10. RISK CHARACTERIZATION (ERAGS STEP 7)

Risk characterization evaluates the likelihood of adverse effects occurring as a result of exposure to chemicals and/or stressors, and discusses the qualitative and quantitative assessment of risks to ecological receptors. Risk estimation integrates effects information (Chapter 9) with exposure profiles (Chapter 8) to provide an estimate of risk (this chapter) and related uncertainties (Chapter 11). Assessment endpoints and the associated measurement endpoints selected during problem formulation (Chapter 6) are evaluated to describe potential risks to receptors, as detailed below.

10.1 Assessment Endpoint: Sustainability of a Macrophyte Community That Can Serve as a Shelter and Food Source for Local Invertebrates, Fish, and Wildlife

10.1.1 Does the Macrophyte Community Structure Reflect the Influence of Chemicals of Concern/Stressors of Concern?

Measurement Endpoint: Comparison of the Onondaga Lake Macrophyte Community to Reference Lakes

As described in Chapter 9, Section 9.1, the macrophyte community of Onondaga Lake has exhibited low diversity and abundance since at least 1940. A typical lake in New York State has an average of 18 species of aquatic plants: 14 submerged, two floating-leaved, and two emergent species (Madsen et al., 1993), and the average eutrophic lake in New York State has 15 species of macrophytes (Madsen et al., 1993). Ten species of macrophytes are currently found in Onondaga Lake (Madsen et al., 1998). High salinity, low visibility, eutrophication, and the poor substrata of Onondaga Lake are likely to have been factors in the decline of species richness.

The density of macrophytes in Onondaga Lake is also quite low. Only 13 percent of 3,498 quadrants surveyed in 1991 had aquatic plants. Sago pondweed (*Potamogeton pectinatus*), a species able to tolerate high salinities, was the dominant, and often the only, species observed (Madsen et al., 1993). Onondaga Lake shows both reduced macrophyte abundance and diversity as compared to reference lakes (Madsen et al., 1993). These results indicate that macrophytes have been extirpated from many areas of Onondaga Lake. Even with remediation and revegetation efforts it could take years before the aquatic macrophytes fully recover.

10.1.2 Do the Chemicals/Stressors Present in Onondaga Lake Affect Macrophyte Growth and Survival?

Measurement Endpoint: Greenhouse Growth Studies and Macrophyte Transplant Studies

In a series of greenhouse studies described in Chapter 9, Section 9.1.1, Madsen et al. (1993, 1996) found that growth on the fertile reference sediment was significantly higher than growth on Onondaga Lake sediments. They predicted that improvement in water clarity or quality alone would not improve plant growth, as sediment degradation is directly related to the input of calcium chloride ($CaCl_2$) into the lake and the resulting calcium carbonate deposition. Even plant leaves and stems were coated with calcium carbonate particles (Madsen et al., 1993).

The macrophyte transplant conducted in 1992 showed macrophyte survival to be minimal at Onondaga Lake, in contrast to higher survival rates seen at the reference lake (Otisco Lake). Habitat restoration efforts are underway, but the limiting factors present in the lake make it difficult to introduce new species and for the macrophytes currently in the lake to spread.

The Onondaga Lake macrophyte community is considered to be adversely affected by the ionic waste discharged into Onondaga Lake. This waste has increased salinity concentrations, decreased water transparency, degraded lake sediments, and created conditions for oncolite formation. The combination of wave action, sediment characteristics, and sparse vegetation results in low plant colonization rates (Madsen et al., 1998).

10.1.3 Do Measured Concentrations of Chemicals and Stressors in Surface Water Exceed Standards, Criteria, and Guidance for the Protection of Aquatic Organisms?

Measurement Endpoint: Comparison of Measured Surface Water Concentrations to Water Quality Values and Qualitative Evaluation of Narrative Standards

There are no standards that specifically address risk to macrophytes, and therefore the potential risk to macrophytes due to exceedances of water quality standards is unknown. New York State has narrative water quality standards (6 NYCRR Part 703.2), which regulate physical parameters and aesthetic conditions that impair the best use of the surface water but may not be physically measurable.

The very high concentrations of calcite ($CaCO_3$) in the lake result in contravention of several of these narrative standards including the prohibitions for suspended, colloidal or settleable solids, and turbidity. When calcite becomes resuspended into the water column during normal wave action, the standard for turbidity is exceeded. Calcite coming out of solution slowly settles to the bottom. The high concentrations of calcite that have been deposited onto the surfaces of macrophytes in Onondaga Lake in the past may have been sufficient to completely coat plants (Auer et al., 1996a). This mechanism may have also been responsible for, or contributed to, the disappearance of charophytes from Onondaga Lake (Dean and Eggleston, 1984). The decrease in macrophytes caused by calcite deposition and formation of oncolites has impaired the best use of the water (Chapter 3, Section 3.2.4.1) through impairment of the fish population, as described in more detail in Section 10.6.2.

High concentrations of nutrients may also influence macrophyte growth. The high concentrations of ammonia, nitrite, phosphorus, and sulfide in Onondaga Lake are in part a result of total loads received from the lake from the Metropolitan Syracuse Sewage Treatment Plant (Metro) (e.g., Matthews et al., 2000). Post-1992 sampling continues to reflect a eutrophic lake, but conditions appear to have improved due to upgrades to the Metro facility and closure of the chlor-alkali facility (which has led to less alteration of the density stratification/mixing regime). Currently, upgrades to Metro are being guided by an Amended Consent Judgment (ACJ) from 1998 and decreases in effluent concentrations have been made in the last several years (e.g., Matthews et al., 2001). Under the ACJ, Onondaga County is to reduce stressors in Metro effluent over two intervals by December 2012.

The high salinity of Onondaga Lake may also preclude some macrophyte species. Salinity has dropped from 3.3 parts per thousand (ppt) in 1981 to 1.1 ppt (Effler et al., 1996; Onondaga Lake Partnership [OLP], 2002), but is still over an order-of-magnitude greater than the average world river salinity (0.1 ppt).

Low dissolved oxygen (DO) can be a factor in limiting macrophyte growth. However, the Onondaga Lake littoral zone (where macrophytes are found) is considered to extend out into the lake 100 m, or to a depth of 3 m (Madsen et al., 1993). Levels of DO remain at acceptable levels at these depths, with the exception of the week of fall turnover. Even during this period, the lowest recorded DO concentration was 3.4 mg/L. Therefore, DO is not considered a major limiting factor to macrophyte growth.

Visibility may also limit macrophyte growth. In 1992, Secchi depths were generally less than 2 m throughout the year and increased to up to almost 6 m after the fall turnover (Chapter 8, Figure 8-21). The 1997 to 2001 data indicate improvement in visibility, with increased visibility in May and June (Appendix I, Table I-20).

10.2 Assessment Endpoint: Sustainability of a Phytoplankton Community That Can Serve as a Food Source for Local Invertebrates, Fish, and Wildlife

10.2.1 Does the Phytoplankton Community Structure Reflect the Influence of Chemicals of Concern/Stressors of Concern?

Measurement Endpoint: Field Observations of the Onondaga Lake Phytoplankton Community

In general, the characteristics of the phytoplankton communities of Onondaga Lake have reflected the polluted and eutrophic nature of the lake. Concentrations of nutrients have also influenced both the types of species found in the lake and the densities of those species (Auer et al., 1996a).

Contaminants present in Onondaga Lake may also affect the phytoplankton community secondarily by influencing the lake community of species feeding on phytoplankton, such as zooplankton (see Section 10.3), which then affect phytoplankton abundance and diversity. This in turn may impact the number and species of higher trophic levels, such as fish.

Although the effect of mercury contamination on the phytoplankton community is unknown, it is evident from the bioaccumulation investigation (PTI, 1993b) that mercury accumulates in phytoplankton and can be passed on to animals feeding on phytoplankton in Onondaga Lake.

10.2.2 Do Measured Concentrations of Chemicals and Stressors in Surface Water Exceed Standards, Criteria, and Guidance for the Protection of Aquatic Organisms?

Measurement Endpoint: **Comparison of Measured Surface Water Concentrations to Water Quality Values and Qualitative Evaluation of Narrative Standards**

There are no standards that specifically address risk to phytoplankton, and therefore the potential risk to phytoplankton due to exceedances of water quality standards is unknown. The summed concentration of total ammonia and nitrate has continuously exceeded levels associated with limitation of phytoplankton growth (Chapter 8, Figure 8-10). Concentrations of nitrate increase in the epilimnion during the summer and early fall and decrease in the hypolimnion during this period. Narrative water quality standards (6 NYCRR Part 703.2) have been exceeded in the lake, specifically those for settleable solids (e.g., calcite), which may physically impact phytoplankton.

10.3 Assessment Endpoint: Sustainability of a Zooplankton Community That Can Serve as a Food Source for Local Invertebrates, Fish, and Wildlife

10.3.1 Does the Zooplankton Community Structure Reflect the Influence of Chemicals of Concern/Stressors of Concern?

Measurement Endpoint: **Studies of Historical Changes of the Onondaga Lake Zooplankton Community and Associated Contaminant/Stressors**

The composition of zooplankton communities in Onondaga Lake has been affected by stressors, including salinity and calcium carbonate deposition. Chloride/salinity levels of Onondaga Lake before the closure of the Honeywell facility were near the upper limit for freshwater organisms, which affected the osmoregulation capabilities of resident zooplankton. As a result of the high salinity and pollution, native species of Daphnia were replaced by exotic high-salinity-tolerant species such as *Daphnia exilis* and *D. curvirostris* during the peak industrial pollution period from the 1950s to the 1980s (Hairston et al., 1999; Duffy et al., 2000). Calcium carbonate particles may have also influenced zooplankton community structure by physically interfering with zooplankton feeding (Auer et al., 1996a).

It has been hypothesized that the successful invasion of exotic Daphnia species was heavily influenced by the absence of effective feeding on zooplankton by fish, as fish species diversity was lower during periods of high salinity (Hairston et al., 1999). As the salinity declined in the 1980s, exotic Daphnia species disappeared and were replaced by native species, such as *D. pulicaria* and *D. ambigua* (Hairston et al., 1999). Despite recent increases in zooplankton diversity, the zooplankton assemblage of the lake remains depauperate compared to other lakes in the region (Auer et al., 1996a). The period of peak mercury concentrations in the sediments (based on ^{210}Pb dating) coincides with zero hatching success of *D. exilis* eggs in laboratory monitoring (Hairston et al., 1999). Whether mercury in the water column caused the eggs to become non-viable at the time they were produced, or mercury and/or other chemicals and stressors in the sediments made the eggs non-viable over the burial period, is uncertain.

10.3.2 Do Measured Concentrations of Chemicals and Stressors in Surface Water Exceed Standards, Criteria, and Guidance for the Protection of Aquatic Organisms?

Measurement Endpoint: **Comparison of Measured Surface Water Concentrations to Water Quality Standards, Criteria, and Guidance and Qualitative Evaluation of Narrative Standards**

Selected COCs detected in lake surface water in 1992 and 1999 were compared to NYSDEC and USEPA water quality standards, criteria, and guidance in Appendix B (see Chapter 5, Table 5-3 for summary). The frequency of exceedances in Onondaga Lake and tributary water varied by contaminant, year, location, and depth, as summarized in the following paragraphs. The total number of samples analyzed for each COC is provided in Table D-1 for 1992 samples, and Table D-46 for 1999 samples. As discussed in Chapter 8, Section 8.1.1, the 1999 sampling was oriented toward collecting data for the Onondaga Lake Human Health Risk Assessment (HHRA) (TAMS, 2002a), and focused on areas where people may be exposed to lake water.

With the exception of mercury, all COCs (i.e., barium, copper, lead, manganese, zinc, chlorobenzene, dichlorobenzenes, trichlorobenzenes, and bis[2-ethylhexyl]phthalate), exceeded USEPA chronic aquatic or Tier II water quality criteria (Chapter 4, Table 4-4).

There were exceedances of mercury standards in a total of 167 samples, 147 of which were collected in 1992 and 20 of which were collected in 1999. Mercury concentrations in Onondaga Lake in 1992 and 1999 exceeded the NYSDEC mercury wildlife value, as discussed below, but not the chronic water quality value for the protection of aquatic organisms.

The 147 surface water samples from 1992 that exceeded the NYSDEC mercury wildlife standard were collected from the following locations in the lake, its tributaries, and Metro discharge (see Chapter 7, Figure 7-1):

- 20 from the East Flume.
- 20 from Tributary 5A.
- 19 from Harbor Brook.
- 18 from Ninemile Creek.
- 16 from Onondaga Creek.
- 14 from Metro.
- 12 from Ley Creek.
- 12 from the lake outlet.
- 8 from the southern basin.
- 5 from the northern basin.
- 2 from Bloody Brook.
- 1 from Sawmill Creek.

Of these, four surface water samples analyzed for dissolved mercury exceeded the NYSDEC wildlife standard (three taken from the southern basin and one taken from the northern basin). Dissolved mercury was not measured in the tributaries in 1992.

The 20 surface water samples from 1999 that were measured for total mercury and exceeded the NYSDEC wildlife standard were collected at the following locations in the lake (see Chapter 2, Figure 2-17 of the Remedial Investigation report [TAMS, 2002b] for locations and station designations, as discussed below):

- Five from the southern basin.
- Three from the northern basin.
- Two from Lake Park at Lakeland.
- Two from Lake Park at Galeville.
- One at the Willis Avenue Lakeshore exposure area.
- One at the observed fishing area near Tributary 5A.
- One at the access from fairgrounds.
- One at the beach access near Ninemile Creek.
- One from near the mouth of Harbor Brook.
- One from the park/picnic/playground area south of Sawmill Creek.
- One from the Liverpool boat ramp area.
- One from the lake outlet.

Of these, seven surface water samples analyzed for dissolved mercury exceeded the NYSDEC wildlife standard: two at the access from the fairgrounds and one apiece at the beach access near Ninemile Creek, Lake Park at Lakeland, the park/picnic area/playground area south of Sawmill Creek, the Liverpool boat ramp area, and the lake outlet.

For COCs other than mercury, exceedances were as discussed below.

- **Barium:** All four lake water samples analyzed for barium in 1992 exceeded the USEPA Tier 2 Aquatic Life barium standard. No surface water samples from 1 m or less were taken, so samples taken at depths of 6 and 12 m were used for barium comparisons.

- **Copper:** There were 28 surface water exceedances of the NYSDEC chronic copper standard in 1992. Of these, 11 occurred in Tributary 5A, five apiece were in Ley Creek and Harbor Brook, two apiece were in Metro, Ninemile Creek, and the East Flume, and one was in Bloody Brook. There were also 18 exceedances of the NYSDEC acute standard. Of these, nine occurred in Tributary 5A, four were in Harbor Brook, three were in Ley Creek, and one apiece were in the East Flume and Bloody Brook. No open lake surface water samples exceeded the NYSDEC copper standards in 1999.

- **Lead:** There were 35 surface water exceedances of the NYSDEC chronic lead standard in 1992. Nine of these occurred in Tributary 5A, eight were in Ley Creek, six were in Harbor Brook, four were in Ninemile Creek, three apiece were in the East Flume and Onondaga Creek, and one apiece were in Bloody Brook and the lake outlet. No surface water samples exceeded the NYSDEC lead standards in 1999.

- **Manganese:** There were 12 surface water exceedances of the USEPA Tier 2 Aquatic Life manganese standard, including four in 1992 (one each in the southern basin, Ley Creek, Ninemile Creek, and Tributary 5A) and eight in 1999 (two apiece in the southern and northern basins, and one each in the lake outlet, the access from fairgrounds, Lake Park at Lakeland, and Lake Park at Galeville).

- **Zinc:** There were 22 surface water exceedances of the NYSDEC chronic zinc standard in 1992, only one of which was recorded in the lake (southern basin). The remainder of exceedances were detected in the tributaries, with nine exceedances in the East Flume, six in Tributary 5A, four in Harbor Brook, one in Ley Creek, and one in Bloody Brook. All nine exceedances of the NYSDEC acute zinc standards were in the tributaries, with four in the East Flume, two in Tributary 5A, one in Harbor Brook, one in Ley Creek, and one in Bloody Brook. Zinc was not analyzed in 1999.

- **Chlorobenzene:** There was one surface water exceedance of the NYSDEC chronic chlorobenzene standard in 1992 at the East Flume and one in 1999 at the Willis Avenue Lakeshore area.

- **Dichlorobenzenes:** There were 14 exceedances of the NYSDEC chronic dichlorobenzenes standard in 1992, 12 of which were in the East Flume and two of which were in Harbor Brook. In 1999 there was one exceedance, which occurred at the Willis Avenue Lakeshore area.

- **Trichlorobenzenes:** There was one exceedance of the NYSDEC chronic trichlorobenzenes standard in the southern basin in 1992. Trichlorobenzenes were not analyzed in 1999.

- **Bis(2-ethylhexyl)phthalate:** One of the four lake water samples analyzed for bis(2-ethylhexyl)phthalate (BEHP) in 1992 exceeded the USEPA chronic aquatic life standard. No surface water samples from 1 m or less were collected, so samples taken at depths of 6 and 12 m were used for BEHP comparisons. BEHP was not analyzed in 1999.

Stressors of Concern

Stressors in Onondaga Lake generally exceeded guidelines (when available) or background levels (see Section 8.1 and Appendix B). Chloride, ammonia, nitrite, phosphorus, and sulfide have consistently exceeded water quality criteria. Although lake salinity has dropped to 1.1 ppt, this value is still an order-of-magnitude greater than the average world river salinity (0.1 ppt). Phosphorus and sulfide concentrations have also consistently exceeded the NYSDEC standards from 1992 to 2001. Narrative water quality standards (6 NYCRR Part 703.2) have been exceeded in the lake, specifically those for settleable solids (e.g., calcite), which may physically impact zooplankton.

10.3.3 Do Measured Concentrations of Chemicals and Stressors in Sediments Exceed Criteria and/or Guidelines for the Protection of Aquatic Organisms?

Measurement Endpoint: **Comparison of Measured Sediment Concentrations to Sediment Guidelines**

Concentrations of COCs/SOCs in sediments were used as a measurement endpoint to evaluate whether certain zooplankton life stages (e.g., eggs) that spend extended periods in contact with Onondaga Lake sediments could be adversely affected by chemicals and stressors.

Concentrations of COCs in sediments exceeded guidelines for all sediment COCs (i.e., antimony, arsenic, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver, vanadium, zinc, benzene, chlorobenzene, dichlorobenzenes [total], trichlorobenzenes [total], ethylbenzene, toluene, xylenes [total], hexachlorobenzene, total polycyclic aromatic hydrocarbons [PAHs], phenol, dibenzofurans, chlordanes, heptachlor/heptachlor epoxide, dieldrin, DDT and metabolites, total PCBs, and dioxins/furans).

The maximum surface sediment arsenic concentration of 47 mg/kg was detected in 2000 along the southwestern shore at Station S333. This value exceeded the NYSDEC and Ontario Ministry of the Environment (OME) lowest effect level (LEL) of 6 mg/kg, the National Oceanic and Atmospheric Administration (NOAA) effects range-low (ER-L) of 8.2 mg/kg, the USEPA toxic equivalent concentration (TEC) of 12 mg/kg, and the NYSDEC and OME severe effect level (SEL) of 33 mg/kg. Ten out of 19 samples (53 percent) analyzed for arsenic in 1992 and 59 out of 85 samples (69 percent) analyzed for arsenic in 2000 exceeded the site-specific probable effect concentration (PEC) of 2.4 mg/kg calculated for Onondaga Lake (see Section 10.5.3 and Chapter 9, Tables 9-13, 10-2, and 10-3).

The maximum surface sediment cadmium concentration of 15 mg/kg was detected in 2000 at Station S322, near the mouth of Ley Creek. This value exceeded the NYSDEC and OME LEL of 0.6 mg/kg, the USEPA TEC of 0.6 mg/kg, the NOAA ER-L of 1.2 mg/kg, the NYSDEC and OME SEL of 10 mg/kg, and the USEPA PEC of 11.7 mg/kg. Forty-five out of 114 samples (39 percent) analyzed for cadmium in 1992 and 23 out of 85 samples (27 percent) analyzed for cadmium in 2000 exceeded the site-specific PEC of 2.4 mg/kg calculated for Onondaga Lake.

The maximum surface sediment chromium concentration of 4,180 mg/kg was detected in 2000 at Station S327, near the mouth of Tributary 5A. This value exceeded the NYSDEC LEL and OME LEL of 26 mg/kg, the USEPA TEC of 56 mg/kg, the NOAA ER-L of 81 mg/kg, and the NYSDEC and OME SEL of 110 mg/kg, the USEPA PEC of 159 mg/kg, and the USEPA high no-effect concentration (NEC) of 312 mg/kg. Fifty-four out of 114 samples (47 percent) analyzed for chromium in 1992 and 40 out of 85 samples (47 percent) analyzed for chromium exceeded the site-specific PEC of 50 mg/kg calculated for Onondaga Lake.

The maximum surface sediment lead concentration of 750 mg/kg was detected in 2000 near the mouth of Harbor Brook (Station S352). This value exceeded the NYSDEC and OME LEL of 31 mg/kg, the USEPA TEC of 34 mg/kg, the NOAA ER-L of 47 mg/kg, USEPA NEC of 69 mg/kg, the NYSDEC SEL of 110 mg/kg, the OME SEL of 250 mg/kg, and the USEPA PEC of 396 mg/kg. Seventy out of 114 samples (61 percent) analyzed for lead in 1992 and 46 out of 85 samples (54 percent) analyzed for lead in 2000 exceeded the site-specific PEC of 35 mg/kg calculated for Onondaga Lake.

The maximum surface sediment mercury concentration of 78 mg/kg was detected in 2000 offshore from the East Flume outlet (Station S344). This value exceeded the NYSDEC LEL and NOAA ER-L of 0.15 mg/kg, the OME LEL of 0.2 mg/kg, the NYSDEC SEL of 1.3 mg/kg and the OME SEL of 2 mg/kg. Sixty out of 114 surface sediment samples (53 percent) analyzed for mercury in 1992 and 86 out of 157 samples analyzed for mercury in 2000 (55 percent) exceeded the site-specific PEC of 2.2 mg/kg calculated for Onondaga Lake.

The maximum surface sediment nickel concentration of 1,670 mg/kg was detected near the mouth of Tributary 5A (Station S327). This value exceeded the NYSDEC and OME LEL of 16 mg/kg, the NOAA ER-L of 21 mg/kg, the USEPA NEC of 38 mg/kg, the USEPA PEC of 39 mg/kg, the USEPA TEC of 40 mg/kg, the NYSDEC SEL of 50 mg/kg and the OME SEL of 75 mg/kg. Seventy-two out of 114 samples (63 percent) analyzed for nickel in 1992 and 50 out of 85 samples (59 percent) analyzed for nickel in 2000 exceeded the site-specific PEC of 16 mg/kg calculated for Onondaga Lake.

The maximum surface sediment dichlorobenzene (sum) concentration of 1,270 μg/gOC was detected in Onondaga Lake in 2000 offshore from the East Flume outlet (Station S344). This concentration exceeded the NYSDEC benthic aquatic life chronic toxicity sediment criterion of 12 μg/gOC and the acute toxicity criterion of 120 μg/gOC. Seventeen out of 114 samples (15 percent) analyzed for dichlorobenzenes in 1992 and 34 out of 85 (40 percent) analyzed for dichlorobenzenes in 2000 exceeded the site-specific PEC of 239 μg/kg calculated for Onondaga Lake.

The maximum surface sediment trichlorobenzene (sum) concentration of 261 μg/gOC was detected in 2000 offshore from the East Flume outlet (Station S344). This value exceeded the NYSDEC benthic aquatic life chronic toxicity sediment criterion of 91 μg/gOC and the acute toxicity criterion of 910 μg/gOC. Three out of 114 samples (3 percent) analyzed for trichlorobenzenes in 1992 and 5 out of 85 samples (6 percent) analyzed for trichlorobenzenes in 2000 exceeded the site-specific PEC of 347 μg/kg calculated for Onondaga Lake.

The maximum surface sediment ethylbenzene concentration detected in the lake of 100 µg/gOC near Tributary 5A (Station S435) exceeded the NYSDEC benthic aquatic life chronic toxicity sediment criterion of 24 µg/gOC, the NYSDEC acute toxicity criterion of 212 µg/gOC, the USEPA sediment quality benchmark (SQB) of 360 µg/gOC, and the Oak Ridge National Laboratory (ORNL) secondary chronic criterion of 8.9 µg/gOC. One out of 114 samples (< 1 percent) analyzed for ethylbenzene in 1992 and 26 out of 61 samples (43 percent) analyzed for ethylbenzene in 2000 exceeded the site-specific PEC of 176 µg/kg calculated for Onondaga Lake.

The maximum surface sediment toluene concentration of 261 µg/gOC was detected near East Flume (Station S345). This concentration exceeded the NYSDEC benthic aquatic life chronic toxicity sediment criterion of 49 µg/gOC, the acute toxicity criterion of 235 µg/gOC, the USEPA SQB of 67 µg/gOC, and the ORNL secondary chronic criterion of 5 µg/gOC. Seventeen out of 114 samples (15 percent) analyzed for toluene in 1992 and 26 out of 62 samples (42 percent) analyzed for toluene in 2000 exceeded the site-specific PEC of 42 µg/kg calculated for Onondaga Lake.

The maximum surface sediment xylene (sum) concentration of 1,000 µg/gOC near Tributary 5A (Station S435). This concentration exceeded the NYSDEC benthic aquatic life chronic toxicity sediment criterion of 92 µg/gOC, the acute toxicity criterion of 833 µg/gOC, the USEPA SQB of 2.5 µg/gOC, and the ORNL secondary chronic criterion of 16 µg/gOC. Three out of 114 samples (3 percent) analyzed for xylenes in 1992 and 18 out of 37 (49 percent) analyzed for xylenes in 2000 exceeded the site-specific PEC of 561 µg/kg calculated for Onondaga Lake.

The maximum surface sediment hexachlorobenzene concentration of 105 µg/gOC was detected near Harbor Brook (Station S314). This concentration exceeded the NYSDEC wildlife bioaccumulation sediment criterion of 12 µg/gOC, the OME LEL of 2 µg/gOC, and the OME SEL of 24 µg/gOC. Twelve out of 89 samples (13 percent) analyzed for hexachlorobenzene in 1992 and 27 out of 85 samples (32 percent) analyzed for hexachlorobenzene in 2000 exceeded the site-specific PEC of 16 µg/kg calculated for Onondaga Lake.

The maximum surface sediment of total polycyclic aromatic hydrocarbons (PAHs) concentration of 29,430,000 µg/kg was detected near Tributary 5A (Station S435). This concentration exceeded the NOAA ER-L of 4,000 µg/kg and numerous criteria for individual PAH compounds. Site-specific PECs were calculated for individual PAH compounds and ranged between 146 µg/kg for benzo(a)pyrene and 1,436 µg/kg for fluoranthene.

The maximum surface sediment phenol concentration of 9.0 µg/gOC was detected between East Flume and Harbor Brook (Station S349). This concentration exceeded the NYSDEC benthic aquatic life chronic toxicity sediment criterion of 0.5 µg/gOC and the ORNL secondary chronic criterion of 3.1 µg/gOC. No samples analyzed for phenol in 1992 and 11 out of 85 samples (13 percent) analyzed from phenol in 2000 exceeded the site-specific PEC of 45 µg/kg calculated for Onondaga Lake.

The maximum surface sediment dibenzofuran concentration of 92 μg/gOC was detected near Harbor Brook (Station S313). This concentration exceeded the ORNL secondary chronic criterion of 42 μg/gOC. Two out of 19 samples (11 percent) analyzed for dibenzofuran in 1992 and 13 out of 85 samples (15 percent) analyzed for dibenzofuran in 2000 exceeded the site-specific PEC of 372 μg/kg calculated for Onondaga Lake.

The maximum surface sediment chlordanes (sum) concentration of 0.4 μg/gOC was detected near Harbor Brook (Station S314). This concentration exceeded the NYSDEC benthic aquatic life chronic toxicity sediment criterion of 0.03 μg/gOC and the NYSDEC wildlife bioaccumulation criterion of 0.006. No samples analyzed for chlordanes in 1992 and 8 out of 84 samples (10 percent) analyzed for chlordanes in 2000 exceeded the site-specific PEC of 5.1 μg/kg calculated for Onondaga Lake.

The maximum surface sediment heptachlor/heptachlor epoxide (sum) concentration of 1.7 μg/gOC was detected near Harbor Brook (Station S314). This concentration exceeded the NYSDEC benthic aquatic life chronic toxicity sediment criterion of 0.01 μg/gOC, the acute toxicity criterion of 13 μg/gOC, and the NYSDEC wildlife bioaccumulation criterion of 0.03 μg/gOC. There were not enough data to calculate a site-specific PEC for heptachlor/heptachlor epoxide.

The maximum surface sediment DDT and metabolites (sum) concentration of 3.6 μg/gOC was detected near Harbor Brook(Station S313). This concentration exceeded the NYSDEC 4-4'-DDT benthic aquatic life chronic toxicity sediment criterion of 1 μg/gOC and the OME LEL of 0.8 μg/gOC. One out of 19 samples (5 percent) analyzed for DDT and metabolites in 1992 and 5 out of 84 samples (6 percent) collected in 2000 exceeded the site-specific PEC of 30 μg/kg calculated for Onondaga Lake.

The maximum surface sediment total PCB concentration of 91 μg/gOC was detected between Tributary 5A and the East Flume (Station S344). This concentration exceeded the NYSDEC benthic aquatic life chronic toxicity sediment criterion of 19 μg/gOC, the NYSDEC wildlife bioaccumulation criterion of 1.4 μg/gOC, and the OME LEL of 7 μg/gOC. Fourteen out of 114 samples (13 percent) analyzed for PCBs in 1992 and 42 out of 115 samples (37 percent) analyzed for PCBs in 2000 exceeded the site-specific PEC of 295 μg/kg calculated for Onondaga Lake.

The maximum surface sediment total dioxins/furan concentration of 129 μg/gOC was detected near Ley Creek (Station S322). This concentration exceeded the NYSDEC wildlife bioaccumulation criterion of 0.0002 μg/gOC. There were not enough data to calculate a site-specific PEC for dioxins/furans.

Although no guidelines address stressors in sediments, the large quantities of ionic waste stressors (e.g., calcium carbonate) deposited on Onondaga Lake sediments may also be detrimental to zooplankton eggs deposited in the sediment.

10.4 Assessment Endpoint: Sustainability of a Terrestrial Plant Community That Can Serve as a Shelter and Food Source for Local Invertebrates and Wildlife

10.4.1 Does the Terrestrial Plant Community Structure Reflect the Influence of Chemicals of Concern/Stressors of Concern?

Measurement Endpoint: Field Observation of Onondaga Lake Plant Communities

The terrestrial plant communities found around Onondaga Lake reflect the development and disposal of contamination that has occurred near the lake over the last two centuries. As this BERA concentrates on the aquatic communities of Onondaga Lake, limited data were collected to evaluate the effects of COCs/SOCs on terrestrial communities. Only obvious effects, such as the sparse vegetation found on the wastebeds, can be directly attributed to activities at Honeywell facilities (i.e., disposal of Solvay and other industrial wastes).

10.4.2 Do Measured Concentrations of Chemicals and Stressors in Soil Exceed Toxicity Values for Terrestrial Plants?

Measurement Endpoint: Comparison of Measured Soil Concentrations to Plant Screening Values

Barium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, vanadium, and zinc were the 12 COCs selected to evaluate plant exposure risks (Chapter 6, Table 6-1). Currently, there is no definitive guidance for setting terrestrial effect thresholds when conducting ecological risk assessments, and therefore the ORNL values used for screening (Efroymson et al., 1997a) were retained as plant toxicity reference values (TRVs). Soil concentrations were analyzed in the dredge spoils area and the wetland areas. Each of the four wetlands (SYW-6, SYW-10, SYW-12, and SYW-19) were evaluated individually for better characterization of the lake and because at least one of the wetlands, SYW-19 in the East Flume/Harbor Brook area, has been contaminated by Honeywell activities.

All COCs, except for copper, exceeded a hazard quotient (HQ) of 1.0 at one or more locations (Table 10-1). Mean and 95 percent upper confidence limit (UCL) concentrations of chromium, mercury, and vanadium exceeded an HQ of 1.0 at all locations (i.e., the dredge spoils and at each individual wetland). The highest HQs for mercury were seen at Wetland SYW-19 at the southwest corner of the lake near Harbor Brook, the highest chromium HQs were calculated for Wetland SYW-12 on the southeast corner of the lake near Ley Creek, and the highest vanadium HQs were calculated for Wetland SYW-10 on the western shore near Ninemile Creek. Zinc HQs exceeded 1.0 for all mean and 95 percent UCL concentrations at all wetland areas.

Selenium HQs exceeded 1.0 for mean and 95 percent UCL concentrations at the dredge spoils area and Wetland SYW-19. Selenium ratios of 1.0 were also exceeded for the 95 percent UCL for combined wetlands and Wetland SYW-10.

Lead HQs exceeded 1.0 for both mean and 95 percent UCL concentrations at all wetland locations, but were below 1.0 at the dredge spoils area. Nickel HQs exceeded 1.0 for the 95 percent UCL concentrations at all individual wetlands and for the mean concentration at Wetland SYW-19.

Cadmium HQs exceeded 1.0 for the 95 percent UCL concentrations for combined wetlands, Wetland SYW-6, and Wetland SYW-12. The mean exposure concentration also exceeded the soil benchmark at Wetland SYW-12. Thallium 95 percent UCL concentrations exceeded the soil benchmark at Wetland SYW-6 and SYW-10. The mean exposure concentration for thallium also exceeded the benchmark at Wetland SYW-10. Silver had a single exceedance of the benchmark at Wetland SYW-12 for the 95 percent UCL, and arsenic also had a single exceedance at Wetland SYW-10 for the 95 percent UCL.

The dredge spoils area had fewer exceedances than the four wetlands, which may be partially due to the absence of a hydrological connection to Onondaga Lake (i.e., the surface of the dredge spoils is approximately 10 ft above the elevation of the lake), and partially due to a soil cover that was placed over the contaminated spoils when they were constructed in 1966 to 1968 by filling in wetlands along the edge of the lake.

These results suggest the potential for adverse effects on plants via exposure to COCs in soils.

10.5 Assessment Endpoint: Sustainability of a Benthic Invertebrate Community That Can Serve as a Food Source for Local Fish and Wildlife

10.5.1 Does the Benthic Community Structure Reflect the Influence of Chemicals of Concern/Stressors of Concern?

Measurement Endpoint: Analysis of Onondaga Lake Benthic Invertebrate Communities

The benthic macroinvertebrate community is closely associated with sediment and porewater, relying on these media for habitat, food, and exchange of gases. Therefore, the characteristics of the benthic invertebrate community are strongly affected by, and reflect, the quality of the sediment and water that the organisms inhabit. The overall health and structure of the benthic community can affect organisms such as fish and wildlife that depend upon it for food.

The Onondaga Lake benthic invertebrate community assessment investigated macroinvertebrate communities in areas of varying mixtures and concentrations of COCs/SOCs throughout the lake to create a general profile of community characteristics and determine whether ecologically based effects of COCs/SOCs could be inferred.

Of the 48 Onondaga Lake stations sampled in 1992, none were found to be non-impaired, 11 stations were found to be slightly impaired, 29 stations were found to be moderately impaired, and eight stations were found to be severely impaired (Figure 10-1). The severely impaired stations are primarily located at the southern end of the lake (i.e., between Onondaga Creek and Tributary 5A). One station (Station S68) considered to be severely impaired is located near Wastebeds 1 through 8. Moderately impaired stations are found throughout the lake.

NYSDEC's kick-sampling results from the mouths of the eight tributaries indicate that Harbor Brook, Ley Creek, Bloody Brook, Ninemile Creek, and Sawmill Creek are moderately impacted and that Onondaga Creek, the East Flume, and Tributary 5A are severely impacted. Based on sampling conducted by Honeywell in 1992, Tributary 5A, Harbor Brook, Onondaga Creek, and Ley Creek were classified as severely impaired, while the rest of the tributary mouth stations were moderately impaired (Figure 10-1).

All of the nine Onondaga Lake stations sampled in 2000 within the 5-m contour were found to be impaired to some extent (Figure 10-1). Two stations were found to be slightly impaired; six stations were found to be moderately impaired; and one station was found to be severely impaired. The severely impaired station (Station S317) is located in the southern end of the lake between the Metro outfall and the mouth of Onondaga Creek. Moderately impaired stations are found throughout the lake, clustered between Tributary 5A and Harbor Brook and near the mouths of Ninemile Creek and Ley Creek. Two of the three slightly impaired stations are located in Onondaga Lake: one (Station S365) is north of the mouth of Tributary 5A, and the other (Station S372) is in the northwestern portion of the lake.

The patterns described above and depicted in Figure 10-1 indicate that much of the littoral zone less than 5 m deep in Onondaga Lake and the mouths of the tributaries are impacted to some degree. The majority of moderately and severely impacted stations are found between Tributary 5A and Ley Creek. This coincides with the locations where most stations have three metrics that are significantly different than the Otisco Lake reference location. In addition, community-level measurements may be confounded by the influence of abiotic parameters (e.g., grain size and low DO levels) and the difficulty of distinguishing between directional (e.g., response to trend or gradient) and nondirectional (e.g., seasonal or annual) variability (Ingersoll et al., 1998).

10.5.2 Do Concentrations of Chemicals and Stressors in Sediment Influence Mortality, Growth, or Fecundity of Invertebrates Living In or On Lake Sediments?

Measurement Endpoint: Results of the 1992 and 2000 Sediment Toxicity Tests

Based on the 1992 toxicity tests, most amphipod toxicity was confined to an area in the southwestern corner of the lake, along Wastebeds 1 through 8 and along the Honeywell lakeshore area near Harbor Brook and the East Flume (Figure 10-2). Most chironomid toxicity was confined to the southern half of the lake, although toxicity was also found in two areas in the northern half of the lake (i.e., off Ninemile Creek and near Sawmill Creek). In the southern half of the lake, lethal chironomid toxicity was found in three general areas:

- Off Tributary 5A.
- Off Ley Creek.
- In the southwestern corner of the lake (off Harbor Brook, the Metro outfall, and the East Flume).

The results of the 42-day sediment toxicity tests from 2000 showed amphipod toxicity at six stations, including all of the shallow (i.e., < 5 m water depth) nearshore stations from Tributary 5A to the East Flume (Stations S332, S337, S342, S344, and S365) and near the Metro outfall (Station S317).

For the chironomid test conducted in 2000, lethal toxicity was found at nine stations, including all five of the shallow nearshore stations from Tributary 5A to the East Flume (i.e., Stations S332, S337, S342, S344, and S365), two stations off Ninemile Creek (Stations S302 and S303), and the stations off Ley Creek (Stations S320 and S323). In addition to the nine stations at which lethal toxicity was found for the chironomid test, sublethal toxicity was found at Station S317 off Onondaga Creek and at Station S372 along the northeastern shoreline of the lake. Chironomid emergence was affected at five locations in the southern portion of the lake at Stations S332, S337, S342, S344, and S354.

Overall, the results of the sediment toxicity tests confirmed that most sediment toxicity in Onondaga Lake is confined to the nearshore zone in the southern part of the lake between Tributary 5A and Ley Creek. By contrast, little toxicity is observed elsewhere in the lake, including the deeper parts of the entire lake and its eastern shore. The spatial patterns of amphipod and chironomid toxicity are presented in Figure 10-2.

10.5.3 Do Measured Concentrations of Chemicals and Stressors in Surface Water Exceed Standards, Criteria, and Guidance for the Protection of Aquatic Organisms?

Measurement Endpoint: Comparison of Measured Surface Water Concentrations to Water Quality Values

Benthic macroinvertebrates are also exposed to COCs/SOCs in the water column. Selected COCs detected in lake surface water in 1992 and 1999 were compared to NYSDEC and USEPA water quality values in Appendix B (see Chapter 5, Table 5-3 for summary). With the exception of mercury, all COCs (i.e., barium copper, lead, manganese, chlorobenzene, dichlorobenzenes, trichlorobenzenes, and bis[2-ethylhexyl]phthalate), exceeded USEPA chronic aquatic or Tier II water quality values (Chapter 4, Table 4-4). Mercury concentrations in Onondaga Lake in 1992 and 1999 exceeded the wildlife value, but not the chronic water quality value for the protection of aquatic organisms.

Stressors in Onondaga Lake generally exceeded guidelines (when available) or background levels and are discussed in greater detail in Section 10.3.2. Chloride concentrations measured from April to November 1992 exceeded the USEPA chronic water quality criterion for chloride of 230 mg/L at all locations sampled (Chapter 8, Figure 8-8 and Appendix B, Table B-26). Although lake salinity has dropped from 3.6 ppt in 1981 to 1.1 ppt, it is still over an order-of-magnitude greater than the average world river salinity (0.1 ppt). From 1992 until 2001, phosphorus and sulfide concentrations also consistently exceeded the NYSDEC standards. Low levels of DO (Chapter 8, Figures 8-18 and 8-20) in the lake at depths greater than 3 m may also limit the benthic community.

The COC/SOC concentrations measured at both lake and tributary stations, as compared to water quality values, indicate that the benthic community may be adversely affected by the levels of COCs and stressors present in the water.

10.5.4 Do Measured Concentrations of Chemicals and Stressors in Sediments Exceed Criteria and/or Guidelines for the Protection of Aquatic Organisms?

Measurement Endpoint: Comparison of Measured Sediment Concentrations to Sediment Guidelines

Onondaga Lake sediment concentrations were compared to site-specific consensus PECs as another measurement endpoint in this strength-of-evidence approach. Consensus-based PECs for COCs in Onondaga Lake were developed to support an assessment to sediment-dwelling organisms and follow the methodology described in MacDonald et al. (2000) and Ingersoll et al. (2000). The PECs are the geometric mean of the apparent effects threshold (AET), probable effect level (PEL), threshold effects level (TEL), effects range-median (ER-M), and effects range-low (ER-L) sediment effect concentrations (SECs) presented in Chapter 9. In addition, the PECs:

- Provide a unifying synthesis of site-specific effects concentrations.
- Reflect causal rather than correlative effects.
- Account for the effects of sediment COCs.

The PECs do not consider the potential for:

- Bioaccumulation in aquatic species.
- Potential effects that could occur throughout the food web as a result of bioaccumulation.
- Synergistic or antagonistic effects of chemical mixes in the sediment.

Onondaga Lake PECs were developed for all compounds identified as COCs (see Chapter 6) based on the 1992 data. Measured surface sediment concentrations exceed the PEC consensus values at many locations throughout the lake. Table 10-2 presents exceedances at stations sampled in 1992 and Table 10-3 presents exceedances at stations sampled in 2000. Figure 10-3 shows the number of PEC exceedances for all of the identified COCs at each of the 1992 and 2000 stations. Only 14 sediment sampling locations in Onondaga Lake do not have at least one compound exceeding an HQ of 1.0 (i.e., sediment concentration less than the PEC). Many of the ratios of measured sediment concentrations to PECs exceed 10, or even 100, between Tributary 5A and Ley Creek. These total HQs are also presented in Tables 10-2 and 10-3. In addition, these sediment locations have the highest number of compounds – between 11 and over 30 compounds per sample – exceeding their PECs in a sample. Maps showing locations in the lake that exceed the SECs and PECs are included in Appendix F.

10.6 Assessment Endpoint: Sustainability of Local Fish Populations

10.6.1 What Does the Fish Community Structure Suggest about the Health of Local Fish Populations?

Measurement Endpoint: Comparison of Onondaga Lake Fish Communities to Reference Lakes

The current level of species diversity in Onondaga Lake is similar to values found in other New York State lakes, and growth rates, age distributions, and mortality rates of several species are similar to those observed in other northeastern US lakes (Auer et al., 1996a). However, sensitive species of fish, such as the Atlantic salmon (*Salmo salar*) and cisco (*Coregonus artedii*) that were historically present, are unable to survive in the lake. The dominant species in the lake are more pollution-tolerant and tolerant of warm-water conditions, unlike the historical cold-water fishery.

However, in contrast to comparison lakes, many of the species found in Onondaga Lake do not reproduce there and recruitment rates are unknown. Only 16 of 48 species captured in 1991 were found to reproduce in the lake, and reproduction within the lake varied by location. Many areas of Onondaga Lake are not suitable for fish reproduction due to industrial pollution and its effects on the lake ecosystem.

The composition of the fish community in the lake varies seasonally, with migration between the Seneca River and the lake being an important contributor to the variability. Several species of fish found in Onondaga Lake generally retreat to deeper cooler waters during hot weather. These are to a great extent the same fish species that migrate out of the lake. This suggests that after stratification the DO in the hypolimnion starts to decrease while the temperature of the epilimnion increases. In mid- to late-summer the water temperature of the lake reaches its highest level in the epilimnion and DO reaches its lowest level in the hypolimnion. Even before fall turnover (which lowers the overall lake DO), some species of fish can seek deeper, cooler waters. When they are unable to use the deeper part of the lake due to low DO, these species can move out of the lake to avoid the heat, particularly in late summer and early fall.

The limited fish reproduction in the lake and migration out of the lake during the fall indicate that Onondaga Lake alone cannot support the full diversity of the current fish community. Only with immigration into Onondaga Lake and refugia used during times of stress is the current diversity of the fish community sustainable.

10.6.2 Has the Presence of Chemicals and/or Stressors Influenced Fish Foraging or Nesting Activities?

Measurement Endpoint: Observations of Suitable Nesting Habitat and Populations of Juveniles

Fish reproduction within the lake varies by location. Based on the absence of juveniles in the catches of shoreline seine hauls, it is doubtful that species such as the walleye (*Stizostedion vitreum*) and northern pike (*Esox lucius*) reproduce in the lake. A lack of nursery area and adequate spawning sites has reduced successful reproduction of fish, resulting in poor year classes (Madsen et al., 1998). Spawning habitats constructed to improve fish habitat in Onondaga Lake had five to 20 times more fish nests than unmanipulated areas (Madsen et al., 1998). Lack of refugia in the deeper waters of the lake during portions of the year can also contribute to the low success or absence of reproduction of some species of the fish community in the lake.

Decreased water clarity, calcium carbonate precipitation, and increased salinity have reduced littoral zone vegetation (see Section 10.1), a critical area for young-of-year (YOY) fish. Areas characterized by the presence of aquatic macrophytes and submerged structures (e.g., near the lake outlet) supported the largest populations of juveniles. Areas with heavy silt loads and that are unprotected from wind are undesirable as spawning areas, as silt loads or wave action may cause eggs to be covered or removed from optimal areas.

Stressors, such as calcite and high salinity, have altered the phytoplankton and zooplankton communities in the lake, thereby affecting the food supply of many fish species. The low amount of littoral zone vegetation also results in lower biomass of macroinvertebrates and zooplankton, which serve as primary food for many YOY fish (Madsen et al., 1998).

The effects of industrial waste on Onondaga Lake have adversely affected fish reproduction and growth, as evidenced by low reproduction in the lake and fewer YOY fish than observed in similar lakes where the habitat has not been impacted by industrial contaminants, as is the case in Onondaga Lake.

10.6.3 Do Fish Found in Onondaga Lake Show Reduced Growth or Increased Incidence of Disease (e.g., Tumors, Lesions) as Compared to Fish from Other Lakes?

Measurement Endpoint: Observations of Incidence of Disease in Onondaga Lake Fish

Limited data are available regarding the incidence of disease in Onondaga Lake fish. During the 1992 nearshore fish study (PTI, 1993c), six fish (three banded killifish [*Fundulus diaphanus*], two pumpkinseed [*Lepomis gibbosus*], and one bluegill [*Lepomis macrochirus*]) were observed with abnormalities. Approximately 5,000 fish were collected during the study, but the number of fish examined was not specified in the report. In 1998, several kinds of grossly visible abnormalities were observed on three white suckers (*Catostomus commersoni*) during field sampling for the Geddes Brook/Ninemile Creek Remedial

Investigation (Exponent, 2001e). A total of 50 fish were collected in Geddes Brook/Ninemile Creek for analysis in 1998.

NYSDEC has not conducted any systematic observations for the fish from Onondaga Lake (Sloan, pers. comm., 2002). Seneca River fish were examined by Ringler et al. (Auer et al., 1996a) for external lesions and parasitic infestations that may be linked to industrial pollution. Rates of parasite occurrence and lesions in the Seneca River fish were determined to be at or below expected rates. Since levels of chemicals and stressors in the Seneca River are much lower than in Onondaga Lake, the relevance of this observation to the Onondaga Lake fish community is unknown.

10.6.4 Do Measured Concentrations of Chemicals and Stressors in Surface Water Exceed Standards, Criteria, and Guidance for the Protection of Aquatic Organisms?

Measurement Endpoint: **Comparison of Measured Surface Water Concentrations to Water Quality Standards, Criteria, and Guidance and Qualitative Evaluation of Narrative Standards**

Selected COCs detected in lake surface water in 1992 and 1999 were compared to NYSDEC and USEPA water quality standards, criteria, and guidance in Appendix B (see Chapter 5, Table 5-3 for summary). With the exception of mercury, all COCs (i.e., barium, copper, lead, manganese, chlorobenzene, dichlorobenzenes, trichlorobenzenes, and bis[2-ethylhexyl]phthalate), exceeded USEPA chronic aquatic or Tier II water quality values (Chapter 4, Table 4-4). Mercury concentrations in Onondaga Lake in 1992 and 1999 exceeded the wildlife value, but not the chronic water quality values for the protection of aquatic organisms.

Stressors in Onondaga Lake generally exceed guidelines (when available) or background levels and are discussed in greater detail in Section 10.3.2. Chloride concentrations measured from April to November 1992 exceeded the USEPA chronic water-quality criterion for chloride of 230 mg/L at all locations sampled (Chapter 8, Figure 8-8 and Appendix B, Table B-26). Although lake salinity dropped to 1.1 ppt, this value is still an order-of-magnitude greater than the average world river salinity (0.1 ppt). From 1992 to 2001, phosphorus and sulfide concentrations have also consistently exceeded the NYSDEC standards.

The summed concentration of total ammonia and nitrate has continuously exceeded standards to protect non-salmonid (as well as salmonid) fish. Low levels of oxygen may also limit the fish community, particularly in fall. Fish generally move out of the lake during periods of low DO, as discussed previously (Auer et al., 1996a; Tango and Ringler, 1996).

Narrative water quality standards for turbidity and suspended, and settleable solids are also exceeded due to calcite resuspension, deposition, and formation of oncolites which result in impairment of the fish population in the lake (see Sections 10.1.3 and 10.6.2)

10.6.5 Do Measured Concentrations of Chemicals and Stressors in Sediments Exceed Criteria and/or Guidelines for the Protection of Aquatic Organisms?

Measurement Endpoint: Comparison of Measured Sediment Concentrations to Sediment Guidelines

The comparison of sediment concentrations to sediment criteria/guidance is only applicable to benthic-dwelling species of fish (e.g., catfish and carp) that are in close contact with sediments. Selected COCs detected in lake sediment in 1992 and 2000 were compared to NYSDEC sediment quality values in Appendix E (see Chapter 5, Table 5-5 for summary) and site-specific SECs and PECs in Appendix F.

Onondaga Lake PECs were developed for all compounds identified as COCs in Chapter 6 based on the 1992 data. Measured sediment concentrations exceed the PEC consensus values at many locations throughout the lake (Tables 10-2 and 10-3 and Figure 10-3). Only 15 sediment sampling locations in Onondaga Lake do not have at least one compound exceeding an HQ of 1.0. Many of the ratios of measured sediment concentrations to PECs exceed 10, or even 100, between Tributary 5A and Ley Creek. In addition, these sediment locations have the highest number of compounds – between 11 and over 30 compounds per sample – exceeding their PECs in a sample. Further discussion of COCs in sediments can be found in Section 10.3.3.

10.6.6 Do Measured Concentrations of Chemicals in Fish Exceed TRVs for Adverse Effects on Fish?

Measurement Endpoint: Comparison of Measured Fish Concentrations to Fish TRVs

Fish COCs were evaluated on a species-specific basis, as discussed in the following paragraphs. Some species (e.g., gizzard shad [*Dorosoma cepedianum*] and largemouth bass [*Micropterus salmoides*]) were only analyzed for a limited number of contaminants and, therefore, all risks may not be represented below.

The results presented below suggest the potential for adverse effects on most fish species via exposure to COCs in water, sediment, and prey.

10.6.6.1 Bluegill

Concentrations of chromium, vanadium, and zinc exceeded no observable adverse effect level (NOAEL) and lowest observable adverse effect level (LOAEL) TRVs at both the 95 percent UCL and mean concentrations in the bluegill (*Lepomis macrochirus*) (Table 10-4). Mercury and selenium concentrations in bluegill exceeded all TRVs except the LOAEL at the mean concentration. The arsenic 95 percent UCL exceeded the NOAEL.

10.6.6.2 Gizzard Shad

Only methylmercury was measured in gizzard shad. The 95 percent UCL and mean concentrations were above the NOAEL TRV (Table 10-4).

10.6.6.3 Carp

Concentrations of chromium, mercury, selenium, vanadium, and zinc exceeded NOAEL and LOAEL TRVs at both the 95 percent UCL and mean concentrations (Table 10-4). Dioxin/furan (TEQ) and arsenic concentrations in carp (*Cyprinus carpio*) exceeded all TRVs except the LOAEL at the mean concentration. PCB concentrations in carp exceeded the NOAEL at the 95 percent UCL mean concentrations and the endrin 95 percent UCL concentration exceeded the NOAEL.

10.6.6.4 Catfish

Concentrations of mercury, vanadium, and zinc exceeded NOAEL and LOAEL TRVs at both the 95 percent UCL and mean catfish concentrations (Table 10-4). Chromium and selenium exceeded all TRVs except the LOAEL at the mean concentration. Total PCBs in catfish exceeded the NOAEL at both the 95 percent UCL and mean concentrations.

10.6.6.5 White Perch

Concentrations of mercury exceeded the NOAEL and LOAEL TRVs for the white perch (*Morone americana*) at both the 95 percent UCL and mean concentrations (Table 10-4). Concentrations of chromium, selenium, and total PCBs exceeded NOAEL TRVs at both the 95 percent UCL and mean concentrations.

10.6.6.6 Smallmouth Bass

Concentrations of mercury and vanadium exceeded NOAEL and LOAEL TRVs at both the 95 percent UCL and mean concentrations for smallmouth bass (*Micropterus dolomieui*) (Table 10-4). Arsenic, selenium, and zinc exceeded all TRVs, except the LOAEL at the mean concentration. The 95 percent UCL concentration of PCBs exceeded the NOAEL TRV.

10.6.6.7 Largemouth Bass

Only mercury, DDT, PCBs, and dioxins/furans were analyzed in largemouth bass. Mercury exceeded NOAEL and LOAEL TRVs at both the 95 percent UCL and mean concentrations (Table 10-4). Dioxins/furans (TEQ) exceeded the NOAEL TRV at the 95 percent UCL.

10.6.6.8 Walleye

Concentrations of mercury exceeded the NOAEL and LOAEL TRVs at both the 95 percent UCL and mean concentrations for the walleye (*Stizostedion vitreum*) (Table 10-4). NOAELs were exceeded for chromium and total PCBs at both 95 percent UCL and mean concentrations.

10.7 Assessment Endpoint: Sustainability of Local Amphibian and Reptile Populations

10.7.1 What Do the Available Field-Based Observations Suggest about the Health of Local Amphibian and Reptile Populations?

Measurement Endpoint: Field Surveys of Local Amphibian and Reptile Populations

A field survey of Onondaga Lake found that habitats around the lake differed dramatically in the amphibian and reptile species found, with the lake itself and many other areas nearly devoid of herpetofauna (Ducey and Newman, 1995). The investigators concluded that the herpetofauna around the lake was generally depauperate, and were surprised by the absence of some common species. They found that the seven amphibian and six reptilian species found around the lake were considerably fewer than the 19 amphibian and 15 reptilian species recorded for Onondaga County as a whole during 1990 to 1996 by NYSDEC (1997b).

10.7.2 Do Measured Concentrations of Chemicals and Stressors in Surface Water Exceed Standards, Criteria, and Guidance for the Protection of Aquatic Organisms?

Measurement Endpoint: Comparison of Measured Surface Water Concentrations to Water Quality Standards, Criteria, and Guidance

Selected COCs detected in lake surface water in 1992 and 1999 were compared to NYSDEC and USEPA water quality standards, criteria, and guidance in Appendix B (see Chapter 5, Table 5-3 for summary). With the exception of mercury, all COCs (i.e., barium, copper, lead, manganese, chlorobenzene, dichlorobenzenes, trichlorobenzenes, and bis[2-ethylhexyl]phthalate), exceeded USEPA chronic aquatic or Tier II water quality values (Chapter 4, Table 4-4). Mercury concentrations in Onondaga Lake in 1992 and 1999 exceeded the wildlife value, but not the chronic water quality value for the protection of aquatic organisms.

Stressors in Onondaga Lake generally exceeded guidelines (when available) or background levels and are discussed in greater detail in Section 10.3.2. Chloride concentrations measured from April to November 1992 exceeded USEPA chronic water-quality criterion for chloride of 230 mg/L at all locations sampled (Chapter 8, Figure 8-8 and Appendix B, Table B-26). Although lake salinity dropped to 1.1 ppt, this value is still an order-of-magnitude greater than the average world river salinity (0.1 ppt). From 1992 to 2001, phosphorus and sulfide concentrations have also consistently exceeded the NYSDEC standard.

10.7.3 Have Laboratory Studies Indicated the Potential for Adverse Effects to Amphibian Embryos from Exposure to Onondaga Lake Water?

Measurement Endpoint: Laboratory Toxicity Studies Using Onondaga Lake Surface Water

Ducey et al. (2000) directly assessed the toxicity of water from Onondaga Lake and associated wetlands on developing amphibian embryos. They found that water from connected wetlands and the lake has variable, but consistently negative, effects on amphibian development relative to controls. They hypothesized that there is a chemical interaction that affects amphibian embryos, because unfiltered Onondaga Lake water is highly toxic to embryos. Filtered water is also toxic, but to a lesser degree.

10.8 Assessment Endpoint: Sustainability of Local Insectivorous Bird Populations

10.8.1 Do Modeled Dietary Doses to Insectivorous Birds Exceed Toxicity Reference Values for Adverse Reproductive Effects?

Measurement Endpoint: Comparison of Modeled Insectivorous Bird Dietary Dose Concentrations to Toxicity Reference Values

Modeled dose concentrations of barium, chromium, methylmercury, mercury, selenium, and total PAHs for the tree swallow (*Tachycineta bicolor*) exceeded NOAEL and LOAEL TRVs at both the 95 percent UCL and mean concentrations (Table 10-5). Cadmium, lead, zinc, dichlorobenzenes, total PCBs, and dioxins/furans (TEQ) dose concentrations also exceeded the NOAEL at the 95 percent UCL and mean concentrations.

These results suggest the potential for adverse effects on insectivorous birds via exposure to COCs in water and prey.

10.8.2 Do Measured Concentrations of Chemicals and Stressors in Surface Water Exceed Standards, Criteria, and Guidance for the Protection of Wildlife?

Measurement Endpoint: Comparison of Measured Surface Water Concentrations to Water Quality Standards, Criteria, and Guidance

Selected COCs detected in lake surface water in 1992 and 1999 were compared to NYSDEC water quality standards, criteria, and guidance in Appendix B (see Chapter 5, Table 5-3 for summary). With the exception of mercury, all COCs (i.e., barium, copper, lead, manganese, chlorobenzene, dichlorobenzenes, trichlorobenzenes, and bis[2-ethylhexyl]phthalate), exceeded USEPA chronic aquatic or Tier II water quality values (Chapter 4, Table 4-4). Mercury concentrations in Onondaga Lake in 1992 and 1999 exceeded the wildlife protection value.

10.8.3 What Do the Available Field-Based Observations Suggest About the Health of Local Insectivorous Bird Populations?

Measurement Endpoint: Field Observations of Insectivorous Birds

It is difficult to separate out the effects of chemical contamination on wildlife from those of development (i.e., habitat loss). Chapter 3, Table 3-11 lists bird species found in covertypes around Onondaga Lake. These covertypes support many insectivorous species, including swallows, mockingbirds, flycatchers, wrens, vireos, and warblers, among others. A number of species in these groups have been confirmed to breed around Onondaga Lake (NYSDEC, 2001a). However, field populations of insectivorous birds have not been studied. Without site-specific data on a representative insectivorous species, the significance of bird sightings is uncertain.

10.9 Assessment Endpoint: Sustainability of Local Benthivorous Waterfowl Populations

10.9.1 Do Modeled Dietary Doses to Benthivorous Waterfowl Exceed Toxicity Reference Values for Adverse Reproductive Effects?

Measurement Endpoint: Comparison of Modeled Benthivorous Bird Dietary Dose Concentrations to Toxicity Reference Values

Modeled dose concentrations of chromium and total PAHs for the mallard (*Anas platyrhynchos*) exceeded NOAEL and LOAEL TRVs at both the 95 percent UCL and mean dose concentrations (Table 10-6). Barium, methylmercury, and zinc also exceeded the NOAEL at both 95 percent UCL and mean dose concentrations and barium also exceeded the LOAEL at the 95 percent UCL concentration. Cadmium, dichlorobenzenes, and dioxins/furans (TEQ) dose concentrations exceeded the NOAEL at the 95 percent UCL concentration.

These results suggest the potential for adverse effects on waterfowl via exposure to COCs in water, sediment, and dietary sources.

10.9.2 Do Measured Concentrations of Chemicals and Stressors in Surface Water Exceed Standards, Criteria, and Guidance for the Protection of Wildlife?

Measurement Endpoint: Comparison of Measured Surface Water Concentrations to Water Quality Standards, Criteria, and Guidance

Selected COCs detected in lake surface water in 1992 and 1999 were compared to NYSDEC water quality standards, criteria, and guidance in Appendix B (see Chapter 5, Table 5-3 for summary). With the exception of mercury, all COCs (i.e., barium, copper, lead, manganese, chlorobenzene, dichlorobenzenes, trichlorobenzenes, and bis[2-ethylhexyl]phthalate), exceeded USEPA chronic aquatic or Tier II water quality values (Chapter 4, Table 4-4). Mercury concentrations in Onondaga Lake in 1992 and 1999 exceeded the wildlife protection value.

10.9.3 What Do the Available Field-Based Observations Suggest About the Health of Local Waterfowl Populations?

Measurement Endpoint: Field Observations of Local Waterfowl

Chapter 3, Table 3-11 lists bird species found in covertypes around Onondaga Lake, Table 3-12 lists additional species observed near the lake, and Table 3-13 lists waterfowl wintering near the lake. Onondaga Lake is home to many waterfowl, including ducks, geese, mergansers, scaups, loons, and grebes. However, few species of waterfowl are listed as confirmed or probable breeders in the New York State Breeding Bird Atlas (NYSDEC, 2001a). Although it is clear that Onondaga Lake is an important resource for many resident and migratory species of waterfowl, its significance as a breeding area is unknown and little can be inferred about the health of local waterfowl populations.

10.10 Assessment Endpoint: Sustainability of Local Piscivorous Bird Populations

10.10.1 Do Modeled Dietary Doses to Piscivorous Birds Exceed Toxicity Reference Values for Adverse Reproductive Effects?

Measurement Endpoint: Comparison of Modeled Piscivorous Bird Dietary Dose Concentrations to Toxicity Reference Values

Modeled methylmercury dose exposure concentrations exceeded NOAEL and LOAEL TRVs at both 95 percent UCL and mean concentrations for all three piscivorous birds modeled (belted kingfisher [*Ceryle alcyon*], great blue heron [*Ardea herodias*], and osprey [*Pandion haliaetus*]) (Tables 10-7 to 10-9). Methylmercury exceeded NOAELs for all piscivorous receptors by an order-of-magnitude. All modeled dose concentrations of DDT exceeded all TRVs for the belted kingfisher, while DDT NOAELs were exceeded for 95 percent UCL and mean dose concentrations for the great blue heron and osprey.

The total PAH and total PCB exposure dose concentrations were greater than the NOAELs for the belted kingfisher and great blue heron at both 95 percent UCL and mean concentrations. The 95 percent UCL total PAH concentration also exceeded the LOAEL for the belted kingfisher. Total PCBs exceeded the NOAEL at the 95 percent UCL concentration for the osprey.

Dioxins/furans (TEQ) exposure dose concentrations were greater than the NOAELs for the belted kingfisher at both 95 percent UCL and mean concentrations. Zinc exposure dose concentrations were greater than the NOAELs for the osprey and great blue heron at the 95 percent UCL concentration, and the mean zinc concentration for the osprey also exceeded the NOAEL.

These results suggest the potential for adverse effects on piscivorous birds via exposure to COCs in water, sediment, and dietary sources.

10.10.2 Do Measured Concentrations of Chemicals and Stressors in Surface Water Exceed Standards, Criteria, and Guidance for the Protection of Wildlife?

Measurement Endpoint: Comparison of Measured Surface Water Concentrations to Water Quality Standards, Criteria, and Guidance

Selected COCs detected in lake surface water in 1992 and 1999 were compared to NYSDEC water quality standards, criteria, and guidance in Appendix B (see Chapter 5, Table 5-3 for summary). With the exception of mercury, all COCs (i.e., barium, copper, lead, manganese, chlorobenzene, dichlorobenzenes, trichlorobenzenes, and bis[2-ethylhexyl]phthalate), exceeded USEPA chronic aquatic or Tier II water quality values (Chapter 4, Table 4-4). Mercury concentrations in Onondaga Lake in 1992 and 1999 exceeded the wildlife protection value.

10.10.3 What Do the Available Field-Based Observations Suggest About the Health of Local Piscivorous Bird Populations?

Measurement Endpoint: Field Observations of Local Piscivorous Birds

Chapter 3, Table 3-11 lists bird species found in covertypes around Onondaga Lake and Table 3-12 lists additional species observed near the lake. Onondaga Lake is home to a number of piscivorous bird species including kingfishers, herons, bald eagles, osprey, cormorants, gulls, and terns, some of which have been observed year-round near the lake (Kirkland Bird Club, 2002). The presence of these species indicates that suitable habitat is available in Onondaga Lake. However, very few piscivorous species are listed as confirmed or probable breeders in the New York State Breeding Bird Atlas (NYSDEC, 2001a). The mud flats area around the mouth of Ninemile Creek is considered by local birders to be a sensitive migratory area that provides good habitat for birds (Kirkland Bird Club, 2002).

10.11 Assessment Endpoint: Sustainability of Local Carnivorous Bird Populations

10.11.1 Do Modeled Dietary Doses to Carnivorous Birds Exceed Toxicity Reference Values for Adverse Reproductive Effects?

Measurement Endpoint: Comparison of Modeled Carnivorous Bird Dietary Dose Concentrations to Toxicity Reference Values

Modeled total PAH exposure dose concentrations exceeded NOAEL and LOAEL TRVs at both 95 percent UCL and mean concentrations for the red-tailed hawk (*Buteo jamaicensis*) (Table 10-10).

Modeled doses of dioxins/furans (TEQ) exceeded the NOAEL at both the 95 percent UCL and mean concentrations. The DDT NOAEL was exceeded for the 95 percent UCL concentration.

These results suggest the potential for adverse effects on carnivorous birds via exposure to COCs in water, sediment, and dietary sources.

10.11.2 What Do the Available Field-Based Observations Suggest About the Health of Local Carnivorous Bird Populations?

Measurement Endpoint: Field Observations of Local Carnivorous Birds

It is difficult to separate out the effects of chemical contamination on wildlife from those of habitat loss and development. Table 3-11 lists bird species found in covertypes around Onondaga Lake. The covertypes may support carnivorous species such as the turkey vulture (*Cathartes atratus),* red-tailed hawk, sharp-shinned hawk (*Accipiter striatus*), Cooper's hawk (*Accipter cooperii*), and American kestrel (*Falco sparverius*). A number of species in these groups have been confirmed to breed around Onondaga Lake (NYSDEC, 2001a). However, populations of carnivorous birds have not been studied at Onondaga Lake to place these observations into the proper perspective.

10.12 Assessment Endpoint: Sustainability of Local Insectivorous Mammal Populations

Insectivorous receptors around Onondaga Lake were divided into insectivores feeding on aquatic invertebrates and insectivores feeding on terrestrial invertebrates.

10.12.1 Do Modeled Dietary Doses to Insectivorous Mammals Feeding on Aquatic Invertebrates Exceed Toxicity Reference Values for Adverse Reproductive Effects?

Measurement Endpoint: Comparison of Modeled Mammal Insectivorous Dietary Dose Concentrations to Toxicity Reference Values

The little brown bat (*Myotis lucifugus*) was used as a representative receptor for mammals feeding on insects with an aquatic life phase. Modeled dose concentrations of barium, chromium, methylmercury, and total PAHs for the little brown bat exceeded NOAEL and LOAEL TRVs at both the 95 percent UCL and mean exposure concentrations (Table 10-11). Copper and dioxins/furans (TEQ) dose concentrations exceeded the NOAEL at the 95 percent UCL and the mean dose concentrations and the LOAEL at the 95 percent UCL concentration. Cadmium, vanadium, and hexachlorobenzene exceeded NOAELs at both 95 percent UCL and mean dose concentrations. Total xylenes exceeded the NOAEL and LOAEL at the 95 percent UCL concentration. Mercury and arsenic exceeded an HQ of 1.0 at the 95 percent UCL concentration based on the NOAEL TRV.

These results suggest the potential for adverse effects on insectivorous mammals via exposure to COCs in water and prey with an aquatic life-phase.

10.12.2 Do Modeled Dietary Doses to Insectivorous Mammals Feeding on Terrestrial Invertebrates Exceed Toxicity Reference Values for Adverse Reproductive Effects?

Measurement Endpoint: Comparison of Modeled Insectivorous Mammal Dietary Dose Concentrations to Toxicity Reference Values

Due to the small home range of the short-tailed shrew (*Blarina brevicauda*) (used as the representative receptor for insectivorous mammals feeding on terrestrial prey), each discretely sampled area was modeled individually for the four wetland areas (SYW-6, SYW-10, SYW-12, and SYW-19) and the dredge spoils area (Table 10-12).

Wetland SYW-19, along the southwest corner of the lake near the mouth of Harbor Brook, had the greatest number of exceedances (12), with modeled doses of methylmercury, total PAHs, hexachlorobenzene, and dioxins/furans (TEQ) exceeding LOAELs and NOAELs at both the 95 percent UCL and mean concentrations. Hazard quotients of total PAHs and dioxins/furans were up to three orders-of-magnitude above 1.0. NOAELs for arsenic, cadmium, lead, selenium, vanadium, trichlorobenzenes, and total PCBs were exceeded at both upper and mean dose exposures.

Wetland SYW-10 on the west side of the lake near the mouth of Ninemile Creek had 10 HQ exceedances. Modeled doses of methylmercury and total PAHs exceeded LOAELs and NOAELs at both the 95 percent UCL and mean concentrations. Arsenic, thallium, vanadium, hexachlorobenzene, and dioxins/furans (TEQ) NOAELs were exceeded at both upper and mean dose exposures, while the cadmium and lead NOAELs were exceeded at the 95 percent UCL dose.

Wetland SYW-6 at the northwest end of the lake also had ten HQ exceedances. Modeled doses of methylmercury and total PAHs exceeded LOAELs and NOAELs at both the 95 percent UCL and mean concentrations. Additional exceedances at SYW-6, were the NOAELs for arsenic, thallium, vanadium, and dioxins/furans at both upper and mean dose exposures, and the cadmium and dioxins/furans LOAEL was also exceeded at the 95 percent UCL dose. The NOAEL and LOAEL for selenium were exceeded at the 95 percent UCL and the chromium and lead NOAELs were exceeded at the 95 percent UCL dose.

Wetland SYW-12 at the southeast end of the lake had eight HQ exceedances. Modeled doses of methylmercury and total PAHs exceeded LOAELs and NOAELs at both the 95 percent UCL and mean concentrations. Cadmium and vanadium NOAELs were exceeded at both upper and mean dose exposures. Arsenic, lead, hexachlorobenzene, and dieldrin NOAELs were exceeded at the 95 percent UCL dose. Data for dioxins/furans were not available at SYW-12.

At the dredge spoils area, arsenic, vanadium, hexachlorobenzene, and total PAH NOAELs were exceeded at both upper and mean dose exposures for surface soils. The hexachlorobenzene 95 percent UCL dose also exceeded the LOAEL and the selenium NOAEL was exceeded at the 95 percent UCL dose.

These results suggest the potential for adverse effects on insectivorous mammals via exposure to COCs in water, sediment, and terrestrial prey. The potential for adverse effects was calculated to be greater in wetlands areas than the dredge spoils area (surface soils). The covertypes of the wetland areas provide more suitable habitat for wildlife than the dredge spoils area (Chapter 3).

10.12.3 Do Measured Concentrations of Chemicals and Stressors in Surface Water Exceed Standards, Criteria, and Guidance for the Protection of Wildlife?

Measurement Endpoint: **Comparison of Measured Surface Water Concentrations to Water Quality Standards, Criteria, and Guidance**

Selected COCs detected in lake surface water in 1992 and 1999 were compared to NYSDEC water quality standards, criteria, and guidance in Appendix B (see Chapter 5, Table 5-3 for summary). With the exception of mercury, all COCs (i.e., barium, copper, lead, manganese, chlorobenzene, dichlorobenzenes, trichlorobenzenes, and bis[2-ethylhexyl]phthalate), exceeded USEPA chronic aquatic or Tier II water quality values (Chapter 4, Table 4-4). Mercury concentrations in Onondaga Lake in 1992 and 1999 exceeded the wildlife protection value.

10.12.4 What Do the Available Field-Based Observations Suggest About the Health of Local Insectivorous Mammal Populations?

Measurement Endpoint: **Field Observations of Local Insectivorous Mammals**

It is difficult to separate out the effects of chemical contamination on wildlife from those of habitat loss and development. Chapter 3, Table 3-14 lists mammalian species found in covertypes around Onondaga Lake. Several insectivorous species, such as shrews and bats, are found in these covertypes. However, local populations of insectivorous mammals have not been studied to determine whether they have been impacted.

10.13 Assessment Endpoint: Sustainability of Local Piscivorous Mammal Populations

10.13.1 Do Modeled Dietary Doses to Piscivorous Mammals Exceed Toxicity Reference Values for Adverse Effects on Reproduction?

Measurement Endpoint: **Comparison of Modeled Piscivorous Mammal Dietary Dose Concentrations to Toxicity Reference Values**

Modeled dose concentrations of total PCBs in the mink (*Mustela vison*) exceeded the NOAEL and LOAEL TRVs at both the 95 percent UCL and mean exposure doses (Table 10-13). Modeled mink dietary doses of methylmercury, total PAHs and dioxins/furans exceeded NOAELs at the 95 percent UCL and mean exposure dose levels and the LOAEL at the 95 percent UCL (Table 10-13). Hexachlorobenzene exceeded a HQ of 1.0 when compared to the NOAEL at both 95 percent UCL and mean concentrations for the mink.

Modeled dose concentrations of methylmercury and total PCBs in the river otter (*Lutra canadensis*) exceeded NOAEL and LOAEL TRVs at both the 95 percent UCL and mean exposure doses (Table 10-14). Modeled river otter dietary doses of total PAHs, DDT and metabolites, and dioxins/furans exceeded NOAELs at the 95 percent UCL and mean exposure dose levels (Table 10-14). DDT and metabolites also exceeded the LOAEL at the 95 percent UCL concentration for the river otter.

These results suggest the potential for adverse effects on piscivorous mammals via exposure to COCs in water, sediment, and prey.

10.13.2 Do Measured Concentrations of Chemicals and Stressors in Surface Water Exceed Standards, Criteria, and Guidance for the Protection of Wildlife?

Measurement Endpoint: **Comparison of Measured Surface Water Concentrations to Water Quality Standards, Criteria, and Guidance**

Selected COCs detected in lake surface water in 1992 and 1999 were compared to NYSDEC water quality standards, criteria, and guidance in Appendix B (see Chapter 5, Table 5-3 for summary). With the exception of mercury, all COCs (i.e., barium, copper, lead, manganese, chlorobenzene, dichlorobenzenes, trichlorobenzenes, and bis[2-ethylhexyl]phthalate), exceeded USEPA chronic aquatic or Tier II water quality values (Chapter 4, Table 4-4). Mercury concentrations in Onondaga Lake in 1992 and 1999 exceeded the wildlife protection value.

10.13.3 What Do the Available Field-Based Observations Suggest About the Health of Local Piscivorous Mammal Populations?

Measurement Endpoint: Field Observations of Local Piscivorous Mammals

It is difficult to separate out the effects of chemical contamination on wildlife from those of habitat loss and development. Chapter 3, Table 3-14 lists mammalian species found in covertypes around Onondaga Lake. The mink and river otter are the only primarily piscivorous mammals found in these covertypes. The New York River Otter Project has records of river otters from the Onondaga Lake area from 1994 to 2002 (NYSDEC, 2002a). Otters have been observed at several locations along Ninemile Creek (e.g., Erie Canal, NY State Fairgrounds) and Onondaga Creek. The low numbers of mink and river otter sighted around Onondaga Lake may be due to a number of factors, such as inadequate habitat, disturbance by humans, and chemical contamination, among others. There has been no standardized effort to document mink and otter populations.

10.14 Summary

Multiple lines of evidence were used to evaluate major components of the Onondaga Lake ecosystem to determine if lake contamination has adversely affected plants and animals around Onondaga Lake. Almost all lines of evidence indicate that the Honeywell-related contaminants, including ionic waste in Onondaga Lake, have produced adverse ecological effects at all trophic levels examined.

The aquatic macrophytes in the lake have been adversely affected by lake conditions, and the resulting loss of macrophyte habitat that formerly provided valuable feeding and nursery areas has undoubtably affected the aquatic invertebrates and vertebrates living in Onondaga Lake. In addition to general habitat loss, there has been bioaccumulation of mercury and possibly other contaminants in most organisms serving as a food source in the lake, including phytoplankton, zooplankton, benthic invertebrates, and fish.

Site-specific sediment PECs indicate adverse effects in the southern areas of the lake and near Ninemile Creek. The area near the Honeywell sites between Tributary 5A and Harbor Brook exhibited the greatest number of exceedances of the PECs (Figure 10-3).

Comparisons of measured tissue concentrations and modeled doses of contaminants to TRVs show exceedances of HQs for site-related chemicals throughout the range of the point estimates of risk. Many of the contaminants in the lake are persistent and, therefore, the risks associated with these contaminants are unlikely to decrease significantly in the short term in the absence of remediation.