Appendix C-T5. Tissue sampling and analysis

Method: Biota-sediment accumulation factor (BSAF)		
$C_{tss}/L = (C_s/TOC) * BSAF$ where C_{tss} = tissue concentration at steady state (mg/kg) L = lipid content (g/g) C_s = sediment concentration (mg/kg) TOC = total organic carbon in sediment (g/g) BSAF = biota-sediment accumulation factor (g carbon/g lipid) **Links:** www.epa.gov/med/Prods_Pubs/bsaf.htm, http://el.erdc.usace.army.mil/bsaf/bsaf.html	**Advantages:** Simple estimation tool that can use default USEPA values or develop site-specific factors based on measured tissue and sediment concentrations. Simple and easily performed using spreadsheet functions data set of BSAFs for nonionic organic chemicals exist from USEPA and the USACE. **Disadvantages:** BSAFs derived from literature sources do not reflect site-specific conditions. Site-derived BSAFs implicitly assume that all exposures occur within the area under investigation.	**Analyte capability:** PAHs, PCBs, nonpolar pesticides, dioxins, energetic compounds (nonpolar organics) **Applicable compound class:** Hydrophobic (nonionic) organics (PCBs, PCDDs, PCDFs, DDTs, PAHs, chlorinated pesticides)
Method: Bioaccumulation factor (BAF)		
Description: Ratio of the concentration in aquatic organism to its concentration in specific media (water, sediment, prey). Bioaccumulation is net uptake and retention of a chemical in an organism from all routes of exposure (diet, dermal, respiratory) and any source (water, sediment, food) in the natural environment. **References:** USEPA n.d. "ECOTOX," Weisbrod et al. 2007	**Advantages:** Simple estimation tool that can use default USEPA values or develop site-specific factors based on measured tissue and other site media concentrations. Can be used for all aquatic and aquatic-dependent wildlife. **Disadvantages:** BAFs derived from literature sources do not reflect site-specific conditions. Site-derived BAFs implicitly assume that all exposures occur within the area under investigation.	**Analyte capability:** PAHs, PCBs, nonpolar pesticides, dioxins, energetic compounds (nonpolar organics) **Applicable compound class:** Hydrophobic (nonionic) organics (PCBs, PCDDs, PCDFs, DDTs, PAHs, chlorinated pesticides)

Method: Biomagnification factor in predator/prey tissue		
Description: Ratio of the chemical concentration of a predator divided by that of its prey. For HOCs, the concentrations are lipid normalized. For metals, the units are mg/kg wet weight. Biomagnification is said to occur when the BMF > 1. **References:** USEPA n.d. "ECOTOX," Weisbrod et al. 2007, USACE n.d., USEPA 1993	**Advantages:** Simple tool that may be used to estimate concentrations in higher trophic level fish, birds or mammals based on measured or previously reported BMFs. Can be used for all aquatic and aquatic-dependent wildlife. **Disadvantages:** BMFs derived from literature sources may not reflect site-specific conditions. Site-derived BMFs implicitly assume that all exposures occur within the area under investigation.	**Analyte capability:** Metals, mercury, VOCs, PAHs, PCPs, pesticides, selenium, dioxins, radionuclides, energetic compounds (nonpolar organics)
Method: Gobas kinetic food web model		
Description: Widely applied food web model that provides estimates of chemical concentrations in organisms of aquatic food webs from chemical concentrations in the water and the sediment. **Measured endpoints:** A prediction of specific body burdens of organic COCs at specified trophic levels and at specified growth stages. Model allows user-specified aquatic food web that can include benthos, phytoplankton, and zooplankton. Recent work by Burkhart, Cook, and Lukasewycz (2005) suggests that model predictions are within a factor of 4 of simple BSAF predictions. **References:** Arnot and Gobas 2004; Gobas 1993; Burkhart, Cook, and Lukasewycz 2005	**Advantages:** Variations of the algorithm have been adapted to both freshwater and marine systems, including the Great Lakes, Lower Fox River, Wisc., San Francisco Bay, Calif., and Willamette River, Ore. Relatively easy for those areas where model has been calibrated and validated (e.g., San Francisco Bay). Increasingly difficult for new systems. Model currently provides point estimates. A better method for quantifying uncertainty (e.g., Monte Carlo simulations) remains to be adequately demonstrated. **Disadvantages:** Data-intensive to populate and calibrate the model. Steep learning curve if not well-versed in fugacity theory.	**Analyte capability:** Metals, PAHs, PCPs, nonpolar pesticides, PCBs, dioxins, energetic compounds (nonpolar organics)
Method: Bioaccumulation and Aquatic System Simulator (BASS)		
Description: Model simulates bioaccumulation of chemical pollutants integrated with population and bioaccumulation dynamics of age-structured fish communities. Provides a prediction of specific body burdens of organic COCs at specified trophic levels and at specified growth stages. Model allows user-specified aquatic food web that can include benthos, phytoplankton, zooplankton, and multiple trophic levels of fish. **References:** USEPA 2008b, Barber 2008	**Advantages:** Applied to PCB dynamics in Lake Ontario; salmonids, largemouth bass-bluegill-catfish communities of Lake Hartwell, S.C.; DDT bioaccumulation in caged channel catfish at various Superfund sites; and to simulate fish methylmercury bioaccumulation in the Florida Everglades. **Disadvantages:** Data-intensive to populate and calibrate the model.	**Analyte capability:** Hydrophobic organic pollutants and metals that complex with sulfhydryl groups (e.g., Cd, Cu, Hg, Ni, Ag, Zn)

Method: Food web model for environmental risk assessment for mercury (SERAFM)		
Description: SERAFM is a steady-state spreadsheet-based model framework that predicts speciated mercury concentrations (Hg^0, Hg^{II}, MeHg, total Hg) in freshwater and sediments and total mercury concentrations in fish tissue. It includes the following measurement endpoints: • bulk sediment Hg concentration • fish tissue Hg • total and dissolved Hg in surface water • TOC and DOC in sediment and water • water-column particle size • water temperature, DO, pH **Test organism categories:** Freshwater omnivore and piscivorous fish at user-specified age classes. **References:** USEPA n.d. "SERAFM," Knightes 2008	**Advantages:** USEPA model that has general acceptance to predict the fate of mercury in aquatic systems and hazard indices for wildlife. **Disadvantages:** Does not consider controlling factors of methylmercury bioavailability in sediments. Requires assumption that sediments are source of Hg.	**Analyte capability:** Mercury
Method: Direct plasma residue assessment		
Description: Plasma from receptor organisms are collected from the field, brought to the laboratory, and measured for target chemical(s). **Measured endpoints** include plasma COCs and percent lipids. Principally used to test organisms to assess chemical levels in T&E species and/or juveniles. **References:** Arcand-Hoy and Bensen 1998	**Advantages:** Integrates all pathways of exposure and provides a direct number for assessing risks without killing receptor. **Disadvantages:** Sampling generally limited to few individuals. Resource-intensive. Plasma COCs not associated with specific toxicological effects.	**Analyte capability:** All classes of chemicals
Method: Direct tissue analysis		
Description: Receptor organisms are harvested from the field and brought to the laboratory, and tissues are measured for target chemical(s). **Measured endpoints** include the following: • bulk sediment COCs concentrations • tissue residue COCs • total and dissolved COCs in surface water • whole body vs. fillet (fish) • TOC and DOC in sediment and water • water-column particle size • fertilized eggs (optional) • lipids **Test organism categories** include fish, shellfish, amphibians, or reptiles. **References:** Puget Sound Partnership 1990, USEPA 2000c	**Advantages:** Integrates all pathways of exposure and provides a direct number for assessing risks. **Disadvantages:** Assumptions include all exposures are within contaminated area, which is not valid for mobile fish or crustaceans. Not suitable for T&E species. Moderate to difficult to implement. Requires capture (trawling, reel, beach seine) of suitable numbers and types of target receptors for evaluation in statistically meaningful way.	**Analyte capability:** All classes of chemicals

Method: In situ bioaccumulation studies		
Description: Surrogate receptor organisms are placed at the target site in cages either in contact with or directly above the sediment. After a specified period of time, the organisms are harvested and the tissues analyzed for COCs. The measurements include survival, tissue residue, and lipids. **Test organisms** include benthic organisms, small fish, clams, and mussels. **References:** USEPA 2000a	**Advantages:** Animals confined to a small, well-defined location. Site-specific exposures that integrate contaminant uptake over all media. **Disadvantages:** Surrogate organisms are often those used in bioassays and may not reflect uptake by site-specific organisms.	**Analytical capability:** Most classes of chemicals but typically PBT compounds
Method: Dietary assimilation efficiency		
Description: Absorption efficiency represents the net result of absorption and elimination. Feeding studies are designed to estimate absorption efficiency based on accumulated chemical residues. The fraction of the chemical retained in the organisms relative to that ingested is the assimilation efficiency, which measures chemical levels in food and residual in feces. Also may involve measuring chemical levels in target organism tissue, organelles, and in developing fetus. **Test organisms** are typically fish, birds, and mammals. **References:** Erickson et al. 2008	**Advantages:** Most direct measure of how much of a contaminant in food is retained by the target organism. **Disadvantages:** Difficult to adequately capture fish fecal matter. Useful for birds and mammals but can be time- and resource-intensive.	**Analyte capability:** All classes of chemicals