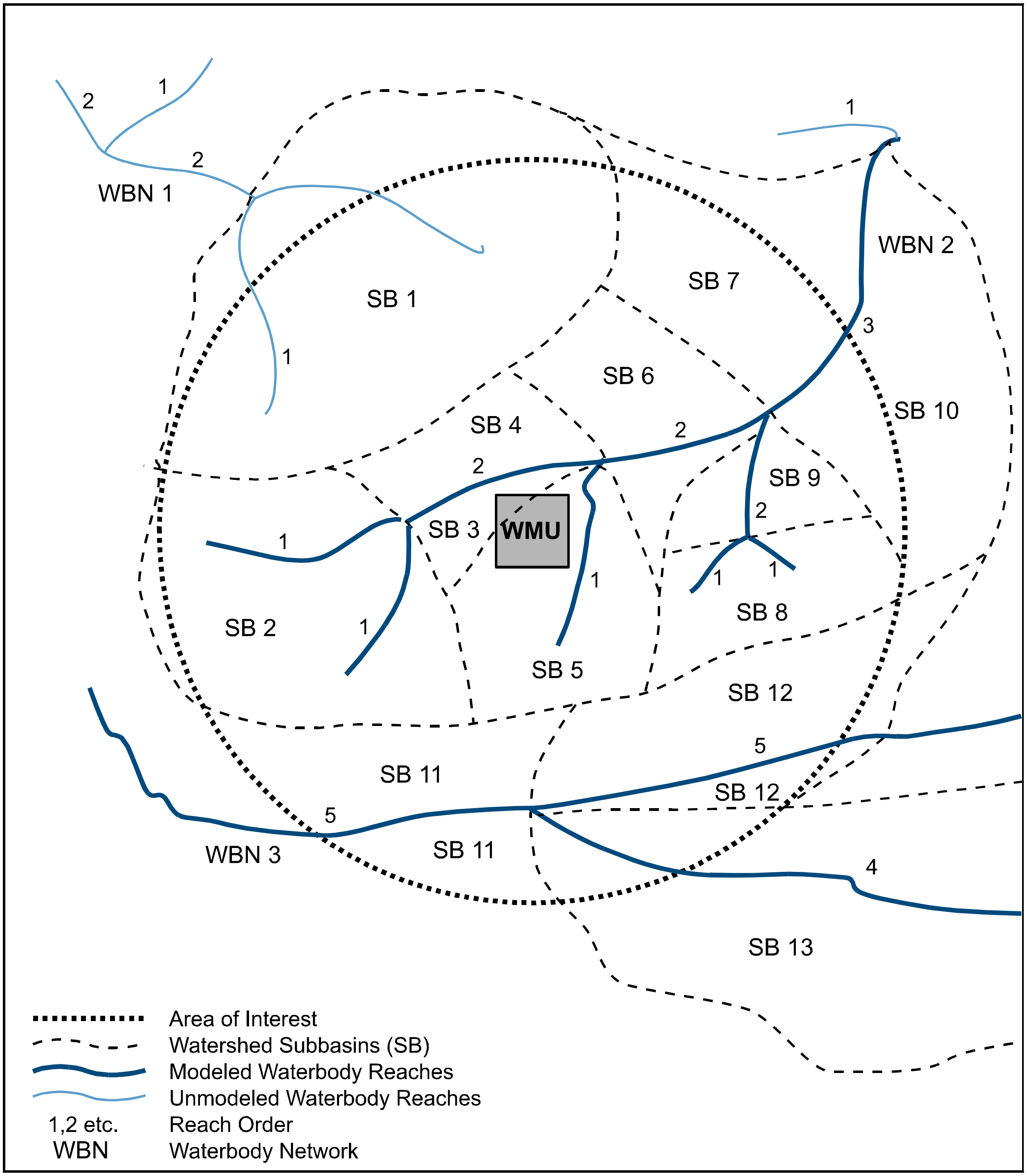


Figure 3-4. Regional watershed subbasin delineation.

3.2.1 Definitions for Watershed and Waterbody Layout

The 3MRA modeling system uses the following definitions for watersheds and waterbodies:

- A *waterbody reach* is a stream segment between tributaries, a lake (or pond),[1] a wetland, or an estuary. A waterbody reach is the basic modeling unit for the Surface Water Module.

- A *headwater reach* (or first-order reach) is a reach that flows into another reach downstream but has no upstream reaches draining into it.

- An *exiting reach* is a nonheadwater reach that flows out of the AOI.

- A *waterbody network* is a series of connected (possibly branching) reaches that defines a stream network (three waterbody networks are shown in Figure 3-4, labeled WBN 1, WBN2, and WBN3).

- A *regional watershed* is the entire drainage basin associated with an individual modeled waterbody network and can extend outside of the AOI, as necessary. Upstream watersheds are not delineated for any waterbody reaches greater than order 5[2] entering the AOI because the volume of water in this size stream or river would dilute the concentration of a constituent from a source. However, tributary lands for reaches greater than order 5 lying *within* the AOI are delineated as regional watershed subbasin(s) (see definition below) to simulate soil concentrations. Such subbasin delineations only include land within the AOI. The upstream boundary of any regional watershed is its natural, upstream boundary (i.e., its headwater basin, except, as noted above, for those greater than order 5).

- A *watershed subbasin* is a portion of the regional watershed. A regional watershed is composed of a set of nonoverlapping subbasins. The set of all subbasins for a given regional watershed will completely cover the regional watershed, except for watersheds greater than order 5. For example, in Figure 3-4, Subbasins 2 through 10 make up the regional watershed for Waterbody Network 2. Depending on the waterbody layout, one or more subbasins can drain into a reach, or a subbasin can drain into one or more reaches. The subbasin is the basic spatial modeling unit for the Watershed Module.

- A *local watershed* is a drainage area that contains a source, such as an LAU. A local watershed extends from the upslope drainage divide downslope to the first

[1] All lakes and ponds were designated as lakes in the waterbody layout data.

[2] As defined by the Strahler ordering system (Strahler, 1957).

defined drainage channel, lake, or pond. It is divided into subareas upslope and downslope of the source and the source itself. These subareas are the basic modeling units for the local watershed model.

3.2.2 Assumptions for Waterbodies and Regional Watersheds

The following assumptions were used to develop and collect data associated with the regional watershed and waterbody layout:

- The Surface Water Module models streams of order 1 through 5, ponds, lakes, and wetlands. All lakes, ponds, and wetlands connected to a waterbody network are modeled regardless of order. Only reaches lying completely or partially within the AOI are modeled.
- Streams of order 1 through 5, ponds, lakes, and wetlands within the AOI are modeled until they exit the AOI. Headwater reaches (order 1) that exit the AOI are not modeled.
- Order 3 and higher stream reaches, along with lakes, ponds, and certain wetlands, are assumed to be fishable (i.e., support fish populations suitable for recreational anglers). Order 1 and 2 stream reaches within the AOI that feed into an order 3 reach within the AOI contribute to the contaminant concentration in the order 3 stream reach.
- Surface waters in the waterbody network are subject to contaminant loads from indirect runoff (i.e., from aerial deposition of a contaminant on the watershed). Some are subject to both indirect and direct loads (i.e., direct runoff/erosion from the source).

3.2.3 Assumptions for Local Watersheds

Some sources, such as waste piles and LAUs, release pollutants directly through runoff and erosion. Assumptions associated with the local watershed component of these sources include the following:

- If the source overlaps a drainage divide, multiple local watersheds are modeled.
- The local watershed will contain at least two subareas—the source (or portion thereof) and a 30.5 m wide (100 ft wide) buffer between the source and the stream (see Figure 3-5). The local watershed may also include a third, upslope subarea from the drainage divide to the source.

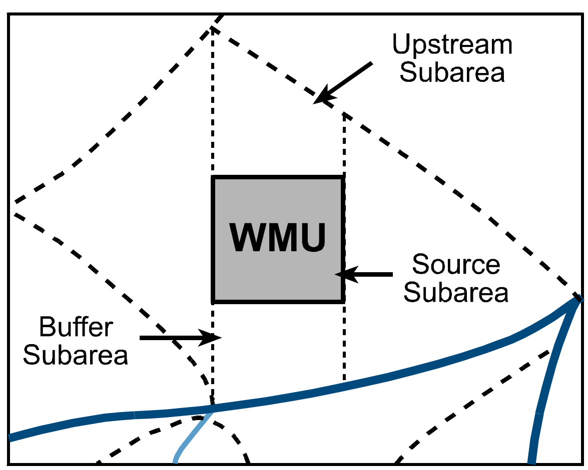


Figure 3-5. Local watershed delineation.

3.2.4 Watershed Soils

The 3MRA modeling system estimates surface soil concentrations of a contaminant in each of the watershed subbasins within the AOI. It also provides estimates of the vadose zone soil concentrations, but only under the source, not in the whole watershed. The depth of the surface soil is defined by the user in the 3MRA modeling system. Vadose zone soil extends from the ground surface to the water table. Depending on the location of the AOI, average (area- and depth-weighted) or predominant soil properties are derived for the soil depth zone of interest across each watershed subbasin or the waste management unit (WMU). All soil parameters are either site-specific or derived from site-specific data using national relationships and thus are considered site-based. Parameters derived from site-specific data include soil hydrologic properties derived from site-specific soil texture or hydrologic class, and other properties derived from a combination of soil texture or class and site-specific land use.

3.3 Human Receptors, Farms, and Wells

Human receptor locations, which include residences and farms, are one of the primary spatial data layers in the 3MRA modeling system. They enable human risk or hazard to be calculated spatially within the AOI where people are likely to be located. GIS data are used to locate these points and collect human receptor numbers and characteristics (e.g., receptor types, age cohorts). Using this information, the 3MRA modeling system can generate risk distributions around a source that are based on the population within the AOI. These data provide a level of specificity for a national-level assessment that accounts for how many people are affected and at what levels of risk.

As discussed in Section 2, human receptors are subdivided into groups that reflect differences in exposure patterns due to either location or behavior. Resident human receptor points are located and populated by 1990 Census block data (U.S. Bureau of the Census, 1987, 1992; U.S. EPA, 1995a,b). Farms are located and populated using Census block group boundaries, subdivided by farm land use, along with county-level agricultural census data.

Figure 3-6 illustrates many of the spatial data elements related to human receptors for a sample AOI. This AOI is relatively simple in terms of receptor population density. It includes 20 residential locations, one for each (populated) Census block, and one farm. Contaminant concentrations are estimated at the single point at the centroid of each Census block to evaluate the exposure and risk or hazard to residential receptors. For example, the soil concentrations are an areal average of the watershed subbasin soil concentrations within the Census block. The ambient air concentration is the average of air concentrations at points modeled within a Census block. The ground water concentration is evaluated at a well at the Census block centroid when some or all of the receptors in the Census block use private drinking water wells. The estimated risk or hazard quotient (HQ) for each receptor type and age cohort at a Census block centroid is assigned to all individuals in that Census block that are the same receptor type and age cohort. The farm is randomly located, but its location is constrained to be both within a Census block group that includes farming activity and also within an agricultural land use area within that block group. For this example, a single representative farm is placed within one block group to

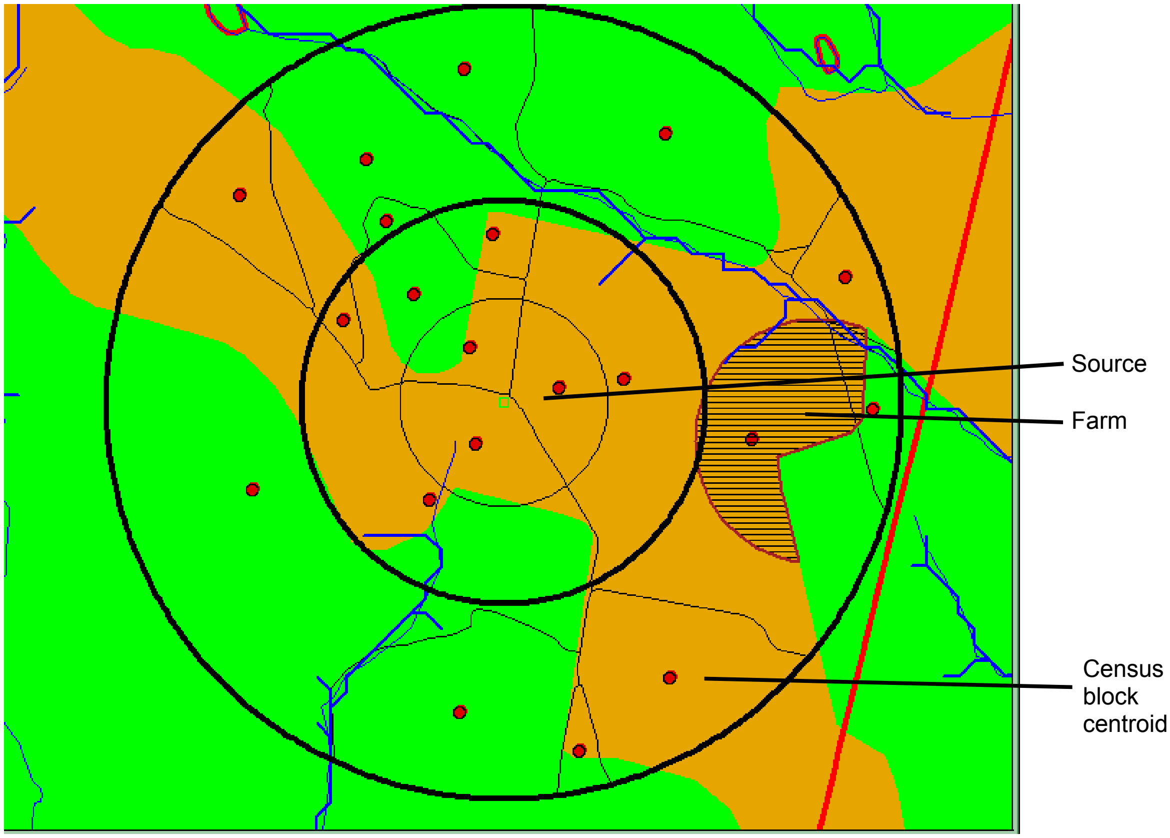


Figure 3-6. Example site layout for human receptors.

represent the exposures for all farms within that block group. The farm population by receptor type and age cohort in the block group is assigned the risk or HQ associated with the representative farm.

The following subsections summarize the steps used to place and process human receptor locations, farms, and wells. Details of these procedures are presented in U.S. EPA (2002). The total number of people within an AOI is divided into receptor types and age cohorts. These are further subdivided by whether or not households have a private drinking water well. Measures are taken with respect to numbers of people at a site in order to maintain the correct total population across the site.

3.3.1 Resident and Home Gardener Locations

Census block coverages are used to locate residents and home gardeners. A resident or home gardner receptor is placed at the centroid of every Census block within the AOI. The characteristics within each Census block coverage are linked to the other spatial data (regional watersheds, local watersheds, and distance rings) within the system. Area weightings are used to calculate the number of receptors/cohorts and the environmental characteristics within the AOI. For example, if Census blocks extend across distance rings, the block data are fractioned into each ring/block combination based on the relative areas in each.

3.3.2 Farm Locations

Farms within the AOI are located by overlaying the Census block groups with the land use coverages that identify areas with farm-type land use (i.e., crop and pastureland) in block groups that have farmers. A farm is placed in each of these block group/farm land use areas as follows:

- The median farm size for the county is determined based on a census of agriculture data (U.S. Bureau of the Census, 1987, 1992). These data include the median farm size and fractions of farms that are beef or dairy farms by county. The fraction of beef or dairy farms is calculated as the number of beef or dairy farms divided by the total number of farms in a county.

- If the block group/farm land use area is larger than the median farm size, then a random point inside the farm land use area of the block group is picked. A circle is created to represent the area of the farm. To keep the farm within the block group/farm land use area, the farm is clipped at the farm land use boundary. The radius of the circle is increased incrementally until a polygon is produced that approximately matches the median farm area and is completely contained within the farm land use area of the block group. If the farm land use area within a block group is smaller than the median farm size, then the entire area of farm land use in the block group is used as the farm.

- Once the farms are placed within the AOI, the fractions of beef farms and dairy farms are applied to the total number of farms to calculate the number of beef and dairy farmers in each block group with a farm.

3.3.3 Well Locations (Private Wells Only)

Census block group data include the number of households with private wells. These data are used to calculate the fraction of people with private water supplies within the AOI. This block group fraction is applied to block-level human receptor points within each block group to identify points with wells. Private wells are located at the centroid of each Census block that contains people on private wells. Wells are also located at the centroid of each farm. Every farm is assumed to be on a private well. Not all private wells are necessarily affected by the ground water contamination from the source, only those that are predicted to be within the plume of contamination given the characteristics at each site.

3.3.4 Recreational Fisher Locations

All receptor types may also be recreational fishers. The location of fishers is the same as for residents, gardeners, and farmers. For example, a recreational fisher may be a resident located at the centroid of a Census block. However, the fisher may catch fish in up to three streams within the AOI. If there are more than three fishable streams in the AOI, the location of the three streams in which a particular receptor fishes is randomly selected.

The number of recreational fishers in each category of receptor types is based on 1996 National Survey of Fishing, Hunting, Wildlife, and Recreation (NSFHWAR) data, which include the percentage of residences with recreational fishing licenses in urban, rural, and rural farm areas by state (U.S. DOI and U.S. DOC, 1997). For each state, recreational fisher percentages can be estimated using the NSFHWAR urban and rural population breakdowns and splitting the rural population into farm and nonfarm populations using farm/nonfarm population fractions calculated from 1990 U.S. Census data (U.S. Bureau of the Census, 1987, 1992). This provides state-by-state estimates of urban, rural-farm, and rural-nonfarm recreational fishers as a percentage of the total state population. These percentages are used to calculate the recreational fisher population within an AOI.

3.4 Habitats and Ecological Receptor Placement

Representative habitats were developed that can be used in the 3MRA modeling system to describe the biological conditions within an AOI. Receptors were assigned to habitats based on wildlife-habitat relationships documented in the literature. The habitat was chosen as the appropriate level of resolution for the spatial element of the ecological risk assessment used for a national-level assessment. In this context, the term habitat implies a level of detail and specificity that is meaningful for estimating exposure but that does not require extensive biological inventory or field investigation for identification or delineation.

Fourteen representative terrestrial, wetland, and margin habitats have been developed for use in the 3MRA modeling system. Table 3-1 presents an overview of the representative habitats. The representative habitats address areas inhabited by land-based receptors. In addition to terrestrial mammals, birds, and herpetofauna, terrestrial receptors also include some species that spend significant time in the water, such as the bullfrog and snapping turtle, and some that derive all or most of their food from the water, such as the osprey and muskrat. In order to fully assess exposure, the margin habitats are defined and delineated to include both the waterbody and its adjacent terrestrial areas, such as stream corridors and pond margins, in which all these receptors are potentially exposed. Section 15 of this document describes how the representative habitats were selected, characterized, and delineated.

3.4.1 Habitat Delineation

The GIS data layers needed for habitat delineation are

- Facility/site location,
- AOI,
- GIRAS land use,
- Delineated waterbodies—rivers, lakes, and wetlands,
- NWI wetlands,
- RF3 waterbodies,
- Managed areas,
- 2 m DEM contours, and
- Preprocessed habitat grid.

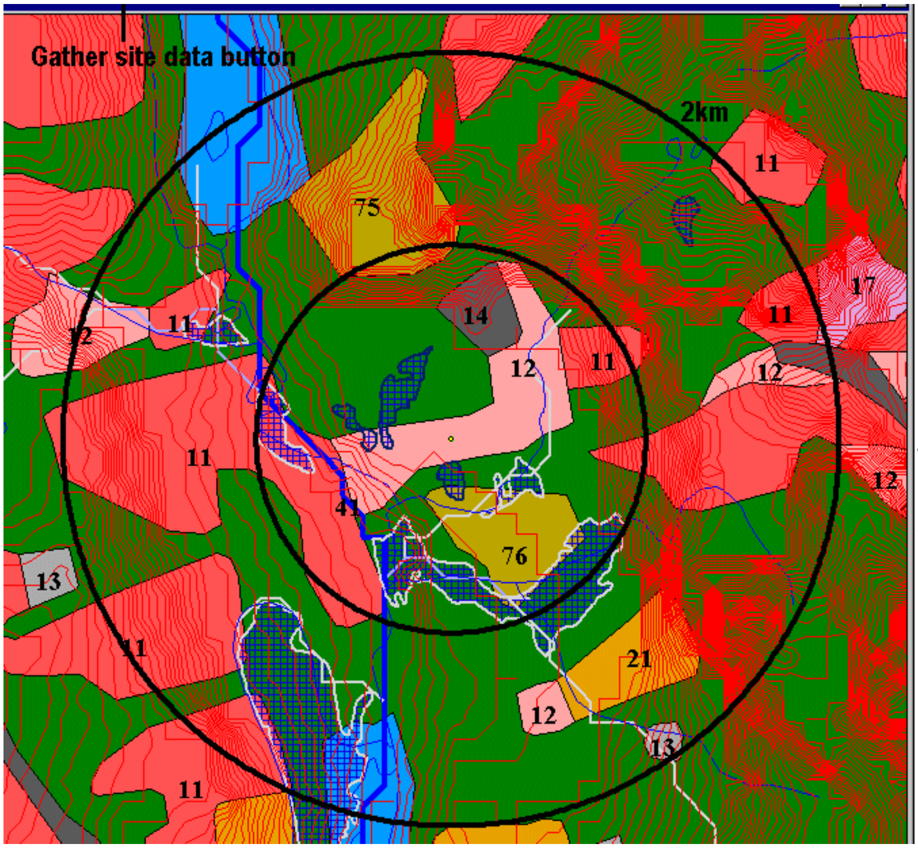
Table 3-1. Ecological Risk Assessment Representative Habitats for Terrestrial Receptors

Terrestrial Habitats
■ Grasslands
■ Shrub/scrub
■ Forests
■ Crop fields and pastures
■ Residential
Waterbody Margin Habitats
■ Rivers/streams
■ Lakes
■ Ponds
Wetland Margin Habitats
■ Intermittently flooded grasslands
■ Intermittently flooded shrub/scrub
■ Intermittently flooded forests
■ Permanently flooded grasslands
■ Permanently flooded shrub/scrub
■ Permanently flooded forests

Habitats are delineated by assigning each grid cell to one of the 14 representative habitats. A grid cell may also be designated as "no habitat" if it consists of highly developed or impervious areas (such as parking lots or train tracks) not likely to support wildlife. Figure 3-7 shows an example AOI with preprocessed habitats.

Terrestrial Habitat Delineation. To delineate the terrestrial habitats at each site, the representative habitat types were correlated with Anderson land use categories. The Anderson Land Use Classification, developed by the U.S. Geological Survey (USGS), assigns land use descriptors to areas that are distinguishable in satellite and other remotely sensed data. Digitized Anderson land use data are readily available through GIRAS and, therefore, provide a useful tool for locating habitats. GIRAS land use/land cover data delineate land use patterns wit respect to vegetation, human activity, and waterbodies. Although these data are 15 to 25 years old and therefore do not reflect current conditions in some locations, the GIRAS data set is the most complete and current national data set available. A full description of GIRAS data and methods for use in the 3MRA modeling system is presented in Volume II (U.S. EPA, 2003) of this report.

Delineation of Waterbody Margin Habitats. Some terrestrial receptor species depend on aquatic systems for some or all of their food. These exposure scenarios are assessed in the waterbody margin habitats. Stream corridor, pond, and lake margin habitats were delineated as being adjacent to the waterbodies generated as part of the waterbody and watershed layout data processing. Data sources for delineation of streams include DEM data (USGS, 1999), RF3 data



Land Use Code and Habitat

11 Residential

12 Commercial and services (nonhabitat)

13 Industrial (nonhabitat)

14 Transportation, communications, and utilities (included in largest adjacent habitat)

17 Other urban or builtup land (residential)

41 Deciduous forest land (forest)

21 Cropland and pastures (crop fields/pastures)

75 Strip mines, quarries, gravel pits (nonhabitat)

76 Transitional areas (nonhabitat)

Figure 3-7. Preprocessed habitat codes.

(U.S. EPA, 1994b), and GIRAS data (U.S. EPA, 1994a). Data sources for delineation of ponds and lakes include GIRAS and the NWI (U.S. FWS, 1998). Once the streams, ponds, and lakes were delineated for an AOI, their respective corridor and margin habitats were added.

There is no simple correlation between waterbody characteristics and wildlife distribution within corridors and margins. The vegetation, topography, and land use of the adjacent land, as well as the size, depth, flow, and aquatic food web of the waterbody, are but a few of the more prominent variables that affect wildlife use of waterbody margin habitats. Elevation contours were assumed to be the best indicators of stream corridors and pond and lake margins. Using DEM contour data, an attempt was made to determine a visual natural limit for the corridor or margin. Because waterbodies occur in the landscape along elevation contours, natural boundaries were frequently evident. If no contour-based boundaries were apparent, surrounding land use was used instead. For example, if GIRAS data indicated a forest buffer running parallel to a stream and a commercial or industrial area adjacent to the forest, the stream corridor would consist of the forest buffer. When neither contours nor land use indicated corridor or margin boundaries, a default minimum margin was delineated. Waterbody margin habitats at a single site were combined, or bridged, as were terrestrial habitat patches.

Delineation of Wetland Margin Habitats. National Wetlands Inventory (NWI) data provide the most complete and readily available digitized data on location and type of wetlands on a national scale (U.S. FWS, 1998). NWI data, however, have not yet been digitized for the entire United States. When digitized NWI data were not available for an AOI, wetland data from GIRAS were used.

Wetland identification and classification in the NWI are based on photo interpretation of remote imagery at a 1:24,000 scale. Each wetland polygon identified is classified and coded according to the Cowardin et al. (1979) classification system, which indicates substrate type, dominant vegetation, and hydrologic regime, as well as additional details regarding soil and water chemistry, where relevant. The GIRAS wetland data are on a 1:80,000 or smaller scale and distinguish only between wetlands dominated by woody vegetation and those not dominated by woody vegetation (Anderson et al., 1976). GIRAS data do not show wetlands smaller than 16 hectares (39.5 acres). Consequently, there is significant variation in the level of detail in the wetland data for sites with and without NWI coverage. Because the NWI provides high-quality data that readily distinguish the different wetland habitat types, it is the preferred source for wetland data.

Wetland Flood Regime. The 3MRA representative habitats include three intermittently flooded and three permanently flooded wetland types. The primary criterion for this division is the wetlands' ability to support fish populations. When NWI data were available, this distinction was made based on water regime modifiers in the NWI code. Based on the descriptions in Cowardin et al. (1979), a decision was made about whether each water regime would be expected to support an aquatic food web that includes TL3 or TL4 fish. Wetland types with flood regimes that indicate the presence of sufficient flooding to support fish populations are delineated as permanently flooded wetlands. Those wetlands in which flooding is infrequent or of short duration are delineated as intermittently flooded wetlands.

All GIRAS-identified wetlands are delineated as permanently flooded because GIRAS generally does not recognize wetland ecosystems at the drier end of the wetland flood regime continuum.

Treatment of Intermittently Flooded Wetlands. Wetlands designated as intermittently flooded were then further classified according to the representative wetland habitats as intermittently flooded grassland, shrub/scrub, or forest wetlands. These determinations also were made based on NWI codes.

For the 3MRA modeling system, the three intermittently flooded wetland habitat types were identified and designated, but their boundaries were not delineated. Many intermittent wetlands occur as small, scattered habitat patches and, even when combined with similar patches in an AOI, often do not constitute large enough areas for placement of home ranges. However, these areas are known to provide important, albeit highly fragmented, habitat. Therefore, during site layout data processing, intermittent wetlands were identified as inclusions within surrounding upland habitats (e.g., grassland, forest), and their unique receptor species are included in the data passed to the Ecological Exposure Module. In this manner, the receptors expected to occur in intermittent wetlands are included in the exposure assessment.

An exception was made to this approach for certain intermittent wetlands adjacent to streams of order 3 and higher. Water regimes for seasonally flooded and seasonally flooded/saturated imply seasonal flooding for extended time periods; in wetlands adjacent to fishable stream reaches (stream order 3 and higher), these water regimes could potentially support an aquatic food web. Therefore, these intermittent wetlands, whether grassland-, shrub/scrub-, or forest-dominated, were delineated when they occurred adjacent to streams of order 3 or higher. These habitats were treated in a manner identical to the permanently flooded wetlands, as described in the following section.

Delineation of Permanently Flooded Wetlands. Permanently flooded wetlands were identified at each site based on the NWI codes. When NWI data were not available, GIRAS data were used. GIRAS data classify wetlands as forested or nonforested and do not include any information on the flood regime. Because most national data sets generally apply the term wetlands to tidal and other aquatic habitats and do not recognize noninundated areas as wetlands, it is assumed that wetlands identified in GIRAS data fall within the permanently flooded wetland habitats. The forested GIRAS wetlands are delineated as permanently flooded forested wetlands; the nonforested GIRAS wetlands are delineated as permanently flooded grasslands. Although some of the wetlands included in the GIRAS data are undoubtedly dominated by shrub/scrub vegetation, the data do not allow this distinction to be made. In the absence of better data, the intermittently flooded grassland habitat is considered the most appropriate alternative.

Permanently flooded wetlands frequently occur in association with streams, rivers, lakes, and ponds. Thus, the potential arises for areas adjacent to waterbodies to include both wetlands and waterbody margin habitats. The most effective and straightforward approach to handling this situation appeared to be to default to the wetland habitat when wetlands and waterbody margin habitats overlapped. In fact, many wildlife receptors probably forage across both waterbody margin and wetland habitats, whereas other species show a preference for or tend to avoid the wetland habitat. Thus, wetland habitats were delineated whenever they were indicated, including within a waterbody margin. The wetlands occurring near waterbodies were not subsumed in the stream corridor or lake and pond margin habitat.

3.4.2 Assignment of Receptors to Habitats

Ecological risk is assessed for the wildlife receptors expected to be present within an AOI. A receptor is placed within the AOI if the AOI is located in the receptor's geographic range and includes suitable habitat to support the receptor species.

The 3MRA modeling system was designed to support national analyses; therefore, the list of receptor species was developed to represent ecological regions throughout the contiguous United States. Within each AOI, the receptor species were assigned to represent all of the faunal classes, trophic levels, and feeding strategies that are typical of terrestrial and margin habitats, respectively. The simple food webs created for the terrestrial and margin habitats provided the context for receptor selection and were used to define the relationships between predators and prey. National applicability was achieved primarily by selecting species that are widely distributed throughout the contiguous United States, and then adding species to cover as many ecological regions as possible. Several criteria were established as part of the selection process, including geographical distribution, availability of data pertinent to exposure (e.g., body weight, dietary preferences), and representation of the faunal classes and functional niches represented in the terrestrial and margin food webs. In some instances, receptor species were added to represent food web components in regions where "common" species were not likely to be found.

For example, the mule deer was selected as a large herbivore representing regions where the white-tailed deer is not distributed. Similarly, the eastern cottontail rabbit and the black-tailed jackrabbit were both included in the grasslands receptor group in order to provide a small mammalian herbivore in temperate regions of the eastern United States and the drier western regions. Based on information describing Bailey's ecological regions (Bailey, 1994), receptor species were assigned to habitats within the AOI only if (1) the species was documented to occur in the ecological region containing the site, and (2) the species represented a component of the food web.

In assigning ecological receptors to habitats within a given AOI, it is important to recognize the implicit assumption with respect to species occurrence. Specifically, it is assumed that all receptor species occur in the representative habitats to which they are assigned regardless of the AOI's position in the landscape. That is, if a forest habitat is delineated at a site, all the species included in the terrestrial food web for the forest habitat that occur in that particular region are assumed to be present. Although the simple food webs represent the major trophic elements and feeding strategies that are likely present in a representative habitat, the food webs are simplifications of what may be very different structures. In fact, it is unlikely that all of the receptor species would be present, particularly those that are less adapted to human impacts and development. For example, the black bear is included in the forest habitat receptor group and is assessed at sites within its geographic range where forest habitat is indicated. However, the black bear requires tracts of land significantly larger than the AOI, and this pattern may not occur to an appreciable extent in areas where the land uses indicate an industrial base. As a result, the list of receptors assigned to each habitat delineated within the AOI does not reflect differences in species diversity related to habitat quality. Although small habitat patches were connected within the AOI to simulate typical habitat use by wildlife, "habitat bridging" reflected in the site layout files does not address the issue of habitat quality and species occurrence.

3.5 Summary

The delineation of habitats allows for the placement of receptor species within the AOI. A substantial amount of data processing is required, including the assignment of receptor species based on habitat and region, and the placement of the receptor species' home ranges at each site. These steps are described in detail in Volume II of this report (U.S. EPA, 2003) and in Section 15 of this document.

The spatial delineation of habitats throughout an AOI and the assignment of species to these habitats provides an overall approach for the national assessment of ecological risk. The variability in species affected by a contaminant release, both within a site and between sites, is captured by this approach.

3.6 References

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