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EFFECTS OF WETLAND RESTORATION USING ANACOSTIA RIVER SEDIMENTS AT KENILWORTH MARSH

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EXECUTIVE SUMMARY

The Anacostia River is a freshwater tributary that flows through Maryland and the District of Columbia to the Potomac River. In D.C., the Anacostia River flows through National Park Service lands including the National Arboretum, Kenilworth Gardens, and Anacostia Park. The river has been the site of moderate oil spills, receives significant input of heavy metals and organic pollutants from urban nonpoint sources, and is known as one of the most polluted rivers in the United States. The sediments of the lower reach of this river have been found to contain elevated levels of polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), chlordane, chromium, lead, and zinc. High levels of PAHs were cited as a potential cause of the high incidence of carcinogenic tumors found in fish from the Anacostia River. The presence of injurious levels of toxic chemicals in the Anacostia Watershed places anadromous fish and endangered and threatened species such as the bald eagle at significant risk.

In 1993, as part of a maintenance dredging action by the U.S. Army Corps of Engineers (ACOE), dredged material from the Anacostia River was used to construct tidal freshwater wetlands in Kenilworth Marsh. This location was identified as the first of several sites along the main stem and side channels of the river where wetland restoration is proposed to enhance tidal mud flats using sediments from the Anacostia River. Early in 1993, ACOE placed dredged materials in three portions of Kenilworth Marsh at elevations designed to support high and low marsh communities. After sediments reached a consolidated state, guts were cut through these areas to insure tidal flows in the marsh.

The Kenilworth Marsh Monitoring Committee, comprised of National Park Service (NPS), the NPS Center for Urban Ecology, U.S. Fish and Wildlife Service (USFWS), ACOE, Metropolitan Washington Council of Governments, Interstate Commission on the Potomac River Basin, University of the District of Columbia, and the D.C. Water Resources Management Division, was formed to monitor the success of the plant and animal communities in the marsh. In 1993, the USFWS Chesapeake Bay Field Office (CBFO) worked with the ACOE to develop a baseline chemical characterization of marsh sediments which included sediment toxicity tests. The new marsh substrates were found to contain PCBs, chlordane, lead, nickel, and zinc at concentrations that exceed the effects range-median (ER-M), a threshold value above which biological impacts frequently occur. Although sediments from some locations were found to be toxic to the test organism, *Hyalella azteca*, the toxicity may be attributable to interstitial ammonia levels.

In this study, sediments, broad-leaf cattails (*Typha latifolia*), and killifish (*Fundulus* sp.) were collected and analyzed for PCBs, chlorinated pesticides, and metals. The objectives of this study were to determine the concentration of toxic chemicals present in the community developing on the new tidal freshwater wetlands in Kenilworth Marsh. Knowledge of transport and fate of the toxic constituents of wetland sediments will be used to substantiate an informed position on future use of dredged materials from the Anacostia River to construct wetlands.

Sediment samples collected from Kenilworth Marsh in 1993 and during this 1996 study contained concentrations of chromium (1993 only) lead, nickel, zinc, total PCB (1993) and total chlordane that exceed ecological threshold values above which toxic effects frequently occur. In addition, several analytes in sediments exceeded thresholds that result in occasional ecological effects. These include arsenic (1993), chromium, copper, mercury, total PCB (1996), and total DDT.

There were no significant differences between metal concentrations in cattail root material from Kenilworth Marsh and a reference site at Mason Neck National Wildlife Refuge (NWR). Zinc concentrations found in cattails from both locations may pose risks to mammalian species.

Concentrations of chromium, copper, lead, nickel, total PCB, total DDT, and total chlordane in killifish collected in Kenilworth Marsh were significantly greater than in killifish collected at the reference site at Mason Neck NWR. Concentrations were also compared with results of the National Contaminant Biomonitoring Program which measured whole body residues of organic and inorganic contaminants in freshwater fish in the mid 1980's. Metals found in fish tissue in exceedance of the 85th percentile of national concentrations included arsenic, cadmium, copper, lead, and zinc. Organochlorines that exceeded the national mean included total PCB, total DDT, and alpha chlordane. These results suggest that concentrations of certain contaminants in killifish living in Kenilworth Marsh are high when compared to regional and national values. In addition, zinc was found in Kenilworth Marsh fish tissue at concentrations that may pose risks to piscivorous birds and are theorized to be harmful to mammals.

In summary, the results of this limited study suggest that: contaminants originating in Anacostia River dredge sediments used to construct a wetland at Kenilworth Marsh are accumulating in killifish; concentrations of certain contaminants in sediments, killifish, and cattails are elevated; several inorganic and organic contaminants were found at concentrations that have been associated with adverse effects to fish-eating birds, mammals, and aquatic biota; and potential ecological risks exist in the marsh. Based on the results of this and previous studies, the Service recommends that Anacostia River sediments not be used for marsh restoration purposes only on a limited basis in the Anacostia Watershed until more in-depth studies are performed in Kenilworth Marsh to determine the extent and magnitude of contamination to biota and the possible ecological effects of that contamination. Future use of Anacostia River dredge sediments for wetland restoration should be evaluated on a case by case basis. In addition, marsh creation projects using Anacostia sediments should be subjected to post-restoration monitoring to determine the effects of sediment contaminants on developing wetland communities.

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1.0 INTRODUCTION

The Anacostia River is a freshwater tributary that flows through Maryland and the District of Columbia to the Potomac River. In D.C., the Anacostia River flows through National Park Service lands including the National Arboretum, Kenilworth Gardens, and Anacostia Park. The river has been the site of moderate oil spills, receives significant input of heavy metals and organic pollutants from urban nonpoint sources, and is known as one of the most polluted rivers in the United States. The sediments of the lower reach of this river have been found to contain elevated levels of polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), chlordane, chromium, lead, and zinc (Velinsky et al. 1994; Wade et al. 1994). High levels of PAHs were cited by May and Harshbarger (1993) as a potential cause of the high incidence of carcinogenic tumors found in fish from the Anacostia River. The presence of injurious levels of toxic chemicals in the Anacostia watershed places anadromous fish and endangered and threatened species such as the bald eagle at significant risk.

In 1993, as part of a maintenance dredging action by the U.S. Army Corps of Engineers (ACOE), dredged material from the Anacostia River was used to construct tidal freshwater wetlands in Kenilworth Marsh. This location was identified as the first of several sites along the main stem and side channels of the river where wetland restoration is proposed to enhance tidal mud flats using sediments from the Anacostia River. Early in 1993, ACOE placed dredged materials in three portions of Kenilworth Marsh at elevations designed to support high and low marsh communities. After sediments reached a consolidated state, guts were cut through these areas to insure tidal flows in the marsh.

Emergent aquatic vegetation was planted to stabilize sediment substrates and encourage rapid development of marsh habitat. Plant distribution and biomass improved rapidly after planting, although volunteers of several plant species also germinated and make up a significant part of the organic matter produced by the new marsh. In 1995, loosestrife control was required to produce a more desirable species mix. Preliminary studies show that the benthic macroinvertebrate community began to establish in the filled areas of Kenilworth Marsh and that its waters support a variety of resident and anadromous fish (May 1994).

The Kenilworth Marsh Monitoring Committee, comprised of National Park Service (NPS), the NPS Center for Urban Ecology, U.S. Fish and Wildlife Service (USFWS), ACOE, Metropolitan Washington Council of Governments, Interstate Commission on the Potomac River Basin, University of the District of Columbia, and the D.C. Water Resources Management Division, was formed to monitor the success of the plant and animal communities in the marsh. In 1993, the Chesapeake Bay Field Office (CBFO) of the USFWS worked with the ACOE to develop a baseline chemical characterization of marsh sediments which included sediment toxicity tests. The new marsh substrates were found to contain PCBs, chlordane, lead, nickel, and zinc at concentrations that exceed the effects range-median (ER-M), a threshold value above which biological impacts frequently occur (USFWS 1997; Long and Morgan 1990). Although sediments from some locations were found to be toxic to the test organism, *Hyalella azteca*, the toxicity may be attributable to interstitial ammonia levels (USFWS 1997).

Management decisions that propose developing and enhancing habitats with contaminated sediments could jeopardize migratory and endangered trust resources. Knowledge of transport and fate of the toxic constituents of wetland sediments in Kenilworth Marsh will be used to substantiate an informed position on future use of dredged materials from the Anacostia River to construct wetlands in Kingman Lake (part of the lower reach of the Anacostia estuary) and fringe wetlands along the main stem of the river. Enhanced tidal wetland habitats in Kenilworth Marsh attract a large number of trust species because limited habitat exists in D.C. High quality tidal wetland nursery areas are important in this system and any enhancement to wetlands should result in communities of healthy, uncontaminated fish and wildlife.

2.0 OBJECTIVE

The objective of this study is to a) compare the concentrations of organic and inorganic contaminants in sediments, vegetation, and fish from Kenilworth Marsh and a reference area at Mason Neck National Wildlife Refuge (NWR), b) compare these concentrations with guidance values and literature data, and c) describe the potential risks of these contaminants to the aquatic community and to avian and mammalian species.

3.0 MATERIALS AND METHODS

Sediments, broad-leaf cattails *(Typha latifolia),* and killifish *(Fundulus* sp.*)* were collected and analyzed for PCB's, chlorinated pesticides, and metals.

3.1 Sampling Locations

Samples were collected at two locations in Kenilworth Marsh and one reference site at Mason Neck National Wildlife Refuge in Fairfax County, Virginia (Figure 1). In Kenilworth Marsh, one sampling site was located in Mass Fill 1 and the other was located in Mass Fill 2 (Figure 2). The reference site was located in Great Marsh on the eastern side of the Mason Neck National Wildlife Refuge, adjacent to the Potomac River (Figure 3). Due to limited residential development on the Mason Neck peninsula, the Great Marsh watershed is relatively pristine with few local (non-tidal) pollution inputs. Great Marsh discharges into and receives tidal flow from the Potomac River through a series of tidal guts and therefore would receive inputs from regional loadings of pollutants. Both Kenilworth Marsh and Great Marsh are classified as tidal freshwater wetlands (Lippson et al. 1979). Latitude and longitude for all sampling locations were recorded with hand held global positioning system units. The field portion of this study was initiated on August 7, 1996 and completed on August 29, 1996.

3.2 Sediment Collections

One sediment grab sample was collected from the top ten centimeters at each cattail sampling location using a steel shovel according to CBFO Standard Operating Procedure (SOP) 113 (Appendix A). Samples were placed in 1-L pre-cleaned glass jars and placed on ice immediately. All samples were stored at -20° C and shipped to the analytical laboratory on dry ice. Sampling equipment was washed with alconox and 10% nitric acid and rinsed with deionized water between collection sites.

Sediment samples were labeled as follows:

K0101SED: where K = Kenilworth Marsh (M = Mason Neck), 01 is the sample station (01 = Mass Fill 1 and Mason Neck and 02 = Mass Fill 2), 01 is the sample number, and SED indicates sediment sample.

3.3 Broad-leaf Cattail (*Typha latifolia)* Collections

Broad-leaf cattail (*Typha latifolia)* root samples were collected at Kenilworth Marsh in Mass Fill 1 in an area corresponding with sediment sample number 93SKEN05 and in Mass Fill 2 corresponding with sediment sample number 93SKEN08, both of which were collected and analyzed as part of a 1993 study (USFWS 1997) (Figure 2). These sites were chosen because both were in mid-marsh areas where cattails were found and both sediment samples had concentrations of lead, zinc, total PCBs, and total chlordane that were greater than ER-M levels (Long and Morgan 1990). The Mason Neck reference cattails were collected along the southern-most gut in Great Marsh (Figure 3). All three cattail sampling sites were accessed by foot. Eight cattail root samples were collected from each site and the reference site according to CBFO SOP 134 (Appendix A). Cattails were dug from the marsh using a steel shovel and the above ground parts were removed using steel shears. Roots were trimmed to sample container size and dead plant tissue, mud, and detritus were removed by rinsing with site water and distilled water. Samples were weighed to the nearest gram (Table 1), placed in 1-L pre-cleaned glass jars, and placed on ice immediately. All samples were stored at -20° C and shipped to the analytical laboratory on dry ice. Sampling equipment was washed with alconox and 10% nitric acid and rinsed with deionized water between collection sites.

Cattail samples were labeled as follows:

K0101TTY: Where K= Kenilworth Marsh (M = Mason Neck), 01 is the sample station (01 = Mass Fill 1 and Mason Neck and 02 = Mass Fill 2), 01 is the sample number, T indicates a tissue sample, and TY is the two letter species abbreviation for cattails.

3.4 Killifish (*Fundulus* sp.*)* Collections

Eight whole body killifish composite samples consisting of ten fish each were collected from each mass fill site and the reference site according to CBFO SOP 114 and USEPA (1995) guidance. At Mass Fill 1, mummichogs *(Fundulus heteroclitus)* were collected at the Kenilworth Aquatic Gardens canoe ramp which is located at the head of a tidal gut that traverses the filled area (Figure 2). Mummichogs were collected at Mass Fill 2 from a large tidal pothole located in the filled area adjacent to the Kenilworth Park ball fields (Figure 2). Four mummichog composites and four banded killifish *(Fundulus diaphanus)* composites were collected from the Mason Neck reference site in the northern most gut of Great Marsh (Figure 3). Fish were collected using a seine at Mass Fill 1 and galvanized minnow traps baited with bread and hotdogs at Mass Fill 2 and Mason Neck. Both Kenilworth Marsh sites were accessible by foot. A boat was employed to access the reference site at Mason Neck. Fish total length was measured to the nearest millimeter and each composite was weighed to the nearest gram (Table 2). Within samples and between sample sites the length of the smallest fish was at least 75 % of the length of the longest. After measurements were obtained, fish were rinsed with site water, placed into pre-cleaned 500-mL glass jars, and placed on ice immediately. All samples were stored at -20° C and shipped to the analytical laboratory on dry ice. Water quality parameters were measured at each sample site using a Hydrolab Surveyor II (Hydrolab Corp Austin, Texas) (Table 3).

Killifish samples were labeled as follows:

K0101TFH: where K = Kenilworth Marsh (M = Mason Neck), 01 is the sample station (01 = Mass Fill 1 and Mason Neck and 02 = Mass Fill 2), 01 is the sample number, T indicates tissue sample, and FH is the two letter species abbreviation for killifish.

3.5 Chemical Analysis

All samples were analyzed by USFWS contract laboratories through the Patuxent Analytical Control Facility, which administers the contracts and provides quality control oversight. Organic analyses were performed on killifish and sediment samples at the Mississippi State Chemical Laboratory (Mississippi State, MS). Inorganic analyses were performed on cattail, killifish, and sediment samples at the Research Triangle Institute (Research Triangle Park, NC). Table 4 lists the types of analyses performed and the desired detection limits. Detailed method descriptions are provided in Appendix B. Tissue results are reported as mg analyte per kg wet tissue weight and sediment results are reported as mg analyte per kg dry sediment weight.

3.6 Quality Assurance/Quality Control

On a regular basis, during field sampling, tissue preparation, and sample bottle preparation, the project manager verified that Standard Operation Procedures were being followed by all staff. Sample bottles were inspected and inventoried to verify label accuracy and to confirm that adequate numbers of samples were collected to satisfy the needs of the study. All data generated was recorded in ink in a bound notebook as per CBFO SOP 101. Laboratory quality assurance/quality control included the use of procedural blanks, duplicate samples, spiked samples, and standard reference materials. All laboratory analyses met the Quality Control approval of the Patuxent Analytical Control Facility.

3.7 Data Analysis

For determinations of means, medians, and standard deviations, one-half the detection limit was substituted for non-detected results. Tables containing summary statistics for inorganic and organic wet weight results and inorganic dry weight results are presented in Appendix C. Total PCB values were determined by the analytical laboratory and do not include half-detection limits in place of undetected aroclors. Total DDT was determined by summing results for o,p'-DDD, p,p'-DDD, o,p'-DDE, p,p'-DDE, o,p'DDT, and p,p'-DDT. Total chlordane was determined by summing results for oxychlordane, alpha-chlordane, gamma-chlordane, cis-nonachlor, and trans-nonachlor. Both total DDT and total chlordane levels were calculated using half-detection values.

Analysis of variance (ANOVA) was used to statistically compare mean concentrations between sampling locations. The non-parametric Kruskal-Wallis test was used to analyze data sets containing greater than 50% non-detects (Sokal and Rohlf 1981). Non-parametric statistics are normally employed to analyze data sets that contain a large percentage of non-detected results (Helsel 1990). Data sets containing greater than 50% detects were analyzed to determine whether they met the assumptions of equal variance and normal distribution necessary for parametric statistics (ANOVA). Where parametric assumptions were not met, the data were log-transformed and re-analyzed. If log-transformed data failed the normality test, the Kruskal-Wallis test was employed to compare median values between sampling locations. Statistical analyses were performed using Sigma Stat software (Jandel Corp., San Rafael, CA).

For killifish and cattail samples, statistical comparisons between sampling sites were performed on wet weight data. Because only one sediment sample was collected at each site, no statistical analyses were performed on sediment results. Since organochlorine compounds tend to concentrate in lipid tissues, killifish data were statistically examined prior to comparing results between sampling sites to determine whether it would be necessary to normalize the data for lipid content (Spacie and Hamelink 1985). If a significant regression (accounting for at least 50% of the variability) was found, the data would be normalized by analysis of covariance or the ratio method and normalized data would be used for comparisons (Pinkney et al. 1997).

Sediment data were summarized and compared to effects range-low (ER-L) and effects range-median (ER-M) values (Long and Morgan 1990) and the threshold effect levels (TEL) and probable effect levels (PEL) derived by Smith *et al.* (1996). Since tidal freshwater sediments were investigated in this study, the original Long and Morgan (1990) values, which are based partly on freshwater data, were used rather than the Long *et al.* (1995) values, which are based exclusively on estuarine and marine habitats. The guidance values developed by Smith *et al.* (1996) are based solely on freshwater data. The ER-L represents the 10th percentile concentration of a data base of chemical concentrations that were found to cause adverse effects, below which adverse effects rarely occur. The ER-M represents the 50th percentile concentration of the data base, above which toxic effects frequently occur. Smith determined TEL values for many analytes by calculating the geometric mean of the 15th percentile level of a data set of concentrations that caused adverse effects and the 50th percentile level of a no effect data set. The PEL values were determined by calculating the geometric mean of the 50th percentile of the effect concentrations and the 85th percentile of the no effect concentrations. Sediment results were also compared to results from three previous studies in the Anacostia River, Kingman Lake, and Kenilworth Marsh (USFWS 1997, Velinsky et al. 1994, and Wade et al. 1994).

Whole body killifish concentrations were summarized and compared to 1984 data from the National Contaminant Biomonitoring Program (NCBP; Schmitt and Brumbaugh 1990 and Schmitt et al. 1990). As part of the NCBP, 315 fish tissue composite samples were collected from 109 stations throughout the United States and analyzed for selected metals (Schmitt and Brumbaugh 1990). Kenilworth fish tissue metal results were compared to the 85th percentile value of the NCBP. In another phase of the NCBP, organochlorine analyses were performed on 321 fish tissue composites from 112 stations nationwide (Schmitt et al. 1990). Because no 85th percentile value was calculated for the NCBP organochlorine data, Kenilworth fish tissue organochlorine results were compared to the geometric mean of the NCBP.

A risk assessment analysis was performed using killifish and sediment data following USEPA ecological risk assessment guidance (USEPA 1997). The racoon (*Procyon lotor*) and the green heron (*Butorides striatus*) were chosen to represent fish-eating avian and mammalian species in Kenilworth Marsh. Ecological risk was analyzed using a spread sheet provided by the USEPA Environmental Response Team Center (ERTC) in Edison, New Jersey. The ERTC spread sheet utilizes life history and exposure profile information to determine hazard quotients (HQ) for each analyte of concern by dividing the No Observed Adverse Effect Level (NOAEL) by the maximum concentration obtained in the study (USEPA 1989; Barnthouse et al. 1986). A HQ of one or greater indicates the potential for adverse effects to the organism when it is exposed to a given concentration of a contaminant. In the analysis, the sediment data is screened by assuming that the diets of the representative species consist of 100% sediment. If the screening analysis indicates the possibility for adverse effects, the assessment is carried one step further by incorporating the fish data in addition to the sediment data. The USEPA recommends using the conservative NOAEL approach when determining ecological risk, however, for comparison purposes, HQs are also calculated by dividing the Lowest Observed Adverse Effect Level (LOAEL) by mean study concentrations.

4.0 RESULTS

4.1 Sediment

Mass Fill 1 metal results were between 2.2 and 8.4 times greater than concentrations in sediments from the reference site (Table 5). Concentrations of arsenic (3.8 ppm), cadmium (1.6 ppm), chromium (57 ppm), copper (44 ppm), lead (168 ppm), mercury (0.19 ppm), nickel (39 ppm), and zinc (294 ppm) in the Mass Fill 1 sediment sample were greater than Mass Fill 2 (2.1, 0.73, 32, 32, 100, 0.10, 35, and 169 ppm, respectively) and the reference site (1.7, 0.25, 12, 13, 20, non-detect, 11, and 49 ppm, respectively). Because there was only one sediment sample collected at each of the three sites, sediment results could not be statistically compared.

Kenilworth Marsh sediments from Mass Fill 1 and Mass Fill 2 contained measurable amounts of total PCB (both 0.14 ppm), total DDT (0.088 and 0.067 ppm, respectively), and total chlordane (0.12 and 0.18 ppm, respectively). With the exception of three PCB congeners, no organochlorine compounds where detected in the reference sample. None of the four PCB aroclors (1242, 1248, 1254, and 1260) that are added to determine total PCB were detected in the reference sample.

4.2 Broad-leaf Cattails

Mean metal wet weight concentrations in cattail roots from Mass Fill 1 were consistently greater than mean concentrations in Mass Fill 2 and the Mason Neck NWR reference site (Table 6). Copper, lead, and zinc results were greater in Mass Fill 2 than reference and arsenic, cadmium, chromium, and nickel were greater in the reference sample than in the Mass Fill 2 sample.

Mean concentrations of arsenic, cadmium, chromium, copper, and nickel measured in cattails were not significantly different in samples collected from the three locations (ANOVA, $p > 0.05$) (Table 6). The differences between sites for lead and zinc were of borderline significance. Mean concentrations of lead were 2.0 ppm at Mass Fill 1, 1.2 ppm at Mass Fill 2, and 0.80 ppm at the reference site (ANOVA on log-transformed Data, $p = 0.087$). Mean zinc concentrations were 130 ppm in cattails collected from Mass Fill 1, 97 ppm in cattails collected from Mass Fill 2, and 83 ppm in cattails from Mason Neck ($p = 0.054$, ANOVA on log-transformed data).

4.3 Killifish

The mean total lengths of killifish sampled in this study were 78 mm at Mass Fill 1, 70 mm at Mass Fill 2, and 72 mm at the Mason Neck NWR reference site (Table 2). The length of the smallest fish sampled in the study (62 mm) was 71% of the length of the largest (87 mm).

The mean chromium result at Mass Fill 1 (2.4 ppm) was significantly greater than the means at Mass Fill 2 (0.87 ppm) and the reference site (0.77 ppm; ANOVA, $p < 0.001$, Tukey's test, $p < 0.05$; Table 7). For copper, both Mass Fill 1 (2.8 ppm) and Mass Fill 2 (1.7 ppm) had mean concentrations that were significantly greater than the reference site (1.1 ppm; ANOVA, $p < 0.001$, Tukey's test, $p < 0.05$). The Mass Fill 1 mean copper value was also significantly greater than the Mass Fill 2 mean. The median lead concentration in Mass Fill 1 killifish (2.6 ppm) was significantly greater than results at the reference site, where no lead was detected (Kruskal-Wallis, $p < 0.0001$; Dunn's method, $p < 0.05$). The Mass Fill 1 mean nickel concentration (1.2 ppm) was significantly greater than those for both Mass Fill 2 (0.28 ppm) and the reference site (0.18; ANOVA, $p < 0.001$, Tukey's test, $p < 0.05$). Concentrations of arsenic, cadmium, and zinc were not statistically different among the sites.

Median total PCB concentrations in killifish at Mass Fill 1 (0.26 ppm) and Mass Fill 2 (0.35

ppm) were significantly higher than the reference site, where PCBs were not detected (Kruskal-Wallis, $p < 0.001$; Dunn's method, $p < 0.05$; Table 7). Median total DDT results for Mass Fill 1 (0.065 ppm) and Mass Fill 2 (0.062 ppm) were significantly greater than the median from the reference site (0.030 ppm; Kruskal-Wallis, $p < 0.001$; Dunn's method, $p < 0.05$). Median total chlordane concentrations at Mass Fill 1 (0.074 ppm) and Mass Fill 2 (0.068 ppm) were also significantly higher than the reference median, where chlordane was not detected (Kruskal-Wallis, $p < 0.001$; Dunn's method, $p < 0.05$). The analysis of lipid normalized total chlordane data showed that Mass Fill 1 killifish contained significantly greater levels of chlordane than Mass Fill 2 killifish (Mann-Whitney Rank Sum Test, $p = 0.003$). Neither total PCBs nor total DDT concentrations were lipid normalized because there were not significant regressions between concentrations and lipid content.

5.0 DISCUSSION

5.1 Sediment

Although sediment concentrations cannot be compared statistically, they appear to be higher at Kenilworth Marsh, especially Mass Fill 1 (Table5). Results for Mass Fill 1 samples were from 2.2 to 8.4 times greater than concentrations found in reference site samples. As with the cattail and killifish samples, Mass Fill 1 sediment concentrations were almost always highest, followed by Mass Fill 2 and the reference site. Total chlordane was the only analyte that was greater at Mass Fill 2 (0.18 ppm) than at Mass Fill 1 (0.12 ppm). Grain size results for the three sites show that Mass Fill 1, Mass Fill 2, and reference sediments contain 93.3 %, 92.0%, and 80.0 % fines, respectively. Higher contaminant levels are more likely to be found in finer sediments, possibly accounting for lower numbers at the reference site. Sediments with higher organic content, however, usually accumulate higher contaminant concentrations. The TOC result for the reference sediment sample was 2.3%, twice as high as Mass Fill 1 (1.1%) and equivalent to Mass Fill 2.

Except for total PCB, Mass Fill 1 results are comparable to mean results from nine samples collected in Mass Fill 1 and Mass Fill 2 in the 1993 USFWS study (USFWS 1997) which are summarized in Table 5. The mean PCB value for the 1993 samples was 0.76 ppm, well above the 0.14 ppm measured in Mass Fill 1 and Mass Fill 2 in this study. The results for the 1996 Mass Fill 2 sediment sample were, in general, lower than those for the 1996 Mass Fill 1 sample and the 1993 means.

Velinsky *et al.* (1994) and Wade *et al.* (1994) collected sediments in the Anacostia River and Kingman Lake in 1991 (Table 5). In general, sediment concentrations from the Anacostia in 1991 were slightly higher than those found in Kenilworth Marsh in 1993 and Mass Fill 1 in 1996. Chromium, copper, lead, and mercury mean values in the 1991 river sediments were greater than those found in Kenilworth Marsh in 1993 and 1996 (arsenic and nickel were not analyzed in 1991). Total DDT and total chlordane in the 1993 Kenilworth samples (0.088 ppm and 0.17 ppm, respectively) and 1996 Kenilworth samples (0.088 ppm and 0.12 ppm, respectively) were greater than in the 1991 river samples (0.066 ppm and 0.10 ppm respectively). The mean 1993 Kenilworth Marsh PCB value (0.76 ppm) was slightly higher than the mean 1991 river sample value (0.70 ppm), both of which were quite higher than the 1996 Kenilworth marsh levels (both 0.14 ppm). Also included in Table 5 are reference data from the Potomac River at Washington, D.C. (USFWS 1997, Velinsky *et al.* 1994, and Wade *et al.* 1994). In general, concentrations in the Potomac River were lower than those measured in the Anacostia River and Kenilworth Marsh.

Sediment guidance values are listed in Table 8. Concentrations of lead (168 ppm), zinc (294 ppm), and total chlordane (0.12 ppm) in the Mass Fill 1 sediment sample exceeded ER-M values and may be associated with adverse biological effects (Long and Morgan 1990). The nickel result exceeded the PEL, denoting a concentration where biological effects frequently occur (Smith et al. 1996). Other analytes found in Mass Fill 1 sediments at concentrations below the ER-M and PEL but greater than ER-L and/or TEL values denoting occasional biological effects include chromium, copper, mercury, total PCB, and total DDT. In Mass Fill 2 sediments, the total chlordane result (0.18 ppm) exceeded the ER-M value and lead (168 ppm) exceeded the PEL. Analytes whose concentrations in Mass Fill 2 sediments exceeded ER-Ls and/or TELs but were lower than ERMs and PELs include nickel, zinc, total PCB, and total DDT. No ER-L, TEL, ER-M, or PEL values were exceeded in the Mason Neck NWR reference sample. In the 1993 Kenilworth marsh samples, ER-Ms and PELs were exceeded for lead, nickel, zinc, total PCB, and total chlordane, and the chromium result was greater than the PEL but less than the ER-M. Arsenic, copper, mercury, and total DDT were detected in sediments collected in 1993 at concentrations that exceeded ER-Ls and/or TELs.

5.2 Broad-leaf Cattails

Wet weight concentrations of arsenic, cadmium, chromium, copper, lead, nickel, and zinc were similar in broad-leaf cattail roots from Kenilworth Marsh Mass Fill 1, Mass Fill 2, and the Mason Neck NWR reference site (Table 6). Mass Fill 1 cattail results were slightly higher than those from Mass Fill 2 and the reference site. Although metal concentrations in Mass Fill 1 sediments were 2.2 to 8.4 times greater than concentrations in Mason Neck sediments, these differences were not apparent in the cattail root concentrations. Only lead and zinc were found at concentrations in Mass Fill 1 cattail roots that were close to being significantly higher than the concentrations in cattail roots from Mason Neck. The lack of significant difference in cattail root concentrations may reflect the much more mature marsh at Mason Neck or be related to physical/chemical conditions in the marshes. In addition to differences in marsh age, accumulation in cattails could have been affected negatively or positively due to the chemical form of each metal, the pH of the water and wetland sediments, water hardness, nutrient quantity, quantity and nature of suspended solids, and the quantity of organic matter, percentage of silt and clay, and the cation exchange capacity of the sediments (Pain 1995). Also, some portion of the metals accumulated by cattails may be transferred from the roots to the leafy parts of the plant which die off every year and become detritus, thus expelling some of the metal tissue burden to the aquatic environment. The distribution pattern of metals in plant tissues is unique for each metal and varies depending on the degree of contamination to the sediments (Miller et al. 1983).

Mean dry weight results for zinc in cattails were 924, 663, and 886 ppm zinc at Mass Fill 1, Mass Fill 2, and the Mason Neck NWR reference site, respectively (Appendix C). Eisler (1993) noted that adverse effects occur in sensitive mammalian species at zinc concentrations in diet as low as 80 to 300 ppm dry weight. Harmful effects were seen in mice fed a diet containing 500 ppm zinc for three months (PHS 1989). While none of the cattail root samples from this study contained levels of zinc that are associated with death in mammals, sublethal effects to animals such the muskrat which feed on marsh vegetation, such as the muskrat, are possible in both Kenilworth Marsh and the Mason Neck NWR reference site. No other metals of concern to this study were found at concentrations in cattail roots which have been shown to cause adverse effects to herbivorous mammals (Eisler 1985, 1986, 1988a, 1988b, 1993; Demayo et al. 1982; Demayo et al. 1980).

5.3 Killifish

Wet weight concentrations of chromium, copper, lead, nickel, total PCB, total DDT, and total chlordane in killifish composite samples from Kenilworth Marsh were significantly greater than those in the Mason Neck NWR reference samples (Table 7). Analytes for which both Mass Fill 1 and Mass Fill 2 contained significantly greater results than reference were copper, total PCB, total DDT, and total chlordane. In addition, Mass Fill 1 results for chromium, copper, nickel, and total chlordane were significantly greater than those found in Mass Fill 2 samples.

In a 1995 study , the CBFO found that banded killifish (*F. diaphanus*) and mummichogs (*F. heteroclitus*) from Quantico embayment on the Potomac River in Quantico,Virginia contained high concentrations of PCBs and DDT compared to a reference location as a result of landfilling and other activities on Quantico Marine Base (Pinkney *et al.* 1997). Mean concentrations of total PCBs in Kenilworth Marsh killifish were similar to those found in killifish from Quantico embayment, an area shown to contain localized contamination from multiple sources. Total DDT results in Quantico killifish were an order of magnitude higher than concentrations found in Kenilworth Marsh killifish.

To determine whether analyte concentrations in killifish were high compared to national values, organochlorine results were compared to National Contaminant Biomonitoring Program (NCBP) results summarized by Schmitt et al. (1990) and metal results were compared to NCBP results summarized by Schmitt and Brumbaugh (1990; Table 7). Arsenic, cadmium, copper, and zinc results exceeded the 85th percentile of the NCBP in at least one sample from all three sites. The 85th percentile concentration for lead was exceeded at the Kenilworth Marsh sites but not at the reference site. Chromium and nickel were not analyzed as part of the NCBP. Frequency of exceedance was greatest in Mass Fill 1 samples, followed by Mass Fill 2 and the reference site. For the Mass Fill 1 killifish, the 85th percentiles for copper, lead, and zinc were exceeded in 100% of the samples. The 85th percentiles for copper and zinc were exceeded in 100% of the

Mass Fill 2 samples. Zinc was the only analyte for which the 85th percentile was exceeded in 100% of the reference samples.

Since 85th percentile values were not determined for organochlorines in the NCBP, total PCB, total DDT, and total chlordane, killifish results were compared to NCBP geometric means. No PCB or DDT results were greater than the geometric means for those analytes. Since no NCBP values were determined for total chlordane, comparisons were made using alpha-chlordane results. The NCBP geometric mean for alpha-chlordane was exceeded in two of eight samples from Mass Fill 1 and two of eight samples from Mass Fill 2. Chlordane was not detected in reference killifish composites.

Whitehead (1995) suggested that mummichogs are among the most sedentary of all fish species. The summer home range for a population of mummichogs in a Delaware tidal creek was estimated at 36 meters (Lotrich 1975). Based on this information, the mummichogs sampled in Mass Fill 1 and Mass Fill 2 probably live and accumulate most of their tissue contaminants in Kenilworth Marsh. As noted earlier, banded killifish comprised one-half of the composite samples from the reference site. No data are available concerning the home range of banded killifish.

Eisler (1986) suggested that fish and wildlife tissue containing greater than 4 ppm total chromium as dry weight is indicative of chromium contamination. The average total chromium level in killifish from Mass Fill 1 was 10 ppm dry weight (Appendix C), over two times greater than the Eisler threshold. The mean total chromium dry weight results for Mass Fill 2 and the reference site were 3.7 and 3.4 ppm, respectively.

Eisler (1993) concluded that bird diets should contain <178 ppm zinc as dry weight to prevent sublethal effects. Most of the zinc results in killifish tissue for all three sites were greater than this value. Mean zinc tissue concentrations in dry weight for Mass Fill 1, Mass Fill 2, and the reference site were 236, 246, and 316 ppm, respectively (Appendix C). These results suggest that tissue levels of zinc in killifish from both Kenilworth Marsh and Great Marsh at Mason Neck NWR might result in adverse effects to fish-eating birds that feed in these areas if other prey species have similar concentrations. Acute effects such as mortality are not expected in birds until zinc concentrations in food reach at least 2000 ppm (Eisler 1993). As discussed earlier, Eisler (1993) noted that adverse effects occurred in mammalian species at levels as low as 80 to 500 ppm zinc as dry weight. These zinc concentrations in fish may be causing adverse sublethal effects in fish eating mammals such as the raccoon in both Kenilworth Marsh and the Mason Neck NWR reference site.

Other analytes (arsenic, cadmium, copper, lead, nickel, total PCBs, total DDT, and total chlordane) that were found at concentrations in fish tissue that significantly exceeded reference results, were greater than 85th percentile of the NCBP, or were greater than the geometric mean of the NCBP, were not detected at concentrations that have been found to be associated with anthropogenic contamination or adverse effects to prey fish, piscivorous fish, and piscivorous birds (Beyer et al. 1996; Eisler 1996, 1993, 1990, 1988a, 1988b, 1986, 1985; Hoffman et al. 1995; Moore and Ramamoorthy 1984; Demayo et al. 1982; Demayo et al. 1980). However, data gaps concerning effects to ecological receptors continue to exist for most of these analytes.

5.4 Risk Analysis

Spreadsheets containing the risk analysis outputs are contained in Appendix D. The results of the green heron food chain model indicated HQs greater than or equal to one for total DDT, total chlordane, arsenic, copper, lead, and zinc (Table 9). For the raccoon, analytes with HQs greater than or equal to one included 4,4'-DDD, 4,4'-DDE, total DDT, total PCBs, arsenic, chromium, copper, lead, and zinc (Table 9). Using the less conservative LOAEL approach, all green heron HQs were less than one, while raccoon HQs for total DDT, total PCBs, and lead were equal to or greater than one.

There is a certain amount of uncertainty inherent in the risk assessment process that should be considered when interpreting results. Because of this uncertainty, risk calculations are performed using the most conservative values found in the literature. This reduces the potential for finding no risk when risk is actually present. According to the results of the risk analysis, there are potential risks to ecological receptors in Kenilworth Marsh as a result of contamination to sediments and biota. In interpreting these results, we considered the magnitude of the exceedance of the risk threshold as well as the chemical condition of the area in and around the study site.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Sediment samples collected from Kenilworth Marsh in 1993 (USFWS 1997) and 1996 contained concentrations of chromium (1993 only) lead, nickel, zinc, total PCB (1993) and total chlordane that exceed ecological threshold levels above which toxic effects frequently occur. In addition, several analytes in sediments exceeded thresholds that result in occasional ecological effects. These include arsenic (1993), chromium, copper, mercury, total PCB (1996), and total DDT. No ecological thresholds were exceeded in reference sediment samples. Mass Fill 2 sediments generally contained lower contaminant concentrations than Mass Fill 1 and the 1993 results. Kenilworth Marsh results from both 1993 and 1996 were much higher than those obtained at the reference site at Mason Neck NWR. In general, sediment results from the Anacostia River in 1991, Kenilworth Marsh in 1993, and Kenilworth Marsh in 1996 are comparable, with a slight decreasing trend from 1991 to 1996. The data suggest that sediments dredged from the Anacostia River and placed in Kenilworth Marsh in 1993 remain similar in chemical composition to Anacostia River sediments with a possible minor decrease in concentration over five years.

There were no significant differences between metal concentrations in cattail root material from Kenilworth Marsh and the reference site. The lack of significant difference in cattail root concentrations may reflect the much more mature marsh at Mason Neck or be related to physical/chemical conditions in the marshes. Also, some portion of the metals accumulated by cattails may be transferred from the roots to the leafy parts of the plant, which die off every year and become detritus, eliminating some of the metal tissue burden to the environment. Zinc concentrations found in cattails from both locations may pose risks to mammalian species.

Concentrations of chromium, copper, lead, nickel, total PCB, total DDT, and total chlordane in killifish collected in Kenilworth Marsh were significantly greater than in killifish collected at a reference site at Mason Neck National Wildlife Refuge. Concentrations were also compared with results of the National Contaminant Biomonitoring Program which measured whole body residues of organic and inorganic contaminants in freshwater fish in the mid 1980's. Metals found in fish tissue in exceedance of the 85th percentile of national concentrations included arsenic, cadmium, copper, lead, and zinc. Organochlorines that exceeded the national mean included total PCB, total DDT, and alpha chlordane. These results suggest that concentrations of certain contaminants in killifish living in Kenilworth Marsh are high when compared to regional and national values. In addition, zinc was found in Kenilworth Marsh fish tissue at concentrations that may pose risks to piscivorous birds and are above thresholds that are theorized to be harmful to mammals.

An ecological risk assessment using data from this study suggested that contaminants in sediments and biota in Kenilworth Marsh pose a potential risk to ecological receptors.

The Mason Neck NWR reference site fish samples contained the highest zinc fish tissue burdens in this study. Zinc levels in reference cattails were not significantly different than concentrations in Kenilworth Marsh cattail roots. The sediment sample collected at the reference site contained zinc at a concentration that was much lower than those found at Kenilworth Marsh and also lower than ecological thresholds that are associated with adverse effects. Although more samples would be required to effectively determine the reason for the high tissue burdens at Mason Neck NWR, based on one sediment sample, it appears that there may be a source other than the aquatic sediments.

The results of this limited study suggest that: contaminants originating in Anacostia River dredge sediments used to construct a wetland at Kenilworth Marsh are accumulating in killifish; concentrations of certain contaminants in sediments, killifish, and cattails are elevated; several inorganic and organic contaminants were found at concentrations that have been associated with adverse effects to fish-eating birds, mammals, and aquatic biota; and potential ecological risks exist in the marsh. Based on the results of this and previous studies, the Service recommends that Anacostia River sediments be used for marsh restoration purposes only on a limited basis in the Anacostia watershed until more in-depth studies are performed in Kenilworth Marsh to determine the extent and magnitude of contamination to biota and the possible ecological effects of that contamination.

Suggested further study in Kenilworth Marsh:

- continued sampling and chemical analysis of killifish, cattails, and sediments in the future to determine whether contaminant levels are decreasing are increasing over time;

- sampling and analysis of tissue levels in other biota inhabiting the marsh, such as benthic macroinvertebrate species which make up a large portion of the food base for many fish and migratory birds;

- amphibian sampling to determine contaminant tissue burdens, population status, and frequency of deformities in this sensitive phyla;

- and bioaccumulation studies to determine whether marsh sediment contaminants have the potential to accumulate in biota (bioaccumulation studies are being performed in Kenilworth Marsh during the summer of 1998).

Future use of Anacostia River dredge sediments for restoration should be evaluated on a case by case basis. Sediments should be tested for toxicity and chemically characterized and compared to ecological guidelines prior to use as restoration substrates. In addition, marsh creation projects using Anacostia sediments should be subjected to post-restoration monitoring to determine the effects of sediment contaminants on the developing wetland communities. Monitoring plans and sediment chemistry analyses should be completed and presented to the Kenilworth Marsh Monitoring Committee for comment prior to construction. Monitoring should continue for at least ten years following construction and should include investigations similar to those listed above.

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Figures

Tables

Table 1. Cattail and sediment sample locations - Kenilworth Marsh and Mason Neck National Wildlife Refuge, 1996.

Sample Number	Location	GPS
K0101TTY	Kenilworth MF-1	N38°54.905' W76°56.668'
K0102TTY	Kenilworth MF-1	N38°54.905' W76°56.668'
K0103TTY	Kenilworth MF-1	N38°54.905' W76°56.668'
K0104TTY	Kenilworth MF-1	N38°54.905' W76°56.668'
K0105TTY	Kenilworth MF-1	N38°54.905' W76°56.668'
K0106TTY	Kenilworth MF-1	N38°54.905' W76°56.668'
K0107TTY	Kenilworth MF-1	N38°54.905' W76°56.668'
K0108TTY	Kenilworth MF-1	N38°54.905' W76°56.668'
K0201TTY	Kenilworth MF-2	N38°54.601' W76°56.872'
K0202TTY	Kenilworth MF-2	N38°54.601' W76°56.872'
K0203TTY	Kenilworth MF-2	N38°54.601' W76°56.872'
K0204TTY	Kenilworth MF-2	N38°54.601' W76°56.872'
K0205TTY	Kenilworth MF-2	N38°54.601' W76°56.872'
K0206TTY	Kenilworth MF-2	N38°54.601' W76°56.872'
K0207TTY	Kenilworth MF-2	N38°54.601' W76°56.872'
K0208TTY	Kenilworth MF-2	N38°54.601' W76°56.872'
M0101TTY	Mason Neck	N38°37.969' W77°10.128'
M0102TTY	Mason Neck	N38°37.969' W77°10.128
M0103TTY	Mason Neck	N38°37.969' W77°10.128
M0104TTY	Mason Neck	N38°37.969' W77°10.128
M0105TTY	Mason Neck	N38°37.969' W77°10.128
M0106TTY	Mason Neck	N38°37.969' W77°10.128
M0107TTY	Mason Neck	N38°37.969' W77°10.128
M0108TTY	Mason Neck	N38°37.969' W77°10.128

Table 2. Killifish sample locations and mean total fish lengths - Kenilworth Marsh and Mason Neck National Wildlife Refuge, 1996.

Sample Number*	Location	GPS	x̄ Length & Range (mm)
K0101TFH	Kenilworth MF-1	N38°54.843' W76°56.547'	82 (79-86)
K0102TFH	Kenilworth MF-1	N38°54.843' W76°56.547'	82 (70-87)
K0103TFH	Kenilworth MF-1	N38°54.843' W76°56.547'	79 (70-87)
K0104TFH	Kenilworth MF-1	N38°54.843' W76°56.547'	75 (70-82)
K0105TFH	Kenilworth MF-1	N38°54.843' W76°56.547'	75 (70-83)
K0106TFH	Kenilworth MF-1	N38°54.843' W76°56.547'	76 (71-82)
K0107TFH	Kenilworth MF-1	N38°54.843' W76°56.547'	79 (71-85)
K0108TFH	Kenilworth MF-1	N38°54.843' W76°56.547'	75 (70-84)
K0201TFH	Kenilworth MF-2	N38°54.596' W76°56.747'	72 (63-83)
K0202TFH	Kenilworth MF-2	N38°54.596' W76°56.747'	71 (65-87)
K0203TFH	Kenilworth MF-2	N38°54.596' W76°56.747'	70 (62-79)
K0204TFH	Kenilworth MF-2	N38°54.596' W76°56.747'	68 (65-80)
K0205TFH	Kenilworth MF-2	N38°54.596' W76°56.747'	68 (62-77)
K0206TFH	Kenilworth MF-2	N38°54.596' W76°56.747'	68 (62-75)
K0207TFH	Kenilworth MF-2	N38°54.596' W76°56.747'	70 (63-75)
K0208TFH	Kenilworth MF-2	N38°54.596' W76°56.747'	73 (66-77)
M0101TFH	Mason Neck	N38°38.364' W77°09.517'	71 (65-85)
M0102TFH	Mason Neck	N38°38.364' W77°09.517'	70 (63-84)
M0103TFH	Mason Neck	N38°38.364' W77°09.517'	68 (62-81)
M0104TFH	Mason Neck	N38°38.364' W77°09.517'	70 (63-80)
M0105TFH	Mason Neck	N38°38.364' W77°09.517'	75 (62-82)
M0106TFH	Mason Neck	N38°38.364' W77°09.517'	76 (66-82)
M0107TFH	Mason Neck	N38°38.364' W77°09.517'	75 (70-82)
M0108TFH	Mason Neck	N38°38.364' W77°09.517'	70 (65-77)

* M0101TFH through M0105TFH were Banded Killifish (*Fundulus diaphanus*) samples

Table 3. Water quality results for fish sampling stations - Kenilworth Marsh and Mason Neck National Wildlife Refuge, 1996

Parameter	Kenilworth Mass Fill 1 8/9/96	Kenilworth Mass Fill 2 8/15/96	Mason Neck Great Marsh 8/28/96	Mason Neck Great Marsh 8/29/96
Conductivity (micromhos/cm)	336	208	219	221
Temperature (°C)	24.31	22.21	25.77	26.10
Dissolved Oxygen (ppm)	1.52	2.16	5.03	5.49
Dissolved Oxygen (% Saturation)	17.4	23.4	61.5	67.5
pH	6.94	6.87	7.42	7.41
Salinity (ppt)	0.2	0.1	0.1	0.1
Total Depth (m)	0.1	0.2	0.9	0.8

Table 4. List of analytes and desired detection limits (ppm dry wt.).

Analyte	Method	Detection Limit -- Tissue	Detection limit -- Sediment
Aluminum	ICP	5.0	10.0
Arsenic	AA	0.50	0.50
Barium	ICP	1.0	1.0
Beryllium	ICP	0.10	0.20
Boron	ICP	2.0	10.0
Cadmium	ICP	0.10	0.20
Chromium	ICP	0.50	1.0
Copper	ICP	0.50	1.0
Iron	ICP	5.0	10.0
Lead	ICP	0.50	5.0
Magnesium	ICP	5.0	10.0
Manganese	ICP	1.0	5.0
Mercury	AA	0.20	0.20
Molybdenum	ICP	2.0	5.0
Nickel	ICP	0.50	5.0
Selenium	AA	0.50	1.0
Strontium	ICP	0.50	5.0
Vanadium	ICP	0.50	1.0
Zinc	ICP	1.0	5.0

Desired detection limits for organochlorines: 0.01- 0.05 ppm

Table 5. Summary of contaminant data in sediment samples (ppm dry wt.) - Kenilworth Marsh (1993, 1996), Mason Neck National Wildlife Refuge (1996), Anacostia River (1991), and the Potomac River (1991, 1993).

Analyte	Kenilworth Mass Fill 1 1996	Kenilworth Mass Fill 2 1996	Mason Neck Great Marsh 1996	Kenilworth Marsh 1993, X (Range), N=9 (1)	Potomac River Near Roosevelt Isl. 1993, X (Range), N=2 (2)	Anacostia River and Kingman Lake 1991, X (Range), N=11 (3)	Potomac River 1991, X (Range), N=4 (4)
Arsenic	3.8	2.1	1.7	4.9 (3.8 - 6.5)+	3.6 (3.3 - 3.9)	-	-
Cadmium	1.6	0.73	0.25	1.5 (1.2 - 2.2)	0.43 (0.42 - 0.43)	1.9 (0.92 - 3.2)+	0.66 (0.52-0.99)+
Chromium	57+	32	12	63 (49 - 100)*++	27 (27 - 27)	115 (90 - 156) **++	74 (63 - 96) *++
Copper	49+	32	13	44 (32 - 64)+	26 (25 - 26)	89 (64 - 127)*+	42 (34 - 60)+
Lead	168**++	100*++	20	156 (108 - 180) **++	32 (30 - 34)	188 (83 - 409) **++	58 (32 - 128) **++
Mercury	0.19*+	0.10	ND	0.17 (0.15 - 0.20) *+	0.15 (0.12 - 0.18) *+	0.44 (0.28 - 1.0) *++	0.25 (0.13-0.56) *++
Nickel	39*++	35*+	11	41 (31 - 50) **++	32 (31 - 32)*+	-	-
Zinc	294**+	168*+	49	314 (250 - 413) **++	143 (141 - 145)*+	406 (279 - 512) **++	223 (168-365) **++
Total PCB	0.14*+	0.14*+	ND	0.76 (0.43 - 1.6) **++	0.054 (0.041-0.067)*+	0.70 (0.22 - 2.2) **++	0.12 (0.068-0.27) *+
Total DDT (5)	0.088*+	0.067*+	ND	0.088 (0.057 - 0.14) *+	0.009 (0.006-0.013)*+	0.066 (0.029-0.12) **+	0.032 (0.007-0.10)*+
Total Chlordane (6)	0.12**++	0.18**++	ND	0.17 (0.11 - 0.23) **++	ND	0.10 (0.028-0.15) **++	0.016 (0.005-0.042)**++
%Silt/Clay	93	92	80	73 (46 - 97)	69 (66 - 71)	94 (86 - 100)	87 (78 - 94)
%TOC	1.1	1.9	2.3	2.9 (2.2 - 4.0)	3.2 (2.9 - 3.5)	4.2 (3.0 - 6.1)	3.6 (2.4 - 4.1)

*Exceeds ERL; **Exceeds ERM; +Exceeds TEL; ++Exceeds PEL - Refer to Table 8 for numerical guidance values for each analyte.

(1) Data from 1993 sampling in Kenilworth Marsh (USFWS 1997)

(2) Potomac River reference data for samples collected near Roosevelt Island during the 1993 Kenilworth Marsh study (USFWS 1997)

(3) Data from 1991 sampling in the Anacostia River (N=6) and Kingman Lake (N=6); Inorganic data from Velinsky et al. 1994; Organic Data from Wade et al 1994

(4) Data from 1991 sampling in the Potomac River; Inorganic data from Velinsky et al. 1994; Organic Data from Wade et al. 1994

(5) Total DDT values are the sum of o,p'-DDD, o,p'-DDE, o,p'-DDT, p,p'-DDD, p,p'-DDE, and p,p'-DDT; the 1993 and 1996 values were determined using ½ the detection limit for non-detects; the detection limits in these studies were above the ERL and TEL for DDT and its metabolites

(6) Total chlordane values are the sum of oxychlordane, alpha chlordane, cis-nonachlor, gamma chlordane, and trans-nonachlor; the 1993 and 1996 values were determined using ½ the detection limit for non-detects; the detection limits in these studies were above the ERL and TEL for the chlordane compounds

Table 6. Summary of contaminant data in broad-leaf cattail samples (ppm wet wt.) - Kenilworth Marsh and Mason Neck National Wildlife Refuge, 1996

Analyte	Frequency of Detection	Mean ± Standard Deviation	Minimum	Maximum
Kenilworth Mass Fill 1				
Arsenic[a]	6/8	0.21±0.16	0.059	0.58
Cadmium[a]	6/8	0.041±0.027	0.013	0.088
Chromium[a]	8/8	1.7±1.2	0.72	3.7
Copper[a]	8/8	0.82±0.54	0.35	1.8
Lead[b]	8/8	2.0±2.0	0.63	6.2
Nickel[a]	8/8	0.86±0.59	0.39	2.2
Zinc[c]	8/8	130±34	78	174
Kenilworth Mass Fill 2				
Arsenic	5/8	0.16±0.08	0.074	0.25
Cadmium	4/8	0.024±0.011	0.013	0.088
Chromium	8/8	0.94±0.47	0.44	2.0
Copper	8/8	0.59±0.33	0.31	1.3
Lead	8/8	1.2±0.4	0.66	1.9
Nickel	8/8	0.60±0.28	0.33	1.2
Zinc	8/8	97±57	57	235
Mason Neck NWR Great Marsh				
Arsenic	7/8	0.20±0.09	0.047	0.31
Cadmium	7/8	0.025±0.010	0.010	0.038
Chromium	8/8	1.7±0.7	0.68	2.4
Copper	8/8	0.55±0.20	0.24	0.85
Lead	8/8	0.80±0.29	0.44	1.4
Nickel	8/8	0.98±0.44	0.33	1.4
Zinc	8/8	83±48	38	176

(a) No significant difference between mean concentrations in cattails from Kenilworth Marsh Mass Fill 1, Mass Fill 2, or Mason neck NWR Great marsh (ANOVA: As, p=0.59; Cd, p=0.11; Cr, p=0.14; Cu, p=0.32; Ni, p=0.26)

(b) No significant difference (ANOVA, log-transformed data, p=0.087)

(c) Of borderline significance (ANOVA, log-transformed data, p=0.054)

Table 7. Summary of contaminant data in whole body killifish samples (ppm wet wt.) - Kenilworth Marsh and Mason Neck National Wildlife Refuge, 1996

Analyte	Frequency of Detection	Mean ± Standard Deviation	Median	Minimum	Maximum	Frequency ≥ NCBP 85% Conc.[a]	Sites that are Significantly Different (p<0.05)[b]
Kenilworth Mass Fill 1							
Arsenic	6/8	0.29 ± 0.13	0.32 [c]	0.11	0.44	5/8	
Cadmium	3/8	0.033 ± 0.013	0.024[d]	0.023	0.054	1/8	
Chromium	8/8	2.4 ± 0.4[e]	2.3	1.8	3.2	*	>M, >K2
Copper	8/8	2.8 ± 0.5[f]	2.6	2.3	3.7	8/8	>M, >K2
Lead	8/8	2.8 ± 0.4	2.6[g]	2.4	3.4	8/8	>M
Nickel	8/8	1.2 ± 0.2[h]	1.2	0.95	1.5	*	>M, >K2
Zinc	8/8	55 ± 9.2	52[i]	45	74	8/8	
PCB	8/8	0.29 ± 0.06	0.26[j]	0.21	0.37	0/8	>M
DDT	8/8	0.064 ± 0.01[k]	0.065	0.057	0.071	0/8	>M
Chlordane	8/8	0.074 ± 0.011	0.074[l]	0.058	0.088	2/8**	>M
Kenilworth Mass Fill 2							
Arsenic	3/8	0.19 ± 0.10	0.12	0.14	0.33	3/8	
Cadmium	1/8	0.028 ± 0.014	0.023	0.022	0.062	1/8	
Chromium	8/8	0.87 ± 0.22	0.86	0.52	1.2	*	<K1
Copper	8/8	1.7 ± 0.4	1.6	1.3	2.4	8/8	>M, <K1
Lead	6/8	0.56 ± 0.33	0.53	0.23	1.3	6/8	
Nickel	5/8	0.28 ± 0.17	0.27	0.11	0.58	*	<K1
Zinc	8/8	58 ± 16	45	40	82	8/8	
PCB	8/8	0.37 ± 0.10	0.35	0.20	0.50	0/8	>M
DDT	8/8	0.063 ±0.01	0.062	0.053	0.078	0/8	>M
Chlordane	8/8	0.070 ± 0.016	0.068	0.054	0.093	2/8**	>M
Mason Neck NWR Great Marsh							
Arsenic	3/8	0.19 ± 0.12	0.12	0.10	0.43	2/8	
Cadmium	1/8	0.027 ± 0.012	0.023	0.021	0.057	1/8	

Analyte	Frequency of Detection	Mean ± Standard Deviation	Median	Minimum	Maximum	Frequency ≥ NCBP 85% Conc.[a]	Sites that are Significantly Different (p<0.05)[b]
Chromium	8/8	0.77 ± 0.13	0.74	0.60	1.0	*	<K1
Copper	8/8	1.1 ± 0.4	1.0	0.70	1.9	4/8	<K1, <K2
Lead	0/8	N/A	N/A	N/A	N/A	N/A	<K1
Nickel	4/8	0.18 ± 0.08	0.17	0.10	0.33	*	<K1
Zinc	8/8	72 ± 37	43	37	138	8/8	
PCB	0/8	N/A	N/A	N/A	N/A	N/A	<K1, <K2
DDT	3/8	0.032 ± 0.003	0.030	0.030	0.038	0/8	<K1, <K2
Chlordane	0/8	N/A	N/A	N/A	N/A	N/A	<K1, <K2

(a) NCBP 85th percentile value: arsenic: 0.27 ppm; cadmium: 0.05 ppm; copper: 1.0 ppm; lead: 0.22 ppm; zinc: 34 ppm; chromium and nickel: * no NCBP values were determined; total PCB and total DDT: no 85th percentile values were determined, however, Kenilworth Marsh and Mason Neck NWR levels are below the 1984 NCBP geometric means for total PCB (0.39 ppm) and total DDT (0.26 ppm) and are, therefore, below the respective 85th percentile values as well; chlordane: no NCBP values were determined for total chlordane, consequently, the comparison is between Kenilworth Marsh/Mason Neck alpha-chlordane results and the 1984 NCBP alpha-chlordane geometric mean of 0.03 ppm (no 85th percentile value was determined for alpha-chlordane)

(b) K1 = Kenilworth Marsh Mass Fill 1, K2 = Kenilworth Marsh Mass Fill 2, and M = Mason Neck NWR Great Marsh, > and < denote whether the mean or median levels are significantly greater than or less than those to which they are compared

(c) No significant difference between median arsenic concentrations in killifish from Kenilworth Marsh Mass Fill 1, Kenilworth Marsh Mass Fill 2, or Mason Neck NWR Great Marsh (Kruskal-Wallis, log-transformed data, p=0.20)

(d) No significant difference between median cadmium concentrations in killifish from Kenilworth Marsh Mass Fill 1, Kenilworth Marsh Mass Fill 2, or Mason Neck NWR Great Marsh (Kruskal-Wallis, log-transformed data, p=0.180)

(e) Significant differences between mean chromium concentration in Kenilworth Marsh Mass Fill 1 killifish and killifish from Kenilworth Marsh Mass Fill 2 and between Kenilworth Marsh Mass Fill 1 killifish and killifish from Mason Neck NWR Great Marsh (ANOVA, p<0.001, Tukeys test, p<0.05)

(f) Significant differences in mean copper concentrations between killifish from all three sites (ANOVA, p<0.001, Tukeys test, p<0.05)

(g) Significant differences between median lead concentration in Kenilworth Marsh Mass Fill 1 killifish and killifish from Mason Neck NWR Great Marsh (Kruskal-Wallis, log-transformed data, p<0.001, Dunn's method, p<0.05)

(h) Significant differences between mean nickel concentration in Kenilworth Marsh Mass Fill 1 killifish and killifish from Kenilworth Marsh Mass Fill 2 and between Kenilworth Marsh Mass Fill 1 killifish and killifish from Mason Neck NWR Great Marsh (ANOVA, p<0.001, Tukeys test, p<0.05)

(i) No significant difference between median zinc concentrations in killifish from Kenilworth Marsh Mass Fill 1, Kenilworth Marsh Mass Fill 2, or Mason Neck NWR Great Marsh (Kruskal-Wallis, log-transformed data, p=0.98)

(j) Significant differences between median total PCB concentration in Kenilworth Marsh Mass Fill 1 killifish and killifish from Mason Neck NWR Great Marsh and between Kenilworth Marsh Mass Fill 2 killifish and Mason Neck NWR Great Marsh killifish (Kruskal-Wallis, log-transformed data, p<0.001, Dunn's method, p<0.05)

(k) Significant differences between mean total DDT concentration in Kenilworth Marsh Mass Fill 1 killifish and killifish from Mason Neck NWR Great Marsh and between Kenilworth Marsh Mass Fill 2 killifish and Mason Neck NWR Great Marsh killifish (Kruskal-Wallis, p<0.001, Dunn's method, p<0.05)

(l) Significant differences between median total chlordane concentration in Kenilworth Marsh Mass Fill 1 killifish and killifish from Mason Neck NWR Great Marsh and between Kenilworth Marsh Mass Fill 2 killifish and Mason Neck NWR Great Marsh killifish (Kruskal-Wallis, p<0.001, Dunn's method, p<0.05)

Table 8. Sediment Guidance Values (ppm dry wt.).

Analyte	ERL [a]	ERM [a]	TEL[b]	PEL[b]
Arsenic	33	85	5.9	17
Cadmium	5	9	0.596	3.53
Chromium	80	145	37.3	90
Copper	70	390	35.7	197
Lead	35	110	35	91.3
Mercury	0.15	1.3	0.174	0.486
Nickel	30	50	18	36
Zinc	120	270	123	315
Total PCB	0.05	0.4	0.0341	0.277
Total DDT	0.003	0.350	0.007	4.45
Total Chlordane	0.0005	0.006	0.0045	0.0089

[a] Long and Morgan 1990

[b] Smith et al. 1996

Table 9. Summary of hazard quotients (HQs)for selected analytes - Kenilworth Marsh, 1996.

Analyte	Green Heron		Raccoon	
	HQ Based on NOAEL	HQ Based on LOAEL	HQ Based on NOAEL	HQ Based on LOAEL
4,4'-DDD	0.0	0.0	**4.0**	0.0
4,4'-DDE	0.4	0.0	**4.7**	0.3
Total DDT	**1.0**	0.1	**11**	**1.0**
Total Chlordane	**4.0**	0.5	0.0	0.0
Total PCBs	0.0	0.0	**5.0**	**2.0**
Arsenic	**1.0**	0.1	**3.0**	0.0
Chromium	0.1	0.0	**18**	0.9
Copper	**11**	0.7	**3.5**	0.2
Lead	**9.0**	0.5	**23**	**1.2**
Zinc	**4.1**	0.3	**3.0**	0.2

Numbers in bold indicate exceedances of the HQ threshold of 1, signifying the potential for adverse effects to the organism.

Appendix A

U.S. Fish and Wildlife Service

Chesapeake Bay Field Office

STANDARD OPERATING PROCEDURES

101. Data Recording and Handling

Revised 3/95; Version 95-1

A. Objective:

Describe the procedures used for data recording and handling in the field and in the laboratory.

B. Procedures:

1. All data will be recorded in indelible black ink at the time of observation.

2. Hand written data generated during a study will be recorded in a bound notebook. Each notebook will be used for one study only.

3. The biologist or technician recording the data will initial and date the bottom of each entry and the bottom of each page of the data book.

4. Corrections will be made by drawing one line through the error. Each error will be initialled, dated, and coded with an error code. The error code which best describes the reason for the correction can be chosen from the list below.

5. When not in use, notebooks will be stored in the study file along with any printed data or correspondence associated with the study. This file will also include the proposal, protocol, and catalog.

6. To prevent unretrievable loses of data through loss or destruction of the data book, certified copies of new data should be made daily during a study and placed in the study file.

Data Entry Error Codes

a - Inadvertently entered the wrong information.

b - Spelling error.

c - Write-over. Inadvertently wrote over existing data.

d - Data not recorded at time of initial observation.

U.S. Fish and Wildlife Service

Chesapeake Bay Field Office

STANDARD OPERATING PROCEDURES

113. COLLECTING SEDIMENTS FOR TOXICITY TESTING AND CHEMICAL ANALYSIS

Revised 9/93; Version 93-1

This SOP is based on the following guidance documents: ASTM 1991, EPA 1990, Maryland Department of the Environment 1989, and Puget Sound Estuary Program 1991.

A. Objective

1. Collection of samples for chemical and toxicological analyses to meet all QA/QC requirements for monitoring programs.

B. Chain of Custody

Chain of Custody forms will be initiated in the field as per SOP 102.

C. Preparatory Cleaning Procedures

1. For chemical analyses, use commercially prepared and certified pre-cleaned glass bottles with teflon lined lids. It is best to have several extra bottles for each type of analysis on board to allow for possible breakage or sampling error.

2. For toxicity testing, purchase 1/2 gallon polyethylene bottles from Western Plastics, Inc. (602-253-1163). Wash the bottles as follows:

a. Wash in laboratory detergent
b. Rinse with tap water to remove detergent
c. Rinse with 10% hydrochloric or nitric acid or immerse in water bath (no more than 10 minutes)
d. Rinse 5 times with distilled water
e. Rinse with pesticide grade acetone
f. Rinse 5 times with distilled water and allow to dry

3. This washing procedure is used to clean the polyethylene tub in which the dredge is emptied, the teflon or glass mixing bowl, and all utensils used to stir or spoon the samples (watch glasses, stirring rod, teflon coated spatula or spoon). For stainless steel items, rinse rather than immerse in acid.

D. Field Sampling Procedures

1. Label all jars for each sampling location, using an indelible marker on sampling labels that have been applied to the jars before going into the field.

2. Using the stainless steel ponar or stainless steel Ekman dredge, collect sediment.

Criteria for sample acceptability are as follows:

- Sampler is not overfilled and overlying water is present.
- Overlying water is not excessively turbid.
- The surface of the sediment is flat.
- The sample is at least 4-6 cm deep.

3. Deposit the sample on a clean polyethylene wash tub.

4. Remove the top 2 cm with a clean watch glass or teflon beaker cover and place in the teflon or glass mixing bowl. Do not collect any material that is in contact with the sampler. Do this by avoiding any material within 2.5 cm of the edges of the sampler.

5. Rinse the sampler in site water to remove excessive sediment and repeat grabs until sufficient sample has been obtained. The major consideration is to ensure that the grabs are collecting sediment that has not been disturbed by previous grabs.

6. Remove any large objects and drain excess water. Stir for at least 2 minutes to ensure that the sample is completely homogenized. Use either a teflon coated spoon (spatula) or a glass stirring rod.

7. Fill the sample jars for chemical analysis and then for toxicity testing.

8. If sediment samples for chemical analysis are to be frozen (for metals and organics analysis), allow about 1/3 head space in the jars.

9. If sediment samples are for analysis of acid volatile sulfides, fill completely to minimize head space. Store at 4 C and do not freeze.

10. At the time samples are collected, measure and record water quality parameters of interest and latitude and longitude from the global positioning system (GPS).

11. Between stations, rinse the sampler and all equipment that contacts samples as follows:

   a. Rinse with site water, using a brush or hose to remove sediment.
   b. Wash equipment with laboratory detergent (in site water)
   c. Rinse with site water
   d. Rinse twice with deionized water
   e. Rinse with pesticide grade acetone
   f. Rinse twice with deionized water

If an equipment blank is measured, collect samples by pouring the second rinse of deionized water over the sampler into the chemical analysis bottles (using a disposable polyethylene or clean glass funnel to aid the process).

12. Store all samples on ice in coolers. Maintain samples at 0-4 C from the time of collection until they are placed in storage at the laboratory.

13. For samples that will be frozen, loosen the caps at the time the jars are placed in the laboratory freezer to avoid breakage. Retighten the lids after 24 hours.

E. Safety Considerations for Collecting for Hazardous Site Studies

1. At least one of the samplers must have completed a 40-hour hazardous waste safety training course and be certified to wear a respirator.

2. All samplers should have Tyvek suits available with an extra supply on hand.
3. Face shields are advisable when handling sediments.

4. Two pairs of gloves should be worn: use vinyl gloves as a liner for rubber gloves that cover the wrists.

5. Perform all operations in an open area of the boat, away from all exhaust. If sediment is extremely odorous, a respirator should be worn by the person in closest contact with the sediment (the person who homogenizes and fills the sample bottles).

F. References

American Society for Testing and Materials (ASTM). 1991. Standard guide for collection, storage, characterization, and manipulation of sediments for toxicological testing. E 1391 - 90. ASTM, Philadelphia, PA.

Environmental Protection Agency (EPA). 1990. Environmental Monitoring and Assessment Program. Near Coastal Component. 1990 Demonstration Project. Training and field operations manual. (Draft)

Maryland Department of the Environment (MDE). 1989. Sample collection guidelines and techniques. MDE, Toxics, Environmental Science and Health, Ecological Assessment Division, Baltimore, MD.

Puget Sound Estuary Program 1991. Interim final recommended guidelines for conducting laboratory bioassays on Puget Sound sediments. Prepared for EPA Region 10, Seattle, WA. July, 1991.

U.S. Fish and Wildlife Service

Chesapeake Bay Field Office

STANDARD OPERATING PROCEDURES

114. PREPARING FISH AND INVERTEBRATE TISSUES FOR CHEMICAL ANALYSIS

Revised 1/97; Version 97-1

This SOP is based on the following guidance documents: Maryland Department of the Environment (1989), Puget Sound Estuary Program (1990a, b), and EPA (1995).

A. Objective

1. Collection and preparation of samples for chemical analyses to meet all QA/QC requirements for monitoring programs

B. Chain of Custody

1. Chain of Custody forms will be initiated in the field as per SOP 102.

C. Preparation

1. If aluminum foil is to be used for wrapping specimens, rinse the dull side of the foil in the following sequence: 10% nitric or hydrochloric acid, distilled water, pesticide residue grade acetone, and distilled water. Allow the foil to dry and place in polyethylene bags.

2. Obtain sufficient one liter or 0.5 liter commercially prepared and certified pre-cleaned glass bottles with teflon lids.

D. Fish and Invertebrate Collection

1. Collection methods include electrofishing, various nets, rod and reel, and crab and eel pots. Collection using electrofishing techniques requires that at least one USFWS staff member be certified by an agency electrofishing course.

2. Fish and invertebrates are placed in 5 gallon buckets which are labelled according to each collection site. Care in labelling the buckets is vital -- use waterproof markers and cards that are tied to the bucket handles. If a particular size is targeted it may be necessary to capture a large number of specimens, sort by size, and release those not needed. In this case, it is essential that sufficient site water and buckets be used to avoid mortality.

E. Packaging Whole Specimens

1. To store whole fish or crabs for resection at the analytical laboratory, rinse the fish with deionized water, pat dry with a paper towel, and place an identifying tag in the fish mouth. Wrap with the dull side of the aluminum foil facing the specimen. Use wrapping tape to encircle the specimen. Attach a stick-on sample label to the outside of the aluminum foil. Place in a ziplock or plastic trash bag. Use indelible marker to identify the specimen on the plastic bag.

2. Store prepared specimen on ice. In the laboratory, freeze specimens and send packed in dry ice to analytical laboratory.

F. Tissue Resection

1. Fish are scaled according to EPA (1995) methods by laying it flat on aluminum foil and using a stainless steel knife that is cleaned with distilled water between each sample.

2. Fish total length and crab carapace width are measured to the nearest millimeter. Whole specimens are weighed.

3. Fish are filleted and crabs are picked to obtain samples of tissues of concern for human health risk assessment.

4. Use only stainless steel instruments and dissecting trays. Clean these between composite samples by:

a. Washing in laboratory detergent
b. Rinsing with tap water
c. Rinsing with deionized water
d. Rinsing with pesticide grade acetone or isopropanol
e. Rinsing with distilled water

5. Filleting follows EPA (1995) methods. Typically, the skin is removed from fish without scales (catfish and eels). Skin-on fillets should include the belly flap and dark muscle.

6. If whole body analyses are to be performed on the remainder of the tissue, small specimens will be placed in chemically clean sample jars. Large samples will be double wrapped in aluminum foil and labelled as described in D.1.

G. Compositing

1. For analysis of organics and metals, a total of 100 grams of tissue is required. This may necessitate compositing of a number of specimens into a single sample. Compositing may also be used as a method of gaining a more accurate estimate of the average concentration of fish from a site when only a small number of samples can be analyzed.

2. Size considerations addressed by EPA (1995) are used as guidance. Within each composite the

shortest fish should be at least 75% of the longest fish. The average lengths of the individual fish from replicate composite samples from the same site should be within 10% (unless different size classes are targeted).

H. Shipping

1. Follow general guidelines of SOP 103 for general sample handling and shipment of samples.

2. Ship all tissue samples with dry ice following overnight shippers packing and labelling instructions.

I. References

Environmental Protection Agency (EPA). 1995. Guidance for assessing chemical contamination data for use in fish advisories. Volume 1 Fish sampling and analysis. Second Edition. Office of Water, Washington, DC.

Maryland Department of the Environment (MDE). 1989. Sample collection guidelines and techniques. MDE, Toxics, Environmental Science and Health, Ecological Assessment Division, Baltimore, MD.

Puget Sound Estuary Program 1990a. Recommended guidelines for measuring organic compounds in Puget Sound sediments and tissue samples. Prepared by PTI Environmental Services for EPA Region 10, Seattle, WA.

Puget Sound Estuary Program 1990b. Recommended guidelines for measuring metals in Puget Sound water, sediment, and tissue samples. Prepared by PTI Environmental Services for EPA Region 10, Seattle, WA.

Appendix B.

ANALYTICAL METHODS

Method Code	Method Description
001	LABORATORY: Research Triangle Institute

I. Homogenization. Tissue samples are prehomogenized using a food processor. A portion of the tissue sample (or sediment) is then freeze dried for determination of moisture content and ground to 100 mesh with a mill.

004 LABORATORY: Research Triangle Institute

IV. Digestion for Graphite Furnace and Cold Vapor Atomic Absorption (GFAA) Measurement. Using a CEM microwave oven, 0.25 to 0.5 g of freeze dried sample is heated in a capped 120 ml Teflon vessel in the presence of 5 ml of Baker Instra-Analyzed nitric acid for three minutes at 120 watts, three minutes at 300 watts, and fifteen minutes at 450 watts. The residue is then diluted to 50 ml with laboratory pure water.

006 LABORATORY: Research Triangle Institute

VI. ICP. ICP measurements are made using a Leeman Labs Plasma Spec I sequential or ES2000 simultaneous spectrometer.

007 LABORATORY: Research Triangle Institute

VII. Graphite Furnace Atomic Absorption (GFAA). GFAA measurements are made using a Perkin-Elmer Zeeman 3030 or 4100ZL atomic absorption spectrometer.

ANALYTICAL METHODS (Cont.)

Method Code	Method Description
008	LABORATORY: Research Triangle Institute

VIII. Cold Vapor Atomic Absorption (CVAA). Hg measurements are conducted using SnC14 as the reducing agent. A Leeman PS200 Hg Analyzer is employed.

ANALYTICAL METHODS

Method Code	Method Description
001	LABORATORY: Research Triangle Institute I. Homogenization. Tissue samples are prehomogenized using a food processor. A portion of the tissue sample (or sediment) is then freeze dried for determination of moisture content and ground to 100 mesh with a mill.
004	LABORATORY: Research Triangle Institute IV. Digestion for Graphite Furnace and Cold Vapor Atomic Absorption (GFAA) Measurement. Using a CEM microwave oven, 0.25 to 0.5 g of freeze dried sample is heated in a capped 120 ml Teflon vessel in the presence of 5 ml of Baker Instra-Analyzed nitric acid for three minutes at 120 watts, three minutes at 300 watts, and fifteen minutes at 450 watts. The residue is then diluted to 50 ml with laboratory pure water.
006	LABORATORY: Research Triangle Institute VI. ICP. ICP measurements are made using a Leeman Labs Plasma Spec I sequential or ES2000 simultaneous spectrometer.
007	LABORATORY: Research Triangle Institute VII. Graphite Furnace Atomic Absorption (GFAA). GFAA measurements are made using a Perkin-Elmer Zeeman 3030 or 4100ZL atomic absorption spectrometer.

ANALYTICAL METHODS (Cont.)

Method Code	Method Description
008	LABORATORY: Research Triangle Institute
	VIII. Cold Vapor Atomic Absorption (CVAA). Hg measurements are conducted using SnC14 as the reducing agent. A Leeman PS200 Hg Analyzer is employed.

ANALYTICAL METHODS

Method Code	Method Description
001	LABORATORY: Mississippi State Chemical Laboratory

Analysis For Organochlorine Pesticides and PCBs In Animal and Plant Tissue

I. Ten gram tissue samples are thoroughly mixed with anhydrous sodium sulfate and soxhlet extracted with hexane for seven hours. The extract is concentrated by rotary evaporation; transferred to a tared test tube, and further concentrated to dryness for lipid determination. The weighed lipid sample is dissolved in petroleum ether and extracted four times with acetonitrile saturated with petroleum ether. Residues are partitioned into petroleum ether which is washed, concentrated, and transferred to a glass chromatographic column containing 20 grams of Florisil. The column is eluted with 200 ml 6% diethyl ether/94% petroleum ether (Fraction I) followed by 200 ml 15% diethyl ether/85% petroleum ether (Fraction II). Fraction II is concentrated to appropriate volume for quantification of residues by packed or capillary column electron capture gas chromatography. Fraction I is concentrated and transferred to a Silicic acid chromatographic column for additional cleanup required for separation of PCBs from other organochlorines. Three fractions are eluted from the silicic acid column. Each is concentrated to appropriate volume for quantification of residues by packed or megabore column, electron capture gas chromatography. PCBs are found in Fraction II.

ANALYTICAL METHODS

Method Code	Method Description
019	LABORATORY: Mississippi State Chemical Laboratory

Grain Size

XIX. Disperse sample of soil or sediment to pass 2 mm sieve and place a weighed 40 gram in a 600 ml beaker. Take additional 30 gram sample for moisture determination so that air-dried weight may be corrected to oven-dried weight. Add 50 ml 10% "Calgon" solution (sodium meta-phosphate with sufficient sodium carbonate to give a pH of approximately 8.3 in a 10% solution) to 40 gram sample and allow to soak for at least 10 minutes. After soaking, quantitatively transfer sample with distilled water to Waring blender cup so that cup is approximately half full. Blend for four minutes and transfer suspension to sedimentation cylinder adjusting liquid level to 1000 ml mark with distilled water. Place cylinder in constant temperature water bath (approximately 38oC). Prepare sample "blank" by adding 50 ml 10% "Calgon" solution to second sedimentation cylinder and add distilled water to the 1000 ml mark. When the suspension reaches water bath temperature, the mixture is thoroughly stirred prior initiation of sedimentation. The time that stirring ceases is noted as the zero settling time. At the end of eight hours, lower the hydrometer (ASTM 152 H) gently into the suspension and read the scale at the end of the meniscus. Record the time of hydrometer reading, the hydrometer reading, and water bath temperature. After thorough mixing, record the hydrometer reading in the sample "blank" solution of water and "Calgon". After hydrometer readings are recorded, pour the suspension onto a 270 mesh, 53 micron sieve and wash all silt and clay out with the water. Transfer sample material remaining on the sieve into an evaporating dish; place in 110oC oven and allow to dry for 24 hours. After cooling, weigh the sample to determine the weight of oven-dry sand left on the sieve. Using moisture data determined, correct sample air-dry weight to oven-dry weight. Calculate the concentration of suspension in grams per liter from the following equation:

ANALYTICAL METHODS (Cont.)

Method Code	Method Description
019	

C = R - R< where C = concentration (gm/liter)
R = hydrometer reading in suspension
R< = hydrometer reading in "Calgon" solution.

Calculate the Clay percentage, PC from the following:

$$Pc = 100 \frac{C}{Co}$$

where Co represents the oven-dry weight of soil per liter of suspension.

Calculate the Sand percentage, Ps from the following:

$$Ps = 100 \frac{S}{Co}$$

where S is the weight of the oven-dry sand left on screen and Co is as in the Clay formula.

Silt percentage is 100 - Pc - Ps

020 LABORATORY: Mississippi State Chemical Laboratory

Total Organic Carbon

XX. Weigh approximately 0.35 g sample into a numbered glazed ceramic boat. Record the weights and boat numbers.

In an acid safe hood, add 1:1 HCl dropwise to each sample until completely moistened, usually 5 to 10 drops. Observe the samples for any bubbling, and note this. Heat the samples on a hot plate until dry. The addition of HCl and hot plate drying must be repeated until no further bubbling occurs. Dry samples in a drying oven at 100oC for 1 hours.

Samples were analyzed using a Leco CR-412 Carbon Analyzer. The instrument was calibrated using $CaCO_3$.

The right anhydrone tube of the furnace was replaced with a chlorine trap

ANALYTICAL METHODS (Cont.)

Method Code	Method Description
020	before TOC samples were analyzed.
035	LABORATORY: Mississippi State Chemical Laboratory

Analysis for Organochlorine Pesticides and PCBs in Soil and Sediment by ASE.

XXXV. Weigh 10-gram soil or sediment sample and 5-grams of Hydromatrix into a PRQ (SOP 1.105) beaker. Stir the sample with a PRQ spatula until the mixture becomes a flowable powder and leaves the sides of the beaker clean. The sample can be stored in a desiccator over night. Pour the sample through a PRQ powder funnel into a PRQ Accelerated Solvent Extractor (ASE) 33-ml cell with a 1.91-cm cellulose filter in the bottom cell cap. Tap the ASE cell to settle the sample and add more Hydromatrix if needed to fill the cell. Rinse the funnel, spatula, and beaker with no more than 6-ml total of pet ether (SOP 1.81) and add the rinses to the cell. Place the top cap on the cell and tighten both caps hand tight. Record the cell number, the position number, and the number of the sample placed in the cell in the ASE logbook as the cell is placed in the ASE for extraction. Place the sample number on the collection vial. Operate the ASE according to SOP 1.260 with the following extraction conditions: 5-min heating cycle, 2x2-min static cycles, 60% solvent flush, 120 sec purge cycle, 100 degrees C @ 2000psi, 1:1 pet ether:acetone (SOP 1.255). Prepare a 500-ml separatory funnel with 200-ml PRQ water (SOP 1.255) and 15-ml PRQ saturated sodium chloride (SOP 1.255). Rinse the sample extract into the separatory funnel with 50ml of 1:1 acetone: pet ether. The separatory funnel is shaken vigorously for one minute and the layers allowed to separate. The pet ether is removed, and the water fraction extracted again with 50-ml pet ether. The combined pet ether is washed twice with 50-ml water and concentrated by Kuderna-Danish (SOP 1.261) to appropriate volume. An aliquot of the concentrated extract representing 2 grams of sample is transferred to a column containing 20 grams of Florisil. The column is eluted with 200 ml 6% diethyl ether/94% petroleum ether (Fraction I) followed by 200 ml 15% diethyl

ANALYTICAL METHODS (Cont.)

Method Code	Method Description
035	ether/85% petroleum ether (Fraction II). Fraction II is concentrated to appropriate volume for quantification of residues by a Varian 3600 gas chromatograph equipped with dual 30M DB-5/DB-608 megabore columns and electron capture detectors. Fraction I is concentrated to 5 ml and transferred to a silicic acid (SOP 1.255) chromatographic column (custom columns 1 cm OD x 40 cm with a 100 ml reservoir on top, Ace Glass) for additional cleanup required for separation of PCBs from other organochlorines. Five grams of hot silicic acid is put into the column, which already has a glass wool plug and about 3-mm sodium sulfate in the bottom. The silicic acid is topped with 10-mm sodium sulfate and prewashed with 10-ml hexane. Three fractions are eluted from the silicic acid column. The sample in 5-ml solvent is added to the column and rinsed into the column with 3,1,1-ml hexane. Then the sample is eluted with 20-ml pet ether (fraction SAI). Fraction SAII is 150-ml pet ether. Fraction SAIII is 20 ml of a mixed solvent consisting of 1 part acetonitrile: 19 parts hexane: 80 parts methylene chloride (SOP 1.255). Each is concentrated to appropriate volume for quantification of residues by megabore column, electron capture gas chromatography. HCB and Mirex are in SAI. PCBs are found in SAII. The rest of the compounds are in SAIII.
	GC determinations for SAI and SAIII were run on a Varian 3600 GC with a Varian Star Data System and a Varian 8200 Autosampler. All GCs were equipped with dual DB-608 (0.83u film thickness, J & W Scientific # 125-1730) and DB-5 (1.5u film thickness, J & W Scientific # 125-5032) 30M megabore columns. All compounds were calculated using a three point standard curve forced through the origin using external standards (SOP 1.267).
	PCB's (SAII) are shot on a Varian 3350 with a 60M DB-5 capillary column

and an EC detector and a Varian Star Data System, version 4.5. All the mixture standards are at 0.5 ng/ul with one ul shot.

Starting with Arochlor 1260, 4 peaks that are unique to this mixture are located. The areas of the standards are summed and the same peaks located in the sample and also summed. Arochlor 1260 is calculated by

ANALYTICAL METHODS (Cont.)

Method Code	Method Description
035	the following formula to obtain PPM 1260.

$$\frac{(\text{Area sample})\ (\text{weight of std shot in ng})}{(\text{Area 1260 std})\ (\text{basis shot in mg})}$$

Arochlor 1254 is calculated by locating the major peaks in the mixture that are normally found in samples. The areas of these peaks are summed. Because some of this area comes from Arochlor 1260 and not all from Arochlor 1254, the contribution from the 1260 has to be subtracted from the total area. Arochlor 1254 is calculated by using the formula:

$$\frac{\{(\text{Area sample})-[((\text{PPM 1260})\ (\text{basis})\ (\text{area from 1260}))/\text{ng 1260 std}]\}\ (\text{wt 1254 std in ng})}{(\text{Area 1254 std})\ (\text{Basis shot in mg})}$$

Results are in PPM.

Arochlor 1248 and Arochlor 1242 are calculated in a similar fashion, subtracting the contribution from 1254 in the 1248 and the 1248 in the 1242.

Total PCBs are calculated by adding the sum of Arochlor 1242, 1248, 1254, and 1260.

Appendix C

Cattail inorganic data (ppm wet weight)

	Sample Weight (g)	% Moisture	Al	As	B	Ba	Be	Cd	Cr	Cu	Fe	Hg	Mg
K0101TTY	131	87.2	**98**	**0.2771**	**1.251**	**3.174**	0.0127	**0.0268**	**3.304**	**0.6637**	**561.8**	0.0127	**154.7**
K0102TTY	169	86.9	**106**	**0.1677**	**1.507**	**4.373**	0.013	**0.0664**	**1.283**	**1.257**	**750.5**	0.013	**318.1**
K0103TTY	148	86.6	**42**	**0.1416**	**0.764**	**2.624**	0.0133	0.0133	**0.7646**	**0.3682**	**345.1**	0.0133	**147.6**
K0104TTY	135	82.6	**76**	0.0862	**0.933**	**4.344**	0.0172	0.0172	**0.8009**	**0.4445**	**609.2**	0.0172	**155.1**
K0105TTY	141	82	**285**	**0.2443**	**1.006**	**5.155**	0.018	**0.0581**	**2.238**	**1.247**	**702.6**	0.018	**232.8**
K0106TTY	149	87.8	**42**	0.0593	**0.936**	**2.85**	0.0119	**0.0325**	**1.091**	**0.4501**	**283.1**	0.0119	**192.4**
K0107TTY	182	86.2	**32**	**0.1556**	**1.034**	**3.306**	0.0137	**0.0283**	**0.7247**	**0.3529**	**598.2**	0.0137	**243.9**
K0108TTY	138	84.8	**358**	**0.5765**	**1.586**	**6.091**	**0.038**	**0.088**	**3.738**	**1.79**	**1351**	0.0149	**211.1**
Freq			8/8	6/8	8/8	8/8	1/8	6/8	8/8	8/8	8/8	0/8	8/8
MIN	131	82	32	0.0593	0.764	2.624	0.0119	0.0133	0.7247	0.3529	283.1		147.6
MAX	182	87.8	358	0.5765	1.586	6.091	0.038	0.088	3.738	1.79	1351		318.1
MEAN	149	85.5	130	0.2135	1.127	3.99	0.0172	0.0413	1.743	0.8217	650.1		206.9
STDEV	17.7	2.17	123	0.1636	0.293	1.215	0.0087	0.0265	1.206	0.5397	325.9		57.99
K0201TTY	181	85	**124**	**0.2208**	**1.229**	**4.117**	0.0145	**0.0337**	**1.966**	**0.8519**	**807.5**	0.0145	**186.2**
K0202TTY	184	86.9	**45**	**0.2478**	**1.35**	**4.067**	0.013	0.013	**0.9665**	**0.3671**	**801**	0.013	**166**
K0203TTY	275	87.7	**65**	**0.129**	**1.147**	**3.855**	0.0121	**0.0248**	**1.068**	**0.4593**	**745.3**	0.0121	**155.8**
K0204TTY	140	84.6	**37**	0.0758	**1.092**	**3.135**	0.0152	0.0152	**0.5889**	**0.367**	**464.3**	0.0152	**204.6**
K0205TTY	182	84.4	**68**	**0.1733**	**1.205**	**3.968**	0.0155	**0.0402**	**0.9806**	**1.273**	**481.7**	0.0155	**170.5**
K0206TTY	191	83.4	**65**	0.0828	**1.092**	**2.97**	0.0166	0.0166	**0.6192**	**0.4789**	**429.7**	0.0166	**152**
K0207TTY	177	85	**42**	0.0743	**1.12**	**2.882**	0.0149	0.0149	**0.4418**	**0.3052**	**369.9**	0.0149	**200.6**
K0208TTY	147	86.3	**103**	**0.2401**	**1.137**	**3.954**	0.0133	**0.0359**	**0.8493**	**0.6425**	**722.2**	0.0133	**171**
Freq			8/8	5/8	8/8	8/8	0/8	4/8	8/8	8/8	8/8	0/8	8/8
MIN	140	83.4	37	0.0743	1.092	2.882		0.013	0.4418	0.3052	369.9		152
MAX	275	87.7	124	0.2478	1.35	4.117		0.0402	1.966	1.273	807.5		204.6
MEAN	185	85.4	69	0.1555	1.172	3.619		0.0243	0.9351	0.593	602.7		175.8
STDEV	40.9	1.44	31	0.0748	0.087	0.526		0.0109	0.4712	0.3267	182.7		19.52
M0101TTY	164	92.6	**60**	**0.0877**	**1.268**	**4.107**	0.0073	**0.0187**	**0.7208**	**0.2411**	**575.2**	0.0073	**113.1**
M0102TTY	142	91.7	**131**	**0.172**	**1.186**	**3.315**	0.0081	**0.032**	**1.934**	**0.3983**	**601.7**	0.0081	**187.5**
M0103TTY	118	90.2	**241**	**0.2445**	**1.178**	**4.727**	**0.0196**	**0.0203**	**2.39**	**0.5952**	**607.1**	0.0097	**230.7**
M0104TTY	195	89.8	**323**	**0.2692**	**1.392**	**5.841**	**0.0278**	**0.0375**	**2.399**	**0.8505**	**791.4**	0.0101	**211.1**
M0105TTY	131	90	**262**	**0.3106**	**1.192**	**3.948**	**0.0263**	**0.0372**	**1.575**	**0.7195**	**857.1**	0.0099	**183.6**
M0106TTY	113	90.3	**95**	0.0473	**1.377**	**5.107**	0.0095	0.0095	**0.6761**	**0.4063**	**595.1**	0.0095	**163.3**
M0107TTY	133	90.2	**213**	**0.2624**	**1.322**	**4.241**	**0.0199**	**0.0211**	**2.361**	**0.4939**	**598.9**	0.0098	**187.9**
M0108TTY	154	89.8	**213**	**0.2081**	**1.173**	**4.084**	**0.0227**	**0.0225**	**1.281**	**0.6633**	**572.9**	0.0102	**215.6**
Freq			8/8	7/8	8/8	8/8	5/8	7/8	8/8	8/8	8/8	0/8	8/8
MIN	113	89.8	60	0.0473	1.173	3.315	0.0073	0.0095	0.6761	0.2411	572.9		113.1
MAX	195	92.6	323	0.3106	1.392	5.841	0.0278	0.0375	2.399	0.8505	857.1		230.7
MEAN	144	90.6	192	0.2002	1.261	4.421	0.0176	0.0248	1.667	0.546	649.9		186.6
STDEV	26.8	1.02	89	0.0923	0.092	0.781	0.0082	0.0098	0.7217	0.1986	109.7		36.52

	Mn	Mo	Ni	Pb	Se	Sr	V	Zn
K0101TTY	48.46	0.2026	0.8118	0.9637	0.0635	2.327	0.2545	148.4
K0102TTY	59.8	0.0651	0.8558	1.681	0.0651	2.974	0.4417	140.4
K0103TTY	33.87	0.0663	0.3937	0.6333	0.0663	2.16	0.1743	127.8
K0104TTY	44.76	0.0862	0.5179	1.395	0.0862	2.751	0.3242	165.2
K0105TTY	64.4	0.3235	1.147	3.849	0.0901	3.612	1.07	99.5
K0106TTY	50.64	0.1779	0.4911	0.7854	0.0593	2.629	0.162	174
K0107TTY	39.8	0.0685	0.472	0.7571	0.0685	2.819	0.0685	105.9
K0108TTY	51.44	0.1562	2.178	6.23	0.0743	2.559	1.682	77.59
Freq	8/8	4/8	8/8	8/8	0/8	8/8	7/8	8/8
MIN	33.87	0.0651	0.3937	0.6333		2.16	0.0685	77.59
MAX	64.4	0.3235	2.178	6.23		3.612	1.682	174
MEAN	49.15	0.1433	0.8584	2.037		2.729	0.5221	129.9
STDEV	9.96	0.0912	0.5906	1.99		0.4426	0.563	33.56
K0201TTY	36.57	0.0724	1.231	1.881	0.0724	2.894	0.5813	70.17
K0202TTY	28.87	0.0648	0.5873	1.455	0.0648	2.893	0.2155	83.38
K0203TTY	35.84	0.0604	0.6181	1.225	0.0604	2.571	0.3157	88.75
K0204TTY	30.92	0.0758	0.3605	0.7018	0.0758	3.143	0.0758	73.71
K0205TTY	55.74	0.0773	0.5373	0.9229	0.0773	2.551	0.2482	234.6
K0206TTY	27.64	0.0828	0.4664	0.8866	0.0828	2.373	0.2649	57.01
K0207TTY	30.79	0.0743	0.3272	0.6623	0.0743	2.51	0.1909	80.81
K0208TTY	36.8	0.1383	0.685	1.533	0.0667	2.445	0.5366	84.62
Freq	8/8	1/8	8/8	8/8	0/8	8/8	7/8	8/8
MIN	27.64	0.0604	0.3272	0.6623		2.373	0.0758	57.01
MAX	55.74	0.1383	1.231	1.881		3.143	0.5813	234.6
MEAN	35.4	0.0807	0.6016	1.158		2.673	0.3036	96.63
STDEV	8.957	0.0243	0.2828	0.4372		0.2705	0.1726	56.65
M0101TTY	27.87	0.0367	0.3271	0.4354	0.0367	2.199	0.2791	55.12
M0102TTY	19.63	0.0818	1.1156	0.7027	0.0407	2.771	0.6774	120.4
M0103TTY	44.29	0.134	1.3876	0.7246	0.0483	3.424	0.8985	37.85
M0104TTY	30.74	0.0367	1.2802	1.363	0.0507	3.097	1.537	104.3
M0105TTY	26.94	0.2888	1.2224	0.9367	0.0496	2.785	1.432	176.3
M0106TTY	47.12	0.0473	0.3323	0.5185	0.0473	2.612	0.4169	46.38
M0107TTY	43.3	0.0978	1.3823	0.7564	0.0488	2.725	0.8849	81.09
M0108TTY	18.98	0.0511	0.8034	0.9414	0.0511	2.887	1.181	42.42
Freq	8/8	4/8	8/8	8/8	0/8	8/8	8/8	8/8
MIN	18.98	0.0367	0.3271	0.4354		2.199	0.279	37.85
MAX	47.12	0.2888	1.3876	1.363		3.424	1.537	176.3
MEAN	32.36	0.0968	0.9814	0.7974		2.812	0.9134	82.98
STDEV	11.17	0.0847	0.4428	0.2892		0.356	0.4528	48.34

Cattail Metal Data (ppm dry weight)

5020049	% Moisture	Al	As	B	Ba	Be	Cd	Cr	Cu	Fe	Hg	Mg	Mn	Mo
K0101TTY	87.2	**760.1**	**2.2**	**9.8**	**24.7**	0.099	**0.21**	**25.8**	**5.2**	**4379**	0.10	**1206**	**377.7**	**1.6**
K0102TTY	86.9	**809.4**	**1.3**	**11.5**	**33.4**	0.099	**0.51**	**9.8**	**9.6**	**5729**	0.10	**2428**	**456.5**	0.50
K0103TTY	86.6	**313.0**	**1.1**	**5.7**	**19.6**	0.099	0.099	**5.7**	**2.8**	**2583**	0.10	**1105**	**253.5**	0.50
K0104TTY	82.6	**434.8**	0.50	**5.4**	**25.0**	0.099	0.099	**4.6**	**2.6**	**3499**	0.10	**890.9**	**257.1**	0.50
K0105TTY	82.0	**1588**	**1.4**	**5.6**	**28.7**	0.10	**0.32**	**12.5**	**6.9**	**3912**	0.10	**1296**	**358.6**	**1.8**
K0106TTY	87.8	**347.9**	0.49	**7.7**	**23.4**	0.097	**0.27**	**8.9**	**3.7**	**2322**	0.10	**1578**	**415.4**	**1.5**
K0107TTY	86.2	**234.0**	**1.1**	**7.5**	**24.0**	0.099	**0.21**	**5.3**	**2.6**	**4344**	0.10	**1771**	**289.0**	0.50
K0108TTY	84.8	**2347**	**3.8**	**10.4**	**39.9**	**0.25**	**0.58**	**24.5**	**11.7**	**8857**	0.10	**1384**	**337.3**	**1.0**
Freq		8/8	6/8	8/8	8/8	1/8	6/8	8/8	8/8	8/8	0/8	8/8	8/8	4/8
Min	82.0	234.0	0.49	5.4	19.6	0.10	0.10	4.6	2.6	2322		890.9	253.5	0.50
Max	87.8	2347	3.8	11.5	39.9	0.25	0.58	25.8	11.7	8857		2428	456.5	1.8
Mean	85.5	854.3	1.5	7.9	27.3	0.12	0.29	12.1	5.6	4453		1457	343.1	1.0
StDev	2.2	745.2	1.1	2.4	6.5	0.053	0.18	8.4	3.5	2080		477.3	73.6	0.56
K0201TTY	85.0	**828.5**	**1.5**	**8.2**	**27.4**	0.096	**0.22**	**13.1**	**5.7**	**5376**	0.10	**1240**	**243.5**	0.48
K0202TTY	86.9	**341.2**	**1.9**	**10.3**	**31.0**	0.099	0.099	**7.4**	**2.8**	**6110**	0.10	**1266**	**220.2**	0.49
K0203TTY	87.7	**529.7**	**1.1**	**9.3**	**31.4**	0.098	**0.20**	**8.7**	**3.7**	**6064**	0.10	**1268**	**291.6**	0.49
K0204TTY	84.6	**241.0**	0.49	**7.1**	**20.4**	0.099	0.099	**3.8**	**2.4**	**3023**	0.10	**1332**	**201.3**	0.49
K0205TTY	84.4	**437.3**	**1.1**	**7.7**	**25.4**	0.099	**0.26**	**6.3**	**8.2**	**3086**	0.10	**1092**	**357.1**	0.50
K0206TTY	83.4	**391.7**	0.50	**6.6**	**17.8**	0.10	0.10	**3.7**	**2.9**	**2581**	0.10	**912.8**	**166.0**	0.50
K0207TTY	85.0	**277.6**	0.50	**7.5**	**19.3**	0.099	0.099	**3.0**	**2.0**	**2471**	0.10	**1340**	**205.7**	0.50
K0208TTY	86.3	**753.9**	**1.8**	**8.3**	**28.8**	0.097	**0.26**	**6.2**	**4.7**	**5264**	0.10	**1246**	**268.2**	**1.0**
Freq		8/8	5/8	8/8	8/8	0/8	4/8	8/8	8/8	8/8	0/8	8/8	8/8	1/8
Min	83.4	241.0	0.5	6.6	17.8		0.10	3.0	2.0	2471		912.8	166.0	0.48
Max	87.7	828.5	1.9	10.3	31.4		0.26	13.1	8.2	6110		1340	357.1	1.0
Mean	85.4	475.1	1.1	8.1	25.2		0.17	6.5	4.0	4247		1212	244.2	0.56
StDev	1.4	215.7	0.6	1.2	5.4		0.075	3.3	2.1	1597		142.8	60.5	0.18
M0101TTY	92.6	**807.6**	**1.2**	**17.2**	**55.7**	0.10	**0.25**	**9.8**	**3.3**	**7804**	0.10	**1535**	**378.2**	0.50
M0102TTY	91.7	**1570**	**2.1**	**14.2**	**39.7**	0.098	**0.38**	**23.2**	**4.8**	**7206**	0.10	**2246**	**235.1**	**0.98**
M0103TTY	90.2	**2452**	**2.5**	**12.0**	**48.1**	**0.20**	**0.21**	**24.3**	**6.1**	**6182**	0.10	**2349**	**451.0**	**1.4**
M0104TTY	89.8	**3175**	**2.7**	**13.7**	**57.5**	**0.27**	**0.37**	**23.6**	**8.4**	**7789**	0.10	**2078**	**302.6**	0.50
M0105TTY	90.0	**2618**	**3.1**	**11.9**	**39.4**	**0.26**	**0.37**	**15.7**	**7.2**	**8554**	0.10	**1832**	**268.9**	**2.9**
M0106TTY	90.3	**976.4**	0.49	**14.2**	**52.7**	0.098	0.098	**7.0**	**4.2**	**6135**	0.10	**1684**	**485.8**	0.98
M0107TTY	90.2	**2176**	**2.7**	**13.5**	**43.3**	**0.20**	**0.22**	**24.1**	**5.0**	**6117**	0.10	**1919**	**442.3**	**1.0**
M0108TTY	89.8	**2090**	**2.0**	**11.5**	**40.0**	**0.22**	**0.22**	**12.6**	**6.5**	**5617**	0.10	**2114**	**186.1**	0.50
Freq		8/8	7/8	8/8	8/8	5/8	7/8	8/8	8/8	8/8	0/8	8/8	8/8	4/8
Min	89.8	807.6	0.49	11.5	39.4	0.10	0.10	7.0	3.3	5617		1535	186.1	0.50
Max	92.6	3175	3.1	17.2	57.5	0.27	0.38	24.3	8.4	8554		2349	485.8	2.9
Mean	90.6	1983	2.1	13.5	47.1	0.18	0.26	17.5	5.7	6926		1970	343.8	1.1
StDev	1.0	815.7	0.86	1.8	7.5	0.074	0.10	7.2	1.7	1055		279	111.2	0.79

5020049	Ni	Pb	Se	Sr	V	Zn
K0101TTY	6.3	7.5	0.49	18.1	2.0	1157
K0102TTY	6.5	12.8	0.50	22.7	3.4	1072
K0103TTY	2.9	4.7	0.50	16.2	1.3	956.9
K0104TTY	3.0	8.0	0.50	15.8	1.9	949.1
K0105TTY	6.4	21.4	0.50	20.1	6.0	553.9
K0106TTY	4.0	6.4	0.49	21.6	1.3	1427
K0107TTY	3.4	5.5	0.50	20.5	1.0	769.2
K0108TTY	14.3	40.9	0.49	16.8	11.0	508.8
Freq	8/8	8/8	0/8	8/8	7/8	8/8
Min	2.9	4.7		15.8	1.0	508.8
Max	14.3	40.9		22.7	11.0	1427
Mean	5.9	13.4		19.0	3.5	924.2
StDev	3.7	12.4		2.6	3.5	308.0
K0201TTY	8.2	12.5	0.48	19.3	3.9	467.2
K0202TTY	4.5	11.1	0.49	22.1	1.6	636.0
K0203TTY	5.0	10.0	0.49	20.9	2.6	722.1
K0204TTY	2.3	4.6	0.49	20.5	1.0	479.9
K0205TTY	3.4	5.9	0.50	16.3	1.6	1503
K0206TTY	2.8	5.3	0.50	14.3	1.6	342.4
K0207TTY	2.2	4.4	0.50	16.8	1.3	539.8
K0208TTY	5.0	11.2	0.49	17.8	3.9	616.8
Freq	8/8	8/8	0/8	8/8	7/8	8/8
Min	2.2	4.4		14.3	1.0	342.4
Max	8.2	12.5		22.1	3.9	1503
Mean	4.2	8.1		18.5	2.2	663.4
StDev	2.0	3.4		2.7	1.1	358.9
M0101TTY	4.4	5.9	0.50	29.8	3.8	747.9
M0102TTY	13.4	8.4	0.49	33.2	8.1	1442
M0103TTY	14.1	7.4	0.49	34.9	9.2	385.4
M0104TTY	12.6	13.4	0.50	30.5	15.1	1027
M0105TTY	12.2	9.3	0.50	27.8	14.3	1759
M0106TTY	3.4	5.3	0.49	26.9	4.3	478.1
M0107TTY	14.1	7.7	0.50	27.8	9.0	828.3
M0108TTY	7.9	9.2	0.50	28.3	11.6	415.9
Freq	8/8	8/8	0/8	8/8	8/8	8/8
Min	3.4	5.3		26.9	3.8	385.4
Max	14.1	13.4		34.9	15.1	1759
Mean	10.3	8.3		29.9	9.4	885.5
StDev	4.4	2.5		2.8	4.2	500.2

Killifish inorganic data (ppm wet weight)

	Al	As	B	Ba	Be	Cd	Cr	Cu	Fe	Hg	Mg	Mn	Mo	Ni
K0101TFH	542.2	0.1137	1.031	7.536	0.0227	0.0455	2.294	3.29	734.4	0.0227	511.6	42.73	0.5381	1.21
K0102TFH	416.5	0.2574	0.4667	6.887	0.0233	0.0233	2.129	2.539	793.7	0.0233	475	33.56	0.4399	1.092
K0103TFH	379.7	0.3994	1.042	7.507	0.0237	0.0237	2.361	3.161	822.4	0.0237	493.2	44.97	0.4446	1.148
K0104TFH	349.6	0.3874	0.4713	6.956	0.0236	0.0236	2.147	2.319	746.9	0.0236	458.7	32.74	0.4757	1.027
K0105TFH	341.8	0.1124	0.4496	6.48	0.0225	0.0225	1.823	2.678	759.6	0.0225	440.9	29.51	0.3894	0.9491
K0106TFH	489.6	0.2877	0.4814	8.08	0.0241	0.0241	3.233	2.609	956.9	0.0241	493.7	37.23	0.3989	1.476
K0107TFH	678.1	0.3505	0.4556	7.638	0.0228	0.0458	2.591	3.727	1086	0.0228	442.4	28.91	0.4396	1.309
K0108TFH	468.2	0.4401	0.9754	7.401	0.0228	0.0539	2.481	2.498	932.8	0.0228	459.1	32.78	0.3578	1.167
Freq	8/8	6/8	3/8	8/8	0/8	3/8	8/8	8/8	8/8	0/8	8/8	8/8	8/8	8/8
MIN	341.8	0.1124	0.4496	6.48		0.0225	1.823	2.319	734.4		440.9	28.91	0.3578	0.9491
MAX	678.1	0.4401	1.042	8.08		0.0539	3.233	3.727	1086		511.6	44.97	0.5381	1.476
MEAN	458.2	0.2936	0.6715	7.311		0.0328	2.382	2.853	854.1		471.8	35.3	0.4355	1.172
STDEV	113.2	0.1261	0.2859	0.5059		0.0132	0.417	0.4856	125.4		25.86	5.888	0.0558	0.165
K0201TFH	19.23	0.1144	0.4575	3.327	0.0229	0.0229	0.7489	1.7	68.28	0.0229	393	23.61	0.3976	0.1144
K0202TFH	20.67	0.3273	0.4509	3.755	0.0225	0.0225	0.5222	1.28	51.48	0.0225	421.3	27.46	0.3885	0.1127
K0203TFH	15.06	0.1158	0.4633	3.228	0.0232	0.0232	0.6694	1.473	42.73	0.0232	399.5	22.89	0.4035	0.1158
K0204TFH	127.8	0.3154	0.4449	4.03	0.0223	0.0223	0.8492	1.422	118.2	0.0223	402.3	29.98	0.4223	0.2616
K0205TFH	34.03	0.1151	0.4602	3.639	0.023	0.0623	0.8635	1.828	81.26	0.023	416.5	29.33	0.3843	0.2755
K0206TFH	19.56	0.1225	0.4899	3.48	0.0245	0.0245	1.078	1.365	52.98	0.0245	458.5	25.78	0.4287	0.3493
K0207TFH	165	0.3034	0.4695	4.536	0.0235	0.0235	1.043	2.014	326.8	0.0235	425.2	45.55	0.3844	0.4674
K0208TFH	167.2	0.1158	0.4632	4.817	0.0232	0.0232	1.177	2.353	538.2	0.0232	391.6	39.68	0.4079	0.5766
Freq	8/8	3/8	0/8	8/8	0/8	1/8	8/8	8/8	8/8	0/8	8/8	8/8	8/8	5/8
MIN	15.06	0.1144	0.4449	3.228	0.0223	0.0223	0.5222	1.28	42.73	0.0223	391.6	22.89	0.3843	0.1127
MAX	167.2	0.3273	0.4899	4.817	0.0245	0.0623	1.177	2.353	538.2	0.0245	458.5	45.55	0.4287	0.5766
MEAN	71.09	0.1912	0.4624	3.852	0.0231	0.028	0.869	1.679	160	0.0231	413.5	30.54	0.4022	0.2842
STDEV	69.38	0.1030	0.0135	0.5718	0.0007	0.0139	0.2217	0.3692	179	0.0007	22.22	8.011	0.0168	0.1734
M0101TFH	12.65	0.2862	0.4706	2.987	0.0235	0.0235	0.7854	0.9647	27.57	0.0235	489.4	28.72	0.1176	0.2378
M0102TFH	21.4	0.115	0.4599	2.283	0.023	0.023	1.011	1.065	38.68	0.023	440.5	22.55	0.115	0.115
M0103TFH	38.82	0.1025	0.4099	2.538	0.0205	0.0566	0.72	0.7835	47.89	0.0205	422.8	21.59	0.1025	0.2209
M0104TFH	14.15	0.1023	0.409	2.164	0.0205	0.0205	0.7649	0.7001	32.08	0.0205	425.1	20.91	0.1023	0.1023
M0105TFH	15.01	0.4347	0.4506	4.614	0.0225	0.0225	0.9088	1.248	39.6	0.0225	459.8	47.86	0.1127	0.3324
M0106TFH	11.12	0.1106	0.4424	1.795	0.0221	0.0221	0.7158	1.88	48.58	0.0221	325.2	17.62	0.1106	0.1106
M0107TFH	6.667	0.1152	0.4608	2.897	0.023	0.023	0.6464	0.9238	31.02	0.023	427.2	32.13	0.1152	0.2422
M0108TFH	12.27	0.2618	0.4737	3.273	0.0237	0.0237	0.5998	1.07	35.58	0.0237	420.1	31.18	0.1184	0.1184
Freq	8/8	3/8	0/8	8/8	0/8	1/8	8/8	8/8	8/8	0/8	8/8	8/8	0/8	4/8
MIN	6.667	0.1023	0.409	1.795	0.0205	0.0205	0.5998	0.7001	27.57	0.0205	325.2	17.62	0.1023	0.1023
MAX	38.82	0.4347	0.4737	4.614	0.0237	0.0566	1.011	1.88	48.58	0.0237	489.4	47.86	0.1184	0.3324
MEAN	16.51	0.191	0.4471	2.819	0.0224	0.0269	0.769	1.079	37.63	0.0224	426.3	27.82	0.1118	0.1849
STDEV	9.915	0.1237	0.0253	0.8705	0.0013	0.0121	0.1349	0.3661	7.657	0.0013	47.2	9.641	0.0063	0.0852

	Pb	Se	Sr	V	Zn
K0101TFH	2.445	0.425	14.83	1.497	61.26
K0102TFH	2.567	0.4914	12.59	1.303	50.52
K0103TFH	2.685	0.4403	14.93	1.312	45.3
K0104TFH	2.603	0.4795	13.08	1.195	74.45
K0105TFH	2.542	0.3859	11.51	1.197	52.32
K0106TFH	3.225	0.3121	13.52	1.43	52.3
K0107TFH	3.411	0.4147	8.791	1.702	49.1
K0108TFH	3.319	0.2855	10.79	1.425	57.93
Freq	8/8	8/8	8/8	8/8	8/8
MIN	2.445	0.2855	8.791	1.195	45.3
MAX	3.411	0.4914	14.93	1.702	74.45
MEAN	2.85	0.4043	12.51	1.383	55.4
STDEV	0.3969	0.0737	2.084	0.1691	9.167
K0201TFH	0.5178	0.2896	11.16	0.3225	62.93
K0202TFH	0.5475	0.4828	13.71	0.1127	42.64
K0203TFH	0.5438	0.4155	12.5	0.1158	81.72
K0204TFH	0.4622	0.4128	13.52	0.346	54.08
K0205TFH	0.2301	0.3473	12.7	0.2838	79.03
K0206TFH	0.2450	0.3627	15.75	0.1225	39.82
K0207TFH	0.6503	0.4148	12.97	0.4811	48.02
K0208TFH	1.284	0.4282	12.74	0.6053	55.52
Freq	6/8	8/8	8/8	5/8	8/8
MIN	0.2301	0.2896	11.16	0.1127	39.82
MAX	1.284	0.4828	15.75	0.6053	81.72
MEAN	0.5601	0.3942	13.13	0.2987	57.97
STDEV	0.3278	0.059	1.309	0.181	15.66
M0101TFH	0.2353	0.2886	16.11	0.1176	103.1
M0102TFH	0.23	0.2706	12.07	0.115	97.37
M0103TFH	0.2049	0.2285	12.1	0.1025	137.9
M0104TFH	0.2045	0.2656	11.88	0.1023	47.36
M0105TFH	0.2253	0.2581	17.58	0.1127	42.83
M0106TFH	0.2212	0.3698	5.865	0.1106	62.66
M0107TFH	0.2304	0.3208	11.47	0.1152	43.66
M0108TFH	0.2369	0.3427	13.03	0.1184	37.32
Freq	0/8	8/8	8/8	0/8	8/8
MIN	0.2045	0.2285	5.865	0.1023	37.32
MAX	0.2369	0.3698	17.58	0.1184	137.9
MEAN	0.2236	0.2931	12.51	0.1118	71.52
STDEV	0.0127	0.0475	3.482	0.0063	36.84

Fish Tissue Metal Data (ppm dry weight)

	% Moisture	Al	As	B	Ba	Be	Cd	Cr	Cu	Fe	Hg	Mg	Mn	Mo
K0101TFH	77.2	2373	0.50	4.5	33.0	0.10	0.20	10.0	14.4	3214	0.10	2239	187.0	2.4
K0102TFH	76.6	1780	1.1	4.0	29.4	0.10	0.10	9.1	10.9	3392	0.10	2030	143.4	1.9
K0103TFH	75.9	1578	1.7	4.3	31.2	0.099	0.099	9.8	13.1	3418	0.099	2050	186.9	1.8
K0104TFH	76.4	1480	1.6	4.0	29.5	0.10	0.10	9.1	9.8	3162	0.10	1942	138.6	2.0
K0105TFH	76.9	1479	0.49	3.9	28.0	0.097	0.097	7.9	11.6	3287	0.097	1908	127.7	1.7
K0106TFH	75.6	2008	1.2	3.9	33.1	0.099	0.099	13.3	10.7	3925	0.099	2025	152.7	1.6
K0107TFH	77.1	2960	1.5	4.0	33.3	0.099	0.20	11.3	16.3	4741	0.099	1931	126.2	1.9
K0108TFH	76.2	1968	1.9	4.1	31.1	0.096	0.23	10.4	10.5	3921	0.096	1930	137.8	1.5
Freq		8/8	6/8	3/8	8/8	0/8	3/8	8/8	8/8	8/8	0/8	8/8	8/8	8/8
Min	75.6	1479	0.49	3.9	28.0		0.10	7.9	9.8	3162		1908	126.2	1.5
Max	77.2	2960	1.9	4.5	33.3		0.23	13.3	16.3	4741		2239	187.0	2.4
Mean	76.5	1953	1.2	4.1	31.1		0.14	10.1	12.2	3633		2007	150.0	1.9
StDev	0.55	508.9	0.53	0.22	2.0		0.057	1.6	2.2	536.8		108.4	24.3	0.26
K0201TFH	76.8	83.0	0.49	3.9	14.4	0.099	0.099	3.2	7.3	294.7	0.099	1696	101.9	1.7
K0202TFH	76.8	89.0	1.4	3.9	16.2	0.097	0.097	2.3	5.5	221.8	0.097	1815	118.3	1.7
K0203TFH	76.0	62.7	0.48	3.9	13.4	0.096	0.096	2.8	6.1	177.9	0.096	1663	95.3	1.7
K0204TFH	76.8	551.3	1.4	3.8	17.4	0.096	0.096	3.7	6.1	509.9	0.096	1735	129.3	1.8
K0205TFH	76.9	147.0	0.50	4.0	15.7	0.099	0.27	3.7	7.9	351	0.099	1799	126.7	1.7
K0206TFH	75.2	78.8	0.49	3.9	14.0	0.099	0.099	4.3	5.5	213.3	0.099	1846	103.8	1.7
K0207TFH	76.3	696.4	1.3	4.0	19.1	0.099	0.099	4.4	8.5	1379	0.099	1794	192.2	1.6
K0208TFH	76.7	718.7	0.50	4.0	20.7	0.10	0.10	5.1	10.1	2313	0.10	1683	170.5	1.8
Freq		8/8	3/8	0/8	8/8	0/8	1/8	8/8	8/8	8/8	0/8	8/8	8/8	8/8
Min	75.2	62.7	0.48		13.4		0.10	2.3	5.5	177.9		1663	95.3	1.6
Max	76.9	718.7	1.4		20.7		0.27	5.1	10.1	2313		1846	192.2	1.8
Mean	76.4	303.4	0.81		16.4		0.12	3.7	7.1	682.6		1754	129.7	1.7
Stdev	0.60	296.6	0.45		2.6		0.061	0.92	1.6	767.3		68.5	34.5	0.062
M0101TFH	75.5	51.7	1.2	3.8	12.2	0.096	0.096	3.2	3.9	112.7	0.096	2001	117.4	0.48
M0102TFH	76.5	91.0	0.49	3.9	9.7	0.098	0.098	4.3	4.5	164.4	0.098	1872	95.8	0.49
M0103TFH	79.0	185.2	0.49	3.9	12.1	0.098	0.27	3.4	3.7	228.5	0.098	2017	103.0	0.49
M0104TFH	79.1	67.7	0.49	3.9	10.4	0.098	0.098	3.7	3.3	153.4	0.098	2033	100.0	0.49
M0105TFH	77.4	66.3	1.9	4.0	20.4	0.10	0.10	4.0	5.5	174.9	0.10	2031	211.4	0.50
M0106TFH	77.6	49.6	0.49	3.9	8.0	0.099	0.099	3.2	8.4	216.8	0.099	1451	78.6	0.49
M0107TFH	75.9	27.6	0.48	3.8	12.0	0.096	0.096	2.7	3.8	128.6	0.096	1771	133.2	0.48
M0108TFH	76.2	51.6	1.1	4.0	13.8	0.10	0.10	2.5	4.5	149.5	0.10	1765	131.0	0.50
Freq		8/8	3/8	0/8	8/8	0/8	1/8	8/8	8/8	8/8	0/8	8/8	8/8	0/8
Min	75.5	27.6	0.48		8.0		0.10	2.5	3.3	112.7		1451	78.6	
Max	79.1	185.2	1.9		20.4		0.27	4.3	8.4	228.5		2033	211.4	
Mean	77.1	73.8	0.83		12.3		0.12	3.4	4.7	166.1		1868	121.3	
Stdev	1.4	48.5	0.53		3.7		0.061	0.61	1.6	40.1		202.7	40.8	

	Ni	Pb	Se	Sr	V	Zn
K0101TFH	5.3	10.7	1.9	64.9	6.6	268.1
K0102TFH	4.7	11.0	2.1	53.8	5.6	215.9
K0103TFH	4.8	11.2	1.8	62.1	5.5	188.3
K0104TFH	4.3	11.0	2.0	55.4	5.1	315.2
K0105TFH	4.1	11.0	1.7	49.8	5.2	226.4
K0106TFH	6.1	13.2	1.3	55.5	5.9	214.5
K0107TFH	5.7	14.9	1.8	38.4	7.4	214.3
K0108TFH	4.9	14.0	1.2	45.4	6.0	243.5
Freq	8/8	8/8	8/8	8/8	8/8	8/8
Min	4.1	10.7	1.2	38.4	5.1	188.3
Max	6.1	14.9	2.1	64.9	7.4	315.2
Mean	5.0	12.1	1.7	53.1	5.9	235.8
StDev	0.67	1.6	0.33	8.6	0.78	39.8
K0201TFH	0.49	2.2	1.3	48.2	1.4	271.6
K0202TFH	0.49	2.4	2.1	59.1	0.49	183.7
K0203TFH	0.48	2.3	1.7	52.0	0.48	340.2
K0204TFH	1.1	2.0	1.8	58.3	1.5	233.2
K0205TFH	1.2	0.99	1.5	54.9	1.2	341.4
K0206TFH	1.4	0.99	1.5	63.4	0.49	160.3
K0207TFH	2.0	2.7	1.8	54.7	2.0	202.6
K0208TFH	2.5	5.5	1.8	54.7	2.6	238.6
Freq	5/8	6/8	8/8	8/8	5/8	8/8
Min	0.48	1.0	1.3	48.2	0.48	160.3
Max	2.5	5.5	2.1	63.4	2.6	341.4
Mean	1.2	2.4	1.7	55.7	1.3	246.5
Stdev	0.74	1.4	0.26	4.6	0.78	67.6
M0101TFH	0.97	0.96	1.2	65.9	0.48	421.5
M0102TFH	0.49	0.98	1.2	51.3	0.49	413.8
M0103TFH	1.1	0.98	1.1	57.7	0.49	657.9
M0104TFH	0.49	0.98	1.3	56.8	0.49	226.5
M0105TFH	1.5	1.0	1.1	77.6	0.50	189.2
M0106TFH	0.49	0.99	1.7	26.2	0.49	279.6
M0107TFH	1.0	0.96	1.3	47.5	0.48	181.0
M0108TFH	0.50	1.0	1.4	54.8	0.50	156.8
Freq	4/8	0/8	8/8	8/8	0/8	8/8
Min	0.49		1.1	26.2		156.8
Max	1.5		1.7	77.6		657.9
Mean	0.81		1.3	54.7		315.8
Stdev	0.37		0.19	14.8		171.8

	% Lipid	% Moisture	PCB-1242	PCB-1248	PCB-1254	PCB-1260	PCB-TOTAL	1254:1260 ratio	o,p'-DDD	o,p'-DDE	o,p'-DDT	p,p'-DDD	p,p'-DDE	p,p'-DDT
K0101TFH	2.23	77	0.025	**0.073**	**0.082**	**0.062**	**0.22**	1.32	0.005	0.005	0.005	**0.02**	**0.018**	0.005
K0102TFH	2.15	77.5	0.025	**0.065**	**0.08**	**0.068**	**0.21**	1.18	0.005	0.005	0.005	**0.018**	**0.019**	0.005
K0103TFH	2.71	77	0.025	**0.087**	**0.11**	**0.094**	**0.29**	1.17	0.005	0.005	0.005	**0.022**	**0.021**	0.005
K0104TFH	2.81	76	0.025	**0.13**	**0.11**	**0.11**	**0.35**	1	0.005	0.005	0.005	**0.024**	**0.025**	0.005
K0105TFH	2.69	76	0.025	**0.15**	**0.11**	**0.11**	**0.37**	1	0.005	0.005	0.005	**0.022**	**0.025**	0.005
K0106TFH	3.08	75.5	0.025	**0.079**	**0.12**	**0.11**	**0.31**	1.09	0.005	0.005	0.005	**0.027**	**0.024**	0.005
K0107TFH	2.5	78	0.025	**0.059**	**0.091**	**0.084**	**0.23**	1.08	0.005	0.005	0.005	**0.019**	**0.019**	0.005
K0108TFH	3.19	77	0.025	**0.093**	**0.11**	**0.1**	**0.33**	1.1	0.005	0.005	0.005	**0.025**	**0.025**	0.005
Freq			0/8	**8/8**	**8/8**	**8/8**	7/8		0/8	0/8	0/8	**8/8**	**8/8**	0/8
MIN	2.15	75.5		0.059	0.08	0.062	0.21	1				0.018	0.018	
MAX	3.19	78		0.15	0.12	0.11	0.37	1.32				0.027	0.025	
MEAN	2.67	76.8		0.092	0.102	0.092	0.289	1.12				0.022	0.022	
STDEV	0.36898	0.845		0.032	0.015	0.019	0.062	0.106				0.003	0.003	
K0201TFH	2.7	77	0.025	**0.089**	**0.12**	**0.12**	**0.33**	1	0.005	0.005	0.005	**0.014**	**0.019**	0.005
K0202TFH	2.7	77.5	0.025	**0.14**	**0.2**	**0.16**	**0.5**	1.25	0.005	0.005	0.005	**0.02**	**0.026**	0.005
K0203TFH	3.43	76.5	0.025	**0.15**	**0.13**	**0.14**	**0.42**	0.929	0.005	0.005	0.005	**0.023**	**0.03**	0.005
K0204TFH	3.45	76.5	0.025	**0.16**	**0.16**	**0.16**	**0.48**	1	0.005	0.005	0.005	**0.025**	**0.033**	0.005
K0205TFH	2.84	76.5	0.025	**0.064**	**0.16**	**0.1**	**0.32**	1.6	0.005	0.005	0.005	**0.016**	**0.021**	0.005
K0206TFH	2.74	76.5	0.025	**0.073**	**0.14**	**0.12**	**0.33**	1.17	0.005	0.005	0.005	**0.017**	**0.025**	0.005
K0207TFH	3.58	76	0.025	**0.084**	**0.17**	**0.11**	**0.36**	1.55	0.005	0.005	0.005	**0.018**	**0.024**	0.005
K0208TFH	2.63	76.5	0.025	0.025	**0.12**	**0.081**	**0.2**	1.48	0.005	0.005	0.005	**0.016**	**0.019**	0.005
Freq			0/8	7/8	**8/8**	**8/8**	**8/8**					**8/8**	**8/8**	0/8
MIN	2.63	76		0.025	0.12	0.081	0.2	0.929				0.014	0.019	
MAX	3.58	77.5		0.16	0.2	0.16	0.5	1.6				0.025	0.033	
MEAN	3.01	76.6		0.098	0.15	0.124	0.368	1.25				0.019	0.025	
STDEV	0.402	0.443		0.047	0.028	0.028	0.097	0.267				0.004	0.005	
M0101TFH	2.62	76.5	0.025	0.025	0.025	0.025	0.025	1	0.005	0.005	0.005	0.005	**0.013**	0.005
M0102TFH	2.15	78.5	0.025	0.025	0.025	0.025	0.025	1	0.005	0.005	0.005	0.005	0.005	0.005
M0103TFH	2.41	79	0.025	0.025	0.025	0.025	0.025	1	0.005	0.005	0.005	0.005	**0.01**	0.005
M0104TFH	1.7	77.5	0.025	0.025	0.025	0.025	0.025	1	0.005	0.005	0.005	0.005	**0.01**	0.005
M0105TFH	1.97	78	0.025	0.025	0.025	0.025	0.025	1	0.005	0.005	0.005	0.005	0.005	0.005
M0106TFH	2.43	78	0.025	0.025	0.025	0.025	0.025	1	0.005	0.005	0.005	0.005	0.005	0.005
M0107TFH	2.37	77.5	0.025	0.025	0.025	0.025	0.025	1	0.005	0.005	0.005	0.005	0.005	0.005
M0108TFH	2.25	76.5	0.025	0.025	0.025	0.025	0.025	1	0.005	0.005	0.005	0.005	0.005	0.005
Freq			0/8	0/8	0/8	0/8	0/8		0/8	0/8	0/8	0/8	3/8	0/8
MIN	1.7	76.5						1					0.005	
MAX	2.62	79						1					0.013	
MEAN	2.24	77.7						1					0.007	
STDEV	0.293	0.884						0					0.003	

	DDT-TOTAL	oxychlordane	alpha chlordane	cis-nonachlor	gamma chlordane	trans-nonachlor	TOTAL Chlordane	alpha BHC	beta BHC	delta BHC
K0101TFH	0.058	0.005	0.023	0.01	0.005	0.02	0.063	0.005	0.005	0.005
K0102TFH	0.057	0.005	0.022	0.005	0.005	0.021	0.058	0.005	0.005	0.005
K0103TFH	0.063	0.005	0.028	0.01	0.01	0.023	0.076	0.005	0.005	0.005
K0104TFH	0.069	0.005	0.029	0.012	0.01	0.025	0.081	0.005	0.005	0.005
K0105TFH	0.067	0.005	0.027	0.01	0.005	0.025	0.072	0.005	0.005	0.005
K0106TFH	0.071	0.005	0.033	0.012	0.011	0.027	0.088	0.005	0.005	0.005
K0107TFH	0.058	0.005	0.024	0.01	0.01	0.02	0.069	0.005	0.005	0.005
K0108TFH	0.07	0.005	0.032	0.013	0.01	0.027	0.087	0.005	0.005	0.005
Freq		0/8	8/8	6/8	5/8	8/8		0/8	0/8	0/8
MIN	0.057		0.022	0.005	0.005	0.02	0.058			
MAX	0.071		0.033	0.013	0.011	0.027	0.088			
MEAN	0.064		0.027	0.01	0.008	0.024	0.074			
STDEV	0.006		0.004	0.002	0.003	0.003	0.011			
K0201TFH	0.053	0.005	0.02	0.005	0.005	0.019	0.054	0.005	0.005	0.005
K0202TFH	0.066	0.005	0.026	0.011	0.005	0.028	0.075	0.005	0.005	0.005
K0203TFH	0.073	0.005	0.032	0.012	0.01	0.032	0.091	0.005	0.005	0.005
K0204TFH	0.078	0.005	0.036	0.012	0.005	0.035	0.093	0.005	0.005	0.005
K0205TFH	0.057	0.005	0.022	0.005	0.005	0.018	0.055	0.005	0.005	0.005
K0206TFH	0.062	0.005	0.024	0.005	0.005	0.025	0.064	0.005	0.005	0.005
K0207TFH	0.062	0.005	0.026	0.01	0.005	0.026	0.072	0.005	0.005	0.005
K0208TFH	0.055	0.005	0.021	0.005	0.005	0.02	0.056	0.005	0.005	0.005
Freq		0/8	8/8	4/8	1/8	8/8		0/8	0/8	0/8
MIN	0.053		0.02	0.005	0.005	0.018	0.054			
MAX	0.078		0.036	0.012	0.01	0.035	0.093			
MEAN	0.063		0.026	0.008	0.006	0.025	0.07			
STDEV	0.009		0.006	0.003	0.002	0.006	0.016			
M0101TFH	0.038	0.005	0.005	0.005	0.005	0.005	0.025	0.005	0.005	0.005
M0102TFH	0.03	0.005	0.005	0.005	0.005	0.005	0.025	0.005	0.005	0.005
M0103TFH	0.035	0.005	0.005	0.005	0.005	0.005	0.025	0.005	0.005	0.005
M0104TFH	0.035	0.005	0.005	0.005	0.005	0.005	0.025	0.005	0.005	0.005
M0105TFH	0.03	0.005	0.005	0.005	0.005	0.005	0.025	0.005	0.005	0.005
M0106TFH	0.03	0.005	0.005	0.005	0.005	0.005	0.025	0.005	0.005	0.005
M0107TFH	0.03	0.005	0.005	0.005	0.005	0.005	0.025	0.005	0.005	0.005
M0108TFH	0.03	0.005	0.005	0.005	0.005	0.005	0.025	0.005	0.005	0.005
Freq		0/8	0/8	0/8	0/8	0/8		0/8	0/8	0/8
MIN	0.03						0.025			
MAX	0.038						0.025			
MEAN	0.032						0.025			
STDEV	0.003						4.98E-10			

	gamma BHC	dieldrin	endrin	HCB	heptachlor epoxide	mirex	toxaphene
K0101TFH	0.005	0.005	0.005	0.005	0.005	0.005	0.025
K0102TFH	0.005	0.005	0.005	0.005	0.005	0.005	0.025
K0103TFH	0.005	0.005	0.005	0.005	**0.011**	0.005	0.025
K0104TFH	0.005	0.005	0.005	0.005	**0.01**	0.005	0.025
K0105TFH	0.005	0.005	0.005	0.005	0.005	0.005	0.025
K0106TFH	0.005	0.005	0.005	0.005	**0.012**	0.005	0.025
K0107TFH	0.005	0.005	0.005	0.005	0.005	0.005	0.025
K0108TFH	0.005	**0.01**	0.005	0.005	**0.012**	0.005	0.025
Freq	0/8	**1/8**	0/8	0/8	**4/8**	0/8	0/8
MIN		0.005			0.005		
MAX		0.01			0.012		
MEAN		0.006			0.008		
STDEV		0.002			0.003		
K0201TFH	0.005	0.005	0.005	0.005	0.005	0.005	0.025
K0202TFH	0.005	0.005	0.005	0.005	**0.01**	0.005	0.025
K0203TFH	0.005	**0.01**	0.005	0.005	**0.012**	0.005	0.025
K0204TFH	0.005	0.005	0.005	0.005	**0.012**	0.005	0.025
K0205TFH	0.005	**0.01**	0.005	0.005	0.005	0.005	0.025
K0206TFH	0.005	0.005	0.005	0.005	0.005	0.005	0.025
K0207TFH	0.005	**0.01**	0.005	0.005	0.005	0.005	0.025
K0208TFH	0.005	0.005	0.005	0.005	0.005	0.005	0.025
Freq	0/8	3/8	0/8	0/8	3/8	0/8	0/8
MIN		0.005			0.005		
MAX		0.01			0.012		
MEAN		0.007			0.007		
STDEV		0.003			0.003		
M0101TFH	0.005	0.005	0.005	0.005	0.005	0.005	0.025
M0102TFH	0.005	0.005	0.005	0.005	0.005	0.005	0.025
M0103TFH	0.005	0.005	0.005	0.005	0.005	0.005	0.025
M0104TFH	0.005	0.005	0.005	0.005	0.005	0.005	0.025
M0105TFH	0.005	0.005	0.005	0.005	0.005	0.005	0.025
M0106TFH	0.005	0.005	0.005	0.005	0.005	0.005	0.025
M0107TFH	0.005	0.005	0.005	0.005	0.005	0.005	0.025
M0108TFH	0.005	0.005	0.005	0.005	0.005	0.005	0.025
Freq	0/8	0/8	0/8	0/8	0/8	0/8	0/8
MIN							
MAX							
MEAN							
STDEV							

	% Lipid	% Moisture	PCB# 8	PCB# 18	PCB# 31	PCB# 33	PCB# 44	PCB# 49	PCB# 52	PCB# 70	PCB# 77	PCB# 88	PCB# 101	PCB# 126
K0101TFH	2.23	77	0.005	0.005	0.011	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
K0102TFH	2.15	77.5	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
K0103TFH	2.71	77	0.005	0.005	0.013	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
K0104TFH	2.81	76	0.005	0.005	0.015	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
K0105TFH	2.69	76	0.005	0.005	0.015	0.005	0.005	0.012	0.005	0.005	0.005	0.005	0.005	0.005
K0106TFH	3.08	75.5	0.005	0.005	0.014	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
K0107TFH	2.5	78	0.005	0.005	0.011	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
K0108TFH	3.19	77	0.005	0.005	0.015	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Freq			0/8	0/8	7/8	0/8	0/8	1/8	0/8	0/8	0/8	0/8	0/8	0/8
MIN	2.15	75.5			0.005			0.005						
MAX	3.19	78			0.015			0.012						
MEAN	2.67	76.8			0.012			0.006						
STDEV	0.369	0.845			0.003			0.002						
K0201TFH	2.7	77	0.005	0.005	0.01	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.01	0.005
K0202TFH	2.7	77.5	0.005	0.005	0.014	0.005	0.005	0.014	0.013	0.005	0.005	0.005	0.014	0.005
K0203TFH	3.43	76.5	0.005	0.005	0.014	0.005	0.005	0.005	0.012	0.005	0.005	0.005	0.013	0.005
K0204TFH	3.45	76.5	0.005	0.005	0.016	0.005	0.005	0.01	0.014	0.005	0.005	0.005	0.015	0.005
K0205TFH	2.84	76.5	0.005	0.005	0.012	0.005	0.005	0.011	0.01	0.005	0.005	0.005	0.01	0.005
K0206TFH	2.74	76.5	0.005	0.005	0.01	0.005	0.005	0.021	0.01	0.005	0.005	0.005	0.012	0.005
K0207TFH	3.58	76	0.005	0.005	0.012	0.005	0.005	0.005	0.012	0.005	0.005	0.005	0.012	0.005
K0208TFH	2.63	76.5	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Freq			0/8	0/8	7/8	0/8	0/8	4/8	6/8	0/8	0/8	0/8	7/8	0/8
MIN	2.63	76			0.005			0.005	0.005				0.005	
MAX	3.58	77.5			0.016			0.021	0.014				0.015	
MEAN	3.01	76.6			0.012			0.01	0.01				0.011	
STDEV	0.402	0.443			0.003			0.006	0.003				0.003	
M0101TFH	2.62	76.5	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
M0102TFH	2.15	78.5	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
M0103TFH	2.41	79	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
M0104TFH	1.7	77.5	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
M0105TFH	1.97	78	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
M0106TFH	2.43	78	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
M0107TFH	2.37	77.5	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
M0108TFH	2.25	76.5	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Freq			0/8	0/8	0/8	0/8	0/8	0/8	0/8	0/8	0/8	0/8	0/8	0/8
MIN	1.7	76.5												
MAX	2.62	79												
MEAN	2.24	77.7												
STDEV	0.293	0.884												

	PCB# 138	PCB# 141	PCB# 151	PCB# 153	PCB# 156	PCB# 158	PCB# 169	PCB# 170	PCB# 174	PCB# 180	PCB# 189	PCB# 194	PCB# 32	PCB# 71
K0101TFH	**0.015**	0.005	0.005	**0.017**	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
K0102TFH	**0.016**	0.005	0.005	**0.017**	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
K0103TFH	**0.018**	0.005	0.005	**0.021**	0.005	0.005	0.005	0.005	0.005	**0.01**	0.005	0.005	0.005	0.005
K0104TFH	**0.02**	0.005	0.005	**0.022**	0.005	0.005	0.005	0.005	0.005	**0.012**	0.005	0.005	0.005	0.005
K0105TFH	**0.022**	0.005	0.005	**0.024**	0.005	0.005	0.005	0.005	0.005	**0.012**	0.005	0.005	0.005	0.005
K0106TFH	**0.021**	0.005	0.005	**0.024**	0.005	0.005	0.005	0.005	0.005	**0.012**	0.005	0.005	0.005	0.005
K0107TFH	**0.016**	0.005	0.005	**0.019**	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
K0108TFH	**0.02**	0.005	0.005	**0.022**	0.005	0.005	0.005	0.005	0.005	**0.011**	0.005	0.005	0.005	0.005
Freq	8/8	0/8	0/8	8/8	0/8	0/8	0/8	0/8	0/8	5/8	0/8	0/8	0/8	0/8
MIN	0.015			0.017						0.005				
MAX	0.022			0.024						0.012				
MEAN	0.019			0.021						0.009				
STDEV	0.003			0.003						0.003				
K0201TFH	**0.022**	0.005	0.005	**0.026**	0.005	0.005	0.005	0.005	0.005	**0.014**	0.005	0.005	0.005	0.005
K0202TFH	**0.033**	0.005	0.005	**0.036**	0.005	0.005	0.005	0.005	0.005	**0.018**	0.005	0.005	0.005	0.005
K0203TFH	**0.028**	0.005	0.005	**0.031**	0.005	0.005	0.005	0.005	0.005	**0.016**	0.005	0.005	0.005	0.005
K0204TFH	**0.037**	0.005	0.005	**0.036**	0.005	0.005	0.005	0.005	0.005	**0.018**	0.005	0.005	0.005	0.005
K0205TFH	**0.024**	0.005	0.005	**0.027**	0.005	0.005	0.005	0.005	0.005	**0.012**	0.005	0.005	0.005	0.005
K0206TFH	**0.026**	0.005	0.005	**0.03**	0.005	0.005	0.005	0.005	0.005	**0.014**	0.005	0.005	0.005	0.005
K0207TFH	**0.026**	0.005	0.005	**0.029**	0.005	0.005	0.005	0.005	0.005	**0.014**	0.005	0.005	0.005	0.005
K0208TFH	**0.019**	0.005	0.005	**0.022**	0.005	0.005	0.005	0.005	0.005	**0.01**	0.005	0.005	0.005	0.005
Freq	8/8	0/8	0/8	8/8	0/8	0/8	0/8	0/8	0/8	8/8	0/8	0/8	0/8	0/8
MIN	0.019			0.022						0.01				
MAX	0.037			0.036						0.018				
MEAN	0.027			0.03						0.015				
STDEV	0.006			0.005						0.003				
M0101TFH	0.005	0.005	0.005	**0.013**	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
M0102TFH	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
M0103TFH	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
M0104TFH	0.005	0.005	0.005	**0.012**	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
M0105TFH	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
M0106TFH	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
M0107TFH	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
M0108TFH	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Freq	0/8	0/8	0/8	2/8	0/8	0/8	0/8	0/8	0/8	0/8	0/8	0/8	0/8	0/8
MIN				0.005										
MAX				0.013										
MEAN				0.007										
STDEV				0.003										

	PCB# 95	PCB# 105/132	PCB# 128/167	PCB# 106/118
K0101TFH	0.01	0.005	0.005	0.005
K0102TFH	0.005	0.005	0.005	0.005
K0103TFH	0.014	0.005	0.005	0.005
K0104TFH	0.017	0.005	0.005	0.011
K0105TFH	0.019	0.005	0.005	0.012
K0106TFH	0.011	0.005	0.005	0.011
K0107TFH	0.005	0.005	0.005	0.005
K0108TFH	0.013	0.005	0.005	0.011
Freq	6/8	0/8	0/8	4/8
MIN	0.005			0.005
MAX	0.019			0.012
MEAN	0.012			0.008
STDEV	0.005			0.003
K0201TFH	0.013	0.005	0.005	0.012
K0202TFH	0.019	0.012	0.005	0.018
K0203TFH	0.019	0.01	0.005	0.015
K0204TFH	0.022	0.012	0.005	0.018
K0205TFH	0.016	0.005	0.005	0.012
K0206TFH	0.021	0.005	0.005	0.013
K0207TFH	0.02	0.005	0.005	0.015
K0208TFH	0.012	0.005	0.005	0.01
Freq	8/8	3/8	0/8	8/8
MIN	0.012	0.005		0.01
MAX	0.022	0.012		0.018
MEAN	0.018	0.007		0.014
STDEV	0.004	0.003		0.003
M0101TFH	0.005	0.005	0.005	0.005
M0102TFH	0.005	0.005	0.005	0.005
M0103TFH	0.005	0.005	0.005	0.005
M0104TFH	0.005	0.005	0.005	0.005
M0105TFH	0.005	0.005	0.005	0.005
M0106TFH	0.005	0.005	0.005	0.005
M0107TFH	0.005	0.005	0.005	0.005
M0108TFH	0.005	0.005	0.005	0.005
Freq	0/8	0/8	0/8	0/8
MIN				
MAX				
MEAN				
STDEV				

Sediment organochlorine data (ppm dry weight)

	Grain Size-Clay	Grain Size-Sand	Grain Size-Silt	% Moisture	Tot. Organic Carbon	PCB-1242	PCB-1248	PCB-1254	PCB-1260	PCB-TOTAL
K0101SED	6.7	63.3	30	39.4	1.1	0.0248	0.0248	**0.0594**	**0.0759**	**0.1353**
K0201SED	8	55.1	36.9	41.6	1.9	0.0257	0.0257	**0.0822**	**0.0582**	**0.1404**
M0101SED	20	24.5	55.5	53	2.3	0.0319	0.0319	0.0319	0.0319	0.0319

Sediment organochlorine data (ppm dry weight)

	1254:1260 ratio	o,p'-DDD	o,p'-DDE	o,p'-DDT	p,p'-DDD	p,p'-DDE	p,p'-DDT	DDT-TOTAL	oxychlordane	alpha chlordane	cis-ñonachlor
K0101SED	0.78	0.0083	0.0083	0.0083	**0.0462**	0.0083	0.0083	0.0875	0.0083	**0.0347**	0.0083
K0201SED	1.4	0.0086	0.0086	0.0086	**0.024**	0.0086	0.0086	0.0668	0.0086	**0.0599**	0.0086
M0101SED	1	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0638	0.0106	0.0106	0.0106

Sediment organochlorine data (ppm dry weight)

	gamma chlordane	trans-nonachlor	TOTAL Chlordane	alpha BHC	beta BHC	delta BHC	gamma BHC	dieldrin	endrin	HCB
K0101SED	**0.0429**	**0.0248**	0.1188	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083
K0201SED	**0.0634**	**0.0394**	0.1798	0.0086	0.0086	0.0086	0.0086	0.0086	0.0086	0.0086
M0101SED	0.0106	0.0106	0.0532	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106

	heptachlor epoxide	mirex	toxaphene
K0101SED	0.0083	0.0083	0.0248
K0201SED	0.0086	0.0086	0.0257
M0101SED	0.0106	0.0106	0.0319

Sediment inorganic data (ppm dry weight)

	% Moisture	Al	As	B	Ba	Be	Cd	Cr	Cu	Fe	Hg	Mg	Mn	Mo
K0101SED	49.73	4830	3.76	21.2	100.1	1.266	1.546	56.9	49.25	19330	0.1913	3585	446.1	2.525
K0201SED	34.72	3386	2.08	16	77.5	0.7952	0.7264	32.33	31.9	15630	0.104	3949	334.5	2.515
M0101SED	51.41	2979	1.72	16.5	72.67	0.6091	0.2505	12.5	13.1	11900	0.0505	890.9	189.7	2.525

Sediment inorganic data (ppm dry weight)

	NI	Pb	Se	Sr	V	Zn
K0101SED	38.77	168.3	0.2526	11.43	47.63	294
K0201SED	34.97	100.3	0.2515	9.429	30.76	168.5
M0101SED	10.85	20.05	0.2526	12.66	28.94	48.82

Sediment organochlorine data (ppm dry weight)

	Grain Size-Clay	Grain Size-Sand	Grain Size-Silt	% Moisture	Tot. Organic Carbon	PCB-1242	PCB-1248	PCB-1254	PCB-1260	PCB-TOTAL
K0101SED	6.7	63.3	30	39.4	1.1	0.0248	0.0248	**0.0594**	**0.0759**	**0.1353**
K0201SED	8	55.1	36.9	41.6	1.9	0.0257	0.0257	**0.0822**	**0.0582**	**0.1404**
M0101SED	20	24.5	55.5	53	2.3	0.0319	0.0319	0.0319	0.0319	0.0319

Sediment organochlorine data (ppm dry weight)

	1254:1260 ratio	o,p'-DDD	o,p'-DDE	o,p'-DDT	p,p'-DDD	p,p'-DDE	p,p'-DDT	DDT-TOTAL	oxychlordane	alpha chlordane	cis-nonachlor
K0101SED	0.78	0.0083	0.0083	0.0083	**0.0462**	0.0083	0.0083	0.0875	0.0083	**0.0347**	0.0083
K0201SED	1.4	0.0086	0.0086	0.0086	**0.024**	0.0086	0.0086	0.0668	0.0086	**0.0599**	0.0086
M0101SED	1	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0638	0.0106	0.0106	0.0106

Sediment organochlorine data (ppm dry weight)

	gamma chlordane	trans-nonachlor	TOTAL Chlordane	alpha BHC	beta BHC	delta BHC	gamma BHC	dieldrin	endrin	HCB
K0101SED	**0.0429**	**0.0248**	0.1188	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083
K0201SED	**0.0634**	**0.0394**	0.1798	0.0086	0.0086	0.0086	0.0086	0.0086	0.0086	0.0086
M0101SED	0.0106	0.0106	0.0532	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106

	heptachlor epoxide	mirex	toxaphene
K0101SED	0.0083	0.0083	0.0248
K0201SED	0.0086	0.0086	0.0257
M0101SED	0.0106	0.0106	0.0319

Sediment PCB congener data (ppm dry weight)

	PCB# 8	PCB# 18	PCB# 31	PCB# 33	PCB# 44	PCB# 49	PCB# 52	PCB# 70	PCB# 77	PCB# 88	PCB# 101	PCB# 118/	PCB# 126	PCB# 128
K0101SED	0.0004	0.0004	**0.0086**	**0.0046**	**0.0017**	**0.0021**	0.0004	**0.0035**	0.0004	0.0004	**0.0071**	**0.0069**	0.0004	**0.0021**
K0201SED	0.0004	0.0004	**0.0084**	0.0004	**0.0031**	**0.0065**	**0.0072**	**0.0055**	0.0004	**0.0021**	**0.0099**	**0.0094**	0.0004	**0.0027**
M0101SED	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005

	PCB# 138	PCB# 151	PCB# 153	PCB# 156	PCB# 158	PCB# 167	PCB# 169	PCB# 170	PCB# 174	PCB# 180	PCB# 189	PCB# 194	PCB# 81	PCB# 32
K0101SED	**0.0129**	0.0004	**0.0132**	**0.0020**	**0.0033**	0.0004	0.0004	**0.0053**	**0.0031**	**0.0073**	0.0004	**0.0018**	0.0004	0.0004
K0201SED	**0.0147**	**0.0031**	**0.0158**	**0.0024**	**0.0036**	0.0004	0.0004	**0.0050**	**0.0038**	**0.0070**	0.0004	0.0004	0.0004	0.0004
M0101SED	**0.0012**	0.0005	**0.0013**	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005

	PCB# 71	PCB# 95	PCB# 132	PCB# 105/141
K0101SED	0.0004	**0.0578**	**0.0038**	**0.0094**
K0201SED	0.0004	**0.0651**	**0.0043**	**0.0062**
M0101SED	0.0005	**0.0140**	0.0005	0.0005

Appendix D

Chemical	Maximum Conc. (mg/kg)	BAF	Conc. in Inverts. (mg/kg)	Conc. in Fish (mg/kg)	Conc. from Sediment (mg/kg)	Ingestion Rate (kg/day)	AUF	Body Weight (1/kg)	Dose (mg/kg/day)	LOAEL (mg/kg/day)
								0.25		
Organochlorines										
4,4'-DDD	0.0462	1	0.0	0.0	0.00	0.048	1	4	0.0089	0.55
4,4'-DDE	0	1	0.0	0.0	0.0	0.048	1	4	0.0000	0.55
4,4'-DDT	0	1	0.0	0.0	0.0	0.048	1	4	0.0000	0.55
total DDT	0.0875	1	0.0	0.0	0.0	0.048	1	4	0.0168	0.55
total chlordane	0.1798	1	0.1	0.1	0.0	0.048	1	4	0.0345	0.1
total PCBs	0.1404	1	0.1	0.1	0.0	0.048	1	4	0.0270	9
Metals								4		
Arsenic	3.76	1	1.7	1.7	0.4	0.048	1	4	0.7219	3.3
Cadmium	1.55	1	0.7	0.7	0.2	0.048	1	4	0.2976	3.31
Chromium (total)	56.9	1	25.6	25.6	5.7	0.048	1	4	10.9248	277.8
Copper	49.3	1	22.2	22.2	4.9	0.048	1	4	9.4656	2.35
Lead	168	1	75.6	75.6	16.8	0.048	1	4	32.2560	3
Mercury	0.19	1	0.1	0.1	0.0	0.048	1	4	0.0365	0.1
Nickel	38.8	1	17.5	17.5	3.9	0.048	1	4	7.4496	NA
Zinc	294	1	132.3	132.3	29.4	0.048	1	4	56.4480	139

Chemical	HQ	NOAEL	HQ
	based on LOAEL	(mg/kg/day)	based on NOAEL
Organochlorines			
4,4'-DDD	0	0.055	0
4,4'-DDE	0.0	0.055	0.0
4,4'-DDT	0.0	0.055	0
total DDT	0.0	0.055	0
total chlordane	0.3	0.01	3
total PCBs	0.0	0.9	0
Metals			
Arsenic	0.2	0.33	2
Cadmium	0.1	0.33	0.9
Chromium (total)	0.04	27.8	0.4
Copper	4.0	0.235	40
Lead	10.8	0.3	108
Mercury	0.4	0.01	3.6
Nickel		NA	
Zinc	0.4	13.9	4.1

Chemical	Maximum Conc. (mg/kg)	Conc. in Fish (mg/kg)	Conc in fish (dry)	Conc. from Sediment (mg/kg)	FishIngestion Rate (kg/day)	Sed Ingestion Rate	AUF	Body Weight (1/kg)	Dose (mg/kg/day)
								0.25	
Organochlorines									
4,4'-DDD	0.046	0.03	0.11	0.00	0.04339	0.00461	1	4	0.0188
4,4'-DDE	0.000	0.03	0.13	0.0	0.04339	0.00461	1	4	0.0229
4,4'-DDT	0.000	0.00	0.00	0.0	0.04339	0.00461	1	4	0.0000
total DDT	0.088	0.08	0.31	0.0	0.04339	0.00461	1	4	0.0543
total chlordane	0.180	0.09	0.37	0.0	0.04339	0.00461	1	4	0.0649
total PCBs	0.140	0.50	2.00	0.0	0.04339	0.00461	1	4	0.3474
Metals									
Arsenic	3.76	0.44	1.76	0.4	0.04339	0.00461	1	4	0.3124
Cadmium	1.55	0.06	0.25	0.2	0.04339	0.00461	1	4	0.0459
Chromium (total)	56.9	3.23	12.92	5.7	0.04339	0.00461	1	4	2.3473
Copper	49.3	3.73	14.92	4.9	0.04339	0.00461	1	4	2.6804
Lead	168	3.41	13.64	16.8	0.04339	0.00461	1	4	2.6772
Mercury	0.19	0.00	0.00	0.0	0.04339	0.00461	1	4	0.0004
Nickel	38.8	1.48	5.92	3.9	0.04339	0.00461	1	4	1.0990
Zinc	294	81.70	326.80	29.4	0.04339	0.00461	1	4	57.2615
	Average Concentrations								
	Sediment	**Fish**							
Organochlorines									
4,4'-DDD	0.035	0.020	0.08	0.00	0.04339	0.00461	1	4	0.0139
4,4'-DDE	0	0.023	0.09	0.0	0.04339	0.00461	1	4	0.0160
4,4'-DDT	0	0.00	0.00	0.0	0.04339	0.00461	1	4	0.0000
total DDT	0.077	0.064	0.26	0.0	0.04339	0.00461	1	4	0.0446
total chlordane	0.149	0.072	0.29	0.0	0.04339	0.00461	1	4	0.0503
total PCBs	0.138	0.330	1.32	0.0	0.04339	0.00461	1	4	0.2294
Metals									
Arsenic	2.92	0.24	0.96	0.3	0.04339	0.00461	1	4	0.1720
Cadmium	1.14	0.03	0.12	0.1	0.04339	0.00461	1	4	0.0229
Chromium (total)	44.6	1.62	6.48	4.5	0.04339	0.00461	1	4	1.2069
Copper	40.6	2.27	9.08	4.1	0.04339	0.00461	1	4	1.6508
Lead	134	1.70	6.80	13.4	0.04339	0.00461	1	4	1.4273
Mercury	0.15	0.00	0.00	0.0	0.04339	0.00461	1	4	0.0003
Nickel	36.9	0.73	2.92	3.7	0.04339	0.00461	1	4	0.5748
Zinc	231	56.70	226.80	23.1	0.04339	0.00461	1	4	39.7894

Chemical	LOAEL (mg/kg/day)	HQ based on LOAEL	NOAEL (mg/kg/day)	HQ based on NOAEL
Organochlorines				
4,4'-DDD	0.55	0	0.055	0
4,4'-DDE	0.55	0.0	0.055	**0.4**
4,4'-DDT	0.55	0.0	0.055	0
total DDT	0.55	0.1	0.055	**1**
total chlordane	0.15	0.4	0.015	**4**
total PCBs	9	0.0	0.9	0
Metals				
Arsenic	3.3	0.1	0.33	**1**
Cadmium	3.31	0.0	0.33	**0.1**
Chromium (total)	277.8	0.01	27.8	0.1
Copper	2.35	1.1	0.235	**11**
Lead	3	0.9	0.3	**9**
Mercury	0.1	0.0	0.01	**0.0**
Nickel	NA		NA	
Zinc	139	0.4	13.9	**4.1**
Organochlorines				
4,4'-DDD	0.55	0	0.055	0
4,4'-DDE	0.55	0.0	0.055	**0.3**
4,4'-DDT	0.55	0.0	0.055	0
total DDT	0.55	0.1	0.055	**1**
total chlordane	0.1	0.5	0.01	**5**
total PCBs	9	0.0	0.9	0
Metals				
Arsenic	3.3	0.1	0.33	**1**
Cadmium	3.31	0.0	0.33	**0.1**
Chromium (total)	277.8	0.00	27.8	0.0
Copper	2.35	0.7	0.235	**7**
Lead	3	0.5	0.3	**5**
Mercury	0.1	0.0	0.01	**0.0**
Nickel	NA		NA	
Zinc	139	0.3	13.9	**2.9**

Chemical	Maximum Conc. (mg/kg)	BAF	Conc. in Inverts. (mg/kg)	Conc. in Fish (mg/kg)	Conc. from Sediment (mg/kg)	Ingestion Rate (kg/day)	Water Conc. (mg/kg)	Water Ingestion (kg/day)	AUF	Body Weight (1/kg)
Organochlorines										
4,4'-DDD	0.462	1	0.1	0	0.0	0.5	0.000	0.18	1	0.5
4,4'-DDE	0	1	0.0	0.0	0.0	0.5	0.000	0.18	1	0.5
4,4'-DDT	0	1	0.0	0.0	0.0	0.5	0.000	0.18	1	0.5
total DDT	0.0875	1	0.0	0.1	0.0	0.5	0.000	0.18	1	0.5
total chlordane	0.1798	1	0.0	0.1	0.0	0.5	0.000	0.18	1	0.5
Total PCBs	0.1404	1	0.0	0.1	0.0	0.5	0.000	0.18	1	0.5
Metals										
Arsenic	3.76	1	0.7	2.7	0.4	0.5	0.000	0.18	1	0.5
Cadmium	1.55	1	0.3	1.1	0.1	0.5	0.234	0.18	1	0.5
Chromium (total)	56.9	1	10.3	41.3	5.3	0.5	0.081	0.18	1	0.5
Copper	49.3	1	8.9	35.7	4.6	0.5	0.435	0.18	1	0.5
Lead	168	1	30.4	122	15.8	0.5	0.498	0.18	1	0.5
Mercury	0.19	1	0.03	0.14	0.02	0.5	0.000	0.18	1	0.5
Nickel	38.8	1	7.0	28.1	3.6	0.5	0.039	0.18	1	0.5
Zinc	294	1	53.2	213	27.6	0.5	0.470	0.18	1	0.5

Chemical	Dose (mg/kg/day)	LOAEL (mg/kg/day)	HQ based on LOAEL	NOAEL (mg/kg/day)	HQ based on NOAEL
Organochlorines					
4,4'-DDD	0.1	0.063	2	0.0063	**18**
4,4'-DDE	0.0	0.063	0.0	0.0063	**0.0**
4,4'-DDT	0.0	0.063	0	0.0063	**0**
total DDT	0.0	0.063	0	0.0063	**3**
total chlordane	0.0	2.5	0	0.25	**0**
Total PCBs	0.0	0.13	0	0.1	**0**
Metals					
Arsenic	0.9	1.5	1	0.15	**6**
Cadmium	0.4	7.5	0.05	0.75	0.5
Chromium (total)	14.2	1.7	8.4	0.17	**83.7**
Copper	12.4	10	1.2	1	**12.4**
Lead	42.0	1.5	28.0	0.15	**280**
Mercury	0.0	0.1	0.5	0.01	**4.8**
Nickel	9.7	625	0.016	62.5	0.16
Zinc	73.5	250	0.3	25	**2.9**

Chemical	Maximum Conc. (mg/kg)	Conc. in Fish (mg/kg)	Conc in fish dry (mg/kg)	Conc. from Sediment (mg/kg)	Food Ingestion Rate (kg/day)	Sed Ingestion Rate (kg/day)	AUF	Body Weight (1/kg)
Organochlorines								
4,4'-DDD	0.0462	0.03	0.11	0.00	0.453	0.047	1	0.5
4,4'-DDE	0	0.03	0.13	0.00	0.453	0.047	1	0.5
4,4'-DDT	0	0.00	0.00	0.00	0.453	0.047	1	0.5
total DDT	0.0875	0.08	0.31	0.01	0.453	0.047	1	0.5
total chlordane	0.1798	0.09	0.37	0.02	0.453	0.047	1	0.5
Total PCBs	0.1404	0.50	2.00	0.01	0.453	0.047	1	0.5
Metals								
Arsenic	3.76	0.4	1.76	0.35	0.453	0.047	1	0.5
Cadmium	1.55	0.1	0.25	0.15	0.453	0.047	1	0.5
Chromium (total)	56.9	3.2	12.92	5.35	0.453	0.047	1	0.5
Copper	49.3	3.7	14.92	4.63	0.453	0.047	1	0.5
Lead	168	3.4	13.64	15.79	0.453	0.047	1	0.5
Mercury	0.19	0.00	0.00	0.02	0.453	0.047	1	0.5
Nickel	38.8	1.5	5.92	3.65	0.453	0.047	1	0.5
Zinc	294	81.7	326.80	27.64	0.453	0.047	1	0.5
	Average Concentrations							
	Sediment	**Fish**						
Organochlorines								
4,4'-DDD	0.035	0.020	0.08	0.00	0.453	0.047	1	0.5
4,4'-DDE	0	0.023	0.09	0.00	0.453	0.047	1	0.5
4,4'-DDT	0	0.00	0.00	0.00	0.453	0.047	1	0.5
total DDT	0.077	0.064	0.26	0.01	0.453	0.047	1	0.5
total chlordane	0.149	0.072	0.29	0.01	0.453	0.047	1	0.5
Total PCBs	0.138	0.330	1.32	0.01	0.453	0.047	1	0.5
Metals								
Arsenic	2.92	0.24	0.96	0.27	0.453	0.047	1	0.5
Cadmium	1.14	0.03	0.12	0.11	0.453	0.047	1	0.5
Chromium (total)	44.6	1.62	6.48	4.19	0.453	0.047	1	0.5
Copper	40.6	2.27	9.08	3.82	0.453	0.047	1	0.5
Lead	134	1.70	6.80	12.60	0.453	0.047	1	0.5
Mercury	0.15	0.00	0.00	0.01	0.453	0.047	1	0.5
Nickel	36.9	0.73	2.92	3.47	0.453	0.047	1	0.5
Zinc	231	56.70	226.80	21.71	0.453	0.047	1	0.5

Chemical	Dose (mg/kg/day)	LOAEL (mg/kg/day)	HQ based on LOAEL	NOAEL (mg/kg/day)	HQ based on NOAEL
Organochlorines					
4,4'-DDD	0.025	0.063	0	0.0063	**4**
4,4'-DDE	0.030	0.063	0.5	0.0063	**4.7**
4,4'-DDT	0.000	0.063	0	0.0063	**0**
total DDT	0.071	0.063	1	0.0063	**11**
total chlordane	0.085	2.5	0	0.25	**0**
Total PCBs	0.453	0.13	3	0.1	**5**
Metals					
Arsenic	0.407	1.5	0	0.15	**3**
Cadmium	0.060	7.5	0.01	0.75	0.1
Chromium (total)	3.052	1.7	1.8	0.17	**18.0**
Copper	3.488	10	0.3	1	**3.5**
Lead	3.461	1.5	2.3	0.15	**23**
Mercury	0.000	0.1	0.0	0.01	0.0
Nickel	1.427	625	0.002	62.5	0.02
Zinc	74.670	250	0.3	25	**3.0**
Organochlorines					
4,4'-DDD	0.018	0.063	0	0.0063	**3**
4,4'-DDE	0.021	0.063	0.3	0.0063	**3.3**
4,4'-DDT	0.000	0.063	0	0.0063	**0**
total DDT	0.058	0.063	1	0.0063	**9**
total chlordane	0.066	2.5	0	0.25	**0**
Total PCBs	0.299	0.13	2	0.1	**3**
Metals					
Arsenic	0.224	1.5	0	0.15	**1**
Cadmium	0.030	7.5	0.00	0.75	0.0
Chromium (total)	1.566	1.7	0.9	0.17	**9.2**
Copper	2.146	10	0.2	1	**2.1**
Lead	1.836	1.5	1.2	0.15	**12**
Mercury	0.000	0.1	0.0	0.01	0.0
Nickel	0.743	625	0.001	62.5	0.01
Zinc	51.880	250	0.2	25	**2.1**

04/29/9902:39:04 PM1

Project 9550002.4 - NE loons

entered under 5F18

Charlie Chandler
04/29/99 02:32 PM

off

To: Tim Fannin@FWS
cc:

Subject: Project 9550002.4 - NE loons

Howdy!

I'm going fishin starting tomorrow, be gone for a week, but thought you might want to know about these two projects.

I'm updating my performance data base. For 9550002.4 on NE Loons, I received the third report ("... Hg Exposure and Risk Between ..." memo date 2/25/99) which I guess the EC Program helped to support, but it looks as though the main work related to the original funding and proposal is still outstanding and so this could be a strike against R5 when I calculate performance later this summer. Last year I only got the two ancillary report and did not get an interim on this, and it was the only one not accounted for by R5. You have had the best record of any Region (except maybe R6) these past couple of years, so it's no big deal, but maybe an interim or draft or final would be possible this summer.

Also, for project 9550001.2 (the redirection from shooting range project to the kennelworth), the status is now listed as a "No Report" which is neutral and does not affect R5 performance. I explained in the side note that the RO request for redirection got "confused". Because there was no officially sanctioned replacement proposal that DEC funded, the final report on kennelworth is not going to fit in my performance data base, but goes in the files as one of those "other" projects the EC program manages to do. Anyway, I hope this compromise is satisfactory to you, and we can close the books on this one. Take care.

I'm trying to do the printout now so all ROs can check their status and get to their FOs, so watch for that in the mail. Take care.

Charlie

United States Department of the Interior

FISH AND WILDLIFE SERVICE
300 WESTGATE CENTER DRIVE
HADLEY, MA 01035-9589

In Reply Refer To:
FWS/Region 5/ES-EC

Memorandum

NOV - 2 1998

To: Chief, Division of Environmental Contaminants

From: Environmental Contaminants Coordinator

Subject: Final Report - Effects of Wetland Restoration Using Anacostia River Sediments at Kenilworth Marsh

The final report for contaminants investigation project 50120-1130-5F18 (MD -- Compatibility between shooting ranges and migratory birds [9550001.2]) has been received in the Regional Office. The accession title for the report is: **"Effects of Wetland Restoration Using Anacostia River Sediments at Kenilworth Marsh"** by Dan Murphy, Alfred E. Pinkney, Robert E. Foley, Peter C. McGowan, Raymond Li, and Lisa Domico. The Region 5 Environmental Contaminants Coordinator is pleased to provide you with a copy.

As always, we welcome the opportunity to document the effectiveness and ingenuity of the Region 5 Field Contaminants Specialists. This report is an indicator of the level of imagination, effort, and perseverance invested in these studies, and reveals the extensive contributions made by the Environmental Contaminants Specialists in providing assistance to other Service programs, preventing injury to our resources, and giving early warning of impending problems in Region 5! We provide you the information in the report, and underline the need for similar investigations, as a stimulus for you to secure expanded Service funding for these important studies.

If you have any further questions or need additional information, call Tim Fannin at 413-253-8646.

CBFO-C98-02

EFFECTS OF WETLAND RESTORATION USING ANACOSTIA RIVER SEDIMENTS AT KENILWORTH MARSH

U.S. Fish and Wildlife Service

OCTOBER 1998

R5/3.4.210

EFFECTS OF WETLAND RESTORATION USING ANACOSTIA RIVER SEDIMENTS AT KENILWORTH MARSH

Publication No. CBFO-C98-02

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U.S. Fish and Wildlife Service
Chesapeake Bay Field Office
177 Admiral Cochrane Drive
Annapolis, MD 21401

October 8, 1998

EXECUTIVE SUMMARY

The Anacostia River is a freshwater tributary that flows through Maryland and Washington, D.C. to the Potomac River. In D.C., the Anacostia River flows through National Park Service lands, including the National Arboretum, Kenilworth Gardens, and Anacostia Park. The river has been the site of moderate oil spills, receives significant input of heavy metals and organic pollutants from urban nonpoint sources, and is known as one of the most polluted rivers in the United States. The sediments of the lower reach of this river have been found to contain elevated levels of polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), chlordane, chromium, lead, and zinc. High levels of PAHs were cited as a potential cause of the high incidence of carcinogenic tumors found in fish from the Anacostia River. The presence of injurious levels of toxic chemicals in the Anacostia watershed may place anadromous fish and endangered and threatened species such as the bald eagle at risk.

In 1993, as part of a maintenance dredging action by the U.S. Army Corps of Engineers (ACOE), dredged material from the Anacostia River was used to construct tidal freshwater wetlands in Kenilworth Marsh. This location was identified as the first of several sites along the main stem and side channels of the river where wetland restoration is proposed to enhance tidal mud flats using sediments from the Anacostia River. Early in 1993, ACOE placed dredged materials in three portions of Kenilworth Marsh at elevations designed to support high and low marsh communities. After sediments reached a consolidated state, guts were cut through these areas to insure tidal flows in the marsh.

The Kenilworth Marsh Monitoring Committee, comprised of National Park Service (NPS), the NPS Center for Urban Ecology, U.S. Fish and Wildlife Service (USFWS), ACOE, Metropolitan Washington Council of Governments, Interstate Commission on the Potomac River Basin, University of the District of Columbia, and the D.C. Water Resources Management Division, was formed to monitor the success of the plant and animal communities in the marsh. In 1993, the USFWS Chesapeake Bay Field Office (CBFO) worked with the ACOE to develop a baseline chemical characterization of marsh sediments which included sediment toxicity tests. The new marsh substrates were found to contain PCBs, chlordane, lead, nickel, and zinc at concentrations that exceed the effects range-median (ER-M), a threshold value above which biological impacts frequently occur. Although sediments from some locations were found to be toxic to the test organism, *Hyalella azteca*, the toxicity may be attributable to interstitial ammonia levels.

In this study, sediments, broad-leaf cattails (*Typha latifolia*), and killifish (*Fundulus* sp.) were collected and analyzed for PCBs, chlorinated pesticides, and metals. The objectives of this study were to determine the concentration of toxic chemicals present in the community developing on the new tidal freshwater wetlands in Kenilworth Marsh. Knowledge of transport and fate of the toxic constituents of wetland sediments will be used to substantiate an informed position on future use of dredged materials from the Anacostia River to construct wetlands.

Sediment samples collected from Kenilworth Marsh in 1993 and during this 1996 study contained concentrations of chromium (1993 only) lead, nickel, zinc, total PCB (1993) and total chlordane that exceed ecological threshold values above which toxic effects frequently occur. In addition, several analytes in sediments exceeded thresholds that are occasionally associated with adverse ecological effects. These include arsenic (1993), chromium, copper, mercury, total PCB (1996), and total DDT.

There were no significant differences between metal concentrations in cattail root material from Kenilworth Marsh and a reference site at Mason Neck National Wildlife Refuge (NWR) on the Potomac River approximately 18 miles downstream from the mouth of the Anacostia. Zinc concentrations found in cattails from both locations may pose risks to mammalian species.

Concentrations of chromium, copper, lead, nickel, total PCB, total DDT, and total chlordane in killifish collected in Kenilworth Marsh were significantly greater than in killifish collected at the reference site at Mason Neck NWR. Concentrations were also compared with results of the National Contaminant Biomonitoring Program which measured whole body residues of organic and inorganic contaminants in freshwater fish in the mid 1980's. Metals found in fish tissue in exceedance of the 85th percentile of national concentrations included arsenic, cadmium, copper, lead, and zinc. Organochlorines that exceeded the national mean included total PCB, total DDT, and alpha chlordane. These results suggest that concentrations of certain contaminants in killifish living in Kenilworth Marsh are high when compared to regional and national values. In addition, zinc was found in Kenilworth Marsh and Mason Neck fish tissue at concentrations that may pose risks to piscivorous birds and are theorized to be harmful to mammals.

A food chain analysis using sediment and fish data from this study suggested that contaminants in sediments and biota in Kenilworth Marsh may pose potential risks to piscivorous birds and mammals. The hazard quotients, however, are low (<1 to 6 using highly conservative assumptions; ≤1 using less conservative assumptions), and risk management recommendations with this level of risk frequently involve monitoring rather than remediation.

In summary, the results of this study suggest that: concentrations of certain contaminants in sediments, killifish, and cattails are elevated; certain contaminants originating in Anacostia River dredge sediments used to construct a wetland at Kenilworth Marsh are accumulating in killifish; several inorganic and organic contaminants were found at concentrations that have been associated with adverse effects to fish-eating birds, mammals, and aquatic biota; and potential ecological risks exist associated with trophic transfer of select contaminants. Based on the results of this and previous studies and the high uncertainty associated with potential effects at higher trophic levels, the Service recommends that Anacostia River sediments be used for marsh restoration purposes only on a limited basis in the Anacostia watershed. More in-depth studies should be performed in Kenilworth Marsh to determine the extent and magnitude of contamination to biota and the possible ecological effects of that contamination. Future use of Anacostia River dredge sediments for wetland restoration should be evaluated on a case-by-case basis. In addition, marsh creation projects using Anacostia sediments should be subjected to post-restoration monitoring to determine the potential effects of sediment associated contaminants on developing wetland communities.

ACKNOWLEDGMENTS

This study was performed with the cooperation and assistance of the National Park Service. The authors are grateful for the help of Dan Roddy and Steve Syphax of the National Park Service, Carol Sanderson, Frederic Milton, and Steve Boska of Mason Neck National Wildlife Refuge, and Peter May of the D.C. Environmental Regulation Administration Fisheries Management Branch. Leslie Gerlich and Karen Fligger of the USFWS and Jamice Hemsley of the National Park Service assisted with field collections. Report graphics were prepared by Laurie Hewitt of the U.S. Fish and Wildlife Service, Chesapeake Bay Field Office. We thank John Moore of the U.S. Fish and Wildlife Service's Patuxent Analytical Control Facility for his advice on chemical analysis and his interaction with the laboratories.

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1.0 INTRODUCTION

The Anacostia River is a freshwater tributary that flows through Maryland and Washington, D.C. to the Potomac River. In D.C., the Anacostia River flows through National Park Service lands, including the National Arboretum, Kenilworth Gardens, and Anacostia Park. The river has been the site of moderate oil spills, receives significant input of heavy metals and organic pollutants from urban nonpoint sources, and is known as one of the most polluted rivers in the United States. The sediments of the lower reach of this river have been found to contain elevated levels of polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), chlordane, chromium, lead, and zinc (Velinsky *et al.* 1994; Wade *et al.* 1994). High levels of PAHs were cited by May and Harshbarger (1993) as a potential cause of the high incidence of carcinogenic tumors found in fish from the Anacostia River. The presence of injurious levels of toxic chemicals in the Anacostia watershed may place anadromous fish and endangered and threatened species such as the bald eagle at risk.

In 1993, as part of a maintenance dredging action by the U.S. Army Corps of Engineers (ACOE), dredged material from the Anacostia River was used to construct tidal freshwater wetlands in Kenilworth Marsh. This location was identified as the first of several sites along the main stem and side channels of the river where wetland restoration is proposed to enhance tidal mud flats using sediments from the Anacostia River. Early in 1993, ACOE placed dredged materials in three portions of Kenilworth Marsh at elevations designed to support high and low marsh communities. After sediments reached a consolidated state, guts were cut through these areas to insure tidal flows in the marsh.

Emergent aquatic vegetation was planted to stabilize sediment substrates and encourage rapid development of marsh habitat. Plant distribution and biomass improved rapidly after planting, although volunteers of several plant species also germinated and make up a significant part of the organic matter produced by the new marsh. In 1995, loosestrife control was required to produce a more desirable species mix. Preliminary studies show that the benthic macroinvertebrate community began to establish in the filled areas of Kenilworth Marsh and that its waters support a variety of resident and anadromous fish (May 1994).

The Kenilworth Marsh Monitoring Committee, comprised of National Park Service (NPS), the NPS Center for Urban Ecology, U.S. Fish and Wildlife Service (USFWS), ACOE, Metropolitan Washington Council of Governments, Interstate Commission on the Potomac River Basin, University of the District of Columbia, and the D.C. Water Resources Management Division, was formed to monitor the success of the plant and animal communities in the marsh. In 1993, the Chesapeake Bay Field Office (CBFO) of the USFWS worked with the ACOE to develop a baseline chemical characterization of marsh sediments which included sediment toxicity tests. The new marsh substrates were found to contain PCBs, chlordane, lead, nickel, and zinc at concentrations that exceed the effects range-median (ER-M), a threshold value above which biological impacts frequently occur (USFWS 1997; Long and Morgan 1991). Although sediments from some locations were found to be toxic to the test organism, *Hyalella azteca*, the toxicity may be attributable to interstitial ammonia levels (USFWS 1997).

Management decisions that propose developing and enhancing habitats with contaminated sediments could jeopardize migratory and endangered trust resources. Knowledge of transport and fate of the toxic constituents of wetland sediments in Kenilworth Marsh is needed to substantiate an informed position on future use of dredged materials from the Anacostia River to construct wetlands in Kingman Lake (part of the lower reach of the Anacostia estuary) and fringe wetlands along the main stem of the river. Enhanced tidal wetland habitats in Kenilworth Marsh attract a large number of trust species because limited habitat exists in D.C. High quality tidal wetland nursery areas are important in this system and any enhancement to wetlands should result in communities of healthy, uncontaminated fish and wildlife.

2.0 OBJECTIVE

The objective of this study is to a) compare the concentrations of organic and inorganic contaminants in sediments, vegetation, and fish from Kenilworth Marsh and a reference area at Mason Neck National Wildlife Refuge (NWR), b) compare these concentrations with guidance values and literature data, and c) describe the potential risks of these contaminants to the aquatic community and to avian and mammalian species.

3.0 MATERIALS AND METHODS

Sediments, broad-leaf cattails *(Typha latifolia),* and killifish *(Fundulus* sp.*)* were collected and analyzed for PCBs, chlorinated pesticides, and metals.

3.1 Sampling Locations

Samples were collected at two locations in Kenilworth Marsh and at a reference site at Mason Neck National Wildlife Refuge in Fairfax County, Virginia (Figure 1). In Kenilworth Marsh, one sampling site was located in Mass Fill 1 and the other was located in Mass Fill 2 (Figure 2). The reference site was located in Great Marsh on the eastern side of the Mason Neck National Wildlife Refuge, adjacent to the Potomac River (Figure 3). Due to limited residential development on the Mason Neck peninsula, the Great Marsh watershed is relatively pristine with few local (non-tidal) pollution inputs. Great Marsh discharges into and receives tidal flow from the Potomac River through a series of tidal guts and therefore would receive inputs from regional loadings of pollutants. Both Kenilworth Marsh and Great Marsh are classified as tidal freshwater wetlands (Lippson *et al.* 1979). Latitude and longitude for all sampling locations were recorded with hand held global positioning system units. The field portion of this study was initiated on August 7, 1996 and completed on August 29, 1996.

3.2 Sediment Collections

One sediment grab sample was collected from the top ten centimeters at each cattail sampling location using a steel shovel according to CBFO Standard Operating Procedure (SOP) 113 (Appendix A). Samples were placed in 1-L pre-cleaned glass jars and placed on ice immediately. All samples were stored at -20° C and shipped to the analytical laboratory on dry ice. Sampling equipment was washed with Alconox detergent and 10% nitric acid and rinsed with deionized water between collection sites.

Sediment samples were labeled as follows:

K0101SED: where K = Kenilworth Marsh (M = Mason Neck), 01 is the sample station (01 = Mass Fill 1 and Mason Neck and 02 = Mass Fill 2), 01 is the sample number, and SED indicates sediment sample.

3.3 Broad-leaf Cattail (*Typha latifolia)* Collections

Broad-leaf cattail (*Typha latifolia)* root samples were collected at Kenilworth Marsh in Mass Fill 1 in an area corresponding with sediment sample number 93SKEN05 and in Mass Fill 2 corresponding with sediment sample number 93SKEN08, both of which were collected and analyzed as part of the 1993 study (USFWS 1997) (Figure 2; Table 1). These sites were chosen because both were in mid-marsh areas where cattails were found and both sediment samples had concentrations of lead, zinc, total PCBs, and total chlordane that were greater than ER-M levels (Long and Morgan 1991). The Mason Neck reference cattails were collected along the southern-most gut in Great Marsh (Figure 3). All three cattail sampling sites were accessed by foot. Eight cattail root samples were collected from each site and the reference site. Cattails were dug from the marsh using a steel shovel and the above ground parts were removed using steel shears. Roots were trimmed to sample container size and dead plant tissue, mud, and detritus were removed by rinsing with site water and distilled water. Samples were weighed to the nearest gram, placed in 1-L pre-cleaned glass jars, and placed on ice immediately. All samples were stored at -20° C and shipped to the analytical laboratory on dry ice. Sampling equipment was washed with Alconox and 10% nitric acid and rinsed with deionized water between collection sites.

Cattail samples were labeled as follows:

K0101TTY: Where K= Kenilworth Marsh (M = Mason Neck), 01 is the sample station (01 = Mass Fill 1 and Mason Neck and 02 = Mass Fill 2), 01 is the sample number, T indicates a tissue sample, and TY is the two letter species abbreviation for cattails.

3.4 Killifish (*Fundulus* sp.*)* Collections

Eight whole body killifish composite samples consisting of ten fish each were collected from each mass fill site and the reference site according to CBFO SOP 114 and USEPA (1995) guidance. At Mass Fill 1, mummichogs *(Fundulus heteroclitus)* were collected at the Kenilworth

Aquatic Gardens canoe ramp which is located at the head of a tidal gut that traverses the filled area (Figure 2). Mummichogs were collected at Mass Fill 2 from a large tidal pothole located in the filled area adjacent to the Kenilworth Park ball fields (Figure 2). Four mummichog composites and four banded killifish *(Fundulus diaphanus)* composites were collected from the Mason Neck reference site in the northern most gut of Great Marsh (Figure 3). Fish were collected using a seine at Mass Fill 1 and galvanized minnow traps baited with bread and hotdogs at Mass Fill 2 and Mason Neck. Both Kenilworth Marsh sites were accessible by foot. A boat was employed to access the reference site at Mason Neck. Fish total length was measured to the nearest millimeter and each composite was weighed to the nearest gram (Table 2). Within samples and between sample sites the length of the smallest fish was at least 71 % of the length of the longest. After measurements were obtained, fish were rinsed with site water, placed into pre-cleaned 500-mL glass jars, and placed on ice immediately. All samples were stored at -20° C and shipped to the analytical laboratory on dry ice. Water quality parameters were measured at each sample site using a Hydrolab Surveyor II (Hydrolab Corp., Austin, Texas) (Table 3).

Killifish samples were labeled as follows:

K0101TFH: where K = Kenilworth Marsh (M = Mason Neck), 01 is the sample station (01 = Mass Fill 1 and Mason Neck and 02 = Mass Fill 2), 01 is the sample number, T indicates tissue sample, and FH is the two letter species abbreviation for killifish.

3.5 Chemical Analysis

All samples were analyzed by USFWS contract laboratories through the Patuxent Analytical Control Facility, which administers the contracts and provides quality control oversight. Organic analyses were performed on killifish and sediment samples at the Mississippi State Chemical Laboratory (Mississippi State, MS). Inorganic analyses were performed on cattail, killifish, and sediment samples at the Research Triangle Institute (Research Triangle Park, NC). Table 4 lists the types of analyses performed and the desired detection limits. Detailed method descriptions are provided in Appendix B. Unless otherwise noted, tissue results are reported as mg analyte per kg wet tissue weight and sediment results are reported as mg analyte per kg dry sediment weight.

3.6 Quality Assurance/Quality Control

On a regular basis, during field sampling, tissue preparation, and sample bottle preparation, the project manager verified that Standard Operation Procedures were being followed by all staff. Sample bottles were inspected and inventoried to verify label accuracy and to confirm that adequate numbers of samples were collected to satisfy the needs of the study. All data generated was recorded in ink in a bound notebook according to CBFO SOP 101. Laboratory quality assurance/quality control included the use of procedural blanks, duplicate samples, spiked samples, and standard reference materials. All laboratory analyses met the Quality Control approval of the Patuxent Analytical Control Facility.

3.7 Data Analysis

For determinations of means, medians, and standard deviations, one-half the detection limit was substituted for non-detected results. Tables containing summary statistics for inorganic and organic wet weight results and inorganic dry weight results are presented in Appendix C. Total PCB values were determined by the analytical laboratory and do not include half-detection limits in place of undetected aroclors. Total DDT was determined by summing results for o,p'-DDD, p,p'-DDD, o,p'-DDE, p,p'-DDE, o,p'DDT, and p,p'-DDT. Total chlordane was determined by summing results for oxychlordane, alpha-chlordane, gamma-chlordane, cis-nonachlor, and trans-nonachlor. Both total DDT and total chlordane levels were calculated using half-detection values.

Analysis of variance (ANOVA) was used to statistically compare mean concentrations between sampling locations. The non-parametric Kruskal-Wallis test was used to analyze data sets containing greater than 50% non-detects (Sokal and Rohlf 1981). Non-parametric statistics are normally employed to analyze data sets that contain a large percentage of non-detected results (Helsel 1990). Data sets containing greater than 50% detects were analyzed to determine whether they met the assumptions of equal variance and normal distribution necessary for parametric statistics (ANOVA). Where parametric assumptions were not met, the data were log-transformed and re-analyzed. If log-transformed data failed the normality test, the Kruskal-Wallis test was used to compare median values between sampling locations. Statistical analyses were performed using Sigma Stat software (Jandel Corp., San Rafael, CA).

For killifish and cattail samples, statistical comparisons between sampling sites were performed on wet weight data. Because only one sediment sample was collected at each site, no statistical analyses were performed on sediment results. Since organochlorine compounds tend to concentrate in lipid tissues, killifish data were examined statistically prior to comparing results between sampling sites to determine whether it would be necessary to normalize the data for lipid content (Spacie and Hamelink 1985). If a significant regression (accounting for at least 50% of the variability) was found, the data would be normalized by analysis of covariance or the ratio method and normalized data would be used for comparisons (Pinkney *et al.* 1997). A t-test was used to determine whether *F. diaphanus* and *F. heteroclitus* data from the Mason Neck NWR reference site could be pooled for comparisons to the Kenilworth Marsh sites. If there was a significant difference between the two species for a given analyte, separate comparisons were made to Kenilworth Marsh data using each species. Where parametric assumptions were not met, the data were log-transformed and re-analyzed. If log-transformed data failed the normality test, the Mann-Whitney Rank Sum test was used to compare median values between the two species.

Sediment data were summarized and compared to effects range-low (ER-L) and effects range-median (ER-M) values (Long and Morgan 1991) and the threshold effect levels (TEL) and probable effect levels (PEL) derived by Smith *et al.* (1996). Since tidal freshwater sediments were investigated in this study, the original Long and Morgan (1991) values, which are based partly on freshwater data, were used rather than the Long *et al.* (1995) values, which are based exclusively on estuarine and marine habitats. The guidance values developed by Smith *et al.* (1996) are based solely on freshwater data. The ER-L represents the 10th percentile concentration of a data base of chemical concentrations that were found to cause adverse effects, below which adverse effects rarely occur. The ER-M represents the 50th percentile concentration of the data base, above which toxic effects frequently occur. Smith *et al.* determined TEL values for many analytes by calculating the geometric mean of the 15th percentile level of a data set of concentrations that caused adverse effects and the 50th percentile level of a no effect data set. The PEL values were determined by calculating the geometric mean of the 50th percentile of the effect concentrations and the 85th percentile of the no effect concentrations. Sediment results were also compared to results from previous studies in the Anacostia River, Kingman Lake, and Kenilworth Marsh (USFWS 1997; Velinsky *et al.* 1994; Wade *et al.* 1994).

Whole body killifish concentrations were summarized and compared to 1984 data from the National Contaminant Biomonitoring Program (NCBP; Schmitt and Brumbaugh 1990; Schmitt *et al.* 1990). As part of the NCBP, 315 fish tissue composite samples were collected from 109 stations throughout the United States and analyzed for selected metals (Schmitt and Brumbaugh 1990). Kenilworth fish tissue metal results were compared to the 85th percentile value of the NCBP. In another phase of the NCBP, organochlorine analyses were performed on 321 fish tissue composites from 112 stations nationwide (Schmitt *et al.* 1990). Because no 85th percentile value was calculated for the NCBP organochlorine data, Kenilworth fish tissue organochlorine results were compared to the geometric mean of the NCBP.

A food chain analysis was performed using killifish and sediment data following USEPA ecological risk assessment guidance (USEPA 1997). The racoon (*Procyon lotor*) and the green heron (*Butorides striatus*) were chosen to represent fish-eating mammalian and avian species in Kenilworth Marsh. Ecological risk of consumption of contaminated food and sediment to these receptors was analyzed using a spreadsheet provided by the USEPA Environmental Response Team Center (ERTC) in Edison, New Jersey. The ERTC spread sheet utilizes life history and exposure profile information to estimate doses for each analyte of concern. The hazard quotient (HQ) is equal to the estimated dose divided by a no observed adverse effect level (NOAEL) obtained from the scientific literature (USEPA 1989; Barnthouse *et al.* 1986). A HQ of one or greater indicates the potential for adverse effects to the organism when it is exposed through diet to a given concentration of a contaminant. In the analysis, the sediment data is first screened by assuming that the diets of the representative species consist of 100% sediment. If the screening analysis indicates the possibility for adverse effects, the assessment is carried one step further by incorporating the fish data in addition to the sediment data. The assumption is that the contaminant concentrations in killifish are representative of the contaminant concentrations that the heron and raccoon would obtain through their diet. For this analysis, HQs were also calculated by dividing the dose obtained using mean concentrations by the lowest observed adverse effect level (LOAEL). This provides a range of HQs and gives an indication of some of the uncertainty in the analysis.

4.0 RESULTS

4.1 Sediment

Mass Fill 1 metal results were between 2.2 and 8.4 times greater than concentrations in sediments from the reference site (Table 5). Concentrations of arsenic (3.8 ppm), cadmium (1.6 ppm), chromium (57 ppm), copper (44 ppm), lead (168 ppm), mercury (0.19 ppm), nickel (39 ppm), and zinc (294 ppm) in the Mass Fill 1 sediment sample were greater than Mass Fill 2 (2.1, 0.73, 32, 32, 100, 0.10, 35, and 169 ppm, respectively) and the reference site (1.7, 0.25, 12, 13, 20, non-detect, 11, and 49 ppm, respectively). Because there was only one sediment sample collected at each of the three sites, these results could not be statistically compared.

Kenilworth Marsh sediments from Mass Fill 1 and Mass Fill 2 contained measurable amounts of total PCB (both 0.14 ppm), total DDT (0.088 and 0.067 ppm, respectively), and total chlordane (0.12 and 0.18 ppm, respectively). With the exception of three PCB congeners, no organochlorine compounds where detected in the Mason Neck NWR reference sample. None of the four PCB Aroclors (1242, 1248, 1254, and 1260) that are added to determine total PCB were detected in the reference sample.

4.2 Broad-leaf Cattails

Mean concentrations of arsenic, cadmium, chromium, copper, and nickel measured in cattails were not significantly different in samples collected from the three locations (ANOVA, $p > 0.05$) (Table 6). The differences between sites for lead and zinc were of borderline significance. Mean concentrations of lead were 2.0 ppm at Mass Fill 1, 1.2 ppm at Mass Fill 2, and 0.80 ppm at the reference site (ANOVA on log-transformed data, $p = 0.087$). Mean zinc concentrations were 130 ppm in cattails collected from Mass Fill 1, 97 ppm in cattails collected from Mass Fill 2, and 83 ppm in cattails from Mason Neck ($p = 0.054$, ANOVA on log-transformed data).

4.3 Killifish

The mean total lengths of killifish sampled in this study were 78 mm at Mass Fill 1, 70 mm at Mass Fill 2, and 72 mm at the Mason Neck NWR reference site (Table 2). The length of the smallest fish sampled in the study (62 mm) was 71% of the length of the largest (87 mm).

The mean chromium concentration at Mass Fill 1 (2.4 ppm) was significantly greater than the means at Mass Fill 2 (0.87 ppm) and the reference site (0.77 ppm; ANOVA, $p < 0.001$, Tukey's test, $p < 0.05$; Table 7). For copper, both Mass Fill 1 (2.8 ppm) and Mass Fill 2 (1.7 ppm) had mean concentrations that were significantly greater than the reference site (1.1 ppm; ANOVA, $p < 0.001$, Tukey's test, $p < 0.05$). The Mass Fill 1 mean copper value was also significantly greater than the Mass Fill 2 mean. The median lead concentration in Mass Fill 1 killifish (2.6 ppm) was significantly greater than results at the reference site, where no lead was detected (Kruskal-Wallis, $p < 0.001$; Dunn's method, $p < 0.05$). The Mass Fill 1 mean nickel concentration (1.2 ppm) was significantly greater than those for both Mass Fill 2 (0.28 ppm) and the reference site (0.18; ANOVA, $p < 0.001$, Tukey's test, $p < 0.05$). There was a significant difference between zinc concentrations in *F. diaphanus* and *F. heteroclitus* collected at Mason Neck (t-test, $p = 0.043$), therefore, zinc results from Kenilworth Marsh were compared separately to both of the species collected at Mason Neck. For *F. heteroclitus*, there was no significant difference between the sites. The mean zinc concentration in *F. diaphanus* from Mason Neck (96.4 ppm) was significantly greater than means for *F. heteroclitus* from both Kenilworth Marsh sites (Mass Fill 1 - 55.4 ppm, Mass Fill 2 - 58.0 ppm; ANOVA, $p = 0.007$, Tukey's test, $p < 0.05$). Concentrations of arsenic and cadmium were not statistically different among the sites.

Median total PCB concentrations in killifish at Mass Fill 1 (0.26 ppm) and Mass Fill 2 (0.35 ppm) were significantly higher than the reference site, where PCBs were not detected (Kruskal-Wallis, $p < 0.001$; Dunn's method, $p < 0.05$; Table 7). Median total DDT results for Mass Fill 1 (0.065 ppm) and Mass Fill 2 (0.062 ppm) were significantly greater than the median from the reference site (0.030 ppm; Kruskal-Wallis, $p < 0.001$; Dunn's method, $p < 0.05$). Median total chlordane concentrations at Mass Fill 1 (0.074 ppm) and Mass Fill 2 (0.068 ppm) were also significantly higher than the reference median, where chlordane was not detected (Kruskal-Wallis, $p < 0.001$; Dunn's method, $p < 0.05$). The analysis of lipid normalized total chlordane data showed that Mass Fill 1 killifish contained significantly greater levels of chlordane than Mass Fill 2 killifish (Mann-Whitney Rank Sum Test, $p = 0.003$). Neither total PCBs nor total DDT concentrations were lipid normalized because there were not significant regressions between concentrations and lipid content.

5.0 DISCUSSION

5.1 Sediment

Although concentrations of sediment associated contaminants could not be compared statistically, they appear to be higher at Kenilworth Marsh (Table 5). Of the three sites, Mass Fill 1 sediment contaminant concentrations were almost always highest, followed by Mass Fill 2 and the reference site. Results for the Mass Fill 1 sample were from 2.2 to 8.4 times greater than concentrations found in the reference site sample. Total chlordane was the only analyte that was greater at Mass Fill 2 (0.18 ppm) than at Mass Fill 1 (0.12 ppm). Grain size analysis indicated that Mass Fill 1, Mass Fill 2, and reference sediments contained 93.3 %, 92.0%, and 80.0 % fines, respectively. Higher contaminant levels are more likely to be found in finer sediments, possibly accounting for lower numbers at the reference site. Sediments with higher organic content, however, usually accumulate higher contaminant concentrations. The TOC of the reference sediment sample was 2.3%, twice as high as Mass Fill 1 (1.1%) and equivalent to Mass Fill 2, suggesting that physicochemical differences in sediments from Kenilworth Marsh and Mason Neck may not account for differences in contaminant concentrations.

For most contaminants, Mass Fill 1 concentrations were comparable to mean concentrations from nine samples collected in Mass Fill 1 and Mass Fill 2 in the 1993 USFWS study (USFWS 1997; Table 5). The exception was the mean concentration of total PCBs which was 0.76 ppm in 1993, well above the 0.14 ppm measured in Mass Fill 1 and Mass Fill 2 in this study. The results for the 1996 Mass Fill 2 sediment sample were, in general, lower than the 1993 means.

Velinsky *et al.* (1994) and Wade *et al.* (1994) collected sediments in the Anacostia River and Kingman Lake in 1991 (Table 5). In general, sediment concentrations from the Anacostia in 1991 were slightly higher than those found in Kenilworth Marsh in 1993 and Mass Fill 1 in 1996. Specifically, chromium, copper, lead, and mercury mean values in the 1991 river sediments were greater than those found in Kenilworth Marsh in 1993 and 1996 (arsenic and nickel were not analyzed in 1991). Total DDT and total chlordane in the 1993 Kenilworth samples (0.088 ppm and 0.17 ppm, respectively) and 1996 Kenilworth samples (0.088 ppm and 0.12 ppm, respectively) were greater than in the 1991 river samples (0.066 ppm and 0.10 ppm, respectively). The mean 1993 Kenilworth Marsh concentration of PCBs (0.76 ppm) and the mean 1991 river sample concentration (0.70 ppm), were higher than the 1996 Kenilworth Marsh concentrations (both 0.14 ppm). Also included in Table 5 are reference data from the Potomac River at Washington, D.C. (USFWS 1997; Velinsky *et al.* 1994; Wade *et al.* 1994). In general, contaminant concentrations in the Potomac River sediments were lower than those measured in the Anacostia River and Kenilworth Marsh.

Sediment quality guidelines are listed in Table 8. Concentrations of lead (168 ppm), zinc (294 ppm), and total chlordane (0.12 ppm) in the Mass Fill 1 sediment sample exceeded ER-M values and may be associated with adverse biological effects (Long and Morgan 1991). In addition, the nickel concentration exceeded the PEL, denoting a concentration where biological effects frequently occur (Smith *et al.* 1996). Other analytes found in Mass Fill 1 sediments at concentrations below the ER-M and PEL but greater than ER-L and/or TEL values denoting occasional biological effects include chromium, copper, mercury, total PCB, and total DDT. In Mass Fill 2 sediments, the total chlordane result (0.18 ppm) exceeded the ER-M value and lead (168 ppm) exceeded the PEL. Analytes whose concentrations in Mass Fill 2 sediments exceeded ER-Ls and/or TELs but were lower than ER-Ms and PELs include nickel, zinc, total PCB, and total DDT. No ER-L, TEL, ER-M, or PEL values were exceeded in the Mason Neck NWR reference sample. In the 1993 Kenilworth marsh samples, ER-Ms and PELs were exceeded for lead, nickel, zinc, total PCB, and total chlordane, and the chromium result was greater than the PEL but less than the ER-M. Arsenic, copper, mercury, and total DDT were detected in sediments collected in 1993 at concentrations that exceeded ER-Ls and/or TELs.

5.2 Broad-leaf Cattails

Wet weight concentrations of arsenic, cadmium, chromium, copper, lead, nickel, and zinc were similar in broad-leaf cattail roots from Kenilworth Marsh Mass Fill 1, Mass Fill 2, and the Mason Neck NWR reference site (Table 6). Interestingly, metal concentrations in Mass Fill 1 sediments were 2.2 to 8.4 times greater than concentrations in Mason Neck sediments, but these differences were not apparent in the cattail root concentrations. Only lead and zinc were found at concentrations in Mass Fill 1 cattail roots that were close to being significantly higher than the concentrations in cattail roots from Mason Neck. The lack of significant difference in cattail root concentrations may reflect the much more mature marsh at Mason Neck and/or be related to physical/chemical conditions in the marshes. Accumulation of metals in cattails could have been affected negatively or positively by the chemical form of each metal, the pH of the water and wetland sediments, water hardness, nutrient quantity, quantity and nature of suspended solids, the quantity of organic matter, sediment sulfide content, percentage of silt and clay, and the cation exchange capacity of the sediments (Pain 1995; Di Toro *et al.* 1990). The distribution pattern of metals in plant tissues is unique for each metal and varies depending on the degree of contamination to the sediments (Miller *et al.* 1983). Some portion of certain metals accumulated by cattails in Kenilworth Marsh may be transferred from the roots to the leafy parts of the plant which die off every year and become detritus, thus expelling some of the metal tissue burden to the aquatic environment.

Mean dry weight results for zinc in cattails were 924, 663, and 886 ppm zinc at Mass Fill 1, Mass Fill 2, and the Mason Neck NWR reference site, respectively (Appendix C). Eisler (1993) noted that adverse effects occur in sensitive mammalian species at zinc concentrations in diet as low as 80 to 300 ppm dry weight. Harmful effects were seen in mice fed a diet containing 500 ppm zinc for three months (PHS 1989). While none of the cattail root samples from this study contained levels of zinc that are associated with death in mammals, sublethal effects to animals such the muskrat which feed on marsh vegetation are possible in both Kenilworth Marsh and the Mason Neck NWR reference site. No other metals of concern to this study were found at concentrations in cattail roots which have been shown to cause adverse effects to herbivorous mammals (Eisler 1985, 1986, 1988a, 1988b, 1993, 1998a, 1998b; Demayo *et al.* 1982; Demayo *et al.* 1980).

5.3 Killifish

Wet weight concentrations of chromium, copper, lead, nickel, total PCB, total DDT, and total chlordane in killifish composite samples from Kenilworth Marsh were significantly greater than those in the Mason Neck NWR reference samples (Table 7). Analytes for which both Mass Fill 1 and Mass Fill 2 contained significantly greater concentrations than reference were copper, total PCBs, total DDT, and total chlordane. In addition, Mass Fill 1 results for chromium, copper, nickel, and total chlordane were significantly greater than those found in Mass Fill 2 samples. Because *F. diaphanus* and *F. heteroclitus* from Mason Neck were found to have significantly different zinc concentrations, they were compared to Kenilworth Marsh results separately. The Mason Neck *F. diaphanus* contained significantly greater concentrations of zinc than the *F. heteroclitus* from both Kenilworth Marsh and Mason Neck.

In a 1995 study, the CBFO found that banded killifish (*F. diaphanus*) and mummichogs (*F. heteroclitus*) from Quantico embayment on the Potomac River in Quantico,Virginia contained high concentrations of PCBs and DDT (compared to a reference location) as a result of landfilling and other activities on Quantico Marine Base (Pinkney *et al.* 1997). Mean concentrations of total PCBs in Kenilworth Marsh killifish were similar to those found in killifish from Quantico embayment. Total DDT results in Quantico killifish were an order of magnitude higher than concentrations found in Kenilworth Marsh killifish.

To determine whether analyte concentrations in killifish were high compared to national values, organochlorine results were compared to National Contaminant Biomonitoring Program (NCBP) results summarized by Schmitt *et al.* (1990) and metal results were compared to NCBP results summarized by Schmitt and Brumbaugh (1990; Table 7). Arsenic, cadmium, copper, and zinc results exceeded the 85th percentile of the NCBP in at least one sample from all three sites. The 85th percentile concentration for lead was exceeded at the Kenilworth Marsh sites but not at the reference site. Chromium and nickel were not analyzed as part of the NCBP. Frequency of exceedance was greatest in Mass Fill 1 samples, followed by Mass Fill 2 and the reference site. For the Mass Fill 1 killifish, the 85th percentiles for copper, lead, and zinc were exceeded in 100% of the samples. The 85th percentiles for copper and zinc were exceeded in 100% of the Mass Fill 2 samples. Zinc was the only analyte for which the 85th percentile was exceeded in 100% of the reference samples.

Since 85th percentile values were not determined for organochlorines in the NCBP, total PCB, total DDT, and total chlordane, killifish results were compared to NCBP geometric means. No PCB or DDT results were greater than the geometric means for those analytes. Since no NCBP values were determined for total chlordane, comparisons were made using alpha-chlordane results. The NCBP geometric mean for alpha-chlordane was exceeded in two of eight samples from Mass Fill 1 and two of eight samples from Mass Fill 2. Chlordane was not detected in reference killifish composites.

Whitehead (1995) suggested that mummichogs are among the most sedentary of all fish species. The summer home range for a population of mummichogs in a Delaware tidal creek was estimated at 36 meters (Lotrich 1975). Based on this information, the mummichogs sampled in Mass Fill 1 and Mass Fill 2 probably live and accumulate most of their tissue contaminants in Kenilworth Marsh. As noted earlier, banded killifish comprised one-half of the composite samples from the reference site. No data are available concerning the home range of banded killifish.

Eisler (1986) suggested that fish and wildlife tissue containing greater than 4 ppm total chromium as dry weight is indicative of chromium contamination. The average total chromium level in killifish from Mass Fill 1 was 10 ppm dry weight (Appendix C), over two times greater than the Eisler threshold. The mean total chromium dry weight results for Mass Fill 2 and the reference site were 3.7 and 3.4 ppm, respectively.

Eisler (1993) concluded that bird diets should contain <178 ppm zinc as dry weight to prevent sublethal effects. Most of the zinc results in killifish tissue for all three sites were greater than this value. Mean zinc tissue concentrations in dry weight for Mass Fill 1, Mass Fill 2, and the reference site were 236, 246, and 316 ppm, respectively (Appendix C). These results suggest that tissue levels of zinc in killifish from both Kenilworth Marsh and Great Marsh at Mason

Neck NWR might result in adverse effects to fish-eating birds that feed in these areas if other prey species have similar concentrations. Acute effects such as mortality are not expected in birds until zinc concentrations in food reach at least 2000 ppm (Eisler 1993). As discussed earlier, Eisler (1993) noted that adverse effects occurred in mammalian species at dietary levels as low as 80 to 500 ppm zinc as dry weight. If these zinc concentrations are present in fish and other components of the diet of omnivorous mammals such as the racoon, adverse sublethal effects could occur. Based on the killifish data, these effects are as likely to occur at Mason Neck as at Kenilworth Marsh.

Other analytes (arsenic, cadmium, copper, lead, nickel, total PCBs, total DDT, and total chlordane) that were found at concentrations in fish tissue that significantly exceeded reference results, were greater than 85th percentile of the NCBP, or were greater than the geometric mean of the NCBP, were not detected at concentrations that have been found to be associated with anthropogenic contamination or adverse effects to prey fish or piscivorous fish, birds, and mammals (Beyer *et al.* 1996; Eisler 1985, 1986, 1988a, 1988b, 1990, 1993, 1996, 1998a, 1998b; Hoffman *et al.* 1995; Moore and Ramamoorthy 1984; Demayo *et al.* 1982; Demayo *et al.* 1980). However, data gaps concerning effects to ecological receptors exist for most of these analytes.

5.4 Food Chain Analysis

The food chain models were first run with the maximum fish and sediment concentrations used as inputs and the doses compared against the NOAELs. For Kenilworth Marsh, green heron HQs greater than or equal to one were calculated for total chlordane (1.0), copper (3.0), lead (2.0), and zinc (1.1; Table 9). Mason Neck green heron HQs were greater than or equal to one for total chlordane (1.0), copper (2.0), and zinc (1.9). For Kenilworth Marsh, there were raccoon HQs greater than or equal to one for total PCBs (1.0), arsenic (1.0), chromium (4.7), and lead (6.0). Mason Neck raccoon HQs were greater than or equal to one for arsenic (1.0), chromium (1.3), and zinc (1.3). Spreadsheets with the risk analysis are contained in Appendix D.

Next, the food chain models were run with the mean fish and sediment concentrations used as inputs and the doses compared against the LOAELs. For green heron, no Kenilworth Marsh or Mason Neck HQs were equal to or greater than one. For Kenilworth Marsh, a raccoon HQ of 1.0 was obtained for total PCBs. No Mason Neck raccoon HQs were greater than or equal to one.

There is uncertainty inherent in the risk assessment process that should be considered when interpreting results. Because of this uncertainty, risk calculations are performed initially using the most conservative values found in the literature. This reduces the potential for finding no risk when risk is actually present. The analysis is repeated using less conservative inputs to provide a risk range. Based on these analyses, ecological receptors at Kenilworth Marsh and Mason Neck NWR may be at risk from exposure to contaminants obtained through the food chain. For both sites, the HQs are in the low range (<1-6) for the conservative model and still lower ($\leq$1) for the less conservative model. Risk management recommendations in cases where HQs are this low, often stress monitoring rather than active remediation.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Sediment samples collected from Kenilworth Marsh in 1993 (USFWS 1997) and 1996 contained concentrations of chromium (1993 only) lead, nickel, zinc, total PCB (1993) and total chlordane that exceed sediment quality guidelines above which toxic effects frequently occur (ER-Ms and PELs). In addition, several analytes in sediments exceeded thresholds that are occasionally associated with adverse biological effects (ER-Ls and TELs). These include arsenic (1993), chromium, copper, mercury, total PCB (1996), and total DDT. No sediment quality guidelines were exceeded in reference sediment samples. Mass Fill 2 sediments generally contained lower contaminant concentrations than Mass Fill 1 and the 1993 results. Concentrations of sediment associated contamination in Kenilworth Marsh in 1993 and 1996 were higher than those from the reference site at Mason Neck NWR. In general, sediment concentrations in the Anacostia River in 1991, Kenilworth Marsh in 1993, and Kenilworth Marsh in 1996 are comparable, with a slight decreasing trend from 1991 to 1996.

There were no significant differences between metal concentrations in cattail root material from Kenilworth Marsh and the reference site. Because the marsh at Mason Neck is more mature than Kenilworth Marsh, the lack of significant difference in cattail root concentrations may result from differences in physical/chemical conditions in the marshes which may affect the bioavailability of sediment associated metals. Also, some portion of certain metals accumulated by cattails may be transferred from the roots to the leafy parts of the plant, which die off every year and become detritus, eliminating some of the metal tissue burden to the environment. Zinc concentrations found in cattails from both locations may pose risks to mammalian species.

Concentrations of chromium, copper, lead, nickel, total PCB, total DDT, and total chlordane in killifish collected in Kenilworth Marsh were significantly greater than in killifish collected at a reference site at Mason Neck National Wildlife Refuge. Concentrations were also compared with results of the National Contaminant Biomonitoring Program which measured whole body residues of organic and inorganic contaminants in freshwater fish in the mid 1980's. Metals found in fish tissue in exceedance of the 85th percentile of national concentrations included arsenic, cadmium, copper, lead, and zinc (no 85th percentile values were determined for nickel and chromium). Organochlorines that exceeded the national mean included total PCB, total DDT, and alpha chlordane. These results suggest that concentrations of certain contaminants in killifish living in Kenilworth Marsh are high when compared to regional and national values. In addition, zinc was found in Kenilworth Marsh fish tissue at concentrations that may pose risks to piscivorous birds and are above thresholds that are theorized to be harmful to mammals.

The Mason Neck NWR reference site fish samples contained the highest zinc fish tissue burdens in this study. Zinc levels in reference cattails were not significantly different than concentrations in Kenilworth Marsh cattail roots. The sediment sample collected at the reference site contained zinc at a concentration that was much lower than those found at Kenilworth Marsh and also lower than ecological thresholds that are associated with adverse effects. Although more samples would be required to effectively determine the reason for the high fish tissue burdens at Mason Neck NWR, it may be the result of higher contaminant bioavailability in Mason Neck sediments or the existence of a contaminant source other than the aquatic sediments.

A food chain analysis using sediment and fish data from this study suggested that contaminants in sediments and biota in Kenilworth Marsh may pose potential risks to piscivorous birds and mammals. The hazard quotients, however, are low (<1 to 6 using highly conservative assumptions; ≤ 1 using less conservative assumptions), and risk management recommendations with this level of risk frequently involve monitoring rather than remediation.

The results of this study suggest that: (1) concentrations of certain contaminants in sediments, killifish, and cattails are elevated; (2) certain contaminants originating in Anacostia River dredge sediments used to construct a wetland at Kenilworth Marsh are accumulating in killifish; (3) several inorganic and organic contaminants were found at concentrations that have been associated with adverse effects to fish-eating birds, mammals, and aquatic biota; (4) and potential ecological risks exist associated with trophic transfer of select contaminants. Based on the results of this and previous studies and the high uncertainty associated with potential effects at higher trophic levels, the Service recommends that Anacostia River sediments be used for marsh restoration purposes only on a limited basis in the Anacostia watershed. More in-depth studies should be performed in Kenilworth Marsh to determine the extent and magnitude of contamination to biota and the possible ecological effects of that contamination in higher trophic levels.

Suggested further studies in Kenilworth Marsh include:

- continued sampling and chemical analysis of killifish, cattails, and sediments in the future to determine temporal trends in contaminant concentrations;

- sampling and analysis of tissue levels in other biota inhabiting the marsh, such as benthic macroinvertebrate species which make up a large portion of the food base for many fish and migratory bird species;

- amphibian sampling to determine contaminant tissue burdens, population status, and frequency of deformities in this sensitive phyla;

- and bioaccumulation studies to determine whether marsh sediment contaminants have the potential to accumulate in biota (bioaccumulation studies are being performed in Kenilworth Marsh during the summer of 1998).

Future use of Anacostia River dredge sediments for restoration should be evaluated on a case-by-case basis. Sediments should be tested for toxicity and chemically characterized and compared to ecological guidelines prior to use as restoration substrates. In addition, marsh creation projects using Anacostia sediments should be subjected to post-restoration monitoring to determine the potential effects of sediment associated contaminants on the developing wetland communities. Monitoring plans and sediment chemistry analyses should be completed and presented to the Kenilworth Marsh Monitoring Committee for comment prior to construction. Monitoring should continue for at least 10 years following construction and should include investigations similar to those listed above.

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Table 1. Cattail and sediment sample locations - Kenilworth Marsh and Mason Neck National Wildlife Refuge, 1996.

Sample Number	Location	GPS
K0101TTY	Kenilworth MF-1	N38°54.905' W76°56.668'
K0102TTY	Kenilworth MF-1	N38°54.905' W76°56.668'
K0103TTY	Kenilworth MF-1	N38°54.905' W76°56.668'
K0104TTY	Kenilworth MF-1	N38°54.905' W76°56.668'
K0105TTY	Kenilworth MF-1	N38°54.905' W76°56.668'
K0106TTY	Kenilworth MF-1	N38°54.905' W76°56.668'
K0107TTY	Kenilworth MF-1	N38°54.905' W76°56.668'
K0108TTY	Kenilworth MF-1	N38°54.905' W76°56.668'
K0201TTY	Kenilworth MF-2	N38°54.601' W76°56.872'
K0202TTY	Kenilworth MF-2	N38°54.601' W76°56.872'
K0203TTY	Kenilworth MF-2	N38°54.601' W76°56.872'
K0204TTY	Kenilworth MF-2	N38°54.601' W76°56.872'
K0205TTY	Kenilworth MF-2	N38°54.601' W76°56.872'
K0206TTY	Kenilworth MF-2	N38°54.601' W76°56.872'
K0207TTY	Kenilworth MF-2	N38°54.601' W76°56.872'
K0208TTY	Kenilworth MF-2	N38°54.601' W76°56.872'
M0101TTY	Mason Neck	N38°37.969' W77°10.128'
M0102TTY	Mason Neck	N38°37.969' W77°10.128
M0103TTY	Mason Neck	N38°37.969' W77°10.128
M0104TTY	Mason Neck	N38°37.969' W77°10.128
M0105TTY	Mason Neck	N38°37.969' W77°10.128
M0106TTY	Mason Neck	N38°37.969' W77°10.128
M0107TTY	Mason Neck	N38°37.969' W77°10.128
M0108TTY	Mason Neck	N38°37.969' W77°10.128

Table 2. Killifish sample locations and mean total fish lengths - Kenilworth Marsh and Mason Neck National Wildlife Refuge, 1996.

Sample Number*	Location	GPS	x̄ Length & Range (mm)
K0101TFH	Kenilworth MF-1	N38°54.843' W76°56.547'	82 (79-86)
K0102TFH	Kenilworth MF-1	N38°54.843' W76°56.547'	82 (70-87)
K0103TFH	Kenilworth MF-1	N38°54.843' W76°56.547'	79 (70-87)
K0104TFH	Kenilworth MF-1	N38°54.843' W76°56.547'	75 (70-82)
K0105TFH	Kenilworth MF-1	N38°54.843' W76°56.547'	75 (70-83)
K0106TFH	Kenilworth MF-1	N38°54.843' W76°56.547'	76 (71-82)
K0107TFH	Kenilworth MF-1	N38°54.843' W76°56.547'	79 (71-85)
K0108TFH	Kenilworth MF-1	N38°54.843' W76°56.547'	75 (70-84)
K0201TFH	Kenilworth MF-2	N38°54.596' W76°56.747'	72 (63-83)
K0202TFH	Kenilworth MF-2	N38°54.596' W76°56.747'	71 (65-87)
K0203TFH	Kenilworth MF-2	N38°54.596' W76°56.747'	70 (62-79)
K0204TFH	Kenilworth MF-2	N38°54.596' W76°56.747'	68 (65-80)
K0205TFH	Kenilworth MF-2	N38°54.596' W76°56.747'	68 (62-77)
K0206TFH	Kenilworth MF-2	N38°54.596' W76°56.747'	68 (62-75)
K0207TFH	Kenilworth MF-2	N38°54.596' W76°56.747'	70 (63-75)
K0208TFH	Kenilworth MF-2	N38°54.596' W76°56.747'	73 (66-77)
M0101TFH	Mason Neck	N38°38.364' W77°09.517'	71 (65-85)
M0102TFH	Mason Neck	N38°38.364' W77°09.517'	70 (63-84)
M0103TFH	Mason Neck	N38°38.364' W77°09.517'	68 (62-81)
M0104TFH	Mason Neck	N38°38.364' W77°09.517'	70 (63-80)
M0105TFH	Mason Neck	N38°38.364' W77°09.517'	75 (62-82)
M0106TFH	Mason Neck	N38°38.364' W77°09.517'	76 (66-82)
M0107TFH	Mason Neck	N38°38.364' W77°09.517'	75 (70-82)
M0108TFH	Mason Neck	N38°38.364' W77°09.517'	70 (65-77)

* M0101TFH through M0105TFH were Banded Killifish (*Fundulus diaphanus*) samples

Table 3. Water quality results for fish sampling stations - Kenilworth Marsh and Mason Neck National Wildlife Refuge, 1996.

Parameter	Kenilworth Mass Fill 1 8/9/96	Kenilworth Mass Fill 2 8/15/96	Mason Neck Great Marsh 8/28/96	Mason Neck Great Marsh 8/29/96
Conductivity (micromhos/cm)	336	208	219	221
Temperature (°C)	24.31	22.21	25.77	26.10
Dissolved Oxygen (ppm)	1.52	2.16	5.03	5.49
Dissolved Oxygen (% Saturation)	17.4	23.4	61.5	67.5
pH	6.94	6.87	7.42	7.41
Salinity (ppt)	0.2	0.1	0.1	0.1
Total Depth (m)	0.1	0.2	0.9	0.8

Table 4. List of analytes and desired detection limits (ppm dry wt.).

Analyte	Method	Detection Limit -- Tissue	Detection limit -- Sediment
Aluminum	ICP	5.0	10.0
Arsenic	AA	0.50	0.50
Barium	ICP	1.0	1.0
Beryllium	ICP	0.10	0.20
Boron	ICP	2.0	10.0
Cadmium	ICP	0.10	0.20
Chromium	ICP	0.50	1.0
Copper	ICP	0.50	1.0
Iron	ICP	5.0	10.0
Lead	ICP	0.50	5.0
Magnesium	ICP	5.0	10.0
Manganese	ICP	1.0	5.0
Mercury	AA	0.20	0.20
Molybdenum	ICP	2.0	5.0
Nickel	ICP	0.50	5.0
Selenium	AA	0.50	1.0
Strontium	ICP	0.50	5.0
Vanadium	ICP	0.50	1.0
Zinc	ICP	1.0	5.0

Desired detection limits for organochlorines: 0.01- 0.05 ppm

Table 5. Summary of contaminant data in sediment samples (ppm dry wt.) - Kenilworth Marsh (1993, 1996), Mason Neck National. Wildlife Refuge (1996), Anacostia River (1991), and the Potomac River (1991, 1993).

Analyte	Kenilworth Mass Fill 1 1996	Kenilworth Mass Fill 2 1996	Mason Neck Great Marsh 1996	Kenilworth Marsh 1993, x̄ (Range), N=9 [1]	Potomac River Near Roosevelt Isl. 1993, x̄ (Range), N=2 [2]	Anacostia River and Kingman Lake 1991, x̄ (Range), N=11 [3]	Potomac River 1991, x̄ (Range), N=4 [4]
Arsenic	3.8	2.1	1.7	4.9 (3.8 - 6.5)+	3.6 (3.3 - 3.9)	-	-
Cadmium	1.6	0.73	0.25	1.5 (1.2 - 2.2)	0.43 (0.42 - 0.43)	1.9 (0.92 - 3.2)+	0.66 (0.52-0.99)+
Chromium	57+	32	12	63 (49 - 100)*++	27 (27 - 27)	115 (90 - 156) **++	74 (63 - 96) *++
Copper	49+	32	13	44 (32 - 64)+	26 (25 - 26)	89 (64 - 127)*+	42 (34 - 60)+
Lead	168**++	100*++	20	156 (108 - 180) **++	32 (30 - 34)	188 (83 - 409) **++	58 (32 - 128) **++
Mercury	0.19*+	0.10	ND	0.17 (0.15 - 0.20)*+	0.15 (0.12 - 0.18)*+	0.44 (0.28 - 1.0) *++	0.25 (0.13-0.56) *++
Nickel	39*++	35*+	11	41 (31 - 50) **++	32 (31 - 32)*+	-	-
Zinc	294**+	168*+	49	314 (250 - 413) **++	143 (141 - 145)*+	406 (279 - 512) **++	223 (168-365) **++
Total PCB	0.14*+	0.14*+	ND	0.76 (0.43 - 1.6) **++	0.054 (0.041-0.067)*+	0.70 (0.22 - 2.2)**++	0.12 (0.068-0.27) *+
Total DDT [5]	0.088*+	0.067*+	ND	0.088 (0.057 - 0.14) *+	0.009 (0.006-0.013)*+	0.066 (0.029-0.12) **+	0.032 (0.007-0.10)*+
Total Chlordane [6]	0.12**++	0.18**++	ND	0.17 (0.11 - 0.23) **++	ND	0.10 (0.028-0.15) **++	0.016 (0.005-0.042) **++
%Silt/Clay	93	92	80	73 (46 - 97)	69 (66 - 71)	94 (86 - 100)	87 (78 - 94)
%TOC	1.1	1.9	2.3	2.9 (2.2 - 4.0)	3.2 (2.9 - 3.5)	4.2 (3.0 - 6.1)	3.6 (2.4 - 4.

*Exceeds ER-L; **Exceeds ER-M; +Exceeds TEL; ++Exceeds PEL - Refer to Table 8 for numerical guidance values for each analyte.

(1) Data from 1993 sampling in Kenilworth Marsh (USFWS 1997)

(2) Potomac River reference data for samples collected near Roosevelt Island during the 1993 Kenilworth Marsh study (USFWS 1997)

(3) Data from 1991 sampling in the Anacostia River (N=6) and Kingman Lake (N=6); Inorganic data from Velinsky et al. 1994; Organic Data from Wade et al. 1994

(4) Data from 1991 sampling in the Potomac River; Inorganic data from Velinsky *et al.* 1994; Organic Data from Wade *et al.* 1994

(5) Total DDT values are the sum of o,p'-DDD, o,p'-DDE, o,p'-DDT, p,p'-DDD, p,p'-DDE, and p,p'-DDT; the 1993 and 1996 values were determined using ½ the detection limit for non-detects; the detection limits in these studies were above the ER-L and TEL for DDT and its metabolites

(6) Total chlordane values are the sum of oxychlordane, alpha chlordane, cis-nonachlor, gamma chlordane, and trans-nonachlor; the 1993 and 1996 values were determined using ½ the detection limit for non-detects; the detection limits in these studies were above the ER-L and TEL for the chlordane compounds

Table 6. Summary of contaminant data in broad-leaf cattail root samples (ppm wet wt.) - Kenilworth Marsh and Mason Neck National Wildlife Refuge, 1996

Analyte	Frequency of Detection	Mean ± Standard Deviation	Minimum	Maximum
Kenilworth Mass Fill 1				
Arsenic[a]	6/8	0.21±0.16	0.059	0.58
Cadmium[a]	6/8	0.041±0.027	0.013	0.088
Chromium[a]	8/8	1.7±1.2	0.72	3.7
Copper[a]	8/8	0.82±0.54	0.35	1.8
Lead[b]	8/8	2.0±2.0	0.63	6.2
Nickel[a]	8/8	0.86±0.59	0.39	2.2
Zinc[c]	8/8	130±34	78	174
Kenilworth Mass Fill 2				
Arsenic	5/8	0.16±0.08	0.074	0.25
Cadmium	4/8	0.024±0.011	0.013	0.088
Chromium	8/8	0.94±0.47	0.44	2.0
Copper	8/8	0.59±0.33	0.31	1.3
Lead	8/8	1.2±0.4	0.66	1.9
Nickel	8/8	0.60±0.28	0.33	1.2
Zinc	8/8	97±57	57	235
Mason Neck NWR Great Marsh				
Arsenic	7/8	0.20±0.09	0.047	0.31
Cadmium	7/8	0.025±0.010	0.010	0.038
Chromium	8/8	1.7±0.7	0.68	2.4
Copper	8/8	0.55±0.20	0.24	0.85
Lead	8/8	0.80±0.29	0.44	1.4
Nickel	8/8	0.98±0.44	0.33	1.4
Zinc	8/8	83±48	38	176

[a] No significant difference between mean concentrations in cattails from Kenilworth Marsh Mass Fill 1, Mass Fill 2, or Mason Neck NWR Great Marsh (ANOVA: As, p=0.59; Cd, p=0.11; Cr, p=0.14; Cu, p=0.32; Ni, p=0.26)

[b] No significant difference (ANOVA, log-transformed data, p=0.087)

[c] Of borderline significance (ANOVA, log-transformed data, p=0.054

Table 7. Summary of contaminant data in whole body killifish samples (ppm wet wt.) - Kenilworth Marsh and Mason Neck National Wildlife Refuge, 1996.

Analyte	Frequency of Detection	Mean ± Standard Deviation	Median	Minimum	Maximum	Frequency ≥ NCBP 85% Conc.[a]	Sites that are Significantly Different (p<0.05)[b]
Kenilworth Mass Fill 1							
Arsenic	6/8	0.29 ± 0.13	0.32 [c]	0.11	0.44	5/8	
Cadmium	3/8	0.033 ± 0.013	0.024[d]	0.023	0.054	1/8	
Chromium	8/8	2.4 ± 0.4[e]	2.3	1.8	3.2	*	>M, >K2
Copper	8/8	2.8 ± 0.5[f]	2.6	2.3	3.7	8/8	>M, >K2
Lead	8/8	2.8 ± 0.4	2.6[g]	2.4	3.4	8/8	>M
Nickel	8/8	1.2 ± 0.2[h]	1.2	0.95	1.5	*	>M, >K2
Zinc	8/8	55 ± 9.2	52[i]	45	74	8/8	
PCB	8/8	0.29 ± 0.06	0.26[j]	0.21	0.37	0/8	>M
DDT	8/8	0.064 ± 0.01[k]	0.065	0.057	0.071	0/8	>M
Chlordane	8/8	0.074 ± 0.011	0.074[l]	0.058	0.088	2/8**	>M
Kenilworth Mass Fill 2							
Arsenic	3/8	0.19 ± 0.10	0.12	0.14	0.33	3/8	
Cadmium	1/8	0.028 ± 0.014	0.023	0.022	0.062	1/8	
Chromium	8/8	0.87 ± 0.22	0.86	0.52	1.2	*	<K1
Copper	8/8	1.7 ± 0.4	1.6	1.3	2.4	8/8	>M, <K1
Lead	6/8	0.56 ± 0.33	0.53	0.23	1.3	6/8	
Nickel	5/8	0.28 ± 0.17	0.27	0.11	0.58	*	<K1
Zinc	8/8	58 ± 16	45	40	82	8/8	
PCB	8/8	0.37 ± 0.10	0.35	0.20	0.50	0/8	>M
DDT	8/8	0.063 ±0.01	0.062	0.053	0.078	0/8	>M
Chlordane	8/8	0.070 ± 0.016	0.068	0.054	0.093	2/8**	>M

Analyte	Frequency of Detection	Mean ± Standard Deviation	Median	Minimum	Maximum	Frequency ≥ NCBP 85% Conc.[a]	Sites that are Significantly Different (p<0.05)[b]
Mason Neck NWR Great Marsh							
Arsenic	3/8	0.19 ± 0.12	0.12	0.10	0.43	2/8	
Cadmium	1/8	0.027 ± 0.012	0.023	0.021	0.057	1/8	
Chromium	8/8	0.77 ± 0.13	0.74	0.60	1.0	*	<K1
Copper	8/8	1.1 ± 0.4	1.0	0.70	1.9	4/8	<K1, <K2
Lead	0/8	N/A	N/A	N/A	N/A	N/A	<K1
Nickel	4/8	0.18 ± 0.08	0.17	0.10	0.33	*	<K1
Zinc	8/8	72 ± 37	43	37	138	8/8	
PCB	0/8	N/A	N/A	N/A	N/A	N/A	<K1, <K2
DDT	3/8	0.032 ± 0.003	0.030	0.030	0.038	0/8	<K1, <K2
Chlordane	0/8	N/A	N/A	N/A	N/A	N/A	<K1, <K2

[a] NCBP 85th percentile value: arsenic: 0.27 ppm; cadmium: 0.05 ppm; copper: 1.0 ppm; lead: 0.22 ppm; zinc: 34 ppm; chromium and nickel: * no NCBP values were determined; total PCB and total DDT: no 85th percentile values were determined, however, Kenilworth Marsh and Mason Neck NWR levels are below the 1984 NCBP geometric means for total PCB (0.39 ppm) and total DDT (0.26 ppm) and are, therefore, below the respective 85th percentile values as well; chlordane: no NCBP values were determined for total chlordane, consequently, the comparison is between Kenilworth Marsh/Mason Neck alpha-chlordane results and the 1984 NCBP alpha-chlordane geometric mean of 0.03 ppm (no 85th percentile value was determined for alpha-chlordane)

[b] K1 = Kenilworth Marsh Mass Fill 1, K2 = Kenilworth Marsh Mass Fill 2, and M = Mason Neck NWR Great Marsh, > and < denote whether the mean or median levels are significantly greater than or less than those to which they are compared

[c] No significant difference between median arsenic concentrations in killifish from Kenilworth Marsh Mass Fill 1, Kenilworth Marsh Mass Fill 2, or Mason Neck NWR Great Marsh (Kruskal-Wallis, log-transformed data, p=0.20)

[d] No significant difference between median cadmium concentrations in killifish from Kenilworth Marsh Mass Fill 1, Kenilworth Marsh Mass Fill 2, or Mason Neck NWR Great Marsh (Kruskal-Wallis, log-transformed data, p=0.180)

[e] Significant differences between mean chromium concentration in Kenilworth Marsh Mass Fill 1 killifish and killifish from Kenilworth Marsh Mass Fill 2 and between Kenilworth Marsh Mass Fill 1 killifish and killifish from Mason Neck NWR Great Marsh (ANOVA, p<0.001, Tukeys test, p<0.05)

[f] Significant differences in mean copper concentrations between killifish from all three sites (ANOVA, p<0.001, Tukeys test, p<0.05)

[g] Significant differences between median lead concentration in Kenilworth Marsh Mass Fill 1 killifish and killifish from Mason Neck NWR Great Marsh (Kruskal-Wallis, log-transformed data, p<0.001, Dunn's method, p<0.05)

[h] Significant differences between mean nickel concentration in Kenilworth Marsh Mass Fill 1 killifish and killifish from Kenilworth Marsh Mass Fill 2 and between Kenilworth Marsh Mass Fill 1 killifish and killifish from Mason Neck NWR Great Marsh (ANOVA, p<0.001, Tukeys test, p<0.05)

[i] No significant difference between median zinc concentrations in killifish from Kenilworth Marsh Mass Fill 1, Kenilworth Marsh Mass Fill 2, or Mason Neck NWR Great Marsh (Kruskal-Wallis, log-transformed data, p=0.98)

[j] Significant differences between median total PCB concentration in Kenilworth Marsh Mass Fill 1 killifish and killifish from Mason Neck NWR Great Marsh and between Kenilworth Marsh Mass Fill 2 killifish and Mason Neck NWR Great Marsh killifish (Kruskal-Wallis, log-transformed data, p<0.001, Dunn's method, p<0.05)

[k] Significant differences between mean total DDT concentration in Kenilworth Marsh Mass Fill 1 killifish and killifish from Mason Neck NWR Great Marsh and between Kenilworth Marsh Mass Fill 2 killifish and Mason Neck NWR Great Marsh killifish (Kruskal-Wallis, p<0.001, Dunn's method, p<0.05)

[l] Significant differences between median total chlordane concentration in Kenilworth Marsh Mass Fill 1 killifish and killifish from Mason Neck NWR Great Marsh and between Kenilworth Marsh Mass Fill 2 killifish and Mason Neck NWR Great Marsh killifish (Kruskal-Wallis, p<0.001, Dunn's method, p<0.05)

Table 8. Sediment Guidance Values (ppm dry wt.).

Analyte	ER-L [a]	ER-M [a]	TEL[b]	PEL[b]
Arsenic	33	85	5.9	17
Cadmium	5	9	0.596	3.53
Chromium	80	145	37.3	90
Copper	70	390	35.7	197
Lead	35	110	35	91.3
Mercury	0.15	1.3	0.174	0.486
Nickel	30	50	18	36
Zinc	120	270	123	315
Total PCB	0.05	0.4	0.0341	0.277
Total DDT	0.003	0.350	0.007	4.45
Total Chlordane	0.0005	0.006	0.0045	0.0089

[a] Long and Morgan 1991
[b] Smith et al. 1996

Table 9. Summary of hazard quotients (HQs) derived for exposure to selected analytes through ingestion of fish and sediment - Kenilworth Marsh, 1996.

Analyte	Green Heron				Raccoon			
	HQ Based on NOAEL[a]		HQ Based on LOAEL[b]		HQ Based on NOAEL[a]		HQ Based on LOAEL[b]	
	Kenilworth Marsh	Mason Neck	Kenilworth Marsh	Mason Neck	Kenilworth Marsh	Mason Neck	Kenilworth Marsh	Mason Neck
Total Chlordane	**1.0**	**1.0**	0.1	0.0	0.0	0.0	0.0	0.0
Total PCBs	0.0	0.0	0.0	0.0	**1.0**	0.0	**1.0**	0.0
Arsenic	0.0	0.0	0.0	0.0	**1.0**	**1.0**	0.0	0.0
Chromium	0.0	0.0	0.0	0.0	**4.7**	**1.3**	0.2	0.1
Copper	**3.0**	**2.0**	0.2	0.1	0.9	0.4	0.1	0.0
Lead	**2.0**	0.0	0.1	0.0	**6.0**	0.0	0.4	0.0
Zinc	**1.1**	**1.9**	0.1	0.1	0.8	**1.3**	0.1	0.1

Numbers in bold indicate exceedances of the HQ threshold of 1, signifying the potential for adverse effects to the receptor.

[a]HQ based on the NOAEL and maximum tissue concentrations

[b]HQ based on the LOAEL and average tissue concentrations

Figure 1. General location of Kenilworth Marsh and Mason Neck NWR

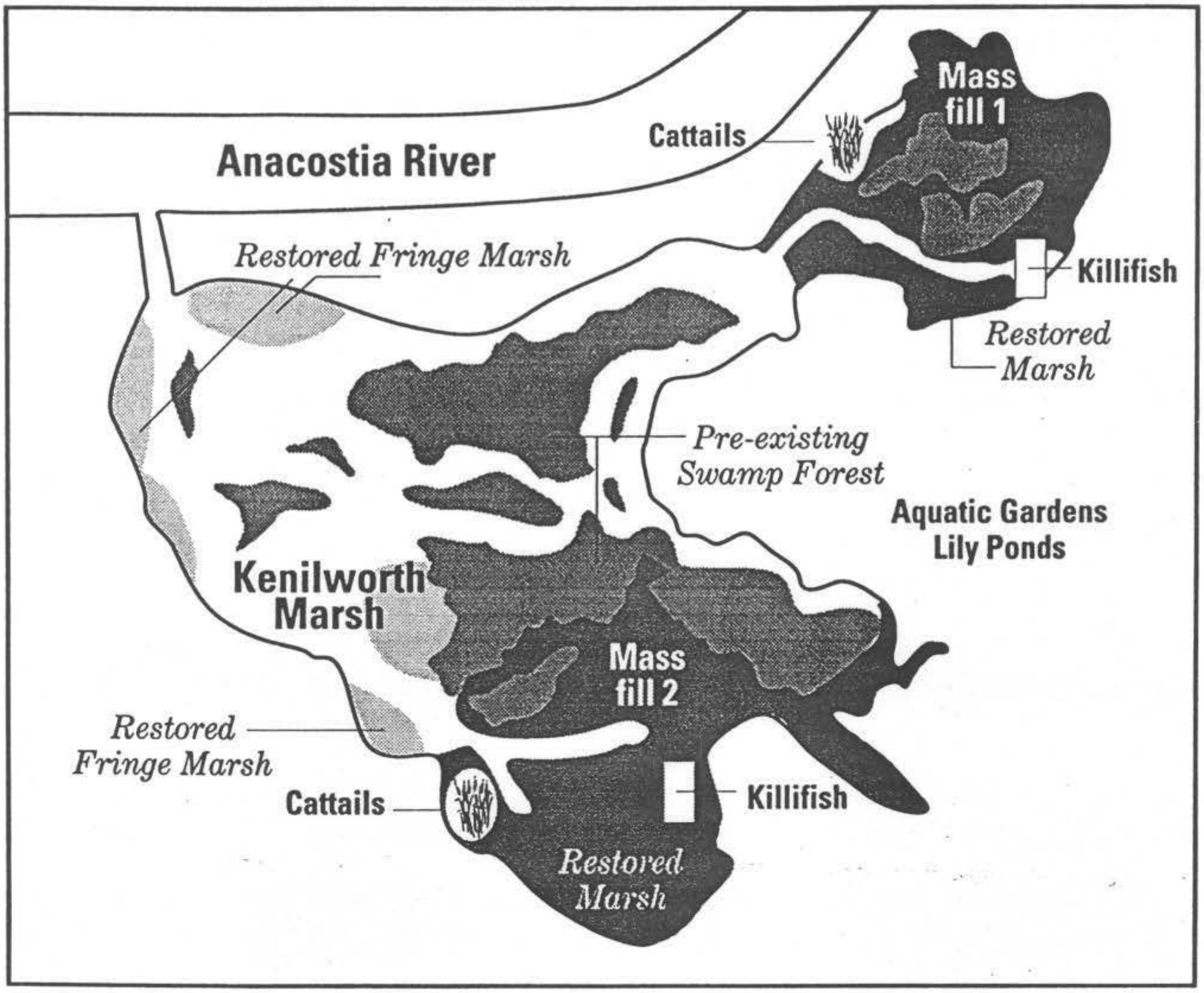


Figure 2. Kenilworth Marsh Mass Fill Sampling Areas

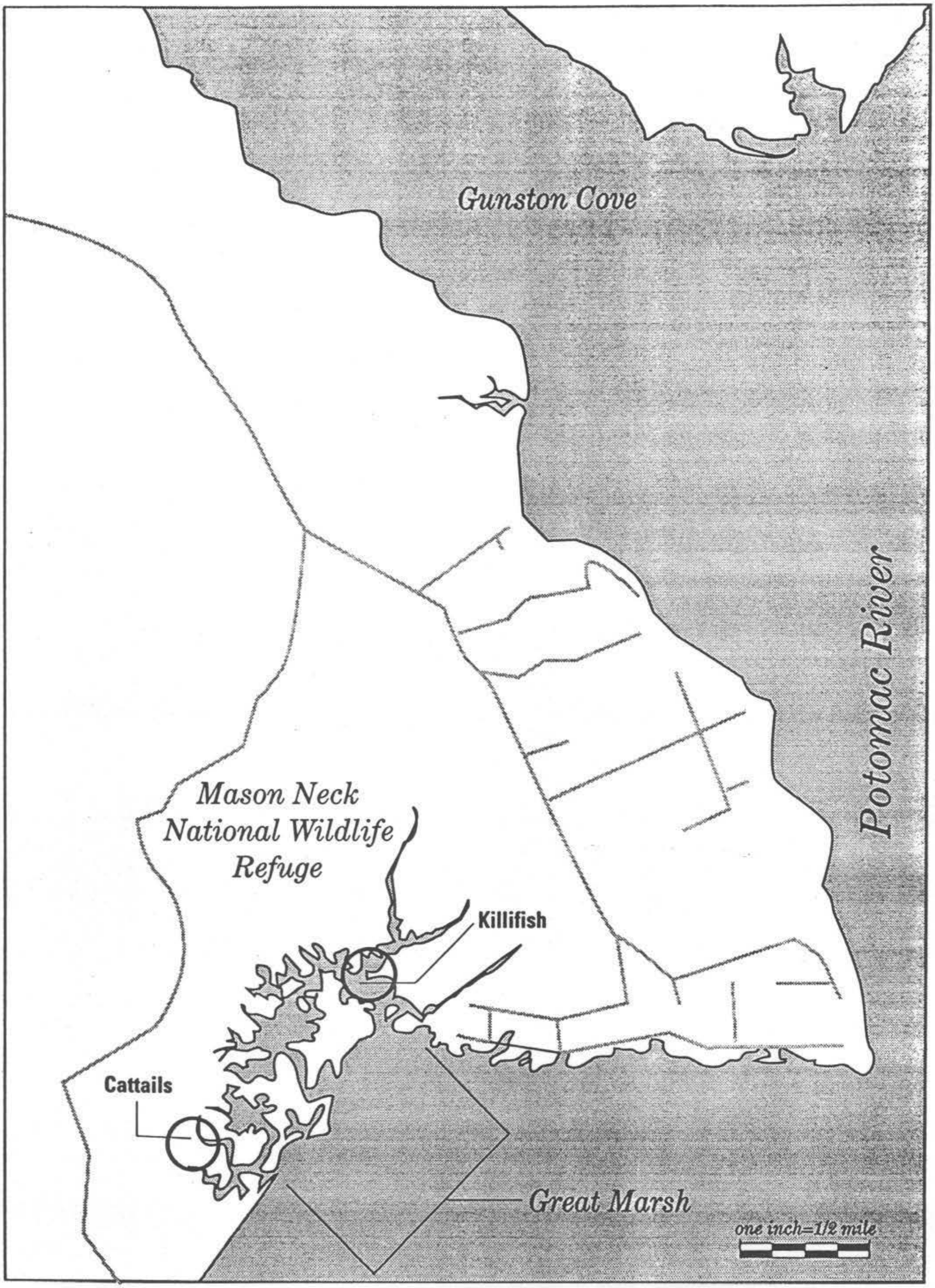


Figure 3. Mason Neck National Wildlife Refuge Sampling Areas (from Ft. Belvoir, VA USGS quad.)

Appendix A

Standard Operating Procedures

U.S. Fish and Wildlife Service

Chesapeake Bay Field Office

STANDARD OPERATING PROCEDURES

101. Data Recording and Handling

Revised 3/95; Version 95-1

A. Objective:

Describe the procedures used for data recording and handling in the field and in the laboratory.

B. Procedures:

1. All data will be recorded in indelible black ink at the time of observation.

2. Hand written data generated during a study will be recorded in a bound notebook. Each notebook will be used for one study only.

3. The biologist or technician recording the data will initial and date the bottom of each entry and the bottom of each page of the data book.

4. Corrections will be made by drawing one line through the error. Each error will be initialled, dated, and coded with an error code. The error code which best describes the reason for the correction can be chosen from the list below.

5. When not in use, notebooks will be stored in the study file along with any printed data or correspondence associated with the study. This file will also include the proposal, protocol, and catalog.

6. To prevent unretrievable loses of data through loss or destruction of the data book, certified copies of new data should be made daily during a study and placed in the study file.

Data Entry Error Codes

a - Inadvertently entered the wrong information.

b - Spelling error.

c - Write-over. Inadvertently wrote over existing data.

d - Data not recorded at time of initial observation.

U.S. Fish and Wildlife Service

Chesapeake Bay Field Office

STANDARD OPERATING PROCEDURES

113. COLLECTING SEDIMENTS FOR TOXICITY TESTING AND CHEMICAL ANALYSIS

Revised 9/93; Version 93-1

This SOP is based on the following guidance documents: ASTM 1991, EPA 1990, Maryland Department of the Environment 1989, and Puget Sound Estuary Program 1991.

A. Objective

1. Collection of samples for chemical and toxicological analyses to meet all QA/QC requirements for monitoring programs.

B. Chain of Custody

Chain of Custody forms will be initiated in the field as per SOP 102.

C. Preparatory Cleaning Procedures

1. For chemical analyses, use commercially prepared and certified pre-cleaned glass bottles with teflon lined lids. It is best to have several extra bottles for each type of analysis on board to allow for possible breakage or sampling error.

2. For toxicity testing, purchase 1/2 gallon polyethylene bottles from Western Plastics, Inc. (602-253-1163). Wash the bottles as follows:

a. Wash in laboratory detergent
b. Rinse with tap water to remove detergent
c. Rinse with 10% hydrochloric or nitric acid or immerse in water bath (no more than 10 minutes)
d. Rinse 5 times with distilled water
e. Rinse with pesticide grade acetone
f. Rinse 5 times with distilled water and allow to dry

3. This washing procedure is used to clean the polyethylene tub in which the dredge is emptied, the teflon or glass mixing bowl, and all utensils used to stir or spoon the samples (watch glasses, stirring rod, teflon coated spatula or spoon). For stainless steel items, rinse rather than immerse in acid.

D. Field Sampling Procedures

1. Label all jars for each sampling location, using an indelible marker on sampling labels that have been applied to the jars before going into the field.

2. Collect sediment using a stainless steel ponar, stainless steel Ekman dredge, steel shovel, or other sediment collection equipment.

Criteria for sample acceptability are as follows:

- Sampler is not overfilled and overlying water is present.
- Overlying water is not excessively turbid.
- The surface of the sediment is flat.
- The sample is at least 4-6 cm deep.

3. Deposit the sample on a clean polyethylene wash tub.

4. Remove the top 2 cm with a clean watch glass or teflon beaker cover and place in the teflon or glass mixing bowl. Do not collect any material that is in contact with the sampler. Do this by avoiding any material within 2.5 cm of the edges of the sampler.

5. Rinse the sampler in site water to remove excessive sediment and repeat grabs until sufficient sample has been obtained. The major consideration is to ensure that the grabs are collecting sediment that has not been disturbed by previous grabs.

6. Remove any large objects and drain excess water. Stir for at least 2 minutes to ensure that the sample is completely homogenized. Use either a teflon coated spoon (spatula) or a glass stirring rod.

7. Fill the sample jars for chemical analysis and then for toxicity testing.
8. If sediment samples for chemical analysis are to be frozen (for metals and organics analysis), allow about 1/3 head space in the jars.

9. If sediment samples are for analysis of acid volatile sulfides, fill completely to minimize head space. Store at 4 C and do not freeze.

10. At the time samples are collected, measure and record water quality parameters of interest and latitude and longitude from the global positioning system (GPS).

11. Between stations, rinse the sampler and all equipment that contacts samples as follows:

a. Rinse with site water, using a brush or hose to remove sediment.
b. Wash equipment with laboratory detergent (in site water)
c. Rinse with site water
d. Rinse twice with deionized water
e. Rinse with pesticide grade acetone

f. Rinse twice with deionized water

If an equipment blank is measured, collect samples by pouring the second rinse of deionized water over the sampler into the chemical analysis bottles (using a disposable polyethylene or clean glass funnel to aid the process).

12. Store all samples on ice in coolers. Maintain samples at 0-4 C from the time of collection until they are placed in storage at the laboratory.

13. For samples that will be frozen, loosen the caps at the time the jars are placed in the laboratory freezer to avoid breakage. Retighten the lids after 24 hours.

E. Safety Considerations for Collecting for Hazardous Site Studies

1. At least one of the samplers must have completed a 40-hour hazardous waste safety training course and be certified to wear a respirator.

2. All samplers should have Tyvek suits available with an extra supply on hand.
3. Face shields are advisable when handling sediments.

4. Two pairs of gloves should be worn: use vinyl gloves as a liner for rubber gloves that cover the wrists.

5. Perform all operations in an open area of the boat, away from all exhaust. If sediment is extremely odorous, a respirator should be worn by the person in closest contact with the sediment (the person who homogenizes and fills the sample bottles).

F. References

American Society for Testing and Materials (ASTM). 1991. Standard guide for collection, storage, characterization, and manipulation of sediments for toxicological testing. E 1391 - 90. ASTM, Philadelphia, PA.

Environmental Protection Agency (EPA). 1990. Environmental Monitoring and Assessment Program. Near Coastal Component. 1990 Demonstration Project. Training and field operations manual. (Draft)

Maryland Department of the Environment (MDE). 1989. Sample collection guidelines and techniques. MDE, Toxics, Environmental Science and Health, Ecological Assessment Division, Baltimore, MD.

Puget Sound Estuary Program 1991. Interim final recommended guidelines for conducting laboratory bioassays on Puget Sound sediments. Prepared for EPA Region 10, Seattle, WA. July, 1991.

U.S. Fish and Wildlife Service

Chesapeake Bay Field Office

STANDARD OPERATING PROCEDURES

114. PREPARING FISH AND INVERTEBRATE TISSUES FOR CHEMICAL ANALYSIS

Revised 1/97; Version 97-1

This SOP is based on the following guidance documents: Maryland Department of the Environment (1989), Puget Sound Estuary Program (1990a, b), and EPA (1995).

A. Objective

1. Collection and preparation of samples for chemical analyses to meet all QA/QC requirements for monitoring programs

B. Chain of Custody

1. Chain of Custody forms will be initiated in the field as per SOP 102.

C. Preparation

1. If aluminum foil is to be used for wrapping specimens, rinse the dull side of the foil in the following sequence: 10% nitric or hydrochloric acid, distilled water, pesticide residue grade acetone, and distilled water. Allow the foil to dry and place in polyethylene bags.

2. Obtain sufficient one liter or 0.5 liter commercially prepared and certified pre-cleaned glass bottles with teflon lids.

D. Fish and Invertebrate Collection

1. Collection methods include electrofishing, various nets, rod and reel, and crab and eel pots. Collection using electrofishing techniques requires that at least one USFWS staff member be certified by an agency electrofishing course.

2. Fish and invertebrates are placed in 5 gallon buckets which are labelled according to each collection site. Care in labelling the buckets is vital -- use waterproof markers and cards that are tied to the bucket handles. If a particular size is targeted it may be necessary to capture a large number of specimens, sort by size, and release those not needed. In this case, it is essential that sufficient site water and buckets be used to avoid mortality.

E. Packaging Whole Specimens

1. To store whole fish or crabs for resection at the analytical laboratory, rinse the fish with deionized water, pat dry with a paper towel, and place an identifying tag in the fish mouth. Wrap with the dull side of the aluminum foil facing the specimen. Use wrapping tape to encircle the specimen. Attach a stick-on sample label to the outside of the aluminum foil. Place in a ziplock or plastic trash bag. Use indelible marker to identify the specimen on the plastic bag.

2. Store prepared specimen on ice. In the laboratory, freeze specimens and send packed in dry ice to analytical laboratory.

F. Tissue Resection

1. Fish are scaled according to EPA (1995) methods by laying it flat on aluminum foil and using a stainless steel knife that is cleaned with distilled water between each sample.

2. Fish total length and crab carapace width are measured to the nearest millimeter. Whole specimens are weighed.

3. Fish are filleted and crabs are picked to obtain samples of tissues of concern for human health risk assessment.

4. Use only stainless steel instruments and dissecting trays. Clean these between composite samples by:

a. Washing in laboratory detergent
b. Rinsing with tap water
c. Rinsing with deionized water
d. Rinsing with pesticide grade acetone or isopropanol
e. Rinsing with distilled water

5. Filleting follows EPA (1995) methods. Typically, the skin is removed from fish without scales (catfish and eels). Skin-on fillets should include the belly flap and dark muscle.

6. If whole body analyses are to be performed on the remainder of the tissue, small specimens will be placed in chemically clean sample jars. Large samples will be double wrapped in aluminum foil and labelled as described in D.1.

G. Compositing

1. For analysis of organics and metals, a total of 100 grams of tissue is required. This may necessitate compositing of a number of specimens into a single sample. Compositing may also be used as a method of gaining a more accurate estimate of the average concentration of fish from a site when only a small number of samples can be analyzed.

2. Size considerations addressed by EPA (1995) are used as guidance. Within each composite the

shortest fish should be at least 75% of the longest fish. The average lengths of the individual fish from replicate composite samples from the same site should be within 10% (unless different size classes are targeted).

H. Shipping

1. Follow general guidelines of SOP 103 for general sample handling and shipment of samples.

2. Ship all tissue samples with dry ice following overnight shippers packing and labelling instructions.

I. References

Environmental Protection Agency (EPA). 1995. Guidance for assessing chemical contamination data for use in fish advisories. Volume 1 Fish sampling and analysis. Second Edition. Office of Water, Washington, DC.

Maryland Department of the Environment (MDE). 1989. Sample collection guidelines and techniques. MDE, Toxics, Environmental Science and Health, Ecological Assessment Division, Baltimore, MD.

Puget Sound Estuary Program 1990a. Recommended guidelines for measuring organic compounds in Puget Sound sediments and tissue samples. Prepared by PTI Environmental Services for EPA Region 10, Seattle, WA.

Puget Sound Estuary Program 1990b. Recommended guidelines for measuring metals in Puget Sound water, sediment, and tissue samples. Prepared by PTI Environmental Services for EPA Region 10, Seattle, WA.

Appendix B

Analytical Methods

ANALYTICAL METHODS

Method Code	Method Description
001	LABORATORY: Research Triangle Institute

I. Homogenization. Tissue samples are prehomogenized using a food processor. A portion of the tissue sample (or sediment) is then freeze dried for determination of moisture content and ground to 100 mesh with a mill.

004 LABORATORY: Research Triangle Institute

IV. Digestion for Graphite Furnace and Cold Vapor Atomic Absorption (GFAA) Measurement. Using a CEM microwave oven, 0.25 to 0.5 g of freeze dried sample is heated in a capped 120 ml Teflon vessel in the presence of 5 ml of Baker Instra-Analyzed nitric acid for three minutes at 120 watts, three minutes at 300 watts, and fifteen minutes at 450 watts. The residue is then diluted to 50 ml with laboratory pure water.

006 LABORATORY: Research Triangle Institute

VI. ICP. ICP measurements are made using a Leeman Labs Plasma Spec I sequential or ES2000 simultaneous spectrometer.

007 LABORATORY: Research Triangle Institute

VII. Graphite Furnace Atomic Absorption (GFAA). GFAA measurements are made using a Perkin-Elmer Zeeman 3030 or 4100ZL atomic absorption spectrometer.

ANALYTICAL METHODS (Cont.)

Method Code	Method Description
008	LABORATORY: Research Triangle Institute

VIII. Cold Vapor Atomic Absorption (CVAA). Hg measurements are conducted using SnC14 as the reducing agent. A Leeman PS200 Hg Analyzer is employed.

ANALYTICAL METHODS

Method Code	Method Description
001	LABORATORY: Research Triangle Institute I. Homogenization. Tissue samples are prehomogenized using a food processor. A portion of the tissue sample (or sediment) is then freeze dried for determination of moisture content and ground to 100 mesh with a mill.
004	LABORATORY: Research Triangle Institute IV. Digestion for Graphite Furnace and Cold Vapor Atomic Absorption (GFAA) Measurement. Using a CEM microwave oven, 0.25 to 0.5 g of freeze dried sample is heated in a capped 120 ml Teflon vessel in the presence of 5 ml of Baker Instra-Analyzed nitric acid for three minutes at 120 watts, three minutes at 300 watts, and fifteen minutes at 450 watts. The residue is then diluted to 50 ml with laboratory pure water.
006	LABORATORY: Research Triangle Institute VI. ICP. ICP measurements are made using a Leeman Labs Plasma Spec I sequential or ES2000 simultaneous spectrometer.
007	LABORATORY: Research Triangle Institute VII. Graphite Furnace Atomic Absorption (GFAA). GFAA measurements are made using a Perkin-Elmer Zeeman 3030 or 4100ZL atomic absorption spectrometer.

ANALYTICAL METHODS (Cont.)

Method Code	Method Description
008	LABORATORY: Research Triangle Institute
	VIII. Cold Vapor Atomic Absorption (CVAA). Hg measurements are conducted using SnC14 as the reducing agent. A Leeman PS200 Hg Analyzer is employed.

ANALYTICAL METHODS

Method Code	Method Description
001	LABORATORY: Mississippi State Chemical Laboratory

Analysis For Organochlorine Pesticides and PCBs In Animal and Plant Tissue

I. Ten gram tissue samples are thoroughly mixed with anhydrous sodium sulfate and soxhlet extracted with hexane for seven hours. The extract is concentrated by rotary evaporation; transferred to a tared test tube, and further concentrated to dryness for lipid determination. The weighed lipid sample is dissolved in petroleum ether and extracted four times with acetonitrile saturated with petroleum ether. Residues are partitioned into petroleum ether which is washed, concentrated, and transferred to a glass chromatographic column containing 20 grams of Florisil. The column is eluted with 200 ml 6% diethyl ether/94% petroleum ether (Fraction I) followed by 200 ml 15% diethyl ether/85% petroleum ether (Fraction II). Fraction II is concentrated to appropriate volume for quantification of residues by packed or capillary column electron capture gas chromatography. Fraction I is concentrated and transferred to a Silicic acid chromatographic column for additional cleanup required for separation of PCBs from other organochlorines. Three fractions are eluted from the silicic acid column. Each is concentrated to appropriate volume for quantification of residues by packed or megabore column, electron capture gas chromatography. PCBs are found in Fraction II.

ANALYTICAL METHODS

Method Code	Method Description
019	LABORATORY: Mississippi State Chemical Laboratory

Grain Size

XIX. Disperse sample of soil or sediment to pass 2 mm sieve and place a weighed 40 gram in a 600 ml beaker. Take additional 30 gram sample for moisture determination so that air-dried weight may be corrected to oven-dried weight. Add 50 ml 10% "Calgon" solution (sodium meta-phosphate with sufficient sodium carbonate to give a pH of approximately 8.3 in a 10% solution) to 40 gram sample and allow to soak for at least 10 minutes. After soaking, quantitatively transfer sample with distilled water to Waring blender cup so that cup is approximately half full. Blend for four minutes and transfer suspension to sedimentation cylinder adjusting liquid level to 1000 ml mark with distilled water. Place cylinder in constant temperature water bath (approximately 38oC). Prepare sample "blank" by adding 50 ml 10% "Calgon" solution to second sedimentation cylinder and add distilled water to the 1000 ml mark. When the suspension reaches water bath temperature, the mixture is thoroughly stirred prior initiation of sedimentation. The time that stirring ceases is noted as the zero settling time. At the end of eight hours, lower the hydrometer (ASTM 152 H) gently into the suspension and read the scale at the end of the meniscus. Record the time of hydrometer reading, the hydrometer reading, and water bath temperature. After thorough mixing, record the hydrometer reading in the sample "blank" solution of water and "Calgon". After hydrometer readings are recorded, pour the suspension onto a 270 mesh, 53 micron sieve and wash all silt and clay out with the water. Transfer sample material remaining on the sieve into an evaporating dish; place in 110oC oven and allow to dry for 24 hours. After cooling, weigh the sample to determine the weight of oven-dry sand left on the sieve. Using moisture data determined, correct sample air-dry weight to oven-dry weight. Calculate the concentration of suspension in grams per liter from the following equation:

ANALYTICAL METHODS (Cont.)

Method Code	Method Description
019	

$C = R - R_<$ where C = concentration (gm/liter)
R = hydrometer reading in suspension
$R_<$ = hydrometer reading in "Calgon" solution.

Calculate the Clay percentage, PC from the following:

$$Pc = 100 \frac{C}{Co}$$

where Co represents the oven-dry weight of soil per liter of suspension.

Calculate the Sand percentage, Ps from the following:

$$Ps = 100 \frac{S}{Co}$$

where S is the weight of the oven-dry sand left on screen and Co is as in the Clay formula.

Silt percentage is 100 - Pc - Ps

020 LABORATORY: Mississippi State Chemical Laboratory

Total Organic Carbon

XX. Weigh approximately 0.35 g sample into a numbered glazed ceramic boat. Record the weights and boat numbers.

In an acid safe hood, add 1:1 HCl dropwise to each sample until completely moistened, usually 5 to 10 drops. Observe the samples for any bubbling, and note this. Heat the samples on a hot plate until dry. The addition of HCl and hot plate drying must be repeated until no further bubbling occurs. Dry samples in a drying oven at 100oC for 1 hours.

Samples were analyzed using a Leco CR-412 Carbon Analyzer. The instrument was calibrated using $CaCO_3$.

The right anhydrone tube of the furnace was replaced with a chlorine trap

ANALYTICAL METHODS (Cont.)

Method Code	Method Description
020	before TOC samples were analyzed.
035	LABORATORY: Mississippi State Chemical Laboratory

Analysis for Organochlorine Pesticides and PCBs in Soil and Sediment by ASE.

XXXV. Weigh 10-gram soil or sediment sample and 5-grams of Hydromatrix into a PRQ (SOP 1.105) beaker. Stir the sample with a PRQ spatula until the mixture becomes a flowable powder and leaves the sides of the beaker clean. The sample can be stored in a desiccator over night. Pour the sample through a PRQ powder funnel into a PRQ Accelerated Solvent Extractor (ASE) 33-ml cell with a 1.91-cm cellulose filter in the bottom cell cap. Tap the ASE cell to settle the sample and add more Hydromatrix if needed to fill the cell. Rinse the funnel, spatula, and beaker with no more than 6-ml total of pet ether (SOP 1.81) and add the rinses to the cell. Place the top cap on the cell and tighten both caps hand tight. Record the cell number, the position number, and the number of the sample placed in the cell in the ASE logbook as the cell is placed in the ASE for extraction. Place the sample number on the collection vial. Operate the ASE according to SOP 1.260 with the following extraction conditions: 5-min heating cycle, 2x2-min static cycles, 60% solvent flush, 120 sec purge cycle, 100 degrees C @ 2000psi, 1:1 pet ether:acetone (SOP 1.255). Prepare a 500-ml separatory funnel with 200-ml PRQ water (SOP 1.255) and 15-ml PRQ saturated sodium chloride (SOP 1.255). Rinse the sample extract into the separatory funnel with 50ml of 1:1 acetone: pet ether. The separatory funnel is shaken vigorously for one minute and the layers allowed to separate. The pet ether is removed, and the water fraction extracted again with 50-ml pet ether. The combined pet ether is washed twice with 50-ml water and concentrated by Kuderna-Danish (SOP 1.261) to appropriate volume. An aliquot of the concentrated extract representing 2 grams of sample is transferred to a column containing 20 grams of Florisil. The column is eluted with 200 ml 6% diethyl ether/94% petroleum ether (Fraction I) followed by 200 ml 15% diethyl

ANALYTICAL METHODS (Cont.)

Method Code	Method Description
035	ether/85% petroleum ether (Fraction II). Fraction II is concentrated to appropriate volume for quantification of residues by a Varian 3600 gas chromatograph equipped with dual 30M DB-5/DB-608 megabore columns and electron capture detectors. Fraction I is concentrated to 5 ml and transferred to a silicic acid (SOP 1.255) chromatographic column (custom columns 1 cm OD x 40 cm with a 100 ml reservoir on top, Ace Glass) for additional cleanup required for separation of PCBs from other organochlorines. Five grams of hot silicic acid is put into the column, which already has a glass wool plug and about 3-mm sodium sulfate in the bottom. The silicic acid is topped with 10-mm sodium sulfate and prewashed with 10-ml hexane. Three fractions are eluted from the silicic acid column. The sample in 5-ml solvent is added to the column and rinsed into the column with 3,1,1-ml hexane. Then the sample is eluted with 20-ml pet ether (fraction SAI). Fraction SAII is 150-ml pet ether. Fraction SAIII is 20 ml of a mixed solvent consisting of 1 part acetonitrile: 19 parts hexane: 80 parts methylene chloride (SOP 1.255). Each is concentrated to appropriate volume for quantification of residues by megabore column, electron capture gas chromatography. HCB and Mirex are in SAI. PCBs are found in SAII. The rest of the compounds are in SAIII. GC determinations for SAI and SAIII were run on a Varian 3600 GC with a Varian Star Data System and a Varian 8200 Autosampler. All GCs were equipped with dual DB-608 (0.83u film thickness, J & W Scientific # 125-1730) and DB-5 (1.5u film thickness, J & W Scientific # 125-5032) 30M megabore columns. All compounds were calculated using a three point standard curve forced through the origin using external standards (SOP 1.267). PCB's (SAII) are shot on a Varian 3350 with a 60M DB-5 capillary column

and an EC detector and a Varian Star Data System, version 4.5. All the mixture standards are at 0.5 ng/ul with one ul shot.

Starting with Arochlor 1260, 4 peaks that are unique to this mixture are located. The areas of the standards are summed and the same peaks located in the sample and also summed. Arochlor 1260 is calculated by

ANALYTICAL METHODS (Cont.)

Method Code	Method Description
035	the following formula to obtain PPM 1260.

$$\frac{(\text{Area sample})\ (\text{weight of std shot in ng})}{(\text{Area 1260 std})\ (\text{basis shot in mg})}$$

Arochlor 1254 is calculated by locating the major peaks in the mixture that are normally found in samples. The areas of these peaks are summed. Because some of this area comes from Arochlor 1260 and not all from Arochlor 1254, the contribution from the 1260 has to be subtracted from the total area. Arochlor 1254 is calculated by using the formula:

$$\frac{\{(\text{Area sample})-[((\text{PPM 1260})\ (\text{basis})\ (\text{area from 1260}))/\text{ng 1260 std}]\}\ (\text{wt 1254 std in ng})}{(\text{Area 1254 std})\ (\text{Basis shot in mg})}$$

Results are in PPM.

Arochlor 1248 and Arochlor 1242 are calculated in a similar fashion, subtracting the contribution from 1254 in the 1248 and the 1248 in the 1242.

Total PCBs are calculated by adding the sum of Arochlor 1242, 1248, 1254, and 1260.

Appendix C

Chemistry Data

(Detected values in bold, non-detects
are reported as ½ the detection limit)

Sediment inorganic data (ppm dry weight)

	% Moisture	Al	As	B	Ba	Be	Cd	Cr	Cu	Fe	Hg	Mg	Mn	Mo
K0101SED	49.73	4830	3.76	21.2	100.1	1.266	1.546	56.9	49.25	19330	0.1913	3585	446.1	2.525
K0201SED	34.72	3386	2.08	16	77.5	0.7952	0.7264	32.33	31.9	15630	0.104	3949	334.5	2.515
M0101SED	51.41	2979	1.72	16.5	72.67	0.6091	0.2505	12.5	13.1	11900	0.0505	890.9	189.7	2.525

Sediment inorganic data (ppm dry weight)

	Ni	Pb	Se	Sr	V	Zn
K0101SED	38.77	168.3	0.2526	11.43	47.63	294
K0201SED	34.97	100.3	0.2515	9.429	30.76	168.5
M0101SED	10.85	20.05	0.2526	12.66	28.94	48.82

Sediment organochlorine data (ppm dry weight)

	Grain Size-Clay	Grain Size-Sand	Grain Size-Silt	% Moisture	Tot. Organic Carbon	PCB-1242	PCB-1248	PCB-1254	PCB-1260	PCB-TOTAL
K0101SED	6.7	63.3	30	39.4	1.1	0.0248	0.0248	**0.0594**	**0.0759**	**0.1353**
K0201SED	8	55.1	36.9	41.6	1.9	0.0257	0.0257	**0.0822**	**0.0582**	**0.1404**
M0101SED	20	24.5	55.5	53	2.3	0.0319	0.0319	0.0319	0.0319	0.0319

Sediment organochlorine data (ppm dry weight)

	1254:1260 ratio	o,p'-DDD	o,p'-DDE	o,p'-DDT	p,p'-DDD	p,p'-DDE	p,p'-DDT	DDT-TOTAL	oxychlordane	alpha chlordane	cis-nonachlor
K0101SED	0.78	0.0083	0.0083	0.0083	**0.0462**	0.0083	0.0083	**0.0875**	0.0083	**0.0347**	0.0083
K0201SED	1.4	0.0086	0.0086	0.0086	**0.024**	0.0086	0.0086	**0.0668**	0.0086	**0.0599**	0.0086
M0101SED	1	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0638	0.0106	0.0106	0.0106

Sediment organochlo[illegible] data (ppm dry weight)

	gamma chlordane	trans-nonachlor	TOTAL Chlordane	alpha BHC	beta BHC	delta BHC	gamma BHC	dieldrin	endrin	HCB
K0101SED	**0.0429**	**0.0248**	**0.1188**	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083
K0201SED	**0.0634**	**0.0394**	**0.1798**	0.0086	0.0086	0.0086	0.0086	0.0086	0.0086	0.0086
M0101SED	0.0106	0.0106	0.0532	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106

	heptachlor epoxide	mirex	toxaphene
K0101SED	0.0083	0.0083	0.0248
K0201SED	0.0086	0.0086	0.0257
M0101SED	0.0106	0.0106	0.0319

Sediment PCB congener data (ppm dry weight)

	PCB# 8	PCB# 18	PCB# 31	PCB# 33	PCB# 44	PCB# 49	PCB# 52	PCB# 70	PCB# 77	PCB# 88	PCB# 101	PCB# 118/	PCB# 126	PCB# 128
K0101SED	0.0004	0.0004	0.0086	0.0046	0.0017	0.0021	0.0004	0.0035	0.0004	0.0004	0.0071	0.0069	0.0004	0.0021
K0201SED	0.0004	0.0004	0.0084	0.0004	0.0031	0.0065	0.0072	0.0055	0.0004	0.0021	0.0099	0.0094	0.0004	0.0027
M0101SED	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005

Sediment PCB congener data (ppm dry weight)

	PCB# 138	PCB# 151	PCB# 153	PCB# 156	PCB# 158	PCB# 167	PCB# 169	PCB# 170	PCB# 174	PCB# 180	PCB# 189	PCB# 194	PCB# 81	PCB# 32
K0101SED	0.0129	0.0004	0.0132	0.0020	0.0033	0.0004	0.0004	0.0053	0.0031	0.0073	0.0004	0.0018	0.0004	0.0004
K0201SED	0.0147	0.0031	0.0158	0.0024	0.0036	0.0004	0.0004	0.0050	0.0038	0.0070	0.0004	0.0004	0.0004	0.0004
M0101SED	0.0012	0.0005	0.0013	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005

	PCB# 71	PCB# 95	PCB# 132	PCB# 105/141
K0101SED	0.0004	0.0578	0.0038	0.0094
K0201SED	0.0004	0.0651	0.0043	0.0062
M0101SED	0.0005	0.0140	0.0005	0.0005

Cattail inorganic data (ppm wet weight)

	Sample Weight (g)	% Moisture	Al	As	B	Ba	Be	Cd	Cr	Cu	Fe	Hg	Mg
K0101TTY	131	87.2	98	0.2771	1.251	3.174	0.0127	0.0268	3.304	0.6637	561.8	0.0127	154.7
K0102TTY	169	86.9	106	0.1677	1.507	4.373	0.013	0.0664	1.283	1.257	750.5	0.013	318.1
K0103TTY	148	86.6	42	0.1416	0.764	2.624	0.0133	0.0133	0.7646	0.3682	345.1	0.0133	147.6
K0104TTY	135	82.6	76	0.0862	0.933	4.344	0.0172	0.0172	0.8009	0.4445	609.2	0.0172	155.1
K0105TTY	141	82	285	0.2443	1.006	5.155	0.018	0.0581	2.238	1.247	702.6	0.018	232.8
K0106TTY	149	87.8	42	0.0593	0.936	2.85	0.0119	0.0325	1.091	0.4501	283.1	0.0119	192.4
K0107TTY	182	86.2	32	0.1556	1.034	3.306	0.0137	0.0283	0.7247	0.3529	598.2	0.0137	243.9
K0108TTY	138	84.8	358	0.5765	1.586	6.091	0.038	0.088	3.738	1.79	1351	0.0149	211.1
Freq			8/8	6/8	8/8	8/8	1/8	6/8	8/8	8/8	8/8	0/8	8/8
MIN	131	82	32	0.0593	0.764	2.624	0.0119	0.0133	0.7247	0.3529	283.1		147.6
MAX	182	87.8	358	0.5765	1.586	6.091	0.038	0.088	3.738	1.79	1351		318.1
MEAN	149	85.5	130	0.2135	1.127	3.99	0.0172	0.0413	1.743	0.8217	650.1		206.9
STDEV	17.7	2.17	123	0.1636	0.293	1.215	0.0087	0.0265	1.206	0.5397	325.9		57.99
K0201TTY	181	85	124	0.2208	1.229	4.117	0.0145	0.0337	1.966	0.8519	807.5	0.0145	186.2
K0202TTY	184	86.9	45	0.2478	1.35	4.067	0.013	0.013	0.9665	0.3671	801	0.013	166
K0203TTY	275	87.7	65	0.129	1.147	3.855	0.0121	0.0248	1.068	0.4593	745.3	0.0121	155.8
K0204TTY	140	84.6	37	0.0758	1.092	3.135	0.0152	0.0152	0.5889	0.367	464.3	0.0152	204.6
K0205TTY	182	84.4	68	0.1733	1.205	3.968	0.0155	0.0402	0.9806	1.273	481.7	0.0155	170.5
K0206TTY	191	83.4	65	0.0828	1.092	2.97	0.0166	0.0166	0.6192	0.4789	429.7	0.0166	152
K0207TTY	177	85	42	0.0743	1.12	2.882	0.0149	0.0149	0.4418	0.3052	369.9	0.0149	200.6
K0208TTY	147	86.3	103	0.2401	1.137	3.954	0.0133	0.0359	0.8493	0.6425	722.2	0.0133	171
Freq			8/8	5/8	8/8	8/8	0/8	4/8	8/8	8/8	8/8	0/8	8/8
MIN	140	83.4	37	0.0743	1.092	2.882		0.013	0.4418	0.3052	369.9		152
MAX	275	87.7	124	0.2478	1.35	4.117		0.0402	1.966	1.273	807.5		204.6
MEAN	185	85.4	69	0.1555	1.172	3.619		0.0243	0.9351	0.593	602.7		175.8
STDEV	40.9	1.44	31	0.0748	0.087	0.526		0.0109	0.4712	0.3267	182.7		19.52
M0101TTY	164	92.6	60	0.0877	1.268	4.107	0.0073	0.0187	0.7208	0.2411	575.2	0.0073	113.1
M0102TTY	142	91.7	131	0.172	1.186	3.315	0.0081	0.032	1.934	0.3983	601.7	0.0081	187.5
M0103TTY	118	90.2	241	0.2445	1.178	4.727	0.0196	0.0203	2.39	0.5952	607.1	0.0097	230.7
M0104TTY	195	89.8	323	0.2692	1.392	5.841	0.0278	0.0375	2.399	0.8505	791.4	0.0101	211.1
M0105TTY	131	90	262	0.3106	1.192	3.948	0.0263	0.0372	1.575	0.7195	857.1	0.0099	183.6
M0106TTY	113	90.3	95	0.0473	1.377	5.107	0.0095	0.0095	0.6761	0.4063	595.1	0.0095	163.3
M0107TTY	133	90.2	213	0.2624	1.322	4.241	0.0199	0.0211	2.361	0.4939	598.9	0.0098	187.9
M0108TTY	154	89.8	213	0.2081	1.173	4.084	0.0227	0.0225	1.281	0.6633	572.9	0.0102	215.6
Freq			8/8	7/8	8/8	8/8	5/8	7/8	8/8	8/8	8/8	0/8	8/8
MIN	113	89.8	60	0.0473	1.173	3.315	0.0073	0.0095	0.6761	0.2411	572.9		113.1
MAX	195	92.6	323	0.3106	1.392	5.841	0.0278	0.0375	2.399	0.8505	857.1		230.7
MEAN	144	90.6	192	0.2002	1.261	4.421	0.0176	0.0248	1.667	0.546	649.9		186.6
STDEV	26.8	1.02	89	0.0923	0.092	0.781	0.0082	0.0098	0.7217	0.1986	109.7		36.52

	Mn	Mo	Ni	Pb	Se	Sr	V	Zn
K0101TTY	48.46	0.2026	0.8118	0.9637	0.0635	2.327	0.2545	148.4
K0102TTY	59.8	0.0651	0.8558	1.681	0.0651	2.974	0.4417	140.4
K0103TTY	33.87	0.0663	0.3937	0.6333	0.0663	2.16	0.1743	127.8
K0104TTY	44.76	0.0862	0.5179	1.395	0.0862	2.751	0.3242	165.2
K0105TTY	64.4	0.3235	1.147	3.849	0.0901	3.612	1.07	99.5
K0106TTY	50.64	0.1779	0.4911	0.7854	0.0593	2.629	0.162	174
K0107TTY	39.8	0.0685	0.472	0.7571	0.0685	2.819	0.0685	105.9
K0108TTY	51.44	0.1562	2.178	6.23	0.0743	2.559	1.682	77.59
Freq	8/8	4/8	8/8	8/8	0/8	8/8	7/8	8/8
MIN	33.87	0.0651	0.3937	0.6333		2.16	0.0685	77.59
MAX	64.4	0.3235	2.178	6.23		3.612	1.682	174
MEAN	49.15	0.1433	0.8584	2.037		2.729	0.5221	129.9
STDEV	9.96	0.0912	0.5906	1.99		0.4426	0.563	33.56
K0201TTY	36.57	0.0724	1.231	1.881	0.0724	2.894	0.5813	70.17
K0202TTY	28.87	0.0648	0.5873	1.455	0.0648	2.893	0.2155	83.38
K0203TTY	35.84	0.0604	0.6181	1.225	0.0604	2.571	0.3157	88.75
K0204TTY	30.92	0.0758	0.3605	0.7018	0.0758	3.143	0.0758	73.71
K0205TTY	55.74	0.0773	0.5373	0.9229	0.0773	2.551	0.2482	234.6
K0206TTY	27.64	0.0828	0.4664	0.8866	0.0828	2.373	0.2649	57.01
K0207TTY	30.79	0.0743	0.3272	0.6623	0.0743	2.51	0.1909	80.81
K0208TTY	36.8	0.1383	0.685	1.533	0.0667	2.445	0.5366	84.62
Freq	8/8	1/8	8/8	8/8	0/8	8/8	7/8	8/8
MIN	27.64	0.0604	0.3272	0.6623		2.373	0.0758	57.01
MAX	55.74	0.1383	1.231	1.881		3.143	0.5813	234.6
MEAN	35.4	0.0807	0.6016	1.158		2.673	0.3036	96.63
STDEV	8.957	0.0243	0.2828	0.4372		0.2705	0.1726	56.65
M0101TTY	27.87	0.0367	0.3271	0.4354	0.0367	2.199	0.2791	55.12
M0102TTY	19.63	0.0818	1.1156	0.7027	0.0407	2.771	0.6774	120.4
M0103TTY	44.29	0.134	1.3876	0.7246	0.0483	3.424	0.8985	37.85
M0104TTY	30.74	0.0367	1.2802	1.363	0.0507	3.097	1.537	104.3
M0105TTY	26.94	0.2888	1.2224	0.9367	0.0496	2.785	1.432	176.3
M0106TTY	47.12	0.0473	0.3323	0.5185	0.0473	2.612	0.4169	46.38
M0107TTY	43.3	0.0978	1.3823	0.7564	0.0488	2.725	0.8849	81.09
M0108TTY	18.98	0.0511	0.8034	0.9414	0.0511	2.887	1.181	42.42
Freq	8/8	4/8	8/8	8/8	0/8	8/8	8/8	8/8
MIN	18.98	0.0367	0.3271	0.4354		2.199	0.279	37.85
MAX	47.12	0.2888	1.3876	1.363		3.424	1.537	176.3
MEAN	32.36	0.0968	0.9814	0.7974		2.812	0.9134	82.98
STDEV	11.17	0.0847	0.4428	0.2892		0.356	0.4528	48.34

5020049	% Moisture	Al	As	B	Ba	Be	Cd	Cr	Cu	Fe	Hg	Mg	Mn	Mo
K0101TTY	87.2	760.1	2.2	9.8	24.7	0.099	0.21	25.8	5.2	4379	0.10	1206	377.7	1.6
K0102TTY	86.9	809.4	1.3	11.5	33.4	0.099	0.51	9.8	9.6	5729	0.10	2428	456.5	0.50
K0103TTY	86.6	313.0	1.1	5.7	19.6	0.099	0.099	5.7	2.8	2583	0.10	1105	253.5	0.50
K0104TTY	82.6	434.8	0.50	5.4	25.0	0.099	0.099	4.6	2.6	3499	0.10	890.9	257.1	0.50
K0105TTY	82.0	1588	1.4	5.6	28.7	0.10	0.32	12.5	6.9	3912	0.10	1296	358.6	1.8
K0106TTY	87.8	347.9	0.49	7.7	23.4	0.097	0.27	8.9	3.7	2322	0.10	1578	415.4	1.5
K0107TTY	86.2	234.0	1.1	7.5	24.0	0.099	0.21	5.3	2.6	4344	0.10	1771	289.0	0.50
K0108TTY	84.8	2347	3.8	10.4	39.9	0.25	0.58	24.5	11.7	8857	0.10	1384	337.3	1.0
Freq		8/8	6/8	8/8	8/8	1/8	6/8	8/8	8/8	8/8	0/8	8/8	8/8	4/8
Min	82.0	234.0	0.49	5.4	19.6	0.10	0.10	4.6	2.6	2322		890.9	253.5	0.50
Max	87.8	2347	3.8	11.5	39.9	0.25	0.58	25.8	11.7	8857		2428	456.5	1.8
Mean	85.5	854.3	1.5	7.9	27.3	0.12	0.29	12.1	5.6	4453		1457	343.1	1.0
StDev	2.2	745.2	1.1	2.4	6.5	0.053	0.18	8.4	3.5	2080		477.3	73.6	0.56
K0201TTY	85.0	828.5	1.5	8.2	27.4	0.096	0.22	13.1	5.7	5376	0.10	1240	243.5	0.48
K0202TTY	86.9	341.2	1.9	10.3	31.0	0.099	0.099	7.4	2.8	6110	0.10	1266	220.2	0.49
K0203TTY	87.7	529.7	1.1	9.3	31.4	0.098	0.20	8.7	3.7	6064	0.10	1268	291.6	0.49
K0204TTY	84.6	241.0	0.49	7.1	20.4	0.099	0.099	3.8	2.4	3023	0.10	1332	201.3	0.49
K0205TTY	84.4	437.3	1.1	7.7	25.4	0.099	0.26	6.3	8.2	3086	0.10	1092	357.1	0.50
K0206TTY	83.4	391.7	0.50	6.6	17.8	0.10	0.10	3.7	2.9	2581	0.10	912.8	166.0	0.50
K0207TTY	85.0	277.6	0.50	7.5	19.3	0.099	0.099	3.0	2.0	2471	0.10	1340	205.7	0.50
K0208TTY	86.3	753.9	1.8	8.3	28.8	0.097	0.26	6.2	4.7	5264	0.10	1246	268.2	1.0
Freq		8/8	5/8	8/8	8/8	0/8	4/8	8/8	8/8	8/8	0/8	8/8	8/8	1/8
Min	83.4	241.0	0.5	6.6	17.8		0.10	3.0	2.0	2471		912.8	166.0	0.48
Max	87.7	828.5	1.9	10.3	31.4		0.26	13.1	8.2	6110		1340	357.1	1.0
Mean	85.4	475.1	1.1	8.1	25.2		0.17	6.5	4.0	4247		1212	244.2	0.56
StDev	1.4	215.7	0.6	1.2	5.4		0.075	3.3	2.1	1597		142.8	60.5	0.18
M0101TTY	92.6	807.6	1.2	17.2	55.7	0.10	0.25	9.8	3.3	7804	0.10	1535	378.2	0.50
M0102TTY	91.7	1570	2.1	14.2	39.7	0.098	0.38	23.2	4.8	7206	0.10	2246	235.1	0.98
M0103TTY	90.2	2452	2.5	12.0	48.1	0.20	0.21	24.3	6.1	6182	0.10	2349	451.0	1.4
M0104TTY	89.8	3175	2.7	13.7	57.5	0.27	0.37	23.6	8.4	7789	0.10	2078	302.6	0.50
M0105TTY	90.0	2618	3.1	11.9	39.4	0.26	0.37	15.7	7.2	8554	0.10	1832	268.9	2.9
M0106TTY	90.3	976.4	0.49	14.2	52.7	0.098	0.098	7.0	4.2	6135	0.10	1684	485.8	0.98
M0107TTY	90.2	2176	2.7	13.5	43.3	0.20	0.22	24.1	5.0	6117	0.10	1919	442.3	1.0
M0108TTY	89.8	2090	2.0	11.5	40.0	0.22	0.22	12.6	6.5	5617	0.10	2114	186.1	0.50
Freq		8/8	7/8	8/8	8/8	5/8	7/8	8/8	8/8	8/8	0/8	8/8	8/8	4/8
Min	89.8	807.6	0.49	11.5	39.4	0.10	0.10	7.0	3.3	5617		1535	186.1	0.50
Max	92.6	3175	3.1	17.2	57.5	0.27	0.38	24.3	8.4	8554		2349	485.8	2.9
Mean	90.6	1983	2.1	13.5	47.1	0.18	0.26	17.5	5.7	6926		1970	343.8	1.1
StDev	1.0	815.7	0.86	1.8	7.5	0.074	0.10	7.2	1.7	1055		279	111.2	0.79

5020049	Ni	Pb	Se	Sr	V	Zn
K0101TTY	6.3	7.5	0.49	18.1	2.0	1157
K0102TTY	6.5	12.8	0.50	22.7	3.4	1072
K0103TTY	2.9	4.7	0.50	16.2	1.3	956.9
K0104TTY	3.0	8.0	0.50	15.8	1.9	949.1
K0105TTY	6.4	21.4	0.50	20.1	6.0	553.9
K0106TTY	4.0	6.4	0.49	21.6	1.3	1427
K0107TTY	3.4	5.5	0.50	20.5	1.0	769.2
K0108TTY	14.3	40.9	0.49	16.8	11.0	508.8
Freq	8/8	8/8	0/8	8/8	7/8	8/8
Min	2.9	4.7		15.8	1.0	508.8
Max	14.3	40.9		22.7	11.0	1427
Mean	5.9	13.4		19.0	3.5	924.2
StDev	3.7	12.4		2.6	3.5	308.0
K0201TTY	8.2	12.5	0.48	19.3	3.9	467.2
K0202TTY	4.5	11.1	0.49	22.1	1.6	636.0
K0203TTY	5.0	10.0	0.49	20.9	2.6	722.1
K0204TTY	2.3	4.6	0.49	20.5	1.0	479.9
K0205TTY	3.4	5.9	0.50	16.3	1.6	1503
K0206TTY	2.8	5.3	0.50	14.3	1.6	342.4
K0207TTY	2.2	4.4	0.50	16.8	1.3	539.8
K0208TTY	5.0	11.2	0.49	17.8	3.9	616.8
Freq	8/8	8/8	0/8	8/8	7/8	8/8
Min	2.2	4.4		14.3	1.0	342.4
Max	8.2	12.5		22.1	3.9	1503
Mean	4.2	8.1		18.5	2.2	663.4
StDev	2.0	3.4		2.7	1.1	358.9
M0101TTY	4.4	5.9	0.50	29.8	3.8	747.9
M0102TTY	13.4	8.4	0.49	33.2	8.1	1442
M0103TTY	14.1	7.4	0.49	34.9	9.2	385.4
M0104TTY	12.6	13.4	0.50	30.5	15.1	1027
M0105TTY	12.2	9.3	0.50	27.8	14.3	1759
M0106TTY	3.4	5.3	0.49	26.9	4.3	478.1
M0107TTY	14.1	7.7	0.50	27.8	9.0	828.3
M0108TTY	7.9	9.2	0.50	28.3	11.6	415.9
Freq	8/8	8/8	0/8	8/8	8/8	8/8
Min	3.4	5.3		26.9	3.8	385.4
Max	14.1	13.4		34.9	15.1	1759
Mean	10.3	8.3		29.9	9.4	885.5
StDev	4.4	2.5		2.8	4.2	500.2

Killifish inorganic data (ppm wet weight)

	Al	As	B	Ba	Be	Cd	Cr	Cu	Fe	Hg	Mg	Mn	Mo	NI
K0101TFH	542.2	0.1137	1.031	7.536	0.0227	0.0455	2.294	3.29	734.4	0.0227	511.6	42.73	0.5381	1.21
K0102TFH	416.5	0.2574	0.4667	6.887	0.0233	0.0233	2.129	2.539	793.7	0.0233	475	33.56	0.4399	1.092
K0103TFH	379.7	0.3994	1.042	7.507	0.0237	0.0237	2.361	3.161	822.4	0.0237	493.2	44.97	0.4446	1.148
K0104TFH	349.6	0.3874	0.4713	6.956	0.0236	0.0236	2.147	2.319	746.9	0.0236	458.7	32.74	0.4757	1.027
K0105TFH	341.8	0.1124	0.4496	6.48	0.0225	0.0225	1.823	2.678	759.6	0.0225	440.9	29.51	0.3894	0.9491
K0106TFH	489.6	0.2877	0.4814	8.08	0.0241	0.0241	3.233	2.609	956.9	0.0241	493.7	37.23	0.3989	1.476
K0107TFH	678.1	0.3505	0.4556	7.638	0.0228	0.0458	2.591	3.727	1086	0.0228	442.4	28.91	0.4396	1.309
K0108TFH	468.2	0.4401	0.9754	7.401	0.0228	0.0539	2.481	2.498	932.8	0.0228	459.1	32.78	0.3578	1.167
Freq	8/8	6/8	3/8	8/8	0/8	3/8	8/8	8/8	8/8	0/8	8/8	8/8	8/8	8/8
MIN	341.8	0.1124	0.4496	6.48		0.0225	1.823	2.319	734.4		440.9	28.91	0.3578	0.9491
MAX	678.1	0.4401	1.042	8.08		0.0539	3.233	3.727	1086		511.6	44.97	0.5381	1.476
MEAN	458.2	0.2936	0.6715	7.311		0.0328	2.382	2.853	854.1		471.8	35.3	0.4355	1.172
STDEV	113.2	0.1261	0.2859	0.5059		0.0132	0.417	0.4856	125.4		25.86	5.888	0.0558	0.165
K0201TFH	19.23	0.1144	0.4575	3.327	0.0229	0.0229	0.7489	1.7	68.28	0.0229	393	23.61	0.3976	0.1144
K0202TFH	20.67	0.3273	0.4509	3.755	0.0225	0.0225	0.5222	1.28	51.48	0.0225	421.3	27.46	0.3885	0.1127
K0203TFH	15.06	0.1158	0.4633	3.228	0.0232	0.0232	0.6694	1.473	42.73	0.0232	399.5	22.89	0.4035	0.1158
K0204TFH	127.8	0.3154	0.4449	4.03	0.0223	0.0223	0.8492	1.422	118.2	0.0223	402.3	29.98	0.4223	0.2616
K0205TFH	34.03	0.1151	0.4602	3.639	0.023	0.0623	0.8635	1.828	81.26	0.023	416.5	29.33	0.3843	0.2755
K0206TFH	19.56	0.1225	0.4899	3.48	0.0245	0.0245	1.078	1.365	52.98	0.0245	458.5	25.78	0.4287	0.3493
K0207TFH	165	0.3034	0.4695	4.536	0.0235	0.0235	1.043	2.014	326.8	0.0235	425.2	45.55	0.3844	0.4674
K0208TFH	167.2	0.1158	0.4632	4.817	0.0232	0.0232	1.177	2.353	538.2	0.0232	391.6	39.68	0.4079	0.5766
Freq	8/8	3/8	0/8	8/8	0/8	1/8	8/8	8/8	8/8	0/8	8/8	8/8	8/8	5/8
MIN	15.06	0.1144	0.4449	3.228	0.0223	0.0223	0.5222	1.28	42.73	0.0223	391.6	22.89	0.3843	0.1127
MAX	167.2	0.3273	0.4899	4.817	0.0245	0.0623	1.177	2.353	538.2	0.0245	458.5	45.55	0.4287	0.5766
MEAN	71.09	0.1912	0.4624	3.852	0.0231	0.028	0.869	1.679	160	0.0231	413.5	30.54	0.4022	0.2842
STDEV	69.38	0.1030	0.0135	0.5718	0.0007	0.0139	0.2217	0.3692	179	0.0007	22.22	8.011	0.0168	0.1734
M0101TFH	12.65	0.2862	0.4706	2.987	0.0235	0.0235	0.7854	0.9647	27.57	0.0235	489.4	28.72	0.1176	0.2378
M0102TFH	21.4	0.115	0.4599	2.283	0.023	0.023	1.011	1.065	38.68	0.023	440.5	22.55	0.115	0.115
M0103TFH	38.82	0.1025	0.4099	2.538	0.0205	0.0566	0.72	0.7835	47.89	0.0205	422.8	21.59	0.1025	0.2209
M0104TFH	14.15	0.1023	0.409	2.164	0.0205	0.0205	0.7649	0.7001	32.08	0.0205	425.1	20.91	0.1023	0.1023
M0105TFH	15.01	0.4347	0.4506	4.614	0.0225	0.0225	0.9088	1.248	39.6	0.0225	459.8	47.86	0.1127	0.3324
M0106TFH	11.12	0.1106	0.4424	1.795	0.0221	0.0221	0.7158	1.88	48.58	0.0221	325.2	17.62	0.1106	0.1106
M0107TFH	6.667	0.1152	0.4608	2.897	0.023	0.023	0.6464	0.9238	31.02	0.023	427.2	32.13	0.1152	0.2422
M0108TFH	12.27	0.2618	0.4737	3.273	0.0237	0.0237	0.5998	1.07	35.58	0.0237	420.1	31.18	0.1184	0.1184
Freq	8/8	3/8	0/8	8/8	0/8	1/8	8/8	8/8	8/8	0/8	8/8	8/8	0/8	4/8
MIN	6.667	0.1023	0.409	1.795	0.0205	0.0205	0.5998	0.7001	27.57	0.0205	325.2	17.62	0.1023	0.1023
MAX	38.82	0.4347	0.4737	4.614	0.0237	0.0566	1.011	1.88	48.58	0.0237	489.4	47.86	0.1184	0.3324
MEAN	16.51	0.191	0.4471	2.819	0.0224	0.0269	0.769	1.079	37.63	0.0224	426.3	27.82	0.1118	0.1849
STDEV	9.915	0.1237	0.0253	0.8705	0.0013	0.0121	0.1349	0.3661	7.657	0.0013	47.2	9.641	0.0063	0.0852

	Pb	Se	Sr	V	Zn
K0101TFH	2.445	0.425	14.83	1.497	61.26
K0102TFH	2.567	0.4914	12.59	1.303	50.52
K0103TFH	2.685	0.4403	14.93	1.312	45.3
K0104TFH	2.603	0.4795	13.08	1.195	74.45
K0105TFH	2.542	0.3859	11.51	1.197	52.32
K0106TFH	3.225	0.3121	13.52	1.43	52.3
K0107TFH	3.411	0.4147	8.791	1.702	49.1
K0108TFH	3.319	0.2855	10.79	1.425	57.93
Freq	8/8	8/8	8/8	8/8	8/8
MIN	2.445	0.2855	8.791	1.195	45.3
MAX	3.411	0.4914	14.93	1.702	74.45
MEAN	2.85	0.4043	12.51	1.383	55.4
STDEV	0.3969	0.0737	2.084	0.1691	9.167
K0201TFH	0.5178	0.2896	11.16	0.3225	62.93
K0202TFH	0.5475	0.4828	13.71	0.1127	42.64
K0203TFH	0.5438	0.4155	12.5	0.1158	81.72
K0204TFH	0.4622	0.4128	13.52	0.346	54.08
K0205TFH	0.2301	0.3473	12.7	0.2838	79.03
K0206TFH	0.2450	0.3627	15.75	0.1225	39.82
K0207TFH	0.6503	0.4148	12.97	0.4811	48.02
K0208TFH	1.284	0.4282	12.74	0.6053	55.52
Freq	6/8	8/8	8/8	5/8	8/8
MIN	0.2301	0.2896	11.16	0.1127	39.82
MAX	1.284	0.4828	15.75	0.6053	81.72
MEAN	0.5601	0.3942	13.13	0.2987	57.97
STDEV	0.3278	0.059	1.309	0.181	15.66
M0101TFH	0.2353	0.2886	16.11	0.1176	103.1
M0102TFH	0.23	0.2706	12.07	0.115	97.37
M0103TFH	0.2049	0.2285	12.1	0.1025	137.9
M0104TFH	0.2045	0.2656	11.88	0.1023	47.36
M0105TFH	0.2253	0.2581	17.58	0.1127	42.83
M0106TFH	0.2212	0.3698	5.865	0.1106	62.66
M0107TFH	0.2304	0.3208	11.47	0.1152	43.66
M0108TFH	0.2369	0.3427	13.03	0.1184	37.32
Freq	0/8	8/8	8/8	0/8	8/8
MIN	0.2045	0.2285	5.865	0.1023	37.32
MAX	0.2369	0.3698	17.58	0.1184	137.9
MEAN	0.2236	0.2931	12.51	0.1118	71.52
STDEV	0.0127	0.0475	3.482	0.0063	36.84

Fish Tissue Metal Data (ppm dry weight)

	% Moisture	Al	As	B	Ba	Be	Cd	Cr	Cu	Fe	Hg	Mg	Mn	Mo
K0101TFH	77.2	2373	0.50	4.5	33.0	0.10	0.20	10.0	14.4	3214	0.10	2239	187.0	2.4
K0102TFH	76.6	1780	1.1	4.0	29.4	0.10	0.10	9.1	10.9	3392	0.10	2030	143.4	1.9
K0103TFH	75.9	1578	1.7	4.3	31.2	0.099	0.099	9.8	13.1	3418	0.099	2050	186.9	1.8
K0104TFH	76.4	1480	1.6	4.0	29.5	0.10	0.10	9.1	9.8	3162	0.10	1942	138.6	2.0
K0105TFH	76.9	1479	0.49	3.9	28.0	0.097	0.097	7.9	11.6	3287	0.097	1908	127.7	1.7
K0106TFH	75.6	2008	1.2	3.9	33.1	0.099	0.099	13.3	10.7	3925	0.099	2025	152.7	1.6
K0107TFH	77.1	2960	1.5	4.0	33.3	0.099	0.20	11.3	16.3	4741	0.099	1931	126.2	1.9
K0108TFH	76.2	1968	1.9	4.1	31.1	0.096	0.23	10.4	10.5	3921	0.096	1930	137.8	1.5
Freq		8/8	6/8	3/8	8/8	0/8	3/8	8/8	8/8	8/8	0/8	8/8	8/8	8/8
Min	75.6	1479	0.49	3.9	28.0		0.10	7.9	9.8	3162		1908	126.2	1.5
Max	77.2	2960	1.9	4.5	33.3		0.23	13.3	16.3	4741		2239	187.0	2.4
Mean	76.5	1953	1.2	4.1	31.1		0.14	10.1	12.2	3633		2007	150.0	1.9
StDev	0.55	508.9	0.53	0.22	2.0		0.057	1.6	2.2	536.8		108.4	24.3	0.26
K0201TFH	76.8	83.0	0.49	3.9	14.4	0.099	0.099	3.2	7.3	294.7	0.099	1696	101.9	1.7
K0202TFH	76.8	89.0	1.4	3.9	16.2	0.097	0.097	2.3	5.5	221.8	0.097	1815	118.3	1.7
K0203TFH	76.0	62.7	0.48	3.9	13.4	0.096	0.096	2.8	6.1	177.9	0.096	1663	95.3	1.7
K0204TFH	76.8	551.3	1.4	3.8	17.4	0.096	0.096	3.7	6.1	509.9	0.096	1735	129.3	1.8
K0205TFH	76.9	147.0	0.50	4.0	15.7	0.099	0.27	3.7	7.9	351	0.099	1799	126.7	1.7
K0206TFH	75.2	78.8	0.49	3.9	14.0	0.099	0.099	4.3	5.5	213.3	0.099	1846	103.8	1.7
K0207TFH	76.3	696.4	1.3	4.0	19.1	0.099	0.099	4.4	8.5	1379	0.099	1794	192.2	1.6
K0208TFH	76.7	718.7	0.50	4.0	20.7	0.10	0.10	5.1	10.1	2313	0.10	1683	170.5	1.8
Freq		8/8	3/8	0/8	8/8	0/8	1/8	8/8	8/8	8/8	0/8	8/8	8/8	8/8
Min	75.2	62.7	0.48		13.4		0.10	2.3	5.5	177.9		1663	95.3	1.6
Max	76.9	718.7	1.4		20.7		0.27	5.1	10.1	2313		1846	192.2	1.8
Mean	76.4	303.4	0.81		16.4		0.12	3.7	7.1	682.6		1754	129.7	1.7
Stdev	0.60	296.6	0.45		2.6		0.061	0.92	1.6	767.3		68.5	34.5	0.062
M0101TFH	75.5	51.7	1.2	3.8	12.2	0.096	0.096	3.2	3.9	112.7	0.096	2001	117.4	0.48
M0102TFH	76.5	91.0	0.49	3.9	9.7	0.098	0.098	4.3	4.5	164.4	0.098	1872	95.8	0.49
M0103TFH	79.0	185.2	0.49	3.9	12.1	0.098	0.27	3.4	3.7	228.5	0.098	2017	103.0	0.49
M0104TFH	79.1	67.7	0.49	3.9	10.4	0.098	0.098	3.7	3.3	153.4	0.098	2033	100.0	0.49
M0105TFH	77.4	66.3	1.9	4.0	20.4	0.10	0.10	4.0	5.5	174.9	0.10	2031	211.4	0.50
M0106TFH	77.6	49.6	0.49	3.9	8.0	0.099	0.099	3.2	8.4	216.8	0.099	1451	78.6	0.49
M0107TFH	75.9	27.6	0.48	3.8	12.0	0.096	0.096	2.7	3.8	128.6	0.096	1771	133.2	0.48
M0108TFH	76.2	51.6	1.1	4.0	13.8	0.10	0.10	2.5	4.5	149.5	0.10	1765	131.0	0.50
Freq		8/8	3/8	0/8	8/8	0/8	1/8	8/8	8/8	8/8	0/8	8/8	8/8	0/8
Min	75.5	27.6	0.48		8.0		0.10	2.5	3.3	112.7		1451	78.6	
Max	79.1	185.2	1.9		20.4		0.27	4.3	8.4	228.5		2033	211.4	
Mean	77.1	73.8	0.83		12.3		0.12	3.4	4.7	166.1		1868	121.3	
Stdev	1.4	48.5	0.53		3.7		0.061	0.61	1.6	40.1		202.7	40.8	

Fish Tissue Metal Data (ppm dry weight)

	Ni	Pb	Se	Sr	V	Zn
K0101TFH	5.3	10.7	1.9	64.9	6.6	268.1
K0102TFH	4.7	11.0	2.1	53.8	5.6	215.9
K0103TFH	4.8	11.2	1.8	62.1	5.5	188.3
K0104TFH	4.3	11.0	2.0	55.4	5.1	315.2
K0105TFH	4.1	11.0	1.7	49.8	5.2	226.4
K0106TFH	6.1	13.2	1.3	55.5	5.9	214.5
K0107TFH	5.7	14.9	1.8	38.4	7.4	214.3
K0108TFH	4.9	14.0	1.2	45.4	6.0	243.5
Freq	8/8	8/8	8/8	8/8	8/8	8/8
Min	4.1	10.7	1.2	38.4	5.1	188.3
Max	6.1	14.9	2.1	64.9	7.4	315.2
Mean	5.0	12.1	1.7	53.1	5.9	235.8
StDev	0.67	1.6	0.33	8.6	0.78	39.8
K0201TFH	0.49	2.2	1.3	48.2	1.4	271.6
K0202TFH	0.49	2.4	2.1	59.1	0.49	183.7
K0203TFH	0.48	2.3	1.7	52.0	0.48	340.2
K0204TFH	1.1	2.0	1.8	58.3	1.5	233.2
K0205TFH	1.2	0.99	1.5	54.9	1.2	341.4
K0206TFH	1.4	0.99	1.5	63.4	0.49	160.3
K0207TFH	2.0	2.7	1.8	54.7	2.0	202.6
K0208TFH	2.5	5.5	1.8	54.7	2.6	238.6
Freq	5/8	6/8	8/8	8/8	5/8	8/8
Min	0.48	1.0	1.3	48.2	0.48	160.3
Max	2.5	5.5	2.1	63.4	2.6	341.4
Mean	1.2	2.4	1.7	55.7	1.3	246.5
Stdev	0.74	1.4	0.26	4.6	0.78	67.6
M0101TFH	0.97	0.96	1.2	65.9	0.48	421.5
M0102TFH	0.49	0.98	1.2	51.3	0.49	413.8
M0103TFH	1.1	0.98	1.1	57.7	0.49	657.9
M0104TFH	0.49	0.98	1.3	56.8	0.49	226.5
M0105TFH	1.5	1.0	1.1	77.6	0.50	189.2
M0106TFH	0.49	0.99	1.7	26.2	0.49	279.6
M0107TFH	1.0	0.96	1.3	47.5	0.48	181.0
M0108TFH	0.50	1.0	1.4	54.8	0.50	156.8
Freq	4/8	0/8	8/8	8/8	0/8	8/8
Min	0.49		1.1	26.2		156.8
Max	1.5		1.7	77.6		657.9
Mean	0.81		1.3	54.7		315.8
Stdev	0.37		0.19	14.8		171.8

Killifish organochlo[illegible] data (ppm wet weight)

	% Lipid	% Moisture	PCB-1242	PCB-1248	PCB-1254	PCB-1260	PCB-TOTAL	1254:1260 ratio	o,p'-DDD	o,p'-DDE	o,p'-DDT	p,p'-DDD	p,p'-DDE	p,p'-DDT
K0101TFH	2.23	77	0.025	**0.073**	**0.082**	**0.062**	**0.22**	1.32	0.005	0.005	0.005	**0.02**	**0.018**	0.005
K0102TFH	2.15	77.5	0.025	**0.065**	**0.08**	**0.068**	**0.21**	1.18	0.005	0.005	0.005	**0.018**	**0.019**	0.005
K0103TFH	2.71	77	0.025	**0.087**	**0.11**	**0.094**	**0.29**	1.17	0.005	0.005	0.005	**0.022**	**0.021**	0.005
K0104TFH	2.81	76	0.025	**0.13**	**0.11**	**0.11**	**0.35**	1	0.005	0.005	0.005	**0.024**	**0.025**	0.005
K0105TFH	2.69	76	0.025	**0.15**	**0.11**	**0.11**	**0.37**	1	0.005	0.005	0.005	**0.022**	**0.025**	0.005
K0106TFH	3.08	75.5	0.025	**0.079**	**0.12**	**0.11**	**0.31**	1.09	0.005	0.005	0.005	**0.027**	**0.024**	0.005
K0107TFH	2.5	78	0.025	**0.059**	**0.091**	**0.084**	**0.23**	1.08	0.005	0.005	0.005	**0.019**	**0.019**	0.005
K0108TFH	3.19	77	0.025	**0.093**	**0.11**	**0.1**	**0.33**	1.1	0.005	0.005	0.005	**0.025**	**0.025**	0.005
Freq			0/8	**8/8**	**8/8**	**8/8**	7/8		0/8	0/8	0/8	**8/8**	**8/8**	0/8
MIN	2.15	75.5		0.059	0.08	0.062	0.21	1				0.018	0.018	
MAX	3.19	78		0.15	0.12	0.11	0.37	1.32				0.027	0.025	
MEAN	2.67	76.8		0.092	0.102	0.092	0.289	1.12				0.022	0.022	
STDEV	0.36898	0.845		0.032	0.015	0.019	0.062	0.106				0.003	0.003	
K0201TFH	2.7	77	0.025	**0.089**	**0.12**	**0.12**	**0.33**	1	0.005	0.005	0.005	**0.014**	**0.019**	0.005
K0202TFH	2.7	77.5	0.025	**0.14**	**0.2**	**0.16**	**0.5**	1.25	0.005	0.005	0.005	**0.02**	**0.026**	0.005
K0203TFH	3.43	76.5	0.025	**0.15**	**0.13**	**0.14**	**0.42**	0.929	0.005	0.005	0.005	**0.023**	**0.03**	0.005
K0204TFH	3.45	76.5	0.025	**0.16**	**0.16**	**0.16**	**0.48**	1	0.005	0.005	0.005	**0.025**	**0.033**	0.005
K0205TFH	2.84	76.5	0.025	**0.064**	**0.16**	**0.1**	**0.32**	1.6	0.005	0.005	0.005	**0.016**	**0.021**	0.005
K0206TFH	2.74	76.5	0.025	**0.073**	**0.14**	**0.12**	**0.33**	1.17	0.005	0.005	0.005	**0.017**	**0.025**	0.005
K0207TFH	3.58	76	0.025	**0.084**	**0.17**	**0.11**	**0.36**	1.55	0.005	0.005	0.005	**0.018**	**0.024**	0.005
K0208TFH	2.63	76.5	0.025	0.025	**0.12**	**0.081**	**0.2**	1.48	0.005	0.005	0.005	**0.016**	**0.019**	0.005
Freq			0/8	7/8	**8/8**	**8/8**	**8/8**					**8/8**	**8/8**	0/8
MIN	2.63	76		0.025	0.12	0.081	0.2	0.929				0.014	0.019	
MAX	3.58	77.5		0.16	0.2	0.16	0.5	1.6				0.025	0.033	
MEAN	3.01	76.6		0.098	0.15	0.124	0.368	1.25				0.019	0.025	
STDEV	0.402	0.443		0.047	0.028	0.028	0.097	0.267				0.004	0.005	
M0101TFH	2.62	76.5	0.025	0.025	0.025	0.025	0.025	1	0.005	0.005	0.005	0.005	**0.013**	0.005
M0102TFH	2.15	78.5	0.025	0.025	0.025	0.025	0.025	1	0.005	0.005	0.005	0.005	0.005	0.005
M0103TFH	2.41	79	0.025	0.025	0.025	0.025	0.025	1	0.005	0.005	0.005	0.005	**0.01**	0.005
M0104TFH	1.7	77.5	0.025	0.025	0.025	0.025	0.025	1	0.005	0.005	0.005	0.005	**0.01**	0.005
M0105TFH	1.97	78	0.025	0.025	0.025	0.025	0.025	1	0.005	0.005	0.005	0.005	0.005	0.005
M0106TFH	2.43	78	0.025	0.025	0.025	0.025	0.025	1	0.005	0.005	0.005	0.005	0.005	0.005
M0107TFH	2.37	77.5	0.025	0.025	0.025	0.025	0.025	1	0.005	0.005	0.005	0.005	0.005	0.005
M0108TFH	2.25	76.5	0.025	0.025	0.025	0.025	0.025	1	0.005	0.005	0.005	0.005	0.005	0.005
Freq			0/8	0/8	0/8	0/8	0/8		0/8	0/8	0/8	0/8	3/8	0/8
MIN	1.7	76.5						1					0.005	
MAX	2.62	79						1					0.013	
MEAN	2.24	77.7						1					0.007	
STDEV	0.293	0.884						0					0.003	

Killifish organochlorine data (ppm wet weight)

	DDT-TOTAL	oxychlordane	alpha chlordane	cis-nonachlor	gamma chlordane	trans-nonachlor	TOTAL Chlordane	alpha BHC	beta BHC	delta BHC
K0101TFH	**0.058**	0.005	**0.023**	**0.01**	0.005	**0.02**	**0.063**	0.005	0.005	0.005
K0102TFH	**0.057**	0.005	**0.022**	0.005	0.005	**0.021**	**0.058**	0.005	0.005	0.005
K0103TFH	**0.063**	0.005	**0.028**	**0.01**	**0.01**	**0.023**	**0.076**	0.005	0.005	0.005
K0104TFH	**0.069**	0.005	**0.029**	**0.012**	**0.01**	**0.025**	**0.081**	0.005	0.005	0.005
K0105TFH	**0.067**	0.005	**0.027**	**0.01**	0.005	**0.025**	**0.072**	0.005	0.005	0.005
K0106TFH	**0.071**	0.005	**0.033**	**0.012**	**0.011**	**0.027**	**0.088**	0.005	0.005	0.005
K0107TFH	**0.058**	0.005	**0.024**	0.01	**0.01**	**0.02**	**0.069**	0.005	0.005	0.005
K0108TFH	**0.07**	0.005	**0.032**	**0.013**	**0.01**	**0.027**	**0.087**	0.005	0.005	0.005
Freq		0/8	**8/8**	**6/8**	**5/8**	**8/8**		0/8	0/8	0/8
MIN	0.057		0.022	0.005	0.005	0.02	0.058			
MAX	0.071		0.033	0.013	0.011	0.027	0.088			
MEAN	0.064		0.027	0.01	0.008	0.024	0.074			
STDEV	0.006		0.004	0.002	0.003	0.003	0.011			
K0201TFH	**0.053**	0.005	**0.02**	0.005	0.005	**0.019**	**0.054**	0.005	0.005	0.005
K0202TFH	**0.066**	0.005	**0.026**	**0.011**	0.005	**0.028**	**0.075**	0.005	0.005	0.005
K0203TFH	**0.073**	0.005	**0.032**	**0.012**	**0.01**	**0.032**	**0.091**	0.005	0.005	0.005
K0204TFH	**0.078**	0.005	**0.036**	**0.012**	0.005	**0.035**	**0.093**	0.005	0.005	0.005
K0205TFH	**0.057**	0.005	**0.022**	0.005	0.005	**0.018**	**0.055**	0.005	0.005	0.005
K0206TFH	**0.062**	0.005	**0.024**	0.005	0.005	**0.025**	**0.064**	0.005	0.005	0.005
K0207TFH	**0.062**	0.005	**0.026**	**0.01**	0.005	**0.026**	**0.072**	0.005	0.005	0.005
K0208TFH	**0.055**	0.005	**0.021**	0.005	0.005	**0.02**	**0.056**	0.005	0.005	0.005
Freq		0/8	**8/8**	4/8	1/8	**8/8**		0/8	0/8	0/8
MIN	0.053		0.02	0.005	0.005	0.018	0.054			
MAX	0.078		0.036	0.012	0.01	0.035	0.093			
MEAN	0.063		0.026	0.008	0.006	0.025	0.07			
STDEV	0.009		0.006	0.003	0.002	0.006	0.016			
M0101TFH	**0.038**	0.005	0.005	0.005	0.005	0.005	0.025	0.005	0.005	0.005
M0102TFH	**0.03**	0.005	0.005	0.005	0.005	0.005	0.025	0.005	0.005	0.005
M0103TFH	**0.035**	0.005	0.005	0.005	0.005	0.005	0.025	0.005	0.005	0.005
M0104TFH	**0.035**	0.005	0.005	0.005	0.005	0.005	0.025	0.005	0.005	0.005
M0105TFH	0.03	0.005	0.005	0.005	0.005	0.005	0.025	0.005	0.005	0.005
M0106TFH	0.03	0.005	0.005	0.005	0.005	0.005	0.025	0.005	0.005	0.005
M0107TFH	0.03	0.005	0.005	0.005	0.005	0.005	0.025	0.005	0.005	0.005
M0108TFH	0.03	0.005	0.005	0.005	0.005	0.005	0.025	0.005	0.005	0.005
Freq		0/8	0/8	0/8	0/8	0/8		0/8	0/8	0/8
MIN	0.03						0.025			
MAX	0.038						0.025			
MEAN	0.032						0.025			
STDEV	0.003						4.98E-10			

Killifish PCB congener data (ppm wet weight)

	% Lipid	% Moisture	PCB# 8	PCB# 18	PCB# 31	PCB# 33	PCB# 44	PCB# 49	PCB# 52	PCB# 70	PCB# 77	PCB# 88	PCB# 101	PCB# 126
K0101TFH	2.23	77	0.005	0.005	0.011	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
K0102TFH	2.15	77.5	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
K0103TFH	2.71	77	0.005	0.005	0.013	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
K0104TFH	2.81	76	0.005	0.005	0.015	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
K0105TFH	2.69	76	0.005	0.005	0.015	0.005	0.005	0.012	0.005	0.005	0.005	0.005	0.005	0.005
K0106TFH	3.08	75.5	0.005	0.005	0.014	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
K0107TFH	2.5	78	0.005	0.005	0.011	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
K0108TFH	3.19	77	0.005	0.005	0.015	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Freq			0/8	0/8	7/8	0/8	0/8	1/8	0/8	0/8	0/8	0/8	0/8	0/8
MIN	2.15	75.5			0.005			0.005						
MAX	3.19	78			0.015			0.012						
MEAN	2.67	76.8			0.012			0.006						
STDEV	0.369	0.845			0.003			0.002						
K0201TFH	2.7	77	0.005	0.005	0.01	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.01	0.005
K0202TFH	2.7	77.5	0.005	0.005	0.014	0.005	0.005	0.014	0.013	0.005	0.005	0.005	0.014	0.005
K0203TFH	3.43	76.5	0.005	0.005	0.014	0.005	0.005	0.005	0.012	0.005	0.005	0.005	0.013	0.005
K0204TFH	3.45	76.5	0.005	0.005	0.016	0.005	0.005	0.01	0.014	0.005	0.005	0.005	0.015	0.005
K0205TFH	2.84	76.5	0.005	0.005	0.012	0.005	0.005	0.011	0.01	0.005	0.005	0.005	0.01	0.005
K0206TFH	2.74	76.5	0.005	0.005	0.01	0.005	0.005	0.021	0.01	0.005	0.005	0.005	0.012	0.005
K0207TFH	3.58	76	0.005	0.005	0.012	0.005	0.005	0.005	0.012	0.005	0.005	0.005	0.012	0.005
K0208TFH	2.63	76.5	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Freq			0/8	0/8	7/8	0/8	0/8	4/8	6/8	0/8	0/8	0/8	7/8	0/8
MIN	2.63	76			0.005			0.005	0.005				0.005	
MAX	3.58	77.5			0.016			0.021	0.014				0.015	
MEAN	3.01	76.6			0.012			0.01	0.01				0.011	
STDEV	0.402	0.443			0.003			0.006	0.003				0.003	
M0101TFH	2.62	76.5	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
M0102TFH	2.15	78.5	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
M0103TFH	2.41	79	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
M0104TFH	1.7	77.5	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
M0105TFH	1.97	78	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
M0106TFH	2.43	78	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
M0107TFH	2.37	77.5	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
M0108TFH	2.25	76.5	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Freq			0/8	0/8	0/8	0/8	0/8	0/8	0/8	0/8	0/8	0/8	0/8	0/8
MIN	1.7	76.5												
MAX	2.62	79												
MEAN	2.24	77.7												
STDEV	0.293	0.884												

Killifish PCB congener data (ppm wet weight)

	PCB# 138	PCB# 141	PCB# 151	PCB# 153	PCB# 156	PCB# 158	PCB# 169	PCB# 170	PCB# 174	PCB# 180	PCB# 189	PCB# 194	PCB# 32	PCB# 71
K0101TFH	**0.015**	0.005	0.005	**0.017**	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
K0102TFH	**0.016**	0.005	0.005	**0.017**	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
K0103TFH	**0.018**	0.005	0.005	**0.021**	0.005	0.005	0.005	0.005	0.005	**0.01**	0.005	0.005	0.005	0.005
K0104TFH	**0.02**	0.005	0.005	**0.022**	0.005	0.005	0.005	0.005	0.005	**0.012**	0.005	0.005	0.005	0.005
K0105TFH	**0.022**	0.005	0.005	**0.024**	0.005	0.005	0.005	0.005	0.005	**0.012**	0.005	0.005	0.005	0.005
K0106TFH	**0.021**	0.005	0.005	**0.024**	0.005	0.005	0.005	0.005	0.005	**0.012**	0.005	0.005	0.005	0.005
K0107TFH	**0.016**	0.005	0.005	**0.019**	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
K0108TFH	**0.02**	0.005	0.005	**0.022**	0.005	0.005	0.005	0.005	0.005	**0.011**	0.005	0.005	0.005	0.005
Freq	8/8	0/8	0/8	8/8	0/8	0/8	0/8	0/8	0/8	5/8	0/8	0/8	0/8	0/8
MIN	0.015			0.017						0.005				
MAX	0.022			0.024						0.012				
MEAN	0.019			0.021						0.009				
STDEV	0.003			0.003						0.003				
K0201TFH	**0.022**	0.005	0.005	**0.026**	0.005	0.005	0.005	0.005	0.005	**0.014**	0.005	0.005	0.005	0.005
K0202TFH	**0.033**	0.005	0.005	**0.036**	0.005	0.005	0.005	0.005	0.005	**0.018**	0.005	0.005	0.005	0.005
K0203TFH	**0.028**	0.005	0.005	**0.031**	0.005	0.005	0.005	0.005	0.005	**0.016**	0.005	0.005	0.005	0.005
K0204TFH	**0.037**	0.005	0.005	**0.036**	0.005	0.005	0.005	0.005	0.005	**0.018**	0.005	0.005	0.005	0.005
K0205TFH	**0.024**	0.005	0.005	**0.027**	0.005	0.005	0.005	0.005	0.005	**0.012**	0.005	0.005	0.005	0.005
K0206TFH	**0.026**	0.005	0.005	**0.03**	0.005	0.005	0.005	0.005	0.005	**0.014**	0.005	0.005	0.005	0.005
K0207TFH	**0.026**	0.005	0.005	**0.029**	0.005	0.005	0.005	0.005	0.005	**0.014**	0.005	0.005	0.005	0.005
K0208TFH	**0.019**	0.005	0.005	**0.022**	0.005	0.005	0.005	0.005	0.005	**0.01**	0.005	0.005	0.005	0.005
Freq	8/8	0/8	0/8	8/8	0/8	0/8	0/8	0/8	0/8	8/8	0/8	0/8	0/8	0/8
MIN	0.019			0.022						0.01				
MAX	0.037			0.036						0.018				
MEAN	0.027			0.03						0.015				
STDEV	0.006			0.005						0.003				
M0101TFH	0.005	0.005	0.005	**0.013**	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
M0102TFH	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
M0103TFH	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
M0104TFH	0.005	0.005	0.005	**0.012**	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
M0105TFH	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
M0106TFH	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
M0107TFH	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
M0108TFH	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Freq	0/8	0/8	0/8	2/8	0/8	0/8	0/8	0/8	0/8	0/8	0/8	0/8	0/8	0/8
MIN				0.005										
MAX				0.013										
MEAN				0.007										
STDEV				0.003										

Killifish PCB congener data (ppm wet weight)

	PCB# 95	PCB# 105/132	PCB# 128/167	PCB# 106/118
K0101TFH	0.01	0.005	0.005	0.005
K0102TFH	0.005	0.005	0.005	0.005
K0103TFH	0.014	0.005	0.005	0.005
K0104TFH	0.017	0.005	0.005	0.011
K0105TFH	0.019	0.005	0.005	0.012
K0106TFH	0.011	0.005	0.005	0.011
K0107TFH	0.005	0.005	0.005	0.005
K0108TFH	0.013	0.005	0.005	0.011
Freq	6/8	0/8	0/8	4/8
MIN	0.005			0.005
MAX	0.019			0.012
MEAN	0.012			0.008
STDEV	0.005			0.003
K0201TFH	0.013	0.005	0.005	0.012
K0202TFH	0.019	0.012	0.005	0.018
K0203TFH	0.019	0.01	0.005	0.015
K0204TFH	0.022	0.012	0.005	0.018
K0205TFH	0.016	0.005	0.005	0.012
K0206TFH	0.021	0.005	0.005	0.013
K0207TFH	0.02	0.005	0.005	0.015
K0208TFH	0.012	0.005	0.005	0.01
Freq	8/8	3/8	0/8	8/8
MIN	0.012	0.005		0.01
MAX	0.022	0.012		0.018
MEAN	0.018	0.007		0.014
STDEV	0.004	0.003		0.003
M0101TFH	0.005	0.005	0.005	0.005
M0102TFH	0.005	0.005	0.005	0.005
M0103TFH	0.005	0.005	0.005	0.005
M0104TFH	0.005	0.005	0.005	0.005
M0105TFH	0.005	0.005	0.005	0.005
M0106TFH	0.005	0.005	0.005	0.005
M0107TFH	0.005	0.005	0.005	0.005
M0108TFH	0.005	0.005	0.005	0.005
Freq	0/8	0/8	0/8	0/8
MIN				
MAX				
MEAN				
STDEV				

Appendix D

Food Chain Analysis

Conservative Food Chain Model (using wet weight concentrations): Green Heron Kenilworth Marsh Sediments

Chemical	Maximum Conc. (mg/kg)	BAF	Conc. in Inverts. (mg/kg)	Conc. in Fish (mg/kg)	Conc. from Sediment (mg/kg)	Ingestion Rate (kg/day)	AUF	Body Weight (1/kg) 0.25	Dose (mg/kg/day)	LOAEL (mg/kg/day)
Organochlorines										
4,4'-DDD	0.028	1	0.0	0.0	0.00	0.048	1	4	0.0054	1.25
4,4'-DDE	0.000	1	0.0	0.0	0.0	0.048	1	4	0.0000	1.25
4,4'-DDT	0.000	1	0.0	0.0	0.0	0.048	1	4	0.0000	1.25
total DDT	0.053	1	0.0	0.0	0.0	0.048	1	4	0.0102	1.25
total chlordane	0.105	1	0.0	0.0	0.0	0.048	1	4	0.0202	0.19
total PCBs	0.082	1	0.0	0.0	0.0	0.048	1	4	0.0157	9
Metals								4		
Arsenic	1.89	1	0.9	0.9	0.2	0.048	1	4	0.3629	3.3
Cadmium	0.78	1	0.4	0.4	0.1	0.048	1	4	0.1498	3.31
Chromium (total)	28.6	1	12.9	12.9	2.9	0.048	1	4	5.4912	277.8
Copper	24.8	1	11.2	11.2	2.5	0.048	1	4	4.7616	2.35
Lead	84.6	1	38.1	38.1	8.5	0.048	1	4	16.2432	3
Mercury	0.096	1	0.0	0.0	0.0	0.048	1	4	0.0184	0.12
Nickel	22.8	1	10.3	10.3	2.3	0.048	1	4	4.3776	31
Zinc	148	1	66.6	66.6	14.8	0.048	1	4	28.4160	139

Chemical	HQ based on LOAEL	NOAEL (mg/kg/day)	HQ based on NOAEL
Organochlorines			
4,4'-DDD	0	0.125	0
4,4'-DDE	0.0	0.125	0.0
4,4'-DDT	0.0	0.125	0
total DDT	0.0	0.125	0
total chlordane	0.1	0.019	1
total PCBs	0.0	0.9	0
Metals			
Arsenic	0.1	0.33	1
Cadmium	0.0	0.33	0.5
Chromium (total)	0.02	27.8	0.2
Copper	2.0	0.235	20
Lead	5.4	0.3	54
Mercury	0.2	0.012	1.5
Nickel	0.1	17	0.3
Zinc	0.2	13.9	2.0

Conservative Food Chain Model (using wet weight concentrations): Green Heron Kenilworth Marsh

Fish

Chemical	Maximum Conc. (mg/kg)	Conc. in Fish (mg/kg)	Conc. from Sediment (mg/kg)	FishIngestion Rate (kg/day)	Sed Ingestion Rate	AUF	Body Weight (1/kg) 0.25	Dose (mg/kg/day)	LOAEL (mg/kg/day)
Organochlorines									
4,4'-DDD	0.028	0.03	0.00	0.048	0.00008	1	4	0.0052	1.25
4,4'-DDE	0.000	0.03	0.0	0.048	0.00008	1	4	0.0063	1.25
4,4'-DDT	0.000	0.00	0.0	0.048	0.00008	1	4	0.0000	1.25
total DDT	0.053	0.08	0.0	0.048	0.00008	1	4	0.0150	1.25
total chlordane	0.105	0.09	0.0	0.048	0.00008	1	4	0.0179	0.19
total PCBs	0.082	0.50	0.0	0.048	0.00008	1	4	0.0960	9
Metals									
Arsenic	1.89	0.44	0.2	0.048	0.00008	1	4	0.0845	3.3
Cadmium	0.78	0.06	0.1	0.048	0.00008	1	4	0.0119	3.31
Chromium (total)	28.6	3.23	2.9	0.048	0.00008	1	4	0.6211	277.8
Copper	24.8	3.73	2.5	0.048	0.00008	1	4	0.7170	2.35
Lead	84.6	3.41	8.5	0.048	0.00008	1	4	0.6574	3
Mercury	0.096	0.00	0.0	0.048	0.00008	1	4	0.0000	0.12
Nickel	22.8	1.48	2.3	0.048	0.00008	1	4	0.2849	31
Zinc	148	81.70	14.8	0.048	0.00008	1	4	15.6911	139
	Average Concentrations								
	Sediment	**Fish**							
Organochlorines									
4,4'-DDD	0.021	0.020	0.00	0.048	0.00008	1	4	0.0038	1.25
4,4'-DDE	0	0.023	0.0	0.048	0.00008	1	4	0.0044	1.25
4,4'-DDT	0	0.00	0.0	0.048	0.00008	1	4	0.0000	1.25
total DDT	0.046	0.064	0.0	0.048	0.00008	1	4	0.0123	1.25
total chlordane	0.089	0.072	0.0	0.048	0.00008	1	4	0.0138	0.19
total PCBs	0.082	0.330	0.0	0.048	0.00008	1	4	0.0634	9
Metals									
Arsenic	1.62	0.24	0.2	0.048	0.00008	1	4	0.0461	3.3
Cadmium	0.62	0.03	0.1	0.048	0.00008	1	4	0.0058	3.31
Chromium (total)	24.8	1.62	2.5	0.048	0.00008	1	4	0.3118	277.8
Copper	22.8	2.27	2.3	0.048	0.00008	1	4	0.4366	2.35
Lead	75	1.70	7.5	0.048	0.00008	1	4	0.3288	3
Mercury	0.082	0.00	0.0	0.048	0.00008	1	4	0.0000	0.12
Nickel	21.2	0.73	2.1	0.048	0.00008	1	4	0.1408	31
Zinc	129	56.70	12.9	0.048	0.00008	1	4	10.8905	139

Chemical	HQ based on LOAEL	NOAEL (mg/kg/day)	HQ based on NOAEL
	Based on Maximum Concentrations		
Organochlorines			
4,4'-DDD	0	0.125	0
4,4'-DDE	0.0	0.125	0.1
4,4'-DDT	0.0	0.125	0
total DDT	0.0	0.125	0
total chlordane	0.1	0.019	1
total PCBs	0.0	0.9	0
Metals			
Arsenic	0.0	0.33	0
Cadmium	0.0	0.33	0.0
Chromium (total)	0.00	27.8	0.0
Copper	0.3	0.235	3
Lead	0.2	0.3	2
Mercury	0.0	0.012	0.0
Nickel	0.0	17	0.0
Zinc	0.1	13.9	1.1
	Based on Average Concentrations		
Organochlorines			
4,4'-DDD	0	0.125	0
4,4'-DDE	0.0	0.125	0.0
4,4'-DDT	0.0	0.125	0
total DDT	0.0	0.125	0
total chlordane	0.1	0.019	1
total PCBs	0.0	0.9	0
Metals			
Arsenic	0.0	0.33	0
Cadmium	0.0	0.33	0.0
Chromium (total)	0.00	27.8	0.0
Copper	0.2	0.235	2
Lead	0.1	0.3	1
Mercury	0.0	0.012	0.0
Nickel	0.0	17	0.0
Zinc	0.1	13.9	0.8

Conservative Food Chain Model (using wet weight concentrations): Raccoon Kenilworth Marsh Sediment

Chemical	Maximum Conc. (mg/kg)	BAF	Conc. in Inverts. (mg/kg)	Conc. in Fish (mg/kg)	Conc. from Sediment (mg/kg)	Ingestion Rate (kg/day)	Water Conc. (mg/kg)	Water Ingestion (kg/day)	AUF	Body Weight (1/kg)
Organochlorines										
4,4'-DDD	0.028	1	0.0	0	0.0	0.5	0.000	0.18	1	0.5
4,4'-DDE	0.000	1	0.0	0.0	0.0	0.5	0.000	0.18	1	0.5
4,4'-DDT	0.000	1	0.0	0.0	0.0	0.5	0.000	0.18	1	0.5
total DDT	0.053	1	0.0	0.0	0.0	0.5	0.000	0.18	1	0.5
total chlordane	0.105	1	0.0	0.1	0.0	0.5	0.000	0.18	1	0.5
Total PCBs	0.082	1	0.0	0.1	0.0	0.5	0.000	0.18	1	0.5
Metals										
Arsenic	1.89	1	0.3	1.4	0.2	0.5	0.000	0.18	1	0.5
Cadmium	0.78	1	0.1	0.6	0.1	0.5	0.234	0.18	1	0.5
Chromium (total)	28.6	1	5.2	20.7	2.7	0.5	0.081	0.18	1	0.5
Copper	24.8	1	4.5	18.0	2.3	0.5	0.435	0.18	1	0.5
Lead	84.6	1	15.3	61	8.0	0.5	0.498	0.18	1	0.5
Mercury	0.096	1	0.02	0.07	0.01	0.5	0.000	0.18	1	0.5
Nickel	22.8	1	4.1	16.5	2.1	0.5	0.039	0.18	1	0.5
Zinc	148	1	26.8	107	13.9	0.5	0.470	0.18	1	0.5

Conservative Food Chain Model (using wet weight concentrations): Raccoon Kenilworth Marsh Sediment

Chemical	Dose (mg/kg/day)	LOAEL (mg/kg/day)	HQ based on LOAEL	NOAEL (mg/kg/day)	HQ based on NOAEL
Organochlorines					
4,4'-DDD	0.0	4	0	1	0
4,4'-DDE	0.0	4	0.0	1	0.0
4,4'-DDT	0.0	4	0	1	0
total DDT	0.0	4	0	1	0
total chlordane	0.0	1.88	0	0.188	0
Total PCBs	0.0	0.13	0	0.1	0
Metals					
Arsenic	0.5	1.5	0	0.15	3
Cadmium	0.2	7.5	0.03	0.75	0.3
Chromium (total)	7.2	1.7	4.2	0.17	42.1
Copper	6.2	10	0.6	1	6.2
Lead	21.2	1.5	14.1	0.15	141
Mercury	0.0	0.1	0.2	0.01	2.4
Nickel	5.7	625	0.009	62.5	0.09
Zinc	37.0	250	0.1	25	1.5

Conservative Food Chain Model (using wet weight concentrations): Raccoon   Kenilworth Marsh   Fish

Chemical	Maximum Conc. (mg/kg)	Conc. in Fish (mg/kg)	Conc. from Sediment (mg/kg)	Food Ingestion Rate (kg/day)	Sed Ingestion Rate (kg/day)	AUF	Body Weight (1/kg)	Dose (mg/kg/day)
Organochlorines								
4,4'-DDD	0.028	0.03	0.00	0.453	0.047	1	0.5	0.006
4,4'-DDE	0.000	0.03	0.00	0.453	0.047	1	0.5	0.007
4,4'-DDT	0.000	0.00	0.00	0.453	0.047	1	0.5	0.000
total DDT	0.053	0.08	0.00	0.453	0.047	1	0.5	0.018
total chlordane	0.105	0.09	0.01	0.453	0.047	1	0.5	0.021
Total PCBs	0.082	0.50	0.01	0.453	0.047	1	0.5	0.113
Metals								0.000
Arsenic	1.89	0.4	0.18	0.453	0.047	1	0.5	0.104
Cadmium	0.78	0.1	0.07	0.453	0.047	1	0.5	0.016
Chromium (total)	28.6	3.2	2.69	0.453	0.047	1	0.5	0.795
Copper	24.8	3.7	2.33	0.453	0.047	1	0.5	0.900
Lead	84.6	3.4	7.95	0.453	0.047	1	0.5	0.959
Mercury	0.096	0.00	0.01	0.453	0.047	1	0.5	0.000
Nickel	22.8	1.5	2.14	0.453	0.047	1	0.5	0.386
Zinc	148	81.7	13.91	0.453	0.047	1	0.5	18.832
	Average Concentrations							
	Sediment	**Fish**						
Organochlorines								
4,4'-DDD	0.021	0.020	0.00	0.453	0.047	1	0.5	0.005
4,4'-DDE	0	0.023	0.00	0.453	0.047	1	0.5	0.005
4,4'-DDT	0	0.00	0.00	0.453	0.047	1	0.5	0.000
total DDT	0.046	0.064	0.00	0.453	0.047	1	0.5	0.015
total chlordane	0.089	0.072	0.01	0.453	0.047	1	0.5	0.017
Total PCBs	0.082	0.330	0.01	0.453	0.047	1	0.5	0.075
Metals								0.000
Arsenic	1.62	0.24	0.15	0.453	0.047	1	0.5	0.058
Cadmium	0.62	0.03	0.06	0.453	0.047	1	0.5	0.008
Chromium (total)	24.8	1.62	2.33	0.453	0.047	1	0.5	0.422
Copper	22.8	2.27	2.14	0.453	0.047	1	0.5	0.565
Lead	75	1.70	7.05	0.453	0.047	1	0.5	0.551
Mercury	0.082	0.00	0.01	0.453	0.047	1	0.5	0.000
Nickel	21.2	0.73	1.99	0.453	0.047	1	0.5	0.212
Zinc	129	56.70	12.13	0.453	0.047	1	0.5	13.128

Conservative Food Chain Model (using wet weight concentrations): Raccoon Kenilworth Marsh Fish

Chemical	LOAEL (mg/kg/day)	HQ based on LOAEL	NOAEL (mg/kg/day)	HQ based on NOAEL
	Based on Maximum Concentrations			
Organochlorines				
4,4'-DDD	4	0	1	0
4,4'-DDE	4	0.0	1	0.0
4,4'-DDT	4	0	1	0
total DDT	4	0	1	0
total chlordane	1.88	0	0.188	0
Total PCBs	0.13	1	0.1	1
Metals				
Arsenic	1.5	0	0.15	1
Cadmium	7.5	0.00	0.75	0.0
Chromium (total)	1.7	0.5	0.17	4.7
Copper	10	0.1	1	0.9
Lead	1.5	0.6	0.15	6
Mercury	0.1	0.0	0.01	0.0
Nickel	625	0.001	62.5	0.01
Zinc	250	0.1	25	0.8
	Based on Average Concentrations			
Organochlorines				
4,4'-DDD	4	0	1	0
4,4'-DDE	4	0.0	1	0.0
4,4'-DDT	4	0	1	0
total DDT	4	0	1	0
total chlordane	1.88	0	0.188	0
Total PCBs	0.13	1	0.1	1
Metals				
Arsenic	1.5	0	0.15	0
Cadmium	7.5	0.00	0.75	0.0
Chromium (total)	1.7	0.2	0.17	2.5
Copper	10	0.1	1	0.6
Lead	1.5	0.4	0.15	4
Mercury	0.1	0.0	0.01	0.0
Nickel	625	0.000	62.5	0.00
Zinc	250	0.1	25	0.5

Chemical	Maximum Conc. (mg/kg)	BAF	Conc. In Inverts. (mg/kg)	Conc. In Fish (mg/kg)	Conc. from Sediment (mg/kg)	Ingestion Rate (kg/day)	AUF	Body Weight (1/kg) 0.25	Dose (mg/kg/day)	LOAEL (mg/kg/day)
Organochlorines										
4,4'-DDD	0	1	0.0	0.0	0.00	0.048	1	4	0.0000	1.25
4,4'-DDE	0	1	0.0	0.0	0.0	0.048	1	4	0.0000	1.25
4,4'-DDT	0	1	0.0	0.0	0.0	0.048	1	4	0.0000	1.25
total DDT	0	1	0.0	0.0	0.0	0.048	1	4	0.0000	1.25
total chlordane	0	1	0.0	0.0	0.0	0.048	1	4	0.0000	0.19
total PCBs	0	1	0.0	0.0	0.0	0.048	1	4	0.0000	9
Metals								4		
Arsenic	0.84	1	0.4	0.4	0.1	0.048	1	4	0.1613	3.3
Cadmium	0.12	1	0.1	0.1	0.0	0.048	1	4	0.0230	3.31
Chromium (total)	6.07	1	2.7	2.7	0.6	0.048	1	4	1.1654	277.8
Copper	6.36	1	2.9	2.9	0.6	0.048	1	4	1.2211	2.35
Lead	9.74	1	4.4	4.4	1.0	0.048	1	4	1.8701	3
Mercury	0	1	0.0	0.0	0.0	0.048	1	4	0.0000	0.12
Nickel	5.27	1	2.4	2.4	0.5	0.048	1	4	1.0118	31
Zinc	23.7	1	10.7	10.7	2.4	0.048	1	4	4.5504	139

Chemical	HQ based on LOAEL	NOAEL (mg/kg/day)	HQ based on NOAEL
Organochlorines			
4,4'-DDD	0	0.125	0
4,4'-DDE	0.0	0.125	0.0
4,4'-DDT	0.0	0.125	0
total DDT	0.0	0.125	0
total chlordane	0.0	0.019	0
total PCBs	0.0	0.9	0
Metals			
Arsenic	0.0	0.33	0
Cadmium	0.0	0.33	0.1
Chromium (total)	0.00	27.8	0.0
Copper	0.5	0.235	5
Lead	0.6	0.3	6
Mercury	0.0	0.012	0.0
Nickel	0.0	17	0.1
Zinc	0.0	13.9	0.3

Conservative Food Chain Model (using wet weight concentrations): Green Heron Mason Neck Fish

Chemical	Maximum Conc. (mg/kg)	Conc. in Fish (mg/kg)	Conc. from Sediment (mg/kg)	Fishingestion Rate (kg/day)	Sed Ingestion Rate	AUF	Body Weight (1/kg)	Dose (mg/kg/day)	LOAEL (mg/kg/day)
Organochlorines									
4,4'-DDD	0	0.00	0.00	0.048	0.00008	1	4	0.0000	1.25
4,4'-DDE	0	0.01	0.0	0.048	0.00008	1	4	0.0025	1.25
4,4'-DDT	0	0.00	0.0	0.048	0.00008	1	4	0.0000	1.25
total DDT	0	0.04	0.0	0.048	0.00008	1	4	0.0073	1.25
total chlordane	0	0.09	0.0	0.048	0.00008	1	4	0.0179	0.19
total PCBs	0	0.00	0.0	0.048	0.00008	1	4	0.0000	9
Metals								0.0000	
Arsenic	0.84	0.43	0.1	0.048	0.00008	1	4	0.0826	3.3
Cadmium	0.12	0.06	0.0	0.048	0.00008	1	4	0.0108	3.31
Chromium (total)	6.07	0.91	0.6	0.048	0.00008	1	4	0.1749	277.8
Copper	6.36	1.88	0.6	0.048	0.00008	1	4	0.3612	2.35
Lead	9.74	0.00	1.0	0.048	0.00008	1	4	0.0003	3
Mercury	0	0.00	0.0	0.048	0.00008	1	4	0.0000	0.1
Nickel	5.27	0.33	0.5	0.048	0.00008	1	4	0.0635	31
Zinc	23.7	137.90	2.4	0.048	0.00008	1	4	26.4776	139
	Average Concentrations								
	Sediment	**Fish**							
Organochlorines									
4,4'-DDD	0	0.000	0.00	0.048	0.00008	1	4	0.0000	1.25
4,4'-DDE	0	0.013	0.0	0.048	0.00008	1	4	0.0025	1.25
4,4'-DDT	0	0.00	0.0	0.048	0.00008	1	4	0.0000	1.25
total DDT	0	0.032	0.0	0.048	0.00008	1	4	0.0061	1.25
total chlordane	0	0.000	0.0	0.048	0.00008	1	4	0.0000	0.19
total PCBs	0	0.000	0.0	0.048	0.00008	1	4	0.0000	9
Metals								0.0000	
Arsenic	0.84	0.19	0.1	0.048	0.00008	1	4	0.0367	3.3
Cadmium	0.12	0.03	0.0	0.048	0.00008	1	4	0.0052	3.31
Chromium (total)	6.07	0.77	0.6	0.048	0.00008	1	4	0.1480	277.8
Copper	6.36	1.08	0.6	0.048	0.00008	1	4	0.2076	2.35
Lead	9.74	0.00	1.0	0.048	0.00008	1	4	0.0003	3
Mercury	0	0.00	0.0	0.048	0.00008	1	4	0.0000	0.12
Nickel	5.27	0.18	0.5	0.048	0.00008	1	4	0.0347	31
Zinc	23.7	71.52	2.4	0.048	0.00008	1	4	13.7326	139

Conservative Food Chain Model (using wet weight concentrations): Green Heron Mason Neck Fish

Chemical	HQ	NOAEL	HQ
	based on LOAEL	(mg/kg/day)	based on NOAEL
	Based on Maximum Concentrations		
Organochlorines			
4,4'-DDD	0	0.125	0
4,4'-DDE	0.0	0.125	0.0
4,4'-DDT	0.0	0.125	0
total DDT	0.0	0.125	0
total chlordane	0.1	0.019	1
total PCBs	0.0	0.9	0
Metals			
Arsenic	0.0	0.33	0
Cadmium	0.0	0.33	0.0
Chromium (total)	0.00	27.8	0.0
Copper	0.2	0.235	2
Lead	0.0	0.3	0
Mercury	0.0	0.01	0.0
Nickel	0.0	17	0.0
Zinc	0.2	13.9	1.9
	Based on Average Concentrations		
Organochlorines			
4,4'-DDD	0	0.125	0
4,4'-DDE	0.0	0.125	0.0
4,4'-DDT	0.0	0.125	0
total DDT	0.0	0.125	0
total chlordane	0.0	0.019	0
total PCBs	0.0	0.9	0
Metals			
Arsenic	0.0	0.33	0
Cadmium	0.0	0.33	0.0
Chromium (total)	0.00	27.8	0.0
Copper	0.1	0.235	1
Lead	0.0	0.3	0
Mercury	0.0	0.012	0.0
Nickel	0.0	17	0.0
Zinc	0.1	13.9	1.0

Conservative Food Chain Model (using wet weight concentrations): Raccoon   Mason Neck   Sediment

Chemical	Maximum Conc. (mg/kg)	BAF	Conc. in Inverts. (mg/kg)	Conc. in Fish (mg/kg)	Conc. from Sediment (mg/kg)	Ingestion Rate (kg/day)	Water Conc. (mg/kg)	Water Ingestion (kg/day)	AUF	Body Weight (1/kg)
Organochlorines										
4,4'-DDD	0	1	0.0	0	0.0	0.5	0.000	0.18	1	0.5
4,4'-DDE	0	1	0.0	0.0	0.0	0.5	0.000	0.18	1	0.5
4,4'-DDT	0	1	0.0	0.0	0.0	0.5	0.000	0.18	1	0.5
total DDT	0	1	0.0	0.0	0.0	0.5	0.000	0.18	1	0.5
total chlordane	0	1	0.0	0.0	0.0	0.5	0.000	0.18	1	0.5
Total PCBs	0	1	0.0	0.0	0.0	0.5	0.000	0.18	1	0.5
Metals										
Arsenic	0.84	1	0.2	0.6	0.1	0.5	0.000	0.18	1	0.5
Cadmium	0.12	1	0.0	0.1	0.0	0.5	0.234	0.18	1	0.5
Chromium (total)	6.07	1	1.1	4.4	0.6	0.5	0.081	0.18	1	0.5
Copper	6.36	1	1.2	4.6	0.6	0.5	0.435	0.18	1	0.5
Lead	9.74	1	1.8	7	0.9	0.5	0.498	0.18	1	0.5
Mercury	0	1	0.00	0.00	0.00	0.5	0.000	0.18	1	0.5
Nickel	5.27	1	1.0	3.8	0.5	0.5	0.039	0.18	1	0.5
Zinc	23.7	1	4.3	17	2.2	0.5	0.470	0.18	1	0.5

Conservative Food Chain Model (using wet weight concentrations): Raccoon Mason Neck Sediment

Chemical	Dose (mg/kg/day)	LOAEL (mg/kg/day)	HQ based on LOAEL	NOAEL (mg/kg/day)	HQ based on NOAEL
Organochlorines					
4,4'-DDD	0.0	4	0	1	0
4,4'-DDE	0.0	4	0.0	1	0.0
4,4'-DDT	0.0	4	0	1	0
total DDT	0.0	4	0	1	0
total chlordane	0.0	1.88	0	0.188	0
Total PCBs	0.0	0.13	0	0.1	0
Metals					
Arsenic	0.2	1.5	0	0.15	1
Cadmium	0.1	7.5	0.01	0.75	0.1
Chromium (total)	1.5	1.7	0.9	0.17	9.0
Copper	1.6	10	0.2	1	1.6
Lead	2.5	1.5	1.7	0.15	17
Mercury	0.0	0.1	0.0	0.01	0.0
Nickel	1.3	625	0.002	62.5	0.02
Zinc	6.0	250	0.0	25	0.2

Conservative Food Chain Model (using wet weight concentrations): Raccoon Mason Neck Fish

Chemical	Maximum Conc. (mg/kg)	Conc. in Fish (mg/kg)	Conc. from Sediment (mg/kg)	Food Ingestion Rate (kg/day)	Sed Ingestion Rate (kg/day)	AUF	Body Weight (1/kg)	Dose (mg/kg/day)
Organochlorines								
4,4'-DDD	0	0.00	0.00	0.453	0.047	1	0.5	0.000
4,4'-DDE	0	0.01	0.00	0.453	0.047	1	0.5	0.003
4,4'-DDT	0	0.00	0.00	0.453	0.047	1	0.5	0.000
total DDT	0	0.04	0.00	0.453	0.047	1	0.5	0.009
total chlordane	0	0.09	0.00	0.453	0.047	1	0.5	0.021
Total PCBs	0	0.00	0.00	0.453	0.047	1	0.5	0.000
Metals								0.000
Arsenic	0.84	0.43	0.08	0.453	0.047	1	0.5	0.099
Cadmium	0.12	0.06	0.01	0.453	0.047	1	0.5	0.013
Chromium (total)	6.07	0.91	0.57	0.453	0.047	1	0.5	0.220
Copper	6.36	1.88	0.60	0.453	0.047	1	0.5	0.440
Lead	9.74	0.00	0.92	0.453	0.047	1	0.5	0.022
Mercury	0	0.00	0.00	0.453	0.047	1	0.5	0.000
Nickel	5.27	0.33	0.50	0.453	0.047	1	0.5	0.086
Zinc	23.7	137.90	2.23	0.453	0.047	1	0.5	31.287
	Average Concentrations							
	Sediment	**Fish**						
Organochlorines								
4,4'-DDD	0	0.000	0.00	0.453	0.047	1	0.5	0.000
4,4'-DDE	0	0.013	0.00	0.453	0.047	1	0.5	0.003
4,4'-DDT	0	0.00	0.00	0.453	0.047	1	0.5	0.000
total DDT	0	0.032	0.00	0.453	0.047	1	0.5	0.007
total chlordane	0	0.000	0.00	0.453	0.047	1	0.5	0.000
Total PCBs	0	0.000	0.00	0.453	0.047	1	0.5	0.000
Metals								0.000
Arsenic	0.84	0.19	0.08	0.453	0.047	1	0.5	0.045
Cadmium	0.12	0.03	0.01	0.453	0.047	1	0.5	0.006
Chromium (total)	6.07	0.77	0.57	0.453	0.047	1	0.5	0.188
Copper	6.36	1.08	0.60	0.453	0.047	1	0.5	0.259
Lead	9.74	0.00	0.92	0.453	0.047	1	0.5	0.022
Mercury	0	0.00	0.00	0.453	0.047	1	0.5	0.000
Nickel	5.27	0.18	0.50	0.453	0.047	1	0.5	0.052
Zinc	23.7	71.52	2.23	0.453	0.047	1	0.5	16.252

Chemical	LOAEL	HQ	NOAEL	HQ
	(mg/kg/day)	based on LOAEL	(mg/kg/day)	based on NOAEL
	Based on Maximum Concentrations			
Organochlorines				
4,4'-DDD	4	0	1	0
4,4'-DDE	4	0.0	1	0.0
4,4'-DDT	4	0	1	0
total DDT	4	0	1	0
total chlordane	1.88	0	0.188	0
Total PCBs	0.13	0	0.1	0
Metals				
Arsenic	1.5	0	0.15	1
Cadmium	7.5	0.00	0.75	0.0
Chromium (total)	1.7	0.1	0.17	1.3
Copper	10	0.0	1	0.4
Lead	1.5	0.0	0.15	0
Mercury	0.1	0.0	0.01	0.0
Nickel	625	0.000	62.5	0.00
Zinc	250	0.1	25	1.3
	Based on Average Concentrations			
Organochlorines				
4,4'-DDD	4	0	1	0
4,4'-DDE	4	0.0	1	0.0
4,4'-DDT	4	0	1	0
total DDT	4	0	1	0
total chlordane	1.88	0	0.188	0
Total PCBs	0.13	0	0.1	0
Metals				
Arsenic	1.5	0	0.15	0
Cadmium	7.5	0.00	0.75	0.0
Chromium (total)	1.7	0.1	0.17	1.1
Copper	10	0.0	1	0.3
Lead	1.5	0.0	0.15	0
Mercury	0.1	0.0	0.01	0.0
Nickel	625	0.000	62.5	0.00
Zinc	250	0.1	25	0.7

United States Department of the Interior

FISH AND WILDLIFE SERVICE
300 Westgate Center Drive
Hadley, Massachusetts 01035-9589

In Reply Refer To:
FWS/Region 5/ES-EC

* Fannin needs to talk to me on this

OFF
NO REPORT

JUN 18 1997

Memorandum

To: Chief, Division of Environmental Contaminants

From: Environmental Contaminants Coordinator

Subject: Interim Report - Evaluating Effects of Wetland Restoration Using Contaminated Sediments at Kenilworth Marsh

The interim report for contaminants investigation project 50120-1130-5F18 has been received in the Regional Office. The accession title for the report is: ***"Evaluating Effects of Wetland Restoration Using Contaminated Sediments at Kenilworth Marsh"*** by Dan Murphy. The Region 5 Environmental Contaminants Coordinator is pleased to provide you with a copy.

As always, we welcome the opportunity to document the effectiveness and ingenuity of the Region 5 Field Contaminants Specialists. This report is an indicator of the level of imagination, effort, and perseverance invested in these studies, and reveals the extensive contributions made by the Environmental Contaminants Specialists in providing assistance to other Service programs, preventing injury to our resources, and giving early warning of impending problems in Region 5! We provide you the information in the report, and underline the need for similar investigations, as a stimulus for you to secure expanded Service funding for these important studies.

If you have any further questions or need additional information, please call Tim Fannin at (413) 253-8646.

Attachment

Progress Report

Evaluating Effects of Wetland Restoration Using Contaminated Sediments at Kenilworth Marsh

Study ID Number 51410-1130-5F18

Prepared by
Daniel Murphy
U.S. Fish and Wildlife Service
Chesapeake Bay Field Office
Annapolis, MD 21401

June 3, 1997

Introduction

The sediments in the lower reaches of the Anacostia River in Washington, D.C. have high levels of polynuclear aromatic hydrocarbons (PAH), polychlorinated biphenyl (PCB), chlordane, and metals. In 1993, as part of a maintenance dredging action by the U.S. Army Corps of Engineers (ACOE), dredged material from the Anacostia River was used to construct tidal freshwater wetlands in Kenilworth Marsh on National Park Service (NPS) lands. Preliminary studies show that the plant and benthic community recolonized the filled areas of the marsh and that its waters support a variety of resident and anadromous fish. In 1993, Chesapeake Bay Field Office (CBFO) worked with the ACOE to develop a baseline chemical characterization of marsh sediments which included sediment bioassays. Chemically, the new marsh substrates are the same as river sediments and contain PCB, chlordane, lead, and zinc levels that exceed the ER-M of Long and Morgan, 1990. Through this and future studies, the CBFO will attempt to determine the levels of toxic chemicals present in the community developing on new tidal freshwater wetlands in Kenilworth Marsh.

The objective of this study is to determine the uptake of contaminated dredge materials in the freshwater tidal wetland community at Kenilworth Marsh by analyzing fish tissue, vegetation, and sediment samples for total PCB's, chlorinated pesticides, and metals.

Progress

In 1996, cattail root material (*Typha latifolia*), sediments, and whole body samples of killifish (*Fundulus diaphanus* and *Fundulus heteroclitus*) were collected from two locations on Kenilworth Marsh in Washington, D.C. and one control site at Mason Neck National Wildlife Refuge (NWR) and analyzed for organochlorine pesticides, PCBs and metals using accepted methods.

Data from the analyses of cattail and fish tissues has been received and a report on the results is being prepared. Sediments are currently being analyzed and results are expected soon.

DATE	INVESTIGATIONS LOG
7/30/96	R5 Coordinator INFORMALLY requested a redirection of funds for the FY 1996 investigation 5F18 to do the unfunded Kenilworth Marsh project proposed in FY 96. Contrary to R5's claim, the proposal supplied looks like a 1993 version, and is really weak. Also, the proposal in 96 was the <u>lowest</u> ranked un-funded proposal, not the highest. (See 8/22/96)
8/22/96	R5 e-mailed a second request to redirect funds on 5F18 by supplying the unrevised FY 1994 (i.e., NOT the FY 96) version of Kenilworth proposal. The reason for not suppling the most current version is unknown. (See 7/30 and 8/23)
8/23/96	CC E-mailed a reply to R5 supporting their 8/22 request to redirect funding from 1995-5F18, but only **if** R5 submits an updated proposal that follows the current process (except for criteria scoring) that everyone else follows. R5 rejected WO's conditional support and according to January 1997 B&B's, the Kenilworth study was done. R5 still owes WO for the original project 5F18.
8/30/96	R5 submits a final report claiming it is for project 1995-5F18. That proposal was funded for $23K to look at the contaminant impacts related to a shooting range, but the final report is on the analysis of 3 loggerhead shrike eggs. See 7/30/96 & 8/23/96.

see Communications file
FY 97 Investigations Process

Author: Charlie Chandler at 9AR¯FWE1
Date: 8/23/96 11:05 AM
Priority: Normal
TO: Tim Fannin at 5HA¯MAIN2
CC: Frank Deluise
CC: Pam Matthes
Subject: Re: Supporting Proposal for Substitution of Kenilworth Proje
-------------------------- Message Contents ----------------------------

Howdy!

The honesty and integrity shown by the FO is admirable and carries a lot of weight with me. Bob Foley is a good man to have on our side. I will fully support this request and recommend that the redirection of funds be approved, but we need to clear up some confusion and there are conditions.

Your reference to priority ranking in FY96 is not accurate, the proposal attached to your memorandum showed a strong disregard for the established procedures, and the proposal attached to this e-mail is very dated. I'm willing to go a long way to support you and the FO on this, but with all due respect, you have to give me something valid to work with; what you have provided so far is nearly useless to me and simply cannot be supported. If we are going to fund a project outside the normal ranking process as a redirection of dollars, then it is even more important that we show that the rest of the process was followed to develop a valid investigation. Here is what I need:

1. Let me know if this e-mail will suffice as a response to your memo to my chief, or do you still need a formal response.

2. I need the appropriate signatures to show commitments from the EC specialist, the FO project leader, you and appropriate RO mgmt.

3. Redraft your first memo following the procedure established in the investigation guidance, chapter 3, page 2, "Redirected Funding". The Director has to approve with concurrence from Division of Budget. Ignore previous rankings of the proposal, express region's current support, and clearly identify the amount (estimate if necessary) of funds under discussion. Include the brief explanation of what happened with the partner, but indicate that a formal memo/report is forthcoming from the FO to show what was/was not accomplished so that we may close the books on the 1995-96 investigation 5F18.

4. The FO should submit this close out memo/report ASAP. Not too much detail, but we need to be able to explain where the money went (sampling, field ops, etc.) and why the investigation was not finished. This way, it will not hurt regional performance score.

5. Attached to your memo, submit a revised proposal that fully follows current format and procedure. Include a budget for use of the remaining funds. Make the project multi-year if necessary to get the job done right, but include the multiyear budget. Note that if it is made into a multiyear investigation, we may need to run it through the scoring process next year just to be fair to the other regions. Include a peer review, identify responsibilities and partners and a complete schedule, basically the works. Send me the soft copy as well

on e-mail.

I will give my full support to the proposal if it appears to be solid and meets all the pass/fail criteria. Keep in mind that I only recommend and cannot guarantee the outcome. Because we can carry over these dollars, there may be some resistance from management or budget. I think the other coordinators would support you in this redirection. Let me know what you think or if I can help in any way.

Charlie

______________________________ Reply Separator ______________________________

Subject: Supporting Proposal for Substitution of Kenilworth Project
Author: Tim Fannin at 5HA_MAIN2
Date: 8/22/96 3:43 PM

Charlie-
I found and have attached the electronic of the Kenilworth Marsh (Anacostia River) 1994/5 project which I requested by July 30, 1996, memo be substituted for the Chesapeake Bay Lead Shot study. Again, the Kenilworth study was the Region's highest ranked non-funded study for 1994/95, so the reason for its "non-selection" was at least as related to availability of national funding as it was to the relative quality/importance of the proposed investigation.

I must reiterate that the FO is being very honest, and I think exhibiting a high degree of integrity, by offering to do this substitute project rather than begging off on doing anything because of poor cooperation from partners.

I anxiously await your decision that this substitution is acceptable to DEC.
Thanks
-Tim

United States Department of the Interior

FISH AND WILDLIFE SERVICE
300 Westgate Center Drive
Hadley, Massachusetts 01035-9589

See Log 7/30/96 8/22/96 8/23/96 8/30/96

In Reply Refer To:
FWS/Region 5/ES-EC

Working Copy
Original is in
FY 97 Communications
file

JUL 30 1996

Memorandum

To: Chief, Division of Environmental Contaminants

From: Contaminants Coordinator, Region 5

Subject: Substitution of Off-Refuge Investigation MD-SHOOTING RANGES & MIGRATORY BIRDS (95-5F18 and 96-5F18/9550001B) with MD-KENILWORTH MARSH INVESTIGATION

Because of unanticipated difficulties in working with partners on the subject study, the Chesapeake Bay Field Office and Region 5 requests that the remaining operational and analytical funds in the subject study instead be applied to determine the effects of PCBs, chlorinated pesticides (including chlordane), and metals in a tidal freshwater marsh created from contaminated sediments as an alternate special study. This Kenilworth Marsh investigation was the subject of Region 5's highest ranked unfunded special study in the FY 96 proposal package last year. The CBFO and Region have a history and a continuing interest in the Kenilworth Marsh site on the Anacostia River which is owned by National Park Service. We have contaminant data on the marsh immediately after placement of the contaminated sediments. Now that a functional wetland community is established at the site, we believe its time to revisit the same locations (pinpointed by GPS data) and determine whether the OC's and metals are moving into the food chain. Please see the attached proposal for details.

This proposed work has important implications in the Baltimore Harbor, Anacostia River, and Elizabeth River areas of Chesapeake Bay because each of these areas has contaminated dredge material disposal problems. The Corps of Engineers has fostered a program of marsh creation with these dredged sediments.

The attached substitute study contains maps of the prospective sample areas and CBFO Standard Operating Procedures which will be followed during the course of the study. After your review of the attached substitute study, please sign on the line below that you concur

We can't fund a whole new proposal!

OPTIONAL FORM 99 (7-90)

FAX TRANSMITTAL	# of pages ▸ 17
To Charlie Chander	From Tim Fannin
Dept./Agency	Phone # 413-253-8646
Fax #	Fax # " " 8482
NSN 7540-01-317-7368 5099-101	GENERAL SERVICES ADMINISTRATION

with the subject substitution and return a copy of the concurrence memorandum to the Regional Ecological Services office. If you have any further questions or need additional information, call Tim Fannin at (413) 253-8646.

Concur: ______________________________

Chief, Division of Environmental Contaminants

Attachment

Kenilworth Work Plan 1996

I. Background

The sediments in the lower reaches of the Anacostia river in Washington, D.C. have high levels of polynuclear aromatic hydrocarbons (PAH), polychlorinated biphenyl, chlordane, and metals. In 1993, as part of a maintenance dredging action by the U.S. Army Corps of Engineers (ACOE), dredged material from the Anacostia River was used to construct tidal freshwater wetlands in Kenilworth Marsh on National Park Service (NPS) lands. Preliminary studies show that the plant and benthic macroinvertebrate community recolonized the filled areas of the marsh and that its waters support a variety of resident and anadromous fish. In 1993, Chesapeake Bay Field Office (CBFO) worked with the ACOE to develop a baseline chemical characterization of marsh sediments which included sediment bioassays. Chemically, the new marsh substrates are the same as river sediments and contain PCB, chlordane, lead, and zinc levels that exceed the ER-M of Long and Morgan, 1990. Chesapeake Bay Field Office proposes to determine the levels of toxic chemicals present in the community developing on new tidal freshwater wetlands in Kenilworth Marsh.

II. Goal

CBFO will perform services necessary to accomplish two objectives. These objectives are:

A. To develop a defensible position for the Anacostia River Restoration Program to consider developing a policy on the use of dredged materials for wetland restoration in the Anacostia River estuary.

B. To determine the effects of contaminated dredge materials on the freshwater tidal wetland community at Kenilworth Marsh by analyzing fish tissue and vegetation samples for total PCB's, chlorinated pesticides (including chlordane) and metals. Cattail root material (*Typha sp.*) and whole body samples of killifish (*Fundulus diaphanus* or *F. heteroclitus*) will be collected from two locations on Kenilworth Marsh and one control site at Mason Neck National Wildlife Refuge (NWR) and analyzed using accepted methods.

III. Types of Data to be Collected

A. Data requirements for this work plan include analysis of whole body fish to determine concentrations of the following analytes: total PCB's, congener specific PCB's, organoclorine pesticides, metals, % moisture, and % lipid. Data will be provided as both wet and dry weight.

B. Data requirements for this work plan include analysis of vegetation to determine concentrations of the following analytes: metals, % moisture, and % lipid. Data will be provided as both wet and dry weight.

IV. Sampling

A. Areas to be sampled

1. The primary area to be sampled will be Kenilworth Marsh (Figure 1). Two sample sites will be located in the marsh: one in Mass Fill Area 1 and one in Mass Fill area 2.

2. A control area will be located on Mason Neck NWR in an unnamed tidal tributary of the Potomac River (Figure 2).

B. Site Reconnaissance

Sample sites will be characterized to document presence of aquatic vegetation, natural influences at the site, water quality parameters, and human influences at the site. Location of sampling sites will be recorded using a Global Positioning System (GPS).

C. Sampling

1. When a sampling event occurs, appropriate information including site descriptions and water quality measurements will be recorded in a field log. Data will be recorded in such a manner that when photography is used to document activity, the photographs can be linked to the sampling sites.

2. Killifish will be collected with minnow traps baited with bread, by seining, and/or backpack electroshocking. Sample collection, handling, and shipment will be conducted according to CBFO SOP 114 (Appendix A).

3. Cattail samples will be collected by obtaining root material and cutting off and discarding the above ground plant parts (CBFO SOP 134).

4. Biological samples will be labeled as follows:
K0101TFH: where K = Kenilworth Marsh (M = Mason Neck), 01 is the site area, 01 is the sample number, and FH is the two letter species abbreviation for mummichogs (FD = banded killifish, TY = cattails).

6. Species:

F. Heteroclitus (mummichog) or *F. Diaphanus* (banded killifish)
Typha sp. (Cattails)

7. Sample Sizes and Compositing Considerations

U.S. EPA guidance on sampling, compositing, and handling of fish will be followed to ensure that fish are handled appropriately (EPA 1993). This guidance recommends procedures to composite fish according to their size to produce samples which provide comparable estimates of contamination between locations and species. Note: EPA (1993) guidance recommends compositing of 50 grams of tissue. EPA (1993) guidance will be followed for acceptable variability within and between samples.

Number of samples of the above species will be as follows:

Killifish: Composites of a given number of fish depending on size available. Eight analyses per location. The number of fish per composite will be determined, based on a 50 gram wet weight requirement. Length of the smallest fish must be 60% of the length of the longest. The same number of fish will be used for all composites and the average size will be similar among locations. Eight samples from each of two locations on Kenilworth Marsh and eight samples from Mason Neck NWR.

Cattails: Eight samples containing at least 50 grams wet weight will be collected at each location. Samples will contain only parts of the plant that are below the sediment. Eight samples from each of two places on Kenilworth marsh and eight samples from Mason Neck NWR.

V. Preservation and Sample shipment

A. Chain of custody will begin at the time of sample collection and individual records will be maintained on all samples through the laboratory analysis (CBFO SOPs 102, 113, and 114; Appendix A).

B. Samples will be shipped to the analytical laboratory in a manner that ensures overnight delivery. The laboratory will be informed prior to the shipment of samples.

C. Samples will be frozen and shipped in coolers with dry ice (CBFO SOP 103).

VI. Analytical Procedures

Samples will be analyzed by USFWS contract laboratories through the Patuxent Analytical Control Facility (PACF) following quality assurance guidelines. All QA/QC reports will include a description of the condition of the sample upon receipt by the laboratory, a brief summary of the methods used, the analytical results, report of the results of duplicate, spiked, blank, and reference samples, and an estimate of the detection limits reached on a sample by sample basis.

VII. CBFO Quality Assurance/Quality Control

On a regular basis, during field sampling, tissue preparation, and preparation of sample bottles, the project manager will inspect and verify that Standard Operating Procedures are followed by all staff. Sample bottles will be inspected and inventoried to verify label accuracy and that adequate numbers have been collected to satisfy the needs of the study.

All data generated by USFWS field personnel will be recorded in ink in bound notebooks or preprinted data sheets. Errors are corrected by drawing a single line through the error and entering the correct information, then initialing and dating the correction. No original information is erased, marked out, or otherwise made illegible (CBFO SOP 101). Field data will be regularly reviewed by the project manager.

VIII. Data Management

Data will be returned to the PACF in digitized format. It will be reviewed by a PACF chemist prior to being delivered to CBFO.

IX. Schedule

Sample collection will be initiated during the week of July 29, 1996. All samples will be shipped shortly after the last day of collection.

X. Report

A. The CBFO will analyze the data and draft a report within 90 days of the receipt of the analytical report.

B. The report will summarize the key findings, interpret the results, compare concentrations with guidance values, and provide recommendations for future studies.

XI. Cost

Organochlorine Scan
    24 fish @ 413.00 = 9912.00

Metals Scan
    24 fish @ 191.00 = 4584.00
    24 plant @ 200.00 = 4800.00

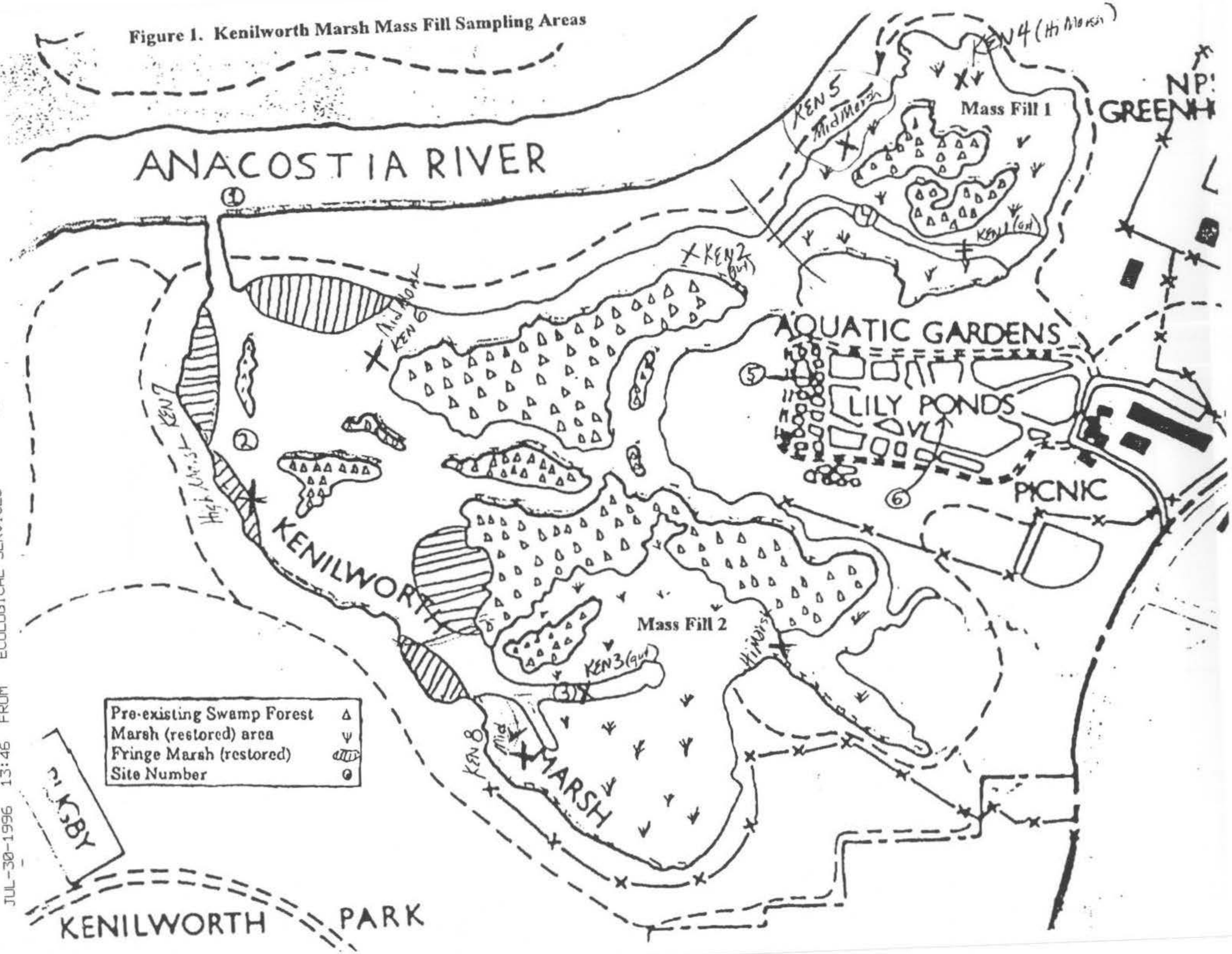
PCB Congener Specific Analysis
    24 fish @ 577.00 = 13,848

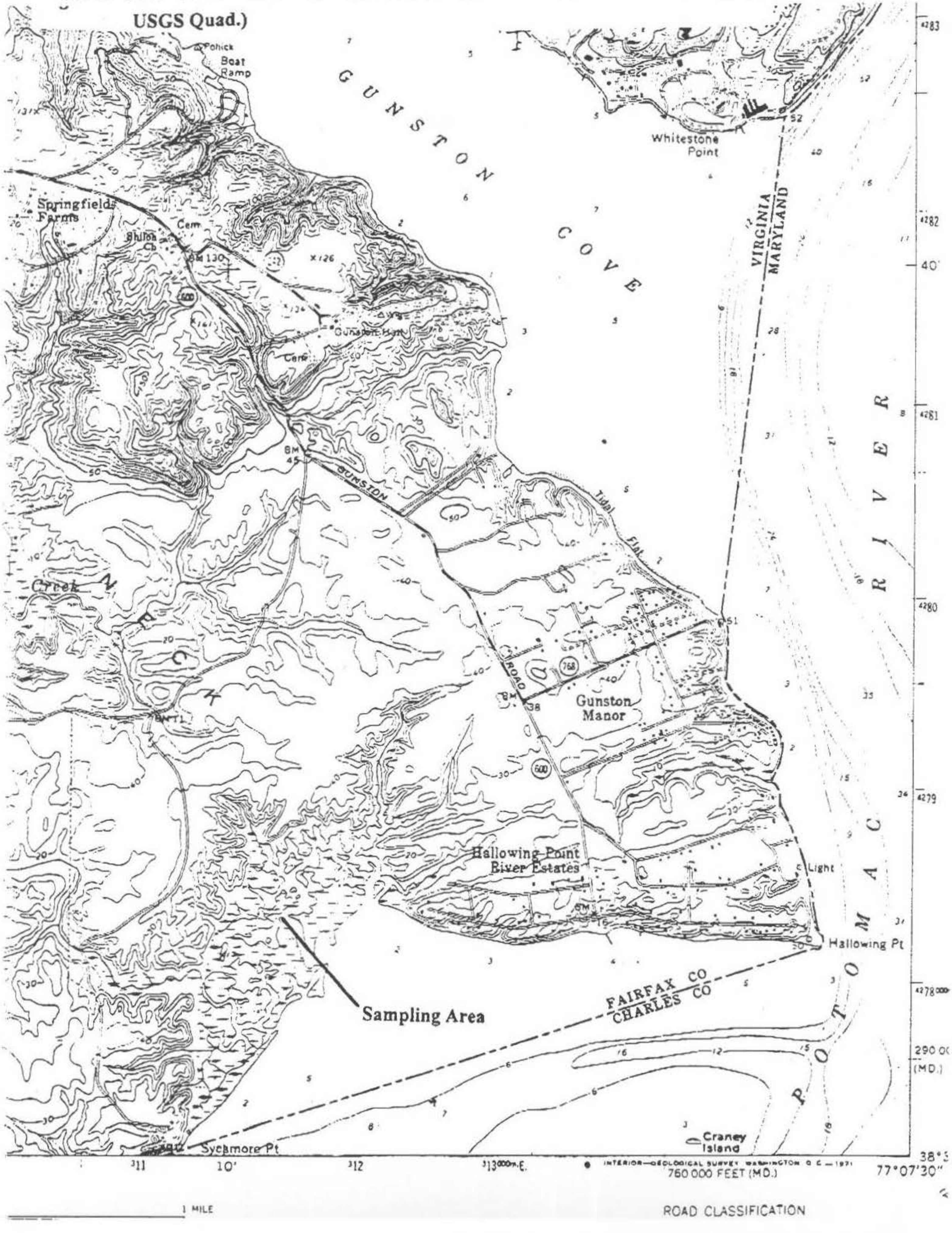
Total Cost = $33,144

XII. References

U.S. Environmental protection agency (EPA). 1993. Guidance for assessing chemical contaminant data for use in fish advisories. Volume 1, fish sampling and analysis. Office of Water, Washington, D.C. EPA 823-R-002.

Figure 1. Kenilworth Marsh Mass Fill Sampling Areas




USGS Quad.)
Pohick Boat Ramp
GUNSTON COVE
Whitestone Point
VIRGINIA
MARYLAND
Springfields Farms
Shiloh Ch
Cem
Gunston Hall
GUNSTON
ROAD
Tidal Flat
Creek
NECK
Gunston Manor
Hallowing Point River Estates
Light
Hallowing Pt
POTOMAC RIVER
FAIRFAX CO
CHARLES CO
Sampling Area
Sycamore Pt
Craney Island
INTERIOR—GEOLOGICAL SURVEY WASHINGTON D C—1971
760 000 FEET (MD.)
290 000 (MD.)
77°07'30"
1 MILE
ROAD CLASSIFICATION

U.S. Fish and Wildlife Service

Chesapeake Bay Field Office

STANDARD OPERATING PROCEDURES

101. Data Recording and Handling

A. Objective:

Describe the procedures used for data recording and handling in the field and in the laboratory.

B. Procedures:

1. All data will be recorded in indelible black ink at the time of observation.

2. Hand written data generated during a study will be recorded in a bound notebook. Each notebook will be used for one study only.

3. The biologist or technician recording the data will initial and date the bottom of each entry and the bottom of each page of the data book.

4. Corrections will be made by drawing one line through the error. Each error will be initialled, dated, and coded with an error code. The error code which best describes the reason for the correction can be chosen from the list below.

5. When not in use, notebooks will be stored in the study file along with any printed data or correspondence associated with the study. This file will also include the proposal, protocol, and catalog.

6. To prevent unretrievable loses of data through loss or destruction of the data book, certified copies of new data should be made daily during a study and placed in the study file.

Data Entry Error Codes

a - Inadvertently entered the wrong information.

b - Spelling error.

c - Write-over. Inadvertently wrote over existing data.

d - Data not recorded at time of initial observation.

e - Miscellaneous (An explanation should be included as close as possible to the error)

U.S. Fish and Wildlife Service

Chesapeake Bay Field Office

STANDARD OPERATING PROCEDURES

102. Chain of Custody Forms

A. Objective:

Chain of Custody forms will be initiated for all water, sediment, soil, and tissue samples collected.

B. Procedures:

1. Chain of custody forms will be initiated in the field when samples are collected. Depending on the goals of the study, chain of custody forms should be completed for each sample or group of samples.

2. An example of a chain of custody form is attached to this SOP. All blocks on the form shall be filled in. At the time of collection and for each transfer of custody, the signature of the sampler and subsequent recipients as well as the dates and times shall be recorded.

3. Also included on the form will be a description of the sampling site location, storage locations, sample type (e.g. water, sediment, soil, or tissue), sample number, sample container size and type, and any preservatives used.

4. The original form will stay with the samples during storage, shipment, and analysis. Copies of the forms should be made by the individuals transferring the samples after each change of custody.

5. After the analyses are complete and the samples disposed of, the completed chain of custody forms should be sent back to the place of origin (usually the Chesapeake Bay Field Office).

U.S. Fish and Wildlife Service

Chesapeake Bay Field Office

STANDARD OPERATING PROCEDURES

103. GENERAL SAMPLE COLLECTION, HANDLING, AND SHIPMENT

Revised 2/94; Version 94-1

A. Objective

1. General procedures for sample collection, handling, and shipment. Methods may vary depending on sample type and study goals.

B. Collection and Handling Procedures

1. Labelling. Sample containers should be labelled prior to or during sample collection. Labels should be affixed to the sample container and include the sample number, initials of collector, type of preservatives (if any), weight (tissue samples) and the date, time, and place of collection. A unique, project specific sample number should also be written on the sample container wall and lid with an indelible marker. Glass containers should be wrapped with strapping tape prior to affixing the labels to reduce breakage during shipment.

2. Just after sampling, sample closures should be sealed with chain of custody tape (to guard against tampering) and placed in zip-locked bags that are labelled with the sample numbers. If the samples are to be shipped in a cardboard box, chain of custody tape can be applied to the box rather than each bottle. The sample number, initials of the collector, and the date and time of collection should be recorded on the tape.

3. Record important information and observations in the field log book. Included in the sampling record should be the purpose of sampling, locations, name, address, and phone number of the field contact, producer of material being sampled (originator of contamination source if known), type of sample, sample numbers, volume (water), weight (sediment, soil, and tissue), sample container type and size, sampling method, date and time of collection, maps, photos, field observations, weather conditions, chemical and physical parameters at each sampling site, and the signatures of personnel responsible for sampling and recording the observations.

4. Search for signs of wildlife mortality at each sampling site and, if possible, collect any dead wildlife for contaminants analysis according to sampling procedures above.

5. Chain of Custody forms will be initiated in the field. See SOP 102.

6. Commercially pre-cleaned sample bottles should be used for contaminants sampling. As a general rule, samples for metals analyses are stored in plastic containers and samples for organic analyses are stored in glass containers with teflon or foil lined lids. Samples should be preserved

according to study needs or placed on ice immediately after collection and stored during transport in coolers to protect them from sunlight and temperature. Most samples will be stored in the dark and either frozen at -20°C or refrigerated at 4°C prior to shipment.

7. There are generally four different types of samples that may be collected during a study: Water, Soil, Sediment, and Tissue (Plant and Animal). See the SOP's for each sample type for matrix-specific procedures.

C. Sample Shipment

1. Samples can be shipped after an Authorization to Ship Notice is received from the Patuxent Analytical Control Facility (PACF).

2. Samples should be shipped on wet or dry ice to maintain the desired temperature. Sediments, soils, and tissues are usually shipped frozen on dry ice. Water samples are shipped cooled on wet ice.

3. Prior to placing the samples into the shipping cooler, wrap the sample bottles in styrofoam wrap, place the bottles into the original manufacturers shipping container, and put the shipping container into a large plastic garbage bag. Place the shipping container into the shipping cooler and pack any empty space with newspaper. Add ten pounds of ice and seal the cooler with tape. For dry ice shipments, the shipping cooler should be constructed of styrofoam within a cardboard outer box (Polyfoam Packers Corp.). High quality plastic coolers (Coleman, Igloo, etc.) can be used if necessary. Wet ice shipments can be can be made in styrofoam or plastic coolers.

4. A cover letter with copies of the catalog and the Authorization to Ship Notice and a self-addressed return label should be placed in a plastic bag and included inside the shipping cooler.

5. Sample shipments should be sent via Federal Express government overnight service. Federal Express dry ice stickers should be placed on shipping coolers that contain dry ice. Sample shipments must be arranged so that delivery will be made when an authorized recipient is available to sign for a shipment. Allow for two days shipping time for overnight service.

6. Call the analytical laboratory when the shipment is made.

U.S. Fish and Wildlife Service

Chesapeake Bay Field Office

STANDARD OPERATING PROCEDURES

114 PREPARING FISH AND INVERTEBRATE TISSUES FOR CHEMICAL ANALYSIS

Revised 9/93; Version 93-1

This SOP is based on the following guidance documents: Maryland Department of the Environment 1989 and Puget Sound Estuary Program 1991.

A. Objective

1. Collection and preparation of samples for chemical analyses to meet all QA/QC requirements for monitoring programs

B. Chain of Custody

1. Chain of Custody forms will be initiated in the field as per SOP 102.

C. Preparation

1. If aluminum foil is to be used for wrapping specimens, rinse the dull side of the foil in the following sequence: 10% nitric or hydrochloric acid, distilled water, pesticide residue grade acetone, and distilled water. Allow the foil to dry and place in polyethylene bags.

2. Obtain sufficient one liter or 0.5 liter commercially prepared and certified pre-cleaned glass bottles with teflon lids.

D. Fish and Invertebrate Collection

1. Collection methods include electrofishing, various nets, rod and reel, and crab and eel pots. Collection using electrofishing techniques requires that at least one USFWS staff member be certified by an agency electrofishing course.

2. Fish and invertebrates are placed in 5 gallon buckets which are labelled according to each collection site. Care in labelling the buckets is vital -- use waterproof markers and cards that are tied to the bucket handles. If a particular size is targeted it may be necessary to capture a large number of specimens, sort by size, and release those not needed. In this case, it is essential that sufficient site water and buckets be used to avoid mortality.

E. Packaging Whole Specimens

1. To store whole fish or crabs for resection at the analytical laboratory, rinse the fish with deionized water, pat dry with a paper towel, and place an identifying tag in the fish mouth. Wrap with the dull side of the aluminum foil facing the specimen. Use wrapping tape to encircle the specimen. Attach a stick-on sample label to the outside of the aluminum foil. Place in a ziplock or plastic trash bag. Use indelible marker to identify the specimen on the plastic

bag.

2. Store prepared specimen on ice. In the laboratory, freeze specimens and send packed in dry ice to analytical laboratory.

F. Tissue Resection

1. Fish are scaled according to EPA (1993) methods by laying it flat on aluminum foil and using a stainless steel knife that is cleaned with distilled water between each sample.

2. Fish total length and crab carapace width are measured to the nearest millimeter. Whole specimens are weighed.

3. Fish are filleted and crabs are picked to obtain samples of tissues of concern for human health risk assessment.

4. Use only stainless steel instruments and dissecting trays. Clean these between composite samples by:

a. Washing in laboratory detergent
b. Rinsing with tap water
c. Rinsing with deionized water
d. Rinsing with pesticide grade acetone or isopropanol
e. Rinsing with distilled water

5. Filleting follows EPA (1993) methods. Typically, the skin is removed from fish without scales (catfish and eels). Skin-on fillets should include the belly flap and dark muscle.

6. If whole body analyses are to be performed on the remainder of the tissue, small specimens will be placed in chemically clean sample jars. Large samples will be double wrapped in aluminum foil and labelled as described in D.1.

G. Compositing

1. For analysis of organics and metals, a total of 100 grams of tissue is required. This may necessitate compositing of a number of specimens into a single sample. Compositing may also be used as a method of gaining a more accurate estimate of the average concentration of fish from a site when only a small number of samples can be analyzed.

2. Size considerations addressed by EPA (1993) are used as guidance. Within each composite the shortest fish should be at least 75% of the longest fish. The average lengths of the individual fish from replicate composite samples from the same site should be within 10% (unless different size classes are targeted).

H. Shipping

1. Follow general guidelines of SOP 103 for general sample handling and shipment of samples.

2. Ship all tissue samples with dry ice following overnight shippers packing and labelling instructions.

I. References

Environmental Protection Agency (EPA). 1993. Fish sampling and analysis: a guidance document for issuing fish advisories. Prepared for Fish Contamination Section, Office of Science and Technology, Washington, DC. Draft.

Maryland Department of the Environment (MDE). 1989. Sample collection guidelines and techniques. MDE, Toxics, Environmental Science and Health, Ecological Assessment Division, Baltimore, MD.

Puget Sound Estuary Program 1990a. Recommended guidelines for measuring organic compounds in Puget Sound sediments and tissue samples. Prepared by PTI Environmental Services for EPA Region 10, Seattle, WA.

Puget Sound Estuary Program 1990b. Recommended guidelines for measuring metals in Puget Sound water, sediment, and tissue samples. Prepared by PTI Environmental Services for EPA Region 10, Seattle, WA.

U.S. Fish and Wildlife Service
Chesapeake Bay Field Office
177 Admiral Cochrane Drive
Annapolis, MD 21401

Office Phone: (410) 573-4519
FAX Number: (410) 269-0832

Date: July 22, 1996

FAX TRANSMITTAL

To: Steve Syphax
Fax Number: 202-690-0862

From: Bob Foley

Distribution:

- ☐ Urgent - Hand Carry
- ☐ Call Recipient at ________
- ☐ Usual Routing

Subject: Draft Monitoring Plan for Kenilworth Marsh

Number of pages (including transmittal sheet): 8

Comments: This is a draft which we want to finalize and send to our regional office for their concurrence. The regional office must approve use of these funds for the work. We understand that the Fish and Wildlife Service has $22,000 for this work.

I would like have your input before we send the final work plan to the region. Please call me at 410-573-4519 or Fax 410-269-0832 if you have any questions.

Refile to FY 1996
R5
off #7

FY-96 ~~ON~~ off-REFUGE PROPOSAL REVIEW CHECKLIST

REGION 5 RANK 7 YEAR 1 OF 1

TITLE: MD Evaluating effects of wetland restoration @ Kenilworth Marsh using contaminated sediments

TECHNICAL REVIEW CHECKLIST

1. Is the format consistent with the Service study proposal writing?
   YES ✓ NO ___

2. Other than signatures, is there evidence of Refuge Management consultation or participation in the development of the study objectives?
   Yes ___ No ___ NA

3. Will the experimental design achieve the study objectives as proposed?
   Yes ___ No ___

4. Are the ranking criteria scored accurately according to their definitions?
   Yes No ✓
   If not explain: 10 Indirect pts should be used as FWS cannot unilaterally make mgmt decisions on this marsh
   20 Documented threat is clear
   Bio org is clear 7 pts [illegible] should be [illegible] pts

5. Does the proposal describe the sampling design in sufficient detail to allow another person to complete the project?
   Yes ✓ No ___

6. Does the proposal adequately describe measures to assure sample integrity and personnel safety?
   Yes ✓ No ___

7. Does the proposal achieve Section VII of the Proposal Ranking Criteria?
   Yes ✓ No ___

B. MANAGEMENT REVIEW CHECKLIST

8. Does the proposal identify partners that clearly contribute in-kind services or funding to the project?

YES (4 points) ✓ NO (0 points) ___ 7 pts

% of CONTRIBUTION:	undefined	1-9%	10%-19%	20%-29%	30%-39%	40%-49%	50%+
POINTS (circle one):	0	1	2	3	4	5	6

9. National performance score: Regions 2,4 Region 1 Regions 3,5,6,7

(circle one) 9 12 15

10. If the project is in its second or subsequent year,

Are any requested funds redundant (i.e. already paid)? NA

YES ___ NO ___

Was it originally proposed as a multi-year project? NA

YES ___ NO ___

What is the status of the project (e.g. last report date)? NA

Continuing projects with ID/study codes across years? NA

11. Regional score math check completed?

YES ✓ NO ___

FINAL SCORE

REGIONAL ____ + PARTNERS ____ + PERFORMANCE ____ = NATIONAL ________

COMMENTS Poor scoring by R5 EC Coordinator

Signature(s): ________________ Date_____

Reviewer

________________ Date:____

Budget Analyst

________________ Date___

Team Leader

FINAL REGIONAL CHECKLIST
(initial box)

	R1	R2	R3	R4	R5	R6	R7
Performance coded properly							
Partnership coded properly							
Regional score coded properly							
Final score coded properly							
Operational cost " "							
Analytical Cost are accurate							
Analytical cost in correct column							
Total costs							
Management issues addressed							
Peer reviewed							

FY 1996 RANKING CRITERIA SCORE SHEET

TITLE: MD - Evaluating effects of wetland restoration at Kenilworth Marsh using contaminated sediments

A. APPLICABILITY OF MANAGEMENT ACTION OR SOLUTION	*Points are not additive* Select only 1 of 3 (15 Points Possible)	**POINTS**	
	Direct (15 points)	15	
	Indirect (10 points)	10	not Service decision
B. THREAT TO RESOURCE IS DOCUMENTED OR ONLY SUSPECTED	*Points are not additive* Select only 1 of 2 (20 points possible)		
	Documented (20 points)		20
	Suspected (15 points)	15	
C. DETERMINATION OF IMPACTS TO SERVICE TRUST RESOURCES	*Points are additive* Score all four categories (20 points possible)		
	Biological Organization (1, 4, or 7 points)	4	7 more than none
	Biological Effects (1, 4, or 7 points)	1	OK rate
	Pathway (0 or 3 points)	3	OK [illegible]
	Source (0 or 3 points)	3	OK ref control
D. REGIONAL PRIORITY	(20 Points Possible)		
	Regional Rank (0-20 points)	14	
		7	
E. NATIONAL PRIORITIES (Scored by DEC)	*Points are additive* Score both categories (25 points possible)		
	Performance (3-15 points)	15	
	Partnerships (0-10 points)	7	OK 20800 73935 28670
	GRAND TOTAL SCORE FOR	77	

*Refer to next page for precise definition. See file "Attach_4" for soft copy of score sheet.

FY 1996 CONTAMINANT INVESTIGATION PROPOSAL

I. **TITLE**

MD - Evaluating effects of wetland restoration at Kenilworth Marsh using contaminated sediments

II. **OBJECTIVE**

A. Management Objective(s): To develop a defensible position for the Anacostia River Restoration to consider in developing a policy on use dredged materials for wetland restoration in the Anacostia River estuary

B. Scientific/Technical Objective(s): To determine the effects of contaminated dredge materials on the freshwater tidal wetland community at Kenilworth Marsh.

III. **BACKGROUND and JUSTIFICATION**

The Anacostia River is a freshwater tributary which flows through Maryland and the District of Columbia to the Potomac River. In D.C., the Anacostia River flows through National Park Service lands including the National Arboretum, Kenilworth Gardens, and Anacostia Park. The river has been the site of moderate oil spills, receives significant input of heavy metals and organic pollutants from urban nonpoint sources, and is known as one of the most polluted rivers in the United States. The sediments of the lower reach of this river have high levels of polynuclear aromatic hydrocarbons, polychlorinated biphenyl, chlordane, and metals. High levels of PAH were cited by Harshbarger and May (Personal communication, 1992) as potential cause of high incidence of carcinogenic tumors in fish from Anacostia River.

In 1993, as part of a maintenance dredging action by the Corps of Engineers, dredged material from the Anacostia River was used to construct tidal freshwater wetlands in Kenilworth Marsh. This location was identified as the first of several sites along the main stem and side channels of the river where wetland restoration is proposed to enhance tidal mud flats using sediments from the Anacostia River. Early in 1993, ACOE placed dredged materials in three portions of Kenilworth marsh at elevations designed to support high and low marsh communities. After sediments reached a consolidated state, guts were cut through these areas to insure tidal flows in the marsh.

Emergent aquatic vegetation was planted to stabilize sediment substrates and encourage rapid development of marsh habitat. Plant distribution and biomass improved rapidly after planting, although volunteers of several plant species also germinated and make up a significant part of the organic matter produced by the new marsh. In 1995, loosestrife control was required to produce a more desirable species mix. Preliminary studies show that the benthic macroinvertebrate community began to establish in the filled areas of Kenilworth Marsh and that its waters support a variety of resident and anadromous fish.

The Kenilworth Marsh Monitoring Committee, comprised of National Park Service, the NPS Center for Urban Ecology, FWS, ACOE, Metropolitan Washington Council of Governments, Interstate Commission on the Potomac River Basin, University of the District of Columbia, and the D.C. Water Resources Management Division, was formed to monitor the success of the plant & animal communities in the marsh. In 1993, Chesapeake Bay Field Office worked with the ACOE to develop a baseline chemical characterization of marsh sediments which included sediment bioassays. Chemically, the new marsh substrates are the same as river sediments and contain PCB, chlordane, lead, zinc, and at levels that exceed the ER-M of Long and Morgan, 1990. Although sediments were found to be toxic, the majority of the toxicity was attributed to interstitial ammonia levels.

In 1995, the Earth Conservation Corps established a hacking tower adjacent to the Anacostia River at the National Arboretum to initiate an eagle hack and release program over several years. The group acquired 4 American bald eaglets which were released in the nations capitol in 1995. The most extensive forested area in DC exists along the Anacostia River which is contiguous to the National Arboretum and Kenilworth Aquatic Gardens. Eagles use this forested area frequently.

Chesapeake Bay Field Office proposes to determine the levels of toxic chemicals present in the community developing on new tidal freshwater wetlands in Kenilworth Marsh. Knowledge of transport and fate of the toxic constituents of wetland sediments will be used to substantiate an informed position on future use of dredged materials from the Anacostia River to construct wetlands in Kingman Lake (part of the lower reach of the Anacostia estuary) and fringe wetlands along the main stem of the river. The Service has advised caution in decisions on these actions until more is known about the fate and effects of toxic components of these sediments from the Anacostia River system. The Services concern lies in management decisions that propose developing and enhancing habitats with contaminated sediments which could jeopardize anadromous and endangered trust resources. Management decisions on cleanup of the Anacostia River must be based on knowledge that the projects which transfer and use dredged materials from this system do not present an unacceptable hazard to natural resources.

IV. METHODS

The chemical signature of sediments in wetlands created with dredged materials from the Anacostia River indicates PCB, chlordane, DDD, DDE, Cd, Cr, Zn, Pb, and Ni may affect the health of resident wildlife species. The specific approach Chesapeake Bay Field Office proposes will be complementary to work performed by the Kenilworth Marsh Monitoring Committee. The study design of the present proposal will follow designs of work carried out by other Committee participants to maximize integration of data and promote meaningful interagency data use and interpretation.

The D.C. Water Resources Management Division is developing baseline data for the aquatic community on the constructed marsh in order to monitor future biotic changes. The D.C. monitoring program will identify species assemblages as well as qualitative and quantitative characteristics of assemblages of benthic macroinvertebrates, phytoplankton, zooplankton, and fish in the marsh. In 1994, this program measured a low diversity macroinvertebrate population dominated by Chironomid and Oligochaete species and a fish community which shows signs of recovery. Apparently, the benthic community survived the manipulation of the system because the community which reestablished itself is similar that which existed before restoration began. These data will be used by D.C. for future monitoring of the community in Kenilworth Marsh and for use as a reference in future marsh restoration efforts.

Additional monitoring by the University of the District of Columbia will characterize vegetation distribution and biomass using transect techniques throughout the entire marsh. Lastly, the ability of the newly created marsh to serve as either a source or a sink for nutrients will measured by the Interstate Commission on the Potomac River Basin (ICPRB). Each of these data sets will be integrated with data from the study from this proposal to guide restoration decisions in the Anacostia River estuary.

A. Design

The design will sample species representative of Kenilworth Marsh from two marsh ~~zones, the high marsh and low marsh zones.~~ Two locations in the marsh and a control marsh at Mason Neck NWR will be sampled. The sediments are considered ~~to be the source of contaminants~~ in this marsh. Contaminant levels in the sediments, as well as the contaminant levels in bivalves, fish, and carnivorous turtles will be measured.

At sites in Kenilworth Marsh previously characterized by the Service, sediment contaminant levels were determined before dredged fill was colonized by plants and prior to planting programs designed to encourage aquatic vegetation. These locations will be sampled during the proposed off refuge study. Representatives of trophic levels of the wetland community will be surveyed to quantitatively assess uptake and bioaccumulation from these sediments.

B. Sampling

The trophic levels of concern are pelecypods, fish, and turtles. Sediments will be sampled with a stainless steel ponar dredge according to CBFO Standard Operating Procedure 113. Gastropods will be collected by hand from the surface of sediments and plants. Pelecypods will be sieved from sediments collected with a stainless steel ponar dredge. Fish and turtles will be collected and prepared for chemical analysis by CBFO SOP 114. General sampling procedures will be followed when collecting and handling samples (SOP 103). This procedure requires use of precleaned glass containers (ICHEM or the equivalent) in storage and transport of samples.

C. Quality Assurance/Quality Control

Major procedures are documented as Standard Operating Procedures which will be followed by all field and laboratory personnel. These procedures and all actions which affect the health and safety of Service staff will be summarized in a Health and Safety Plan which will be reviewed by all staff involved with field activities. Field sampling plans will be developed with information on numbers and types of samples to be collected as well as storage and handling procedures. All sampling locations will be recorded using Global Positioning System instrumentation. Chemical quality assurance/quality control procedures will be reviewed by the Patuxent Analytical Control Facility and include the use of laboratory and field blanks and duplicates, internal standards, and spiked samples. A field QC inspection will be performed once during active field sampling activities by Dr. Fred Pinkney to review and validate the methods employed by field personnel.

V. ROLES, RESPONSIBILITIES, AND PARTNERSHIPS

A. Roles and Responsibilities

Bob Foley, Environmental Contaminants Supervisor, CBFO, will oversee the management, scheduling, and reporting of project accomplishments, and preparation and distribution of a final report to insure the study is completed in a timely and professional manner.

B. Partnerships

CBFO will coordinate with the Richard Hammerschlag, National Park Service, on the characterization of habitat quality and the implications for biota using Kenilworth Marsh. NPS is the lead agency in monitoring the marsh and is cooperating with FWS and other agencies on the monitoring results and possible implications on use of dredged materials from the Anacostia River for future restorations of this type. The FWS is interested in sharing these data and promoting use of better data which focus on biological effects as the basis for decisions on beneficial uses of dredged materials. FWS will share these data with EPA and ACOE so that this monitoring effort can be used as background for biological criteria for tidal freshwater marsh systems. EPA's Chesapeake Bay Program supports monitoring by ICPRB in the Kenilworth Marsh and has designated the Anacostia River as a Region of Concern. The Chesapeake Bay Program Toxic Subcommittee is particularly interested in effects of toxic substances, baseline characterizations of significant habitat, and restoration of contaminated estuarine habitats. Total value of the partnerships is $20,800

20,400
43,735

VI. **RANKING FACTORS**

A. Applicability of Study Results to Management Actions/Solutions

not new decision ACOE is direct mgmt agency!

Direct Actions: The Service will use data from this study to identify hazards of use of contaminated sediments for wetland enhancement and restoration. If contaminants found in Anacostia sediments accumulate in higher trophic levels to unacceptable concentrations known to cause physiological or developmental problems in fish and wildlife resources then use of these sediments would be curtailed or prohibited from use in restoration of tidal wetlands.

Indirect Actions: The EPA, ACOE, and FWS are particularly interested in findings from this monitoring effort as background for biological criteria for tidal freshwater marsh systems. EPA's Chesapeake Bay Program supports monitoring by ICPRB in the Kenilworth Marsh and has designated the Anacostia River as a Region of Concern. The Chesapeake Bay Program Toxic Subcommittee is particularly interested in the results of this study as it quantifies potential effects of toxic substances, provides a baseline characterization of significant habitat, and will contribute to restoration of contaminated estuarine habitats.

B. Threat(s) to Resource - Documented or Suspected

15 pts OK

The Anacostia River is designated as one of the most contaminated river systems in the United States because of the levels of toxic substances in the watershed, in its sediments, and in its biota. A fish consumption advisory was placed on the Anacostia River by D.C. in 1990. The presence of injurious levels of toxic chemicals places the anadromous and endangered species in the Anacostia watershed at significant risk. PAH's were cited as the most important potential cause of tumors in bullhead from the lower Anacostia River (Harshbarger and May, Personal communication). The sediments of the river were used to restore or enhance tidal freshwater mudflats in Kenilworth Marsh and may pose a significant threat to the wetland community which is now developing on these sediments.

C. Determination of Impacts to Service Trust Resources

1. Biological Organization: The level of biological organization addressed by this study are contaminant impacts on representatives of three trophic levels -- from detritus and particulate matter to clams, from insects to fish, and from insects and fish to turtles. Interactions between the populations of three trophic levels and the sediment of the restored marsh will be included in the study. Data from this study will form the basis of the Service position on beneficial use of dredged material from the Anacostia River prevents restoration of tidal wetland sites to a toxic status. Enhanced tidal wetland habitats in this National Park Service marsh attract a large number of trust species because limited habitat exists in D.C. High quality tidal wetland nursery areas are important in this system and any enhancement to wetlands should improve these areas to levels capable of producing healthy, uncontaminated fish and wildlife.

2. Measurement of Contaminant Effects: No measurement of contaminant effects is proposed in this study.

3. Contaminant Source(s): The source of contaminants (sediments) at sites in Kenilworth Marsh are well characterized from previous work. The types of measurement will quantify the exposure of trust resources to contaminants placed in the Kenilworth system by marsh enhancement efforts.

4. Contaminant Pathway(s): A pathway of exposure exists from the sediment to the lower trophic levels and from producers to consumers. Although information exists on the source and pathway of exposure, there

is no recognition of the hazard to trust resources by agencies responsible for the source of the problem.

D. Partnerships

See V. B. above, and:

CBFO, as a member of the Kenilworth Marsh Monitoring Committee, plans and coordinates monitoring with NPS, the District of Columbia, and the Interstate Commission on the Potomac River Basin. The Committee supports and conducts comprehensive monitoring of nutrients, marsh hydrology, and nutrient cycling between the Anacostia River and the marsh. The ICPRB has primary responsibility for this activity and receives grant funds to conduct this monitoring. Results from monitoring these transport processes by ICPRB will be incorporated in the work proposed by CBFO and will be especially useful in source identification. Cost of the ICPRB monitoring exchange between the river and marsh, which is part of the overall effort to characterize the success of marsh restoration, is $12,000.

The District of Columbia Regulatory Administration is monitoring fish and macroinvertebrate use of the new marsh habitat. The diversity and biomass densities produced by DCRA will be used by CBFO in determining relative importance and relative risks from specific exposure pathways for those trust species using Kenilworth Marsh. Cost of the DCRA monitoring is $8,800.

Same value as p 3 use 20,800 total value

VII. SCHEDULE/STATUS

Task	Performed by	Date(FY96)
Sample collection	CBFO personnel	June/July
Sample submission	CBFO personnel	July/August
Analytical Chemistry	PACF	March 1997
Final Reports	CBFO personnel	120 days afterfield office approval of analytical data

VIII. **REPORTS, PUBLICATIONS, AND PRESENTATIONS**

Results of this study will be presented in graphical, tabular, photographic, and descriptive formats. All results will appear in the final report. Reports will be of high quality and publication of the study will be pursued in peer reviewed scientific journals. Interim and final reports will be provided to the Kenilworth Marsh Monitoring Committee and to the EPA Chesapeake Bay Program subcommittees on Living Resources and Toxics. Results of this study will be used by the regional contaminant personnel at the CBFO to substantiate Service positions regarding risk to natural resources from contaminated sediments. Overall results will provide information on the potential biological impact on fish resident to contaminated systems.

IX. OPERATIONAL COST ESTIMATES

Previous Operational Expenditures

FY 1993	$ 6,000
FY 1995	$ 0

FY 1996

Personnel Costs (salaries and benefits) (e.g., Field Office)	$ 11950
Travel	$ 0
Supplies	$ 600
Equipment	$ 0
Non-PACF Analytical (necropsy, biochemical indicators, histopathology, etc.)	$ 0
Other (specify): (e.g., cooperative agreement, contracts, etc.)	$ 0
SUB-TOTAL for Operational Costs	$ 12550
Operational Overhead:	
Field office	$ 1255
Regional office	$ 630
TOTAL Operational Request for FY 1996	$ 14435

Value of partnership contributions: $20,800

Future Operational Costs

FY 1997	$
FY 199??	$

X. ANALYTICAL COST ESTIMATES

Past Analytical Costs

FY 1993	$ 7800
FY 1995	$ 0

FY 1996

Chemical laboratory	$ 59300
TOTAL Analytical Request for FY 1996	$ 59300

Future Analytical Costs

FY 1997	$ 0
FY 199?	$ 0

GRAND TOTAL OF REQUESTED FUNDS FOR FY 1996 $ 73,735

Value of partnership contributions: $20,800

TITLE: MD - Evaluating effects of wetland restoration at Kenilworth Marsh using contaminated sediments

XI. **APPROVALS**

*Submitted by:	Robert E. Foley Contaminant Specialist, Field Office	Date: 9/21/95
Reviewed by:	Senior Contaminant Specialist, Field Office (if applicable)	Date:
Reviewed by:	Field Supervisor	Date: 21 Sept 95
*Reviewed by:	Refuge Manager	Date:
*Reviewed by:	Environmental Contaminants Coordinator	Date SEP 30 1995
Concurrence:	ARD Ecological Services	Date: 10/2/95
Concurrence:	ARD Refuges and Wildlife	Date:
Concurrence:	Regional Director	Date: 10/2/95

Acting A ES

*DEC required signature; other signatures are Regional requirement

- Field Supervisor and Refuge Manger signatures indicate Management Review
- Senior Contaminant Specialist and Environmental Contaminants Coordinator are Scientific Peer reviews (attach Scientific Peer Review form)

LITERATURE CITED

SUMMARY SHEET
FY 1993 CONTAMINANT STUDY PROPOSALS

1. STUDY TITLE: MD - Evaluating effects of wetland restoration at Kenilworth Marsh using contaminated sediments

2a. YEAR OF STUDY: 1 of 1

2b. PROJECT CODE IDENTIFIER: 96 - ______ - ______

3. SUBMITTED BY: Region 5, Chesapeake Bay Field Office

4. PROPOSAL SUMMARY: The Anacostia River is a freshwater tributary which flows through Maryland and the District of Columbia to the Potomac River. In D.C., the Anacostia River flows through National Park Service lands including the National Arboretum, Kenilworth Gardens, and Anacostia Park. The river has been the site of moderate oil spills, receives significant input of heavy metals and organic pollutants from urban nonpoint sources, and is known as one of the most polluted rivers in the United States. The sediments of the lower reach of this river have high levels of polynuclear aromatic hydrocarbons, and moderately high levels of polychlorinated biphenyl, and chlordane. In 1993, as part of a maintenance dredging action by the Corps of Engineers, dredged material from the Anacostia River was used to construct tidal freshwater wetlands in Kenilworth Marsh. Chesapeake Bay Field Office worked with the ACOE to develop a baseline chemical characterization of marsh sediments which included sediment bioassays. Chemically, the new marsh substrates are the same as river sediments and contain PCB, chlordane, Pb, Zn, and at levels that exceed the ER-M of Long and Morgan, 1990. Chesapeake Bay Field Office proposes to determine the levels of toxic chemicals present in the community developing on new tidal freshwater wetlands in Kenilworth Marsh. Knowledge of transport and fate of the toxic constituents of wetland sediments will be used to substantiate an informed position on future use of dredged materials from the Anacostia River to construct wetlands in Kingman Lake (part of the lower reach of the Anacostia estuary) and fringe wetlands along the main stem of the river.

5. PRINCIPLE INVESTIGATOR: Robert Foley

6. REFUGE (If applicable): n/a

7. FUNDING REQUESTED: $14,435 (Operational) + $59,300 (Analytical) = $73,735 (Total)

8. FUNDING SOURCE(S): Non-refuge
Value of in kind services - $20,800

9. ANALYTICAL SUPPORT REQUIREMENTS: (Include both Field Office and PACF analytical costs)

Type of Samples	Number of Samples	Estimated Analytical Costs (Organic)	(Inorganic)	Other	Total Cost
Bivalves	24	$14,400	$4,584		$18,984
Fish	24	$14,400	$4,584		$18,984
Turtles	24	$14,400	$4,584		$18,984
Sediments	3	$1,490	$582	$195	$2,277

10. **NON-ROUTINE CHEMICAL ANALYSES:** ______ Yes X No

11. **APPROVED:** ______________________ EC Coordinator   SEP 30 1995 Date