12. CONCLUSIONS

This chapter summarizes the results of the baseline ecological risk assessment presented in the preceding chapters. Each assessment endpoint and its associated measurement endpoints are presented in a strength-of-evidence approach along with a summary of the results. A strength-of-evidence approach is used to integrate different types of data, or lines of evidence used in this BERA to support a conclusion. The results of the risk characterization are evaluated in the context of the uncertainty analysis (Chapter 11) to assess the potential for adverse effects to receptors as a result of exposure to contaminants and stressors present in Onondaga Lake.

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

Does the Aquatic Macrophyte Community Structure Reflect the Influence of Chemicals of Concern/Stressors of Concern (COCs/SOCs)?

Studies of the Onondaga Lake macrophyte community, as compared to reference lakes, indicate that the current impoverished community does reflect the influence of COCs and SOCs, particularly ionic waste. Lower species diversity is seen than in similar lakes, and macrophyte coverage of the lake is low.

Do the COCs/SOCs Present in Onondaga Lake Affect Macrophyte Growth and Survival?

Laboratory (greenhouse studies) and field experiments indicate that SOCs and/or COCs in Onondaga Lake inhibit macrophyte growth and survival, limiting colonization and spread of macrophytes in Onondaga Lake as compared to a reference lake (i.e., Otisco Lake). The effects of the ionic waste discharged into Onondaga Lake, including increased salinity concentrations, reduced water transparency, degraded lake sediments, and oncolite formation, as well as natural processes, such as wave action, have resulted in a depauperate macrophyte community in the lake.

Do Measured Concentrations of COCs/SOCs in Surface Water Exceed Standards, Criteria, and Guidance for the Protection of Aquatic Organisms?

There are no standards, criteria, and guidance that specifically address risk to macrophytes. 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.

Low dissolved oxygen (DO) levels that occur in the deeper waters of the lake do not occur in the shallower waters (shoreline) of the lake. Therefore, low DO is not considered a major limiting factor to macrophyte growth, which is primarily in shallower shoreline areas of water with adequate oxygen. Visibility and associated light availability are relatively low most of the year, with the exception of after the fall turnover in November, which will restrict the presence of macrophytes at greater depths.

The reduced water transparency due to ionic waste contravenes the narrative water quality standard (Part 703.2) for turbidity (and possibly color). Oncolite formation is evidence of past contravention of the same standards (Part 703.2) for suspended, colloidal, and settleable solids. Any present day degradation of the sediments (e.g., wave action causing excessive resuspension of oncolites such that it affects macrophyte growth) contravenes the narrative standard for settleable solids. Any excessive resuspension of Solvay waste in the water column, such as during storms events, would contravene both the narrative standard for turbidity and suspended/settleable solids.

Summary

Sustainability of an aquatic macrophyte community that can serve as a shelter and food source for local invertebrates, fish, and wildlife was assessed using three lines of evidence, as follows:

- Comparison of the Onondaga Lake macrophyte community to reference location communities.
- Evaluation of growth and survival of macrophytes in Onondaga Lake using field and laboratory studies.
- Qualitative evaluation of narrative water quality standards.

The Onondaga Lake aquatic macrophyte community has been impacted by pollution. The community shows lower diversity than other eutrophic lakes in New York State and growth and survival of individual plants is low. Qualitative evaluation of water quality conditions indicate that current water quality is suboptimal for macrophyte growth. Based on field studies and the literature, one of the major influences resulting in the current poor condition of the macrophyte community is the vast amount of ionic waste that has been discharged into the lake. In addition to increasing salinity to the point where only a small number of plant species with a limited distribution could survive in the lake, the ionic waste discharge also resulted in low visibility and degradation of sediments due to physical changes caused by the input of high concentrations of calcium carbonate. Sediment degradation can exacerbate the natural effects of wave action, increasing the difficulties of colonizing and spreading in an area. The formation of oncolites may also restrict the presence of macrophytes, particularly in areas that are subject to strong wave action.

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

Does the Phytoplankton Community Structure Reflect the Influence of COCs/SOCs?

In general, the characteristics of the phytoplankton communities of Onondaga Lake reflect 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. The effect of mercury contamination on the

phytoplankton community is unknown, but it has been shown to bioaccumulate in phytoplankton and subsequently can be passed on to animals feeding on phytoplankton in Onondaga Lake.

Do Measured Concentrations of COCs/SOCs in Surface Water Exceed Standards, Criteria, and Guidance for the Protection of Aquatic Organisms?

There are no standards, criteria, and guidance that specifically address risk to phytoplankton. However, the summed concentration of total ammonia and nitrate has continuously exceeded levels associated with limitation of phytoplankton growth. 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.

Summary

The sustainability of a phytoplankton community that can serve as a food source for local invertebrates, fish, and wildlife was assessed using two lines of evidence, as follows:

- Field observations of the Onondaga Lake phytoplankton community.
- Qualitative evaluation of narrative water quality standards.

The phytoplankton community in Onondaga Lake reflects the polluted and eutrophic nature of the lake. Qualitative evaluation of water quality conditions indicate that current water quality is suboptimal for phytoplankton growth. Mercury has been shown to bioaccumulate in phytoplankton in Onondaga Lake, and other COCs may also bioaccumulate, although no analyses have been performed to date. Although the phytoplankton community has been impacted by lake conditions, it still serves as a food source for local invertebrates, fish, and wildlife, and as such passes bioaccumulative contaminants such as mercury on in the food chain.

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

Does the Zooplankton Community Structure Reflect the Influence of COCs/SOCs?

The zooplankton community of Onondaga Lake has been affected by stressors, including salinity and calcium carbonate deposition. Native species of daphnids were replaced by exotic high-salinity-tolerant species during the peak industrial pollution period from the 1950s to the 1980s, and did not return until levels of salinity declined in the late 1980s. Despite recent increases in zooplankton diversity, the zooplankton assemblage of the lake remains depauperate compared to other lakes in the region. High concentrations of mercury in the sediments have been shown to be associated with low hatching success of daphnid eggs in laboratory monitoring. The effect of mercury contamination on juvenile or adult daphnids

has not been examined, but mercury has been shown to bioaccumulate in zooplankton in Onondaga Lake and subsequently would be passed on to animals feeding on zooplankton in Onondaga Lake.

Do Measured Concentrations of COCs/SOCs in Surface Water Exceed Standards, Criteria, and Guidance for the Protection of Aquatic Organisms?

Selected COCs detected by Honeywell in lake and tributary surface water in 1992 and 1999 were compared to NYSDEC and USEPA water quality standards, criteria, and guidance. The frequency and magnitude of exceedances in Onondaga Lake and tributary water varied by contaminant, year, location, and depth. 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 values. Mercury concentrations, ranging from 0.0009 to 0.307 µg/L (307 ng/L), exceeded the NYSDEC wildlife value of 0.0026 µg/L at various locations throughout the lake and in the tributaries, but not the chronic water quality value (0.77 µg/L) for the protection of aquatic organisms. Sixty out of 114 samples (53 percent) analyzed for mercury in 1992 and 12 out of 56 samples (21 percent) analyzed for mercury in 1999 had concentrations above the NYSDEC wildlife value.

Other exceedances of surface water standards, criteria, and guidance for the protection of aquatic organisms are as follows:

- Copper exceedances of the NYSDEC and USEPA chronic aquatic water quality value of 11.6 µg/L, the NYSDEC and USEPA acute aquatic water quality value of 17.8 µg/L, and the USEPA Ambient Water Quality Criterion Final Chronic Value (AWQC/FCV) of 14.7 µg/L occurred in tributary surface water, which was only sampled in 1992.

- Lead exceedances of the USEPA chronic water quality value of 3.5 µg/L, the USEPA AWQC/FCV of 3.7 µg/L, and NYSDEC chronic aquatic water quality value of 5.2 µg/L occurred in tributary surface water, which was sampled in 1992.

- Manganese concentrations exceeded the USEPA Tier II aquatic life standard of 880 µg/L in the lake in both 1992 and 1999. However, concentrations were approximately within a factor of two of background levels (using Otisco Lake as a reference lake), which also exceeded the USEPA Tier II aquatic life standard.

- One lake sample analyzed for zinc in 1992 exceeded the NYSDEC chronic aquatic water quality value of 107 µg/L. The remaining 21 exceedances occurred in tributaries. Zinc was not analyzed in the lake in 1999.

- Most exceedances of the NYSDEC chronic standard of 5 µg/L for chlorobenzene and dichlorobenzenes were in tributaries (mainly the East Flume). There was one

exceedance in the lake at the Willis Avenue Lakeshore area. Exceedances were found in 1992 and 1999.

- One sample exceeded the NYSDEC chronic trichlorobenzenes standard of 5 µg/L in the southern basin in 1992. Trichlorobenzenes were not analyzed in 1999.

Based on these results, concentrations of contaminants of Onondaga Lake water affect aquatic organisms living in certain areas of the lake.

Stressors in Onondaga Lake, including chloride, salinity, ammonia, nitrite, and phosphorus, generally exceeded guidelines or background levels. Although lake salinity has dropped to 1.1 parts per thousand (ppt) (Effler et al., 1996; Onondaga Lake Partnership [OLP], 2002), this value is still an order-of-magnitude greater than the average world river salinity (0.11 ppt) and is several times higher than salinity levels in Otisco Lake (0.25 ppt), whose drainage basin is also within the Limestone Belt of central New York State. These levels of salinity are likely to exclude some species of macrophytes from the lake.

The high total ammonia (ammonia and nitrite) concentrations present in Onondaga Lake are in part a result of loads received by the lake from the Metropolitan Syracuse Sewage Treatment Plant (Metro) (Matthews et al., 2000). Currently, upgrades to Metro are being guided by an Amended Consent Judgment (ACJ) from 1998. Decreases in total ammonia concentrations have been made, and improved status has been achieved, with respect to ammonia toxicity standards in the last several years and further reductions are planned through December 2012 (Matthews et al., 2001).

Although concentrations of phosphorus have exceeded the aesthetic effects guidance value, this is considered to have minimal impact on macrophytes in the lake. Nonetheless, under the ACJ, concentrations of total phosphorus will be reduced in two phases over the next ten years. Total phosphorus is to be reduced to 0.12 mg/L by April 2006 and to 0.02 mg/L by December 2012.

The large quantities of ionic waste stressors (e.g., calcium carbonate) deposited on Onondaga Lake sediments are also likely to be detrimental to zooplankton eggs deposited in the sediment. If the disturbance of the sediments in the lake causes resuspension of calcite materials (e.g., oncolites or Solvay waste) such that zooplankton eggs or other aquatic organisms are impacted, then there is a violation of the narrative water quality standards (6 NYCRR Part 703.2).

In summary, concentrations of COCs and SOCs in Onondaga Lake water affect zooplankton living in certain areas of the lake, while the majority of the lake is habitable in terms of chemical water quality. Stressors in Onondaga Lake, including chloride, salinity, ammonia, nitrite, and phosphorus, exceeded guidelines (when available) or background levels. Although lake salinity has decreased since the closure of the chlor-alkali plant, it likely excludes some species of zooplankton from the lake.

Do Measured Concentrations of COCs/SOCs in Sediments Exceed Criteria and/or Guidelines for the Protection of Aquatic Organisms?

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 surface sediments exceeded guidelines for all sediment COCs (i.e., arsenic, cadmium, chromium, lead, mercury, nickel, dichlorobenzenes [total], trichlorobenzenes [total], ethylbenzene, toluene, xylenes, hexachlorobenzene, total polycyclic aromatic hydrocarbons [PAHs], phenol, dibenzofurans, chlordanes, heptachlor/heptachlor epoxide, DDT and metabolites, total polychlorinated biphenyls [PCBs], and dioxins/furans).

Exceedances of sediment criteria and/or guidance values for the protection of aquatic organisms are as follows:

- Arsenic was detected in 2000 above 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) collected in 1992 and 59 out of 85 samples (69 percent) collected in 2000 exceeded the site-specific probable effect concentration (PEC) of 2.4 mg/kg calculated for Onondaga Lake.

- Cadmium was detected in 2000 above 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) collected in 1992 and 23 out of 85 samples (27 percent) collected in 2000 exceeded the site-specific PEC of 2.4 mg/kg calculated for Onondaga Lake.

- Chromium was detected in 2000 above 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, 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) collected in 1992 and 40 out of 85 samples (47 percent) exceeded the site-specific PEC of 50 mg/kg calculated for Onondaga Lake.

- Lead was detected in 2000 above 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) collected in 1992 and 46 out of 85 samples (54 percent) collected in 2000 exceeded the site-specific PEC of 35 mg/kg calculated for Onondaga Lake.

- Mercury was detected in 2000 above 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 samples (53 percent) collected in 1992 and 86 out of 157 samples collected in 2000 (55 percent) exceeded the site-specific PEC of 2.2 mg/kg calculated for Onondaga Lake.

- Nickel was detected above 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) collected in 1992 and 50 out of 85 samples (59 percent) collected in 2000 exceeded the site-specific PEC of 16 mg/kg calculated for Onondaga Lake.

- Dichlorobenzenes (sum) were detected above 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 (12 percent) collected in 1992 and 34 out of 85 (40 percent) collected in 2000 exceeded the site-specific PEC of 239 µg/kg calculated for Onondaga Lake.

- Trichlorobenzenes (sum) were detected above 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) collected in 1992 and 5 out of 85 samples (6 percent) exceeded the site-specific PEC of 347 µg/kg calculated for Onondaga Lake.

- Ethylbenzene was detected above 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 ORNL secondary chronic criterion of 8.9 µg/gOC. One out of 114 samples (< 1 percent) collected in 1992 and 26 out of 61 samples (42 percent) collected in 2000 exceeded the site-specific PEC of 176 µg/kg calculated for Onondaga Lake.

- Toluene was detected above 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) collected in 1992 and 26 out

of 62 samples (42 percent) collected in 2000 exceeded the site-specific PEC of 42 µg/kg calculated for Onondaga Lake.

- Xylenes (sum) were detected above 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) collected in 1992 and 18 out of 37 (49 percent) collected in 2000 exceeded the site-specific PEC of 561 µg/kg calculated for Onondaga Lake.

- Hexachlorobenzene was above the NYSDEC wildlife bioaccumulation sediment criterion of 12 µg/gOC, the OME LEL of 2.0 µg/gOC, and the OME SEL of 24 µg/gOC. Twelve out of 89 samples (13 percent) collected in 1992 and 27 out of 85 samples (32 percent) collected in 2000 exceeded the site-specific PEC of 16 µg/kg calculated for Onondaga Lake.

- Total PAHs were detected above 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.

- Phenol was detected above 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 collected in 1992 and 11 out of 85 samples (13 percent) collected in 2000 exceeded the site-specific PEC of 45 µg/kg calculated for Onondaga Lake.

- Dibenzofuran was detected above the ORNL secondary chronic criterion of 42 µg/gOC. Two out of 19 samples (11 percent) collected in 1992 and 13 out of 85 samples (15 percent) collected in 2000 exceeded the site-specific PEC of 372 µg/kg calculated for Onondaga Lake.

- Chlordanes (sum) were detected above 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 collected in 1992 and 8 out of 84 samples (10 percent) collected in 2000 exceeded the site-specific PEC of 5.1 µg/kg calculated for Onondaga Lake.

- Heptachlor/heptachlor epoxide (sum) were detected above 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.

- DDT and metabolites (sum) were detected above the NYSDEC 4-4'-DDT benthic aquatic life chronic toxicity sediment criterion of 1.0 µg/gOC and the OME LEL of 0.8 µg/gOC. One out of 19 samples (<1.0 percent) collected 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.

- Total PCBs were detected above 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 (12 percent) collected in 1992 and 42 out of 115 samples (37 percent) collected in 2000 exceeded the site-specific PEC of 295 µg/kg calculated for Onondaga Lake.

- Dioxins/furans were detected above the NYSDEC wildlife bioaccumulation criterion of 0.0002 µg/gOC. There were not enough data to calculate a site-specific PEC for dioxins/furans.

Summary

Sustainability of a zooplankton community that can serve as a food source for local invertebrates, fish, and wildlife was assessed using three lines of evidence, as follows:

- Field observations of the Onondaga Lake zooplankton community.

- Comparison of surface water concentrations to water quality standards, criteria, and guidance developed for the protection of aquatic life and qualitative evaluation of narrative standards.

- Comparison of contaminant concentrations in sediment to guidelines.

All three of these lines of evidence indicate that the zooplankton community of Onondaga Lake has been impacted by high levels of COCs and/or SOCs in lake water. In particular, high levels of salinity and mercury have influenced community structure and abundance. Although the zooplankton community has been impacted by lake conditions, it still serves as a food source for local invertebrates, fish, and wildlife, and as such passes bioaccumulative contaminants such as mercury on in the food chain.

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

Does the Terrestrial Plant Community Structure Reflect the Influence of COCs/SOCs?

The terrestrial plant communities found around Onondaga Lake reflect the development that has occurred near the lake over the last two centuries. Only obvious effects, such as the sparse vegetation found on the wastebeds, can be conclusively attributed to activities at Honeywell facilities (i.e., disposal of Solvay and other industrial wastes).

Do Measured Concentrations of COCs/SOCs in Soil Exceed Toxicity Values for Terrestrial Plants?

Arsenic, cadmium, chromium, lead, mercury, nickel, silver, selenium, thallium, vanadium, and zinc exceeded a hazard quotient (HQ) of 1.0 in plants at one or more of the four wetlands and in the dredge spoils area, indicating that potential risks to plants exist at these locations. In particular, surface soil concentrations of chromium and mercury were over an order-of-magnitude greater than benchmark values. Risks from nickel, selenium, vanadium, and zinc (except at Wetland SYW-6) may be due to background concentrations of these inorganic compounds. Potential risks attributed to site contamination are:

- Wetland SYW- 6: chromium, lead, mercury, nickel, thallium, and zinc.
- Wetland SYW-10: chromium, lead, mercury, and thallium.
- Wetland SYW-12: cadmium, chromium, lead, mercury, and silver.
- Wetland SYW-19: cadmium, chromium, lead, and mercury.
- Dredge spoils area: chromium and mercury.

These results suggest the potential for adverse effects on plants via exposure to COCs in soils at all four wetland areas and the dredge spoils area.

Summary

Sustainability of a terrestrial plant community that can serve as a shelter and food source for local invertebrates and wildlife was assessed using two lines of evidence, as follows:

- Field observations of the Onondaga Lake terrestrial plant community.
- Comparison of surface soil concentrations to plant toxicity values.

There was not enough information on the plant community to determine if it had been affected. Comparisons of soil contaminant concentrations to plant toxicity values indicate that high levels of contaminants, in particular chromium and mercury, may adversely affect the plant community and, subsequently, local invertebrates and wildlife that live or forage in local habitats.

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

Does the Benthic Invertebrate Community Structure Reflect the Influence of COCs/SOCs?

Many of the benthic invertebrates communities living in the littoral zone (less than 5 m depth) in Onondaga Lake and the mouths of its tributaries have been impacted to some degree by COCs and/or SOCs. The majority of moderately and severely impacted stations were located between Tributary 5A and Ley Creek, with the most severely impacted stations located between Tributary 5A and Onondaga Creek. Most stations in this area have three metrics of the five metrics that are significantly different than Otisco Lake, which was used as a reference station.

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

The 10-day toxicity tests conducted in 1992 indicated that amphipod toxicity due to the high levels of COCs was confined to an area in the southwestern corner of the lake, along Wastebeds 1 through 8 and along the lakeshore area near Harbor Brook and the East Flume. Most chironomid toxicity was confined to the southern half of the lake in three general areas: 1) off Tributary 5A; 2) Ley Creek; and 3) in the southwestern corner of the lake (off Harbor Brook, the Metro outfall, and the East Flume).

The results of the 42-day chronic sediment toxicity tests conducted in 2000 showed amphipod toxicity to the high levels of COCs from Tributary 5A to the East Flume and near the Metro outfall. Chironomid toxicity occurred in three areas: 1) from Tributary 5A to the East Flume; 2) off Ninemile Creek; and 3) off Ley Creek.

The results of the sediment toxicity tests confirmed that some Onondaga Lake sediments are toxic to benthic invertebrates and increase mortality and reduce growth and fecundity of these organisms. The most toxic sediments are found in the nearshore zone in the southern part of the lake between Tributary 5A and Ley Creek.

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

Measured concentrations of barium, copper, lead, manganese, mercury, zinc, cyanide, chlorobenzene, dichlorobenzenes, and trichlorobenzenes exceed surface water criteria. Concentrations of contaminants in Onondaga Lake water may affect organisms living in Onondaga Lake, particularly in the southern basin. There were exceedances of surface water criteria in the tributaries emptying in to Onondaga Lake. Macroinvertebrates living at tributary mouths are likely affected by contaminants found in those waters.

Stressors in Onondaga Lake, including chloride, salinity, ammonia, nitrite, and phosphorus, generally exceeded guidelines (when available) or background levels. The DO in the deeper Onondaga Lake water (greater than 3 m) is often lower than the NYSDEC standard, making the deeper part of the lake uninhabitable by benthic invertebrates. In the hypolimnion, concentrations of sulfide, DO, and ammonia currently result in limited use of this portion of the lake by fish and macroinvertebrates.

The large quantities of ionic waste stressors (e.g., calcium carbonate) deposited on Onondaga Lake sediments are also likely to be detrimental to macroinvertebrate eggs deposited in the sediment. If the disturbance of the sediments in the lake causes resuspension of calcite materials (e.g., oncolites or Solvay waste) such that macroinvertebrate eggs or other aquatic organisms are impacted, then there is a violation of the narrative water quality standards (6 NYCRR Part 703.2).

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

Measured surface sediment concentrations of COCs exceed the consensus probable effect concentration (PEC) values at many locations throughout Onondaga Lake. Only nine of the 114 locations sampled in 1992 and five of the 84 locations sampled in 2000 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. In addition, these sediment locations have the highest number of compounds – between 11 and over 30 compounds per sample (note that PAH compounds are considered individually) – exceeding their PECs in a sample.

Mercury exceeded its PEC value of 2.2 mg/kg in 49 percent of the 0 to 15 cm sediment samples from Onondaga Lake. Samples were collected principally from the East Flume to Harbor Brook, in the central basins of Onondaga Lake, and off Ninemile Creek. BTEX and chlorinated benzenes were found to exceed one or more PEC value for each group of compounds in 28 and 21 percent of the analyzed surface sediment samples, respectively. These exceedances were found to occur primarily from the Interstate 690 (I-690) lakeshore area to Harbor Brook. Total PCBs were found to exceed the PEC value in 20 percent of the collected 0 to 15 cm sediment samples primarily located in the I-690 lakeshore area to Harbor Brook, and off Ley Creek. One or more PAH exceeded its PEC in 53 percent of the analyzed surface sediment samples. Exceedances occurred primarily from Tributary 5A to Ley Creek and off Ninemile Creek.

In addition to the site-specific consensus PECs developed for this BERA, concentrations of COCs in sediments exceeded NYSDEC sediment quality guidelines for all sediment COCs (i.e., arsenic, cadmium, chromium, lead, mercury, nickel, dichlorobenzenes [total], trichlorobenzenes [total], ethylbenzene, toluene, xylenes, hexachlorobenzene, total PAHs, phenol, dibenzofurans, chlordanes, heptachlor/heptachlor epoxide, DDT and metabolites, total PCBs, and dioxins/furans). In particular, sediment guidelines for the protection of wildlife were exceeded lakewide for PCBs and for dioxins/furans immediately off the I-690 lakeshore area, at the mouth of the East Flume, off the Harbor Brook/Metro area, and at the mouths of Ley Creek and Ninemile Creek.

No guidelines address stressors in sediments, in particular the large quantities of ionic waste stressors (e.g., calcium carbonate and the presence of oncolites) deposited on Onondaga Lake sediments. Based on the BERA analysis it can not be clearly defined if there are potential direct effects of calcium carbonate or oncolites on the benthic community in Onondaga Lake, although the above-stated effects on the macrophyte community could affect the benthic invertebrate community.

Summary

Benthic invertebrate community structure as a food source for local fish and wildlife was assessed using four lines of evidence, as follows:

- Evaluation of the benthic invertebrate community structure and abundance relative to regional conditions.
- Examination of the toxicity of sediments collected from different lake locations.
- Comparison of measured water column concentrations to water quality standards, criteria, and guidance for the protection of aquatic life and qualitative evaluation of narrative standards.
- Comparison of measured sediment concentrations to site-specific sediment effect levels developed specifically for the protection of the benthic invertebrate community in Onondaga Lake and to NYSDEC screening criteria.

All four lines of evidence suggest an adverse effect of COCs on the benthic invertebrate populations in Onondaga Lake. Therefore, local fish and wildlife populations using the benthic invertebrate community as a food source are likely in turn to be impacted.

12.6 Assessment Endpoint: Sustainability of Local Fish Populations

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

The current level of fish species diversity in Onondaga Lake is similar to values found in other New York State lakes, although species diversity was lower during the time when the chlor-alkali plants operated. In contrast to comparison lakes, the majority of the species found in Onondaga Lake do not reproduce there and recruitment rates are unknown. Many areas of Onondaga Lake are not suitable for fish reproduction due to industrial and municipal pollution and its effects on the lake ecosystem, such as reduced macrophyte cover and depleted DO levels.

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. 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 and low DO, 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.

Has the Presence of COCs/SOCs Influenced Fish Foraging or Nesting Activities?

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 some of the larger species such as the walleye (*Stizostedion vitreum*) and northern pike (*Esox lucius*) reproduce in the lake. Based on historical data, the lack of current lack of nursery area and adequate spawning sites has reduced successful reproduction of fish, resulting in poor year classes. Decreased water clarity, calcium carbonate precipitation, and increased salinity have reduced littoral zone vegetation, a critical area for spawning and 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, which will in turn impact the food supply of many fish species. The low amount of littoral zone vegetation also results in lower biomass of macroinvertebrates, which serve as primary food for many YOY fish. The conditions in Onondaga Lake have adversely affected fish reproduction and growth, as evidenced by low reproduction in the lake and fewer YOY fish than observed in lakes with similar characteristics.

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?

Limited data are available regarding the incidence of disease in Onondaga Lake fish. The rate of abnormalities observed in the lake in 1992 and in Geddes Brook and Ninemile Creek in 1998 by Honeywell was inconclusive. Therefore, insufficient data are available to evaluate this endpoint.

Do Measured Concentrations of COCs/SOCs in Surface Water Exceed Standards, Criteria, and Guidance for the Protection of Aquatic Organisms?

Concentrations of COCs/SOCs in surface water exceeded surface water criteria in both Onondaga Lake and its tributaries, with more exceedances of surface water criteria in the Onondaga Lake tributaries than in the lake itself. Stressors in Onondaga Lake, including chloride, salinity, ammonia, nitrite, and phosphorus, generally exceeded guidelines (when available) or background levels. Although lake salinity showed a decline from the high levels measured prior to closure of the chlor-alkali plants, it is currently about 1.1 ppt, which is still an order-of-magnitude greater than the average world river salinity (0.1 ppt). These levels of

salinity are likely to exclude some species of fish from the lake. The summed concentration of total ammonia and nitrate has continuously exceeded standards to protect non-salmonid (as well as salmonid) fish.

The DO in the hypolimnion of Onondaga Lake water generally fails to meet the NYSDEC standard It is likely that in mid- to late summer, when the temperature is reaching its highest level in the epilimnion and DO is reaching its lowest level in the hypolimnion, fish seek deeper, cooler waters. When they are unable to use the deeper part of the lake because of low DO these species move out of the lake to avoid the heat, and possibly other shallow water stressors as well.

The large quantities of ionic waste stressors (e.g., calcium carbonate) deposited on Onondaga Lake sediments are also likely to be detrimental to fish eggs deposited in the sediment. If the disturbance of the sediments in the lake causes resuspension of calcite materials (e.g., oncolites or Solvay waste) such that fish eggs or other aquatic organisms are impacted, then the contaminants in the sediments may cause a violation of the narrative water quality standards (6 NYCRR Part 703.2). Calcite deposition and resuspension, ionic stratification, and oncolite formation have negative effects on the fish community and thereby impair the best use of the water (fish propagation and survival). Water quality standards for turbidity and suspended or settleable solids are exceeded.

Do Measured Concentrations of COCs/SOCs in Sediments Exceed Criteria and/or Guidelines for the Protection of Aquatic Organisms?

Concentrations of COCs in Onondaga Lake sediments exceeded NYSDEC sediment screening criteria for all sediment COCs (i.e., arsenic, cadmium, chromium, lead, mercury, nickel, dichlorobenzenes [total], trichlorobenzenes [total], ethylbenzene, toluene, xylene, hexachlorobenzene, total PAHs, phenol, dibenzofurans, chlordane, heptachlor/heptachlor epoxide, DDT and metabolites, total PCBs, and dioxins/furans). Concentrations of COCs in Onondaga Lake sediments exceeded consensus PECs developed for this BERA for one or more contaminant at about 92 percent of all 1992 sampling locations and about 96 percent of all 2000 sampling locations.

Do Measured Concentrations of COCs in Fish Exceed Toxicity Reference Values for Adverse Effects on Fish?

Risks to fish from contaminants were evaluated on a species-specific basis using measured body burdens. Eight fish species were analyzed to represent the Onondaga Lake fish community. A limited number of contaminants (e.g., methylmercury) were analyzed in some species (e.g., gizzard shad [*Dorosoma cepedianum*] and largemouth bass [*Micropterus salmoides*]); therefore, actual risks from contaminants in lake water may be greater for these species than calculated. HQs greater than 1.0 were calculated for the following contaminants (by fish species):

- Bluegill (*Lepomis macrochirus*) – arsenic, chromium, endrin, mercury, selenium, vanadium, and zinc.

- Carp (*Cyprinus carpio*) – arsenic, chromium, dioxin/furans, endrin, mercury, total PCBs, selenium, vanadium, and zinc.

- Catfish – chromium, endrin, methylmercury, mercury, total PCBs, selenium, vanadium, and zinc.

- Gizzard shad – methylmercury.

- Largemouth bass – methylmercury and dioxins/furans.

- Smallmouth bass (*Micropterus dolomieui*) – arsenic, chromium, mercury, methylmercury, total PCBs, selenium, vanadium, and zinc.

- Walleye – chromium, mercury, methylmercury, and total PCBs.

- White perch (*Morone americana*) – chromium, mercury, methylmercury, selenium, and total PCBs.

Such results suggest adverse effects on most fish species via exposure to COCs in water, sediment, and prey. Concentrations of chromium and mercury exceeded TRVs in all fish species examined (when included in analyses) throughout much of the point estimate range of risk (i.e., from the 95 percent upper confidence limit [UCL] concentration to no observable adverse effect level [NOAEL] HQ to the mean concentration to lowest observable adverse effect level [LOAEL] HQ). Contaminant levels in Onondaga Lake fish were greater than those in background fish. Although background fish HQs for arsenic, chromium, selenium, vanadium, and zinc sometimes exceeded 1.0 (primarily for upper-bound exposure; i.e., the maximum concentration compared to NOAEL), all contaminant concentrations were considered to be site-related. These results indicate that measured concentrations of contaminants in fish are adversely affecting fish populations, particularly where embryos and young are exposed to these levels.

Summary

The sustainability of local fish populations was assessed using six lines of evidence, as follows:

- Examination of the fish community structure as compared to similar lakes and historic accounts of Onondaga Lake (prior to industrial activities) in relation to local fish populations.

- Looking for potential effects of COCs/SOCs on fish foraging and nesting.

- Comparison of visual abnormalities (e.g., tumors, lesions) in Onondaga Lake fish to fish from other lakes.

- Comparison of measured water column concentrations to water quality criteria for the protection of aquatic life and qualitative evaluation of narrative standards.

- Comparison of measured sediment concentrations to guidelines for the protection of aquatic life.

- Comparison of measured concentrations of contaminants in fish representing various feeding strategies and trophic levels to TRVs.

Five of the six lines of evidence suggest adverse effects of COCs on the Onondaga Lake fish community and the remaining line of evidence, incidence of visual abnormalities, was inconclusive. This strength-of-evidence approach indicates that local fish populations are adversely affected by the contaminants and stressors present in Onondaga Lake.

12.7 Assessment Endpoint: Sustainability of Local Amphibian and Reptile Populations

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

A field survey of Onondaga Lake concluded that the herpetofauna around the lake was generally depauperate, including the absence of some common species. The number of amphibian and reptilian species found around the lake was considerably lower than the number of species recorded for Onondaga County as a whole. Nearly all amphibians and reptiles appear to inhabit only terrestrial and wetland areas isolated from direct contact with the lake, primarily along the northwest shoreline of the lake.

Do Measured Concentrations of COCs/SOCs in Surface Water Exceed Standards, Criteria, and Guidance for the Protection of Aquatic Organisms?

Concentrations of COCs and SOCs in Onondaga Lake water affect organisms living in certain areas of the lake. There were more exceedances of surface water criteria in the Onondaga Lake tributaries than in the lake itself. The majority of wetland areas, some of which could provide suitable habitats for amphibians and reptiles, are found near tributary mouths (e.g., Ninemile Creek, Harbor Brook, and Ley Creek).

Stressors in Onondaga Lake, including chloride, salinity, ammonia, nitrite, sulfide, and phosphorus, generally exceeded guidelines (when available) or background levels. Although lake salinity showed a decline from the highest levels measured prior to closure of the chlor-alkali plants, it is still an order-of-magnitude greater than the average world river salinity (0.1 ppt). These high levels of salinity are detrimental to amphibian reproduction and growth.

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

The toxicity of water from Onondaga Lake and associated wetlands on developing amphibian embryos was evaluated in laboratory studies (Ducey et al., 2000) and found to have variable, but consistently negative, effects on amphibian development relative to controls.

Summary

Sustainability of local amphibian and reptile populations was assessed using three lines of evidence, as follows:

- Conducting a field survey of local amphibian and reptile populations around Onondaga Lake.
- Comparison of measured water column concentrations to water quality criteria for the protection of aquatic life.
- Performing laboratory studies examining the effects of Onondaga Lake water on amphibian embryos.

All three lines of evidence strongly indicate that amphibian and reptile populations have been adversely affected by contaminants and/or stressors found in Onondaga Lake water.

12.8 Assessment Endpoint: Sustainability of Local Insectivorous Bird Populations

Do Modeled Dietary Doses to Insectivorous Birds Exceed TRVs for Adverse Reproductive Effects?

The tree swallow (*Tachycineta bicolor*) was selected to represent insectivorous birds around Onondaga Lake and was used for modeling dose exposures. Modeled dose concentrations of barium, chromium, methylmercury, mercury, selenium, and total PAHs for the tree swallow exceeded NOAEL and LOAEL TRVs at both the 95 percent UCL and mean concentrations. Cadmium, lead, zinc, dichlorobenzene, total PCBs, and dioxin/furan (toxicity equivalent [TEQ]) dose concentrations exceeded the NOAEL at the 95 percent UCL and mean concentrations. Only selenium and zinc risks may be due to background levels, rather than site contamination. These results suggest adverse effects on insectivorous birds via exposure to COCs in water and particularly in prey.

Do Measured Concentrations of COCs/SOCs in Surface Water Exceed Standards, Criteria, and Guidance for the Protection of Wildlife?

Mercury concentrations in Onondaga Lake in 1992 and 1999 exceeded the NYSDEC wildlife protection value of 0.0026 µg/L. The other contaminants for which there were available wildlife water quality standards, criteria, or guidance values were not detected (i.e., DDT and PCBs) or not analyzed (i.e., dioxins/furans).

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

Insectivorous birds have been sighted year-round around Onondaga Lake. However, no site-specific data have been collected; therefore, the significance of bird sightings is uncertain.

Summary

Sustainability of local insectivorous bird populations was assessed using three lines of evidence, as follows:

- Modeling of dietary doses of contaminants.
- Comparison of measured water column concentrations to water quality standards, criteria, and guidance for the protection of wildlife.
- Field-based observation.

The first two lines of evidence indicated that insectivorous birds may be adversely affected by contaminants found in Onondaga Lake and taken up by aquatic invertebrates. The third line of evidence, field observations, was inconclusive.

12.9 Assessment Endpoint: Sustainability of Local Benthivorous Waterfowl Populations

Do Modeled Dietary Doses to Benthivorous Waterfowl Exceed TRVs for Adverse Reproductive Effects?

The mallard (*Anas platyrhynchos*) was selected to represent benthivorous waterfowl around Onondaga Lake and was used for modeling dose exposures. Modeled dose concentrations of barium, cadmium, chromium, dichlorobenzene, dioxins/furans (TEQ), methylmercury, total PAHs, and zinc exceeded TRVs for the mallard. Only zinc risks may be due to background levels, rather than contamination. HQs were exceeded over the range of point estimates of risk. These results suggest adverse effects on waterfowl via exposure to COCs in water, sediment, and particularly dietary sources.

Do Measured Concentrations of COCs/SOCs in Surface Water Exceed Standards, Criteria, and Guidance for the Protection of Wildlife?

Mercury concentrations in Onondaga Lake in 1992 and 1999 exceeded the NYSDEC wildlife protection value of 0.0026 µg/L. The other contaminants for which there were available wildlife water quality standards, criteria, or guidance values were not detected (i.e., DDT and PCBs) or not analyzed (i.e., dioxins/furans).

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

Onondaga Lake is a year-round home to many waterfowl. 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.

Summary

Sustainability of local waterfowl populations was assessed using three lines of evidence, as follows:

- Modeling dietary doses of contaminants.
- Comparison of measured water column concentrations to water quality criteria standards, criteria, and guidance for the protection of wildlife.
- Performing field-based observations.

The first two lines of evidence indicated that waterfowl may be adversely affected by contaminants found in Onondaga Lake via exposure to contaminated water and food sources. The third line of evidence, field observations, was inconclusive.

12.10 Assessment Endpoint: Sustainability of Local Piscivorous Bird Populations

Do Modeled Dietary Doses to Piscivorous Birds Exceed TRVs for Adverse Reproductive Effects?

Three piscivorous birds, the belted kingfisher (*Ceryle alcyon*), great blue heron (*Ardea herodias*), and osprey (*Pandion haliaetus*), were selected to represent piscivorous birds around Onondaga Lake. These species represent a range of prey size preferences and feeding methods. The following COCs exceeded a hazard quotient of one in each species:

- Belted kingfisher – methylmercury, total PAHs, DDT and metabolites, total PCBs, and dioxins/furans.

- Great blue heron – methylmercury, total PAHs, DDT and metabolites, total PCBs, and zinc.

- Osprey – methylmercury, DDT and metabolites, total PCBs, and zinc.

For all three piscivorous birds, modeled methylmercury dose exposure concentrations exceeded NOAEL and LOAEL TRVs at both 95 percent UCL and mean concentrations by up to an order-of-magnitude. All fish COCs were considered to be site-specific based upon comparisons to background levels. These results suggest adverse effects on piscivorous birds via exposure to COCs in water, sediment, and particularly dietary sources.

Do Measured Concentrations of COCs/SOCs in Surface Water Exceed Standards, Criteria, and Guidance for the Protection of Wildlife?

Mercury concentrations in Onondaga Lake in 1992 and 1999 exceeded the NYSDEC wildlife protection value of 0.0026 µg/L. The other contaminants for which there were available wildlife water quality standards, criteria, or guidance values were not detected (i.e., DDT and PCBs) or not analyzed (i.e., dioxins/furans).

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

Onondaga Lake is a year-round home to a number of piscivorous bird species. However, very few piscivorous species are listed as confirmed or probable breeders. 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, but also has high concentrations of some contaminants. Insufficient field data are available to evaluate the health of local piscivorous bird populations.

Summary

Sustainability of local piscivorous bird populations was assessed using three lines of evidence, as follows:

- Modeling dietary doses of contaminants.

- Comparison of measured water column concentrations to water quality standards, criteria, and guidance for the protection of wildlife.

- Performing field-based observations.

The first two lines of evidence indicated that piscivorous birds may be adversely affected by contaminants found in Onondaga Lake, and in particular by mercury, for which HQs were greater than 1.0 for the full point estimate range of risk for all three species. The third line of evidence, field observations, was inconclusive.

12.11 Assessment Endpoint: Sustainability of Local Carnivorous Bird Populations

Do Modeled Dietary Doses to Carnivorous Birds Exceed TRVs for Adverse Reproductive Effects?

The red-tailed hawk (*Buteo jamaicensis*) was selected to represent carnivorous birds around Onondaga Lake and was used for modeling dose exposures. Modeled PAH exposure dose concentrations exceeded NOAEL and LOAEL TRVs at both 95 percent UCL and mean concentrations. Modeled doses of dioxins/furans (TEQ) exceeded the NOAEL at both the 95 percent UCL and mean concentrations and the DDT NOAEL was exceeded for the 95 percent UCL concentration. No exceedances were attributable to background risks.

These results suggest adverse effects on carnivorous birds via exposure to COCs in water, soil, and dietary sources.

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

Covertypes around Onondaga Lake may support carnivorous bird species and a number of species have been confirmed to breed around Onondaga Lake. However, populations of carnivorous birds have not been studied at Onondaga Lake to place these observations into the proper perspective and the health of local carnivorous bird populations cannot be evaluated.

Summary

Sustainability of local carnivorous bird populations was assessed using two lines of evidence, as follows:

- Modeling dietary doses of contaminants.
- Field-based observations.

Modeled dietary doses indicated that carnivorous birds may be adversely affected by contaminants found in Onondaga Lake, and in particular by total PAHs, for which HQs were greater than 1.0 for the full point estimate range of risk. The second line of evidence, field observations, was inconclusive.

12.12 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. The little brown bat (*Myotis lucifugus*) was selected to represent insectivorous mammals feeding on aquatic invertebrates and the short-tailed shrew (*Blarina brevicauda*) was used as the representative receptor for insectivorous mammals feeding on terrestrial prey around Onondaga Lake. These two species were used for modeling dose exposures of insectivorous receptors.

Do Modeled Dietary Doses to Insectivorous Mammals Feeding on Aquatic Invertebrates Exceed TRVs for Adverse Reproductive Effects?

Modeled dose concentrations of barium, chromium, methylmercury, and total PAHs for the little brown bat exceeded TRVs over the full range of risk estimates. Arsenic, cadmium, copper, dioxins/furans (TEQ), hexachlorobenzene, mercury, and vanadium exceeded an HQ of 1.0 over a portion of the range of risk estimates. Risks from arsenic, copper, and vanadium may be attributable to background levels of contaminants.

These results suggest adverse effects on insectivorous mammals via exposure to COCs in water, and in particular to insect prey with an aquatic life-phase.

Do Modeled Dietary Doses to Insectivorous Mammals Feeding on Terrestrial Invertebrates Exceed TRVs for Adverse Reproductive Effects?

Due to the small home range of the short-tailed shrew, the four wetland areas (SYW-6, SYW-10, SYW-12, and SYW-19) and the dredge spoils area were modeled individually. Modeled dietary doses were greater than TRVs for the following contaminants (by area):

- Wetland SYW-19, along the southwest corner of the lake near the mouths of Harbor Brook and the East Flume, had the greatest number of exceedances, with modeled doses of methylmercury, dieldrin, dioxins/furans, hexachlorobenzene, and total PAHs exceeding LOAELs and NOAELs at both the 95 percent UCL and mean concentrations (full range of exposure estimates). NOAELs for arsenic, cadmium, lead, selenium, vanadium, trichlorobenzenes, and total PCBs were exceeded at both upper and mean dose exposures. Most contaminants, with the exception for arsenic, selenium, thallium, and vanadium, were considered to be site-related (i.e., above reference or background levels). Wetland SYW-19 will be evaluated further as part of the Wastebed B/Harbor Brook site RI/FS.

- Wetland SYW-10, on the west side of the lake near the mouth of Ninemile Creek, had ten COCs with HQs over 1.0. Modeled doses of methylmercury and total

PAHs exceeded LOAELs and NOAELs at both the 95 percent UCL and mean concentrations. Arsenic, cadmium, dioxins/furans, hexachlorobenzene, lead, selenium, thallium, and vanadium TRVs were also exceeded at one or more points within the risk estimate range. Arsenic, cadmium, lead, methylmercury, hexachlorobenzene, and dioxins/furans were considered to be site-related. Wetland SYW-10 will be evaluated further as part of the Geddes Brook/Ninemile Creek site RI/FS.

- Wetland SYW-6, on the northwest side of the lake, had ten COCs with HQs over 1.0. Modeled doses of methylmercury and total PAHs exceeded LOAELs and NOAELs at both the 95 percent UCL and mean concentrations. Arsenic, cadmium, chromium, dioxins/furans, lead, total PAHs, thallium, and vanadium HQs were above 1.0. Cadmium, chromium, lead, methylmercury, and dioxins/furans were considered to be site-related.

- Wetland SYW-12, at the southeast end of the lake between Ley and Onondaga Creeks, had eight COCs with HQs over 1.0. Methylmercury and total PAHs exceeded LOAELs and NOAELs at both the 95 percent UCL and mean concentrations. Arsenic, cadmium, dieldrin, hexachlorobenzene, lead, and vanadium HQs were above 1.0. Cadmium, dieldrin, lead, methylmercury, and hexachlorobenzene were considered to be site-related.

- The dredge spoils area surface soils had arsenic, hexachlorobenzene, total PAHs, selenium, and vanadium HQs above 1.0. Hexachlorobenzene was considered to be site-related. The dredge spoils area will be evaluated further as a separate site with its own investigation.

These results suggest adverse effects on insectivorous mammals via exposure to COCs in water, sediment, and primarily terrestrial prey in all four wetland areas. Risks from exposure to surface soils in the dredge spoils area are comparable to those of background locations.

Do Measured Concentrations of COCs/SOCs in Surface Water Exceed Standards, Criteria, and Guidance for the Protection of Wildlife?

Mercury concentrations in Onondaga Lake in 1992 and 1999 exceeded the NYSDEC wildlife protection value of 0.0026 µg/L. The other contaminants for which there were available wildlife water quality standards, criteria, or guidance values were not detected (i.e., DDT and PCBs) or not analyzed (i.e., dioxins/furans).

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

It is difficult to separate out the effects of chemical contamination on wildlife from those of habitat loss and development. Insectivorous species, such as shrews and bats, are found in covertypes around the lake, but local populations of insectivorous mammals have not been studied to determine whether they have been impacted.

Summary

Sustainability of local insectivorous mammal populations was assessed using three lines of evidence, as follows:

- Modeling dietary doses of contaminants.
- Comparison of measured water column concentrations to water quality standards, criteria, and guidance for the protection of wildlife.
- Field-based observation.

The first two lines of evidence indicated that insectivorous mammals feeding on aquatic invertebrates and insectivorous mammals feeding on terrestrial invertebrates in the wetlands around Onondaga Lake may be adversely affected by contaminants found in Onondaga Lake and the adjacent wetlands. The third line of evidence, field observations, was inconclusive.

12.13 Assessment Endpoint: Sustainability of Local Piscivorous Mammal Populations

Do Modeled Dietary Doses to Piscivorous Mammals Exceed TRVs for Adverse Effects on Reproduction?

Two piscivorous mammals, the mink (*Mustela vison*) and river otter (*Lutra canadensis*), were selected to represent piscivorous mammals. As these piscivorous mammals show differences in prey selection and composition, use of these two receptors is considered to represent the range of potential piscivorous mammal exposure. The following COCs exceeded an HQ of 1.0 in each species:

- Mink – dioxins/furans, hexachlorobenzene, methylmercury, total PAHs, and total PCBs.
- River otter – DDT and metabolites, dioxins/furans, methylmercury, total PAHs, and total PCBs.

Modeled dose concentrations of total PCBs in the mink exceeded the NOAEL and LOAEL TRVs at both the 95 percent UCL and mean exposure doses. 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. Modeled dose concentrations of methylmercury and total PCBs in the river otter exceeded NOAEL and LOAEL TRVs at both the 95 percent UCL and mean exposure doses. 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 and DDT and metabolites also exceeded the LOAEL at the 95 percent UCL concentration for the river otter. All contaminants in fish prey are considered to be site-related. These results suggest adverse effects on piscivorous mammals via exposure to COCs in water, sediment, and primarily prey and exceedances of HQs over the range of exposure and toxicity concentrations modeled indicate a high likelihood of risk.

Do Measured Concentrations of COCs/SOCs in Surface Water Exceed Standards, Criteria, and Guidance for the Protection of Wildlife?

Mercury concentrations in Onondaga Lake in 1992 and 1999 exceeded the NYSDEC wildlife protection value of 0.0026 µg/L. The other contaminants for which there were available wildlife water quality standards, criteria, or guidance values were not detected (i.e., DDT and PCBs) or not analyzed (i.e., dioxins/furans).

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

It is difficult to separate out the effects of chemical contamination on wildlife from those of habitat loss and development. The mink and river otter are the only primarily piscivorous mammals found in these covertypes; however, there are no data regarding mink or otter populations in the area of Onondaga Lake. The lack of field observations of mink and few otter observations may indicate depressed populations although both species are secretive and can be difficult to see in the field. Populations of mink and otter could be impacted by inadequate habitat, disturbance by humans, and chemical contamination.

Summary

The sustainability of local piscivorous mammal populations was assessed using three lines of evidence, as follows:

- Modeling dietary doses of contaminants.
- Comparison of measured water column concentrations to water quality standards, criteria, and guidance for the protection of wildlife.
- Performing field-based observations.

The first two lines of evidence indicated that piscivorous mammals feeding around Onondaga Lake may be adversely affected by contaminants found in Onondaga Lake, in particular by mercury and total PCBs. The third line of evidence, field observations, was inconclusive.

12.14 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 the lake. Contaminants and stressors in the lake have either impacted or potentially impacted every trophic level and feeding preference examined in this BERA. The aquatic macrophytes in the lake have been adversely affected by lake conditions, and the resulting loss of habitat that formerly provided valuable feeding and nursery areas has undoubtably impacted the aquatic invertebrates and vertebrates living in Onondaga Lake. In addition to general aquatic habitat loss occurring at the time that massive quantities of ionic waste were dumped into the lake, 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.

Almost all lines of evidence indicate that the COCs and ionic waste in Onondaga Lake have produced adverse ecological effects at all trophic levels examined. Comparisons of measured tissue concentrations and modeled doses of contaminants to TRVs show exceedances of HQs 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.