4. SCREENING-LEVEL PROBLEM FORMULATION AND ECOLOGICAL EFFECTS EVALUATION (ERAGS STEP 1)

This initial ecological screening assessment includes a screening-level problem formulation and an ecological-effects evaluation (USEPA, 1997a), which are presented in this chapter. These components are then used to complete the screening-level exposure estimate and risk calculations (ERAGS Step 2) contained in Chapter 5.

The site description, required for Step I of the FWIA (NYSDEC, 1994a) and used to assist in this screening-level problem formulation, was included in Chapter 3. A summary of chemical contamination at the site and around the lake, which is a component of ERAGS Step 1, has been included in Chapter 2 and in the remedial investigation (RI) report (TAMS, 2002b).

Honeywell largely completed the initial screening-level problem formulation for Onondaga Lake during preparation of the Onondaga Lake RI/FS Work Plan (PTI, 1991), based on a review of existing information for the lake. As part of the work plan, Honeywell developed a conceptual site model, identified preliminary chemicals of potential concern/stressors of potential concern (COPCs/SOPCs) and representative ecological receptors, defined assessment and measurement endpoints, formulated the objectives of the BERA, and developed a study design to collect the data needed to satisfy the BERA objectives.

Several elements of the screening-level problem formulation have been refined by Honeywell and NYSDEC since the work plan was completed in 1991, based on information collected during the 1992 and 1999/2000 Honeywell RI field investigations and more recent investigations, such as the 2002 sampling conducted by NYSDEC.

In developing the contents of this BERA, several exchanges have occurred between Honeywell (formerly AlliedSignal) and NYSDEC since the RI/FS Work Plan was finalized in 1991 (e.g., PTI, 1995a,b; Larson, pers. comm., 1995, pers. comm., 1996). The relevant content of these exchanges, NYSDEC comments (submitted in March 1999) on the May 1998 draft BERA, and the results of the subsequent meetings have been incorporated into this document.

The following sections present the major components of the initial problem formulation, including:

- Development of a preliminary conceptual site model, including contaminant fate and transport and complete exposure pathways.
- Preliminary identification of COPCs/SOPCs.
- Preliminary identification of representative ecological receptors.
- Preliminary identification of assessment and measurement endpoints.

- Preliminary ecological-effects evaluation and the establishment of conservative contaminant exposure levels.

4.1 Preliminary Conceptual Site Model

The preliminary conceptual site model for the Onondaga Lake BERA, presented in Figure 4-1, is the final version of the conceptual model presented in the Onondaga Lake RI/FS Work Plan (PTI, 1991). The preliminary conceptual site model identifies the following:

- Primary and secondary sources.
- Potential pathways.
- Major chemical/stressor groups.
- Potential exposure routes and receptors.
- Effects to be initially evaluated as part of the BERA.

As described in Chapter 1, Comprehensive Environmental Response Compensation and Liability Act of 1980- (CERCLA-) related stressors are referred to as chemicals, whereas non-CERCLA stressors, such as chloride, phosphorus, depleted dissolved oxygen (DO), and reduced water transparency, are referred to as stressors. The term "contaminants" is also used throughout this document to describe these substances, and chemical contaminants in particular.

Through the primary conceptual model, Honeywell identified that primary sources of contaminants and stressors to Onondaga Lake are point-source discharges, including tributaries, and non-point sources, including groundwater. Although the atmosphere may be an additional source of some substances, atmospheric inputs into the lake are considered minor as compared to point-source and other non-point sources discharges. Significant point-source discharges to the lake, including tributaries, are the Honeywell sources (e.g., the East Flume and Interstate 690 [I-690] outfalls) and the Metropolitan Syracuse Sewage Treatment Plant (Metro). The larger tributaries to the lake are Onondaga Creek, Ninemile Creek, Ley Creek, and Harbor Brook. Smaller tributaries include Bloody Brook, Sawmill Creek, and Tributary 5A. Honeywell facilities and disposal areas near Onondaga Lake are described in Chapter 2 of this report and in the RI (TAMS, 2002b).

After chemical contaminants enter Onondaga Lake, they are distributed among the water, sediments, floodplain soils (including wetlands), and biota. Contaminants enter the sediment by deposition or precipitation from the water column. Deposition is usually facilitated by adsorption to particles or incorporation into planktonic organisms that eventually die and sink to the bottom of the lake. Precipitation of substances is controlled primarily by the temperature and chemical composition of the lake water. Contaminants are deposited onto adjacent wetlands and floodplain soils from lake tributaries during high flows or via hydrologic connections with the lake.

Water, sediment, soil, and biota may then become secondary sources of contamination by releasing compounds to aquatic, terrestrial, and human receptors (Figure 4-1). Receptors may be exposed to contaminants by absorption from the water column through dermal layers or respiratory organs and ingestion via food, sediment, soil, or water.

The stressors in Onondaga Lake include nutrients (i.e., nitrite, phosphorous, sulfide), calcite, chloride, salinity, ammonia, depleted DO, reduced transparency, and wave scour. Calcium, chloride, and sodium are associated with ionic waste inputs into the lake from former Honeywell facilities, as well as natural sources. Many of the lake nutrients originate from sewage that is discharged from the Metro outfalls or the combined sewer overflows (CSOs) that discharge into lake tributaries (e.g., Onondaga Creek, Ley Creek, Bloody Brook, and Harbor Brook). Within the lake, secondary sources of stressors include water and sediment. The extremely high concentrations of calcite in the lake are due to soda-ash manufacturing activities (see the RI for details [TAMS, 2002b]).

Stressors, such as salinity, reduced transparency, and depleted DO, are associated with the pollution of Onondaga Lake. Wave-scour stress can be associated with lake-level management, although over an approximately ten-year period from 1983 to 1992 the lake level has been fairly consistent, with a difference between minimum lake elevations of 0.6 ft (18 cm) and a difference between maximum lake elevations of 3.2 ft (98 cm) (Table 3-1). The Phoenix Dam regulates the water level of Onondaga Lake.

4.1.1 Preliminary Identification of Chemicals/Stressors of Potential Concern

Preliminary COPCs/SOPCs are divided into two categories: 1) those identified by Honeywell in the RI/FS Work Plan that was finalized in 1992, and 2) those based on results of data collected by Honeywell during the 1992, 1999, and 2000 RI field investigations, or on results of more recent investigations, such as the 2002 wetland sampling, conducted by NYSDEC (Table 4-1). As described earlier, the COPCs/SOPCs include both CERCLA-related and non-CERCLA-related chemicals and stressors.

4.1.1.1 Chemicals of Potential Concern

The chemical contaminant that has historically received the most attention in Onondaga Lake is mercury, which was used in Honeywell's chlor-alkali process. However, numerous other potentially toxic chemicals, including cadmium; chromium; copper; lead; nickel; zinc; polychlorinated biphenyls (PCBs); polycyclic aromatic hydrocarbon (PAH) compounds; benzene, toluene, ethylbenzene, and xylenes (BTEX); chlorinated benzenes; and dioxins/furans have been found at elevated concentrations in various lake media. A preliminary list of chemicals of potential concern is provided in Table 4-1, with the COPCs identified in the original work plan listed separately. The screening-level exposure estimates consider all contaminants detected during sampling, which is a larger group of compounds than identified in this preliminary step (see Chapter 5). Chemicals with the potential to bioaccumulate or biomagnify in the food chain are of particular concern in the ecological risk assessment.

4.1.1.2 Stressors of Potential Concern

The stressors in Onondaga Lake include nutrients (i.e., nitrite, phosphorus, sulfide), calcium, chloride, salinity, ammonia, depleted DO, reduced transparency, and oncolites (Table 4-1). Of these, depleted DO, nitrogen, phosphorus, and sulfide were added to the initial work plan SOPC list after potential problems related to those eutrophication-related variables were identified (Effler et al., 1996a). Salinity was added after concerns were expressed that this variable may have affected various kinds of biological communities in the lake (Auer et al. 1996a). Oncolites were added after they were identified as a potential limiting factor to macrophytes in shallow parts of Onondaga Lake (Auer et al., 1996a).

4.1.1.3 Ionic Waste Discharges

A class of substances that has been historically discharged to Onondaga Lake is the ionic waste that was produced as a result of Honeywell's soda-ash manufacturing process and pumped to the Honeywell wastebeds in the form of a slurry (5 to 10 percent suspended solids). Ionic waste overflow from some, if not all, of the Honeywell wastebeds has drained off and entered Onondaga Lake over the last 100 years (PTI, 1991). The overflow, contaminated with calcium, chloride, and sodium ions entered the lake, primarily via Ninemile Creek (Effler and Harnett, 1996). Solvay waste was also discharged into the lake (e.g., via the East Flume; see RI Chapter 4, Section 4.5.1 [TAMS, 2002b]), with the solids forming a substantial delta in the area of the lake in front of Wastebed B. See Chapter 4 of the Onondaga Lake RI report for additional information on the Solvay Wastebeds and the Honeywell in-lake waste disposal.

Although the amount of ionic waste entering the lake has decreased since the 1987 closure of the Honeywell facility, large quantities of ionic waste remain in and continue to be released to the lake. The various components of this waste and the potential risks they pose to ecological receptors in and around the lake are evaluated in this BERA. For evaluation purposes, ionic waste is considered as part of the total input of individual ions (e.g., calcium, chloride), rather than as components of a separate class of substances termed "ionic waste." The potential risks of ionic waste are evaluated in the BERA as follows:

- All ions: these chemicals were evaluated as a group in the BERA as components of the salinity of lake water, which undermines water quality. These chemicals were also evaluated as a group in the RI as potential contributors to lake stratification.

- Chloride: this chemical was evaluated individually as a stressor in lake and tributary water because it has been found to be toxic at elevated concentrations to various groups of aquatic organisms.

- Calcium: this chemical was evaluated individually as a stressor in sediments, due to the contamination of lake sediments with calcium, as well as the formation of oncolites. Oncolites have formed in the lake as a result of the calcium-contaminated discharge of ionic waste during the production of soda ash (Dean and Eggleston, 1984). Oncolite formation is likely to adversely affect fish spawning success and/or impede the establishment of macrophyte communities. Calcite precipitates alter aquatic habitats in Onondaga Lake by reducing transparency in the lake, which causes reductions in photosynthesis.

4.1.2 Preliminary Identification of Ecological Receptors

The key groups of ecological receptors considered in the BERA include representatives of major trophic groups that are found in and around Onondaga Lake. These groups, which were identified in the Onondaga Lake RI/FS Work Plan (PTI, 1991) and refined in later documents and through discussions with NYSDEC, include:

- Aquatic macrophytes.
- Phytoplankton.
- Zooplankton.
- Terrestrial plants.
- Benthic macroinvertebrates.
- Amphibians and reptiles.
- Fish.
- Insectivorous birds, such as the tree swallow (*Tachycineta bicolor*).
- Benthivorous birds, such as the mallard (*Anas platyrhynchos*).
- Piscivorous birds, such as the belted kingfisher (*Ceryle alcyon*), great blue heron (*Ardea herodias*), and osprey (*Pandion haliaetus*).
- Carnivorous birds, such as the red-tailed hawk (*Buteo jamaicensis*).
- Insectivorous mammals, such as the little brown bat (*Myotis lucifugus*) and short-tailed shrew (*Blarina brevicauda*).
- Piscivorous mammals, such as the mink (*Mustela vison*) and river otter (*Lutra canadensis*).

Groups that are not covered by these receptors, such as herbivorous birds and mammals and omnivorous birds and mammals, are considered to be at lower risk than some of the receptors selected, based on their feeding habits. Generally, concentrations of bioaccumulative contaminants are lower in plants and the animals feeding on them than in higher-level trophic organisms. Therefore, use of the receptors identified above is considered to be protective of most of the flora and fauna found in and around Onondaga Lake.

4.1.3 Preliminary Identification of Assessment and Measurement Endpoints

The preliminary assessment and measurement endpoints evaluated in this BERA are presented in Table 4-2.

4.1.3.1 Assessment Endpoints

Assessment endpoints are explicit expressions of the actual environmental values that are to be protected, operationally defined by an ecological entity and its attributes (USEPA, 1998). They are expressed in terms of the ecological receptor (e.g., local population of a particular species, community of organisms, or other ecosystem component) and an attribute (e.g., survival or reproduction). Communities and populations selected for the endpoints represent receptors in the absence of COPC and SOPC inputs. Assessment endpoints include:

- Sustainability of an aquatic macrophyte community that can serve as a shelter and food source for local invertebrates, fish, and wildlife.
- Sustainability of a phytoplankton community that can serve as a food source for local invertebrates, fish, and wildlife.
- Sustainability of a zooplankton community that can serve as a food source for local invertebrates, fish, and wildlife.
- Sustainability of a terrestrial plant community that can serve as a shelter and food source for local invertebrates and wildlife.
- Sustainability of a benthic invertebrate community that can serve as a food source for local fish and wildlife.
- Sustainability (i.e., survival, growth, and reproduction) of local fish populations.
- Sustainability (i.e., survival, growth, and reproduction) of local amphibian and reptile populations.
- Sustainability (i.e., survival, growth, and reproduction) of local insectivorous bird populations.

- Sustainability (i.e., survival, growth, and reproduction) of local benthivorous waterfowl populations.

- Sustainability (i.e., survival, growth, and reproduction) of local piscivorous bird populations.

- Sustainability (i.e., survival, growth, and reproduction) of local carnivorous bird populations.

- Sustainability (i.e., survival, growth, and reproduction) of local insectivorous mammalian populations.

- Sustainability (i.e., survival, growth, and reproduction) of local piscivorous mammalian populations.

Final assessment endpoints are selected in Step 3 of ERAGS, contained in Chapter 6 of this report.

4.1.3.2 Measurement Endpoints

Measurement endpoints are the measurable changes in an attribute of an assessment endpoint or in response to a chemical/stressor to which a receptor is exposed. Measurement endpoints include expressions such as toxicity test results, benthic community diversity measures, contaminant concentration in exposure media, and field observations. It is common practice to use more than one measurement endpoint to evaluate each assessment endpoint, when possible.

Specific measurement endpoints associated with each assessment endpoint are established in Step 3 of the ERAGS process, which is contained in Chapter 6 of this report. General measurement endpoints to be considered in this risk assessment relative to assessment endpoints are:

- Field observations of community structure and abundance (aquatic macrophyte, phytoplankton, zooplankton, benthic invertebrate, fish, amphibian, and reptile) in relation to measured concentrations of contaminants and stressors.

- Measured concentrations of COPCs/SOPCs in surface water as compared to NYSDEC, USEPA, and other water quality standards, criteria, and guidance for aquatic life (see Chapter 3, Section 3.4).

- Measured concentrations of COPCs/SOPCs in sediment as compared to NYSDEC, USEPA, site-specific, and other sediment-quality guidelines for aquatic life (see Chapter 3, Section 3.4).

- Measured concentrations of COPCs in soil as compared to USEPA and/or other guidance (see Chapter 3, Section 3.4).

- Laboratory (greenhouse studies) and field experiments measuring macrophyte growth and survival.

- Sediment toxicity to aquatic invertebrates based on laboratory tests of field-collected sediments using standard laboratory test species and protocol for survival, growth, and reproductive endpoints.

- Benthic invertebrate community indices, such as richness, abundance, diversity, and biomass.

- Measured fish tissue concentrations as compared to toxicity values found in peer-reviewed literature.

- Observed effects on fish foraging and nesting.

- Field observations of deformation or disease in fish.

- Modeled dietary doses of COPCs, based on measured concentrations of COPCs in lake media (surface water, sediment, and prey), as compared to toxicity reference values (TRVs) for aquatic food-chain receptors.

- Modeled dietary doses of COPCs, based on measured concentrations of COPCs in lake-related media (surface water, soils, and prey), as compared to toxicity reference values for terrestrial food-chain receptors.

4.2 Screening-Level Ecological-Effects Evaluation

The screening-level ecological-effects evaluation establishes contaminant exposure levels that represent conservative thresholds for adverse ecological effects. For each complete exposure pathway, route, and contaminant, a screening ecotoxicity value is selected. Details of the ecological screening are provided in Appendix D. NYSDEC and USEPA values were the primary screening values used for surface water (Tables 4-3 [organics] and 4-4 [inorganics]), sediments (Tables 4-5 [dry weight] and 4-6 [organic carbon-normalized]), and soils (Table 4-7). These values were supplemented with values from the Ontario Ministry of the Environment (Persaud et al., 1993) and the Oak Ridge National Laboratory (ORNL) (Jones et al., 1997) for some media. Soil benchmarks developed by ORNL (Efroymson et al., 1997a) were used to screen plants (Table 4-8).

Toxicity values for fish tissue were not readily available; therefore, measures of toxicity in fish tissue from NYSDEC (Newell et al., 1987), the International Joint Commission (IJC) of the United States and Canada (IJC, 1988), and ORNL (Sample et al., 1996) were used for screening (Table 4-9).

For wildlife receptors a screening ecotoxicity value was selected for each complete exposure pathway, route, and contaminant. Consistent with USEPA guidance (1997a), no observed adverse effect level (NOAEL) toxicity values were used for avian and mammalian receptors, when available, to ensure that risk was not underestimated. When only lowest observed adverse effect level (LOAEL) toxicity values were available, a correction factor of 0.1 was applied. Table 4-10 contains toxicity values used to screen avian receptors and Table 4-11 contains values used for mammalian screening. The primary literature sources used to select toxicity values include Sample et al. (1996), Newell et al. (1987), and values presented in Honeywell's revised draft BERA (Exponent, 2001b).

For wildlife toxicity values, the most conservative value available for each class (e.g., avian, mammal) was used. When toxicity values were only available for one wildlife class (i.e., mammals or birds), those values were used for both classes for screening purposes only. If a toxicity value was not available for a compound, toxicity values for compounds with similar physical/chemical characteristics were used.

Several of the COPCs did not have any published toxicity values available, and alternate toxicity values were considered inappropriate. Therefore these compounds were not carried through to the final quantitative assessment performed for the risk characterization (Chapter10), but are discussed in Chapter 11, Uncertainty Analysis.