Tissue Residue Analysis

Chemical concentrations measured in crab and fish tissues collected during the Phase 3 investigation were used in the baseline ecological risk assessment (BERA), along with the other lines of evidence first discussed in Section 2.3 of the ecological risk assessment (ERA), to evaluate potential risks to benthic macroinvertebrates and fish. The approach for conducting this evaluation and its results are discussed in the following sections.

Evaluated Tissue Residue Data

A detailed description of the crab and fish tissue collected during the Phase 3 sample effort and used in the ERA is presented in Section 2.5 of the RI. Whole-body crab, small prey fish, and larger fish species tissue chemical residue concentrations were used to directly screen for potential risks to these species. The following subsections discuss the approach used to estimate tissue residue exposure concentrations for these species.

Crab

The wet weight, weighted average whole-body crab tissue residue concentration of each chemical was estimated for each of the 12 crab samples according to the procedures presented in Section 5.1.3 of the ERA. Table 5-1 of the ERA summarizes the maximum and mean wet weight tissue residue concentrations for the combined crab tissue samples. These whole-body wet weight concentrations are used in this attachment to evaluate the potential for adverse effects to benthic macroinvertebrates.

Small Prey Fish

Small prey fish tissue concentration estimates were based on whole-body concentrations measured with four Atlantic tomcod and four mummichog samples (eight total small prey fish samples) collected from the Gowanus Canal (Table 2-5 of the RI). The chemical concentrations determined in each of the eight small prey fish samples were combined to estimate the maximum and mean wet weight chemical concentrations for small prey fish in the Gowanus Canal. Table 5-3 of the ERA summarizes the maximum and mean wet weight concentrations for the combined small prey fish samples. These whole-body wet weight concentrations are used in this attachment to evaluate the potential for adverse effects to benthic macroinvertebrates.

Larger Fish Species

Larger fish tissue whole-body concentration estimates were based on concentrations measured in 13 samples from three larger fish species (six Atlantic eel, five striped bass, and two white perch) that were collected from the Gowanus Canal (Table 2-5 of the RI).

Wet weight, weighted average whole-body tissue residue concentrations were estimated for each of the larger fish species by taking a weighted average of the chemical residue concentrations measured in edible and corresponding offal tissue (skin included) samples. Weighted average whole-body tissue wet weight residue concentrations were estimated for each of the 13 fish samples using the following lab-measured data:

- Measured chemical concentrations in the fillet (two fillets/fish) sample;
- Measured chemical concentrations detected in the corresponding offal sample;
- Total wet weight mass of the fillet sample; and
- Total wet weight mass of the offal sample.

For each of the 13 fish samples, a weighted average whole body concentration was calculated for each chemical by taking the weighted average concentration of the chemical detected in the fillet and offal tissues using the following equation:

$$FWBTC_x = \frac{[[(FTC_x)(FTW)] + [(OC_x)(OW)]]}{TW}$$

Where:

$FWBTC_x$ = Weighted average fish whole body tissue concentration for constituent x (wet weight)
FTC_x = Fillet tissue concentration for constituent x (wet weight)
FTW = Fillet tissue weight (wet weight)
OC_x = Offal tissue concentration for constituent x (wet weight)
OW = Offal tissue weight (wet weight)
TW = Total weight of fillet and offal tissues (wet weight)

The chemical concentrations determined in each of the 13 fish samples were then combined by species to estimate the maximum and mean wet weight chemical concentrations for each larger fish species within the Gowanus Canal. Tables E-1 through E-3 summarize the maximum and mean wet weight concentrations for each species. These whole-body wet weight concentrations are used in this attachment to screen the potential for adverse effects to fish.

Approach to Risk Evaluation

Benthic Macroinvertebrates

The BERA further evaluated benthic macroinvertebrate (blue crab) tissue to refine the estimate of risk for benthic macroinvertebrates. Whole-body wet weight tissue residue concentrations in composite crab samples collected from Gowanus Canal were compared to literature-based tissue residue benchmark concentrations for decapods to evaluate the potential for adverse effects to benthic macroinvertebrates. The maximum and mean wet weight concentrations determined for the 12 crab samples collected from Gowanus Canal are summarized in Table 5-1 of the ERA.

A literature review was conducted to identify available aquatic invertebrate tissue residue screening values for this evaluation. The screening values selected for this assessment were based primarily on conservative values identified for the BERA associated with the Lower Passaic River Restoration Project (LPRRP) via the technical memorandum "Refinement of

Toxicity Values and Development of Critical Biota Residues and Biomagnification Factors (BMFs), Conceptual Site Model/Problem Formulation, Lower Passaic River Restoration Project, March 3, 2006" (Battelle, 2006). The majority of the toxicological data used to develop tissue screening values for the LPRRP were obtained from the U.S. Army Corps of Engineers' Environmental Residue-Effects Database (http://el.erdc.usace.army.mil/ered). Additional tissue residue data were also obtained from the broader scientific literature. A summary of the tissue residue screening benchmarks selected for use in this BERA, as well as the sources of these values, is presented in Table E-4.

Maximum Allowable Toxicant Concentrations (MATCs) were presented in the above cited memorandum, while the no-observed-effect concentration (NOEC) and the lowest-observed-effect concentration (LOEC) values were used for screening in this BERA. The MATC is the geometric mean of the NOEC and LOEC. The underlying NOEC and LOEC values, which were used to derive the MATC, were thus used in this evaluation. The NOEC represents the concentration below which adverse effects are not expected, while the LOEC represents the concentration above which adverse effects are expected. Both values were used for the evaluation in order to place bounds on the range of concentrations in which a potential risk would occur.

Following selection of the screening benchmarks, HQs were derived for each chemical in the BERA by dividing both the maximum and mean crab tissue residue concentrations by the corresponding screening value. Chemicals were identified as COCs if the maximum tissue concentrations exceeded either the NOEC or the LOEC.

Water-Column-Dwelling Aquatic Life

The BERA further evaluated fish tissue to refine the estimate of risk for water-column-dwelling aquatic life. Whole-body fish tissue residue concentrations detected in samples collected from Gowanus Canal were compared to literature-based tissue residue benchmark concentrations for fish to evaluate the potential for adverse effects to fish populations. Both small prey fish (mummichog and Atlantic tomcod) and larger fish (striped bass, white perch, American eel) species captured from the canal were used in this analysis. The maximum and mean wet weight concentrations determined for small prey fish species collected from Gowanus Canal is summarized in Table 5-3 of the ERA. The maximum and mean wet weight concentrations determined for larger fish species collected from Gowanus Canal are summarized in Tables E-1 through E-3.

A literature review was conducted to identify available tissue residue screening values for this evaluation. Both NOEC and LOEC were used for screening. The NOEC represents the concentration below which adverse effects are not expected, while the LOEC represents the concentration above which adverse effects are expected. Both values were used for this evaluation in order to bound the range of concentrations in which a potential risk is likely to occur. A summary of the fish tissue residue screening benchmarks selected for use in the BERA is presented in Table E-5.

The source of LPRRP BERA tissue screening values used for invertebrates (Battelle 2006) was also the primary source of fish tissue screening values for this BERA. Additional tissue residue data were also obtained from the broader scientific literature. A summary of the fish tissue residue screening benchmarks selected for use in the BERA, as well as the sources of these values, is presented in Table E-5.

Following selection of the screening benchmarks, HQs were derived for each parameter in the BERA by dividing both the maximum and mean tissue residue concentrations for each evaluated fish species by the screening value. Chemicals were identified as COCs if the maximum tissue concentrations exceeded either the NOEC or LOEC.

Risk Evaluation

This section presents a final evaluation of risks to benthic macroinvertebrates and water-column-dwelling aquatic life using the data and approach discussed in this attachment. The outcome of this step is a final list of COCs for each medium-pathway-receptor combination identified for evaluation. Because risk to each receptor is being evaluated using multiple data inputs, conclusions about the potential for adverse effects to each receptor will be based on a weight-of-evidence analysis of the available data. The results of this evaluation should be used, along with consideration of the other lines of evidence evaluated for these receptors, to draw conclusions about the overall potential for adverse effects to ecological receptors in the Gowanus Canal.

Benthic Macroinvertebrates

The maximum and mean concentrations of DDE, total DDTs, copper, mercury, silver, and zinc had HQs exceeding 1 when compared to the NOEC and LOEC (Table E-6 and E-7). The maximum and mean concentrations of total PAHs had HQs exceeding 1 when compared to the NOEC (Table E-6), while only the maximum concentration of total PAHs had HQs exceeding when compared to the LOEC (Table E-7). Fifteen PAHs and 8 metals were detected in crab tissue samples; however, screening benchmarks were not available for these chemicals, and the potential for adverse effects to blue crabs could not be evaluated.

Water-Column-Dwelling Aquatic Life

The following sections present the results of the whole-body fish tissue residue analysis for the combined small prey fish species (mummichog and Atlantic tomcod) and for each larger fish species (striped bass, white perch, and American eel).

Small Prey Fish. The maximum and mean concentrations of total PCB congeners, copper, mercury, and selenium had HQs exceeding 1 when compared to the NOEC and LOEC (Tables E-8 and E-9). The maximum concentrations of DDE, DDT, and lead had HQs exceeding 1 when compared to the NOEC and LOEC (Tables E-8 and E-9), while the mean concentrations of these chemicals could not be evaluated because they were detected in only a single fish sample. The maximum and mean concentrations of alpha-chlordane and the maximum concentrations of endrin and gamma-chlordane had HQs exceeding 1 when compared to the NOEC (Table E-8), but not when compared to the LOEC (Table E-9). Nine inorganic chemicals were detected but could not be evaluated because screening benchmarks were not available for those chemicals.

American Eel. The maximum and mean concentrations of total PCB congeners, alpha-chlordane, DDD, copper, mercury, and selenium had HQs exceeding 1 when compared to the NOEC and LOEC (Tables E-10 and E-11). The maximum concentrations of DDE, DDT, and lead had HQs exceeding 1 when compared to the NOEC and LOEC (Tables E-10 and E-11), while the mean concentrations of these chemicals could not be evaluated because they were detected in only a single eel sample. The maximum and mean concentrations of gamma-chlordane and the maximum concentration of dieldrin had HQs exceeding 1 when compared to the NOEC (Table E-10), but not when compared to the LOEC (Table E-11). Nine inorganic chemicals were detected but could not be evaluated because screening benchmarks were not available for those chemicals.

Striped Bass. The maximum and mean concentrations of DDE, DDD, DDT, total PCB congeners, copper, mercury, and selenium had HQs exceeding 1 when compared to the NOEC and LOEC (Tables E-12 and E-13). The maximum concentration of total DDT had an HQ exceeding 1 when compared to the NOEC and LOEC (Tables E-12 and E-13), while the mean concentration of this chemical could not be evaluated because it was detected in only one fish sample. The maximum and mean concentrations of alpha-chlordane and the maximum concentration of gamma-chlordane had HQs exceeding 1 when compared to the NOEC (Table E-12), but not when compared to the LOEC (Table E-13). Eight inorganic chemicals were detected but could not be evaluated because screening benchmarks were not available for those chemicals.

White Perch. The maximum and mean concentrations of total PCB congeners, copper, mercury, and selenium had HQs exceeding 1 when compared to the NOEC and LOEC (Tables E-14 and E-15). The maximum concentrations of DDT and silver had HQs exceeding 1 when compared to the NOEC and LOEC (Tables E-14 and E-15), while the mean concentrations of these chemicals could not be evaluated because they were detected in only a single fish sample. The maximum and mean concentrations of alpha-chlordane and the maximum concentration of gamma-chlordane had HQs exceeding 1 when compared to the NOEC (Table E-14), but not when compared to the LOEC (Table E-15). Seven inorganic chemicals were detected but could not be evaluated because screening benchmarks were not available for those chemicals.

Risk Summary and Conclusions

Benthic Macroinvertebrate Communities

Risks to benthic macroinvertebrate communities were evaluated primarily through the use of laboratory-based sediment bioassays, which were conducted with two sediment-dwelling invertebrates (amphipods and polychaetes), and through the comparison of sediment chemical concentrations to literature-based screening benchmarks. Chemical concentrations measured in crab tissue also indicate a potential for adverse effects to benthic macroinvertebrates. Among these chemicals, PAHs and several metals (copper, mercury and silver), were detected in canal sediment at concentrations exceeding those detected in the Gowanus Bay reference samples (Table 4-5 of the RI), suggesting those chemicals represent a potential site-related risk.

Water-Column-Dwelling Aquatic Life Communities

Chemical concentrations measured in fish tissue indicate a potential for adverse effects to water-column-dwelling aquatic life. Several of the chemicals indicating risk in one or more fish species, including PCBs and several metals (copper, mercury and silver), were detected in canal sediment at concentrations exceeding those detected in the Gowanus Bay reference samples (Table 4-5 of the RI), suggesting those chemicals represent a potential site-related risk.

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