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SEDIMENT QUALITY OF THE LOWER ST. JOHNS RIVER AND CEDAR-ORTEGA RIVER BASIN: CHEMICAL CONTAMINANT CHARACTERISTICS

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

SEDIMENT QUALITY OF THE LOWER ST. JOHNS RIVER AND CEDAR-ORTEGA RIVER BASIN:

CHEMICAL CONTAMINANT CHARACTERISTICS

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ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
FINAL REPORT

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EXECUTIVE SUMMARY

This report presents the findings of a basin-wide sediment quality assessment conducted within the lower St. Johns River basin by the St. Johns River Water Management District from 1996 through 1999. A total of 135 sites were selected and analytically assessed for sediment quality and the presence of contaminants. Sediments were analyzed for a number of constituents of concern that included more than 100 organic compounds and 20 metals. The objective of the project was to determine the presence, concentration, and distribution of potentially toxic organic compounds and metals, with areas of high concentration identified for more intensive sampling and characterization. The resulting data provide a first level screening analysis of a broad range of contaminants and enhance understanding of the overall contaminant burden of the sediments of the lower St. Johns River.

Methods

The scope of work included measuring trace organic and trace metal contaminants in sediments from 77 sites in the main stem of the Lower St. Johns River and from 58 sites in the Cedar-Ortega River Basin. Optimized versions of the National Oceanic and Atmospheric Administration (NOAA) National Status and Trends (NS&T) analytical methods were employed for the analysis of trace metals and nonpolar organic compounds. Generally, the very low detection limits provided by the NOAA NS&T analytical methods are achieved by using larger sample sizes, employing several additional sample cleanup steps prior to instrumental analysis, and targeted final instrumental analysis. The techniques that were used provide analytical data down to “clean” background concentrations, allowing for true risk-based analysis of the data and monitoring of subtle changes and elevations over background.

Findings and Conclusions

The quality of the sediments in the Lower St. Johns River and the Cedar-Ortega River were quite variable, particularly in the Lower St. Johns River. The Lower St. Johns River had a few locations that had notably elevated concentrations, as compared to the rest of the River and suitable environmental guidelines. However, the sediments of the Lower St. Johns River appear to, for the most part, be of relatively good environmental quality from a chemical contaminant load perspective, considering the large drainage area and the relative proximity to industry and urban areas. The sediments of the Cedar-Ortega River Basin, on the other hand, are widely contaminated with a variety of organic and metal contaminants, and the data analysis suggests this is an area that warrants environmental action.

Lower St. Johns River

The contaminant data were quite variable within the Lower St. Johns River study area, indicating differences in contaminant concentrations and also in the natural composition of the sample matrix. When concentrations of organic and metal contaminants were compared to the NOAA NS&T nationally derived reference value for “high” sediment concentrations, exceedances were observed. The rates of exceedances were, generally, comparable to those observed in broad-based national sediment monitoring studies. However, a higher rate of NOAA NS&T “high” value exceedances were observed for PAH, PCB, mercury, and cadmium. These exceedances were not observed throughout the river; they were generally from samples collected in the northern-most part of the river, near Jacksonville, and in the Rice Creek area.

The measured sediment contaminant concentrations were compared to effects-based sediment quality guideline values, such as coastal sediment effects range low (ERL), effects range median (ERM) and freshwater sediment threshold effects level (TEL) and probable effects level (PEL) values. The ERL and TEL values are often quite comparable, and are lower, and thus more conservative and protective, than the ERM and PEL values. The highlights of these comparisons were:

Organic Contaminants

- The ERM values for total PCB, p,p'-DDT, and high molecular weight PAH were exceeded at 10, 4, and 1 of the 77 study sites, respectively. The freshwater PEL values were exceeded at 4, 1, 11, and 3 sites for total PCB, DDT (as the degradation product DDE), lindane, and heptachlor epoxide, respectively, and up to 5 sites exceeded the PEL value for individual PAH compounds.
- The ERL values for total PCB, total DDT, total PAH, chlordane, and dieldrin were exceeded at 58, 64, 6, 33, and 53 sites, respectively. The freshwater TEL concentrations for total PCB, total DDT lindane, and heptachlor epoxide were exceeded at 52, 30, 20, and 10 sites, respectively, and up to 62 of the 77 sites exceeded the TEL value for individual PAH compounds.

Metals Contaminants

- The mercury concentrations exceeded the ERM and the freshwater PEL at 1 and 2 sites, respectively.
- The lead and chromium concentrations exceeded the freshwater PELs at 1 site.
- There were ERL and TEL exceedances for arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and/or zinc at between one and 49 of the 77 sites. Mercury, followed by chromium, arsenic, lead, and cadmium, had the greatest combined number of ERL/TEL exceedances.

Generally, the quality of the sedimentary environment in the Lower St. Johns River appears to be quite good, based on this chemical contaminant assessment, but a few parts of the River clearly had elevated concentrations of contaminants when compared to the rest of the area. Contaminant profiles and other considerations that may be of environmental quality interest include the following:

- The northern-most part of the Lower St. Johns River, near Jacksonville (represented by sites LSJ01, LSJ02, and HSP05), was clearly the most contaminated part of the St. Johns River study area, with significantly elevated concentrations of a number of organic contaminants. The elevated contaminant signals were particularly evident for PAH, PCB, and some pesticides, such as DDT, chlordane, and endosulfan. There appeared to also be elevated levels of certain metals in this area, but the relative magnitude of this elevation was smaller than for the organic contaminants.

- The Lower St. Johns River by Rice Creek (e.g., sites LSJRC06, LSJRC10, LSJRC11, LSJRC02) had elevated concentrations of several sediment contaminants. This area had elevated concentrations of PAH, PCB, and some pesticides, including chlordane and endosulfan, and some metals. There also appeared to be an elevated signal of selected industrial chlorinated compounds, including chlorinated phenolics. Some of the contaminant profiles (e.g., the PAH compound composition, chlorinated phenolics, elevated mercury and zinc) were different in this area than in most other parts of the River, indicating local source(s).

- Selected individual sites had elevated concentrations of one or several contaminants, suggesting the possible presence of a localized source of contaminants. This included site NASCP01, which is by the Naval Air Station (elevated PAH, PCB, and DDT), and CO06, which is inside the Cedar-Ortega River Basin, confirming the overall contamination issues of that area.

Large urbanized areas, and potentially some specific industrial activities, appear to be exerting some influence on the contaminant concentrations in the sediments of parts of the Lower St. Johns River. These locations described above had concentrations of several of the organic and metal contaminants that were greater than what would be considered typical, based on data from different national environmental monitoring programs. A series of general sediment quality guideline value exceedances were also observed for these locations, suggesting there may be a potential for adverse biological impact from some of the measured contaminants.

Cedar-Ortega River Basin

The contaminant concentrations were more consistently elevated in the Cedar Ortega River Basin than in the Lower St. Johns River. There were a large number of sites that had organic and metals contaminant concentrations that exceeded the NOAA NS&T "high" reference value. The rates of exceedances were higher than those observed in broad-based national sediment monitoring studies for PAH, PCB, DDT, chlordane, mercury, cadmium, lead, zinc, silver, tin, and copper. These exceedances were fairly widespread, although some of the contaminants exceeded these reference values more frequently in samples collected from specific parts of the Cedar Ortega River Basin.

The sediment contaminant concentrations were also compared to effects-based sediment quality guideline values (e.g., coastal sediment ERL/ERM and freshwater TEL/PEL values). Highlights of these comparisons were:

Organic Contaminants

- The ERM values for total PCB, total DDT, total chlordane, and high molecular weight PAH were exceeded at 42, 2, 22, and 8 of the 51 broadly characterized study sites, respectively. The freshwater PEL values were exceeded at 31, 19, 15, 19, and 1 sites for total PCB, DDT (as the degradation product DDE), chlordane, lindane, and dieldrin, respectively, and up to 11 sites exceeded the PEL value for individual PAH compounds.
- The ERL values for total PCB, total DDT, total PAH, chlordane, and dieldrin were exceeded at 50, 49, 29, 44, and 41 sites, respectively. The freshwater TEL concentrations for total PCB, total DDT chlordane, lindane, dieldrin, and heptachlor epoxide were exceeded at 48, 43, 27, 24, 5, and 2 sites, respectively, and up to 49 of the 51 sites exceeded the TEL value for individual PAH compounds.

Metals Contaminants

- The mercury concentrations exceeded the ERM at 23 of the 51 sites. The zinc, lead, and silver concentrations exceeded the ERM at 9, 4, and 2 sites, respectively.
- The mercury concentrations exceeded the freshwater PEL at 42 sites. The lead, zinc, cadmium, chromium, and arsenic concentrations exceeded the freshwater PELs at 14, 11, 2, 2, and 1 sites, respectively.
- There were ERL and TEL exceedances for arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and/or zinc at between two and 47 of the 51 sites. Mercury, followed by lead, zinc, cadmium, chromium, and copper, had the greatest combined number of ERL/TEL exceedances.

The Cedar-Ortega River Basin is clearly widely contaminated with different organic and metals contaminants, and within the Basin there are still locations with clearly elevated concentrations, compared to the rest of the Basin.

- The upper parts of the Cedar River has very high concentrations of PCB, and also significantly elevated concentrations of phthalates and DDT, and several metals (arsenic, lead, silver, and zinc). There was a sharp increase in the contaminant signals up the river, suggesting there is a significant source of these contaminants upstream of site CED01.

- The lower part of the Cedar River, near the confluence with the Ortega River (as represented by site CED09), had significantly elevated concentrations of PAH and selected pesticides (particularly chlordane).

- The small water body in which sites ORT33 and ORT31 are located, near the mouth of the Ortega River, had elevated concentrations of PAH, phthalates, DDT, chlordane, and selected metals (lead, silver, zinc), indicating the presence of a local source.

- Elevated contaminant concentrations, although to a lesser degree than the other three locations, were also measure at site ORT19. The slightly elevated concentrations of PAH, mercury, and copper, in combination with the relatively site-specific composition of these contaminants, suggests there may be a small local source of contamination.

The areas around the Cedar-Ortega River Basin are clearly exerting significant influence on the contaminant concentrations in the sediments. Although much of the contamination may be historic, the data clearly suggest that there are significant current sources of contamination. The concentrations of PCB, PAH, some of the pesticides, and several metals are very high in this area, whether they are compared to the Lower St. Johns River, other national monitoring programs, or widely used sediment quality guidelines. The PAH and PCB compound composition is also relatively unique in the Cedar-Ortega River Basin, suggesting there may be a fairly limited number of sources. These sediments are of poor quality, from a chemical contaminant perspective, throughout the lower parts of the Cedar-Ortega River Basin, and much of the Cedar River, and there is significant potential for adverse biological impact from the measured contaminants.

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LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviation or Acronym	Explanation
BHC	Benzene Hexachloride
BS	Blank Spike
CLP	Contract Laboratory Program
CVAAS	Cold Vapor Atomic Absorption Spectroscopy
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DEP	Department of Environmental Protection
DQO	Data Quality Objective
DUP	Duplicate
EAS	Environmental Assessment Section
EMAP	Environmental Monitoring and Assessment Program
EPC	Electronic Pressure Control
ER-L	Effects Range-Low
ER-M	Effects Range-Median
ES	Environmental Sciences
FDEP	Florida Department of Environmental Protection
GFAAS	Graphite Furnace Atomic Absorption Spectroscopy
GPC	Gel Permeation Chromatography
GS/MS	Gas Chromatography/Mass Spectrometry
HCI	Hydrochloric Acid
HMW	High Molecular Weight Polycyclic Aromatic Hydrocarbon
HPLC	High Performance Liquid Chromatography
ICP/MS	Inductively Coupled Plasma/Mass Spectroscopy
LCS	Laboratory Control Sample
LEL	Lowest Effect Level
LMW	Low Molecular Weight Polycyclic Aromatic Hydrocarbon
LSJRB	Lower St. Johns River Basin
MDL	Method Detection Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ND	Not Detected
N-Evap	Nitrogen Evaporation
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NS&T	National Status and Trends
PAH	Polycyclic Aromatic Hydrocarbon
PB	Procedural Blank
PCB	Polychlorinated Biphenyl
PEL	Probable Effect Level

Abbreviation or Acronym	Explanation
PFTBA	Perfluorotributylamine
QA	Quality Assurance
QAP	Quality Assurance Plan
QAPP	Quality Assurance Project Plan
QC	Quality Control
QMP	Quality Management Plan
RIS	Recovery Internal Standards
SIM	Selected Ion Monitoring
SIS	Surrogate Internal Standards
SJRWMD	St. Johns River Water Management District
SOP	Standard Operating Procedure
SRM	Standard Reference Material
STORET	Storage and Retrieval System for Water and Biological Monitoring Data
SWIM	Surface Water Improvement and Management
SWQMP	Surface Water Quality Monitoring Program
TEL	Threshold Effects Level
TOC	Total Organic Carbon
TS	Total Solids
TVS	Total Volatile Solids

1. INTRODUCTION

1.1 Background

The St. Johns River Water Management District (SJRWMD) was created in 1972 by the Florida Legislature in response to the need for protecting and preserving the state's water resources. The mission of the SJRWMD is to manage water resources to ensure their continued availability while maximizing both environmental and economic benefits. The SJRWMD comprises approximately 12,000 square miles in northeastern Florida, or about 21 percent of the state's total area (Figure 1-1). The SJRWMD has a population of approximately 3.2 million (1990 census), or 25 percent of the state's total. The SJRWMD's population has grown rapidly in recent decades, is expected to continue growing at a comparable rate, and is projected to reach over 4.5 million by the year 2010. The most prevalent economic activities within the SJRWMD are tourism, agriculture, forestry, and paper manufacturing. For instance, the SJRWMD contains about one-third of the state's citrus acreage and half the pulp mills.

To facilitate the planning and management of surface water, the SJRWMD is divided into ten hydrologic units or surface water basins (Figure 1-1). The boundaries of these basins approximate drainage basins delineated by the U.S. Geological Survey. One of the ten surface water basins, the Lower St. Johns River Basin, is located in northeast Florida and represents about 22 percent of the area within the boundaries of the SJRWMD (Figure 1-1). The LSRJB extends from the City of DeLand, in the south, to Jacksonville, in the north, where the St. Johns River empties into the Atlantic Ocean. The LSJRB includes Jacksonville, many smaller cities, and large tracts of agricultural and forestry land. The topography is generally low and flat, with surface elevations range from sea level up to 200 feet (61 meters) in the western part of the LSJRB. A generalized land use distribution of the area around the Lower St. Johns River is shown in Figure 1-2.

Approximately 70 percent of the SJRWMD is drained by the St. Johns River and its tributaries. The St. Johns River, is the longest river located entirely in Florida, approximately 270 miles long, and is one of few northward flowing rivers in the United States. The lower St. Johns River is the northern part of the St. Johns River, extending from the mouth of the Ocklawaha River in Putnam County downstream to the confluence at the Atlantic Ocean in Duval County. The elevation in the upper river at the confluence with the Ocklawaha River is less than 10 feet (3.0 meters) above sea level, so the average gradient of the river is less than 0.1 foot per mile. Ocean tides can affect the entire lower St. Johns River, forming an elongated, shallow estuary with an extensive floodplain (Brody, 1994). Mixing of salt and fresh water along this estuarine gradient influences water quality and the characteristics of sediments and contaminants in the river.

The SJRWMD's original focus on flood control has broadened to include water supply protection, water quality protection, and environmental enhancement. Various programs and projects have been initiated to address these responsibilities. In 1987, the SJRWMD was required by Florida Statute (Chap. 373.451-373.4595 F.S.) to develop and implement Surface Water Improvement and Management (SWIM) Plans for critical water bodies. To date, four water bodies have been identified for priority restoration and protection: the Indian River Lagoon, Lake Apopka, the Upper Ocklawaha River, and the Lower St. Johns River. The SWIM Act required that a plan be developed to direct the restoration and improvement of the Lower St. Johns River. The SWIM Plan for the Lower St. Johns River (SJRWMD, 1993) has specific goals, including the restoration and protection of the health of the basin's natural systems and restoration of surface water quality to Class III or better standards. The program initiatives included monitoring of sediments for priority pollutants. Priority pollutants include metals, hydrocarbons, pesticides and industrial chemicals known to be acutely or chronically toxic to organisms living in the river.

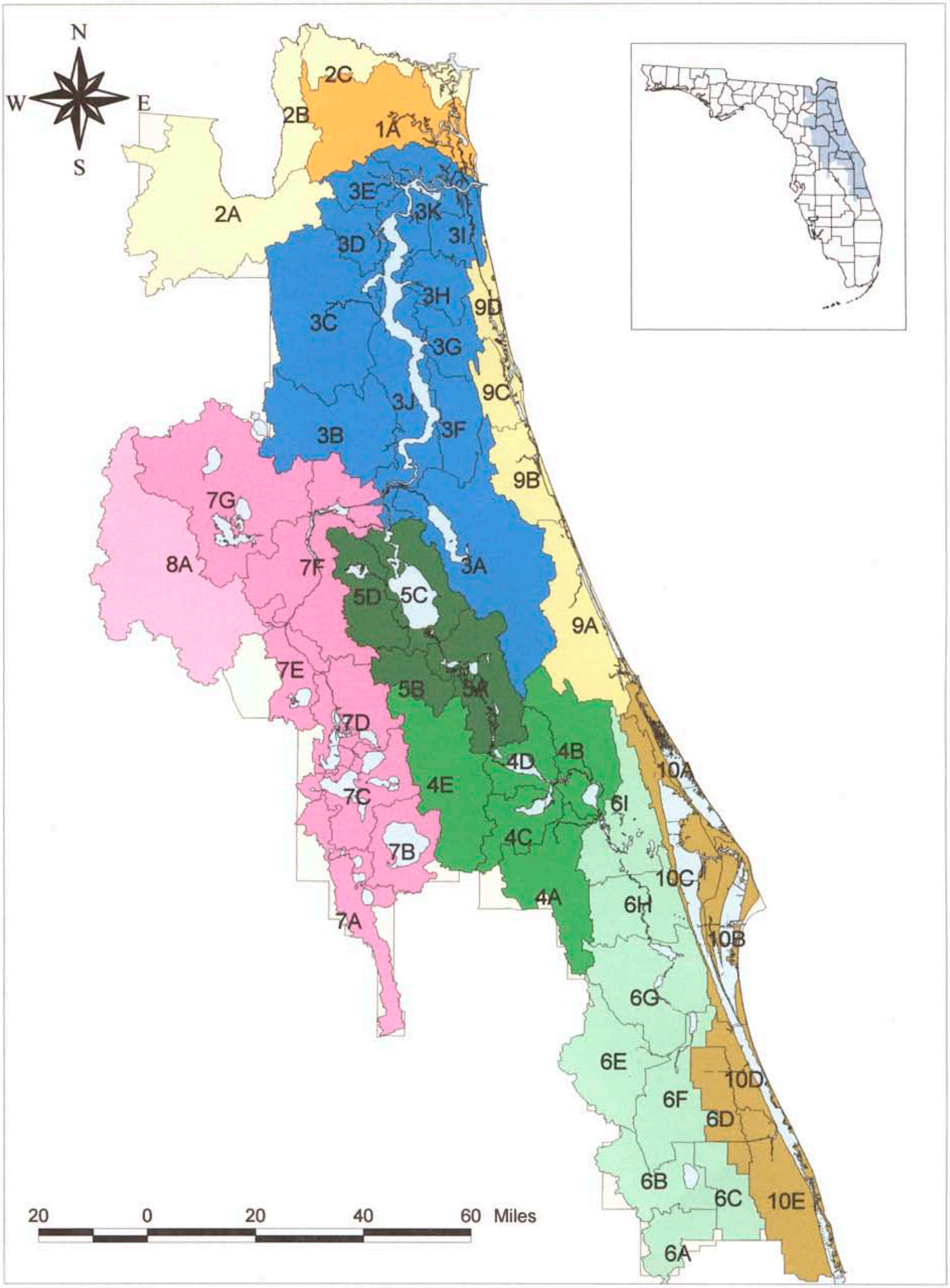

Figure 1-1. Hydrological Units in the St. Johns River Water Management District

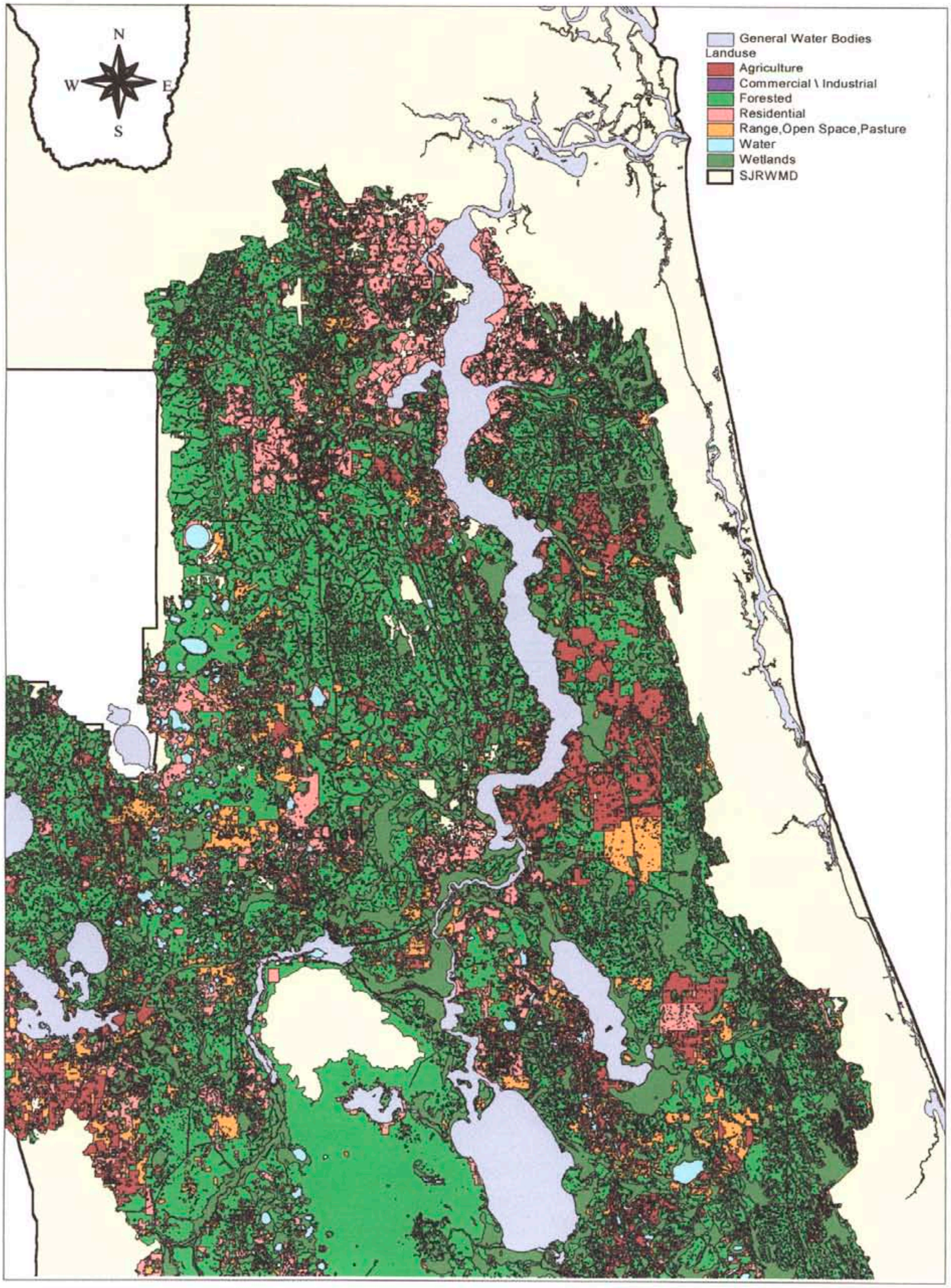

Figure 1-2. Land Uses Around the Lower St. Johns River and Cedar-Ortega River Basin

The St. Johns River has, because of its overall importance and potential for environmental damage, been the subject of several environmental studies. In the 1980's and 1990's preliminary studies were conducted to obtain baseline data on environmental quality of the Lower St. Johns River (e.g., SJRWMD, 1993; SJRWMD, 1994), and it was identified as a water body needing particular management attention. It was soon recognized that the lower portions of the river were of particular concern (Dames and Moore, 1983; Shropp and Windom, 1987; Pierce et al., 1988; FDER, 1988; Delfino et al., 1991 and 1993).

Most of the early monitoring and assessment programs had primarily been directed at basic water quality measurements of the water column, but restoration of the basin's water and natural systems requires knowledge of the characteristics of the river sediment. The Lower St. Johns River sediments provide habitat for invertebrates and submerged aquatic vegetation, and sediments accumulate and concentrate contaminants from the water column.

Staff of the SJRWMD have been sampling water, submerged vegetation, plankton, and invertebrates, to determine the relationship between the biotic communities and the quality of sediments and water in the Lower St. Johns River. Water and plankton samples have been collected monthly since 1995 and benthic invertebrate samples have also been collected periodically. Colonization of the river bottom by plants and animals is, in part, determined by the physical-chemical characteristics of the sediments. The sediment characteristics also play an important role in determining where nutrients and contaminants become concentrated. Assessment of the sediments for physical and chemical characteristics is needed to help determine why areas of the Lower St. Johns River are not colonized by invertebrates or submerged vegetation, and provide other critical information for understanding the environmental quality of the Lower St. Johns River.

1.2 Objectives

Most SJRWMD programs to date have focused on water quality monitoring. In recent years the sediments that underlie water bodies have also been chosen as a medium for assessing aquatic ecosystem health. Sediment-bound contaminants can pose a direct risk to benthic organisms and the aquatic food web due to their acute or chronic toxicity. Unlike rapidly changing water chemistry, sediments integrate pollution over time and can thus indicate a history of contamination. A sampling program that addresses the distribution and change over time of toxic substances in sediment is therefore an essential component of an integrated and comprehensive environmental quality assessment.

The sediments of the Lower St. Johns River have been identified as having elevated concentrations of selected organic (e.g., polycyclic aromatic hydrocarbons) and metals contaminants. In addition, the Cedar and Ortega River Basin was identified as a inadequately assessed water body with significant input to the Lower St. Johns River. The Cedar Ortega River Basin had been identified as having elevated concentrations of a few identified contaminants, including polychlorinated biphenyls, but the contamination was poorly understood and other possible contaminants had not been well characterized. This study of the Lower St. Johns River Basin therefore included the Cedar and Ortega River Basin. The earlier studies were relatively limited spatially, with fairly few potential contaminants being investigated. There was clearly a need for more thorough investigations to obtain a better understanding of the contaminant characteristics, including their magnitude and distribution.

The project reported on in this document was initiated for the collection and chemical analysis of sediment samples to meet these obvious data needs. The objective of the project was to determine the presence and concentration of potentially toxic organic compounds and metals, with areas of high concentration identified for more intensive sampling to further characterize the sediment. Sediments were analyzed for multiple carefully selected constituents that included more than 100 organic compounds (such as semi-volatile organic compounds, pesticides, and polychlorinated biphenyls) and 20 metals (including heavy metals such as mercury, cadmium, and lead). These data were generated as a first-level screening analysis of a broad range of compounds to obtain an understanding of the overall contaminant burden of the sediments of the Lower St. Johns River. The data will also enable the District to compare sediment, water, submerged vegetation, and benthic data to monitor the health of the aquatic environment of the Lower St. Johns River Basin.

Adverse environmental affects can potentially be observed with exposures to very low contaminant concentrations, and it was therefore critical that this sediment assessment program be performed using analytical procedures with very low limits of detection. Specialized, trace-level, analyte targeted, analytical protocols were therefore needed and applied in this project to detect subtle differences in contaminant loads at near-background concentrations.

1.3 Scope of Work

Battelle, the U.S. EPA's Environmental Monitoring and Assessment Program (EMAP), and the SJRWMD staff jointly developed an analytical program in which Battelle could assist the SJRWMD with the measurement and assessment of relevant organic and trace metal contaminants in sediments from waters of the Lower St. Johns River Basin, including the Cedar Ortega River Basin.

Sediment sampling locations were selected and sampled by SJRWMD staff following appropriate procedures, as described in the methods section, and the samples were shipped to the laboratory for chemical and physical-chemical analysis. The target analytical parameters, and the method detection limits, are listed in Table 1-1. Battelle was responsible for determining the sediment concentrations of the target organic and trace metal contaminants, and Battelle's subcontracting laboratory (Mote Marine) performed the analysis for physical-chemical parameters identified as Ancillary Measurements.

The target contaminants and ancillary measures were selected based on the following considerations:

- Identification of the most important and persistent organic and metal contaminants found in sediments, as documented by major national monitoring programs conducted over the last 15 years [e.g., the U.S. EPA's Environmental Monitoring and Assessment Program (EMAP) and the National Oceanic and Atmospheric Administration's (NOAA) National Status and Trends Program (NS&T)]. In addition, selected contaminants were included based on the land use and industry characteristics of the area. Central to this theme was the selection of those organic compounds that are sufficiently non-polar, and thus accumulate in sediments, and have demonstrated abilities to bioaccumulate in benthic and higher aquatic organisms.
- Inclusion of the most useful physical-chemical parameters to aid in the interpretation of the contaminant data.

Sediment analytical results have been reported to the SJRWMD in both hardcopy and electronic format (for inclusion in the SJRWMD database). Battelle was then responsible for preparing this interpretative report based on the results of the surface sediment analyses of 77 Lower St. Johns River sites and 58 Cedar-Ortega River sites. The report includes the following:

- Study background and objectives
- Listing of sampling locations and field sample collection methods
- The analytical methods used and the detection limits
- The analytical quality control program
- Analytical results of contaminant burdens by sampling location, in tabular and graphical form

- Analysis of relationships between contaminant burdens and physiochemical composition of the sediments
- Intercomparison of contaminant burdens among sampling sites
- A comparison of measured sediment burdens with sediment quality reference values as first-level indicators of possible risks that in-place contaminants might pose to the benthic ecological systems
- Conclusions and recommendations

Table 1-1. Analytical Parameters and Method Detection Limits

TARGET ANALYTE	Sediment MDL (µg/kg, dry weight)	Analysis Method [a]
Organic Compounds - PAH		
1-Methylnaphthalene	0.46	8270M
1-Methylphenanthrene	0.30	8270M
2-Methylnaphthalene	0.71	8270M
1-Chloronaphthalene	0.43	8270M
2-Chloronaphthalene	0.47	8270M
2,6-Dimethylnaphthalene	0.36	8270M
2,3,5-Trimethylnaphthalene	0.32	8270M
Acenaphthene	0.40	8270M
Acenaphthylene	0.31	8270M
Anthracene	0.24	8270M
Benzo(a)anthracene	0.21	8270M
Benzo(a)pyrene	0.30	8270M
Benzo(e)pyrene	0.21	8270M
Benzo(b)fluoranthene	0.19	8270M
Benzo(g,h,i)perylene	0.83	8270M
Benzo(k)fluoranthene	0.24	8270M
Biphenyl	0.38	8270M
Chrysene	0.24	8270M
Dibenz(a,h)anthracene	0.16	8270M
Fluoranthene	0.29	8270M
Fluorene	0.34	8270M
Indeno(1,2,3-cd)pyrene	0.17	8270M
Isophorone	0.36	8270M
Naphthalene	0.60	8270M
Perylene	0.15	8270M
Phenanthrene	0.88	8270M
Pyrene	0.26	8270M
Organic Compounds - Phthalates		
Butylbenzylphthalate	1.97	8270M
Di-N-butylphthalate	6.00	8270M
Diethylphthalate	12.0	8270M
Dimethylphathalate	2.33	8270M
Bis(2-ethylhexyl)phthalate	8.97	8270M
Di-N-octylphthalate	2.03	8270M

Table 1-1 (continued). Analytical Parameters and Method Detection Limits

TARGET ANALYTE	Sediment MDL (μg/kg, dry weight)	Analysis Method [a]
Organic Compounds - PCB Congeners		
Cl_2(8)	0.08	8081M
Cl_3(18)	0.09	8081M
Cl_3(28)	0.15	8081M
Cl_4(52)	0.09	8081M
Cl_4(44)	0.07	8081M
Cl_4(66)	0.07	8081M
Cl_4(77)/Cl_5(110)	0.07	8081M
Cl_5(101)	0.10	8081M
Cl_5(118)	0.07	8081M
Cl_6(153)	0.08	8081M
Cl_5(105)	0.07	8081M
Cl_6(138)	0.07	8081M
Cl_5(126)/Cl_6(129)	0.59	8081M
Cl_7(187)	0.07	8081M
Cl_6(128)	0.07	8081M
Cl_7(180)	0.06	8081M
Cl_6(169)	0.1	8081M
Cl_7(170)	0.10	8081M
Cl_8(195)	0.08	8081M
Cl_9(206)	0.11	8081M
Cl_{10}(209)	0.12	8081M
Organic Compounds - Other Chlorinated		
1,2-Dichlorobenzene	1.31	8081M
1,3-Dichlorobenzene	0.80	8081M
1,4-Dichlorobenzene	1.32	8081M
1,2,4-Trichlorobenzene	0.29	8081M
1,2,4,5-Tetrachlorobenzene	0.11	8081M
Hexachlorobutadiene	0.16	8081M
Hexachloroethane	0.12	8081M
Hexachlorocyclopentadiene	0.20	8081M
Organic Compounds - Pesticides		
Chlordecone (Kepone)	0.10	8270M
4,4'-DDD	0.05	8081M
2,4'-DDD	0.06	8081M
4,4'-DDE	0.06	8081M
2,4'-DDE	0.08	8081M
4,4'-DDT	0.08	8081M
2,4'-DDT	0.08	8081M
Aldrin	0.12	8081M
α-BHC	0.09	8081M
β-BHC	0.08	8081M
δ-BHC	0.06	8081M
γ-BHC (Lindane)	0.09	8081M
Chlorpyriphos (Dursban)	0.10	8081M

Table 1-1 (continued). Analytical Parameters and Method Detection Limits

TARGET ANALYTE	Sediment MDL (μg/kg, dry weight)	Analysis Method [a]
Organic Compounds - Pesticides (cont.)		
α-Chlordane	0.08	8081M
γ-Chlordane	0.07	8081M
Oxychlordane	0.1	8081M
trans-Nonachlor	0.07	8081M
cis-Nonachlor	0.1	8081M
Dieldrin	0.07	8081M
Endosulfan I	0.08	8081M
Endosulfan II	0.06	8081M
Endosulfan sulfate	0.06	8081M
Endrin	0.09	8081M
Endrin aldehyde	0.10	8081M
Endrin ketone	0.07	8081M
Heptachlor	0.12	8081M
Heptachlor epoxide	0.08	8081M
Hexachlorobenzene	0.11	8081M
Methoxychlor	0.10	8081M
Mirex	0.07	8081M
Toxaphene	5	8081M
Organic Compounds – Chlorinated Phenolics		
2-Chlorophenol	4.27	8321M
2,4-Dichlorophenol	4.78	8321M
2,6-Dichlorophenol	4.77	8321M
2,4,5-Trichlorophenol	2.59	8321M
2,4,6-Trichlorophenol	4.13	8321M
2,3,4,5-Tetrachlorophenol	8.96	8321M
2,3,4,6-Tetrachlorophenol	4.45	8321M
Pentachlorophenol	23.4	8321M
4-Chloro-3-methylphenol	7.17	8321M
2-Chloroanisole	5.16	8321M
2,4-Dichloroanisole	4.79	8321M
Pentachloroanisole	5.13	8321M
4,5-Dichloroguaiacol	4.40	8321M
3,4,5-Trichloroguaiacol	4.25	8321M
3,4,6-Trichloroguaiacol	5.33	8321M
4,5,6-Trichloroguaiacol	7.20	8321M
Tetrachloroguaiacol	11.8	8321M
4-Chlorocatechol	69.3	8321M
3,5-Dichlorocatechol	32.7	8321M
4,5-Dichlorocatechol	39.3	8321M
3,4,5-Trichlorocatechol	48.3	8321M
3,4,6-Trichlorocatechol	43.0	8321M
Tetrachlorocatechol	10.8	8321M

Table 1-1 (continued). Analytical Parameters and Method Detection Limits

TARGET ANALYTE	Sediment MDL (mg/kg, dry weight)	Analysis Method [a]
Metals		
Aluminum (Al)	14.3	200.8M
Antimony (Sb)	0.078	200.8M
Arsenic (As)	1.03	200.9M
Berylium (Be)	0.106	200.8M
Cadmium (Cd)	0.074	200.8M
Chromium (Cr)	1.0	200.8M
Cobalt (Co)	0.171	200.8M
Copper (Cu)	0.657	200.8M
Iron (Fe)	400	200.8M
Lead (Pb)	0.746	200.8M
Lithium (Li)	0.928	200.8M
Manganese (Mn)	0.662	200.8M
Mercury (Hg)	0.01	245.5
Nickel (Ni)	1.14	200.8M
Selenium (Se)	0.27	200.9M
Silver (Ag)	0.022	200.9M
Thallium (Tl)	0.084	200.8M
Tin (Sn)	0.056	200.8M
Vanadium (V)	0.968	200.8M
Zinc (Zn)	3.26	200.8M
Elutriate Water Measurements		
Calcium (Ca)	0.1 µg/L	6010M
Magnesium (Mg)	0.5 µg/L	6010M
Potassium (K)	75 µg/L	6010M
Sodium (Na)	5 µg/L	6010M
Conductivity	1 µmhos/cm	9050M
Ancillary Measurements		
Total Organic Carbon (TOC)	0.01 % (dry weight)	
Total solids (TS)	0.5 % (wet weight)	
Total volatile solids (TVS)	0.5 % (dry weight)	
Grain Size	0.5 %	
% Moisture	0.5 %	

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[a] The instrumental analysis methods listed apply the following analytical instrumentation:
8270M: Gas chromatography/mass spectrometry (GC/MS)
8081M: Gas chromatography/electron capture detection (GC/ECD)
8321M: High-performance liquid chromatography/ultra-violet detection (HPLC/UV)
200.8M: Inductively coupled plasma/mass spectrometry (ICP/MS)
200.9M: Graphite furnace atomic absorption spectroscopy (GFAAS)
245.5: Cold vapor atomic absorption spectroscopy (CVAAS)
6010M: Inductively coupled plasma/atomic emission spectroscopy (ICP/AES)

2. TECHNICAL APPROACH

2.1 Site Selection

A total of 135 study sites, selected from the Lower St. Johns River Basin (LSJRB) and analytically assessed for sediment quality and contamination, are included in this report. Seventy-seven (77) of these study sites are located in the mainstem of the lower St. Johns River (LSJR), and 58 study sites represent the Cedar and Ortega River Basin (COR). These study sites were selected during four sediment contaminant assessments made from 1996 through 1999. The assessments include the following:

1. the Lower St. Johns River main stem sediment assessment,
2. the assessment of sediment in the Palatka reach of the Lower St. Johns River,
3. the Cedar and Ortega rivers contaminant assessment, and
4. the assessment of sediments adjacent to submerged aquatic vegetation beds.

The study sites for the first three of these assessments were selected following the U.S. Environmental Protection Agency's (EPA) Environmental Monitoring and Assessment Program (EMAP) probability based sampling design protocol (Hyland *et. al*., 1996). This protocol was not followed for the fourth assessment project because the aquatic vegetation beds are not randomly distributed throughout the river, and those sites were specifically selected adjacent to submerged aquatic vegetation. Sediment sites were placed closer together at locations suspected of potentially having significant contaminant levels and/or in areas that had previously not been well characterized in other programs (e.g., in the Cedar-Ortega River Basin).

The locations of the 135 sediment assessment sites are shown in Figure 2-1. Figures 2-2, 2-3, 2-4 and 2-5 are enlarged scale maps that present the locations of the sites selected during the assessment of sediment in the northern segment of the Lower St. Johns River, the southern segment of the Lower St. Johns River, the Palatka reach segment of the St. Johns River, and the Cedar-Ortega River Basin, respectively. Additional maps are presented in Appendix A with information on population density, physiography, and geology.

2.2 Sediment Sample Collection and Field Procedures

The SJRWMD staff collected the samples for this project. Battelle provided the SJRWMD with clean, jars for the sample collection, along with labels, chain-of-custody forms, and coolers for sample storage and shipment. Three sediment grabs were collected at each LSJR sampling site and at seven of the COR sites; a sediment core was collected from the other COR sites. The three site replicates (i.e., the surface sediment grabs) were placed in separate glass jars, and chilled and shipped to the laboratory. At the laboratory, the sediment was mixed thoroughly and the site replicates analyzed separately. Two of the replicates were analyzed, and the third was archived. Most of the COR samples (51 sites) were obtained with a piston-core sampler, and since these study sites were in close proximity to each other, replicate sediment samples were not collected (Figure 2-5). Only data for the surface sediment section of the core are presented in this report, along with the rest of the surface sediment sample data.

The SJRWMD staff collected the sediment samples during different sampling periods between June 1996 and February 1999. Quality Assurance/Quality Control procedures in compliance with the SJRWMD's Comprehensive Quality Assurance Plan (CompQAP) were followed. The materials (e.g., clean stainless steel, glass, and Teflon materials) and procedures used to collect the samples have been demonstrated to be appropriate for collecting samples for trace chemical analysis (EPA, 1996; EPA, 1994; EPA, 1993; EPA, 1991a,b; Peven and Uhler, 1993a,b).

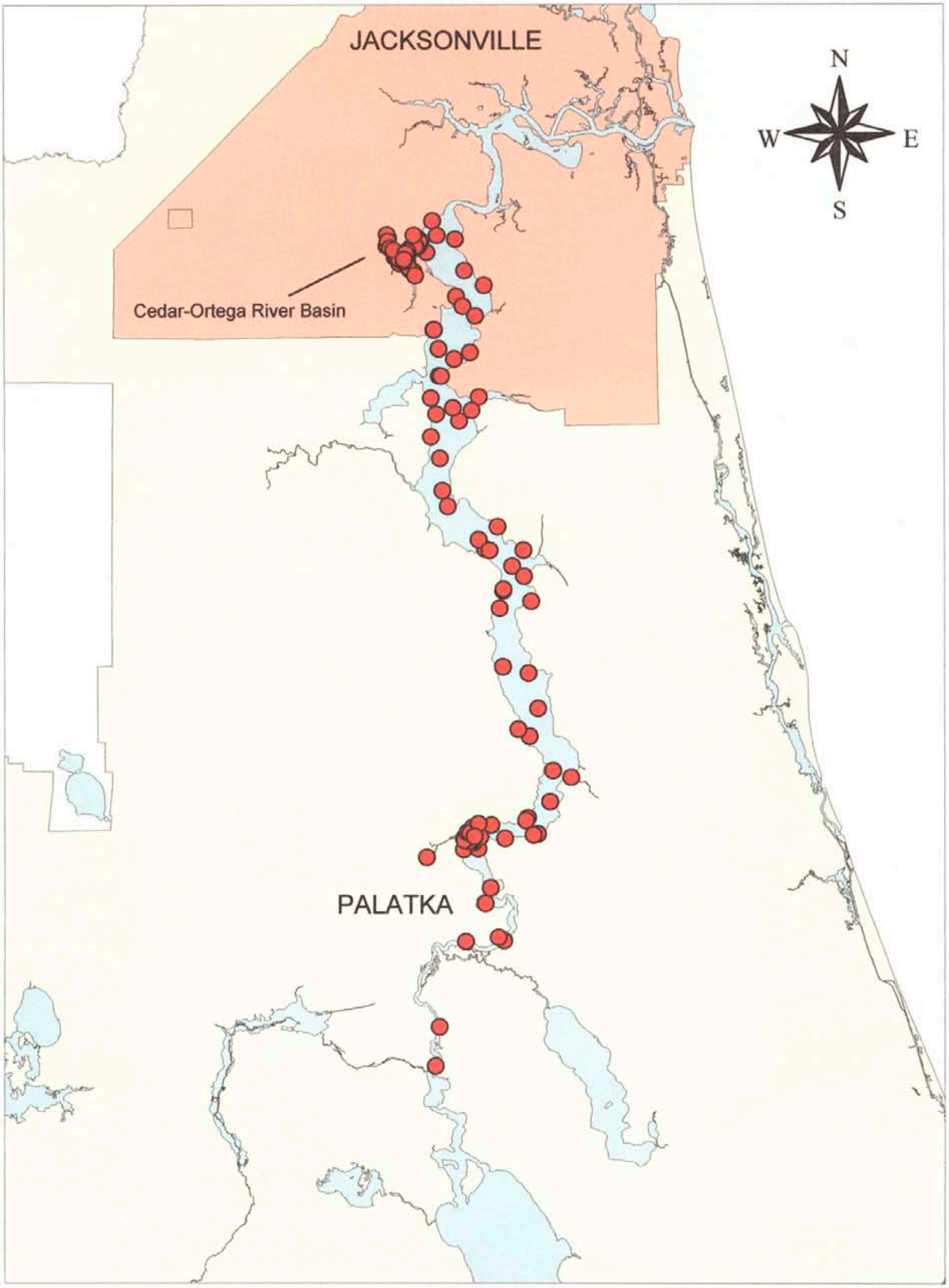


Figure 2-1. Locations of All 77 Lower St. Johns and 58 Cedar-Ortega River Sampling Sites

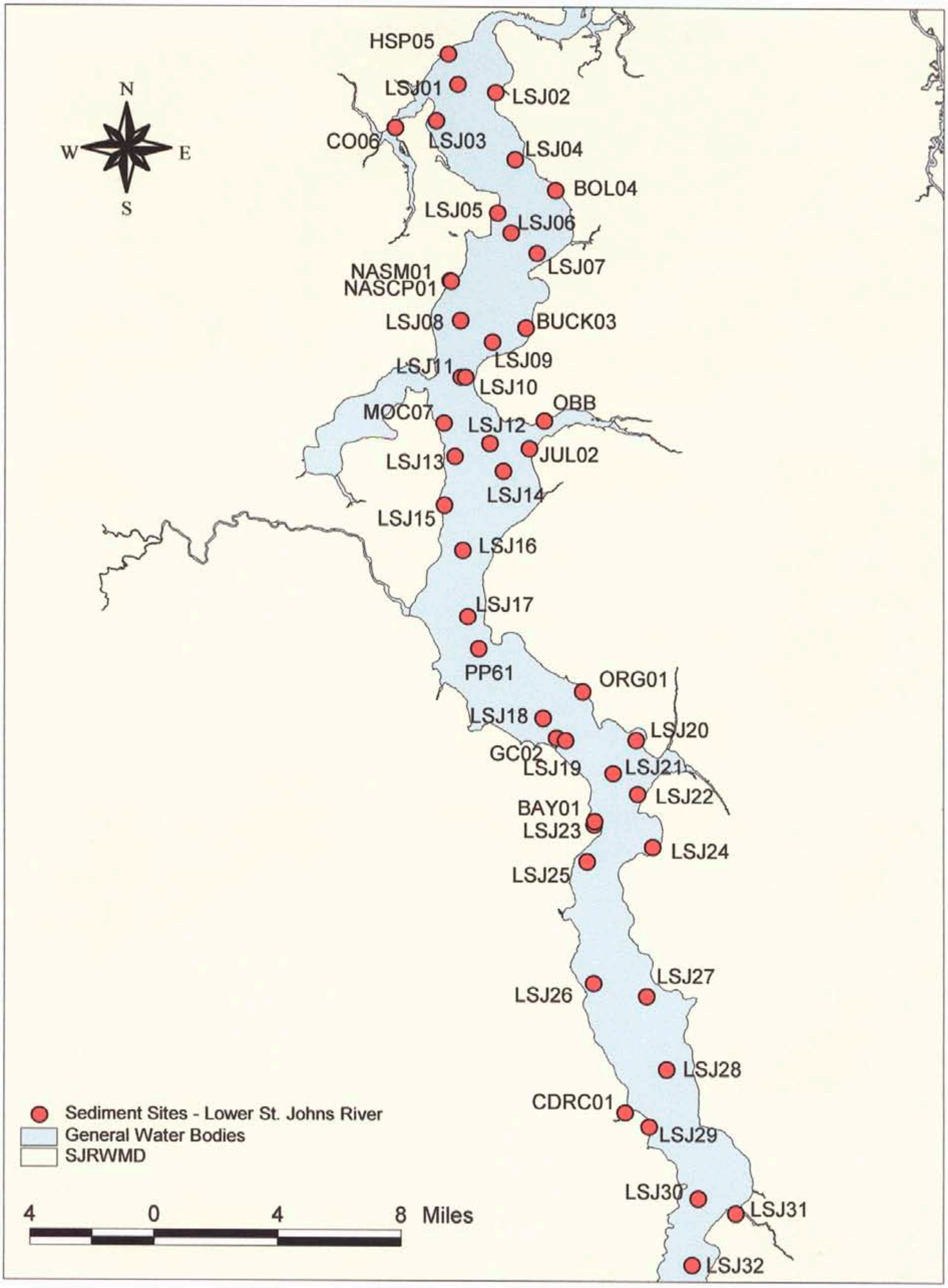


Figure 2-2. Locations of the Lower St. Johns River Sampling Sites — Northern Segment

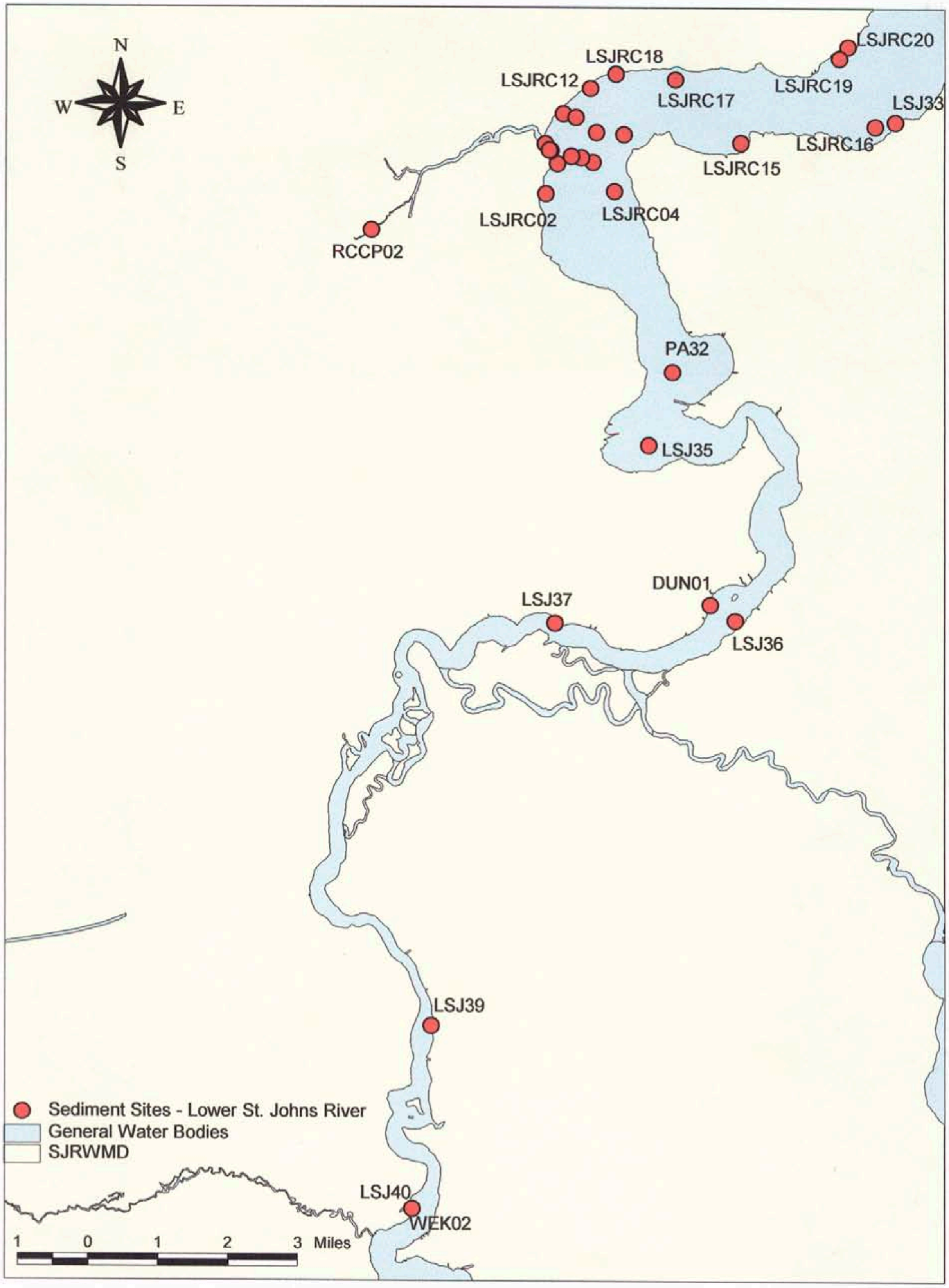


Figure 2-3. Locations of the Lower St. Johns River Sampling Sites — Southern Segment

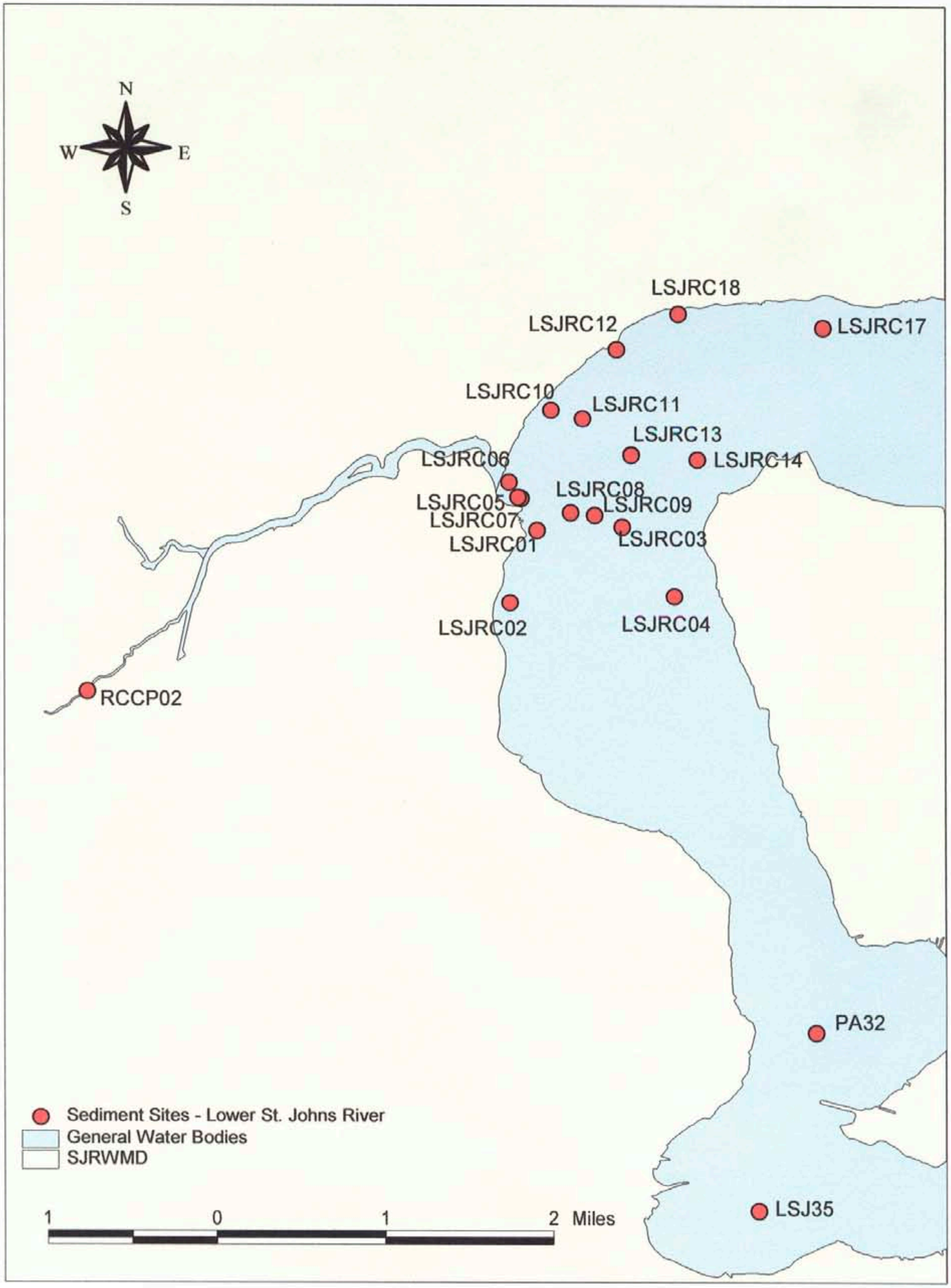


Figure 2-4. Locations of the Lower St. Johns River Sampling Sites — Palatka Reach Segment

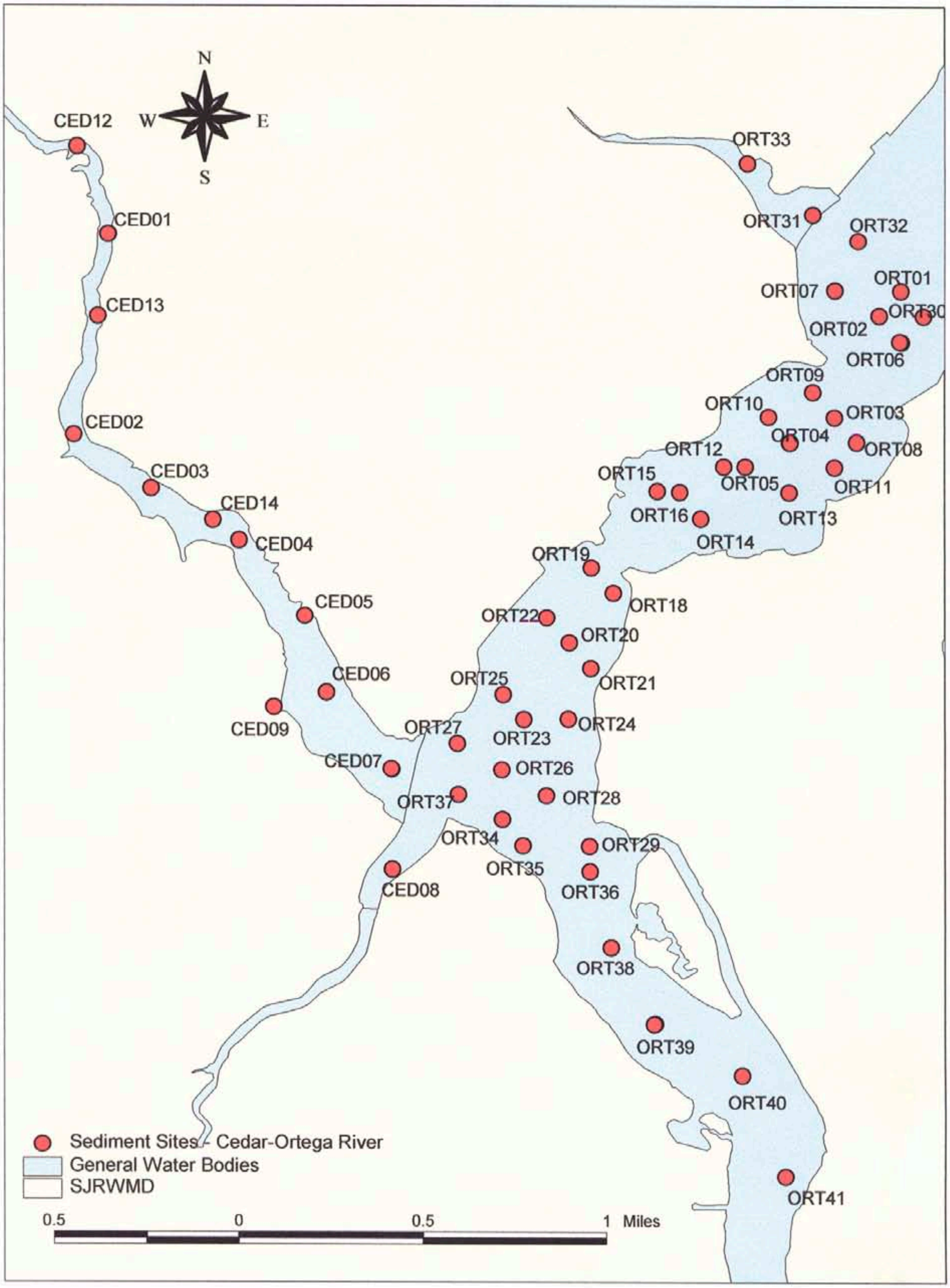


Figure 2-5. Locations of the 58 Cedar-Ortega River Basin Sampling Sites

2.2.1 Sample Collection Containers

Battelle provided 500 mL certified trace-level pre-cleaned glass jars with Teflon lined caps for samples collected for organic compound and metal analysis. Battelle was responsible for obtaining and shipping these containers, which had been cleaned in a manner that was consistent with the organic and metal contaminant analyses, to the SJRWMD.

2.2.2 Sample Collection Equipment

SJRWMD staff used Global Positioning System (GPS) equipment to locate pre-selected sample study sites, and to record the position of the actual sample site as the sediment samples were collected. Surface sediment samples were obtained using pre-cleaned stainless steel petite Ponar dredges and/or Eckman dredges. Pre-cleaned glass dishes and stainless steel spoons were utilized in mixing the individual samples and scooping them into pre-labeled containers. The procedures for the decontamination of the dredges, dishes, and spoons were developed and followed by SJRWMD staff in accordance with the CompQAP. A piston-core sampler was used for the collection of the sediment cores in the Cedar-Ortega River Basin; the coring equipment and procedure will not be further discussed because this report describes the surface sediment.

2.2.3 Sample Collection Procedures

Sediment collection procedures at the 77 LSJR and 58 COR sites involved using a SJRWMD boat. Pre-determined EMAP study site coordinates were entered into the GPS equipment and used to navigate to the sample collection site. Upon arrival at the site, an Eckman or Ponar dredge was chosen for the surface sediment grab sampling. SJRWMD staff employed the following protocol for dredge usage and sediment collection:

Surface Sediment

1. Unwrapped aluminum foil from the pre-cleaned dredge, stainless steel spoon and glass tray.
2. Pre-rinsed the dredge, stainless steel spoon and glass tray with 2-propanol and deionized water.
3. Lowered the dredge into the water body until it reached the sediment. If needed, a messenger was sent down the line to trip the spring mechanism and close the jaws of the dredge.
4. Retrieved the sample and insured sample integrity and quality (e.g. grab-jaws completely closed, no sample wash-out).
5. Deposited the entire sample into a glass mixing tray.
6. Logged the position using the GPS equipment and recorded the water temperature.
7. Used a stainless steel spoon to carefully remove exterior sediment that had contacted the dredge jaws, sides or top. Rinsed the excess sediment from the stainless steel spoon, and then rinsed again with 2-propanol and deionized water. Selected and scooped the sample from the sediment remaining in the glass tray.
8. Promptly transferred the sediment sample into the appropriate pre-cleaned glass jar to prevent oxidation of metal ions or volatilization of organic compounds from the sample.
9. Stored the samples immediately in a cooler with wet ice. Adhered to FDEP and EPA sample handling, storage, and holding times, which obviates the need for chemical preservatives (Table 2-1).
10. Repeated this sequence for the second and third site replicate sediment sample.

Successive site replicate sediment samples were collected after the sampling equipment had been cleaned following Standard Operating Procedures (SOP) for field cleaning of equipment. Field cleaning procedures included washing the dredge, stainless steel spoon, and glass tray and rinsing with deionized water, and then reagent grade 2-propoanol and additional deionized water. The sample containers were filled nearly to capacity at each site and immediately placed into a cooler with wet ice. Sample collection and shipment was coordinated with the analytical laboratories (Battelle) to ensure that sample holding times were not exceeded. The preservation and maximum holding times of sediment samples for laboratory analysis followed Florida Department of Environmental Protection (FDEP) SOPs, as listed in Table 2-1.

Table 2-1. Sediment Sample Storage and Holding Times

Measurement	Preservation Method	Maximum Holding Time
Extractable Organics	Cool at 4°C	14 days until extraction, 40 days to analysis after extraction
Total Metals (except mercury)	Cool at 4°C	6 months
Mercury	Cool at 4°C	28 days
Total Organic Carbon	Cool at 4°C	28 days

Field blanks comprised of water were collected at various intervals as required by SJRWMD's CompQAP. De-ionized water was poured over the sampling equipment (spoons, dredges, and dishes) and collected into clean containers for analysis. The SJRWMD contract laboratory analyzed the field blank samples, following the SJRWMD Field QA Plan.

2.3 Laboratory Sample Analysis Procedures

Selection of Analytical Parameters

The collected sediment samples were analyzed for a series of organic and trace metal contaminants, and various physical and chemical ancillary measures to support the monitoring program objectives of this study. The targeted analytical parameters, and the associated method detection limits (MDLs), are listed in Table 1-1. This target analyte list was jointly developed by Battelle, NOAA, FDEP and SJRWMD staff and includes most of the applicable contaminants from NOAA National Status &Trends (NS&T), EPA Environmental Monitoring Assessment Program (EMAP), as well as, EPA's priority pollutant list, except for some of the polar organic compounds that do not readily accumulate or do not have significant life-times in sediment. The full analyte list was measured in samples from all 77 LSJR sites. The full analyte list was also measured at 16 of the COR sites. All analytes, except the chlorophenols were determined at 35 COR sites. These are the data presented in this report. A separate extended PCB congener analyte list was measured at the other seven COR sites, and in the surface and sub-surface sediment core samples, and those data will be included in a separate COR-specific report.

This SJRWMD sediment monitoring list included all the important 2-, 3-, 4-, and 5- ring polycyclic aromatic hydrocarbons (PAH). Alkylated PAHs (e.g., methylated naphthalene and phenanthrene) were included to provide more complete data on the type of PAH contamination and assist in the identification of petrogenic contamination. Polychlorinated biphenyls (PCBs, as individual congeners) were included as target variables because these remain ubiquitous and environmentally important compounds. Several other persistent and environmentally relevant chlorinated pesticides were also included (e.g., δ-BHC, γ-BHC (lindane), methoxychlor, trans-nonachlor, chlorpyriphos, α-chlordane, and γ-chlordane) to improve the representation of each contaminant group. Chlorinated phenolic compounds (e.g., chlorinated phenols, anisoles, catechols, and guaiacols) were included as environmentally relevant compounds as they are potentially related to specific industrial activities in the area.

The contaminants determined in this project include the key environmentally important and persistent organic and metal contaminants found in sediment, as documented by major monitoring programs conducted in the U.S. over the past decade (e.g., NOAA's NS&T and EPA's EMAP program). The compounds had to be sufficiently non-polar to accumulate in sediments and have demonstrated abilities to bioaccumulate in benthic and higher aquatic organisms to be included in the consideration when selecting the organic target compounds. Additionally, an effort was made to provide comparability to other programs being conducted by national agencies (e.g., the NS&T program, the EMAP program, and the USACE dredged material assessment projects).

Selection of Analytical Procedures

The analytical work for this study required the use of specialized low detection limit procedures. Two principal considerations drove the selection of analytical methods for this study:

- In order to assess the true status of anthropogenic chemicals, analytical methods capable of measuring contaminants at ambient (background) concentrations were required. By using such methods it would be possible to develop a reliable picture of the background conditions, areas of impact, and severity of chemical contamination.

- Sensitive low-level measurements of contaminants needed to be performed in order to determine linkages between chemical presence and observed bioeffects, ecological perturbations, or change. A large body of literature has been amassed demonstrating that such effects occur at very low contaminant concentrations (e.g., EPA Water Quality Criteria, EPA Proposed Sediment Quality Criteria, NOAA ERL and ERM Observed Effect Concentrations) well below concentrations capable of being measured by standard EPA methods of analysis.

It has been clearly documented that standard methods of analysis such as EPA SW-846 or Contract Laboratory Program (CLP) methods cannot obtain the detection limits needed to achieve the goals listed above (e.g., Douglas and Uhler, 1993), simply because those standard methods were designed for high level, hazardous waste site or discharge regulatory compliance monitoring. Hence, another set of analytical procedures was needed to achieve the method performance goals required for the desired environmental quality monitoring.

Achieving meaningful detection limits for organic and trace metal contaminants for environmental quality monitoring has been of special concern to the NOAA and the U.S. EPA. Through the NOAA NS&T Program and the EPA EMAP Program, a set of analytical methods have been developed specifically to meet the low detection limit requirements necessary for successful environmental quality monitoring. Developed over the last 10 years, these methods are modifications and improvements on standard EPA methods of analysis. Generally, the very low detection limits provided by the NOAA NS&T analytical methods are achieved by using larger sample sizes, employing several additional sample cleanup steps prior to instrumental analysis, and by employing instrumental analysis procedures that are highly targeted to the analytes of interest.

These methods are used by NOAA for the NS&T Program, by EPA in the EMAP Program, and are required by the U.S. Army Corps of Engineers in the guidance manual for *Evaluation of Proposed Discharge of Dredged Material into Ocean Water* ("Green Book"), and the USACE *Inland Testing Manual* ("Yellow Book"). The methods are also used in components of the U.S. Navy CLEAN program, the Navy Installation Restoration Programs, and are approved for use in the Naval Energy and Environmental Support Activity (NEESA) program.

The analytical methods have been published in a NOAA Technical Memorandum in which Battelle scientists were principal authors (NOAA, 1998; Peven and Uhler, 1993a,b; Crecelius *et al.*, 1993), and in EPA/USACE testing and analysis documents (EPA, 1996; EPA, 1994; EPA, 1993; EPA, 1991a,b). Constant refinement to keep the methods state-of-the-art, strict laboratory quality control procedures, and an external quality control program administered by the National Institute of Standards and Technology (NIST) ensures that these methods are robust, accurate, and precise for low-level environmental quality monitoring programs.

Battelle employed the NOAA NS&T analytical methods for the analysis of trace metals and the nonpolar organic compounds (PAH, phthalates, chlorinated benzenes/butadienes, chlorinated pesticides, and PCB). A large suite of chlorinated phenolic compounds was analyzed by modified EPA Method 8321, which had been optimized for the target compounds. Battelle obtained FDEP approval for the application of these specialized methods, which have been incorporated into Battelle's FDEP CompQAP. The methods, detection limits, and quality control procedures are described in Battelle's FDEP-approved CompQAP, and are summarized below. The ancillary measurements were also performed in accordance with FDEP CompQAP approved methods.

2.3.1 Sample Analysis for Organic Analytes

The general scheme that was used for the laboratory analyses of organic contaminants and metals is shown in Figure 2-6. The laboratory procedures are further described below.

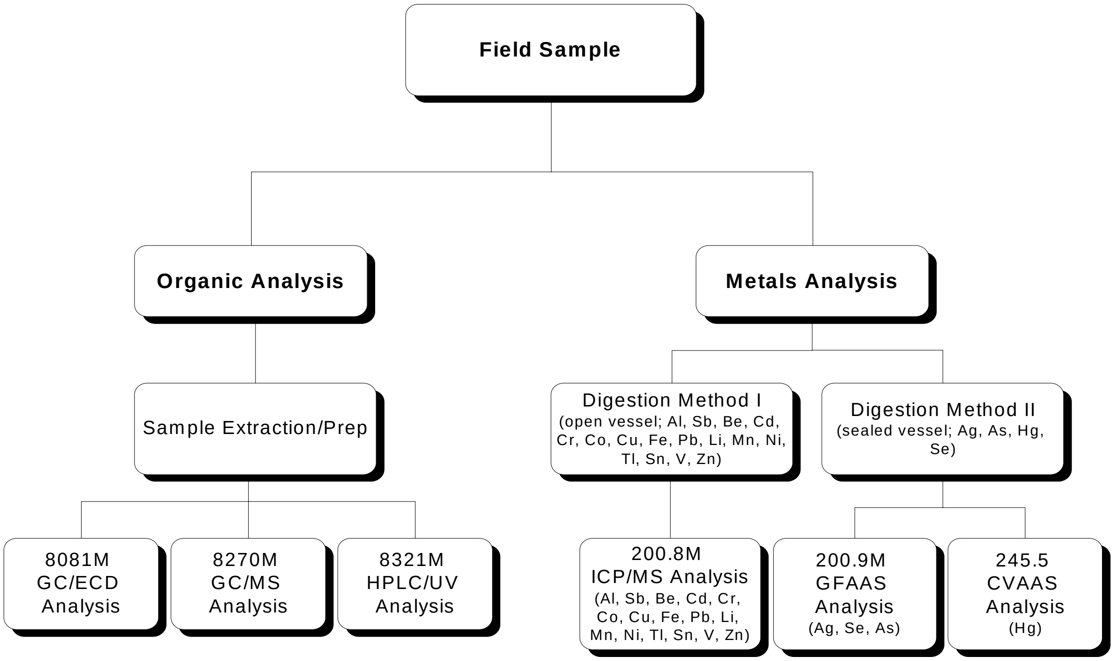


Figure 2-6. Laboratory Scheme for Organic Contaminant and Metals Analysis

Sample Preparation

The sediment samples were kept refrigerated at approximately 4 ºC until laboratory processing could begin. Sample extraction started within 14 days of collection. Laboratory quality control procedures included the analysis of a procedural blank (PB), a blank spike (BS), a matrix spike (MS), a matrix spike duplicate (MSD), and a sediment Standard Reference Material (SRM) with each set of no more than 20 field samples. Additionally, surrogate compound recoveries were monitored for each sample.

The sediment sample was thoroughly homogenized and approximately 30 grams were removed for the extraction. The sample was fortified with surrogate internal standards [(SISs); naphthalene-d$_{8}$, acenaphthene-d$_{10}$ or phenanthrene-d$_{10}$, and chrysene-d$_{12}$ for the 8270M analysis; PCB congeners Cl$_{3}$(34) and Cl$_{5}$(112) for the 8081M analysis)] to monitor procedural efficiency and for sample quantification. The sample was serially extracted three times (24, 4, and 1 hour) in a Teflon jar on a tumbling/agitation table using dichloromethane as the solvent (100, 75, and 75 mL). The combined extract was treated with activated copper for removal of residual sulfur, filtered through a glass fiber filter, and concentrated using a Kuderna-Danish apparatus and gentle nitrogen gas evaporation on an N-Evap.

The extract was next purified using a chromatography column packed with 20 grams of 2% deactivated F-20 alumina to remove biogenic and other bulk undesirable sample matrix material coextracted with the target analytes. Further sample purification was obtained using an automated high performance liquid chromatographic (HPLC) gel permeation chromatography (GPC) cleanup procedure. The GPC column purification procedure employs a 300 mm × 21.2 mm Phenogel (100 Å pore size, 10 µm particle size) semipreparative GPC column (Phenomenex Corp.), with a 50 mm × 7.8 mm Phenogel pre-column. The HPLC system was calibrated specifically for the target analytes of interest prior to the fractionation of each set of samples, and the calibration was monitored with a check standard at least every 10 samples. The sample was loaded onto the column, eluted with 100% dichloromethane, the eluant monitored with a UV detector set at 254 nm, and the target analyte fraction collected using a fraction collector. The entire procedure was automated, and the accuracy and reproducibility of this process far exceeds what can be obtained with traditional, open, gravity-fed liquid chromatography columns.

Note: If chlorinated phenolic compounds were to be determined (this analysis was not performed on all samples), the sample was also fortified with the SIS compounds 2-fluorophenol and 3,4,5-trichlorophenol and approximately 0.4 g of ascorbic acid was mixed in with the sample prior to solvent extraction. The extract was split after the extraction, with the portion for chlorophenolic analysis put directly to HPLC/GPC cleanup (i.e., the alumina column cleanup was by-passed).

The purified sample extract was concentrated using N-Evap and adjusted to a volume of 600–800 µL. The final sample was then solvent exchanged to isooctane, spiked with recovery internal standards [(RIS); acenaphthene-d$_{10}$, fluorene-d$_{10}$, and benzo(a)pyrene-d$_{12}$ for the 8270M analysis; PCB congeners Cl$_{3}$(29) and Cl$_{6}$(166) for the 8081M analysis)], split approximately 50/50, and the two splits submitted for their respective instrumental analyses. If chlorophenolic compound analysis was performed, that portion of the sample was solvent exchanged to methanol, spiked with the RIS (3,4,6-tribromophenol and pentafluorophenol) and submitted for 8321M analysis.

8270M — GC/MS Instrumental Analysis

The concentrations of the Method 8270M target compounds (e.g., PAH, phthalates, kepone) were determined by high-resolution capillary gas chromatography/mass spectrometry (GC/MS). The analytical system was comprised of a Hewlett-Packard (H-P) 5890II GC equipped with an electronic pressure controlled (EPC) inlet and a H-P 5972 MSD operating in the selected ion monitoring (SIM) mode to achieve the needed sensitivity and specificity. Analyte separation was carried out on a 30-m or 60-m, 0.25-mm i.d., 0.25-µm film thickness, DB-5MS (J&W Scientific, Inc.) fused silica column using helium as the carrier gas. A 2 µL sample was injected and analyzed with the following GC conditions:

Initial column temperature:	40 °C
Initial hold time:	1 minute
Program rate:	6 °C/minutes
Final column temperature:	290 °C
Final hold time:	10 minutes
Injector temperature:	300 °C
Detector temperature:	280 °C
Column flow rate:	1 mL/min (helium; EPC controlled)
Injection mode:	splitless (with EPC control)

The analytical system was tuned with perfluorotributylamine (PFTBA), and calibrated with a five-point calibration curve consisting of each individual target compound with an approximate concentration range of 0.01 to 5 ng/µL. The validity of the initial calibration was monitored with a continuing calibration check analysis at least every 10 samples. Quantification of individual target compounds was performed by the method of internal standards, using the relative response factors versus the RIS.

8081M — GC/ECD Instrumental Analysis

The Method 8081M target analytes (e.g., PCB, pesticides, and other chlorinated organic compounds) were analyzed by high-performance capillary gas chromatography with electron capture detection (GC/ECD) using a Hewlett-Packard 5890II or 6890 GC fitted with a ^{63}Ni-electron capture detector. Gas chromatographic separation was carried out on a 60-m, 0.25-mm i.d., 0.25-µm film thickness, DB-5 fused silica capillary column (J&W Scientific, Inc.) using hydrogen as the carrier gas. A 1 µL sample was injected onto the instrument, which was equipped with an EPC inlet for optimum sensitivity and reproducibility. The following gas chromatographic conditions were used:

Initial column temperature:		60 °C
Initial hold time:		1 minute
Program rate.	Ramp 1:	10 °C/minute to 140 °C
	Ramp 2:	1 °C/minute to 220 °C
	Ramp 3:	5 °C/minute to 290 °C
Final column temperature:		290 °C
Final hold time:		15 minutes
Injection temperature:		280 °C
Detector temperature:		300 °C
Column flow rate:		1.2 mL/min (hydrogen; EPC controlled)
Injection mode:		splitless (with EPC control)

The instrumental analysis method used a 5-point calibration curve with an approximate analyte concentration range of 0.005 to 0.12 ng/µL. Each target analyte was fitted to a quadratic equation to best represent the response of the ECD. The validity of the initial calibration was monitored with a continuing calibration check analysis at least every 10 samples. Analytes were quantified by the method of internal standards using the RIS as the quantification internal standard.

8321M — HPLC/UV Instrumental Analysis

The Method 8321M analysis was performed for the analysis of the chlorophenolic compounds (chlorinated phenols, anisoles, catechols, and guaiacols) using high-performance liquid chromatography with ultraviolet detection. (HPLC/UV) using a Hewlett-Packard 1050 HPLC system fitted with a programmable multiple wavelength UV detector. Chromatographic separation was carried out on a 250 mm × 4.6-mm i.d., 5 µm particle size, C18 column (Hypersil BDS) using gradient elution.

The resolution of the target analytes in a set of standard runs was reviewed prior to the analysis of field samples, and minor adjustments (e.g., to gradient program time lines, temperature) made to maintain optimum chromatography for the target compounds. The detector was programmed to provide the needed sensitivity for the different target compounds. A 10 µL sample extract was injected onto the instrument which was maintained at 28 °C, operated with a flow rate of 1 mL/min, and the following chromatographic conditions:

Mobile Phase and Gradient Program:	***Time (min)***	***%Methanol***	***%Water***
	0	50	50
	21	85	15
	24	100	0
	31	100	0
	32	50	50
Programmable UV Detector Settings:	***Time (min)***	***λ A***	***λ B***
	0	272	260
	8	280	265
	14	285	—
	23	260	280

Wavelength A data are for quantification. Wavelength B data may be used for confirmation.

The instrumental analysis method used a 5-point calibration curve with an approximate analyte concentration range of 0.5 to 10 µg/mL. The validity of the initial calibration was monitored with a continuing calibration check analysis at least every 10 samples. Analytes were quantified by the method of internal standards using the RIS as the quantification internal standard.

8270M, 8081M, and 8321M — Data Quantification and Reporting

The analytical data for the organic compound analyses were originally generated by the method of internal standards using the recovery internal standard (i.e., internal standard added at the end of the sample processing and immediately prior to instrumental analysis) as the quantification internal standard. This is how the data were originally reported to the SJRWMD, in accordance with FDEP guidelines. However, for the purposes of this report those data have been corrected for surrogate compound recoveries. Surrogate corrected data typically provide a better representation of the actual field sample contaminant concentrations than non-corrected data, and this is the standard analytical approach in most major environmental monitoring programs (e.g., NOAA’s NS&T and EPA’s EMAP programs). In addition to providing a better representation of the true contaminant levels, surrogate corrected data allow for more reliable comparisons among the study sites.

2.3.2 Sample Analysis for Metal Analytes

The analysis for inorganic parameters involved two digestion procedures to quantitatively recover all elements of interest and three separate instrumental analyses (200.8M, 200.9M, and 245.5). The procedures were designed for quantitative determinations of the following 20 metals (MDLs are listed in Table 1-1): aluminum (Al), arsenic (As), antimony (Sb), berylium (Be), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), iron (Fe), lead (Pb), lithium (Li), manganese (Mn), mercury (Hg), nickel (Ni), selenium (Se), silver (Ag), thallium (Tl), tin (Sn), vanadium (V), and zinc (Zn). The general laboratory sample analysis scheme is summarized in Figure 2-2, and further described below.

Laboratory quality control procedures included the analysis of a procedural blank (PB), a blank spike (BS), a matrix spike (MS), a sample duplicate (DUP), and two sediment Standard Reference Materials (SRM) with each set of no more than 20 field samples.

Sample Preparation

To prepare sediment samples for digestion, the samples were dried using a freeze drying technique and blended in a Spex mixer-mill. About 5 g of the mixed sample was then ground in a ceramic ball mill.

For recovery of the majority of the metals (Al, Sb, Be, Cd, Cr, Co, Cu, Fe, Pb, Li, Mn, Ni, Tl, Sn, V, and Zn), the samples were digested using a modified version of EPA Method 200.*2 "Sample Preparation Procedure for Spectrochemical Determination of Total Recoverable Element"***.** This procedure accomplishes a total digestion of the entire sample matrix and allows quantitation of the crustal elements present as part of the matrix itself, as well as those metals bound to the surface of the material. The modifications include precluding the addition of hydrochloric acid and inclusion of hydrofluoric acid instead, in order to achieve a total digestion of the target metals. A 0.2 gram aliquot of dried homogenous sample was digested using a mixture of nitric and hydrofluoric acids in a nitrogen vented system. The acid mixture was brought to dryness and diluted back to 20 mL using dilute nitric acid. This vented digestion bomb method was employed to allow volatilization of SiF_4, thus removing a significant amount of matrix interference from the digestate and allowing quantitative recovery of the crustal elements such as aluminum and manganese.

A second digestion method was used to achieve optimum recovery of mercury, a relatively volatile element that is lost in an evaporative digestion method when the sample is taken to dryness, and of arsenic, selenium, and silver. There would also be significant loss of mercury in a vented digestion system. This second digestion method is similar to EPA Method 200.2 "*Sample Preparation Procedure for Spectrochemical Determination of Total Recoverable Element"*, is known as an Aqua Regia digestion, and was performed to achieve optimum recovery of silver, arsenic, selenium and mercury. The method modifications include digestion of 0.2 grams of dry sediment (versus 1 gram of wet sediment), and a slight variation in the ratios of the HCl and HNO_3 acids (5 mL HCl and 3.5 mL HNO_3 was used). In addition, the digestion takes place in a sealed Teflon bomb to further reduce the risk of evaporation of mercury.

200.8M — ICP/MS Instrumental Analysis

The Method 200.8M analysis, which is performed by inductively coupled plasma/mass spectroscopy (ICP/MS), is similar to EPA Method 200.8 except that the calibration acceptance criteria have been modified to be of +/- 15%, to reflect the trace detection nature of the method, rather than 10% as specified in Method 200.8. This wider tolerance window is needed to account for the slightly greater variability encountered when analyzing lower concentration standards. The evaporative, open vessel, sediment digests were analyzed by this method for Al, Sb, Be, Cd, Cr, Co, Cu, Fe, Pb, Li, Mn, Ni, Tl, Sn, V, and Zn.

200.9M — GFAAS Instrumental Analysis

Method 200.9M is performed by graphite furnace atomic absorption spectroscopy (GFAAS) and is similar to EPA Method 200.9 except that the calibration acceptance criteria of +/- 15% is used rather than 10% as specified in Method 200.9. The modified criteria reflect analytical procedures developed for the analysis of trace levels of the subject metals. The elements Ag, Se, and As were analyzed by this method using the Aqua Regia sediment digestate.

245.5 — CVAAS Instrumental Analysis

The Method 245.5 analysis is a cold vapor atomic absorption spectroscopy (CVAAS) procedure that was performed according to standard protocols, but targeted for ultra-trace concentrations of mercury. Mercuric ions in the Aqua Regia digestate were reduced to Hg^o with $SnCl_2$, and then purged onto a gold trap as a means of preconcentration and interference removal. Mercury vapor was thermally desorbed into the absorption pathway. The CVAA technique was based on the atomic absorption of 254 nm radiation by excited Hg^o atoms in an inert gas stream.

2.3.3 Sample Analysis for Ancillary Measurements

Total Organic Carbon

Following Method 9060 (EPA SW-846), organic carbon was converted by high temperature combustion to carbon dioxide and then measured by either infrared absorbance, or by conversion to methane and subsequent flame ionization.

The sediment was dried at 70°C and ground to a powder. The sample was then treated with 10% hydrochloric acid. After effervescing was completed, more HCl was added. This process of incremental addition of acid continued until introduction of an additional aliquot caused no effervescing. After acid treatment, the sample was dried at 70 ºC and placed in a desiccator to cool. A 5 to 30 mg aliquot of the ground, dry sediment was weighed to the nearest milligram and placed in a carbon-free crucible. Total organic carbon (TOC) was determined using a high-temperature furnace to combust the material to carbon dioxide in an oxygen atmosphere. From the reaction chamber the sample combustion gases were carried through a Balston water vapor filter to two reaction filters. The first filter contained magnesium perchlorate, which removes any remaining water vapor. The second filter contained acid dichromate on Silocel and manganese dioxide; the manganese dioxide absorbs any sulfur oxides present and the acid dichromate oxidizes and removes NO_x products that would otherwise interfere with the analysis. The gases then passed to a Coulometer that measured the CO_2 by coulometric titration. The output was sent to a PC via interface software that calculated the percent organic carbon present.

Total Solids (Percent Solids) and Percent Moisture

Analysis of samples for total solids (percent solids) and percent moisture followed Method 2540G of Standard Methods, 17th Edition (APHA, 1989). Aliquots of homogenized sample were apportioned into predried, tared crucibles, dried at 103-105 ºC to a constant weight in pre-combusted evaporating dishes. The material remaining after a sample was dried is considered to be the total solids. The total solids of the sediment sample were calculated by dividing the weight of the dried residue by the initial weight of the sample. Results were calculated as percent total solids.

Total Volatile Solids (Percent Organics)

Analysis of samples for total volatile solids (percent organics) also followed Method 2540G of Standard Methods, 17th Edition (APHA, 1989). Dried sediments from the total solids determinations were ashed for 1 hour at 550 ºC ± 50 ºC. The weight of the material lost at the higher temperature was normalized to the initial weight of the sample and reported as percent volatile solids.

Grain Size Distributions, Raw Sample

Grain size distributions of moist field sediment were determined using a laser diffraction instrument (Coulter LS-200), capable of measurement between 0.4 and 2000 µm equivalent spherical diameters. In this instrument, the angle and intensity of laser light scattered by a solution of sediment sample are selectively measured and converted to volume distributions based on a Fraunhofer optical model. Similar to other methods of particle sizing (e.g., pipette or hydrometer analyses), the optical model is based on assumptions of partial sphericity.

During operation, filtered tap water was used for background determinations and sample resuspensions. Samples were homogenized and representative portions introduced to the sample chamber. Samples were recirculated for 60 seconds, and then analyzed for 60 seconds. Repetitive analyses of the sample aliquot indicated that a 60 second analysis time was sufficient for reproducible data. The recirculation time was determined to be sufficient for distributions to stabilize (destruction of loose agglomerates), based on experiments with sediments supplied by the SJRWMD. Surfactants provided no additional change in distribution and so were not employed. Sonication, on the other hand, produced extensive changes in sample size distribution, with the numbers of larger particles continuing to decrease and smaller ones continuing to increase as continued sonication disrupted more and more of the fragments within the sediment. Extensively sonicated sediments, however, were not considered to be representative of the collected samples and so after discussions with the SJRWMD, no sonication was used in the protocol.

Duplicate evaluations were conducted on each separate aliquot from a sample jar introduced into the instrument. As sample aliquots were comparatively small (1-2 g wet weight), low or non-representative concentrations of coarser fragments that were not readily homogenized produced variations that were more extensive than from a more uniform sediment. Glass beads of known mean grain size were used to perform continuing calibrations.

Results were determined in 93 logarithmically distributed size channels as the volume percent of the entire sample within that spherical size range. Within rounding error, the sum of volume percents from all size ranges totaled 100%. For purposes of clarity, the 93 channels were combined into 26 intervals (Table 2-2), still totaling 100%, which represents the classical half-phi distribution (Folk, 1974), in which:

$$\phi \quad = \quad -1 \bullet \mathrm{LOG}_2\,(\text{size, mm})$$

As the instrument was sensitive only to 2,000 µm (2.000 mm), sediments were sieved through a 2 mm mesh prior to diffraction analysis. If material was retained by the screen, then a larger sample aliquot was weighed (field moist), wet sieved through a 2 mm mesh, and the coarse retained material dried and ashed as in the determination of percent solids and percent organics discussed above. In these samples, the particles that fail to pass a 2 mm sieve were generally shell fragments or intact shells from small bivalves, and it varied by sample as to whether the larger shell fragments were a representative part of the sample. For calculations, all sediments greater than 2,000 µm were assigned to the range between -1.0ϕ and -1.5ϕ (2,000-2,830 µm), and proportionally incorporated into the results of the diffraction analysis, for presentation of the results on the entire sample.

Table 2-2. Half-Phi Intervals and Equivalent µm Sizes used for Reporting Grain Size Data

ϕ Size	µm
11.0	0.49
10.5	0.69
10.0	0.98
9.5	1.38
9.0	1.95
8.5	2.76
8.0	3.91
7.5	5.52
7.0	7.81
6.5	11.0
6.0	15.6
5.5	22.1
5.0	31.0
4.5	44.0
4.0	62.5
3.5	88.0
3.0	125
2.5	177
2.0	250
1.5	350
1.0	500
0.5	710
0.0	1,000
-0.5	1,410
-1.0	2,000
-1.5	2,830

Total percent sand, silt and clay were calculated as the sum of volume percent between 2,830 and 62.5 µm, 62.5 and 3.91 µm, and 3.91 to 0.04 µm, respectively, using the Wentworth size scales and a 8.0ϕ value as the clay-silt boundary. Only the sand, silt, and clay percentages were reported and used for discussion and interpretive purposes in this report. Data for each of the 26 individual size intervals listed in Table 2-2 are included in the appendices (Appendix F).

That grain size data included in the appendices also include geometric distributional statistics, which were computations based on the logarithmic center of each size grouping as sediment distributions are typically more log-normal than normal. Statistics provided included mean, median, and modal grain sizes and are in units of µm. The standard deviation was also reported in µm and is a measure of the spread of the sediment distribution. Skewness, a unitless coefficient, is a measure of the distortion from a symmetrical distribution, with a skewness of zero (where mean, median, and mode coincide) being perfectly symmetrical. Samples with an excess of material in the finer sizes (left-hand skewed) will have negative skewness coefficients, while samples with an excess of coarser material (right-hand skewed) will have skewness values greater than zero. Kurtosis is also unitless and is a measure of the peakedness of a distribution, with kurtosis values of zero representing a normal distribution (mesokurtic), values greater than zero (leptokurtic) indicating a higher sharper peak, and values less than zero (platykurtic) indicating a comparatively broad distribution.

2.3.4 Elutriate/Pore Water Analysis

Sample Preparation

The sediment to be used for the elutriate/pore-water analysis was subsampled from the original sample for determination of key metal concentrations and conductivity. Approximately 150 to 200 g of sediment was placed into a 250-mL centrifuge jar for each sample. The jar was centrifuged (maximum of 10,000 RPM) to bring the water to the top. The water was filtered using a 0.45 µm membrane filter (e.g., Polysulfon, or equivalent) and the sample was split and submitted for conductivity and ICP analysis.

The split for conductivity measurement was stored refrigerated at approximately 4ºC until analysis, and the measurement was performed within 24 hours of filtration. The sample split designated for ICP analysis was preserved by adding 1 µL reagent grade nitric acid per mL of sample.

9050M — Conductivity Analysis

The conductivity measurements were performed in accordance with Battelle SOP 3-161, *Use of the Cole Parmer TDSTESTR 20 Conductivity Meter*. A Cole Parmer TDS Testr20 was calibrated with standard solutions at the low end of the expected sample conductivity (typically in the range from 500 to 5,000 µmhos/cm). The validity of the calibration was checked with an independent check standard no less frequently than every 10 samples.

6010M — ICP Analysis

The sample preparation, instrumental analysis, and instrument operation for the major metals analysis were performed using the procedures described in Battelle SOP 3-277 *Determination of Metals by Inductively Coupled Plasma/Atomic Emission Spectrometry* and SOP 3-152 *Operation of Perkin Elmer Optima 3000 Inductively Coupled Plasma Atomic Emission Spectrometer*. A Perkin Elmer Optima 3000 inductively coupled plasma (ICP) atomic emission spectrometer (AES) was employed for the analysis, and was calibrated with at least 3 calibration levels, covering the expected concentration range of the samples. The validity of the calibration was checked with an independent check standard no less frequently than every 10 samples. The filtered aqueous samples were direct-injected onto the ICP/AES, and concentrations of calcium, magnesium, potassium, and sodium were determined. Samples with concentrations outside the calibration range were diluted and re-analyzed.

2.4 Laboratory Quality Assurance and Quality Control Procedures

2.4.1 Implementation of Battelle's Quality Assurance Program

Battelle's Quality Assurance (QA) program is described in Battelle's Quality Management Plan (QMP). The QA program is implemented by each Project Manager to ensure that data generated by Battelle are of known and acceptable quality. It is designed to support the commitment to quality defined in Battelle's quality policy statement.

> *Battelle is committed to providing the highest quality programs designed to meet the needs of its clients, and to ensuring that all environmental data collection activities be scientifically valid, and that the data so collected be complete, representative, comparable, and of a known and documented quality. It is also Battelle policy that all Battelle-generated field and laboratory data include, where possible, documented quality control (QC) data. This policy is implemented by ensuring that adequate quality assurance (QA) procedures are employed for all data generating activities, from study design and sample analysis to data generation, reduction, and reporting.*

At the *organizational level*, policies defined in the QMP apply to all program activities and address management assessment, personnel qualifications and training, procurement policies, and document control. These policies provide guidance to project management so that consistent technical management and data collection activities are implemented. At the *technical level*, the implementation of QA Program activities identified in the QMP are defined in project-specific Quality Assurance Project Plans (QAPPs) to ensure that the data collected are of the appropriate amount, type, and quality. The project scope, organization, schedule, communication plan, quality control requirements, analytical procedures (defined as standard operating procedures), and reporting requirements are defined in the QAPP. The QMP defines roles and responsibilities at the organizational level; the QAPPs define roles and responsibilities for each project.

Battelle is certified to perform analyses for a n umber of state and federal programs, including for the Florida State DEP, Commonwealth of Massachusetts DEP, New Jersey DEP, New York State DEC, California DEP, US Army Corps of Engineers, and the US Naval Energy and Environmental Support Activity. In addition, Battelle participates in the NIST annual interlaboratory calibration program for the analysis of sediments and tissues for PCBs, pesticides, PAH, and metals.

Several components of this QA Program have particular relevance to the SJRWMD Project. A *QAPP* was prepared for this project prior to the initiation of work. This document was prepared by the Project Manager, distributed to each member of the project team, and discussed during a project kick-off meeting prior to the start of project activities.

Standard Operating Procedures (SOPs) were in place for the operation, maintenance, and calibration of all data-generating equipment and all environmental data collection activities performed for the project. SOPs applicable to the project were cited in the QAPP; these SOPs were readily available in laboratory SOP manuals. It is a Battelle requirement that *training* is complete and documented before a staff member uses equipment or a technical procedure. All project staff are trained in each SOP. Each SOP contains a "training" section that defines appropriate training and proficiency requirements for a specific procedure. Documented training records were in place for all members of the project team.

Quality Assurance audits were performed throughout the study. As part of the Quality Assurance initiation audit, the QAPP was reviewed for completeness, the training records for each team member were reviewed to ensure that documented training had been completed for each team member, and the SOPs applicable to the project were reviewed to ensure that they were current.

All data packages and final report tables were audited by Quality Assurance personnel to verify that the reported data were complete, accurate, and traceable. The results of each audit were reported to the project manager and the laboratory manager. Corrective action for each audit finding was documented and verified prior to release of data to the client. All audit issues were addressed during these audits; no unresolved issues exist.

2.4.2 Compliance with Florida Department of Environmental Protection (FDEP) CompQAP

Battelle has obtained FDEP approval for the application of the specialized low detection limit methods that were used in this program, and these methods have been incorporated into Battelle's FDEP CompQAP. The Project Manager and the project QA Officer reviewed both the original CompQAP and the amendments to verify that the documents were accurate and current. Battelle's FDEP CompQAP is reviewed and updated with the FDEP annually.

To ensure that all staff members were familiar with the specific requirements of the FDEP SOPs, training packets were assembled for the project and laboratory manager, the sample custodian, the laboratory technicians, the analysts, and QA personnel. These packets included the specific FDEP SOPs that applied to the project activities anticipated for each staff member with a sign-off sheet indicating that each SOP had been read and understood. Battelle's intent to comply with FDEPs SOPs was documented with FDEP on 10/10/95.

2.4.3 Quality Control Program

The accuracy, precision, and reliability of data generated for the SJRWMD was of paramount importance. The quality control procedures that were followed to assure analytical integrity associated with the determination of trace levels of organic and inorganic analytes include the following:

- Documentation of method detection limits
- Documentation of analytical accuracy
- Documentation of analytical precision

The quality control samples incorporated into each batch of no more than 20 field samples included:

- Procedural Blank
- Blank Spike
- Matrix Spike
- Matrix Spike Duplicate
- Field Sample Duplicate
- Standard Reference Material
- Surrogate Internal Standards (2 or 3 per sample for organic compound analysis)

2.4.3.1 Method Detection Limits

The method detection limit (MDL) is the lowest concentration of an analyte that a method can reliably detect in either a sample or blank. The MDLs reported in Battelle's CompQAP were determined following protocols published in the *Federal Register* (40 CFR part 136, Appendix A). Seven aliquots of sediment were spiked with the analytes of interest at concentrations equivalent to approximately 3 to 5 times the detection limits. The MDL for each compound was calculated by multiplying the standard deviation of the seven replicates by the student-*t* value (3.000, as per FDEP guidelines — EPA protocol is to use 3.143). This MDL represents the statistically determined minimum concentration of the compound that can be measured with 99% confidence that the analyte concentration is greater than zero. Target compounds confidently detected below the MDL (typically with a signal:noise criteria of approximately 3:1) were reported and qualified appropriately in the original data delivery.

However, actual detectability varies on a sample-by-sample basis depending on the actual sample matrix and target compound concentration. For this report, *uncensored* data were generated, reported, and used (i.e., if the analysts could confidently detect and identify an analyte in a sample it was reported, regardless of how it compared to a calculated MDL).

2.4.3.2 Analytical Accuracy and Precision

Analytical accuracy and precision is ensured by conducting all analytical work within the framework of a well-defined and appropriate quality control plan. Analytical accuracy was monitored through the use of standard reference materials, surrogate internal standards, and procedural (method) blanks. In addition, blank spikes, matrix spikes, and matrix spike duplicate samples were spiked with target analytes and processed and analyzed with each analytical batch. Analytical precision was monitored as the relative percent difference between matrix spike and matrix spike duplicate samples, and/or field sample duplicate samples.

- *Procedural (Method) Blanks* (PB) were prepared, processed, and analyzed with each analytical batch of field samples to check the purity of reagents and glassware, as well as to monitor the possibility of laboratory contamination. The PB is a combination of all solvents and/or reagents used during the extraction, and for organic contaminant analysis also the surrogate compounds, and is subjected to the same sample processing as the field samples.

- *Blank Spikes* (BS) or Laboratory Control samples (LCS) were processed with each batch of trace metals, organic contaminant, and TOC analysis. The BS or LCS was prepared identically to the procedural blank and spiked with contaminants of interest at known concentrations. Recovery of the target analytes in the BS/LCS samples provided a measure of the extraction efficiency for the analytes in the absence of the sample matrix.

- *Matrix Spikes/Matrix Spike Duplicate* (MS/MSD) samples were processed and analyzed with each batch of samples for trace metals and organic compound analysis. Two aliquots of one field sample were spiked with known amounts of target contaminants prior to extraction. The background-corrected recovery of spiked contaminants in the environmental samples demonstrates the extraction efficiency in the presence of a matrix that may impair either complete extraction during sample processing or detection and quantitation. When used in conjunction with the BS/LCS samples, the recovery of target compounds that may be affected by the sample matrix can be identified. The reproducibility in the two recovery determinations provides a measure of the analytical precision.

- *Duplicate (DUP)* field samples were collected and processed for each surface sediment site. Field duplicates incorporated the precision in the field sampling with the analytical precision. In addition, laboratory duplicate analysis (replicate analysis of the *same* field sample) was performed with each batch of metals, TOC, and grain size analysis.

- *Standard Reference Materials* (SRMs) were processed and analyzed with each analytical batch of field samples (two SRMs with each batch of trace metals samples). The National Institute of Standards and Testing Materials (NIST) provides certified concentration values for analytes present in the SRM sample; these values were used to calculate the SRM percent recovery. The NIST SRMs are appropriate because they have certified concentrations for many of the target analytes at environmentally relevant concentrations, which are often near the project's MDLs.

- *Surrogate Internal Standards* (SIS) were spiked into each field and quality control sample prior to organic compound extraction and analysis. The percentage of spiked SIS compounds recovered in each sample provides a measure of the overall sample extraction and processing efficiency.

The quality control data quality objectives (DQOs) are presented in Table 2-3. The complete data for all quality control samples have been reported to the SJRWMD along with the field sample data.

The analyses yielded quality control data of high quality, and with few exceptions met the relatively strict quality control program that had been developed for the project. The few exceedances of procedural blank DQOs were typically minor exceedances (analytes in the 3-5 × MDL range) of compounds that were measured at significantly higher concentrations in the field samples and therefore had no notable impact on the reliability of the field sample results. The few target compound recovery (accuracy) exceedances that were observed in fortified samples (BS and MS/MSD) were typically slight exceedances. Similarly, the exceedances that were observed for certified materials analysis (SRMs) were generally for target compounds with concentrations near or below the detection limit, or for trace-level constituents that do not have certified values but only semi-quantitative consensus values — this was particularly the case for the exceedances observed for the Method 8081M analyses. In general, these quality control sample results verified that sample processing and analytical procedures were well in control.

Table 2-3. Laboratory Analysis Data Quality Objectives

QC Measurement	Frequency	Acceptability Limits	Corrective Action
ORGANIC CONTAMINANTS			
Method	8270Mod (PAH, phthalates, kepone) 8081Mod (PCB, Pesticide) 8321Mod (Phenolics)		Deviations will be documented.
Procedural blank	1 per 20 samples	<3 × MDL (qualify if < MDL)	Reextraction or reanalysis, and/or justification documented.
SRM[1]	1 per 20 samples	<35% (or 65-135% recovery) of/relative to 95% confidence intervals. Applies to parameters with certified values >5 × MDL	Reextraction or reanalysis and/or justification documented.
MS/MSD	1 per 20 samples	30-130% recovery[2], <30% RPD[3]. Applies to parameters with spikes >5 × background.	Reextraction or reanalysis and/or justification documented.
BS	1 per 20 samples	30-130% recovery[2]	Reextraction or reanalysis and/or justification documented.
Surrogate recovery	8270M: 3 per sample 8081M: 2 per sample 8321M: 2 per sample	30-130% recovery[4]	Reextraction or reanalysis and/or justification documented.
Instrument calibration	Initial calibration	8270M: <25% RSD[5] each analytes and <15% RSD average all analytes. 8081M and 8321M: r^2: 0.995,	Reanalyze or justification documented.
	Continuing calibration checks	<25% PD individual analytes and <15% PD avg all analytes	Remedial maintenance, new initial calibration, or reanalysis documented and justified.
TOTAL ORGANIC CARBON			
Method	Standard Methods (9060)		Deviations will be documented.
Procedural blank	1 per 20 samples	<5 × MDL	TOC sample concentrations will be blank subtracted.
Laboratory control spike	1 per 20 samples	<10% of certified/acceptance value	Reanalysis and/or justification documented.
Duplicates	1 per 20 samples	<20% RPD if conc. <0.20% <10% RPD if conc. >0.20%	Reanalysis and/or justification documented.
Instrument calibration	Continuing checks	± 5% true value	Remedial maintenance, new initial calibration, reanalyze samples at discretion of analyst and Task Leader. Documented and justified.

Table 2-3 (continued). Laboratory Analysis Data Quality Objectives

QC Measurement	Frequency	Acceptability Limits	Corrective Action
TRACE AND MAJOR METALS			
Method	200.8Mod, 200.9Mod, and 245.5		Deviations will be
Procedural blank	1 per 20 samples	<3 × MDL (qualify if < MDL)	Reextraction, reanalysis, or blank subtraction documented.
SRM	1 per 20 samples	70-130% recovery versus certified value	Reextraction or reanalysis and/or justification documented.
MS	1 per 20 samples	70-130% recovery. Applies to parameters with spikes >5 × background.	Reextraction or reanalysis and/or justification documented.
Duplicate	1 per 20 samples	<20% RPD[3]	Reextraction or reanalysis and/or justification documented
BS	1 per 20 samples	70-130% recovery; <30% RPD	Reextraction or reanalysis and/or justification documented.
Instrument calibration	Initial calibration Continuing calibration checks	r^2 0.99 <15% PD individual analytes	Reanalysis or justification documented. Remedial maintenance, new initial calibration, or reanalysis documented and justified.
GRAIN SIZE			
Method	Fraunhofer		Deviations will be documented.
Duplicates	1 per 20 samples	<20% RPD for sand, silt, clay[6]	Reanalysis documented.

[1] Certified values for sediment SRM are available for selected PAH, PCB, pesticides, and metals. DQO apply when the consensus/certified value is >5 × MDL.

[2] % recovery (MS/MSD) = [((MS concentration – Background concentration) × (MS dry weight)) / spike amount] × 100. MS/MSD criteria apply when spiking level >5 × background level.

[3] Relative Percent Difference (RPD)(%) = [(|replicate 1 – replicate 2| × 2) / (replicate 1 + replicate 2)] × 100. DQO applies when the concentration is >5 × MDL.

[4] One PAH SIS may exceed acceptability limits only after other data quality indicators are reviewed.

[5] Relative Standard Deviation (RSD) = [(standard deviation of the response factors)/mean response factor] ×100

[6] No criteria for gravel fraction.

3. RESULTS

This section summarizes the results of the organic compound, metals and geophysical analyses. It is divided into the following three sections: Section 3.1 includes organic compound analyses ([polycyclic aromatic hydrocarbons (PAH), phthalate esters, polychlorinated biphenyl (PCB), pesticides, other chlorinated compounds, and chlorinated phenolic compounds), Section 3.2 includes metals analyses (major metals and trace metals), Section 3.3 includes geophysical (ancillary) analyses (total organic carbon (TOC), grain size, moisture content, total solids (TS), total volatile solids (TVS), and elutriate metals). The complete data set, including the analyses for each site replicate, have been reported to the SJRWMD. This complete data set was also reviewed for this report, and site replicate differences are discussed, as appropriate. However, for the purposes of presentation in this report, the data have been limited to a single set of contaminant data for each site — the results for the surface sediment site duplicates have been averaged. The sediment chemistry results for each site and each measured parameter are reported in Appendix B through G. The data tables in the appendices, and the summary data in the main body of the report, are organized alphabetically by site name, beginning with the Lower St. Johns River (LSJR) sites followed by the Cedar-Ortega River (COR) sites.

All chemistry data presented and discussed in this report are presented on a dry weight basis. The use of dry weight to report contaminant concentrations reduces data variability caused by varying amounts of water retained by the sediment, and provides for a more reliable data comparison. The term dry weight refers to sediment that has been dried to remove water and is the standard method of reporting and comparing sediment contaminant concentrations.

All organic contaminant data are presented as surrogate corrected data in this report. Target compounds are corrected for the recovery of a representative surrogate compound in the sample. The main purpose of the correction is to account for sample loss that may have occurred during sample processing. Surrogate correction is widely applied in environmental monitoring programs (e.g., NOAA NS&T Program and EPA EMAP) and is generally accepted a useful technique to generate data that better represent the contaminant concentration in the original field sample than non-corrected data.

3.1 Results for Organic Compound Analysis

This subsection presents the results of the organic compound analysis and is divided into three sections; the results from the Method 8270M analyses (PAH and phthalate results), the Method 8081M analyses (PCB, pesticide, and other chlorinated compound results), and the Method 8321M analyses (chlorophenolic compound results). Individual concentrations for a total of 116 organic compounds were determined in this study (Table 1-1). The analytical data for each individual compound are listed in Appendix B (Method 8270M analytes), Appendix C (Method 8081M analytes), and Appendix D (Method 8321M analytes). All individual compound data were reviewed. However, it is most illuminating to focus on classes of analytes for data summary and analysis purposes, and that is the approach used for most of this report. Individual organic compounds are discussed when the data review revealed them to be of particular interest.

Non-polar organic contaminants have an affinity for the organic matter in the sediment, and tend to concentrate in organic-rich sediments to a higher degree than in low organic content sediments, given the same concentrations and conditions in the water phase. It can therefore be useful to normalize the organic contaminant data to the TOC content of the sediment for data analysis purposes, and both normalized (as µg/g TOC) and non-normalized organic contaminant data are presented in this report. The normalization can help ascertain if elevated levels of organic contaminants could be the result of significant nearby sources of anthropogenic organic contaminants (both non-normalized and TOC-normalized levels are typically elevated), or if it is primarily a sediment concentration effect (elevated TOC-normalized levels, but the non-normalized levels are not elevated). Additionally, a review of both the non-normalized and TOC-normalized concentrations can provide a first-level indication of the bioavailable organic contamination (i.e., organic contaminants tightly bound to organic matter, or particulates, are generally less bioavailable than compounds in sandy, low-TOC, sediment). Although the TOC measurement will include hydrocarbons and other contaminants that may be used in the normalization process, these compounds are negligible compared to the majority of the bulk organic material measured in the TOC analysis and do not significantly impact the normalization (e.g., petroleum hydrocarbons and other anthropogenic organic compounds may together constitute a few tens or hundreds of mg/kg of the organic material in these samples, compared to an overall TOC that averaged about 10% for these samples).

3.1.1 PAH and Phthalate Compound Results

Sediment samples were analyzed for 34 aromatic compounds by method 8270M; 24 individual polycyclic aromatic hydrocarbons (PAHs), 6 phthalate esters, 2 chlorinated naphthalenes, isophorone, and kepone. The chloronaphthalenes, isophorone, and kepone data were reviewed. These compounds were typically not detected at notable levels in the sediment samples, are thus of little concern, and are therefore not elaborated on in this report; the results for these compounds are briefly discussed at the end of section 3.1.1. For presentation and discussion purposes this report focuses on the 30 PAH and phthalate compounds, which are categorized as (1) low molecular weight (LMW) PAH, (2) high molecular weight (HMW) PAH, (3) total PAH, and (4) total phthalate. Table 3-1 lists the analytes that comprise each group.

LMW PAH are frequently associated with refined and unrefined petroleum products. HMW PAH are primarily derived from the combustion of fossil fuels or as principal components of creosote-type formulations or coal tar handling/processing. Phthalates are widely used industrial compounds, primarily associated with the manufacture and handling of plastics, and are, like PAH, ubiquitous throughout our society and environment.

Table 3-1. Aromatic Hydrocarbon and Phthalate Groups

LMW PAH (Σ of)	HMW PAH (Σ of)	Total PAH (Σ of)	Total Phthalate (Σ of)
Naphthalene	Fluoranthene	Low PAH	Dimethylphthalate
2-Methylnaphthalene	Pyrene	High PAH	Diethylphthalate
1-Methylnaphthalene	Benz(a)anthracene		Di-N-butylphthalate
Biphenyl	Chrysene		Butylbenzylphthalate
2,6-Dimethylnaphthalene	Benzo(b)fluoranthene		Bis(2-ethylhexyl)phthalate
2,3,5-Trimethylnaphthalene	Benzo(k)fluoranthene		Di-N-octylphthalate
Acenaphthylene	Benzo(e)pyrene		
Acenaphthene	Benzo(a)pyrene		
Fluorene	Indeno(1,2,3-c,d)pyrene		
Phenanthrene	Dibenz(a,h)anthracene		
Anthracene	Benzo(g,h,i)perylene		
1-Methyphenanthrene	Perylene		

A summary of the median values and ranges of concentrations of selected classes of aromatic organic compounds is listed in Table 3-2. A summary of the concentration data for each of the 77 LSJR and the 51 broadly characterized COR sites is presented in Table 3-3. These data are presented both non-normalized and normalized to total organic carbon (TOC). The data for each Method 8270M compound are presented in Appendix B.

Table 3-2. Concentration Ranges for PAH and Phthalates

	Not Normalized (µg/kg dry weight)			Normalized to TOC (µg/g TOC)		
	Median	Min	Max	Median	Min	Max
Lower St. Johns River Sites						
Total PAH	1,300	10.7	13,800	10.8	1.69	190
Low PAH (LMW)	177	3.23	3,190	1.62	0.168	43.7
High PAH (HMW)	1,130	7.48	10,700	9.52	1.52	146
Total Phthalate	162	12.3	1,710	1.86	0.294	32.5
Cedar-Ortega River Basin Sites						
Total PAH	4,840	560	29,800	32.8	5.78	353
Low PAH (LMW)	366	26.5	1,150	2.87	2.07	36.3
High PAH (HMW)	4,230	478	28,600	29.2	5.57	332
Total Phthalate	280	56.4	2,570	1.88	0.436	38.6

PAH – Total PAH

The PAH concentrations were generally higher at the COR sites than at the LSJR sites, with a median total PAH concentration of 4,840 and 1,300 µg/kg, respectively. Only 5 (LSJ01, LJS02, LJS05, LSJRC02, LSJRC06) of the 77 LSJR sites had a total PAH concentration higher than the median concentration for the COR sites. The data indicate that the PAH concentrations in the sediment samples vary greatly, particularly in the Lower St. Johns River where a number of locations had quite low concentrations of PAH. The variation in concentrations was typically due to the influence of the sediment characteristics (i.e. grain size, TOC content). Total PAH concentrations at the LSJR sites ranged from 10.7 (site LSJRC12) to 13,800 µg/kg (site LSJ01), and ranged from 560 (site ORT30) to 29,800 µg/kg (site CED09) at the COR sites. LSJR and COR samples were analyzed against 2 standard deviations from their medians to determine sites with significantly higher concentrations than the medians. Five of the LSJR sites had total PAH concentrations above 5,500 µg/kg (median concentration + 2 standard deviations). These sites were LSJ01 (13,800 µg/kg), LSJ02 (6,350 µg/kg), LSJ05 (6,830 µg/kg), LSJRC02 (6,920 µg/kg), and LSJRC06 (7,340 µg/kg). Three of the COR sites had total PAH concentrations above 14,900 µg/kg (median concentration + 2 standard deviations). These sites were CED04 (16,000 µg/kg), CED09 (29,800 µg/kg), and ORT33 (15,200 µg/kg).

The highest PAH concentrations in the LSJR sites were at the sites in the northern-most part of the St. Johns River, near the urban areas of southern Jacksonville (e.g., sites LSJ01, LSJ02, LSJ03, LSJ05, and HSP05). Slightly elevated PAH concentrations, as compared to the general main stem background levels, were also detected at sites near the confluence of Rice Creek and the St. Johns River (e.g., sites LSJRC02 and LSJRC06). Most of the LSJR sites had total PAH concentrations below 2,000 µg/kg dry weight; 22 of the 77 sites had concentrations above 2,000 µg/kg and only one site (LSJ01) had a sediment total PAH concentration above 10,000 µg/kg dry weight. However, the majority of the COR sites had total PAH concentrations *above* 2,000 µg/kg dry weight; 44 of the 58 sites had concentrations above 2,000 µg/kg and eight sites (CED02, CED03, CED04, CED06, CED09, ORT25, ORT31, and ORT33) had a sediment total PAH concentration above 10,000 µg/kg dry weight.

Table 3-3. Organic Contaminant Summary Data — PAH and Phthalates

FIELD ID	Not Normalized (µg/kg dry weight)				Normalized to TOC (µg/g TOC)			
	Total PAH	Low PAH	High PAH	Total Phthalates	Total PAH	Low PAH	High PAH	Total Phthalates
Lower St. Johns River Sites								
BAY01	1,340	166	1,170	183	6.83	0.851	5.98	0.935
BOL04	1,870	286	1,580	2,060	16.8	2.58	14.2	18.6
BUCK03	1,010	198	808	231	7.29	1.43	5.86	1.67
CDRC01	849	85.4	764	953	4.39	0.441	3.95	4.92
CO06	2,380	282	2,090	396	18.3	2.17	16.1	3.05
DUN01	1,050	127	920	516	3.59	0.437	3.16	1.77
GC02	1,220	191	1,030	143	18.1	2.84	15.3	2.12
HSP05	4,630	1,210	3,420	1,710	54.9	14.3	40.6	20.3
JUL02	1,920	271	1,650	207	11.6	1.63	9.95	1.25
LSJ01	13,800	3,190	10,700	833	190	43.7	146	11.4
LSJ02	6,350	845	5,510	382	59.0	7.85	51.1	3.54
LSJ03	3,290	440	2,850	203	23.4	3.12	20.2	1.44
LSJ04	1,450	308	1,150	92.2	67.8	14.4	53.4	4.30
LSJ05	6,830	1,060	5,770	314	44.4	6.91	37.4	2.04
LSJ06	1,700	293	1410	73.3	21.8	3.76	18.1	0.939
LSJ07	2,700	392	2,300	199	15.9	2.32	13.6	1.18
LSJ08	2,880	379	2,510	166	18.4	2.42	16.0	1.06
LSJ09	1,570	217	1,350	107	8.31	1.15	7.17	0.568
LSJ10	95.3	16.4	78.9	13.1	18.7	3.22	15.5	2.57
LSJ11	2,270	314	1,950	110	13.1	1.81	11.2	0.633
LSJ12	2,100	253	1,840	162	10.8	1.31	9.52	0.835
LSJ13	873	88.3	785	105	14.9	1.51	13.4	1.80
LSJ14	2,070	225	1,840	274	11.4	1.25	10.2	1.52
LSJ15	256	27.0	229	56.7	12.9	1.36	11.5	2.86
LSJ16	1,510	154	1,360	678	9.17	0.934	8.24	4.11
LSJ17	1,010	103	910	180	9.44	0.959	8.48	1.68
LSJ18	688	59.6	628	105	12.1	1.05	11.1	1.86
LSJ19	325	32.3	293	120	1.69	0.168	1.52	0.624
LSJ20	91.3	14.2	77.1	48.4	5.89	0.914	4.98	3.12
LSJ21	438	52.4	386	167	3.95	0.472	3.47	1.51
LSJ22	310	42.7	267	104	6.24	0.861	5.38	2.10
LSJ23	768	56.3	712	387	64.6	4.73	59.8	32.5
LSJ24	676	70.0	606	130	5.81	0.601	5.21	1.12
LSJ25	790	75.2	715	121	6.12	0.583	5.54	0.937
LSJ26	32.5	7.40	25.1	30.0	3.51	0.798	2.71	3.23
LSJ27	1,300	170	1,130	198	6.25	0.820	5.43	0.953
LSJ28	1,240	103	1,140	64.2	9.96	0.827	9.14	0.516
LSJ29	995	129	867	77.2	13.8	1.78	12.0	1.07
LSJ30	1,520	118	1,400	117	6.51	0.508	6.00	0.500
LSJ31	19.1	4.05	15.0	12.3	8.31	1.77	6.55	5.36
LSJ32	2,120	217	1,900	89.6	14.3	1.46	12.8	0.603
LSJ33	27.7	5.77	21.9	16.4	10.3	2.15	8.18	6.13
LSJ35	1,790	222	1,570	708	7.13	0.882	6.25	2.81
LSJ36	562	53.0	509	56.6	19.8	1.87	17.9	2.00

FIELD ID	Not Normalized (µg/kg dry weight)				Normalized to TOC (µg/g TOC)			
	Total PAH	Low PAH	High PAH	Total Phthalates	Total PAH	Low PAH	High PAH	Total Phthalates
LSJ37	37.2	4.75	32.5	18.2	13.1	1.68	11.4	6.43
LSJ39	80.6	9.44	71.1	19.6	32.6	3.82	28.8	7.95
LSJ40	2,340	177	2,160	152	10.8	0.817	9.98	0.702
LSJRC01	1,500	425	1,080	214	15.8	4.48	11.3	2.25
LSJRC02	6,920	1,940	4,990	956	20.0	5.61	14.4	2.77
LSJRC03	3,520	507	3,020	616	14.5	2.09	12.4	2.54
LSJRC04	890	152	737	189	20.4	3.50	16.9	4.34
LSJRC05	215	92.2	122	117	19.8	8.53	11.3	10.8
LSJRC06	7,340	2,650	4,680	638	18.5	6.70	11.8	1.61
LSJRC07	965	405	560	166	22.2	9.34	12.9	3.81
LSJRC08	3,310	1,260	2,060	657	10.6	4.00	6.55	2.09
LSJRC09	3,010	799	2,210	688	10.4	2.77	7.66	2.38
LSJRC10	3,090	1,010	2,080	504	9.27	3.02	6.24	1.51
LSJRC11	3,310	891	2,420	189	10.8	2.91	7.90	0.618
LSJRC12	10.7	3.23	7.48	12.7	4.05	1.22	2.83	4.81
LSJRC13	1,480	186	1,290	57.7	7.53	0.948	6.58	0.294
LSJRC13-02	1,780	229	1,550	143	9.84	1.27	8.57	0.788
LSJRC14	646	71.0	575	123	8.18	0.898	7.28	1.55
LSJRC15	1,980	220	1,760	184	8.23	0.914	7.31	0.761
LSJRC16	1,120	118	999	219	9.43	0.998	8.43	1.85
LSJRC17	586	89.6	496	56.0	8.11	1.24	6.87	0.776
LSJRC18	39.4	7.46	32.0	24.2	5.59	1.06	4.53	3.43
LSJRC19	1,430	184	1,250	160	5.87	0.752	5.11	0.652
LSJRC20	1,290	192	1,100	156	5.13	0.765	4.36	0.620
MOC07	840	153	687	965	8.88	1.62	7.26	10.2
NASCP01	2,780	599	2,190	145	43.6	9.38	34.2	2.27
NASM01	1,710	535	1,180	531	10.5	3.29	7.25	3.26
OBB	786	119	667	237	4.56	0.690	3.87	1.37
ORG01	873	157	716	113	5.22	0.939	4.29	0.676
PA32	1,650	143	1,510	762	40.9	3.53	37.4	18.8
PP61	294	33.2	261	19.1	16.3	1.84	14.4	1.06
RCCP02	914	353	561	44.5	40.7	15.7	25.0	1.98
WEK02	2,860	243	2,620	570	12.8	1.08	11.7	2.54
Cedar-Ortega River Basin Sites								
CED01	5,510	544	4,960	1,200	83.9	8.30	75.6	18.3
CED02	12,400	594	11,900	1,460	116	5.55	111	13.6
CED03	10,400	498	9,900	1,690	92.9	4.44	88.4	15.1
CED04	16,000	766	15,200	2,570	112	5.39	107	18.1
CED05	2,200	119	2,090	2,380	29.6	1.60	28.0	31.9
CED06	13,700	623	13,100	391	102	4.65	97.6	2.92
CED07	8,310	412	7,890	199	66.4	3.29	63.2	1.60
CED08	7,600	366	7,230	1,010	53.5	2.58	50.9	7.13
CED09	29,800	1,150	28,600	684	250	9.69	240	5.74
ORT01	2,620	304	2,320	77.2	25.0	2.90	22.1	0.735
ORT02	962	51.6	910	136	9.88	0.530	9.35	1.40
ORT03	899	27.7	871	205	7.75	0.239	7.51	1.77
ORT04	2,190	261	1,930	221	18.5	2.22	16.3	1.87

FIELD ID	Not Normalized (µg/kg dry weight)				Normalized to TOC (µg/g TOC)			
	Total PAH	Low PAH	High PAH	Total Phthalates	Total PAH	Low PAH	High PAH	Total Phthalates
ORT05	3,240	575	2,660	66.7	25.9	4.60	21.3	0.534
ORT06	1,800	228	1,570	676	16.4	2.07	14.3	6.15
ORT06-1	2,460	249	2,210	109	26.4	2.67	23.7	1.17
ORT07	5,280	486	4,800	529	38.8	3.57	35.3	3.89
ORT08	2,180	207	1,970	95.4	18.6	1.77	16.9	0.815
ORT09	3,940	579	3,360	338	43.7	6.43	37.3	3.76
ORT10	4,020	486	3,530	1,010	31.1	3.77	27.4	7.81
ORT11	2,930	260	2,670	183	22.9	2.03	20.9	1.43
ORT12	5,600	488	5,110	566	43.1	3.76	39.3	4.36
ORT13	5,270	680	4,590	454	36.1	4.66	31.4	3.11
ORT14	1,880	234	1,650	181	17.1	2.13	15.0	1.64
ORT15	7,070	534	6,530	262	45.0	3.40	41.6	1.67
ORT16	4,460	488	3,970	242	32.8	3.59	29.2	1.78
ORT18	4,840	625	4,210	699	37.8	4.88	32.9	5.46
ORT19	8,150	1,030	7,120	327	288	36.3	252	11.6
ORT20	1,770	62.8	1,710	182	16.1	0.571	15.5	1.65
ORT21	3,900	310	3,590	106	31.2	2.48	28.7	0.850
ORT22	5,470	405	5,070	624	46.0	3.40	42.6	5.24
ORT23	3,970	294	3,680	84.2	28.4	2.10	26.3	0.601
ORT24	5,760	491	5,270	280	38.7	3.30	35.4	1.88
ORT25	12,300	702	11,600	359	78.3	4.47	73.8	2.29
ORT26	6,830	433	6,400	269	45.2	2.87	42.4	1.78
ORT27	8,380	410	7,970	570	57.4	2.81	54.6	3.91
ORT28	5,020	326	4,690	205	31.2	2.02	29.2	1.27
ORT29	739	26.5	713	61.0	5.78	0.207	5.57	0.477
ORT30	560	81.1	478	56.4	24.1	3.50	20.6	2.43
ORT31	11,100	742	10,400	476	90.5	6.04	84.4	3.87
ORT32	6,310	433	5,870	146	55.3	3.80	51.5	1.28
ORT33	15,200	915	14,300	1,670	353	21.2	332	38.6
ORT34	4,180	288	3,900	361	25.2	1.74	23.5	2.17
ORT35	3,910	224	3,690	75.4	28.8	1.65	27.1	0.554
ORT36	4,010	219	3,790	958	24.2	1.32	22.8	5.77
ORT37	6,660	358	6,300	153	45.6	2.45	43.2	1.05
ORT38	5,150	327	4,820	111	33.6	2.14	31.5	0.725
ORT39	4,460	225	4,230	78.0	24.9	1.26	23.6	0.436
ORT39-1	3,900	184	3,720	527	20.6	0.971	19.7	2.79
ORT40	4,860	290	4,570	187	29.5	1.76	27.7	1.13
ORT41	2,030	78.1	1,950	291	9.40	0.362	9.04	1.35

PAH – LMW PAH

The concentration of LMW PAH (Low PAH), the primarily petrogenic PAH, ranged from 3.23 (site LSJRC12) to 3,190 µg/kg (site LSJ01) in the Lower St. Johns River and from 26.5 (site ORT29) to 1,150 µg/kg (site CED09) in Cedar-Ortega River basin. Three of the LSJR sites had LMW PAH concentrations above 1,270 µg/kg (median concentration + 2 standard deviations). These sites were LSJ01 (3,190 µg/kg), LSJRC02 (1,940 µg/kg), and LSJRC06 (2,650 µg/kg). Two of the COR sites had LMW PAH concentrations above 863 µg/kg (median concentration + 2 standard deviations). These sites were CED09 (1,150 µg/kg) and ORT19 (1,030 µg/kg).

PAH – HMW PAH

The concentration of HMW PAH (High PAH), the primarily pyrogenic PAH were generally significantly higher than the LMW PAH, and ranged from 7.48 (site LSJRC12) to 10,700 µg/kg (site LSJ01) for the LSJR sites and from 478 (site ORT30) to 28,600 µg/kg (site CED09) for the COR sites. This was particularly the case for the COR samples, which had a median HMW PAH concentrations that was about 12 times higher than the median LMW PAH concentrations; for the LSJR sites the difference was about a factor of 6.

Five of the LSJR sites had HMW concentrations above 4,350 µg/kg (median concentration + 2 standard deviations). These sites were LSJ01 (10,700 µg/kg), LSJ02 (5,510 µg/kg), LSJ05 (5,770 µg/kg), LSJRC02 (4,990 µg/kg), and LSJRC06 (4,680 µg/kg). Three of the COR sites had HMW concentrations above 13,900 µg/kg (median concentration + 2 standard deviations). These sites were CED04 (15,200 µg/kg), CED09 (28,600 µg/kg), and ORT33 (14,300 µg/kg).

The variability in the sediment PAH concentrations remained high even after the PAH data were normalized to sediment TOC content (Tables 3-2 and 3-3). For instance, the TOC-normalized total PAH concentration ranged from 1.66 (site LSJ19) to 190 µg/g TOC (site LSJ01) for the LSJR sites and from 5.78 (site ORT29) to 353 µg/g TOC (site ORT33) for the COR Basin sites.

Phthalate Esters

The phthalate concentrations were by and large lower than the PAH concentrations. The total phthalate concentrations distribution pattern was similar to the PAH pattern in that they were generally higher at the COR sites than the LSJR sites with the total phthalate concentrations at the LSJR sites ranging from 12.3 (site LSJ31) to 1,710 µg/kg (site HSP05). The phthalate concentrations for the COR sites ranged from 56.4 (site ORT30) to 2,570 µg/kg (site CED04). Analysis of LSJR and COR sites against 2 standard deviations from their medians was performed to determine those sites that had significantly elevated concentrations, compared with the medians for these general locations. Five of the LSJR sites had total phthalate concentrations above 887 µg/kg (median concentration + 2 standard deviations). These were BOL04 (2,060 µg/kg), CDRC01 (953 µg/kg), HSP05 (1,710 µg/kg), LSJRC02 (956 µg/kg), and MOC07 (965 µg/kg). Five of the COR sites had total phthalate concentrations above 1,420 µg/kg (median concentration + 2 standard deviations); sites CED02 (1460 µg/kg), CED03 (1,690 µg/kg), CED04 (2,570 µg/kg), CED05 (2,380 µg/kg), and ORT33 (1,670 µg/kg).

Two of the LSJR sites (BUCK03 and ORG01) had very high concentrations of two of the six phthalates [di-N-octylphthalate and bis(2-ethylhexyl)phthalate] in only one of the two site replicates. The BUCK03 site replicates, for instance, had a total phthalate concentration of 3,840 and 91,000 µg/kg, respectively, suggesting that one of the replicates sediment samples might have contained a small fragment of plastic from the field, rather than high concentrations of sediment-associated molecular-level phthalates. The two site replicate outlier data points were therefore omitted for the reporting in Tables 3-2 and 3-3, and for the generation of the figures in the appendices (they were, however, included in the data tables in Appendix B, to allow for a complete data evaluation).

The variability in the sediment phthalate concentrations remained high even after the data were normalized to sediment TOC content (Tables 3-2 and 3-3). For instance, the TOC-normalized total phthalate concentration ranged from 0.294 (site LSJRC13) to 32.5 µg/g TOC (site LSJ23) for the LSJR sites and from 0.436 (site ORT39) to 38.6 µg/g TOC (site ORT33) for the COR Basin sites.

Four other compounds, 2-chloronaphthalene, 1-chloronaphthalene, isophorone, and kepone were also analyzed using Method 8270M and reported with the PAH data (Appendix B), but are not classified as PAH or phthalate and therefore are not included in the total PAH or total phthalate calculations. The chloronaphthalenes (1- and 2-) were detected least frequently of these additional compounds, but isophorone and kepone were also rarely detected at environmentally relevant concentrations. 1-Chloronaphthalene was not detected in any of the LSJR or COR samples, and 2-chloronaphthalene was detected at trace levels in only 3 samples. Isophorone, which is primarily used in metals coatings and paints, and plastic adhesives, was detected at low concentrations in samples from the many of LSJR sites, but at relatively few COR sites. Kepone, a rarely used insecticide, was detected at low levels in 10 of the LSJR sites, but was not detected in any of the COR sites.

3.1.2 PCB, Pesticide, and Other Chlorinated Compound Results

The sediment samples were analyzed for 61 chlorinated compounds (23 individual PCB congeners, 30 pesticides, and 8 other chlorinated compounds) using Method 8081M. Table 3-4 below shows the analytes that are summarized as separate groups/classes for presentation and discussion purposes. The analytes are categorized as (1) sum of PCB congeners, (2) total DDT compounds, (3) total chlordanes, (4) total benzene hexachlorides [(BHCs), which includes the pesticide lindane (γ-BHC)], (5) total endosulfans, and (6) total other industrial chlorinated compounds. Total DDT, DDE, and DDD compounds, each as sums of their 4,4’- and 2,4’-isomers, were also determined to further characterize the DDT contamination. The data for the additional pesticides that were determined, but are not captured in these compound summations, were also reviewed and were, for the most part, of less environmental significance. However, the review of these other analyzed pesticides is discussed below.

Table 3-4. Chlorinated Organic Compound Groups

Sum of PCBs (Σ of)		Total DDTs (Σ of)	Total Chlordanes (Σ of)	Total BHCs (Σ of)	Total Endosulfans (Σ of)	Total Other Chlorinated Compounds (Other Chloros; Σ of)
Cl_2(8)	Cl_3(18)	2,4’-DDT	Oxychlordane	α-BHC	Endosulfan I	1,3-Dichlorobenzene
Cl_3(28)	Cl_4(52)	4,4’-DDT	γ-Chlordane	β-BHC	Endosulfan II	1,4-Dichlorobenzene
Cl_4(44)	Cl_4(66)	2,4’-DDE	α-chlordane	γ-BHC	Endosulfan sulfate	1,2-Dichlorobenzene
Cl_4(77)	Cl_5(110)	4,4’-DDE		δ-BHC		1,2,4-Trichlorobenzene
Cl_5(101)	Cl_5(118)	2,4’-DDD				1,2,4,5-Tetrachlrorobenzene
Cl_6(153)	Cl_5(105)	2,4’-DDD				Hexachloroethane
Cl_6(138)	Cl_5(126)					Hexachlorobutadiene
Cl_6(129)	Cl_7(187)					Hexachlororcyclopentadiene
Cl_6(128)	Cl_7(180)					
Cl_6(169)	Cl_7(170)					
Cl_8(195)	Cl_9(206)					
Cl_{10}(209)						

Table 3-5 presents the median concentrations and the concentration ranges of chlorinated compounds found at the sampling locations, and the data for the individual sites are presented in Table 3-6. The data for each Method 8081M compound are presented in Appendix C. The data indicate that concentrations of PCB, pesticides, and other chlorinated compounds were quite variable in the sediment samples from both the LSJR and COR sites.

PCB

The 23 PCB congeners determined in this project typically constitute about one-half of the total PCB concentrations in most environmental samples (i.e., the true total PCB concentrations is generally approximately two times the sum of these congeners), as determined in the NOAA NS&T program. A set of samples in this project were separately processed and analyzed for a detailed PCB congener characterization by quantifying more than 100 congeners that comprise about 99% of the total PCB; those data will be reported separately in a COR-specific report. The congener set in this study was, on average, determined to represent 42% of the total PCB (it ranged from 40 to 45% for most samples). Therefore, although the total PCB in these samples were not measured, they can be confidently estimated by multiplying the sum of the PCB congener concentrations by 2.4. For this data set, using the 2.4 multiplier will provide a more accurate estimate than using the general NS&T figure of 2.0.

Table 3-5. Concentration Ranges for Selected Chlorinated Organic Compounds

	Not Normalized (μg/kg dry weight)			**Normalized to TOC (μg/g TOC)**		
	Median	**Min**	**Max**	**Median**	**Min**	**Max**
Lower St. Johns River Sites						
ΣPCBs	26.9	0.09	257	0.245	0.012	2.71
ΣDDT Compounds	5.81	ND	30.3	0.047	ND	0.416
DDTs	1.25	ND	15.5	0.012	ND	0.143
DDDs	2.13	ND	13.3	0.016	ND	0.182
DDEs	1.79	ND	7.23	0.016	ND	0.138
ΣChlordanes	0.38	ND	4.11	0.005	ND	0.292
ΣBHCs	0.67	ND	5.77	0.007	ND	0.098
ΣEndosulfans	0.68	ND	16.6	0.008	ND	0.145
ΣOther Chloros	16.6	ND	152	0.205	ND	7.86
Cedar-Ortega River Basin Sites						
ΣPCBs	135	3.76	3,710	1.08	0.105	56.6
ΣDDT Compounds	14.8	0.93	87.8	0.116	0.010	1.34
DDTs	2.70	ND	16.4	0.023	ND	0.379
DDDs	5.71	0.23	52.2	0.040	0.0026	0.796
DDEs	5.53	ND	33.0	0.044	ND	0.502
ΣChlordanes	4.87	ND	85.4	0.037	ND	1.25
ΣBHCs	0.89	ND	6.60	0.008	ND	0.050
ΣEndosulfans	2.04	ND	29.0	0.016	ND	0.442
ΣOther Chloros	24.9	0.12	136	0.196	0.0009	0.872

The sum of the PCB congener concentrations ranged from 0.09 (site LSJ37) to 257 µg/kg (site LSJRC11) at the LSJR sites and from 3.76 (site ORT30) to 3,710 µg/kg (site CED01) at the COR Basin sites. The PCB concentrations were, generally, much higher in the Cedar-Ortega River than in the main stem of the Lower St. Johns River; the median concentrations were 135 and 26.9 µg/kg, respectively. Only 3 (LSJ01, LSJRC06, and LSJRC11) of the 77 LSJR sites had a PCB concentration higher than the median concentration for the COR sites. Analysis of LSJR and COR sites against 2 standard deviations from their medians was performed to determine those sites that had notably elevated concentrations, relative to the rest of the sites in these locations. Four of the LSJR sites had sum of PCB concentrations above 117 µg/kg (median concentration + 2 standard deviations). These sites were HSP05 (121 µg/kg), LSJ01 (192 µg/kg), LSJRC06 (197 µg/kg), and LSJRC11 (257 µg/kg). One of the COR sites (CED12, 14,600 µg/kg) had a sum of PCB concentrations above 2,040 µg/kg (median concentration + 2 standard deviations); the PCB concentrations were clearly more broadly elevated at the COR sites.

Table 3-6. Organic Contaminant Summary Data — PCB, Pesticides and Other Chlorinated Compounds

FIELD ID	Not Normalized (µg/kg dry weight)									Normalized to TOC (µg/g TOC)								
	Sum PCBs	Sum DDTs	DDT	DDE	DDD	Chlor-danes	BHCs	Endo-sulfans	Other Chloros	Sum PCBs	Sum DDTs	DDT	DDE	DDD	Chlor-danes	BHCs	Endo-sulfans	Other Chloros
Lower St. Johns River Sites																		
BAY01	38.3	8.22	2.61	3.48	2.13	0.19	ND	0.37	ND	0.196	0.0420	0.0133	0.0178	0.0109	0.0010	ND	0.0019	ND
BOL04	70.1	14.1	0.51	4.81	8.82	0.58	0.47	4.47	18.1	0.632	0.127	0.0046	0.0433	0.0794	0.0052	0.0042	0.0403	0.163
BUCK03	64.7	6.41	ND	3.62	2.79	ND	0.40	0.41	15.8	0.469	0.0465	ND	0.0262	0.0202	ND	0.0029	0.0030	0.114
CDRC01	47.3	7.73	1.35	3.33	3.05	ND	ND	0.41	5.63	0.245	0.0400	0.0070	0.0172	0.0158	ND	ND	0.0021	0.0291
CO06	83.3	10.4	ND	4.98	5.39	3.66	0.86	ND	22.4	0.641	0.0798	ND	0.0383	0.0415	0.0282	0.0066	ND	0.172
DUN01	21.7	7.02	1.60	2.32	3.11	0.54	ND	0.49	26.7	0.0744	0.0241	0.0055	0.0079	0.0107	0.0019	ND	0.0017	0.0916
GC02	12.8	2.62	ND	1.27	1.35	0.64	ND	0.19	10.3	0.191	0.0390	ND	0.0189	0.0201	0.0095	ND	0.0028	0.153
HSP05	121	20.8	5.71	7.23	7.82	0.66	0.74	4.36	14.4	1.43	0.246	0.0677	0.0856	0.0927	0.0078	0.0088	0.0517	0.171
JUL02	43.4	5.88	ND	3.60	2.28	0.12	ND	0.42	13.8	0.261	0.0354	ND	0.0217	0.0137	0.0007	ND	0.0025	0.0830
LSJ01	192	30.3	10.4	6.62	13.3	3.49	1.08	8.31	7.76	2.62	0.416	0.143	0.0907	0.182	0.0478	0.0147	0.114	0.106
LSJ02	78.3	18.0	4.91	4.83	8.22	4.11	1.59	3.42	10.4	0.727	0.167	0.0456	0.0449	0.0763	0.0382	0.0148	0.0317	0.0961
LSJ03	64.2	8.15	1.64	2.86	3.65	1.61	0.57	1.19	54.2	0.456	0.0578	0.0116	0.0203	0.0259	0.0114	0.0040	0.0084	0.385
LSJ04	35.7	2.44	0.79	0.68	0.98	0.18	0.36	0.32	17.2	1.67	0.114	0.0368	0.0317	0.0454	0.0082	0.0165	0.0148	0.803
LSJ05	62.4	12.4	2.75	5.57	4.11	2.45	1.47	0.90	48.0	0.405	0.0807	0.0179	0.0362	0.0267	0.0159	0.0095	0.0059	0.312
LSJ06	23.8	4.07	1.25	1.89	0.94	0.87	0.82	0.22	31.5	0.305	0.0522	0.0160	0.0242	0.0120	0.0112	0.0105	0.0028	0.403
LSJ07	42.6	7.59	1.82	3.62	2.15	2.19	ND	0.80	64.2	0.252	0.0449	0.0108	0.0214	0.0127	0.0130	ND	0.0047	0.380
LSJ08	102	10.2	1.98	4.55	3.68	0.64	0.22	2.77	45.9	0.649	0.0652	0.0127	0.0291	0.0235	0.0041	0.0014	0.0177	0.294
LSJ09	27.5	4.29	1.59	1.41	1.29	1.00	ND	0.32	59.6	0.145	0.0227	0.0084	0.0075	0.0068	0.0053	ND	0.0017	0.316
LSJ10	1.42	0.46	0.18	0.19	0.09	0.10	0.04	0.01	12.4	0.278	0.0908	0.0359	0.0376	0.0173	0.0203	0.0072	0.0018	2.42
LSJ11	82.4	10.4	1.25	3.28	5.89	1.02	0.79	1.50	55.5	0.475	0.0601	0.0072	0.0189	0.0340	0.0059	0.0045	0.0087	0.320
LSJ12	39.7	5.79	1.18	2.37	2.24	0.84	1.33	0.40	64.5	0.205	0.0299	0.0061	0.0122	0.0116	0.0043	0.0069	0.0020	0.333
LSJ13	20.9	3.55	0.38	1.34	1.83	0.56	0.82	0.80	18.5	0.356	0.0607	0.0065	0.0230	0.0313	0.0096	0.0140	0.0137	0.316
LSJ14	51.2	9.93	1.20	3.62	5.11	1.36	2.45	2.32	34.4	0.283	0.0550	0.0067	0.0200	0.0283	0.0075	0.0136	0.0129	0.190
LSJ15	7.16	1.50	0.17	0.49	0.84	0.17	0.46	0.26	8.12	0.361	0.0755	0.0086	0.0248	0.0421	0.0087	0.0230	0.0130	0.409
LSJ16	34.0	7.50	1.07	2.62	3.8	0.98	1.83	1.14	32.8	0.206	0.0454	0.0065	0.0159	0.0230	0.0060	0.0111	0.0069	0.199
LSJ17	17.6	5.00	1.01	2.04	1.96	0.49	2.07	0.65	22.0	0.164	0.0466	0.0094	0.0190	0.0182	0.0045	0.0193	0.0060	0.205
LSJ18	23.6	3.96	0.74	1.17	2.04	0.40	0.91	1.52	17.6	0.415	0.0696	0.0130	0.0206	0.0360	0.0070	0.0160	0.0267	0.309
LSJ19	5.08	1.39	0.65	0.32	0.42	0.45	1.77	0.30	23.2	0.0263	0.0072	0.0034	0.0017	0.0022	0.0023	0.0092	0.0015	0.120
LSJ20	2.79	0.73	0.23	0.27	0.23	0.09	0.44	0.68	6.64	0.180	0.0469	0.0145	0.0174	0.0150	0.0060	0.0283	0.0441	0.429
LSJ21	8.52	1.77	0.48	0.70	0.60	0.60	0.97	0.71	24.4	0.0767	0.0160	0.0043	0.0063	0.0054	0.0054	0.0087	0.0064	0.220

FIELD ID	Not Normalized (µg/kg dry weight)									Normalized to TOC (µg/g TOC)								
	Sum PCBs	Sum DDTs	DDT	DDE	DDD	Chlor-danes	BHCs	Endo-sulfans	Other Chloros	Sum PCBs	Sum DDTs	DDT	DDE	DDD	Chlor-danes	BHCs	Endo-sulfans	Other Chloros
LSJ22	7.38	1.97	0.47	0.82	0.69	0.45	1.03	1.22	18.8	0.149	0.0397	0.0094	0.0164	0.0139	0.0091	0.0208	0.0245	0.380
LSJ23	8.55	2.19	0.54	1.65	ND	3.47	1.16	ND	3.52	0.718	0.184	0.0453	0.138	ND	0.292	0.0976	ND	0.296
LSJ24	13.3	3.86	1.30	1.86	0.70	0.35	0.26	0.30	5.85	0.115	0.0332	0.0112	0.0160	0.0060	0.0030	0.0022	0.0026	0.0502
LSJ25	19.2	6.06	1.66	2.60	1.81	ND	0.71	0.66	6.41	0.149	0.0470	0.0129	0.0201	0.0140	ND	0.0055	0.0051	0.0497
LSJ26	1.73	0.40	0.31	0.09	ND	ND	0.04	0.03	1.48	0.186	0.0429	0.0334	0.0096	ND	ND	0.0040	0.0030	0.159
LSJ27	30.8	11.3	4.35	3.57	3.38	ND	2.84	0.82	7.64	0.148	0.0545	0.0210	0.0172	0.0163	ND	0.0137	0.0039	0.0368
LSJ28	40.3	13.9	1.11	6.32	6.51	ND	1.14	1.20	7.94	0.324	0.112	0.0089	0.0508	0.0523	ND	0.0092	0.0096	0.0638
LSJ29	10.5	2.09	1.13	0.95	ND	ND	0.54	ND	4.08	0.144	0.0288	0.0157	0.0132	ND	ND	0.0075	ND	0.0565
LSJ30	8.59	3.90	2.88	1.01	ND	ND	4.37	ND	9.39	0.0369	0.0167	0.0124	0.0043	ND	ND	0.0187	ND	0.0403
LSJ31	0.51	0.09	ND	0.09	ND	ND	ND	ND	1.39	0.220	0.0398	ND	0.0398	ND	ND	ND	ND	0.605
LSJ32	67.9	11.9	3.53	5.86	2.52	ND	1.57	2.14	9.42	0.457	0.0802	0.0238	0.0395	ND	ND	0.0105	0.0144	0.0634
LSJ33	7.25	0.31	0.14	0.07	0.10	0.06	ND	ND	0.64	2.70	0.117	0.0527	0.0267	0.0376	0.0227	ND	ND	0.240
LSJ35	16.9	6.50	1.38	1.69	3.43	1.02	1.65	1.33	6.15	0.0673	0.0258	0.0055	0.0067	0.0137	0.0041	0.0066	0.0053	0.0245
LSJ36	1.64	0.31	0.24	0.07	ND	ND	0.62	ND	1.78	0.0579	0.0110	0.0084	0.0026	ND	ND	0.0220	ND	0.063
LSJ37	0.09	0.06	0.05	0.01	ND	ND	0.06	0.02	1.15	0.0321	0.0203	0.0185	0.0018	ND	ND	0.0222	0.0063	0.405
LSJ39	0.31	0.15	0.12	0.03	ND	ND	ND	ND	1.11	0.124	0.0592	0.0477	0.0115	ND	ND	ND	ND	0.451
LSJ40	2.53	4.57	2.01	2.56	ND	ND	0.95	ND	7.32	0.0117	0.0211	0.0093	0.0118	ND	ND	0.0044	ND	0.0338
LSJRC01	26.9	4.02	2.69	ND	1.33	0.27	1.02	2.64	14.5	0.283	0.0424	0.0283	ND	0.0141	0.0028	0.0108	0.0278	0.153
LSJRC02	78.5	12.2	5.11	1.84	5.22	1.91	2.97	4.19	43.5	0.227	0.0352	0.0148	0.0053	0.0151	0.0055	0.0086	0.0121	0.126
LSJRC03	40.0	11.6	4.24	2.57	4.80	0.30	1.42	2.68	32.3	0.165	0.0479	0.0175	0.0106	0.0198	0.0012	0.0059	0.0110	0.133
LSJRC04	8.68	2.43	1.26	0.41	0.76	0.16	0.32	0.46	14.7	0.199	0.0557	0.0289	0.0093	0.0175	0.0037	0.0073	0.0105	0.339
LSJRC05	5.56	0.56	0.51	ND	0.06	0.08	0.25	0.68	6.36	0.515	0.0521	0.0467	ND	0.0054	0.0070	0.0228	0.0633	0.589
LSJRC06	197	18.3	8.66	0.32	9.35	2.24	5.77	13.27	81.7	0.497	0.0463	0.0219	0.0008	0.0236	0.0057	0.0146	0.0335	0.206
LSJRC07	24.6	3.05	2.49	0.06	0.50	0.53	0.74	2.61	10.5	0.568	0.0704	0.0573	0.0015	0.0115	0.0123	0.0172	0.06	0.241
LSJRC08	59.9	8.98	5.29	1.13	2.57	2.64	2.21	4.69	52.4	0.191	0.0286	0.0168	0.0036	0.0082	0.0084	0.0070	0.0149	0.167
LSJRC09	67.1	12.3	4.87	1.91	5.56	3.83	2.62	3.06	63.3	0.232	0.0427	0.0169	0.0066	0.0192	0.0132	0.0091	0.0106	0.219
LSJRC10	81.8	18.9	15.5	0.61	2.73	2.36	3.66	13.43	47.4	0.245	0.0565	0.0465	0.0018	0.0082	0.0071	0.0110	0.0403	0.142
LSJRC11	257	16.5	7.54	3.03	5.94	1.81	1.15	16.61	148	0.840	0.0539	0.0246	0.0099	0.0194	0.0059	0.0038	0.0542	0.482
LSJRC12	1.48	ND	ND	ND	ND	ND	ND	ND	20.8	0.559	ND	ND	ND	ND	ND	ND	ND	7.86
LSJRC13	17.6	6.25	1.56	1.77	2.92	0.27	1.31	4.58	68.7	0.0900	0.0319	0.0080	0.0090	0.0149	0.0014	0.0067	0.0234	0.350
LSJRC13-02	34.8	8.92	ND	4.57	4.35	0.38	0.67	0.19	16.6	0.192	0.0493	ND	0.0252	0.0241	0.0021	0.0037	0.0010	0.0915
LSJRC14	11.4	3.12	1.77	0.24	1.11	0.14	0.53	3.62	44.9	0.144	0.0395	0.0224	0.0030	0.0140	0.0018	0.0067	0.0458	0.568
LSJRC15	34.9	9.56	1.49	4.97	3.09	2.21	1.32	3.74	124	0.145	0.0397	0.0062	0.0206	0.0128	0.0092	0.0055	0.0155	0.513

FIELD ID	Not Normalized (µg/kg dry weight)									Normalized to TOC (µg/g TOC)								
	Sum PCBs	Sum DDTs	DDT	DDE	DDD	Chlor-danes	BHCs	Endo-sulfans	Other Chloros	Sum PCBs	Sum DDTs	DDT	DDE	DDD	Chlor-danes	BHCs	Endo-sulfans	Other Chloros
LSJRC16	18.4	5.93	0.60	2.56	2.77	0.74	0.37	3.12	43.1	0.155	0.05	0.0050	0.0216	0.0234	0.0062	0.0031	0.0263	0.363
LSJRC17	25.6	4.79	2.79	0.52	1.48	0.65	0.11	4.07	35.8	0.355	0.0663	0.0386	0.0072	0.0205	0.0090	0.0015	0.0563	0.496
LSJRC18	1.97	0.20	0.20	ND	ND	0.07	0.05	0.23	17.7	0.278	0.0282	0.0282	ND	ND	0.0098	0.0067	0.0323	2.51
LSJRC19	35.8	4.18	1.40	1.33	1.44	1.54	0.51	3.89	104	0.146	0.0171	0.0057	0.0055	0.0059	0.0063	0.0021	0.0159	0.425
LSJRC20	40.4	5.85	2.16	1.79	1.91	1.66	1.31	4.41	152	0.161	0.0233	0.0086	0.0071	0.0076	0.0066	0.0052	0.0176	0.607
MOC07	27.9	2.61	ND	1.14	1.48	ND	0.53	ND	20.1	0.295	0.0276	ND	0.0120	0.0156	ND	0.0056	ND	0.212
NASCP01	47.5	8.78	0.67	3.20	4.9	ND	0.53	0.00	12.0	0.743	0.137	0.0105	0.0502	0.0768	ND	0.0083	ND	0.188
NASM01	49.1	10.0	ND	4.48	5.53	ND	0.80	1.28	11.4	0.302	0.0616	ND	0.0276	0.0340	ND	0.0049	0.0078	0.0699
OBB	27.9	5.81	ND	2.76	3.05	ND	ND	ND	13.6	0.162	0.0337	ND	0.0160	0.0177	ND	ND	ND	0.0786
ORG01	33.7	5.90	0.69	3.08	2.14	ND	1.47	0.67	32.3	0.202	0.0353	0.0041	0.0184	0.0128	ND	0.0088	0.0040	0.194
PA32	14.5	2.67	1.28	0.55	0.84	ND	0.67	0.46	3.38	0.359	0.0661	0.0316	0.0136	0.0209	ND	0.0165	0.0114	0.0836
PP61	11.9	2.22	0.32	0.96	0.94	ND	0.15	0.22	2.91	0.657	0.123	0.0178	0.0532	0.0521	ND	0.0081	0.0120	0.161
RCCP02	18.5	5.29	1.42	ND	3.87	ND	0.26	3.26	6.13	0.822	0.236	0.0634	ND	0.172	ND	0.0116	0.145	0.273
WEK02	11.9	9.34	2.98	3.67	2.69	0.47	ND	ND	12.0	0.0532	0.0417	0.0133	0.0164	0.0120	0.0021	ND	ND	0.0535
Cedar-Ortega River Basin Sites																		
CED01	3,710	87.8	2.62	33.0	52.2	5.60	ND	29.0	37.6	56.6	1.34	0.0400	0.502	0.796	0.0853	ND	0.442	0.574
CED02	2,210	31.2	3.63	8.86	18.7	16.2	4.94	9.04	33.4	20.7	0.292	0.0339	0.0828	0.175	0.152	0.0462	0.0845	0.312
CED03	870	18.7	0.73	10.5	7.46	14.3	ND	3.65	6.31	7.77	0.167	0.0066	0.0938	0.0666	0.128	ND	0.0326	0.0563
CED04	1,070	20.2	1.05	9.74	9.38	18.0	ND	3.21	0.12	7.56	0.142	0.0074	0.0686	0.0660	0.126	ND	0.0226	0.0009
CED05	121	9.00	1.10	5.47	2.44	8.59	1.30	2.43	31.9	1.63	0.121	0.0147	0.0735	0.0327	0.116	0.0175	0.0327	0.428
CED06	479	23.4	4.79	10.1	8.53	26.3	1.63	6.96	26.7	3.57	0.175	0.0358	0.0751	0.0636	0.196	0.0122	0.0519	0.199
CED07	642	12.1	4.12	4.39	3.63	14.2	1.85	4.28	36.1	5.14	0.0972	0.0330	0.0351	0.0291	0.113	0.0148	0.0342	0.289
CED08	151	13.1	2.70	4.74	5.64	17.1	ND	0.95	35.2	1.07	0.0921	0.0190	0.0334	0.0397	0.120	ND	0.0067	0.248
CED09	375	36.1	5.51	18.8	11.7	60.1	0.55	5.81	26.2	3.15	0.303	0.0463	0.158	0.0987	0.505	0.0046	0.0488	0.220
ORT01	141	10.6	2.41	4.74	3.43	0.72	3.41	3.07	57.0	1.34	0.101	0.0229	0.0451	0.0326	0.0068	0.0325	0.0293	0.543
ORT02	12.5	1.85	0.60	0.45	0.79	ND	0.10	ND	8.52	0.128	0.0190	0.0062	0.0047	0.0081	ND	0.0010	ND	0.0874
ORT03	12.1	1.16	0.86	ND	0.31	ND	1.82	0.19	53.5	0.105	0.0100	0.0074	ND	0.0026	ND	0.0156	0.0016	0.462
ORT04	33.0	5.52	1.11	1.96	2.44	0.65	0.18	0.19	11.9	0.280	0.0468	0.0095	0.0166	0.0207	0.0055	0.0015	0.0016	0.101
ORT05	89.9	9.78	2.56	3.56	3.66	ND	ND	2.33	96.3	0.719	0.0782	0.0205	0.0285	0.0293	ND	ND	0.0186	0.771
ORT06	38.3	5.96	1.06	3.13	1.77	ND	1.72	1.79	56.9	0.348	0.0542	0.0096	0.0285	0.0161	ND	0.0156	0.0162	0.518
ORT06-1	67.4	9.12	1.77	4.11	3.24	0.79	0.84	0.45	3.47	0.724	0.0979	0.0190	0.0441	0.0348	0.0085	0.0090	0.0049	0.0373
ORT07	284	45.8	8.65	16.5	20.6	6.33	0.22	1.79	8.69	2.09	0.336	0.0636	0.121	0.151	0.0466	0.0016	0.0132	0.0639
ORT08	80.4	11.1	1.96	4.54	4.63	1.85	ND	1.30	24.9	0.687	0.0951	0.0167	0.0388	0.0395	0.0158	ND	0.0111	0.213

FIELD ID	Not Normalized (µg/kg dry weight)									Normalized to TOC (µg/g TOC)								
	Sum PCBs	Sum DDTs	DDT	DDE	DDD	Chlor-danes	BHCs	Endo-sulfans	Other Chloros	Sum PCBs	Sum DDTs	DDT	DDE	DDD	Chlor-danes	BHCs	Endo-sulfans	Other Chloros
ORT09	107	15.8	3.93	7.48	4.38	3.29	2.68	3.99	13.7	1.18	0.175	0.0436	0.0831	0.0487	0.0365	0.0298	0.0443	0.152
ORT10	97.5	9.47	2.67	3.20	3.60	3.12	1.77	2.38	26.8	0.756	0.0734	0.0207	0.0248	0.0279	0.0242	0.0137	0.0185	0.208
ORT11	81.0	11.0	1.11	6.65	3.23	2.43	0.32	2.61	53.0	0.633	0.0858	0.0087	0.0519	0.0252	0.0189	0.0025	0.0204	0.414
ORT12	143	15.8	4.45	5.21	6.17	4.39	0.5	3.72	113	1.10	0.122	0.0342	0.0400	0.0475	0.0338	0.0039	0.0286	0.872
ORT13	185	20.8	6.44	7.92	6.44	4.45	ND	4.43	67.4	1.27	0.142	0.0441	0.0542	0.0441	0.0305	ND	0.0303	0.461
ORT14	15.0	4.54	1.75	0.81	1.98	ND	0.48	ND	2.60	0.137	0.0413	0.0159	0.0073	0.0180	ND	0.0043	ND	0.0236
ORT15	169	22.9	6.06	6.13	10.7	9.66	ND	0.89	74.3	1.07	0.146	0.0386	0.0391	0.0679	0.0615	ND	0.0057	0.473
ORT16	136	15.8	4.09	5.03	6.68	2.88	1.18	0.67	4.05	0.997	0.116	0.0301	0.0370	0.0491	0.0212	0.0087	0.0049	0.0298
ORT18	165	8.05	1.71	3.03	3.31	3.24	0.99	0.33	3.59	1.29	0.0629	0.0133	0.0237	0.0259	0.0253	0.0077	0.0025	0.0280
ORT19	208	11.7	1.24	2.16	8.26	1.88	ND	1.24	5.54	7.37	0.413	0.0440	0.0765	0.292	0.0667	ND	0.0439	0.196
ORT20	16.7	2.93	1.24	0.56	1.13	0.44	0.51	0.07	3.12	0.152	0.0266	0.0112	0.0051	0.0103	0.0040	0.0046	0.0007	0.0284
ORT21	124	13.6	3.74	5.53	4.37	3.65	1.35	1.26	27.0	0.989	0.109	0.0299	0.0442	0.0349	0.0292	0.0108	0.0101	0.216
ORT22	191	14.0	1.18	5.35	7.43	6.14	0.61	1.14	5.57	1.61	0.117	0.0100	0.0450	0.0624	0.0516	0.0051	0.0096	0.0468
ORT23	132	14.8	2.62	6.00	6.18	5.70	6.64	2.78	40.2	0.945	0.106	0.0187	0.0429	0.0442	0.0407	0.0474	0.0199	0.287
ORT24	166	27.0	8.04	11.5	7.46	8.49	2.11	2.37	42.4	1.11	0.181	0.0539	0.0769	0.0501	0.0570	0.0142	0.0159	0.285
ORT25	354	25.1	7.54	9.15	8.39	23.7	2.28	7.78	19.7	2.25	0.160	0.0480	0.0583	0.0535	0.151	0.0145	0.0496	0.125
ORT26	271	21.6	6.51	8.60	6.49	10.9	1.58	2.44	29.8	1.79	0.143	0.0431	0.0569	0.0430	0.0721	0.0104	0.0162	0.197
ORT27	476	17.2	3.28	6.49	7.44	11.8	ND	3.11	35.5	3.26	0.118	0.0225	0.0445	0.0510	0.0805	ND	0.0213	0.243
ORT28	134	19.9	7.49	6.74	5.71	8.05	1.84	2.01	12.9	0.835	0.124	0.0465	0.0419	0.0355	0.0500	0.0114	0.0125	0.0799
ORT29	49.2	2.28	0.83	0.26	1.19	1.60	0.27	ND	10.9	0.384	0.0178	0.0065	0.0020	0.0093	0.0125	0.0021	ND	0.0851
ORT30	3.76	0.93	ND	0.70	0.23	ND	0.40	0.32	19.0	0.162	0.0402	ND	0.0302	0.0100	ND	0.0172	0.0139	0.818
ORT31	133	35.2	5.41	23.1	6.66	85.4	2.67	2.04	19.7	1.08	0.286	0.0440	0.188	0.0542	0.695	0.0217	0.0166	0.161
ORT32	108	27.4	5.25	11.5	10.6	23.6	2.02	2.69	17.8	0.949	0.240	0.0460	0.101	0.0934	0.207	0.0177	0.0236	0.156
ORT33	87.9	51.4	16.4	16.4	18.7	53.8	0.63	0.07	6.03	2.04	1.19	0.379	0.380	0.434	1.25	0.0146	0.0017	0.140
ORT34	114	12.9	2.30	5.51	5.09	3.65	0.89	0.44	3.25	0.689	0.0777	0.0139	0.0332	0.0307	0.0220	0.0054	0.0026	0.0196
ORT35	90.0	11.7	3.69	4.89	3.15	4.69	1.54	2.33	18.7	0.661	0.086	0.0271	0.0360	0.0232	0.0345	0.0113	0.0172	0.137
ORT36	105	19.2	8.32	6.35	4.52	5.95	1.51	1.41	16.7	0.634	0.116	0.0501	0.0383	0.0272	0.0359	0.0091	0.0085	0.101
ORT37	310	17.3	3.32	7.64	6.30	13.1	1.69	3.75	26.1	2.12	0.118	0.0227	0.0523	0.0432	0.0896	0.0116	0.0257	0.179
ORT38	140	37.6	7.97	22.6	6.97	4.87	ND	3.90	62.0	0.913	0.246	0.0521	0.148	0.0456	0.0318	ND	0.0255	0.405
ORT39	305	30.4	4.22	14.6	11.6	6.76	1.33	0.41	26.5	1.70	0.170	0.0236	0.0817	0.0647	0.0378	0.0075	0.0023	0.148
ORT39-1	117	19.6	3.53	8.74	7.34	3.38	1.28	0.36	5.21	0.618	0.104	0.0187	0.0462	0.0388	0.0179	0.0068	0.0019	0.0275
ORT40	128	7.43	1.14	3.84	2.45	7.23	2.62	2.65	136	0.776	0.0450	0.0069	0.0233	0.0149	0.0438	0.0159	0.0161	0.822
ORT41	92.4	9.78	1.31	4.71	3.76	1.18	0.66	0.23	5.66	0.428	0.0453	0.0061	0.0218	0.0174	0.0055	0.0031	0.0011	0.0262

Pesticides - DDTs

The median total DDT concentration was 5.89 µg/kg for the LSJR sites and 14.8 µg/kg for the COR sites. The total DDT concentration ranged from not detected (ND) to 30.3 µg/kg (site LSJ01) for the LSJR sites and from 0.93 (site ORT30) to 87.8 µg/kg (site CED01) for the COR sites (again demonstrating that the Cedar-Ortega tributary sites were generally more contaminated than the main stem sites). Investigation of concentrations of DDT and its degradation products DDD and DDE reveal that the greatest concentration of DDT compounds was typically found as DDD or DDE; the original pesticide compound (DDT) was less frequently the predominant DDT constituent. An apparent exception is LSJRC10 which had greater levels of DDT detected than the degradation products, but the majority of this is reported as 2,4-DDT, and not 4,4-DDT. The 2,4-DDT may actually be the result of PCB congener interference because it is atypical to have higher levels of 2,4-DDT than 4,4-DDT (the original pesticide formulation was generally 70-90% 4,4-DDT, with lower amounts of the 2,4-isomer present). This sample had notable levels of PCB and 2,4-DDT can often be difficult to distinguish from a specific PCB congener when the relative levels of PCB are high.

Analysis of the DDT concentrations at the LSJR and COR sites against 2 standard deviations from their medians was performed to determine those sites that elevated concentrations, compared to the rest of the sites from the same general locations. Five of the LSJR sites had total DDT concentrations greater than 17.1 µg/kg (median concentration + 2 standard deviations). These sites were HSP05 (20.8 µg/kg), LSJ01 (30.3 µg/kg), and LSJRC06 (18.3 µg/kg), as well as LSJ02 (18.0 µg/kg), and LSJRC10 (18.9 µg/kg). The median total DDT concentration for the COR sites (14.8 µg/kg) was approximately 2.5 times higher than the LSJR median (5.81 µg/kg). Three of the COR sites, CED01 (87.8 µg/kg), ORT07 (45.8 µg/kg), and ORT33 (51.4 µg/kg), had total DDT concentrations above 44.7 µg/kg (median concentration + 2 standard deviations).

Pesticides – Chlordanes, BHCs, Endosulfans, and other Chlorinated Compounds

Concentrations of the other chlorinated pesticides, such as chlordane, BHC and endosulfan, were generally significantly lower than total DDT, and their concentration ranges were also smaller. Exceptions were observed at some locations (CED06, CED09, ORT31, and ORT33) in the Cedar-Ortega River Basin where some site had chlordane concentrations that were higher than the DDT concentrations. Although the “cleanest” LSJR and COR sites had no chlordane, BHC, or endosulfan detected, sites such as ORT31, ORT33, and CED09 had 85.4, 53.8, and 60.1 µg/kg of total chlordane, respectively. The chlordane concentrations would be higher for many samples if the heptachlor and nonachlor compounds were included in the summation for this class of pesticide; these compounds are sometimes included in chlordane summations and are sometimes not used in the calculation, as they are not always considered true chlordane constituents. In addition, these two compounds were not included in chlordane summation for the recent District-wide sediment assessment work (SJRWMD, 1998), and comparability to that work may be desirable. Heptachlor was rarely detected, but *trans*-nonachlor was often present at concentrations that were significant relative to the overall chlordane concentrations.

The concentrations of the other analyzed pesticides that were not included in the base pesticide data presentation (e.g, aldrin, dieldrin, chlorpyriphos, endrin, hexachlorobenzene, mirex, and methoxychlor), for the most part, quite low, compared to the major pesticide classes of compounds. Dieldrin was most widely detected of these additional pesticides, but generally at concentrations that were well below the DDT and chlordane concentrations. Toxaphene was not detected in any samples.

The concentrations of total other chlorinated compounds ranged from ND to 152 µg/kg (site LSJRC20) in the Lower St. Johns River and from less than 1 µg/kg to 136 µg/kg (site ORT40) in the Cedar-Ortega River Basin. The variability of the sediment concentrations of chlorinated compounds was reduced somewhat when the data were normalized to sediment TOC content (Table 3-6), but the contaminant concentrations still covered a wide range in magnitude.

3.1.3 Chlorophenolic Compound Results

Sediment samples were analyzed for 23 chlorinated compounds using method 8321M; 9 individual chlorinated phenols, 3 chlorinated anisoles, 5 guaiacols, and 6 catechols. Table 3-7 lists the analytes that comprise each of these sub-groups of chlorinated phenolic compounds. Chlorinated phenols and anisoles are widely used industrial compounds, being a component and/or by-product of many industrial processes. Guaiacols and catechols are also more commonly considered industrial by-products, and are often associated with pulp and paper industry activities.

Table 3-7. Chlorinated Phenolic Compound Groups

Total Chlorophenolic Compounds (Total CP; Σ of)	Total Phenols (Σ of)	Total Anisoles (Σ of)	Total Guaiacols (Σ of)	Total Catechols (Σ of)
Σ Phenols	2-Chlorophenol	2-Chloroanisole	4,5-Dichloroguaiacol	4-Chlorocatechol
Σ Anisoles	2,4-Dichlorophenol	2,4-Dichloroanisole	3,4,5-Trichloroguaiacol	3,5-Dichlorocatechol
Σ Guaiacols	2,6-Dichlorophenol	Pentachloroanisole	3,4,6-Trichloroguaiacol	4,5-Dichlorocatechol
Σ Catechols	2,4,5-Trichlorophenol		4,5,6-Trichloroguaiacol	3,4,5-Trichlorocatechol
	2,4,6-Trichlorophenol		Tetrachloroguaiacol	3,4,6-Trichlorocatechol
	2,3,4,5-Tetrachlorophenol			Tetrachlorocatechol
	2,3,4,6-Tetrachlorophenol			
	Pentachlorophenol			
	4-Chloro-3-methylphenol			

Table 3-8 presents the concentration ranges of chlorinated compounds found at the sampling locations, and the data for the individual sites are presented in Table 3-9. The data for each of the individual chlorophenolic compounds are included in Appendix D.

Table 3-8. Concentration Ranges for Chlorinated Phenolic Compounds

	Not Normalized (µg/kg dry weight)			Normalized to TOC (µg/g TOC)		
	Median	Min	Max	Median	Min	Max
Lower St. Johns River Sites						
Total Chlorophenolics	2,500	ND	13,800	26.1	ND	1,070
Σ Phenols	952	ND	5,530	9.36	ND	317
Σ Anisoles	ND	ND	2,710	ND	ND	120
Σ Guaiacols	753	ND	7,260	6.83	ND	610
Σ Catechols	161	ND	11,500	1.86	ND	64.5
Cedar-Ortega River Basin Sites						
Total Chlorophenolics	5,240	1,400	22,100	52.0	ND	155
Σ Phenols	1,190	305	6,310	7.89	ND	123
Σ Anisoles	150	ND	376	1.18	ND	4.88
Σ Guaiacols	62.3	ND	4,360	0.58	ND	32.0
Σ Catechols	3,378	ND	15,100	30.1	ND	106

Table 3-9. Organic Contaminant Summary Data — Chlorinated Phenolics

FIELD ID	Not Normalized (µg/kg dry weight)					Normalized to TOC (µg/g TOC)				
	Total Phenols	Total Anisoles	Total Guaiacols	Total Catechols	Total CPs	Total Phenols	Total Anisoles	Total Guaiacols	Total Catechols	Total CPs
Lower St. Johns River Sites										
BAY01	1,170	103	ND	7,730	9,010	5.99	0.527	ND	39.5	46.1
BOL04	95.8	ND	ND	ND	95.8	0.863	ND	ND	ND	0.863
BUCK03	491	ND	841	ND	1,330	3.56	ND	6.10	ND	9.65
CDRC01	4,710	88.3	201	980	5,980	24.3	0.456	1.04	5.07	30.9
CO06	494	2,710	2,190	734	6,130	3.80	20.8	16.8	5.65	47.1
DUN01	1,770	258	245	11,500	13,800	6.06	0.885	0.839	39.5	47.3
GC02	494	184	ND	4,340	5,010	7.35	2.74	ND	64.5	74.6
HSP05	312	ND	2,510	630	3,460	3.69	ND	29.8	7.46	41.0
JUL02	2,890	ND	481	9,010	12,400	17.4	ND	2.89	54.3	74.6
LSJ01	5,530	ND	3,850	344	9,720	75.8	ND	52.7	4.71	133
LSJ02	4,610	ND	1,790	140	6,540	42.8	ND	16.6	1.30	60.8
LSJ03	1,440	54.8	1,780	161	3,430	10.2	0.388	12.6	1.14	24.4
LSJ04	234	ND	837	ND	1,070	10.9	ND	39.0	ND	49.9
LSJ05	3,490	ND	3,750	ND	7,240	22.7	ND	24.3	ND	47.0
LSJ06	492	ND	1,340	ND	1,830	6.30	ND	17.2	ND	23.5
LSJ07	1,010	ND	958	ND	1,970	5.97	ND	5.67	ND	11.6
LSJ08	1,680	ND	1,900	622	4,200	10.7	ND	12.1	3.97	26.9
LSJ09	781	ND	893	ND	1,670	4.13	ND	4.73	ND	8.86
LSJ10	63.8	ND	46.3	30.9	141	12.5	ND	9.08	6.06	27.7
LSJ11	631	116	1,780	158	2,680	3.64	0.670	10.2	0.911	15.5
LSJ12	898	ND	1,160	442	2,500	4.64	ND	5.97	2.28	12.9
LSJ13	1,360	ND	491	177	2,030	23.3	ND	8.39	3.03	34.7
LSJ14	2,320	ND	1,360	533	4,210	12.8	ND	7.53	2.95	23.3
LSJ15	441	ND	177	15.6	634	22.2	ND	8.92	0.788	31.9
LSJ16	1,540	ND	918	ND	2,460	9.36	ND	5.57	ND	14.9
LSJ17	1,300	ND	1,120	ND	2,420	12.1	ND	10.4	ND	22.5
LSJ18	305	ND	254	ND	559	5.36	ND	4.48	ND	9.83
LSJ19	399	ND	269	ND	667	2.07	ND	1.39	ND	3.46
LSJ20	316	ND	182	28.8	527	20.4	ND	11.7	1.86	34.0
LSJ21	402	ND	ND	ND	402	3.62	ND	ND	ND	3.62
LSJ22	952	ND	345	ND	1,300	19.2	ND	6.94	ND	26.1
LSJ23	3,780	1,420	7,260	248	12,700	317	120	610	20.8	1070
LSJ24	517	ND	1,400	1,030	2,950	4.43	ND	12.0	8.88	25.3
LSJ25	1,940	ND	501	902	3,340	15.0	ND	3.88	6.99	25.9
LSJ26	233	ND	ND	260	494	25.2	ND	ND	28.0	53.2
LSJ27	3,040	ND	2,490	919	6,450	14.7	ND	12.0	4.43	31.1
LSJ28	740	ND	850	124	1,710	5.94	ND	6.83	0.997	13.8
LSJ29	1,790	ND	1,540	452	3,780	24.7	ND	21.3	6.25	52.3
LSJ30	4,260	ND	269	ND	4,530	18.3	ND	1.16	ND	19.6
LSJ31	287	ND	ND	ND	287	125	ND	ND	ND	125
LSJ32	2,770	ND	3,320	501	6,590	18.6	ND	22.3	3.38	44.4
LSJ33	149	ND	ND	29.5	178	55.5	ND	ND	11.0	66.5
LSJ35	4,890	ND	2,410	1,380	8,670	19.4	ND	9.56	5.48	34.5
LSJ36	175	ND	327	171	673	6.18	ND	11.5	6.04	23.8
LSJ37	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LSJ39	30.4	ND	ND	ND	30.4	12.3	ND	ND	ND	12.3

FIELD ID	Not Normalized (µg/kg dry weight)					Normalized to TOC (µg/g TOC)				
	Total Phenols	Total Anisoles	Total Guaiacols	Total Catechols	Total CPs	Total Phenols	Total Anisoles	Total Guaiacols	Total Catechols	Total CPs
LSJ40	1,890	ND	6,250	682	8,820	8.71	ND	28.9	3.15	40.8
LSJRC01	1,190	183	918	312	2,610	12.6	1.93	9.67	3.29	27.5
LSJRC02	2,990	678	2,960	419	7,050	8.65	1.96	8.57	1.21	20.4
LSJRC03	4,250	ND	2,880	ND	7,130	17.5	ND	11.9	ND	29.4
LSJRC04	1,870	ND	559	ND	2,430	42.9	ND	12.8	ND	55.7
LSJRC05	1,380	ND	41.1	872	2,290	127	ND	3.80	80.7	212
LSJRC06	1,970	1,490	2,140	1,090	6,690	4.98	3.75	5.40	2.75	16.9
LSJRC07	728	236	116	707	1,790	16.8	5.43	2.68	16.3	41.2
LSJRC08	3,670	776	3,150	557	8,150	11.7	2.47	10.0	1.77	25.9
LSJRC09	4,970	557	2,260	775	8,560	17.2	1.93	7.81	2.68	29.6
LSJRC10	2,680	737	4,530	1,460	9,410	8.03	2.21	13.6	4.39	28.2
LSJRC11	536	2,170	390	144	3,240	1.75	7.08	1.27	0.469	10.6
LSJRC12	19.2	ND	ND	ND	19.2	7.26	ND	ND	ND	7.26
LSJRC13	560	186	264	328	1,340	2.86	0.947	1.35	1.68	6.83
LSJRC13-02	599	111	ND	6,150	6,860	3.31	0.615	ND	34.0	37.9
LSJRC14	503	33.8	493	136	1,170	6.36	0.428	6.23	1.72	14.7
LSJRC15	1,570	291	844	111	2,820	6.53	1.21	3.50	0.462	11.7
LSJRC16	960	298	655	89.1	2,000	8.10	2.52	5.53	0.751	16.9
LSJRC17	314	113	443	93.2	963	4.35	1.56	6.13	1.29	13.3
LSJRC18	99.4	13.6	9.83	105	228	14.1	1.92	1.39	14.9	32.3
LSJRC19	1,330	386	708	194	2,620	5.43	1.58	2.90	0.795	10.7
LSJRC20	1,230	224	967	140	2,560	4.89	0.893	3.85	0.558	10.2
MOC07	276	ND	382	176	834	2.92	ND	4.03	1.86	8.81
NASCP01	381	ND	904	34.8	1,320	5.96	ND	14.2	0.545	20.7
NASM01	541	ND	573	572	1,690	3.33	ND	3.52	3.52	10.4
OBB	566	ND	1,720	ND	2,280	3.28	ND	9.94	ND	13.2
ORG01	745	ND	1,490	702	2,940	4.46	ND	8.91	4.20	17.6
PA32	1,330	ND	560	131	2,020	32.9	ND	13.8	3.24	50.0
PP61	584	ND	315	79.9	979	32.4	ND	17.5	4.42	54.3
RCCP02	2,010	508	1,850	557	4,930	89.5	22.6	82.5	24.8	219
WEK02	2,560	127	753	8,800	12,200	11.4	0.568	3.36	39.3	54.6
Cedar-Ortega River Basin Sites										
CED03	1,020	202	43.1	136	1,400	9.07	1.80	0.385	1.22	12.5
CED04	6,310	358	345	15,100	22,100	44.4	2.52	2.43	106	155
ORT02	653	376	57.9	1960	3,050	6.71	3.86	0.595	20.1	31.3
ORT04	1,680	152	122	ND	1,950	14.2	1.28	1.03	ND	16.5
ORT06-1	570	ND	ND	4,800	5,370	6.12	ND	ND	51.5	57.6
ORT07	4,280	163	166	514	5,120	31.5	1.19	1.22	3.78	37.7
ORT14	305	ND	ND	5,230	5,530	2.77	ND	ND	47.5	50.3
ORT16	513	ND	4,350	7,610	12,500	3.77	ND	32.0	56.0	91.8
ORT18	850	ND	1670	6,840	9,360	6.64	ND	13.0	53.4	73.1
ORT19	3,480	138	207	425	4,250	123	4.88	7.34	15.0	150
ORT20	338	ND	ND	5,590	5,930	3.07	ND	ND	50.8	53.9
ORT22	2,850	149	66.6	620	3,680	23.9	1.25	0.560	5.21	30.9
ORT33	3,290	190	402	802	4,680	76.2	4.40	9.31	18.6	108
ORT34	4,710	ND	ND	8,760	13,500	28.4	ND	ND	52.8	81.1
ORT39-1	635	220	ND	7,580	8,430	3.36	1.16	ND	40.1	44.6
ORT41	1,370	190	ND	ND	1,560	6.36	0.878	ND	ND	7.24

The data indicate that the chlorinated phenolic compound concentrations were highly variable in the sediment samples. The total chlorophenolic compound concentrations at the LSJR sites ranged from not detected (site LSJ37) to 13,800 µg/kg (site LSJRC05), and from 1,400 (site CED03) to 22,100 µg/kg (site CED04) at the COR sites. The median concentration was 2,500 µg/kg for the main stem of the Lower St. Johns River and 5,200 µg/kg for Cedar-Ortega River Basin. Total chlorophenolic compound concentrations for the sites adjacent to the mouth of Rice Creek (i.e. LSCRC01, -05, -06, -07, -08, and –09) were above 1,000 mg/kg and ranged from 1,790 to 9,410 mg/kg. The majority of these sites and sites located in the same vicinity (LSJRC sites) contained phenols, anisoles, guaiacols, and catechols.

Six of the LSJR sites had total chlorophenolic concentrations above 9,360 µg/kg (median concentration + 2 standard deviations). These sites were DUN01 (13,800 µg/kg), JUL02 (12,400 µg/kg), LSJ01 (9,720 µg/kg), LSJ23 (12,700 µg/kg), LSJRC10 (9,410 µg/kg), and WEK02 (12,200 µg/kg). The median total chlorophenolic concentration for the COR sites (5,240 µg/kg) was approximately 2 times higher than the LSJR median (2,500 µg/kg). Only one of the COR sites (CED04, 22,100 µg/kg) had a total chlorophenolic concentration above the higher reference value of 16,100 µg/kg for this location (median concentration + 2 standard deviations). The phenols generally contributed the largest proportion of the total chlorophenolic concentration at both the LSJR and COR sites. However, the second largest contribution to the total chlorophenolic concentration was different for the LSJR and COR sites. Guaiacols were the second largest contributor to the total chlorophenolic concentration for the LSJR sites, whereas catechols were the second largest contributor to the total chlorophenolic concentration for the COR sites.

There were a few instances of an apparently inexplicable lack of site precision for selected individual data points. For instance, 4-chlorocatechol was measured at 41,200 µg/kg in one of the LSJRC05 site duplicates but not detected at all in the other site duplicate, and tetrachloroguiaiacol was detected at 14,200 µg/kg in one of the LSJ30 site duplicates but only at 268 µg/kg in the other. Similar single compound outliers were observed for one of the site replicates at LSJ40 and ORG01 (both for pentachloroanisole). These four elevated data points resulted in an apparent high site average for these compounds and for the total chlorophenolics for these sites (even though only one of the 46 data points contributed the vast majority). It is not likely that these relatively mobile compounds would be present at such different concentrations in sediments collected within a few feet of each other, and these two elevated data points are likely anomalies and should be considered unreliable. The outlier site replicate was therefore omitted for the reporting in Tables 3-8 and 3-9, and in the figures in the appendices (they were however included in the data tables in Appendix D, to allow for a complete data evaluation).

It should also be noted that there were some instances of surprisingly high individual compound concentrations that did not follow an anticipated compound composition pattern. For instance, relatively high levels of tetrachlorocatechol were detected at BAY01, DUN01, GC02, JUL02, LSJRC13-02, and WEK02, when few or no commonly related compounds were identified. Similarly, elevated levels of tetrachloroguaiacol and/or pentachloroanisole were detected at site CO06, LSJ23, and LSJ40. These unexpected data may be real measured concentrations, the composition of which is not understood at this time, or it could be contributed by non-analyte sample matrix components. These target compounds were particularly challenging to resolve in the analytical procedure, especially in the high-organic complex sample matrices that were encountered with many of these samples.

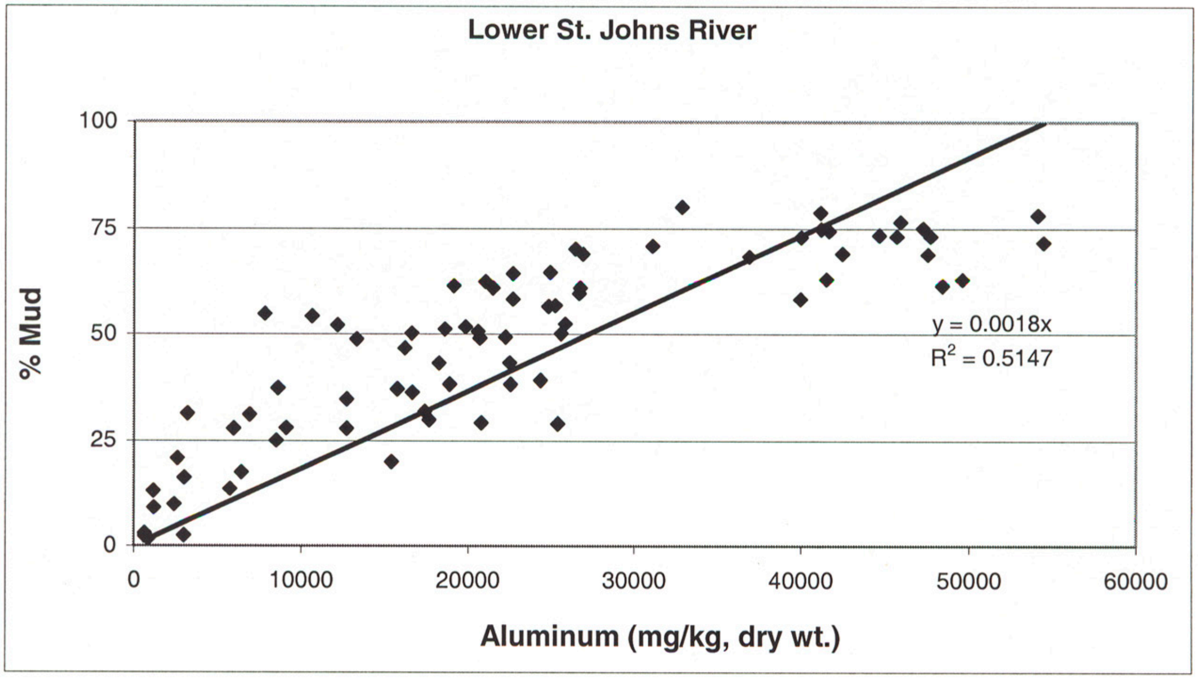
The analytical method that was developed for the chlorophenolic analysis for this project was intended to provide a first-level screening analysis of a very broad range of compounds simultaneously, with the intent to identify locations and/or compounds that may warrant more detailed investigation. Since the method accommodated chlorinated phenolic compounds with highly varying chemical characteristics, it could not be optimized for a specific narrow class of compounds and there was a significant potential for matrix contributions (i.e., non-analyte matrix contribution to measured target compounds, and even false positives). The chlorophenolic data should therefore be used with caution. However, the analysis served it's intended purpose in identifying locations and compounds that may be of concern, and these data can form the basis for further studies that should use more targeted and specific analytical methods (e.g., GC/MS or LC/MS).

3.2 Results for Metals Analysis

The sediment metals concentrations were determined for 20 elements. Three of the metals (aluminum, iron, and manganese) are considered major metals and are naturally abundant in most geological formations. The other 17 metals that were analyzed are potentially environmental contaminants of concern. These major metals are commonly used as data normalizers to distinguish between metals concentrations that can be attributed to the natural geology of the location, and those that can potentially be attributed to anthropogenic sources of contamination. Lithium is also sometimes used as a geological "marker" and may be used to normalize metals data for subsequent data analysis. The use of data normalizers, and the relationships between metal contaminants and common normalizers such as the major crustal elements, grain size, and total organic carbon, is discussed in more detail below.

***Relationships Among Metals and Data Normalization*.**
Metals distributions are controlled by several factors in sediments. These include the grain size, the amount of organic carbon, and the water column concentration and proximity to contaminant sources. During the initial data analysis process, the sediment contaminant metal concentrations were plotted versus the 1) sediment major metals concentrations, 2) grain size, and 3) TOC, in order to determine which normalizing parameter was most suitable for this sample set. Normalizing metals concentrations to aluminum is the most common approach for differentiating anthropogenic contamination from metals naturally occurring in the geology of the sediment, although iron, manganese, and/or lithium normalization can also be useful. Normalizing to grain size (using the fines (silt + clay) fraction, such as %mud) is also frequently done to determine anthropogenic contamination, because of 1) the natural geological abundance differences and 2) the fact that many metals adhere/associate with the fine particulates of the sediment, which would add a concentration effect similar to what is often observed with TOC and organic contaminants. Similarly, it has also been demonstrated that some metals bind to organic matter of the sediment, and TOC normalizing the metals data may therefore also be appropriate.

Comparison of the aluminum concentrations to the fine-grained (silt + clay), or mud, fraction of the sediments revealed a general, but fairly weak, correspondence in this system (Figure 3-1). Similar variability was observed when the TOC content was used to compare to the aluminum concentrations, and when the other crustal elements were used instead of aluminum. Some of the variability may relate to the very high amount of TOC in many of the sediment samples (>20% at a large number of sites); many of these sediments were clearly comprised of significant proportions of this organic non-geological material. The toxic metals concentrations also generally increased with the aluminum content (or mud fraction), but the correspondence was more variable than one might expect (Figures 3-2 and 3-3). The relationship was particularly weak with grain size and TOC, and it became evident that metal contamination was best identified using normalization to one of the crustal elements. The relationship between a number of toxic metals and aluminum, iron, manganese, and lithium was also investigated. Lithium, though often thought of as a potential environmental contaminant, is sometimes used as a geological marker, and has been found to be useful for data normalizing in certain environments. Of the four elements, aluminum co-varied most consistently with the other metals, and was therefore chosen as the primary normalized for the metals data assessment.



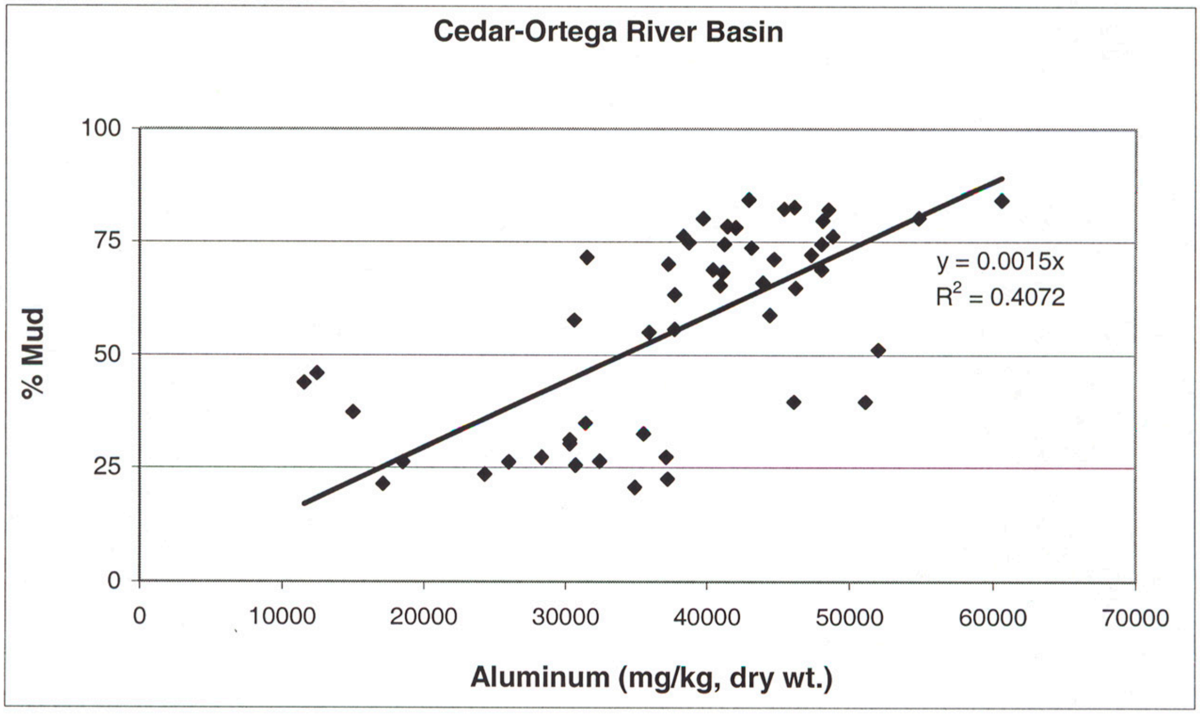


Figure 3-1. Grain Size (% Mud) versus Aluminum Concentration of Sediments

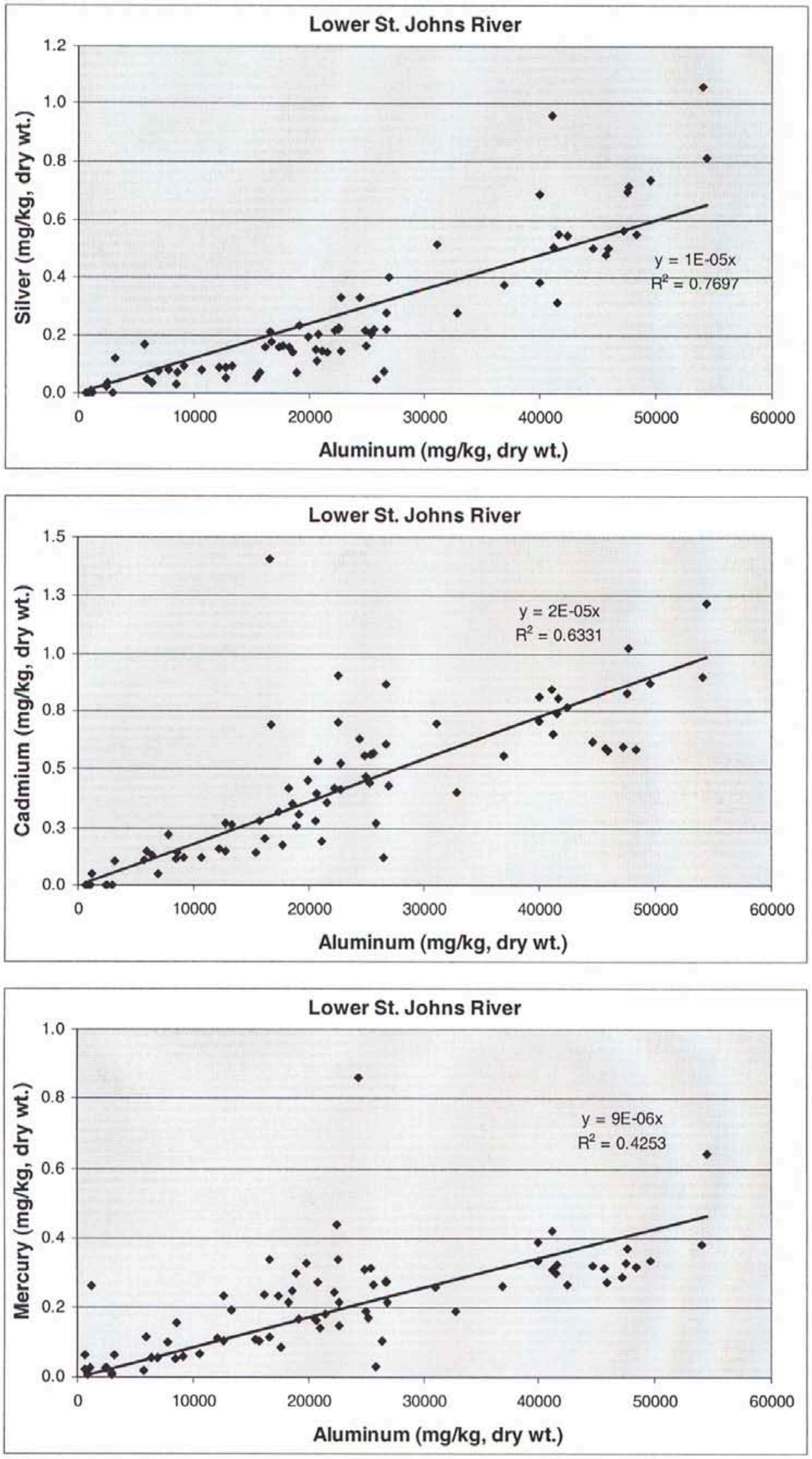


Figure 3-2. Silver, Cadmium, and Mercury versus Aluminum Concentration of Sediments

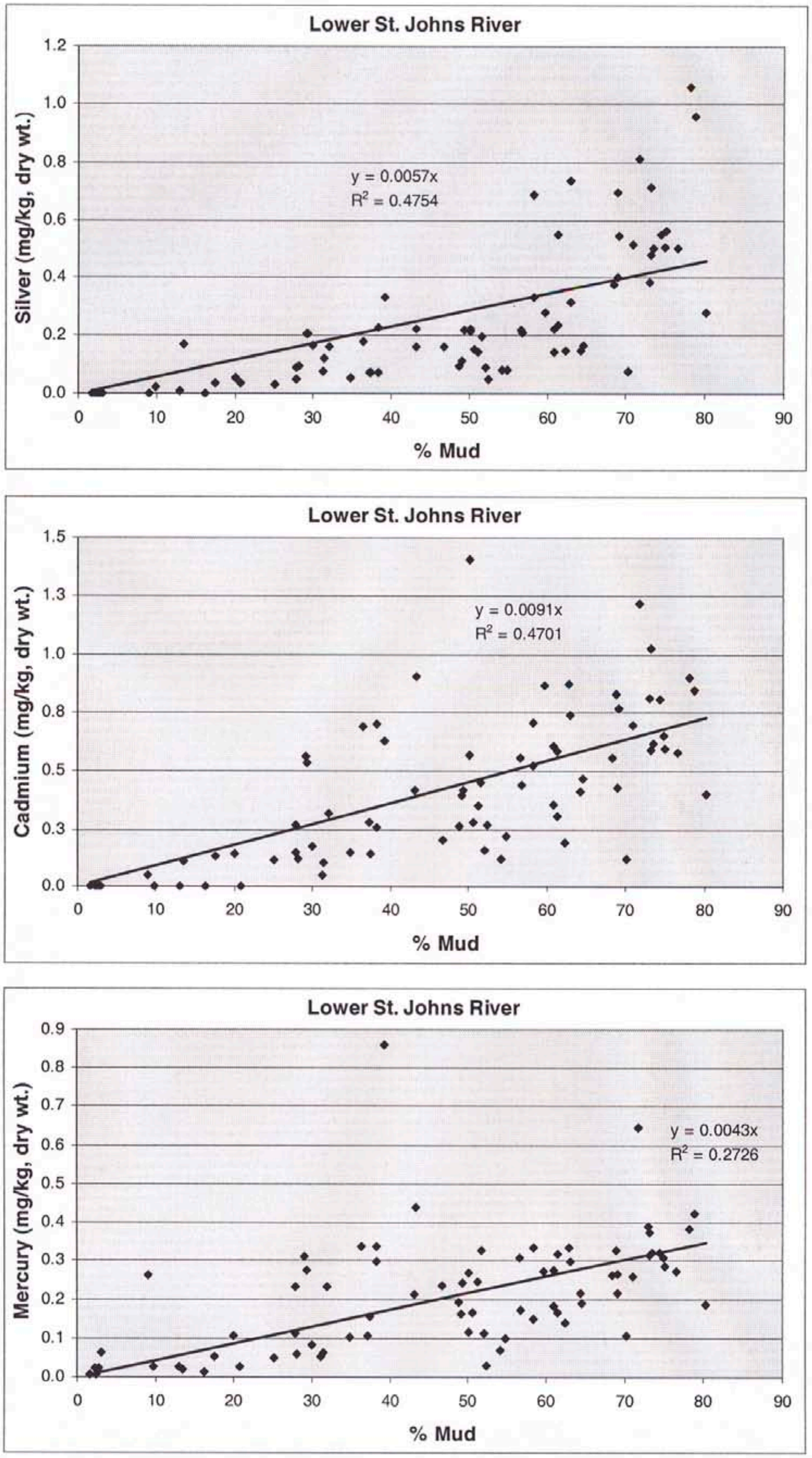


Figure 3-3. Silver, Cadmium, and Mercury Concentrations versus Grain Size of Sediments

In addition to the correspondence with aluminum, there is usually a strong correlation between TOC and fraction of mud within sediments. This correspondence was examined for the sediments in this study to determine if there were any unusual features within this system relating to this common paradigm. The exercise showed the correspondence between the fraction of mud and level of TOC in the sediments to be generally *very poor* (Section 3.3.1). Similarly, the correspondence between aluminum and TOC was weak. Striking in the relationship between TOC and grain size is the apparent correspondence between TOC and mud fraction in St. Johns River sediments with TOC under 10% and the complete lack of correspondence between these two parameters in sediments with TOC greater than 10%; the Cedar-Ortega River Basin sediments consistently had poor correlation between %TOC and grain size. This presentation demonstrates that many of the sediments were highly enriched in organic carbon and that accumulation of TOC in these sediments was independent of sediment grain size (e.g. the grain size of the sediments exerted very little control over TOC accumulation). The high values were also consistent with observation of samples with significant amounts of detritus, undegraded, or only partially degraded, vegetative debris that probably skewed the grain size and elevated the TOC content in many samples. Aluminum normalization provided better correlation to the other metal concentrations than grain size or TOC normalization, and better than what the other major metals provided.

Measured Metal Concentrations

The ranges of major and trace metal concentrations varied widely within the study area (see summary Table 3-10). The data from the metals analyses of sediment samples are summarized for each of the 77 LSJR sites and 51 COR sites in Tables 3-11a through 3-11c; Table 3-11a contains the non-normalized metals data (which are also presented in Appendix E), Table 3-11b the aluminum normalized data, and Table 3-11c the grain size normalized data. Tables 3-11b and 3-11c present the normalized data for the potential metal contaminants; the 3 major crustal elements (aluminum, iron, and manganese) are not included in these two tables.

As expected, the nonanthropogenic, crustal major metals, aluminum, iron, and manganese, were present at the highest concentrations in the sediments, whereas the potentially toxic trace metals, such as arsenic, cadmium, chromium, copper, lead, mercury, nickel, and silver were detected at lower concentrations (Tables 3-10 and 3-11a). The sediment metals concentrations were less variable when normalized to sediment aluminum concentrations (Tables 3-10 and 3-11b). For instance, the Al-normalized lead concentration in the LSJR sediment samples ranged from 0.000362 to 0.00321 (unitless), a factor of approximately 9 in concentration range, as compared to the non-normalized lead data which ranged by a factor of approximately 305 between the high and the low concentrations. Notable reductions in variability, by normalizing to aluminum, were observed for most samples and most other metals (a few anomalies were observed for low-mineral, high-organic sediment samples).

Sediment metals concentrations were also somewhat less variable once the data were normalized to sediment grain size (% Mud, also referred to as % Fines, which is defined as the sum of the %silt and %clay; Table 3-11c). For example, the grain-size normalized chromium concentration in the sediment samples ranged from 0.218 to 2.61 mg/kg/% mud, a factor of about 12 difference in the concentration between the high and the low sites. The non-normalized chromium results showed a high-to-low site concentration difference of a factor of about 31. Significant reductions in variability, by normalizing to grain size, were observed for several of the other metals, although grain size normalization reduced the variability less than aluminum normalization for most samples.

Table 3-10. Concentration Ranges for Major and Trace Metals

	Not Normalized (raw) (mg/kg dry weight)			Normalized to Al		
	Median	Min	Max	Median	Min	Max
Lower St. Johns River Sites						
Major Metals						
Aluminum (Al)	20,800	637	54,450	1	1	1
Iron (Fe)	14,300	ND	32,700	6.37E-01	ND	2.20
Manganese (Mn)	119	20.8	485	7.29E-03	2.84E-03	7.38E-02
Trace Metals						
Antimony (Sb)	0.235	0.046	0.953	1.18E-05	7.08E-06	1.43E-04
Arsenic (As)	3.46	0.120	13.2	1.64E-04	4.49E-05	6.56E-04
Beryllium (Be)	0.486	ND	1.65	2.39E-05	ND	4.92E-04
Cadmium (Cd)	0.401	ND	1.41	1.75E-05	ND	1.14E-04
Chromium (Cr)	38.0	2.97	91.8	1.69E-03	7.59E-04	6.23E-03
Cobalt (Co)	2.18	0.158	5.97	1.08E-04	6.75E-05	4.29E-04
Copper (Cu)	11.4	0.664	62.0	5.76E-04	1.99E-04	1.56E-03
Lead (Pb)	20.9	0.311	94.7	1.04E-03	3.62E-04	3.21E-03
Lithium (Li)	13.4	1.42	45.0	7.00E-04	3.98E-04	4.72E-03
Mercury (Hg)	0.214	0.008	0.859	8.40E-06	1.12E-06	2.22E-04
Nickel (Ni)	9.54	0.314	29.8	4.20E-04	1.70E-04	1.32E-03
Selenium (Se)	2.03	ND	4.74	8.53E-05	ND	4.18E-04
Silver (Ag)	0.165	ND	1.06	9.56E-06	ND	7.12E-05
Thallium (Tl)	0.290	ND	0.511	1.45E-05	ND	1.30E-04
Tin (Sn)	1.55	0.204	6.21	8.24E-05	3.29E-05	6.40E-04
Vanadium (V)	36.4	3.84	87.3	1.63E-03	7.77E-04	1.10E-02
Zinc (Zn)	57.1	2.09	241	2.72E-03	8.49E-04	1.49E-02
Cedar-Ortega River Basin Sites						
Major Metals						
Aluminum (Al)	39,700	11,600	60,600	1	1	1
Iron (Fe)	27,600	8,070	36,600	7.16E-04	4.80E-01	1.14
Manganese (Mn)	166	96	270	4.32E-03	1.95E-03	1.00E-02
Trace Metals						
Antimony (Sb)	0.339	0.093	1.20	8.50E-06	2.30E-06	3.08E-05
Arsenic (As)	5.09	1.36	24.5	1.42E-04	4.71E-05	4.47E-04
Beryllium (Be)	0.975	0.008	3.18	2.89E-05	6.80E-07	9.42E-05
Cadmium (Cd)	1.11	0.139	3.83	3.06E-05	5.01E-06	8.92E-05
Chromium (Cr)	57.1	15.5	96.0	1.44E-03	1.06E-03	3.07E-03
Cobalt (Co)	4.59	1.48	7.42	1.13E-04	9.00E-05	1.96E-04
Copper (Cu)	32.2	4.88	104	9.05E-04	1.23E-04	7.95E-03
Lead (Pb)	69.5	10.1	384	1.82E-03	4.80E-01	1.14E+00
Lithium (Li)	33.0	11.5	54.0	8.36E-04	4.32E-04	1.29E-03
Mercury (Hg)	0.642	0.057	2.10	1.68E-05	1.33E-06	1.81E-04
Nickel (Ni)	15.2	4.30	23.9	3.81E-04	2.87E-04	7.73E-04
Selenium (Se)	1.69	0.246	3.28	4.45E-05	1.98E-05	8.40E-05
Silver (Ag)	0.683	0.107	5.39	1.88E-05	2.52E-06	1.28E-04
Thallium (Tl)	0.353	0.122	0.510	8.82E-06	6.73E-06	2.38E-05
Tin (Sn)	4.27	1.07	15.7	1.21E-04	2.89E-05	3.10E-04
Vanadium (V)	54.2	17.8	72.3	1.38E-03	1.09E-03	2.58E-03
Zinc (Zn)	189	47.1	2,050	5.04E-03	1.10E-03	3.74E-02

Table 3-11a. Metals Data — Non-Normalized

FIELD ID	Non-Normalized Metals Concentrations (mg/kg, dry weight)																			
	Al	**Sb**	**As**	**Be**	**Cd**	**Cr**	**Co**	**Cu**	**Fe**	**Pb**	**Li**	**Mn**	**Hg**	**Ni**	**Se**	**Ag**	**Tl**	**Sn**	**V**	**Zn**
Lower St. Johns River Sites																				
BAY01	26,700	0.216	3.42	0.239	0.864	46.7	3.12	19.3	20,100	27.7	24.3	155	0.271	14.6	2.80	0.276	0.410	1.81	43.7	160
BOL04	54,100	0.389	8.99	1.30	0.900	91.8	5.97	31.2	32,100	74.5	40.7	331	0.383	19.4	1.85	1.06	0.448	5.10	73.5	163
BUCK03	47,700	0.440	6.81	0.983	1.03	83.0	5.48	23.4	30,800	49.1	32.8	280	0.373	19.2	2.13	0.715	0.381	4.06	71.7	219
CDRC01	19,900	0.235	2.09	0.507	0.450	17.2	2.28	12.6	13,100	25.2	12.4	69.4	0.327	9.44	2.14	0.193	0.265	1.44	30.0	72.5
CO06	54,500	0.508	7.66	1.25	1.22	86.2	5.55	62.0	32,700	94.7	40.7	278	0.645	19.4	1.95	0.81	0.411	6.21	63.8	241
DUN01	17,400	0.138	2.80	0.216	0.319	38.0	2.16	11.1	23,900	20.3	15.8	91.3	0.231	9.54	3.61	0.157	0.450	1.17	31.4	87.4
GC02	16,600	0.236	2.13	0.503	1.41	12.6	1.42	10.6	8,150	21.8	7.19	142	0.115	5.45	0.794	0.213	0.290	1.07	21.2	40.9
HSP05	49,600	0.953	9.57	1.18	0.870	78.3	5.43	40.0	28,600	76.2	32.9	361	0.335	17.9	1.63	0.735	0.430	4.94	66.6	176
JUL02	41,700	0.295	6.57	0.705	0.806	74.5	5.55	26.3	30,500	45.2	45.0	265	0.322	19.1	2.45	0.553	0.410	3.09	67.9	240
LSJ01	48,400	0.639	6.27	1.65	0.587	66.4	5.36	37.3	24,400	63.0	34.9	364	0.318	16.3	1.21	0.552	0.378	2.72	73.1	169
LSJ02	47,300	0.478	7.38	1.55	0.598	69.4	5.53	27.5	29,200	53.1	40.6	485	0.285	18.0	2.03	0.563	0.379	3.88	74.1	147
LSJ03	47,600	0.455	8.78	1.31	0.829	74.4	5.42	52.6	27,800	50.5	36.3	380	0.328	18.9	2.72	0.699	0.323	4.21	74.4	148
LSJ04	17,700	0.200	7.30	0.391	0.174	15.6	1.77	8.11	4,360	13.8	8.34	152	0.083	4.96	0.370	0.165	0.173	1.14	24.6	39.1
LSJ05	42,500	0.390	7.52	1.11	0.766	62.6	4.55	20.3	24,200	35.4	29.7	347	0.265	16.0	2.44	0.547	0.290	3.42	60.3	109
LSJ06	32,900	0.410	13.2	0.872	0.401	45.1	3.21	11.6	16,600	18.8	22.6	235	0.186	9.92	1.62	0.276	0.290	2.25	47.1	53.2
LSJ07	45,900	0.394	6.74	1.17	0.581	68.4	5.21	22.7	26,800	40.7	34.9	332	0.271	17.7	2.73	0.503	0.298	3.62	69.7	125
LSJ08	40,000	0.433	7.08	0.944	0.707	55.7	4.10	17.4	18,800	39.2	26.0	312	0.336	14.6	2.48	0.687	0.291	3.14	60.6	95.9
LSJ09	45,700	0.376	6.96	1.28	0.588	69.3	4.95	21.4	26,800	38.1	35.3	361	0.314	17.4	2.92	0.481	0.262	3.44	70.4	118
LSJ10	2,410	0.063	0.725	ND	ND	5.50	0.290	1.16	1,270	1.67	3.31	23.3	0.026	0.607	0.315	0.0237	0.226	0.204	6.26	5.79
LSJ11	41,200	0.427	7.62	1.15	0.843	68.7	4.28	22.8	23,200	50.6	30.8	425	0.423	17.3	2.77	0.959	0.307	4.10	70.4	109
LSJ12	44,700	0.403	6.90	1.25	0.617	67.6	4.60	22.2	26,100	38.4	32.4	324	0.321	17.0	3.14	0.501	0.269	3.51	65.3	114
LSJ13	19,200	0.256	10.3	0.445	0.310	28.0	2.13	8.40	10,400	19.0	16.7	144	0.166	6.75	0.895	0.235	0.190	1.55	28.8	48.8
LSJ14	41,200	0.435	7.90	1.11	0.650	63.2	4.45	20.8	22,900	43.3	34.8	306	0.309	16.0	2.80	0.507	0.301	3.53	62.9	110
LSJ15	6,910	0.114	3.80	0.110	0.052	8.62	0.907	3.11	3,050	6.36	7.45	109	0.054	2.57	0.365	0.076	0.075	0.570	11.9	18.9
LSJ16	36,900	0.565	6.86	0.782	0.56	54.2	3.44	16.0	21,900	31.4	28.7	275	0.261	13.0	3.19	0.376	0.287	2.81	51.3	84.2
LSJ17	21,100	0.318	10.4	0.438	0.196	32.2	1.95	8.51	14,300	13.4	17.2	139	0.141	7.05	1.47	0.147	0.244	1.31	30.1	37.9
LSJ18	12,200	0.450	7.98	0.168	0.162	21.2	1.24	5.64	7,890	10.7	8.17	113	0.112	4.09	0.795	0.0897	0.168	0.936	9.44	35.0
LSJ19	26,500	0.205	6.56	0.447	0.121	40.3	2.28	5.26	17,900	14.0	19.4	194	0.105	9.75	2.83	0.0753	0.266	0.948	35.5	22.5
LSJ20	2,580	0.055	1.68	0.066	ND	4.53	0.365	1.65	1,750	1.99	3.94	20.8	0.026	1.20	0.240	0.035	0.025	0.283	6.81	7.84
LSJ21	20,600	0.263	10.5	0.337	0.279	25.3	1.92	9.79	11,400	15.0	12.8	175	0.166	7.39	1.78	0.152	0.345	1.35	28.8	47.3
LSJ22	10,600	0.156	6.39	0.178	0.121	15.9	1.15	5.08	6,640	7.67	7.93	94.0	0.068	4.06	0.685	0.082	0.155	0.815	17.6	25.2

FIELD ID	Non-Normalized Metals Concentrations (mg/kg, dry weight)																			
	Al	Sb	As	Be	Cd	Cr	Co	Cu	Fe	Pb	Li	Mn	Hg	Ni	Se	Ag	Tl	Sn	V	Zn
LSJ23	15,400	0.180	1.39	0.338	0.145	19.0	1.11	4.89	8,970	12.1	9.02	121	0.107	3.17	1.37	0.052	0.257	0.831	20.8	28.5
LSJ24	22,700	0.298	2.43	0.594	0.416	40.1	2.25	11.4	17,600	22.8	19.5	132	0.214	9.56	1.69	0.145	0.339	1.75	37.0	57.9
LSJ25	21,500	0.248	2.64	0.594	0.358	39.3	2.34	11.6	16,300	24.0	17.8	155	0.181	10.3	1.84	0.140	0.353	1.60	39.1	52.4
LSJ26	3,010	0.066	0.180	0.084	ND	5.04	0.321	1.19	1,630	1.65	3.49	40.9	0.012	0.834	0.285	ND	0.044	0.257	7.49	4.81
LSJ27	25,000	0.248	3.19	0.704	0.471	46.8	2.61	16.5	18,500	24.7	21.0	112	0.187	14.0	2.46	0.162	0.366	1.74	45.8	57.6
LSJ28	12,700	0.177	5.14	0.251	0.270	23.3	1.30	6.63	14,400	15.8	9.11	91.4	0.232	5.85	2.61	0.090	0.323	0.460	22.8	34.3
LSJ29	7,810	0.126	2.56	0.171	0.219	16.1	1.05	6.13	7,080	11.3	6.64	55.1	0.100	4.81	1.18	0.080	0.179	0.896	15.7	42.3
LSJ30	15,800	0.230	4.50	0.385	0.283	28.1	2.06	6.71	11,500	9.28	9.37	109	0.105	6.99	3.54	0.073	0.511	0.814	36.4	27.1
LSJ31	647	0.048	0.120	ND	ND	2.97	0.234	0.717	870	0.311	2.71	23.8	0.022	0.314	ND	ND	ND	0.246	5.27	2.09
LSJ32	18,600	0.206	3.68	0.526	0.355	33.9	1.81	11.0	14,300	20.7	11.4	96.5	0.245	9.56	2.89	0.141	0.489	1.44	33.2	42.9
LSJ33	651	0.093	0.145	ND	ND	4.05	0.279	0.664	1,430	0.582	3.07	48.0	0.022	0.421	ND	ND	ND	0.286	7.18	2.92
LSJ35	25,300	0.267	3.32	0.562	0.440	42.0	2.61	15.9	17,600	29.1	15.5	87.2	0.171	13.1	3.18	0.207	0.343	2.08	40.9	52.4
LSJ36	25,900	0.221	1.16	0.718	0.268	40.3	1.75	5.55	9,360	9.37	15.7	73.3	0.029	6.15	3.65	0.047	0.298	0.851	53.5	27.4
LSJ37	867	0.075	0.155	ND	ND	4.44	0.368	0.777	1,400	0.622	2.92	59.8	0.008	0.392	0.280	ND	0.011	0.286	7.64	4.36
LSJ39	2,980	0.072	0.430	1.46	ND	5.00	0.384	0.887	1,260	1.61	2.42	62.6	0.008	0.506	ND	ND	0.089	0.294	7.42	3.33
LSJ40	20,700	0.234	3.27	0.583	0.397	56.9	2.18	9.34	17,200	24.7	14.1	131	0.161	8.78	4.74	0.109	0.380	1.73	38.4	41.8
LSJRC01	5,950	0.137	1.06	0.070	0.151	9.59	0.703	5.06	2,890	8.36	3.47	83.9	0.113	4.64	0.705	0.047	0.116	1.14	18.1	39.5
LSJRC02	20,800	0.225	3.64	0.441	0.535	33.9	2.29	18.2	13,300	22.8	11.1	123	0.273	16.8	2.58	0.203	0.339	1.77	38.3	93.1
LSJRC03	22,300	0.250	4.68	0.466	0.419	40.3	2.15	12.1	15,900	26.9	12.5	99.4	0.243	11.7	3.09	0.218	0.469	1.64	33.8	57.1
LSJRC04	8,500	0.110	1.00	0.155	0.114	11.2	0.613	3.18	3,790	8.59	3.39	82.6	0.051	2.34	0.800	0.032	0.165	0.636	11.4	27.0
LSJRC05	1,150	0.046	0.225	ND	ND	3.02	0.186	1.33	ND	1.91	1.53	26.0	0.026	1.30	0.080	0.011	0.022	0.283	5.32	11.5
LSJRC06	22,500	0.259	2.56	0.423	0.907	35.7	3.02	27.1	10,500	24.8	11.7	313	0.440	29.8	2.07	0.223	0.356	2.25	87.3	162
LSJRC07	3,190	0.086	0.400	ND	0.104	6.86	0.486	3.18	1,410	4.25	2.51	44.7	0.063	3.96	0.245	0.120	0.052	0.557	16.4	28.2
LSJRC08	22,600	0.209	3.31	0.460	0.701	40.2	2.84	18.6	13,900	24.2	13.4	157	0.338	22.6	3.01	0.224	0.368	2.07	58.2	102
LSJRC09	25,600	0.206	4.21	0.572	0.566	48.3	2.87	16.4	16,800	28.3	15.9	119	0.267	18.0	3.40	0.222	0.417	2.23	45.3	78.0
LSJRC10	16,700	0.243	4.05	0.462	0.692	30.7	2.41	20.0	10,000	19.9	10.6	161	0.338	19.3	2.27	0.177	0.326	1.87	56.8	101
LSJRC11	24,400	0.428	3.17	0.543	0.630	46.1	2.64	30.2	15,700	28.7	13.6	106	0.859	18.9	3.43	0.330	0.409	2.70	52.3	96.9
LSJRC12	637	0.086	0.140	0.194	ND	3.43	0.158	0.996	505	2.05	1.42	37.2	0.062	0.434	ND	ND	0.016	0.408	3.84	3.78
LSJRC13	18,900	0.189	3.06	0.486	0.261	31.3	1.67	6.26	12,100	12.8	9.55	82.9	0.299	7.32	3.14	0.072	0.241	1.33	28.5	22.7
LSJRC13-02	16,200	0.118	2.50	0.113	0.205	29.1	1.73	8.59	11,500	14.1	15.3	91.6	0.235	8.59	2.18	0.161	0.242	1.14	31.5	82.8
LSJRC14	12,700	0.268	1.80	0.385	0.147	18.7	0.992	3.96	7,520	9.19	5.10	95.6	0.102	4.23	1.99	0.052	0.214	0.823	17.5	14.9
LSJRC15	26,800	0.286	3.52	0.780	0.605	46.9	2.68	18.1	18,800	29.3	14.7	109	0.274	15.0	3.74	0.220	0.396	2.36	40.8	61.5
LSJRC16	13,300	0.177	2.47	0.379	0.266	21.5	1.26	7.46	9,570	13.7	6.72	90.9	0.192	6.03	1.90	0.093	0.242	1.22	22.1	27.8
LSJRC17	8,590	0.183	1.45	0.435	0.144	14.5	0.807	6.66	5,230	9.24	4.49	71.2	0.155	4.27	1.36	0.073	0.121	0.840	16.0	18.8

FIELD ID	Non-Normalized Metals Concentrations (mg/kg, dry weight)																			
	Al	**Sb**	**As**	**Be**	**Cd**	**Cr**	**Co**	**Cu**	**Fe**	**Pb**	**Li**	**Mn**	**Hg**	**Ni**	**Se**	**Ag**	**Tl**	**Sn**	**V**	**Zn**
LSJRC18	1,180	0.100	0.22	0.227	0.047	3.85	0.208	1.23	773	2.66	1.54	41.4	0.262	0.749	ND	ND	0.020	0.428	4.44	6.66
LSJRC19	25,400	0.296	3.46	0.619	0.561	43.3	2.52	23.4	16,800	23.0	13.3	87.9	0.312	17.2	3.36	0.205	0.395	1.98	39.8	64.6
LSJRC20	24,900	0.255	3.15	0.600	0.555	43.0	2.53	19.8	16,400	20.9	13.1	79.4	0.308	16.4	2.95	0.215	0.314	3.13	38.0	69.3
MOC07	26,900	0.215	5.17	0.609	0.432	44.8	3.37	14.9	18,300	28.9	18.3	190	0.215	10.8	1.62	0.400	0.232	2.28	41.8	76.4
NASCP01	22,700	0.287	5.06	0.534	0.524	38.8	2.83	14.4	14,700	27.5	14.4	152	0.148	9.12	0.890	0.330	0.225	2.22	35.2	119
NASM01	31,100	0.342	7.31	0.764	0.696	63.4	4.56	21.8	25,100	39.5	25.0	299	0.259	16.0	2.20	0.515	0.310	3.33	59.1	148
OBB	40,000	0.476	5.24	0.886	0.812	69.1	4.52	28.8	28,600	41.7	27.9	196	0.390	16.1	2.12	0.385	0.367	3.59	52.7	152
ORG01	41,500	0.415	6.18	0.875	0.739	69.2	3.79	18.5	25,900	45.0	24.0	214	0.298	16.4	2.56	0.315	0.480	3.20	51.5	96.1
PA32	6,430	0.125	1.03	0.144	0.13	11.1	0.617	2.53	4,500	4.85	4.36	71.3	0.053	1.85	0.975	0.033	0.169	0.569	12.4	12.4
PP61	9,090	0.112	1.05	0.600	0.121	12.0	0.683	2.55	4,340	7.35	6.23	61.4	0.060	2.08	0.430	0.091	0.101	0.539	12.0	17.3
RCCP02	5,740	0.109	0.395	ND	0.111	10.5	0.672	3.46	2,350	4.29	3.67	94.8	0.020	7.40	0.300	0.169	0.057	0.673	38.5	85.8
WEK02	18,300	0.164	2.45	0.128	0.417	52.7	1.98	11.6	15,400	27.8	16.9	133	0.212	8.13	4.44	0.158	0.368	1.21	33.5	117
Cedar-Ortega River Basin Sites																				
CED01	54,800	1.20	24.5	0.340	3.83	96.0	5.96	83.1	28,900	268	23.7	107	0.921	22.8	3.28	5.39	0.376	15.7	72.3	2050
CED02	48,000	1.13	15.1	0.777	3.64	93.9	7.42	104	36,600	384	31.8	151	0.918	23.9	2.30	4.04	0.464	14.9	69.8	1430
CED03	37,700	0.686	6.23	1.06	2.07	52.6	5.40	65.5	21,400	176	26.5	143	0.738	16.5	1.70	1.06	0.424	6.88	46.2	608
CED04	60,600	0.846	8.61	0.796	3.03	81.0	6.54	88.1	29,100	315	52.1	175	0.953	22.6	1.64	1.37	0.498	12.2	65.8	796
CED05	17,100	0.208	1.73	1.61	0.559	22.6	2.56	13.7	15,300	58.9	13.5	96.3	0.294	7.31	0.813	0.263	0.226	3.04	27.5	151
CED06	28,300	0.584	5.50	1.13	1.33	57.5	4.60	54.0	26,500	144	23.0	143	0.638	15.1	1.49	0.868	0.355	7.54	43.7	449
CED07	31,400	0.355	5.16	0.845	1.65	66.4	4.72	56.8	30,200	157	24.7	152	1.14	16.6	1.68	1.11	0.369	6.71	46.3	423
CED08	30,600	0.461	2.85	0.413	1.29	48.9	3.95	45.8	24,300	84.1	25.0	127	0.538	14.0	2.13	0.471	0.318	5.12	42.5	286
CED09	35,900	0.588	5.01	0.360	1.43	51.7	4.02	52.5	21,300	149	27.0	126	0.530	15.0	2.01	0.683	0.295	5.34	45.1	523
ORT01	38,300	0.279	5.36	2.15	1.43	58.2	4.06	21.5	29,100	52.0	32.0	170	0.642	13.8	1.51	0.799	0.343	4.14	52.8	112
ORT02	46,100	0.244	3.81	1.45	0.503	54.8	4.86	10.5	27,200	16.8	38.6	180	0.482	14.4	1.56	0.367	0.420	1.60	59.9	52.6
ORT03	42,900	0.099	4.18	2.69	0.215	50.8	4.24	5.29	32,200	11.7	33.5	160	0.057	12.7	1.97	0.108	0.337	1.24	54.6	58.2
ORT04	45,400	0.239	4.35	1.27	0.661	54.6	4.92	13.8	26,900	23.5	39.8	172	0.598	15.2	1.71	0.386	0.420	1.92	58.7	65.1
ORT05	41,400	0.189	4.36	2.32	0.762	53.6	4.30	18.9	35,200	40.7	35.2	165	0.499	13.6	2.02	0.456	0.345	3.06	54.6	108
ORT06	39,700	0.214	4.89	2.68	0.835	61.8	4.09	14.5	28,300	28.3	34.9	166	0.383	13.2	1.74	0.451	0.298	2.96	56.0	84.4
ORT06-1	42,000	0.230	3.89	0.803	0.933	53.8	4.32	16.1	24,600	30.4	43.5	182	0.345	13.8	1.60	0.501	0.351	2.39	55.6	77.4
ORT07	48,800	0.617	7.37	1.41	1.63	74.9	5.92	54.9	28,400	90.2	39.9	270	1.04	20.9	1.94	1.08	0.447	5.51	70.3	229
ORT08	48,000	0.341	5.47	0.506	1.08	65.7	4.63	24.9	34,100	47.0	35.9	189	0.588	16.7	2.67	0.903	0.352	3.98	58.8	172
ORT09	31,500	0.343	6.37	2.70	1.70	58.7	4.10	28.5	29,300	63.2	33.3	170	1.03	13.8	1.53	0.911	0.351	6.18	56.1	234
ORT10	41,200	0.276	6.50	2.40	1.36	59.5	4.40	37.0	31,700	69.8	32.2	205	1.06	14.8	1.73	0.942	0.359	5.19	55.0	189
ORT11	46,100	0.299	6.78	2.34	1.04	63.1	4.95	26.0	33,100	55.1	33.2	199	0.492	16.0	1.65	0.646	0.400	4.27	63.5	219

FIELD ID	Non-Normalized Metals Concentrations (mg/kg, dry weight)																			
	Al	Sb	As	Be	Cd	Cr	Co	Cu	Fe	Pb	Li	Mn	Hg	Ni	Se	Ag	Tl	Sn	V	Zn
ORT12	47,300	0.293	6.59	2.07	0.906	62.0	4.85	44.6	35,400	62.7	34.8	185	0.571	15.8	1.84	0.629	0.403	4.36	61.3	155
ORT13	48,100	0.318	6.66	2.97	1.32	66.1	5.06	38.2	34,500	82.7	36.9	207	0.638	17.1	1.76	0.791	0.403	5.30	63.3	248
ORT14	43,100	0.162	3.20	0.833	0.413	51.5	4.59	10.9	27,000	17.5	51.8	167	0.161	13.7	1.46	0.289	0.362	1.59	55.9	47.6
ORT15	40,900	0.501	10.2	1.05	1.25	68.5	5.33	101	29,300	74.3	33.7	249	0.751	18.5	2.84	1.16	0.351	5.51	60.3	315
ORT16	48,500	0.258	4.09	0.683	0.844	60.1	4.84	31.7	27,400	49.1	52.0	179	0.607	15.9	1.67	0.574	0.376	3.09	59.4	127
ORT18	40,400	0.303	3.73	0.679	0.908	50.2	4.36	29.0	23,900	56.5	42.6	185	0.536	14.1	1.29	0.501	0.323	3.28	51.0	140
ORT19	11,600	0.339	2.87	0.008	0.296	15.5	1.67	91.9	8,360	51.9	14.9	116	2.10	4.40	0.503	0.266	0.122	2.92	17.8	134
ORT20	38,700	0.186	3.33	0.590	0.291	41.4	4.23	12.5	23,900	18.3	43.7	148	0.105	12.3	1.26	0.191	0.308	1.16	48.4	47.1
ORT21	32,400	0.259	4.63	1.27	0.855	56.9	3.98	30.3	25,900	69.5	25.2	154	0.822	13.9	1.69	0.704	0.286	3.95	45.2	137
ORT22	37,300	0.403	6.51	0.846	1.28	54.1	4.61	80.8	24,600	78.7	37.5	239	1.68	15.3	1.39	0.728	0.334	4.51	52.1	366
ORT23	30,300	0.246	4.61	1.17	0.580	56.3	4.09	26.3	27,600	51.5	34.5	151	0.698	13.7	1.47	0.474	0.262	3.02	46.8	189
ORT24	37,200	0.353	6.61	1.22	1.01	66.4	4.71	50.3	29,700	89.0	31.7	195	0.885	16.8	1.89	0.851	0.328	5.09	53.4	233
ORT25	34,900	0.797	6.95	1.39	1.73	80.6	5.77	85.3	31,100	133	30.7	228	0.746	20.1	2.25	1.18	0.508	6.58	67.2	520
ORT26	30,700	0.560	5.38	1.16	1.57	70.8	5.04	58.7	30,300	107	28.2	203	0.952	18.0	1.89	0.953	0.474	5.80	57.6	251
ORT27	44,700	0.649	6.12	0.702	1.74	71.4	4.84	71.4	36,100	133	31.2	191	1.09	18.7	2.60	1.39	0.375	7.77	52.4	587
ORT28	24,300	0.472	7.54	0.764	1.17	58.2	4.37	51.4	25,200	76.9	27.2	205	0.650	15.5	2.04	0.706	0.405	4.27	50.9	327
ORT29	44,400	0.339	2.09	0.572	1.11	55.9	4.31	27.8	26,600	57.3	34.3	151	0.737	15.9	1.83	0.625	0.299	4.17	49.2	125
ORT30	15,000	0.093	1.36	1.33	0.139	18.5	1.48	4.88	10,600	10.1	11.5	100	0.101	4.30	0.410	0.107	0.137	1.07	26.8	75.5
ORT31	18,500	0.570	5.07	0.935	1.65	56.8	3.62	42.2	21,100	243	21.5	172	0.896	14.3	1.48	2.36	0.441	5.36	47.8	274
ORT32	37,100	0.522	6.60	0.906	1.21	64.0	4.52	42.4	24,200	98.1	25.7	217	0.551	15.7	1.65	1.24	0.437	5.03	56.2	187
ORT33	12,500	0.333	1.81	0.975	0.571	16.8	1.63	21.8	8,070	86.6	15.3	101	0.089	5.10	0.246	0.251	0.144	2.22	21.8	217
ORT34	41,100	0.304	3.31	0.719	1.06	53.8	4.73	33.1	27,200	66.2	50.0	172	0.587	15.2	1.44	0.551	0.349	3.94	53.0	181
ORT35	26,000	0.258	5.09	0.806	0.478	48.3	3.65	28.3	23,500	53.2	27.2	139	0.582	12.3	1.67	0.375	0.232	3.15	40.4	140
ORT36	35,500	0.390	5.12	0.595	1.02	57.1	4.36	32.1	26,400	64.2	26.2	159	0.547	14.8	1.92	0.554	0.428	3.73	50.1	148
ORT37	30,300	0.534	5.13	0.836	1.27	63.5	4.68	48.2	30,300	101	25.5	166	0.917	16.3	1.85	0.649	0.510	5.42	48.3	248
ORT38	51,100	0.354	7.89	2.34	1.71	60.8	4.60	29.1	32,000	71.3	33.0	142	1.38	15.4	1.65	0.792	0.372	6.65	59.8	154
ORT39	52,000	0.442	4.53	0.367	1.73	77.1	5.03	32.2	29,900	79.6	31.4	134	1.68	19.5	2.06	1.03	0.353	5.91	57.6	222
ORT39-1	43,900	0.260	3.74	0.656	0.976	53.0	4.96	21.7	27,600	52.7	54.0	143	0.562	15.8	1.41	0.462	0.361	3.15	54.3	145
ORT40	46,200	0.289	4.78	3.18	1.46	56.9	4.40	41.8	30,100	98.4	34.0	147	0.725	16.2	1.44	0.712	0.331	6.13	54.2	276
ORT41	37,700	0.315	3.02	1.19	0.647	40.0	4.29	19.2	23,900	28.7	37.5	115	0.728	13.0	1.71	0.325	0.335	1.99	44.2	80.3

Table 3-11b. Metals Data — Normalized to Aluminum

FIELD ID	Aluminum Normalized Metals Concentrations																
	Sb	As	Be	Cd	Cr	Co	Cu	Pb	Li	Hg	Ni	Se	Ag	Tl	Sn	V	Zn
Lower St. Johns River Sites																	
BAY01	8.07E-06	1.28E-04	8.95E-06	3.23E-05	1.75E-03	1.17E-04	7.23E-04	1.04E-03	9.10E-04	1.01E-05	5.47E-04	1.05E-04	1.03E-05	1.54E-05	6.78E-05	1.64E-03	5.99E-03
BOL04	7.18E-06	1.66E-04	2.39E-05	1.66E-05	1.70E-03	1.10E-04	5.76E-04	1.38E-03	7.51E-04	7.08E-06	3.59E-04	3.41E-05	1.96E-05	8.27E-06	9.42E-05	1.36E-03	3.01E-03
BUCK03	9.21E-06	1.43E-04	2.06E-05	2.15E-05	1.74E-03	1.15E-04	4.91E-04	1.03E-03	6.87E-04	7.81E-06	4.03E-04	4.45E-05	1.50E-05	7.98E-06	8.50E-05	1.50E-03	4.59E-03
CDRC01	1.18E-05	1.05E-04	2.55E-05	2.27E-05	8.66E-04	1.15E-04	6.35E-04	1.27E-03	6.22E-04	1.65E-05	4.75E-04	1.08E-04	9.70E-06	1.33E-05	7.25E-05	1.51E-03	3.65E-03
CO06	9.33E-06	1.41E-04	2.30E-05	2.24E-05	1.58E-03	1.02E-04	1.14E-03	1.74E-03	7.47E-04	1.18E-05	3.55E-04	3.57E-05	1.49E-05	7.55E-06	1.14E-04	1.17E-03	4.42E-03
DUN01	7.90E-06	1.61E-04	1.24E-05	1.83E-05	2.18E-03	1.24E-04	6.38E-04	1.17E-03	9.05E-04	1.33E-05	5.48E-04	2.07E-04	9.02E-06	2.58E-05	6.73E-05	1.80E-03	5.02E-03
GC02	1.42E-05	1.28E-04	3.03E-05	8.48E-05	7.59E-04	8.55E-05	6.39E-04	1.31E-03	4.33E-04	6.93E-06	3.28E-04	4.78E-05	1.28E-05	1.74E-05	6.42E-05	1.27E-03	2.46E-03
HSP05	1.92E-05	1.93E-04	2.37E-05	1.75E-05	1.58E-03	1.09E-04	8.06E-04	1.54E-03	6.63E-04	6.75E-06	3.60E-04	3.28E-05	1.48E-05	8.67E-06	9.96E-05	1.34E-03	3.55E-03
JUL02	7.08E-06	1.58E-04	1.69E-05	1.93E-05	1.79E-03	1.33E-04	6.31E-04	1.08E-03	1.08E-03	7.73E-06	4.59E-04	5.88E-05	1.33E-05	9.83E-06	7.41E-05	1.63E-03	5.76E-03
LSJ01	1.32E-05	1.29E-04	3.40E-05	1.21E-05	1.37E-03	1.11E-04	7.70E-04	1.30E-03	7.20E-04	6.56E-06	3.37E-04	2.49E-05	1.14E-05	7.81E-06	5.63E-05	1.51E-03	3.49E-03
LSJ02	1.01E-05	1.56E-04	3.28E-05	1.26E-05	1.47E-03	1.17E-04	5.81E-04	1.12E-03	8.59E-04	6.03E-06	3.80E-04	4.30E-05	1.19E-05	8.01E-06	8.20E-05	1.57E-03	3.10E-03
LSJ03	9.56E-06	1.85E-04	2.75E-05	1.74E-05	1.56E-03	1.14E-04	1.11E-03	1.06E-03	7.63E-04	6.90E-06	3.96E-04	5.72E-05	1.47E-05	6.78E-06	8.85E-05	1.56E-03	3.11E-03
LSJ04	1.13E-05	4.14E-04	2.21E-05	9.86E-06	8.83E-04	1.00E-04	4.59E-04	7.84E-04	4.72E-04	4.72E-06	2.81E-04	2.10E-05	9.35E-06	9.80E-06	6.47E-05	1.39E-03	2.21E-03
LSJ05	9.18E-06	1.77E-04	2.60E-05	1.80E-05	1.47E-03	1.07E-04	4.78E-04	8.34E-04	7.00E-04	6.23E-06	3.76E-04	5.75E-05	1.29E-05	6.82E-06	8.06E-05	1.42E-03	2.56E-03
LSJ06	1.25E-05	4.00E-04	2.65E-05	1.22E-05	1.37E-03	9.77E-05	3.54E-04	5.71E-04	6.88E-04	5.66E-06	3.02E-04	4.92E-05	8.40E-06	8.83E-06	6.85E-05	1.43E-03	1.62E-03
LSJ07	8.57E-06	1.47E-04	2.55E-05	1.26E-05	1.49E-03	1.13E-04	4.93E-04	8.86E-04	7.60E-04	5.90E-06	3.85E-04	5.95E-05	1.09E-05	6.48E-06	7.89E-05	1.52E-03	2.72E-03
LSJ08	1.08E-05	1.77E-04	2.36E-05	1.77E-05	1.39E-03	1.03E-04	4.34E-04	9.80E-04	6.50E-04	8.40E-06	3.65E-04	6.21E-05	1.72E-05	7.27E-06	7.86E-05	1.52E-03	2.40E-03
LSJ09	8.22E-06	1.52E-04	2.79E-05	1.29E-05	1.52E-03	1.08E-04	4.68E-04	8.33E-04	7.71E-04	6.86E-06	3.80E-04	6.39E-05	1.05E-05	5.72E-06	7.53E-05	1.54E-03	2.57E-03
LSJ10	2.63E-05	3.01E-04	ND	ND	2.29E-03	1.21E-04	4.80E-04	6.94E-04	1.38E-03	1.08E-05	2.52E-04	1.31E-04	9.83E-06	9.41E-05	8.46E-05	2.60E-03	2.41E-03
LSJ11	1.04E-05	1.85E-04	2.80E-05	2.05E-05	1.67E-03	1.04E-04	5.53E-04	1.23E-03	7.47E-04	1.03E-05	4.20E-04	6.72E-05	2.33E-05	7.45E-06	9.95E-05	1.71E-03	2.64E-03
LSJ12	9.03E-06	1.55E-04	2.79E-05	1.38E-05	1.51E-03	1.03E-04	4.97E-04	8.59E-04	7.26E-04	7.19E-06	3.80E-04	7.03E-05	1.12E-05	6.02E-06	7.86E-05	1.46E-03	2.55E-03
LSJ13	1.33E-05	5.36E-04	2.32E-05	1.62E-05	1.46E-03	1.11E-04	4.38E-04	9.90E-04	8.69E-04	8.67E-06	3.52E-04	4.67E-05	1.22E-05	9.90E-06	8.09E-05	1.50E-03	2.55E-03
LSJ14	1.06E-05	1.92E-04	2.68E-05	1.58E-05	1.53E-03	1.08E-04	5.05E-04	1.05E-03	8.45E-04	7.49E-06	3.87E-04	6.78E-05	1.23E-05	7.29E-06	8.56E-05	1.53E-03	2.67E-03
LSJ15	1.65E-05	5.50E-04	1.59E-05	7.52E-06	1.25E-03	1.31E-04	4.50E-04	9.20E-04	1.08E-03	7.82E-06	3.71E-04	5.29E-05	1.10E-05	1.09E-05	8.25E-05	1.72E-03	2.74E-03
LSJ16	1.53E-05	1.86E-04	2.12E-05	1.52E-05	1.47E-03	9.32E-05	4.32E-04	8.51E-04	7.76E-04	7.07E-06	3.51E-04	8.63E-05	1.02E-05	7.76E-06	7.62E-05	1.39E-03	2.28E-03
LSJ17	1.51E-05	4.95E-04	2.08E-05	9.29E-06	1.53E-03	9.24E-05	4.04E-04	6.37E-04	8.17E-04	6.67E-06	3.35E-04	6.98E-05	6.96E-06	1.16E-05	6.22E-05	1.43E-03	1.80E-03
LSJ18	3.70E-05	6.56E-04	1.38E-05	1.33E-05	1.74E-03	1.02E-04	4.64E-04	8.78E-04	6.72E-04	9.18E-06	3.36E-04	6.54E-05	7.38E-06	1.38E-05	7.70E-05	7.77E-04	2.88E-03
LSJ19	7.73E-06	2.48E-04	1.69E-05	4.59E-06	1.52E-03	8.62E-05	1.99E-04	5.31E-04	7.32E-04	3.96E-06	3.69E-04	1.07E-04	2.85E-06	1.01E-05	3.58E-05	1.34E-03	8.49E-04
LSJ20	2.13E-05	6.51E-04	2.54E-05	ND	1.76E-03	1.41E-04	6.38E-04	7.71E-04	1.53E-03	1.00E-05	4.67E-04	9.30E-05	1.35E-05	9.75E-06	1.10E-04	2.64E-03	3.04E-03
LSJ21	1.28E-05	5.08E-04	1.64E-05	1.35E-05	1.23E-03	9.32E-05	4.75E-04	7.26E-04	6.19E-04	8.06E-06	3.58E-04	8.62E-05	7.35E-06	1.67E-05	6.53E-05	1.40E-03	2.29E-03
LSJ22	1.47E-05	6.02E-04	1.68E-05	1.14E-05	1.49E-03	1.08E-04	4.78E-04	7.23E-04	7.47E-04	6.41E-06	3.82E-04	6.45E-05	7.69E-06	1.46E-05	7.68E-05	1.66E-03	2.37E-03

FIELD ID	Aluminum Normalized Metals Concentrations																
	Sb	**As**	**Be**	**Cd**	**Cr**	**Co**	**Cu**	**Pb**	**Li**	**Hg**	**Ni**	**Se**	**Ag**	**Tl**	**Sn**	**V**	**Zn**
LSJ23	1.17E-05	9.03E-05	2.19E-05	9.39E-06	1.23E-03	7.18E-05	3.18E-04	7.84E-04	5.86E-04	6.92E-06	2.06E-04	8.86E-05	3.38E-06	1.67E-05	5.40E-05	1.35E-03	1.85E-03
LSJ24	1.31E-05	1.07E-04	2.62E-05	1.83E-05	1.77E-03	9.91E-05	5.00E-04	1.00E-03	8.57E-04	9.41E-06	4.21E-04	7.44E-05	6.39E-06	1.49E-05	7.69E-05	1.63E-03	2.55E-03
LSJ25	1.15E-05	1.23E-04	2.76E-05	1.67E-05	1.83E-03	1.09E-04	5.40E-04	1.12E-03	8.28E-04	8.40E-06	4.78E-04	8.53E-05	6.51E-06	1.64E-05	7.44E-05	1.82E-03	2.44E-03
LSJ26	2.20E-05	5.99E-05	2.80E-05	ND	1.68E-03	1.07E-04	3.94E-04	5.47E-04	1.16E-03	4.09E-06	2.78E-04	9.48E-05	ND	1.45E-05	8.55E-05	2.49E-03	1.60E-03
LSJ27	9.92E-06	1.28E-04	2.82E-05	1.89E-05	1.87E-03	1.05E-04	6.61E-04	9.88E-04	8.42E-04	7.49E-06	5.61E-04	9.86E-05	6.49E-06	1.46E-05	6.97E-05	1.83E-03	2.31E-03
LSJ28	1.39E-05	4.04E-04	1.97E-05	2.12E-05	1.83E-03	1.02E-04	5.21E-04	1.24E-03	7.16E-04	1.82E-05	4.60E-04	2.05E-04	7.09E-06	2.54E-05	3.62E-05	1.79E-03	2.69E-03
LSJ29	1.61E-05	3.28E-04	2.18E-05	2.80E-05	2.06E-03	1.34E-04	7.85E-04	1.44E-03	8.50E-04	1.28E-05	6.16E-04	1.50E-04	1.02E-05	2.29E-05	1.15E-04	2.01E-03	5.41E-03
LSJ30	1.46E-05	2.86E-04	2.44E-05	1.79E-05	1.78E-03	1.31E-04	4.26E-04	5.89E-04	5.95E-04	6.63E-06	4.44E-04	2.24E-04	4.61E-06	3.24E-05	5.17E-05	2.31E-03	1.72E-03
LSJ31	7.41E-05	1.86E-04	ND	ND	4.59E-03	3.61E-04	1.11E-03	4.81E-04	4.19E-03	3.39E-05	4.85E-04	ND	ND	ND	3.80E-04	8.15E-03	3.23E-03
LSJ32	1.11E-05	1.98E-04	2.83E-05	1.91E-05	1.82E-03	9.70E-05	5.89E-04	1.11E-03	6.13E-04	1.31E-05	5.14E-04	1.55E-04	7.55E-06	2.63E-05	7.72E-05	1.78E-03	2.31E-03
LSJ33	1.43E-04	2.23E-04	ND	ND	6.23E-03	4.29E-04	1.02E-03	8.94E-04	4.72E-03	3.41E-05	6.47E-04	ND	ND	ND	4.39E-04	1.10E-02	4.48E-03
LSJ35	1.06E-05	1.31E-04	2.23E-05	1.74E-05	1.66E-03	1.03E-04	6.30E-04	1.15E-03	6.14E-04	6.75E-06	5.17E-04	1.26E-04	8.20E-06	1.36E-05	8.24E-05	1.62E-03	2.07E-03
LSJ36	8.53E-06	4.49E-05	2.78E-05	1.04E-05	1.56E-03	6.75E-05	2.15E-04	3.62E-04	6.05E-04	1.12E-06	2.38E-04	1.41E-04	1.80E-06	1.15E-05	3.29E-05	2.07E-03	1.06E-03
LSJ37	8.64E-05	1.79E-04	ND	ND	5.12E-03	4.24E-04	8.97E-04	7.17E-04	3.37E-03	9.00E-06	4.52E-04	3.23E-04	ND	1.22E-05	3.29E-04	8.82E-03	5.03E-03
LSJ39	2.42E-05	1.45E-04	4.92E-04	ND	1.68E-03	1.29E-04	2.98E-04	5.41E-04	8.12E-04	2.61E-06	1.70E-04	ND	ND	2.99E-05	9.87E-05	2.49E-03	1.12E-03
LSJ40	1.13E-05	1.58E-04	2.81E-05	1.92E-05	2.75E-03	1.05E-04	4.51E-04	1.19E-03	6.79E-04	7.78E-06	4.24E-04	2.29E-04	5.24E-06	1.84E-05	8.36E-05	1.86E-03	2.02E-03
LSJRC01	2.29E-05	1.78E-04	1.18E-05	2.53E-05	1.61E-03	1.18E-04	8.50E-04	1.41E-03	5.82E-04	1.90E-05	7.80E-04	1.18E-04	7.90E-06	1.95E-05	1.91E-04	3.03E-03	6.63E-03
LSJRC02	1.08E-05	1.75E-04	2.12E-05	2.57E-05	1.63E-03	1.10E-04	8.73E-04	1.09E-03	5.31E-04	1.31E-05	8.08E-04	1.24E-04	9.74E-06	1.63E-05	8.51E-05	1.84E-03	4.47E-03
LSJRC03	1.12E-05	2.10E-04	2.09E-05	1.88E-05	1.81E-03	9.64E-05	5.44E-04	1.21E-03	5.62E-04	1.09E-05	5.26E-04	1.39E-04	9.78E-06	2.11E-05	7.35E-05	1.52E-03	2.56E-03
LSJRC04	1.29E-05	1.18E-04	1.82E-05	1.34E-05	1.32E-03	7.21E-05	3.74E-04	1.01E-03	3.98E-04	6.02E-06	2.75E-04	9.41E-05	3.71E-06	1.94E-05	7.48E-05	1.34E-03	3.18E-03
LSJRC05	4.00E-05	1.95E-04	ND	ND	2.62E-03	1.62E-04	1.16E-03	1.66E-03	1.33E-03	2.22E-05	1.13E-03	6.95E-05	9.56E-06	1.95E-05	2.46E-04	4.62E-03	9.97E-03
LSJRC06	1.15E-05	1.14E-04	1.88E-05	4.03E-05	1.58E-03	1.34E-04	1.20E-03	1.10E-03	5.18E-04	1.96E-05	1.32E-03	9.18E-05	9.89E-06	1.58E-05	9.98E-05	3.88E-03	7.18E-03
LSJRC07	2.69E-05	1.25E-04	ND	3.27E-05	2.15E-03	1.52E-04	9.95E-04	1.33E-03	7.85E-04	1.97E-05	1.24E-03	7.68E-05	3.76E-05	1.62E-05	1.74E-04	5.14E-03	8.82E-03
LSJRC08	9.25E-06	1.47E-04	2.04E-05	3.11E-05	1.78E-03	1.26E-04	8.23E-04	1.07E-03	5.94E-04	1.50E-05	1.00E-03	1.33E-04	9.93E-06	1.63E-05	9.16E-05	2.58E-03	4.52E-03
LSJRC09	8.05E-06	1.64E-04	2.23E-05	2.21E-05	1.88E-03	1.12E-04	6.41E-04	1.11E-03	6.19E-04	1.04E-05	7.01E-04	1.33E-04	8.67E-06	1.63E-05	8.69E-05	1.77E-03	3.04E-03
LSJRC10	1.46E-05	2.43E-04	2.77E-05	4.16E-05	1.84E-03	1.44E-04	1.20E-03	1.19E-03	6.34E-04	2.03E-05	1.16E-03	1.36E-04	1.06E-05	1.95E-05	1.12E-04	3.41E-03	6.09E-03
LSJRC11	1.76E-05	1.30E-04	2.23E-05	2.59E-05	1.89E-03	1.08E-04	1.24E-03	1.18E-03	5.56E-04	3.53E-05	7.76E-04	1.41E-04	1.36E-05	1.68E-05	1.11E-04	2.15E-03	3.98E-03
LSJRC12	1.35E-04	2.20E-04	3.04E-04	ND	5.39E-03	2.48E-04	1.56E-03	3.21E-03	2.23E-03	9.71E-05	6.81E-04	ND	ND	2.55E-05	6.40E-04	6.03E-03	5.94E-03
LSJRC13	9.97E-06	1.62E-04	2.57E-05	1.38E-05	1.65E-03	8.84E-05	3.31E-04	6.77E-04	5.05E-04	1.58E-05	3.87E-04	1.66E-04	3.81E-06	1.27E-05	7.01E-05	1.51E-03	1.20E-03
LSJRC13-02	7.27E-06	1.54E-04	6.98E-06	1.26E-05	1.80E-03	1.06E-04	5.30E-04	8.70E-04	9.44E-04	1.45E-05	5.30E-04	1.35E-04	9.91E-06	1.49E-05	7.02E-05	1.94E-03	5.11E-03
LSJRC14	2.11E-05	1.42E-04	3.03E-05	1.16E-05	1.47E-03	7.81E-05	3.12E-04	7.24E-04	4.02E-04	8.00E-06	3.33E-04	1.56E-04	4.06E-06	1.68E-05	6.48E-05	1.38E-03	1.17E-03
LSJRC15	1.07E-05	1.32E-04	2.92E-05	2.26E-05	1.75E-03	1.00E-04	6.75E-04	1.09E-03	5.48E-04	1.02E-05	5.61E-04	1.40E-04	8.22E-06	1.48E-05	8.80E-05	1.53E-03	2.30E-03
LSJRC16	1.33E-05	1.86E-04	2.85E-05	2.00E-05	1.62E-03	9.44E-05	5.61E-04	1.03E-03	5.05E-04	1.44E-05	4.53E-04	1.43E-04	6.99E-06	1.82E-05	9.14E-05	1.66E-03	2.09E-03

FIELD ID	Aluminum Normalized Metals Concentrations															
	Sb	As	Be	Cd	Cr	Co	Cu	Pb	Li	Hg	Ni	Se	Ag	Tl	Sn	V	Zn
LSJRC17	2.13E-05	1.68E-04	5.06E-05	1.68E-05	1.69E-03	9.40E-05	7.76E-04	1.08E-03	5.23E-04	1.80E-05	4.97E-04	1.58E-04	8.44E-06	1.40E-05	9.78E-05	1.86E-03	2.19E-03
LSJRC18	8.46E-05	1.86E-04	1.92E-04	3.97E-05	3.26E-03	1.76E-04	1.04E-03	2.25E-03	1.30E-03	2.22E-04	6.34E-04	ND	ND	1.65E-05	3.63E-04	3.76E-03	5.64E-03
LSJRC19	1.16E-05	1.36E-04	2.44E-05	2.21E-05	1.70E-03	9.90E-05	9.19E-04	9.04E-04	5.22E-04	1.23E-05	6.75E-04	1.32E-04	8.07E-06	1.55E-05	7.80E-05	1.56E-03	2.54E-03
LSJRC20	1.03E-05	1.27E-04	2.41E-05	2.23E-05	1.73E-03	1.02E-04	7.97E-04	8.39E-04	5.25E-04	1.24E-05	6.58E-04	1.19E-04	8.65E-06	1.26E-05	1.26E-04	1.53E-03	2.79E-03
MOC07	7.99E-06	1.92E-04	2.26E-05	1.61E-05	1.67E-03	1.25E-04	5.52E-04	1.07E-03	6.78E-04	7.97E-06	4.01E-04	6.00E-05	1.49E-05	8.62E-06	8.46E-05	1.55E-03	2.84E-03
NASCP01	1.26E-05	2.23E-04	2.35E-05	2.31E-05	1.71E-03	1.25E-04	6.32E-04	1.21E-03	6.34E-04	6.50E-06	4.02E-04	3.92E-05	1.45E-05	9.91E-06	9.78E-05	1.55E-03	5.24E-03
NASM01	1.10E-05	2.35E-04	2.46E-05	2.24E-05	2.04E-03	1.47E-04	6.99E-04	1.27E-03	8.04E-04	8.31E-06	5.13E-04	7.06E-05	1.66E-05	9.95E-06	1.07E-04	1.90E-03	4.76E-03
OBB	1.19E-05	1.31E-04	2.21E-05	2.03E-05	1.73E-03	1.13E-04	7.20E-04	1.04E-03	6.96E-04	9.75E-06	4.03E-04	5.30E-05	9.63E-06	9.16E-06	8.98E-05	1.32E-03	3.80E-03
ORG01	9.99E-06	1.49E-04	2.11E-05	1.78E-05	1.67E-03	9.13E-05	4.46E-04	1.08E-03	5.77E-04	7.18E-06	3.94E-04	6.16E-05	7.59E-06	1.16E-05	7.70E-05	1.24E-03	2.31E-03
PA32	1.95E-05	1.60E-04	2.24E-05	2.02E-05	1.73E-03	9.60E-05	3.93E-04	7.55E-04	6.79E-04	8.30E-06	2.88E-04	1.52E-04	5.16E-06	2.63E-05	8.85E-05	1.93E-03	1.93E-03
PP61	1.23E-05	1.15E-04	6.60E-05	1.33E-05	1.32E-03	7.51E-05	2.80E-04	8.08E-04	6.85E-04	6.60E-06	2.28E-04	4.73E-05	1.00E-05	1.11E-05	5.93E-05	1.32E-03	1.90E-03
RCCP02	1.90E-05	6.88E-05	ND	1.93E-05	1.83E-03	1.17E-04	6.03E-04	7.47E-04	6.39E-04	3.48E-06	1.29E-03	5.23E-05	2.94E-05	9.94E-06	1.17E-04	6.70E-03	1.49E-02
WEK02	8.99E-06	1.34E-04	7.01E-06	2.28E-05	2.89E-03	1.08E-04	6.34E-04	1.52E-03	9.23E-04	1.16E-05	4.45E-04	2.43E-04	8.63E-06	2.01E-05	6.60E-05	1.83E-03	6.38E-03
Cedar-Ortega River Basin Sites																	
CED01	2.19E-05	4.47E-04	6.20E-06	6.99E-05	1.75E-03	1.09E-04	1.52E-03	4.89E-03	4.32E-04	1.68E-05	4.16E-04	5.99E-05	9.84E-05	6.86E-06	2.86E-04	1.32E-03	3.74E-02
CED02	2.35E-05	3.15E-04	1.62E-05	7.58E-05	1.96E-03	1.55E-04	2.17E-03	8.00E-03	6.63E-04	1.91E-05	4.98E-04	4.79E-05	8.42E-05	9.67E-06	3.10E-04	1.45E-03	2.98E-02
CED03	1.82E-05	1.65E-04	2.81E-05	5.49E-05	1.40E-03	1.43E-04	1.74E-03	4.67E-03	7.03E-04	1.96E-05	4.38E-04	4.51E-05	2.81E-05	1.12E-05	1.82E-04	1.23E-03	1.61E-02
CED04	1.40E-05	1.42E-04	1.31E-05	5.00E-05	1.34E-03	1.08E-04	1.45E-03	5.20E-03	8.60E-04	1.57E-05	3.73E-04	2.71E-05	2.26E-05	8.22E-06	2.01E-04	1.09E-03	1.31E-02
CED05	1.22E-05	1.01E-04	9.42E-05	3.27E-05	1.32E-03	1.50E-04	8.01E-04	3.44E-03	7.89E-04	1.72E-05	4.27E-04	4.75E-05	1.54E-05	1.32E-05	1.78E-04	1.61E-03	8.83E-03
CED06	2.06E-05	1.94E-04	3.99E-05	4.70E-05	2.03E-03	1.63E-04	1.91E-03	5.09E-03	8.13E-04	2.25E-05	5.34E-04	5.27E-05	3.07E-05	1.25E-05	2.66E-04	1.54E-03	1.59E-02
CED07	1.13E-05	1.64E-04	2.69E-05	5.25E-05	2.11E-03	1.50E-04	1.81E-03	5.00E-03	7.87E-04	3.63E-05	5.29E-04	5.35E-05	3.54E-05	1.18E-05	2.14E-04	1.47E-03	1.35E-02
CED08	1.51E-05	9.31E-05	1.35E-05	4.22E-05	1.60E-03	1.29E-04	1.50E-03	2.75E-03	8.17E-04	1.76E-05	4.58E-04	6.96E-05	1.54E-05	1.04E-05	1.67E-04	1.39E-03	9.35E-03
CED09	1.64E-05	1.40E-04	1.00E-05	3.98E-05	1.44E-03	1.12E-04	1.46E-03	4.15E-03	7.52E-04	1.48E-05	4.18E-04	5.60E-05	1.90E-05	8.22E-06	1.49E-04	1.26E-03	1.46E-02
ORT01	7.28E-06	1.40E-04	5.61E-05	3.73E-05	1.52E-03	1.06E-04	5.61E-04	1.36E-03	8.36E-04	1.68E-05	3.60E-04	3.94E-05	2.09E-05	8.96E-06	1.08E-04	1.38E-03	2.92E-03
ORT02	5.29E-06	8.26E-05	3.15E-05	1.09E-05	1.19E-03	1.05E-04	2.28E-04	3.64E-04	8.37E-04	1.05E-05	3.12E-04	3.38E-05	7.96E-06	9.11E-06	3.47E-05	1.30E-03	1.14E-03
ORT03	2.30E-06	9.74E-05	6.27E-05	5.01E-06	1.18E-03	9.88E-05	1.23E-04	2.73E-04	7.81E-04	1.33E-06	2.96E-04	4.59E-05	2.52E-06	7.86E-06	2.89E-05	1.27E-03	1.36E-03
ORT04	5.26E-06	9.58E-05	2.80E-05	1.46E-05	1.20E-03	1.08E-04	3.04E-04	5.18E-04	8.77E-04	1.32E-05	3.35E-04	3.77E-05	8.50E-06	9.25E-06	4.23E-05	1.29E-03	1.43E-03
ORT05	4.57E-06	1.05E-04	5.60E-05	1.84E-05	1.29E-03	1.04E-04	4.57E-04	9.83E-04	8.50E-04	1.21E-05	3.29E-04	4.88E-05	1.10E-05	8.33E-06	7.39E-05	1.32E-03	2.61E-03
ORT06	5.39E-06	1.23E-04	6.75E-05	2.10E-05	1.56E-03	1.03E-04	3.65E-04	7.13E-04	8.79E-04	9.65E-06	3.32E-04	4.38E-05	1.14E-05	7.51E-06	7.46E-05	1.41E-03	2.13E-03
ORT06-1	5.48E-06	9.26E-05	1.91E-05	2.22E-05	1.28E-03	1.03E-04	3.83E-04	7.24E-04	1.04E-03	8.21E-06	3.29E-04	3.81E-05	1.19E-05	8.36E-06	5.69E-05	1.32E-03	1.84E-03
ORT07	1.26E-05	1.51E-04	2.89E-05	3.34E-05	1.53E-03	1.21E-04	1.13E-03	1.85E-03	8.18E-04	2.13E-05	4.28E-04	3.98E-05	2.21E-05	9.16E-06	1.13E-04	1.44E-03	4.69E-03
ORT08	7.10E-06	1.14E-04	1.05E-05	2.25E-05	1.37E-03	9.65E-05	5.19E-04	9.79E-04	7.48E-04	1.23E-05	3.48E-04	5.56E-05	1.88E-05	7.33E-06	8.29E-05	1.23E-03	3.58E-03
ORT09	1.09E-05	2.02E-04	8.57E-05	5.40E-05	1.86E-03	1.30E-04	9.05E-04	2.01E-03	1.06E-03	3.27E-05	4.38E-04	4.86E-05	2.89E-05	1.11E-05	1.96E-04	1.78E-03	7.43E-03

FIELD ID	Aluminum Normalized Metals Concentrations															
	Sb	As	Be	Cd	Cr	Co	Cu	Pb	Li	Hg	Ni	Se	Ag	Tl	Sn	V	Zn
ORT10	6.70E-06	1.58E-04	5.83E-05	3.30E-05	1.44E-03	1.07E-04	8.98E-04	1.69E-03	7.82E-04	2.57E-05	3.59E-04	4.20E-05	2.29E-05	8.71E-06	1.26E-04	1.33E-03	4.59E-03
ORT11	6.49E-06	1.47E-04	5.08E-05	2.26E-05	1.37E-03	1.07E-04	5.64E-04	1.20E-03	7.20E-04	1.07E-05	3.47E-04	3.58E-05	1.40E-05	8.68E-06	9.26E-05	1.38E-03	4.75E-03
ORT12	6.19E-06	1.39E-04	4.38E-05	1.92E-05	1.31E-03	1.03E-04	9.43E-04	1.33E-03	7.36E-04	1.21E-05	3.34E-04	3.89E-05	1.33E-05	8.52E-06	9.22E-05	1.30E-03	3.28E-03
ORT13	6.61E-06	1.38E-04	6.17E-05	2.74E-05	1.37E-03	1.05E-04	7.94E-04	1.72E-03	7.67E-04	1.33E-05	3.56E-04	3.66E-05	1.64E-05	8.38E-06	1.10E-04	1.32E-03	5.16E-03
ORT14	3.76E-06	7.42E-05	1.93E-05	9.58E-06	1.19E-03	1.06E-04	2.53E-04	4.06E-04	1.20E-03	3.74E-06	3.18E-04	3.39E-05	6.71E-06	8.40E-06	3.69E-05	1.30E-03	1.10E-03
ORT15	1.22E-05	2.49E-04	2.57E-05	3.06E-05	1.67E-03	1.30E-04	2.47E-03	1.82E-03	8.24E-04	1.84E-05	4.52E-04	6.94E-05	2.84E-05	8.58E-06	1.35E-04	1.47E-03	7.70E-03
ORT16	5.32E-06	8.43E-05	1.41E-05	1.74E-05	1.24E-03	9.98E-05	6.54E-04	1.01E-03	1.07E-03	1.25E-05	3.28E-04	3.44E-05	1.18E-05	7.75E-06	6.37E-05	1.22E-03	2.62E-03
ORT18	7.50E-06	9.23E-05	1.68E-05	2.25E-05	1.24E-03	1.08E-04	7.18E-04	1.40E-03	1.05E-03	1.33E-05	3.49E-04	3.19E-05	1.24E-05	8.00E-06	8.12E-05	1.26E-03	3.47E-03
ORT19	2.94E-05	2.48E-04	6.80E-07	2.56E-05	1.34E-03	1.44E-04	7.95E-03	4.49E-03	1.29E-03	1.81E-04	3.81E-04	4.35E-05	2.30E-05	1.06E-05	2.53E-04	1.54E-03	1.16E-02
ORT20	4.81E-06	8.60E-05	1.52E-05	7.52E-06	1.07E-03	1.09E-04	3.23E-04	4.73E-04	1.13E-03	2.71E-06	3.18E-04	3.26E-05	4.94E-06	7.96E-06	3.00E-05	1.25E-03	1.22E-03
ORT21	7.99E-06	1.43E-04	3.92E-05	2.64E-05	1.76E-03	1.23E-04	9.35E-04	2.15E-03	7.78E-04	2.54E-05	4.29E-04	5.22E-05	2.17E-05	8.83E-06	1.22E-04	1.40E-03	4.23E-03
ORT22	1.08E-05	1.75E-04	2.27E-05	3.42E-05	1.45E-03	1.24E-04	2.17E-03	2.11E-03	1.01E-03	4.50E-05	4.09E-04	3.73E-05	1.95E-05	8.97E-06	1.21E-04	1.40E-03	9.83E-03
ORT23	8.12E-06	1.52E-04	3.86E-05	1.91E-05	1.86E-03	1.35E-04	8.68E-04	1.70E-03	1.14E-03	2.30E-05	4.52E-04	4.85E-05	1.56E-05	8.65E-06	9.97E-05	1.54E-03	6.24E-03
ORT24	9.49E-06	1.78E-04	3.28E-05	2.72E-05	1.78E-03	1.27E-04	1.35E-03	2.39E-03	8.52E-04	2.38E-05	4.52E-04	5.08E-05	2.29E-05	8.82E-06	1.37E-04	1.44E-03	6.26E-03
ORT25	2.28E-05	1.99E-04	3.98E-05	4.96E-05	2.31E-03	1.65E-04	2.44E-03	3.81E-03	8.80E-04	2.14E-05	5.76E-04	6.45E-05	3.38E-05	1.46E-05	1.89E-04	1.93E-03	1.49E-02
ORT26	1.82E-05	1.75E-04	3.78E-05	5.11E-05	2.31E-03	1.64E-04	1.91E-03	3.49E-03	9.19E-04	3.10E-05	5.86E-04	6.16E-05	3.10E-05	1.54E-05	1.89E-04	1.88E-03	8.18E-03
ORT27	1.45E-05	1.37E-04	1.57E-05	3.89E-05	1.60E-03	1.08E-04	1.60E-03	2.98E-03	6.98E-04	2.44E-05	4.18E-04	5.82E-05	3.11E-05	8.39E-06	1.74E-04	1.17E-03	1.31E-02
ORT28	1.94E-05	3.10E-04	3.14E-05	4.81E-05	2.40E-03	1.80E-04	2.12E-03	3.16E-03	1.12E-03	2.67E-05	6.38E-04	8.40E-05	2.91E-05	1.67E-05	1.76E-04	2.09E-03	1.35E-02
ORT29	7.64E-06	4.71E-05	1.29E-05	2.50E-05	1.26E-03	9.71E-05	6.26E-04	1.29E-03	7.73E-04	1.66E-05	3.58E-04	4.12E-05	1.41E-05	6.73E-06	9.39E-05	1.11E-03	2.82E-03
ORT30	6.21E-06	9.07E-05	8.87E-05	9.27E-06	1.23E-03	9.87E-05	3.25E-04	6.73E-04	7.67E-04	6.73E-06	2.87E-04	2.73E-05	7.13E-06	9.13E-06	7.13E-05	1.79E-03	5.03E-03
ORT31	3.08E-05	2.74E-04	5.05E-05	8.92E-05	3.07E-03	1.96E-04	2.28E-03	1.31E-02	1.16E-03	4.84E-05	7.73E-04	8.00E-05	1.28E-04	2.38E-05	2.90E-04	2.58E-03	1.48E-02
ORT32	1.41E-05	1.78E-04	2.44E-05	3.26E-05	1.73E-03	1.22E-04	1.14E-03	2.64E-03	6.93E-04	1.49E-05	4.23E-04	4.45E-05	3.34E-05	1.18E-05	1.36E-04	1.51E-03	5.04E-03
ORT33	2.67E-05	1.45E-04	7.83E-05	4.59E-05	1.35E-03	1.31E-04	1.75E-03	6.95E-03	1.23E-03	7.15E-06	4.10E-04	1.98E-05	2.02E-05	1.15E-05	1.78E-04	1.75E-03	1.74E-02
ORT34	7.40E-06	8.05E-05	1.75E-05	2.58E-05	1.31E-03	1.15E-04	8.05E-04	1.61E-03	1.22E-03	1.43E-05	3.70E-04	3.50E-05	1.34E-05	8.49E-06	9.59E-05	1.29E-03	4.40E-03
ORT35	9.92E-06	1.96E-04	3.10E-05	1.84E-05	1.86E-03	1.40E-04	1.09E-03	2.05E-03	1.05E-03	2.24E-05	4.73E-04	6.42E-05	1.44E-05	8.92E-06	1.21E-04	1.55E-03	5.38E-03
ORT36	1.10E-05	1.44E-04	1.68E-05	2.87E-05	1.61E-03	1.23E-04	9.04E-04	1.81E-03	7.38E-04	1.54E-05	4.17E-04	5.41E-05	1.56E-05	1.21E-05	1.05E-04	1.41E-03	4.17E-03
ORT37	1.76E-05	1.69E-04	2.76E-05	4.19E-05	2.10E-03	1.54E-04	1.59E-03	3.33E-03	8.42E-04	3.03E-05	5.38E-04	6.11E-05	2.14E-05	1.68E-05	1.79E-04	1.59E-03	8.18E-03
ORT38	6.93E-06	1.54E-04	4.58E-05	3.35E-05	1.19E-03	9.00E-05	5.69E-04	1.40E-03	6.46E-04	2.70E-05	3.01E-04	3.23E-05	1.55E-05	7.28E-06	1.30E-04	1.17E-03	3.01E-03
ORT39	8.50E-06	8.71E-05	7.06E-06	3.33E-05	1.48E-03	9.67E-05	6.19E-04	1.53E-03	6.04E-04	3.23E-05	3.75E-04	3.96E-05	1.98E-05	6.79E-06	1.14E-04	1.11E-03	4.27E-03
ORT39-1	5.92E-06	8.52E-05	1.49E-05	2.22E-05	1.21E-03	1.13E-04	4.94E-04	1.20E-03	1.23E-03	1.28E-05	3.60E-04	3.21E-05	1.05E-05	8.22E-06	7.18E-05	1.24E-03	3.30E-03
ORT40	6.26E-06	1.03E-04	6.88E-05	3.16E-05	1.23E-03	9.52E-05	9.05E-04	2.13E-03	7.36E-04	1.57E-05	3.51E-04	3.12E-05	1.54E-05	7.16E-06	1.33E-04	1.17E-03	5.97E-03
ORT41	8.36E-06	8.01E-05	3.16E-05	1.72E-05	1.06E-03	1.14E-04	5.09E-04	7.61E-04	9.95E-04	1.93E-05	3.45E-04	4.54E-05	8.62E-06	8.89E-06	5.28E-05	1.17E-03	2.13E-03

Table 3-11c. Metals Data — Normalized to Grain Size (% Mud)

FIELD ID	Grain Size Normalized Metals Concentrations (mg/kg/%Mud)																
	Sb	**As**	**Be**	**Cd**	**Cr**	**Co**	**Cu**	**Pb**	**Li**	**Hg**	**Ni**	**Se**	**Ag**	**Tl**	**Sn**	**V**	**Zn**
Lower St. Johns River Sites																	
BAY01	3.61E-03	5.73E-02	4.01E-03	1.45E-02	0.782	5.22E-02	0.324	0.464	0.407	4.53E-03	0.245	4.69E-02	4.63E-03	6.87E-03	3.03E-02	0.733	2.68
BOL04	4.97E-03	1.15E-01	1.66E-02	1.15E-02	1.17	7.63E-02	0.398	0.952	0.520	4.90E-03	0.248	2.36E-02	1.36E-02	5.72E-03	6.52E-02	0.940	2.08
BUCK03	6.00E-03	9.30E-02	1.34E-02	1.40E-02	1.13	7.49E-02	0.320	0.671	0.447	5.09E-03	0.262	2.90E-02	9.77E-03	5.20E-03	5.54E-02	0.980	2.99
CDRC01	4.54E-03	4.04E-02	9.82E-03	8.71E-03	0.333	4.40E-02	0.244	0.487	0.239	6.33E-03	0.183	4.14E-02	3.73E-03	5.12E-03	2.79E-02	0.580	1.40
CO06	7.09E-03	1.07E-01	1.74E-02	1.70E-02	1.20	7.74E-02	0.864	1.32	0.567	9.00E-03	0.270	2.71E-02	1.13E-02	5.73E-03	8.65E-02	0.889	3.35
DUN01	4.30E-03	8.73E-02	6.73E-03	9.95E-03	1.19	6.73E-02	0.347	0.634	0.492	7.22E-03	0.298	1.13E-01	4.91E-03	1.40E-02	3.66E-02	0.980	2.73
GC02	4.70E-03	4.24E-02	1.00E-02	2.81E-02	0.251	2.83E-02	0.211	0.435	0.143	2.29E-03	0.109	1.58E-02	4.24E-03	5.77E-03	2.12E-02	0.422	0.816
HSP05	1.52E-02	1.52E-01	1.87E-02	1.38E-02	1.24	8.63E-02	0.636	1.21	0.523	5.33E-03	0.284	2.58E-02	1.17E-02	6.84E-03	7.85E-02	1.06	2.80
JUL02	3.96E-03	8.82E-02	9.47E-03	1.08E-02	1.00	7.45E-02	0.353	0.606	0.604	4.33E-03	0.257	3.29E-02	7.42E-03	5.50E-03	4.14E-02	0.912	3.22
LSJ01	1.04E-02	1.02E-01	2.68E-02	9.55E-03	1.08	8.73E-02	0.607	1.03	0.568	5.17E-03	0.265	1.96E-02	8.99E-03	6.16E-03	4.44E-02	1.19	2.75
LSJ02	6.36E-03	9.82E-02	2.06E-02	7.96E-03	0.923	7.36E-02	0.366	0.706	0.541	3.79E-03	0.239	2.70E-02	7.50E-03	5.04E-03	5.16E-02	0.987	1.95
LSJ03	6.60E-03	1.27E-01	1.90E-02	1.20E-02	1.08	7.86E-02	0.763	0.733	0.527	4.76E-03	0.274	3.95E-02	1.01E-02	4.68E-03	6.11E-02	1.08	2.15
LSJ04	6.67E-03	2.43E-01	1.30E-02	5.80E-03	0.520	5.90E-02	0.270	0.462	0.278	2.78E-03	0.165	1.23E-02	5.50E-03	5.77E-03	3.81E-02	0.820	1.30
LSJ05	5.64E-03	1.09E-01	1.60E-02	1.11E-02	0.906	6.58E-02	0.294	0.512	0.430	3.83E-03	0.231	3.53E-02	7.91E-03	4.19E-03	4.95E-02	0.872	1.57
LSJ06	5.11E-03	1.64E-01	1.09E-02	5.00E-03	0.562	4.00E-02	0.145	0.234	0.282	2.32E-03	0.124	2.01E-02	3.44E-03	3.62E-03	2.81E-02	0.587	0.663
LSJ07	5.14E-03	8.80E-02	1.53E-02	7.58E-03	0.892	6.80E-02	0.296	0.531	0.456	3.54E-03	0.230	3.56E-02	6.56E-03	3.88E-03	4.73E-02	0.910	1.63
LSJ08	7.42E-03	1.21E-01	1.62E-02	1.21E-02	0.955	7.02E-02	0.298	0.672	0.445	5.75E-03	0.250	4.25E-02	1.18E-02	4.98E-03	5.39E-02	1.04	1.64
LSJ09	5.13E-03	9.50E-02	1.74E-02	8.03E-03	0.947	6.76E-02	0.292	0.520	0.482	4.28E-03	0.237	3.99E-02	6.57E-03	3.57E-03	4.70E-02	0.961	1.61
LSJ10	6.45E-03	7.40E-02	ND	ND	0.561	2.96E-02	0.118	0.170	0.338	2.65E-03	0.062	3.21E-02	2.41E-03	2.31E-02	2.08E-02	0.639	0.59
LSJ11	5.42E-03	9.66E-02	1.46E-02	1.07E-02	0.871	5.43E-02	0.289	0.642	0.390	5.37E-03	0.220	3.51E-02	1.22E-02	3.89E-03	5.20E-02	0.893	1.38
LSJ12	5.48E-03	9.39E-02	1.69E-02	8.39E-03	0.920	6.26E-02	0.302	0.522	0.441	4.37E-03	0.231	4.27E-02	6.82E-03	3.66E-03	4.78E-02	0.888	1.55
LSJ13	4.16E-03	1.67E-01	7.24E-03	5.05E-03	0.456	3.46E-02	0.137	0.309	0.271	2.70E-03	0.110	1.46E-02	3.82E-03	3.09E-03	2.52E-02	0.468	0.794
LSJ14	5.81E-03	1.05E-01	1.48E-02	8.67E-03	0.843	5.93E-02	0.278	0.578	0.465	4.12E-03	0.213	3.73E-02	6.76E-03	4.01E-03	4.71E-02	0.840	1.47
LSJ15	3.65E-03	1.22E-01	3.51E-03	1.67E-03	0.276	2.91E-02	0.100	0.204	0.239	1.73E-03	0.082	1.17E-02	2.44E-03	2.41E-03	1.83E-02	0.380	0.606
LSJ16	8.25E-03	1.00E-01	1.14E-02	8.18E-03	0.792	5.03E-02	0.233	0.459	0.419	3.82E-03	0.189	4.66E-02	5.50E-03	4.19E-03	4.11E-02	0.749	1.23
LSJ17	5.10E-03	1.67E-01	7.01E-03	3.13E-03	0.516	3.12E-02	0.136	0.215	0.276	2.25E-03	0.113	2.36E-02	2.35E-03	3.91E-03	2.10E-02	0.482	0.607
LSJ18	8.64E-03	1.53E-01	3.22E-03	3.11E-03	0.407	2.38E-02	0.108	0.205	0.157	2.14E-03	0.078	1.53E-02	1.72E-03	3.22E-03	1.80E-02	0.181	0.671
LSJ19	2.91E-03	9.34E-02	6.37E-03	1.73E-03	0.574	3.25E-02	0.075	0.200	0.276	1.49E-03	0.139	4.03E-02	1.07E-03	3.79E-03	1.35E-02	0.505	0.320
LSJ20	2.64E-03	8.08E-02	3.15E-03	ND	0.218	1.75E-02	0.079	0.096	0.189	1.24E-03	0.058	1.15E-02	1.68E-03	1.21E-03	1.36E-02	0.327	0.377
LSJ21	5.20E-03	2.07E-01	6.66E-03	5.50E-03	0.499	3.79E-02	0.193	0.295	0.252	3.28E-03	0.146	3.51E-02	2.99E-03	6.81E-03	2.66E-02	0.568	0.934
LSJ22	2.88E-03	1.18E-01	3.28E-03	2.24E-03	0.292	2.12E-02	0.094	0.142	0.146	1.25E-03	0.075	1.26E-02	1.51E-03	2.85E-03	1.50E-02	0.325	0.464

FIELD ID	Grain Size Normalized Metals Concentrations (mg/kg/%Mud)																
	Sb	As	Be	Cd	Cr	Co	Cu	Pb	Li	Hg	Ni	Se	Ag	Tl	Sn	V	Zn
LSJ23	8.98E-03	6.95E-02	1.69E-02	7.23E-03	0.948	5.53E-02	0.245	0.604	0.451	5.33E-03	0.159	6.83E-02	2.61E-03	1.28E-02	4.16E-02	1.04	1.42
LSJ24	4.63E-03	3.77E-02	9.24E-03	6.46E-03	0.624	3.50E-02	0.177	0.355	0.302	3.32E-03	0.149	2.63E-02	2.26E-03	5.27E-03	2.71E-02	0.575	0.900
LSJ25	4.07E-03	4.33E-02	9.75E-03	5.88E-03	0.644	3.83E-02	0.190	0.394	0.292	2.96E-03	0.169	3.01E-02	2.30E-03	5.80E-03	2.63E-02	0.642	0.860
LSJ26	4.08E-03	1.11E-02	5.19E-03	ND	0.311	1.98E-02	0.073	0.102	0.215	7.59E-04	0.052	1.76E-02	ND	2.68E-03	1.59E-02	0.462	0.297
LSJ27	3.83E-03	4.94E-02	1.09E-02	7.29E-03	0.724	4.04E-02	0.255	0.382	0.325	2.89E-03	0.217	3.81E-02	2.51E-03	5.66E-03	2.69E-02	0.708	0.892
LSJ28	6.33E-03	1.84E-01	8.98E-03	9.66E-03	0.835	4.64E-02	0.238	0.565	0.326	8.32E-03	0.210	9.34E-02	3.23E-03	1.16E-02	1.65E-02	0.815	1.23
LSJ29	2.30E-03	4.67E-02	3.11E-03	4.00E-03	0.294	1.91E-02	0.112	0.205	0.121	1.83E-03	0.088	2.14E-02	1.46E-03	3.26E-03	1.63E-02	0.286	0.771
LSJ30	6.18E-03	1.21E-01	1.03E-02	7.59E-03	0.755	5.54E-02	0.18	0.249	0.252	2.81E-03	0.188	9.50E-02	1.95E-03	1.37E-02	2.19E-02	0.978	0.728
LSJ31	1.77E-02	4.44E-02	ND	ND	1.10	8.65E-02	0.266	0.115	1.00	8.11E-03	0.116	ND	ND	ND	9.09E-02	1.95	0.774
LSJ32	4.02E-03	7.18E-02	1.03E-02	6.93E-03	0.662	3.53E-02	0.214	0.404	0.223	4.78E-03	0.187	5.63E-02	2.74E-03	9.55E-03	2.80E-02	0.648	0.838
LSJ33	4.04E-02	6.30E-02	ND	ND	1.76	1.21E-01	0.289	0.253	1.33	9.65E-03	0.183	ND	ND	ND	1.24E-01	3.12	1.27
LSJ35	4.70E-03	5.85E-02	9.89E-03	7.74E-03	0.739	4.59E-02	0.280	0.511	0.273	3.00E-03	0.230	5.60E-02	3.64E-03	6.04E-03	3.66E-02	0.719	0.922
LSJ36	4.21E-03	2.21E-02	1.37E-02	5.11E-03	0.769	3.33E-02	0.106	0.179	0.299	5.54E-04	0.117	6.96E-02	8.90E-04	5.68E-03	1.62E-02	1.02	0.523
LSJ37	4.41E-02	9.12E-02	ND	ND	2.61	2.16E-01	0.457	0.366	1.72	4.59E-03	0.231	1.65E-01	ND	6.19E-03	1.68E-01	4.49	2.56
LSJ39	2.88E-02	1.72E-01	5.85E-01	ND	2.00	1.53E-01	0.355	0.644	0.966	3.10E-03	0.202	ND	ND	3.56E-02	1.17E-01	2.97	1.33
LSJ40	4.76E-03	6.66E-02	1.19E-02	8.09E-03	1.16	4.43E-02	0.190	0.503	0.286	3.28E-03	0.179	9.64E-02	2.21E-03	7.74E-03	3.52E-02	0.782	0.850
LSJRC01	4.89E-03	3.80E-02	2.51E-03	5.39E-03	0.344	2.52E-02	0.181	0.300	0.124	4.05E-03	0.166	2.53E-02	1.68E-03	4.16E-03	4.08E-02	0.647	1.41
LSJRC02	7.66E-03	1.24E-01	1.50E-02	1.82E-02	1.16	7.82E-02	0.619	0.776	0.377	9.32E-03	0.573	8.79E-02	6.91E-03	1.16E-02	6.04E-02	1.31	3.18
LSJRC03	5.06E-03	9.48E-02	9.44E-03	8.49E-03	0.816	4.35E-02	0.245	0.545	0.254	4.93E-03	0.237	6.27E-02	4.41E-03	9.50E-03	3.32E-02	0.685	1.16
LSJRC04	4.38E-03	3.98E-02	6.18E-03	4.54E-03	0.446	2.44E-02	0.127	0.342	0.135	2.04E-03	0.093	3.19E-02	1.25E-03	6.55E-03	2.53E-02	0.452	1.08
LSJRC05	3.54E-03	1.73E-02	ND	ND	0.232	1.43E-02	0.102	0.147	0.118	1.97E-03	0.100	6.15E-03	8.46E-04	1.72E-03	2.18E-02	0.409	0.883
LSJRC06	5.97E-03	5.91E-02	9.77E-03	2.09E-02	0.823	6.96E-02	0.626	0.573	0.269	1.02E-02	0.688	4.77E-02	5.14E-03	8.22E-03	5.18E-02	2.02	3.73
LSJRC07	2.74E-03	1.27E-02	ND	3.32E-03	0.218	1.55E-02	0.101	0.135	0.080	2.00E-03	0.126	7.80E-03	3.82E-03	1.64E-03	1.77E-02	0.522	0.896
LSJRC08	5.44E-03	8.64E-02	1.20E-02	1.83E-02	1.05	7.40E-02	0.484	0.632	0.350	8.81E-03	0.590	7.85E-02	5.85E-03	9.61E-03	5.39E-02	1.52	2.66
LSJRC09	4.11E-03	8.39E-02	1.14E-02	1.13E-02	0.963	5.72E-02	0.327	0.565	0.316	5.32E-03	0.358	6.78E-02	4.43E-03	8.31E-03	4.44E-02	0.904	1.56
LSJRC10	6.68E-03	1.11E-01	1.27E-02	1.90E-02	0.842	6.61E-02	0.549	0.545	0.290	9.29E-03	0.529	6.24E-02	4.86E-03	8.94E-03	5.14E-02	1.56	2.79
LSJRC11	1.09E-02	8.09E-02	1.39E-02	1.61E-02	1.17	6.72E-02	0.769	0.732	0.346	2.19E-02	0.482	8.75E-02	8.42E-03	1.04E-02	6.88E-02	1.33	2.47
LSJRC12	2.87E-02	4.67E-02	6.45E-02	ND	1.14	5.27E-02	0.332	0.682	0.473	2.06E-02	0.145	ND	ND	5.40E-03	1.36E-01	1.28	1.26
LSJRC13	4.92E-03	7.98E-02	1.27E-02	6.80E-03	0.816	4.36E-02	0.163	0.334	0.249	7.81E-03	0.191	8.19E-02	1.88E-03	6.28E-03	3.46E-02	0.744	0.593
LSJRC13-02	2.52E-03	5.35E-02	2.42E-03	4.37E-03	0.622	3.69E-02	0.184	0.302	0.327	5.02E-03	0.184	4.66E-02	3.43E-03	5.18E-03	2.43E-02	0.674	1.77
LSJRC14	7.69E-03	5.17E-02	1.11E-02	4.22E-03	0.537	2.85E-02	0.114	0.264	0.147	2.92E-03	0.122	5.70E-02	1.48E-03	6.14E-03	2.36E-02	0.503	0.428
LSJRC15	4.69E-03	5.78E-02	1.28E-02	9.93E-03	0.770	4.40E-02	0.296	0.480	0.241	4.50E-03	0.246	6.14E-02	3.61E-03	6.49E-03	3.87E-02	0.670	1.01
LSJRC16	3.63E-03	5.06E-02	7.76E-03	5.44E-03	0.441	2.57E-02	0.153	0.280	0.138	3.92E-03	0.124	3.89E-02	1.91E-03	4.95E-03	2.49E-02	0.452	0.569
LSJRC17	4.88E-03	3.86E-02	1.16E-02	3.85E-03	0.388	2.16E-02	0.178	0.247	0.120	4.13E-03	0.114	3.64E-02	1.94E-03	3.22E-03	2.24E-02	0.426	0.503

FIELD ID	Grain Size Normalized Metals Concentrations (mg/kg/%Mud)															
	Sb	**As**	**Be**	**Cd**	**Cr**	**Co**	**Cu**	**Pb**	**Li**	**Hg**	**Ni**	**Se**	**Ag**	**Tl**	**Sn**	**V**	**Zn**
LSJRC18	1.11E-02	2.44E-02	2.52E-02	5.21E-03	0.428	2.31E-02	0.136	0.295	0.171	2.91E-02	0.083	ND	ND	2.16E-03	4.76E-02	0.493	0.739
LSJRC19	1.02E-02	1.19E-01	2.13E-02	1.93E-02	1.49	8.64E-02	0.802	0.789	0.455	1.07E-02	0.589	1.15E-01	7.04E-03	1.36E-02	6.80E-02	1.37	2.22
LSJRC20	4.51E-03	5.57E-02	1.06E-02	9.80E-03	0.760	4.47E-02	0.350	0.368	0.231	5.44E-03	0.289	5.20E-02	3.80E-03	5.55E-03	5.53E-02	0.671	1.22
MOC07	3.12E-03	7.49E-02	8.83E-03	6.26E-03	0.649	4.88E-02	0.215	0.418	0.264	3.11E-03	0.157	2.34E-02	5.80E-03	3.36E-03	3.30E-02	0.605	1.11
NASCP01	4.91E-03	8.67E-02	9.16E-03	8.98E-03	0.666	4.85E-02	0.246	0.471	0.247	2.53E-03	0.156	1.53E-02	5.66E-03	3.86E-03	3.81E-02	0.604	2.04
NASM01	4.82E-03	1.03E-01	1.08E-02	9.81E-03	0.893	6.43E-02	0.307	0.557	0.352	3.64E-03	0.225	3.09E-02	7.26E-03	4.36E-03	4.69E-02	0.833	2.09
OBB	6.52E-03	7.18E-02	1.21E-02	1.11E-02	0.946	6.18E-02	0.395	0.571	0.382	5.34E-03	0.221	2.90E-02	5.27E-03	5.02E-03	4.92E-02	0.722	2.08
ORG01	6.58E-03	9.81E-02	1.39E-02	1.17E-02	1.10	6.02E-02	0.294	0.714	0.38	4.73E-03	0.260	4.06E-02	5.00E-03	7.61E-03	5.07E-02	0.817	1.52
PA32	7.14E-03	5.86E-02	8.23E-03	7.41E-03	0.634	3.53E-02	0.144	0.277	0.249	3.05E-03	0.106	5.57E-02	1.89E-03	9.66E-03	3.25E-02	0.709	0.709
PP61	3.98E-03	3.72E-02	2.14E-02	4.29E-03	0.425	2.43E-02	0.091	0.261	0.222	2.13E-03	0.074	1.53E-02	3.25E-03	3.60E-03	1.92E-02	0.426	0.614
RCCP02	8.07E-03	2.93E-02	ND	8.19E-03	0.779	4.98E-02	0.256	0.318	0.271	1.48E-03	0.548	2.22E-02	1.25E-02	4.23E-03	4.98E-02	2.85	6.36
WEK02	3.80E-03	5.67E-02	2.96E-03	9.65E-03	1.22	4.58E-02	0.268	0.642	0.390	4.91E-03	0.188	1.03E-01	3.65E-03	8.51E-03	2.79E-02	0.774	2.70
Cedar-Ortega River Basin Sites																	
CED01	1.50E-02	3.05E-01	4.24E-03	4.78E-02	1.20	7.43E-02	1.04	3.34	0.296	1.15E-02	0.284	4.09E-02	6.72E-02	4.69E-03	1.96E-01	0.901	25.6
CED02	1.52E-02	2.03E-01	1.04E-02	4.89E-02	1.26	9.96E-02	1.40	5.15	0.427	1.23E-02	0.321	3.09E-02	5.42E-02	6.23E-03	2.00E-01	0.937	19.2
CED03	1.08E-02	9.83E-02	1.67E-02	3.26E-02	0.830	8.52E-02	1.03	2.78	0.418	1.16E-02	0.260	2.68E-02	1.67E-02	6.69E-03	1.09E-01	0.729	9.59
CED04	1.01E-02	1.02E-01	9.46E-03	3.60E-02	0.963	7.78E-02	1.05	3.75	0.620	1.13E-02	0.269	1.95E-02	1.63E-02	5.92E-03	1.45E-01	0.782	9.46
CED05	9.72E-03	8.08E-02	7.52E-02	2.61E-02	1.06	1.20E-01	0.640	2.75	0.631	1.37E-02	0.342	3.80E-02	1.23E-02	1.06E-02	1.42E-01	1.29	7.06
CED06	2.15E-02	2.02E-01	4.15E-02	4.89E-02	2.11	1.69E-01	1.99	5.29	0.846	2.35E-02	0.555	5.48E-02	3.19E-02	1.31E-02	2.77E-01	1.61	16.5
CED07	1.02E-02	1.49E-01	2.44E-02	4.76E-02	1.91	1.36E-01	1.64	4.52	0.712	3.29E-02	0.478	4.84E-02	3.20E-02	1.06E-02	1.93E-01	1.33	12.2
CED08	7.98E-03	4.93E-02	7.15E-03	2.23E-02	0.846	6.83E-02	0.792	1.46	0.433	9.31E-03	0.242	3.69E-02	8.15E-03	5.50E-03	8.86E-02	0.735	4.95
CED09	1.07E-02	9.09E-02	6.53E-03	2.60E-02	0.938	7.30E-02	0.953	2.70	0.490	9.62E-03	0.272	3.65E-02	1.24E-02	5.35E-03	9.69E-02	0.819	9.49
ORT01	3.66E-03	7.03E-02	2.82E-02	1.88E-02	0.764	5.33E-02	0.282	0.682	0.420	8.43E-03	0.181	1.98E-02	1.05E-02	4.50E-03	5.43E-02	0.693	1.47
ORT02	2.95E-03	4.61E-02	1.76E-02	6.09E-03	0.663	5.88E-02	0.127	0.203	0.467	5.84E-03	0.174	1.89E-02	4.44E-03	5.08E-03	1.94E-02	0.725	0.637
ORT03	1.17E-03	4.96E-02	3.19E-02	2.55E-03	0.603	5.04E-02	0.063	0.139	0.398	6.78E-04	0.151	2.34E-02	1.28E-03	4.00E-03	1.47E-02	0.648	0.691
ORT04	2.91E-03	5.29E-02	1.55E-02	8.04E-03	0.664	5.99E-02	0.168	0.286	0.484	7.27E-03	0.185	2.08E-02	4.70E-03	5.11E-03	2.34E-02	0.714	0.792
ORT05	2.41E-03	5.56E-02	2.96E-02	9.72E-03	0.684	5.48E-02	0.241	0.519	0.449	6.36E-03	0.173	2.58E-02	5.82E-03	4.40E-03	3.90E-02	0.696	1.38
ORT06	2.67E-03	6.10E-02	3.35E-02	1.04E-02	0.772	5.11E-02	0.181	0.353	0.436	4.78E-03	0.165	2.17E-02	5.63E-03	3.72E-03	3.70E-02	0.699	1.05
ORT06-1	2.94E-03	4.98E-02	1.03E-02	1.19E-02	0.689	5.53E-02	0.206	0.389	0.557	4.42E-03	0.177	2.05E-02	6.41E-03	4.49E-03	3.06E-02	0.712	0.991
ORT07	8.10E-03	9.67E-02	1.85E-02	2.14E-02	0.983	7.77E-02	0.720	1.18	0.524	1.36E-02	0.274	2.55E-02	1.42E-02	5.87E-03	7.23E-02	0.923	3.01
ORT08	4.95E-03	7.94E-02	7.34E-03	1.57E-02	0.954	6.72E-02	0.361	0.682	0.521	8.53E-03	0.242	3.88E-02	1.31E-02	5.11E-03	5.78E-02	0.853	2.50
ORT09	4.79E-03	8.90E-02	3.77E-02	2.37E-02	0.820	5.73E-02	0.398	0.883	0.465	1.44E-02	0.193	2.14E-02	1.27E-02	4.90E-03	8.63E-02	0.784	3.27
ORT10	3.70E-03	8.72E-02	3.22E-02	1.83E-02	0.799	5.91E-02	0.497	0.937	0.432	1.42E-02	0.199	2.32E-02	1.26E-02	4.82E-03	6.97E-02	0.738	2.54
ORT11	7.57E-03	1.72E-01	5.92E-02	2.63E-02	1.60	1.25E-01	0.658	1.39	0.841	1.25E-02	0.405	4.18E-02	1.64E-02	1.01E-02	1.08E-01	1.61	5.54

FIELD ID	Grain Size Normalized Metals Concentrations (mg/kg/%Mud)															
	Sb	**As**	**Be**	**Cd**	**Cr**	**Co**	**Cu**	**Pb**	**Li**	**Hg**	**Ni**	**Se**	**Ag**	**Tl**	**Sn**	**V**	**Zn**
ORT12	4.06E-03	9.14E-02	2.87E-02	1.26E-02	0.860	6.73E-02	0.619	0.87	0.483	7.92E-03	0.219	2.55E-02	8.72E-03	5.59E-03	6.05E-02	0.850	2.15
ORT13	3.99E-03	8.37E-02	3.73E-02	1.66E-02	0.830	6.36E-02	0.480	1.04	0.464	8.02E-03	0.215	2.21E-02	9.94E-03	5.06E-03	6.66E-02	0.795	3.12
ORT14	2.20E-03	4.34E-02	1.13E-02	5.60E-03	0.699	6.23E-02	0.148	0.237	0.703	2.18E-03	0.186	1.98E-02	3.92E-03	4.91E-03	2.16E-02	0.758	0.646
ORT15	7.65E-03	1.56E-01	1.60E-02	1.91E-02	1.05	8.14E-02	1.54	1.13	0.515	1.15E-02	0.282	4.34E-02	1.77E-02	5.36E-03	8.41E-02	0.921	4.81
ORT16	3.15E-03	4.99E-02	8.33E-03	1.03E-02	0.733	5.90E-02	0.387	0.599	0.634	7.40E-03	0.194	2.04E-02	7.00E-03	4.59E-03	3.77E-02	0.724	1.55
ORT18	4.40E-03	5.41E-02	9.85E-03	1.32E-02	0.729	6.33E-02	0.421	0.820	0.618	7.78E-03	0.205	1.87E-02	7.27E-03	4.69E-03	4.76E-02	0.740	2.03
ORT19	7.74E-03	6.55E-02	1.79E-04	6.75E-03	0.354	3.80E-02	2.10	1.18	0.339	4.78E-02	0.100	1.15E-02	6.06E-03	2.79E-03	6.67E-02	0.406	3.06
ORT20	2.49E-03	4.45E-02	7.89E-03	3.89E-03	0.553	5.66E-02	0.167	0.245	0.584	1.40E-03	0.164	1.68E-02	2.55E-03	4.12E-03	1.55E-02	0.647	0.630
ORT21	9.81E-03	1.75E-01	4.81E-02	3.24E-02	2.16	1.51E-01	1.15	2.63	0.955	3.11E-02	0.527	6.40E-02	2.67E-02	1.08E-02	1.50E-01	1.71	5.19
ORT22	5.75E-03	9.29E-02	1.21E-02	1.82E-02	0.772	6.57E-02	1.15	1.12	0.534	2.39E-02	0.218	1.98E-02	1.04E-02	4.76E-03	6.43E-02	0.743	5.22
ORT23	8.15E-03	1.53E-01	3.87E-02	1.92E-02	1.86	1.35E-01	0.871	1.71	1.14	2.31E-02	0.454	4.87E-02	1.57E-02	8.68E-03	1.00E-01	1.55	6.26
ORT24	1.57E-02	2.94E-01	5.42E-02	4.49E-02	2.95	2.09E-01	2.24	3.96	1.41	3.93E-02	0.747	8.40E-02	3.78E-02	1.46E-02	2.26E-01	2.37	10.4
ORT25	3.85E-02	3.36E-01	6.71E-02	8.36E-02	3.89	2.79E-01	4.12	6.43	1.48	3.60E-02	0.971	1.09E-01	5.70E-02	2.45E-02	3.18E-01	3.25	25.1
ORT26	2.20E-02	2.11E-01	4.55E-02	6.16E-02	2.78	1.98E-01	2.30	4.20	1.11	3.73E-02	0.706	7.41E-02	3.74E-02	1.86E-02	2.27E-01	2.26	9.84
ORT27	9.12E-03	8.60E-02	9.86E-03	2.44E-02	1.00	6.80E-02	1.00	1.87	0.438	1.53E-02	0.263	3.65E-02	1.95E-02	5.27E-03	1.09E-01	0.736	8.24
ORT28	2.01E-02	3.21E-01	3.25E-02	4.98E-02	2.48	1.86E-01	2.19	3.27	1.16	2.77E-02	0.660	8.68E-02	3.00E-02	1.72E-02	1.82E-01	2.17	13.9
ORT29	5.76E-03	3.55E-02	9.71E-03	1.88E-02	0.949	7.32E-02	0.472	0.973	0.582	1.25E-02	0.270	3.11E-02	1.06E-02	5.08E-03	7.08E-02	0.835	2.12
ORT30	2.50E-03	3.66E-02	3.58E-02	3.74E-03	0.497	3.98E-02	0.131	0.272	0.309	2.72E-03	0.116	1.10E-02	2.88E-03	3.68E-03	2.88E-02	0.720	2.03
ORT31	2.18E-02	1.94E-01	3.57E-02	6.30E-02	2.17	1.38E-01	1.61	9.27	0.821	3.42E-02	0.546	5.65E-02	9.01E-02	1.68E-02	2.05E-01	1.82	10.5
ORT32	1.91E-02	2.42E-01	3.32E-02	4.43E-02	2.34	1.66E-01	1.55	3.59	0.941	2.02E-02	0.575	6.04E-02	4.54E-02	1.60E-02	1.84E-01	2.06	6.85
ORT33	7.26E-03	3.94E-02	2.13E-02	1.25E-02	0.365	3.54E-02	0.474	1.89	0.334	1.94E-03	0.111	5.37E-03	5.47E-03	3.13E-03	4.84E-02	0.475	4.73
ORT34	4.45E-03	4.85E-02	1.05E-02	1.55E-02	0.788	6.93E-02	0.485	0.969	0.732	8.59E-03	0.223	2.11E-02	8.07E-03	5.11E-03	5.77E-02	0.776	2.65
ORT35	9.85E-03	1.94E-01	3.08E-02	1.82E-02	1.84	1.39E-01	1.08	2.03	1.04	2.22E-02	0.469	6.37E-02	1.43E-02	8.85E-03	1.20E-01	1.54	5.34
ORT36	1.20E-02	1.58E-01	1.84E-02	3.15E-02	1.76	1.35E-01	0.991	1.98	0.809	1.69E-02	0.457	5.93E-02	1.71E-02	1.32E-02	1.15E-01	1.55	4.57
ORT37	1.72E-02	1.65E-01	2.69E-02	4.08E-02	2.04	1.50E-01	1.55	3.25	0.820	2.95E-02	0.524	5.95E-02	2.09E-02	1.64E-02	1.74E-01	1.55	7.97
ORT38	8.96E-03	2.00E-01	5.92E-02	4.33E-02	1.54	1.16E-01	0.737	1.81	0.835	3.49E-02	0.390	4.18E-02	2.01E-02	9.42E-03	1.68E-01	1.51	3.90
ORT39	8.63E-03	8.85E-02	7.17E-03	3.38E-02	1.51	9.82E-02	0.629	1.55	0.613	3.28E-02	0.381	4.02E-02	2.01E-02	6.89E-03	1.15E-01	1.13	4.34
ORT39-1	3.94E-03	5.67E-02	9.94E-03	1.48E-02	0.803	7.52E-02	0.329	0.798	0.818	8.52E-03	0.239	2.14E-02	7.00E-03	5.47E-03	4.77E-02	0.823	2.20
ORT40	4.45E-03	7.37E-02	4.90E-02	2.25E-02	0.877	6.78E-02	0.644	1.52	0.524	1.12E-02	0.250	2.22E-02	1.10E-02	5.10E-03	9.45E-02	0.835	4.25
ORT41	5.65E-03	5.41E-02	2.13E-02	1.16E-02	0.717	7.69E-02	0.344	0.514	0.672	1.30E-02	0.233	3.06E-02	5.82E-03	6.00E-03	3.57E-02	0.792	1.44

Based solely on the effects-based sediment quality guideline values (discussed further in Section 4), specifically the effects range-median (ERM) values, one would expect the abundance of the following non-crustal metals to be approximately as follows:

Zn > Cr > Cu > Pb > As > Ni > Cd > Ag > Hg

Comparisons of the median metal concentrations in the Lower St. Johns River Sites (Table 3-10) indicate that the abundance of the metals follows a similar trend, with a few exceptions. The lead concentrations were, on average, actually higher than copper concentrations, the nickel concentrations were higher than arsenic, and the mercury concentrations were higher than silver concentrations. The median metals concentrations were in the following order:

Zn > Cr > Pb > Cu > Ni > As > Cd > Hg > Ag

Comparison of the median metal concentrations in the Cedar-Ortega River Basin Sites (Table 3-10) indicate that, again, the abundance of the metals followed a similar trend to the ERM relationship, with a few exceptions. Lead concentrations were higher than both chromium and copper concentrations, on average, and nickel concentrations were higher on average than arsenic. The median metals in the Cedar-Ortega River sediments concentrations were in the following order:

Zn > Pb > Cr > Cu > Ni > As > Cd > Ag > Hg

3.3 Results for Ancillary Measurements

The total organic carbon (TOC), grain size, moisture content, total solids (TS), and total volatile solids (TVS) results are presented in Tables 3-12 and 3-13, and in Appendix F. Sediment elutriate results are presented in Tables 3-14 and 3-15, and Appendix G. TOC and TVS data are presented as percent dry weight. Moisture and TS data are presented as percent wet weight. The grain-size data are presented as percent distribution of sand, silt, and clay. Percent mud was determined by adding the percent silt and clay, and is used for normalizing the metals concentrations to grain size.

3.3.1 TOC Results

The TOC concentrations for the LSJR and COR sampling sites are illustrated in Figures 3-4 and 3-5, respectively. As was observed with the organic and metals contaminants, the TOC content of the sediment varied greatly, ranging from 0.2% (site LSJ39) to 39.6% (LSJRC06) in the Lower St. Johns River, and from 2.3% (site ORT30) to 21.6% (ORT41) in the Cedar-Ortega River Basin. Low TOC concentrations are generally associated with coarse, sandy sediments (>80% sand). For instance, TOC concentrations were consistently less than 0.7% at sites with more than 90% sand. However, there was still *not* a good correlation between TOC and the sediment grain size (Figures 3-6 and 3-7); many of the samples were highly non-homogeneous and significant amounts of plant debris was observed in some samples, resulting in an atypical TOC/grain size relationships. Several sites, including DUN01, LSJRC02, and LSJRC18 had elevated TOC concentrations (25 to 35%) with relatively high apparent sand content (about 70%). The COR sites had a particularly unique TOC to grain size relationship, with most samples having a relatively high and uniform TOC content (most were in the 10 to 20% TOC range), while the grain size was more variable (%mud mostly in the 20 to 80% range), indicating a lack of relationship between the sources and physico-chemistry of the organic carbon and the mineral component of the sediment.

3.3.2 Grain Size Results

The sediment grain-size distributions were highly variable and complex (Table 3-13 and Figures 3-8 and 3-9). The sites included areas dominated by muddy (fine-grained, silty) sediments and a few others dominated by coarse sediments (primarily sand). The grain size composition can be characterized as a continuum of grain-size distributions and is reported as a percentage of the total wet sediment volume. Overall, the grain size composition was variable throughout the area and ranged from 2% to 84% mud and from approximately 15% to 98 % sand.

The sediments were, for the most part, fairly fine in consistency. The median mud content was 50.6% and 65.8% for the LSJR and COR, respectively. However, most of the fine grain material or mud was comprised of silt; the clay content was generally low (mostly less than 10% clay). Only approximately 9% (7 of 77) of the LSJR sites had <10% mud (mud is defined as the silt plus clay fraction) and none of the COR sites had less than 20% mud. The Cedar-Ortega samples were, on average, less sandy and more muddy than the Lower St. Johns River samples.

3.3.3 Sediment Moisture Content, Total Solids, and Total Volatile Solids

Sediment moisture content, TS, and TVS also varied greatly for the sediment samples. Moisture, TS, and TVS content were characterized by a range of distributions, with no obvious groupings of sediment types. Percent moisture content ranges from 22% to 91%. TS and TVS concentrations range from 9% to 78%, and 0.3 to 58%, respectively. The moisture content was, on average, more uniform among the COR sites than among the LSJR sites.

Table 3-12. Ranges for Ancillary Measurements

	Median	Min	Max
Lower St. Johns River Sites			
%Moisture	82.0	22.0	90.8
%TOC	12.5	0.2	39.6
%TS (wet weight)	18.0	9.2	78.1
%TVS (dry weight)	21.3	0.3	58.2
%Sand	49.3	19.8	98.4
%Silt	47.5	1.2	75.4
%Clay	2.8	0.5	11.1
%Mud	50.6	1.7	80.2
Cedar-Ortega River Basin Sites			
%Moisture	77.8	55.2	84.1
%TOC	12.5	2.3	21.6
%TS (wet weight)	22.2	15.9	44.8
%TVS (dry weight)	20.6	5.5	29.9
%Sand	34.4	15.9	79.3
%Silt	58.0	19.1	75.9
%Clay	6.4	1.6	23.7
%Mud	65.8	20.7	84.2

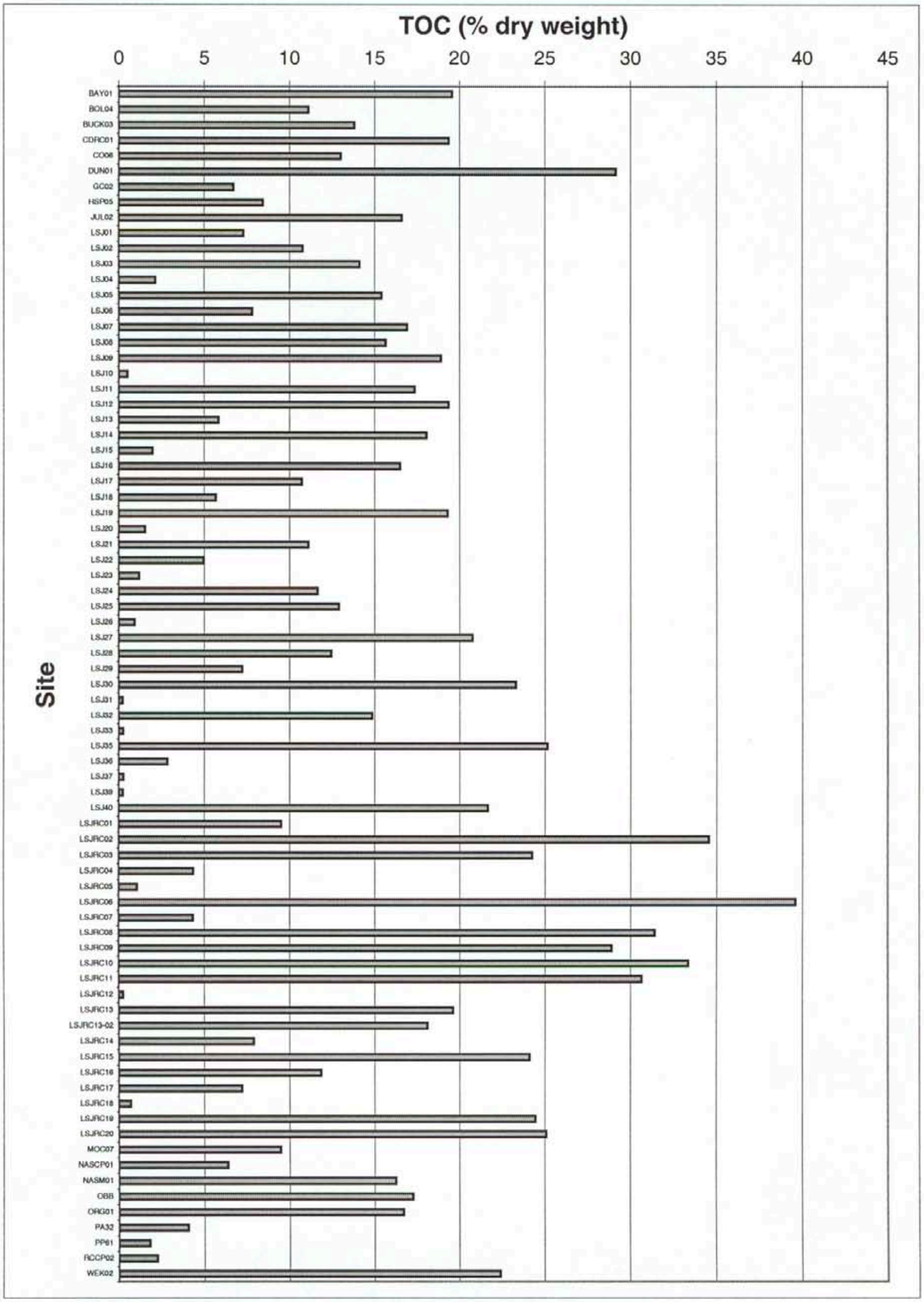


Figure 3-4. Lower St. Johns River — Total Organic Carbon (%TOC) of Sediments

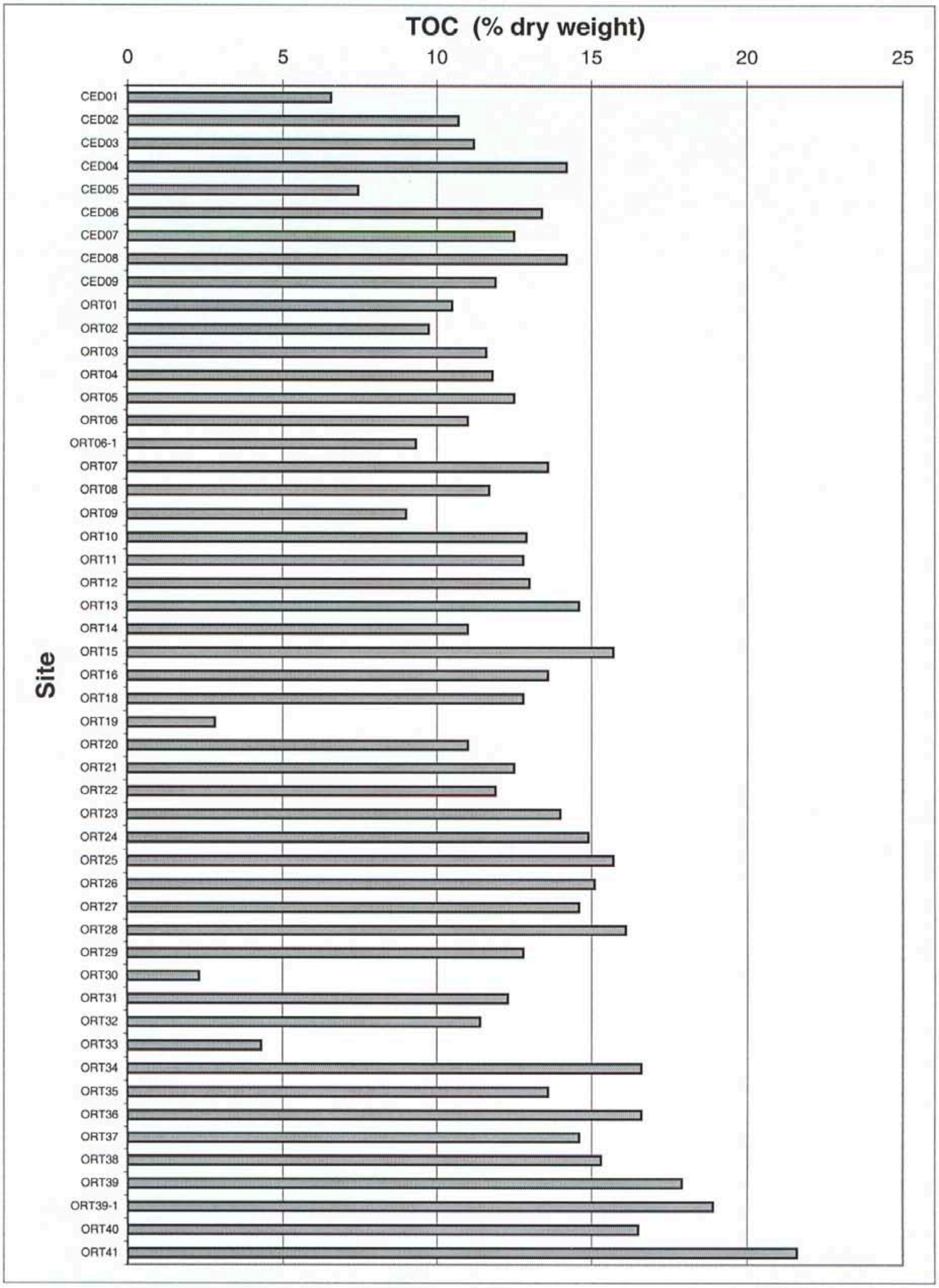


Figure 3-5. Cedar-Ortega River Basin — Total Organic Carbon (%TOC) of Sediments

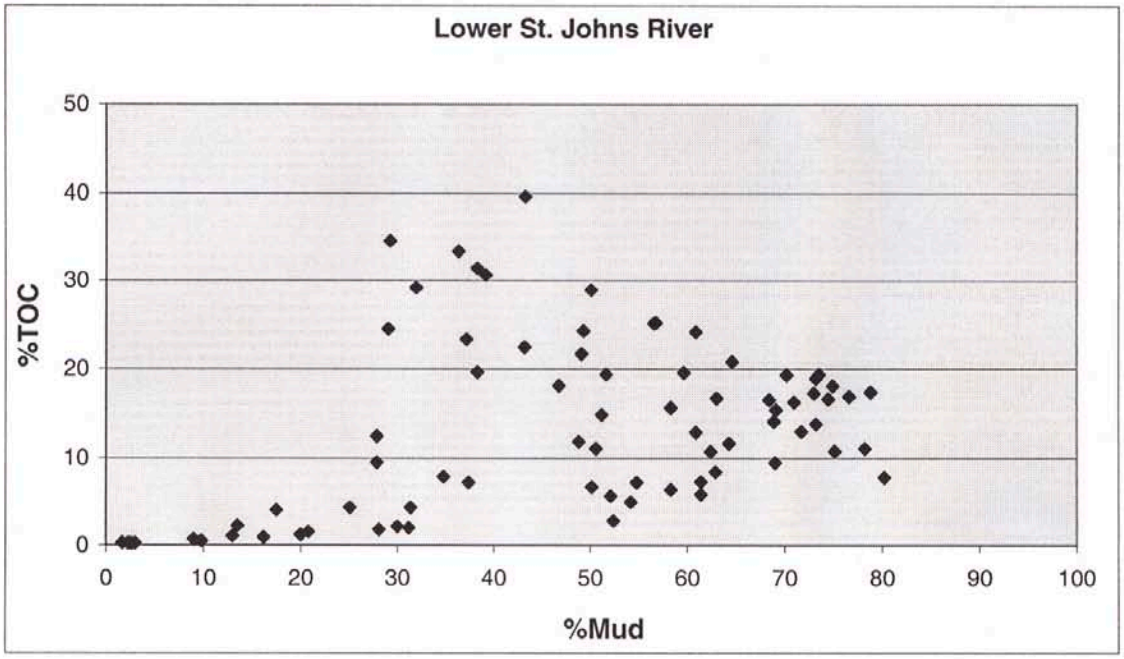


Figure 3-6. Lower St. Johns River — %TOC versus %Mud

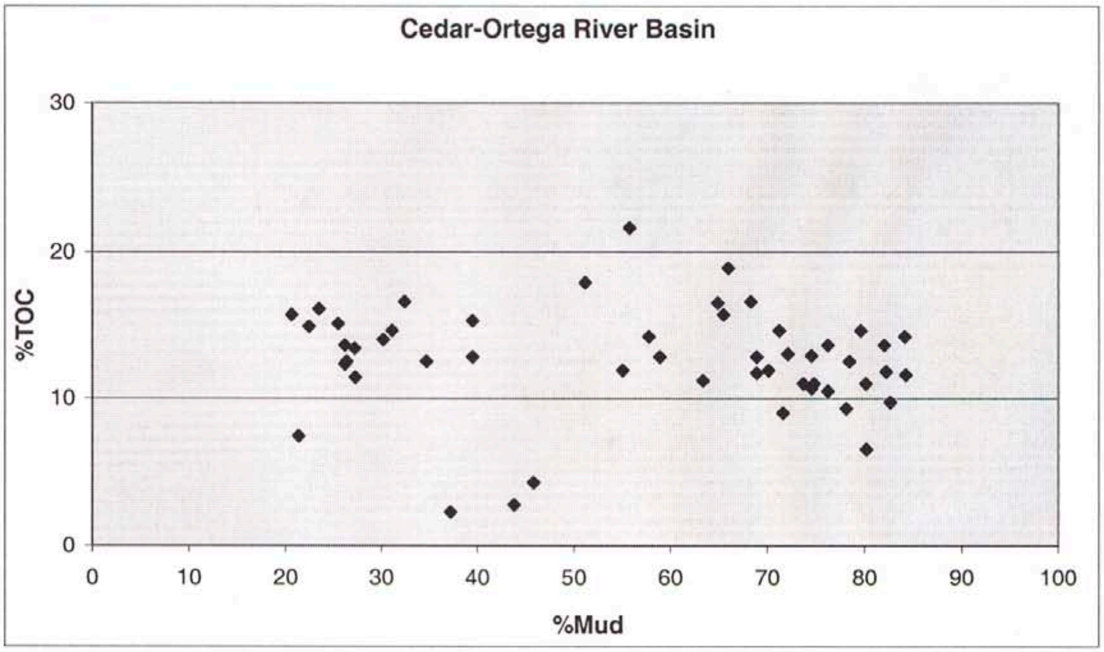


Figure 3-7. Cedar-Ortega River Basin — %TOC versus %Mud

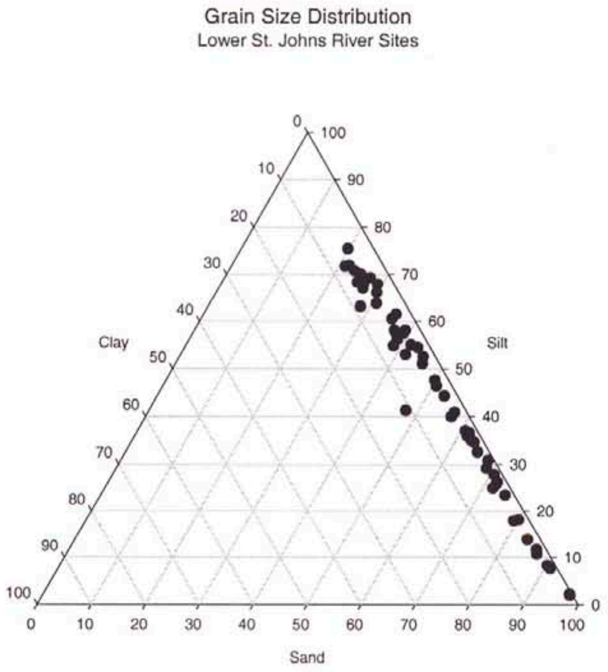


Figure 3-8. Lower St. Johns River — Grain Size Distribution of Sediments

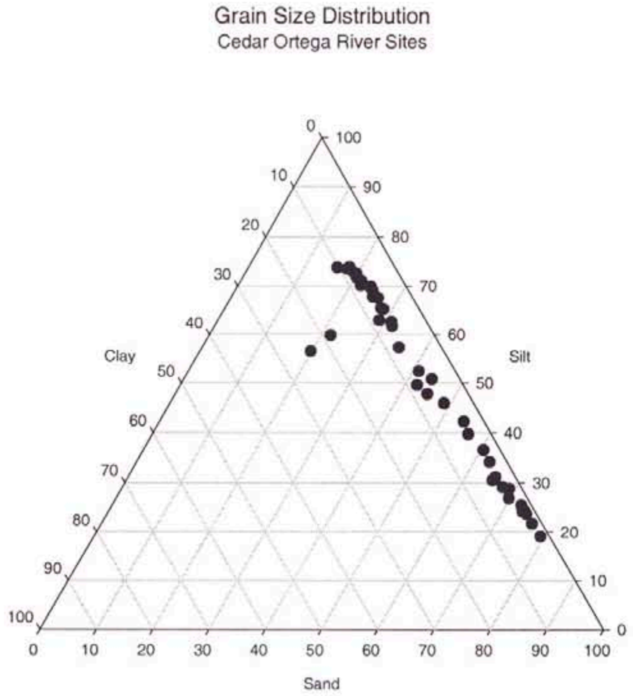


Figure 3-9. Cedar-Ortega River Basin — Grain Size Distribution of Sediments

Table 3-13. Ancillary Measurement Summary Data

FIELD ID	%Moisture	%TOC	%TS (wet wt)	%TVS (dry wt)	%Sand	%Silt	%Clay	%Mud
Lower St. Johns River Sites								
BAY01	86.3	19.6	13.7	28.2	40.4	56.8	2.9	59.7
BOL04	83.2	11.1	16.8	21.3	21.8	71.9	6.3	78.2
BUCK03	85.9	13.8	14.1	25.5	26.7	69.3	3.9	73.2
CDRC01	87.1	19.4	12.9	30.6	48.5	49.6	2.1	51.7
CO06	77.6	13.0	22.5	19.4	28.3	63.1	8.6	71.7
DUN01	89.0	29.2	11.1	48.6	68.0	30.9	1.2	32.0
GC02	72.1	6.7	28.0	11.5	49.9	47.6	2.6	50.2
HSP05	78.8	8.4	21.2	17.6	37.1	58.1	4.8	62.9
JUL02	85.4	16.6	14.7	28.0	25.6	69.9	4.6	74.5
LSJ01	76.8	7.3	23.3	14.3	38.6	54.8	6.6	61.4
LSJ02	85.4	10.8	14.7	21.2	24.9	70.0	5.1	75.1
LSJ03	84.6	14.1	15.5	22.9	31.0	63.3	5.6	68.9
LSJ04	47.7	2.2	52.3	5.3	70.1	26.5	3.5	30.0
LSJ05	84.2	15.4	15.9	23.7	30.9	63.8	5.3	69.1
LSJ06	72.6	7.8	27.5	14.6	19.8	75.4	4.8	80.2
LSJ07	87.5	16.9	12.5	26.2	23.4	70.7	5.9	76.6
LSJ08	83.0	15.7	17.1	21.4	41.7	53.0	5.3	58.3
LSJ09	86.4	18.9	13.6	27.1	26.8	67.0	6.2	73.2
LSJ10	26.0	0.5	74.0	0.9	90.2	8.3	1.5	9.8
LSJ11	83.6	17.4	16.5	22.7	21.2	71.7	7.1	78.8
LSJ12	85.4	19.4	14.7	26.1	26.5	67.9	5.6	73.5
LSJ13	71.9	5.9	28.2	11.1	38.6	56.1	5.3	61.4
LSJ14	85.9	18.1	14.2	26.3	25.1	68.3	6.6	74.9
LSJ15	45.0	2.0	55.1	3.2	68.7	27.4	3.8	31.2
LSJ16	85.0	16.5	15.0	24.1	31.5	63.5	4.9	68.4
LSJ17	75.4	10.7	24.7	15.8	37.6	57.6	4.8	62.4
LSJ18	67.7	5.7	32.3	9.3	48.0	47.5	4.6	52.1
LSJ19	80.7	19.3	19.4	21.2	29.8	66.1	4.1	70.2
LSJ20	43.5	1.6	56.6	2.7	79.2	17.9	2.9	20.8
LSJ21	80.3	11.1	19.7	18.4	49.3	47.3	3.3	50.6
LSJ22	70.5	5.0	29.5	9.4	45.8	51.1	3.1	54.2
LSJ23	66.7	1.2	33.4	23.2	80.0	18.1	1.9	20.0
LSJ24	82.3	11.7	17.7	21.0	35.7	61.5	2.8	64.3
LSJ25	82.0	12.9	18.0	22.4	39.1	57.4	3.5	60.9
LSJ26	36.7	0.9	63.3	1.6	83.8	13.8	2.4	16.2
LSJ27	86.5	20.8	13.6	32.6	35.4	60.5	4.1	64.6
LSJ28	78.9	12.5	21.1	21.6	72.1	26.2	1.7	27.9
LSJ29	71.7	7.2	28.3	12.6	45.2	52.5	2.3	54.8
LSJ30	86.6	23.3	13.5	38.0	62.8	35.1	2.1	37.2
LSJ31	25.3	0.2	74.8	0.3	97.3	2.2	0.5	2.7
LSJ32	82.8	14.9	17.2	25.3	48.9	47.7	3.5	51.2
LSJ33	27.7	0.3	72.4	0.4	97.8	1.8	0.5	2.3
LSJ35	89.9	25.2	10.2	40.9	43.2	54.5	2.3	56.8
LSJ36	49.4	2.8	50.7	7.4	47.6	41.3	11.1	52.4
LSJ37	25.2	0.3	74.8	0.4	98.4	1.2	0.5	1.7
LSJ39	24.6	0.2	75.4	0.9	97.5	2.0	0.5	2.5

FIELD ID	%Moisture	%TOC	%TS (wet wt)	%TVS (dry wt)	%Sand	%Silt	%Clay	%Mud
LSJ40	86.9	21.7	13.2	36.8	51.0	46.3	2.8	49.1
LSJRC01	66.7	9.5	33.4	14.0	72.1	25.8	2.1	27.9
LSJRC02	88.7	34.6	11.3	51.9	70.7	27.8	1.5	29.3
LSJRC03	85.5	24.3	14.5	36.1	50.7	46.4	2.9	49.3
LSJRC04	61.3	4.4	38.8	8.1	74.9	23.4	1.7	25.1
LSJRC05	29.2	1.1	70.9	2.3	87.0	10.8	2.2	13.0
LSJRC06	89.1	39.6	10.9	58.2	56.7	40.0	3.3	43.3
LSJRC07	53.2	4.3	46.9	7.3	68.6	29.1	2.3	31.4
LSJRC08	88.3	31.4	11.7	48.5	61.7	36.6	1.7	38.3
LSJRC09	90.8	28.9	9.2	45.0	49.8	47.8	2.3	50.1
LSJRC10	87.7	33.4	12.4	50.5	63.6	34.6	1.8	36.4
LSJRC11	87.6	30.7	12.4	45.6	60.8	37.0	2.2	39.2
LSJRC12	22.0	0.3	78.1	0.3	96.9	2.5	0.5	3.0
LSJRC13	82.7	19.6	17.4	29.5	61.7	35.9	2.4	38.3
LSJRC13-02	81.8	18.1	18.3	24.8	53.3	44.3	2.5	46.8
LSJRC14	69.0	7.9	31.1	14.7	65.2	32.6	2.2	34.8
LSJRC15	87.4	24.1	12.7	39.2	39.1	58.1	2.8	60.9
LSJRC16	75.6	11.9	24.5	20.8	51.3	46.4	2.4	48.8
LSJRC17	65.0	7.2	35.0	10.5	62.7	35.1	2.3	37.4
LSJRC18	28.1	0.7	72.0	1.3	91.0	7.7	1.3	9.0
LSJRC19	86.3	24.5	13.8	39.9	70.8	27.6	1.5	29.1
LSJRC20	90.1	25.1	10.0	42.5	43.3	54.3	2.3	56.6
MOC07	82.7	9.5	17.4	18.3	31.1	64.7	4.3	69.0
NASCP01	73.7	6.4	26.3	12.0	41.7	55.1	3.3	58.3
NASM01	88.8	16.3	11.3	29.3	29.1	67.9	3.1	71.0
OBB	86.5	17.3	13.6	27.1	27.0	69.2	3.8	73.0
ORG01	84.7	16.7	15.4	26.3	36.9	60.2	2.8	63.0
PA32	59.3	4.1	40.7	9.7	82.6	15.8	1.7	17.5
PP61	45.9	1.8	54.2	3.2	71.9	24.9	3.2	28.1
RCCP02	45.0	2.3	55.1	6.6	86.5	11.8	1.8	13.5
WEK02	82.1	22.4	18.0	29.7	56.8	40.9	2.3	43.2
Cedar-Ortega River Basin Sites								
CED01	64.8	6.6	35.2	16.2	19.8	56.5	23.7	80.2
CED02	71.1	10.7	28.9	21.8	25.6	61.6	12.9	74.5
CED03	74.8	11.2	25.2	19.2	36.7	56.3	7.1	63.4
CED04	80.6	14.2	19.4	23.4	15.9	73.8	10.3	84.1
CED05	73.9	7.4	26.1	17.7	78.5	19.8	1.6	21.4
CED06	71.6	13.4	28.4	23.1	72.9	24.7	2.5	27.2
CED07	74.2	12.5	25.8	24.5	65.3	31.1	3.6	34.7
CED08	64.7	14.2	35.3	21.7	42.2	49.6	8.2	57.8
CED09	69.9	11.9	30.1	21.7	44.9	47.8	7.3	55.1
ORT01	78.9	10.5	21.1	18.5	23.8	69.7	6.5	76.2
ORT02	74.5	9.7	25.5	17.6	17.3	73.6	9.0	82.6
ORT03	78.5	11.6	21.5	19.0	15.9	75.9	8.3	84.2
ORT04	76.8	11.8	23.2	20.1	17.8	73.5	8.7	82.2
ORT05	78.6	12.5	21.4	21.3	21.6	71.0	7.4	78.4
ORT06	77.0	11.0	23.0	17.3	19.9	72.6	7.5	80.1
ORT06-1	75.1	9.3	24.9	17.0	21.9	70.1	8.0	78.1
ORT07	82.3	13.6	17.7	22.4	23.8	69.9	6.3	76.2

FIELD ID	%Moisture	%TOC	%TS (wet wt)	%TVS (dry wt)	%Sand	%Silt	%Clay	%Mud
ORT08	75.7	11.7	24.3	20.1	31.1	62.6	6.3	68.9
ORT09	78.2	9.0	21.8	19.4	28.4	65.2	6.4	71.6
ORT10	80.8	12.9	19.2	22.0	25.5	67.9	6.6	74.5
ORT11	80.6	12.8	19.4	23.5	60.5	36.5	3.0	39.5
ORT12	81.2	13.0	18.8	22.2	27.9	65.4	6.7	72.1
ORT13	81.4	14.6	18.6	23.8	20.4	71.7	7.9	79.6
ORT14	78.2	11.0	21.8	19.8	26.3	67.5	6.2	73.7
ORT15	78.8	15.7	21.2	25.1	34.6	59.1	6.4	65.5
ORT16	79.3	13.6	20.7	19.9	18.0	73.9	8.1	82.0
ORT18	78.5	12.8	21.5	19.9	31.2	62.4	6.5	68.9
ORT19	58.5	2.8	41.6	6.3	56.2	39.7	4.1	43.8
ORT20	76.4	11.0	23.6	19.8	25.2	67.8	7.0	74.8
ORT21	72.9	12.5	27.1	18.1	73.6	24.2	2.2	26.4
ORT22	81.0	11.9	19.0	18.4	30.0	64.9	5.3	70.1
ORT23	72.8	14.0	27.2	20.4	69.8	26.9	3.3	30.2
ORT24	78.0	14.9	22.0	25.3	77.6	20.8	1.7	22.5
ORT25	77.9	15.7	22.1	27.5	79.3	19.1	1.6	20.7
ORT26	79.4	15.1	20.6	24.9	74.5	23.7	1.8	25.5
ORT27	73.2	14.6	26.8	25.2	28.8	62.9	8.3	71.2
ORT28	80.3	16.1	19.7	25.3	76.5	21.7	1.8	23.5
ORT29	73.0	12.8	27.0	20.4	41.1	52.4	6.5	58.9
ORT30	55.2	2.3	44.8	5.5	62.8	34.1	3.1	37.2
ORT31	73.3	12.3	26.7	19.6	73.8	24.4	1.8	26.2
ORT32	74.5	11.4	25.5	20.5	72.7	25.5	1.8	27.3
ORT33	58.9	4.3	41.2	7.5	54.2	42.2	3.7	45.9
ORT34	79.7	16.6	20.3	23.7	31.7	61.7	6.6	68.3
ORT35	77.7	13.6	22.3	23.5	73.9	23.5	2.7	26.2
ORT36	76.7	16.6	23.3	28.5	67.6	29.1	3.3	32.4
ORT37	79.2	14.6	20.8	25.0	68.9	28.8	2.3	31.1
ORT38	79.9	15.3	20.1	27.2	60.4	35.6	3.9	39.5
ORT39	79.1	17.9	20.9	29.1	48.8	45.9	5.3	51.2
ORT39-1	80.1	18.9	19.9	29.9	34.1	58.6	7.4	66.0
ORT40	84.1	16.5	15.9	28.2	35.1	57.3	7.6	64.9
ORT41	83.1	21.6	16.9	27.7	44.2	50.8	5.0	55.8

3.3.4 Elutriate Metals

The elutriate sample metals concentrations (Ca, Mg, K, and Na), and the conductivity, were more variable in the LSJR sediments than in COR sediments. Calcium, magnesium, potassium, and sodium concentrations in elutriate waters isolated from the sediments from the LSJR sites ranged from 41,500 to 156,000 µg/L, 8,180 to 280,000 µg/L, 2,610 to 85,100 µg/L, and 64,500 to 2,240,000 µg/L, respectively. The concentrations of these same elutriate metal ranged from 36,400 to 78,900 µg/L, 40,800 to 112,000 µg/L, 14,200 to 36,300 µg/L, and 208,000 to 869,000 µg/L for the COR sites. LSJR sites, LSJ02, LSJ03, LSJ04, CO06, and HSP05 had concentrations of magnesium, potassium, and sodium that were 8, 10, and 15 times greater than the median concentration for the LSJR sites. Elutriate metal concentrations and conductivity were, on average, more uniform among the COR sites than among the LSJR sites.

Table 3-14. Ranges for Elutriate Metals

	Median (µg/L)	Min (µg/L)	Max (µg/L)
Lower St. Johns River Sites			
Calcium	71,700	41,500	156,000
Magnesium	22,000	8,180	280,000
Potassium	5,050	2,610	85,100
Sodium	97,700	64,500	2,240,000
Conductivity[1]	1,010	422	12,900
Cedar Ortega River Basin Sites			
Calcium	54,400	36,400	78,900
Magnesium	57,300	40,800	112,000
Potassium	23,400	14,200	36,300
Sodium	473,000	208,000	869,000
Conductivity[1]	2,770	678	5,100

[1] Conductivity measured in units of µmhoms/cm.

Table 3-15. Elutriate Metals Summary Data

FIELD ID	Calcium (µg/L)	Magnesium (µg/L)	Potassium (µg/L)	Sodium (µg/L)	Conductivity (µmhoms/cm)
Lower St. Johns River Sites					
BOL04	108,000	127,000	34,400	904,000	5,900
BUCK03	91,200	90,500	18,300	655,000	4,250
CO06	138,000	197,000	52,800	1,440,000	7,430
HSP05	156,000	280000	85,100	2,240,000	12,900
JUL02	54,200	26,600	6,690	98,600	990
LSJ01	86,500	133,000	34,300	967,000	5,830
LSJ02	129,000	195,000	44,100	1,390,000	8,380
LSJ03	136,000	124,000	33,600	1,010,000	6,350
LSJ04	71,700	131,000	42,600	1,080,000	6,350
LSJ05	133,000	97,200	23,800	596,000	4,160
LSJ06	94,600	114,000	34,100	895,000	5,540
LSJ07	87,600	88,700	24,400	625,000	4,270
LSJ08	85,300	77,000	18,800	506,000	3,460
LSJ09	64,500	51,700	13,000	325,000	2,190
LSJ11	75,000	78,300	18,300	525,000	3,460
LSJ12	65,000	41,600	11,800	260,000	1,910
LSJ13	103,000	50,700	12,500	403,000	2,710
LSJ14	67,900	44,200	10,700	238,000	1,730
LSJ15	87,900	37,700	8,800	258,000	2,030
LSJ16	53,600	42,200	9,220	225,000	1,620
LSJ17	53,200	22,200	5,990	127,000	1,040
LSJ18	60,000	20,900	4,520	110,000	904
LSJ19	56,300	25,500	6,660	113,000	983
LSJ20	46,800	15,600	4,460	90,600	757
LSJ21	65,400	19,200	4,700	95,600	881

FIELD ID	Calcium (µg/L)	Magnesium (µg/L)	Potassium (µg/L)	Sodium (µg/L)	Conductivity (µmhoms/cm)
LSJ22	52,600	16,000	4,310	86,800	768
LSJ23	49,100	19,300	5,050	83,800	833
LSJ24	66,200	23,200	4,810	87,500	959
LSJ25	75,600	24,100	5,490	87,800	1,010
LSJ26	42,600	14,100	3,550	71,600	1,140
LSJ27	72,200	22,000	4,700	82,500	928
LSJ28	82,300	21,100	4,570	93,100	912
LSJ29	93,100	20,200	3,900	80,700	891
LSJ30	74,200	15,000	3,080	77,900	711
LSJ31	74,000	16,800	6,820	76,700	530
LSJ32	95,200	20,800	3,850	92,600	955
LSJ33	62,600	12,300	5,050	77,400	530
LSJ35	77,700	25,300	4,630	90,900	1,010
LSJ36	47,300	15,200	3,740	82,200	791
LSJ37	56,200	17,500	5,890	91,500	843
LSJ39	43,700	13,600	4,230	75,400	422
LSJ40	87,600	19,600	6,150	77,800	938
LSJRC01	54,800	12,300	2,870	91,000	734
LSJRC02	105,000	25,700	5,350	82,600	1,180
LSJRC03	83,000	18,100	3,460	97,400	979
LSJRC04	64,000	16,300	3,810	97,100	918
LSJRC05	48,200	8,280	2,640	64,500	561
LSJRC06	74,200	16,700	4,550	112,000	1,080
LSJRC07	41,500	8,180	2,610	69,100	520
LSJRC08	85,400	23,300	5,480	109,000	1,140
LSJRC09	64,500	18,400	3,930	94,300	877
LSJRC10	63,000	13,700	2,870	88,300	734
LSJRC11	70,300	17,300	3,040	97,700	918
LSJRC12	66,600	14,300	5,090	92,800	1,070
LSJRC13	61,000	14,500	3,260	90,600	867
LSJRC14	72,200	17,300	3,640	96,500	918
LSJRC15	89,200	22,000	3,880	105,000	1,100
LSJRC16	75,100	18,800	3,580	95,800	968
LSJRC17	82,700	19,800	4,080	75,100	897
LSJRC18	51,400	14,400	4,440	105,000	867
LSJRC19	90,200	24,300	4,820	99,400	1,140
LSJRC20	86,100	23,600	4,290	100,000	1,070
MOC07	71,700	49,600	12,200	341,000	2,440
NASCP01	80,700	46,400	12,400	276,000	2,230
NASM01	67,800	88,900	23,000	433,000	2,980
ORG01	67,550	24,750	5,520	111,500	1,110
PA32	65,800	15,100	3,090	80,900	711
PP61	55,400	19,500	4,750	95,100	796
RCCP02	45,400	8,380	7,870	299,000	1,750
Cedar Ortega River Basin Sites					
CED01	52,500	55,300	15,900	358,000	2,450
CED02	63,500	72,800	23,700	572,000	3,340
CED06	71,300	42,200	16,400	301,000	1,930
CED07	53,800	51,100	25,700	473,000	678

FIELD ID	Calcium (μg/L)	Magnesium (μg/L)	Potassium (μg/L)	Sodium (μg/L)	Conductivity (μmhoms/cm)
CED08	52,500	40,800	14,800	208,000	1,560
CED09	41,900	42,400	14,200	241,000	1,550
ORT08	75,600	112,000	32,700	869,000	5,100
ORT15	40,400	52,800	18,600	368,000	2,160
ORT21	52,600	60,500	27,300	541,000	3,160
ORT23	69,500	65,300	27,700	571,000	3,280
ORT25	51,750	49,700	17,600	327,000	2,025
ORT26	47,000	62,900	25,900	499,000	2,820
ORT27	65,800	93,800	27,700	705,000	4,020
ORT28	36,400	46,300	19,200	344,000	2,000
ORT29	60,900	52,700	20,500	394,000	2,550
ORT31	63,700	59,800	27,900	513,000	5,100
ORT32	61,200	105,000	36,300	868,000	4,740
ORT35	54,900	56,300	22,600	453,000	2,710
ORT36	62,800	77,300	24,900	564,000	3,390
ORT37	48,900	58,300	21,400	472,000	2,820
ORT39	78,900	97,400	29,100	699,000	4,220

4. DISCUSSION

The samples collected in this study were from two major water bodies: the main stem of the Lower St. Johns River (LSJR) and the Cedar-Ortega River (COR) Basin (Figures 2-1 through 2-5). The LSJR sites were mostly in the wide main stem portion of the river, where the river is 1.5 to 2.5 miles across. A few samples were also collected south of Palatka in locations where the river was as narrow as 1,000 ft. Most of the COR samples were collected in a 2 mile long and 1,000 to 2,000 ft. wide segment of the basin, below the confluence of the Cedar and Ortega Rivers and down to the mouth at the confluence with the Lower St. Johns River. A few samples were also collected to about 1 mile upstream in the Ortega River and to about 2 miles upstream in the Cedar River, where that river was no more than about 150 ft. wide.

The predominant land use types are wetlands, forest, and agriculture along the main stem of the Lower St. Johns River (Figure 1-2 and Appendix A), with pockets of more densely populated residential areas at Welaka, Palatka, Green Cove Springs, Black Creek, and Doctors Lake. The near-shore area along the northern most 5 miles of the river segment that was studied (near Jacksonville) is dominated by residential use. Of course, and as discussed in Section 1, the St. Johns River drains a very large area, and the near-shore land use is only part of what impacts the contaminant characteristics of the river.

The presentation below focuses on three aspects of the sediment contamination. These include 1) the general contaminant concentrations, distribution, and composition in the study area, and how the measured contaminant levels compare to those reported for other aquatic systems around the country, 2) identification of geographically unique contaminant profiles and a summary of possible “hot spots”, and 3) the potential of measured concentrations to cause impact to the water bodies. The data assessment is separated by the two main water bodies that were investigated; the Lower St. Johns River (Section 4.1) and the Cedar-Ortega River Basin (Section 4.2), and there are separate discussions of the organic compound and metals contaminants.

4.1 Lower St. Johns River Contaminant Levels

4.1.1 Organic Compound Contaminant Levels

Organic Contaminant Compounds — Review/Overview

The major classes of organic compounds analyzed were polycyclic aromatic hydrocarbons (PAH), phthalates, polychlorinated biphenyls (PCBs), a group of other chlorinated industrial organic compounds, a series of chlorinated pesticides (e.g., DDTs, chlordane, BHCs, and endosulfans), and selected classes of chlorinated phenolic compounds (chlorinated phenols, anisoles, guaiacols, and catechols). These groups of compounds were categorized, and the analytical results presented, in Sections 3.1.1, 3.1.2, and 3.1.3.

PAH. PAH are among the most widespread and important organic contaminants. PAH are ubiquitous trace components of terrestrial, aquatic, and marine environments. PAH are composed of two or more fused benzene (aromatic) rings. Naphthalene ($C_{10}H_8$), which consists of two fused aromatic rings, is the lowest molecular weight PAH. PAH with up to nine rings have been identified in the heavy residual fractions of crude oil and in coal tars. PAH from two to six ring [e.g., benzo(g,h,i)perylene] are most commonly monitored as environmental contaminants, and this was the molecular weight range included in this project.

PAH may be formed by four different mechanisms (Neff, 1979):

- Very rapid, high temperature (e.g., 700°C) incomplete combustion (pyrolysis) of organic matter (e.g., combustion of fossil fuels)
- Very slow (e.g., millions of years) rearrangement and transformation of organic matter at moderate temperatures of 100–300°C to form fossil fuels (coal and petroleum)
- Relatively rapid (days to years) transformation of certain pigments and sterols in soils and sediments
- Direct biosynthesis by organisms

The last two processes appear not to be quantitatively important sources of PAH in the environment and result in the production of very simple assemblages of PAH. Examples of these assemblages include perylene and certain C_2 and C_3 alkyl phenanthrenes (retene).

Coal and petroleum are rich sources of PAH. Coal generally is considered an aromatic material. Most of the PAH in coal is tightly bound in the coal structure and is not readily leached out. Nevertheless, a substantial fraction of the total PAH in sediments from industrial bays and estuaries may be derived from coal dust (Tripp, *et al*., 1981).

Typical crude petroleum may contain from 0.2 to more than 7 percent PAH. The abundance of aromatic hydrocarbons in petroleum decreases markedly with increasing molecular weight. In most cases, the 1-ring (benzenes) through 3-ring (phenanthrenes) aromatics account for at least 90 percent of the aromatic hydrocarbons that can be resolved in crude petroleum.

The aromatic hydrocarbons in coal and petroleum usually contain one or more alkyl hydrocarbon chains containing one or more carbon atoms. As a general rule, these alkyl aromatics are more abundant than the parent compounds in petroleum. Homologues with two to five alkyl carbons usually are more abundant than less or more highly alkylated homologues.

A major source of PAH containing three or more aromatic rings in the environment is combustion of organic matter (Neff, *et al*., 1979). Combustion of any organic material, including fossil fuels, will generate a wide variety of PAH. The PAH assemblages produced by pyrolysis of organic matter are complex, and, unlike the assemblages in petroleum, are dominated by 4-, 5-, and 6-ring PAH. In pyrogenic PAH assemblages, the dominant compound in each homologous series is the unalkylated parent compound or a homologue with only one or two alkyl carbons. In contrast, as mentioned above, in petrogenic PAH assemblages, the relative abundance of compounds in each homologous series increases to a maximum for the homologues containing three to four, and occasionally five, alkyl carbons. However, the relative distribution for the different alkyl homologues varies significantly for different crude oils and refined petroleum products.

Another important, though localized, source of PAH in the aquatic environment is creosote, coal tars, and related materials derived from the high-temperature carbonization of coal and petroleum. These materials are derived from high-temperature processing of fossil fuels, and so the PAH contained in them have some of the properties of both pyrogenic and petrogenic PAH assemblages. Asphalt and tar, used to pave roads and parking lots and to waterproof the roofs of houses, also are byproducts of petroleum and contain abundant PAH. Paved road surfaces often contain high concentrations of PAHs, derived from a combination of deposition of exhaust soot from vehicles, wear of tires releasing carbon black, which is rich in pyrogenic PAHs, and wear of the asphalt pavement. PAH washed by rain from road surfaces often reaches the aquatic environment in runoff from land, particularly through storm drains and combined sewer overflows.

It has been proposed that PAH of pyrogenic and petrogenic origins have a different behavior in the aquatic environment (Farrington, *et al*., 1986). PAH of pyrogenic origin are mostly tightly bound to soot particles owing to the high-temperature formation process and are not readily desorbed and bioaccumulated by aquatic organisms. Crude and refined petroleum products enter the aquatic environment in soluble, colloidal, bulk, or more loosely bound form and, therefore, are more mobile and available for uptake and bioaccumulation. PAH from creosote and other solid tar-derived products seem to have a behavior intermediate between those of pyrogenic and petrogenic PAH (Hugget *et al*., 1987).

Phthalate Esters. The phthalate ester compounds are also ubiquitous in the environment. Phthalates are typically not considered to cause adverse effects to the same degree as many of the other organic compounds that were analyzed, but they are among the most widely used industrial chemicals (e.g., major components of most plastics), and are part of our daily life and, therefore, are introduced into the environment from countless sources. They are also common laboratory contaminants, in particular bis(2-ethylhexyl)phthalate and di-N-butylphthalate.

Industrial Chlorinated Compounds. The “other industrial chlorinated compounds” are a group of chlorinated, relatively low molecular weight, organic compounds. These compounds include di, tri, and tetrachlorinated benzenes, and they are also widely used in many industrial processes and applications.

PCB and Chlorinated Pesticides. PCBs have been widely used in a number of industries. Although they are used less today than they were in the past, they are a highly persistent class of chlorinated hydrocarbons that remain of significant environmental concern and are found throughout our environment. Similarly, the concentrations of several persistent and once widely used chlorinated pesticides, such as DDT and its degradation products DDD and DDE, chlordane, BHCs, and endosulfans, were studied. The manufacturing and broad uses of these compounds has either been stopped or severely limited. However, endosulfan, for instance, is still being permitted for use as an insecticide on tobacco, fruits, and vegetables, and for wood preservation, BHC compounds are used in small-scale pest control (e.g., ticks, fleas), and stockpiles of banned pesticides are still a concern. Nonetheless, the majority of the PCB and chlorinated pesticides that are detected in the environment today were introduced more than 20 years ago.

Organic Compounds — Contaminant Concentration, Distribution, and Composition.

The organic contaminant concentrations varied greatly throughout the study area (Tables 3-3, 3-6, 3-9, Appendices B, C, and D). Some of the variability can likely be attributed to anthropogenic sources, while others are more a reflection of the bulk composition of the sediment and the different contaminant concentration potential of the sediments, and of contaminant transport and depositional characteristics.

PAH

The total PAH concentrations in the LSJR sediments are presented in Figures 4-1 (non-normalized) and 4-2 (TOC-normalized), and are also displayed on a map in Figure 4-3. Additional supplemental bar charts of organic contaminant concentrations are compiled in Appendix H, and maps illustrating the general geographical distribution of the contaminants can be found in Appendix N. The sites in the bar graph are sorted alphabetically by site name, as indicated in Figures 4-1 and 4-2, and Table 3-3.

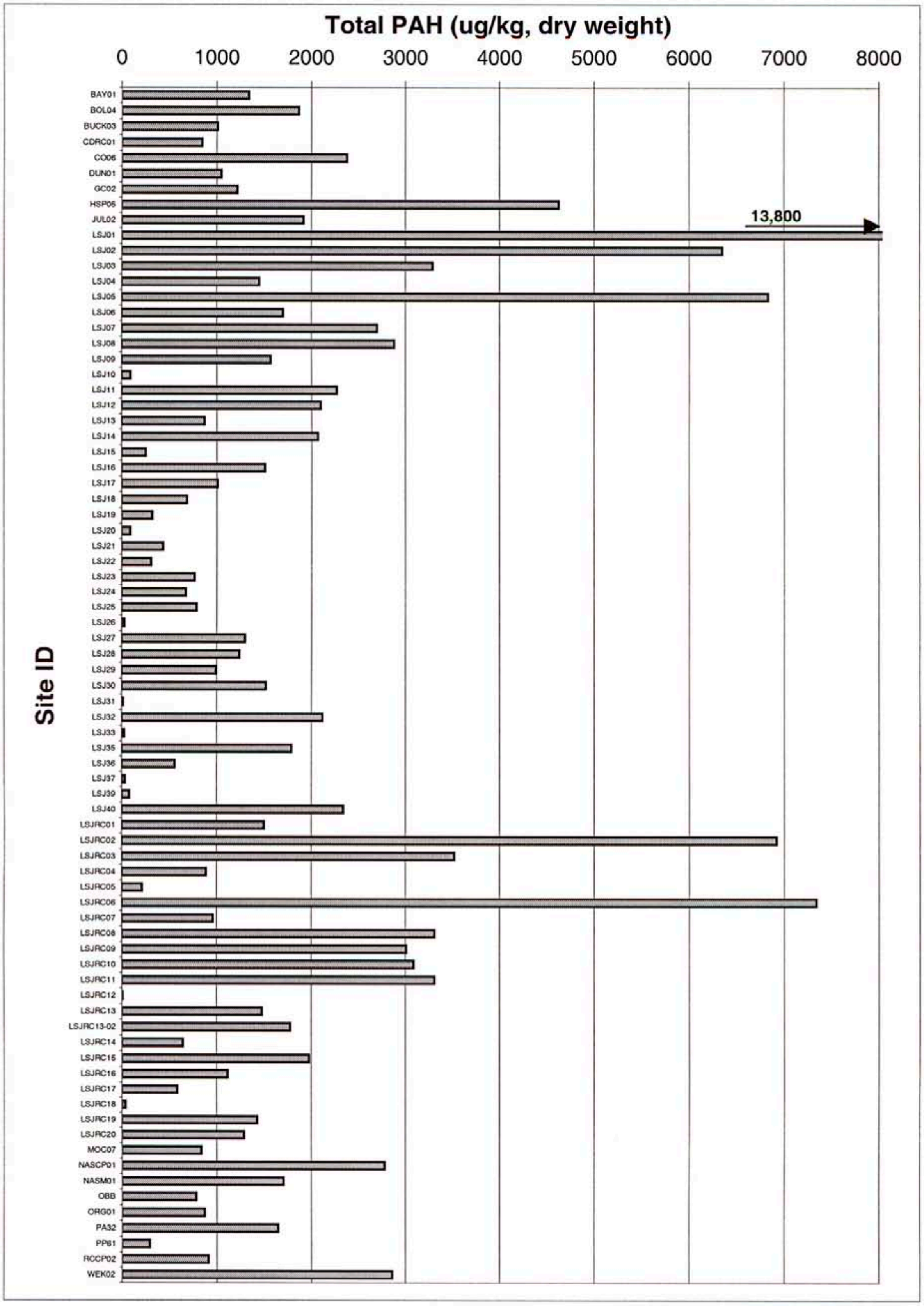


Figure 4-1. Lower St. Johns River — Total PAH Concentrations

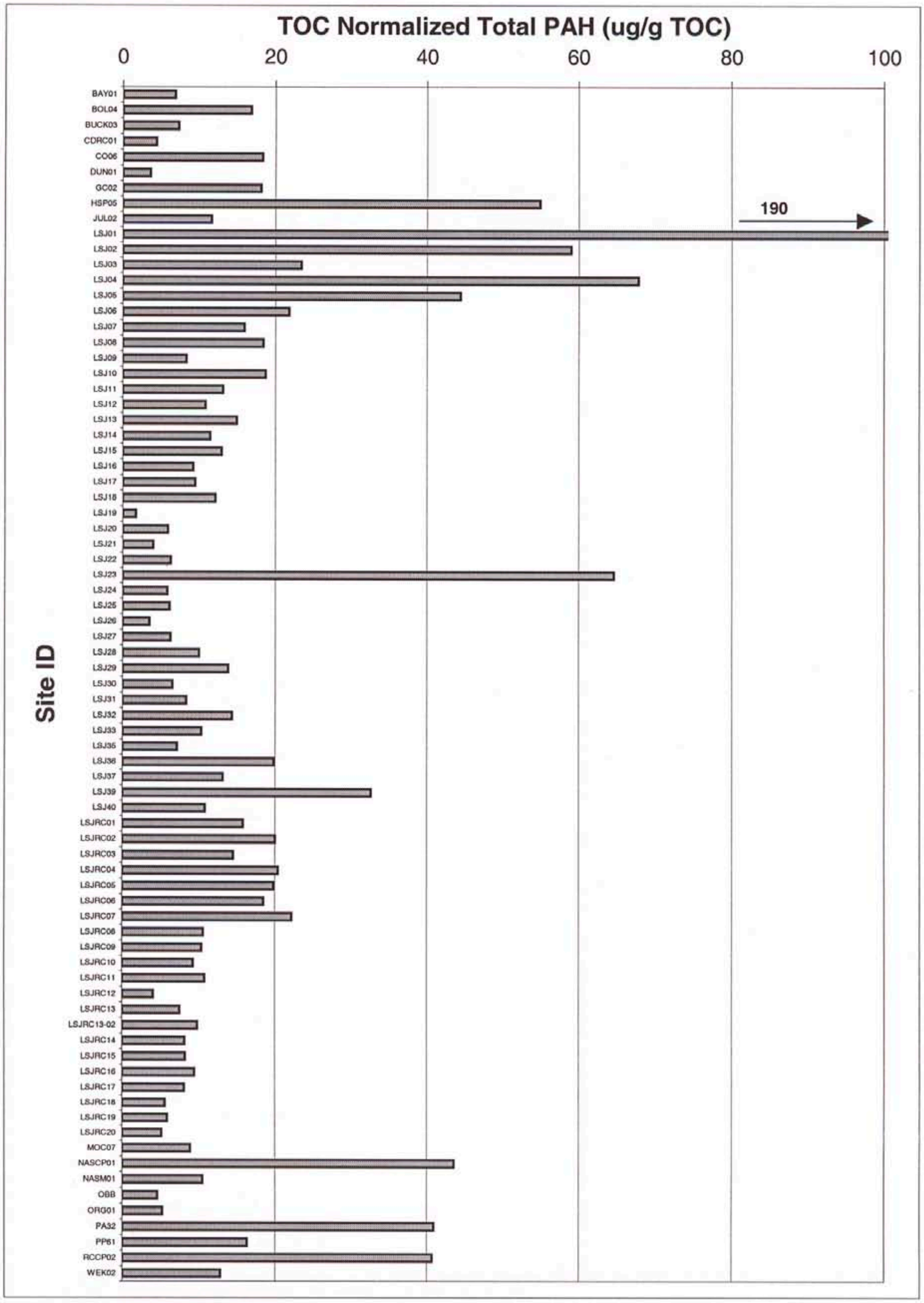


Figure 4-2. Lower St. Johns River — TOC-Normalized Total PAH Concentrations

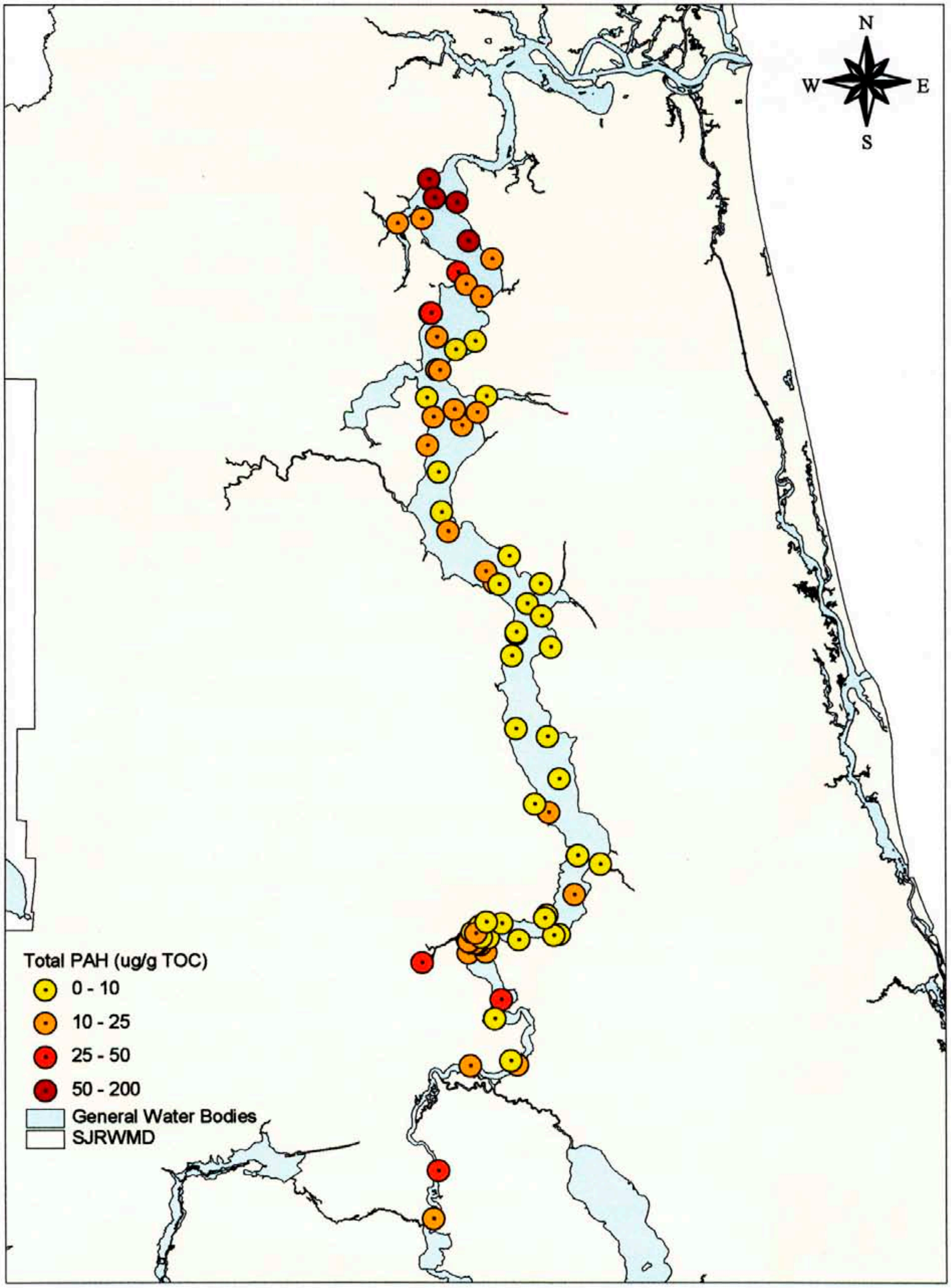


Figure 4-3. Lower St. Johns River — Map Displaying TOC-Normalized Total PAH Concentrations

The LSJR sediment sites near the urban areas of Jacksonville (e.g., sites LSJ01, LSJ02, LSJ03, LSJ05, and HSP05) had the highest PAH concentrations. Slightly elevated PAH concentrations, as compared to the general main stem levels, were also detected at sites near the confluence of Rice Creek and the St. Johns River (e.g., sites LSJRC02 and LSJRC06). The total PAH concentrations were mostly below 2,000 µg/kg; 22 (CO06, HSP05, LSJ01, LSJ02, LSJ03, LSJ05, LJS07, LSJ08, LSJ11, LSJ12, LSJ14, LSJ32, LSJ40, LSJRC02, LSJRC03, LSJRC06, LSJRC08, LSJRC09, LSJRC10, LSJRC11, NASCP01, WEK02) of the 77 sites had concentrations above 2,000 µg/kg and only one site had a sediment total PAH concentration above 10,000 µg/kg (the LSJ01 sediment sample had 13,800 µg/kg total PAH). A total of 18 of the LSJR sites (CO06, HSP05, LSJ01, LSJ02, LSJ03, LSJ05, LSJ07, LSJ08, LSJ40, LSJRC02, LSJRC03, LSJRC06, LSJRC08, LSJRC09, LSJRC10, LSJRC11, NAPCP01, WEK02) had HMW above 2,000 µg/kg and two sites (LSJ01 and LSJRC06) had LMW above 2,000 µg/kg.

The TOC normalized PAH concentration distribution (Figures 4-2 and 4-3) has a slightly different appearance than the non-normalized distribution, with some sites appearing elevated even though their non-normalized concentrations were low (e.g., sites LSJ23 and LSJ39). This is clearly a reflection of a very low TOC content of these sediments and not of PAH concentration that is of real concern — it is important to view all the related data as a whole; non-normalized and normalized contaminant data along with the bulk sediment characterization data. Some sites with moderate non-normalized PAH concentrations (and more typical TOC content) have more pronounced TOC-normalized concentrations, (e.g., site NASCP01 at the Naval Air Station), which could be an indication of a local source of the contamination. After considering all the PAH and sediment characteristics data, the sites that appear to have the most significant contamination of PAH include LSJ01, LSJ02, HSP05, and other sites in the northern parts of the river, and, to a lesser degree, some areas near Rice Creek.

The PAH concentrations measured in this study were generally within an expected range for urban or near-urban locations, and most urban sites had PAH concentrations comparable to or lower than concentrations measured for urban coastal sediments elsewhere in the U.S. However, much of the river would probably not be considered urban or near-urban, and would therefore be expected to have fairly low PAH concentrations. Concentrations of total PAHs (sum of only 8 parent PAH compounds) in surficial sediments from western Lake Erie near the mouth of the River Raisin, Michigan, ranged from 530 to 3,750 µg/kg (Eadie, *et al*., 1982). Concentrations of total PAH in surficial sediments from offshore lake Michigan range from 200 to 12,000 µg/kg (Helfrich and Armstrong, 1986; Zhang *et al*., 1993). PAH concentrations in coastal or lake sediments tend to decrease with distance from the shore.

In 1990, total PAH concentrations of approximately 600 to 66,000 µg/kg were measured in Dorchester Bay sediment. Dorchester Bay is within Massachusetts Bay, and about 5-7 miles south of central Boston. In 1994 the same Dorchester Bay stations were resampled, and sediment was also collected at several other Boston Harbor locations (Battelle, 1995). This time the total PAH concentrations in the surface sediment ranged from 500 to 128,000 µg/kg, and the concentrations were between 700 and 40,000 µg/kg for 12 of the 14 stations. The highest sediment PAH concentrations were measured near combined sewer overflow (CSO) discharge locations in both the 1990 and 1994 studies. Concentrations of total PAH in sediments from Boston Harbor, Massachusetts, ranged from 48 to 718,000 µg/kg in a mid 1980s sediment profile (Shiaris and Jambard-Sweet, 1986).

A total of 60 sites were sampled in a 1990 survey of sediment contamination of Long Island Sound (Battelle, 1991a). The samples were mostly collected away from urban locations, and total PAH concentrations ranged from about 700 to 22,000 µg/kg, and averaged about 6,000 µg/kg in this study. The concentrations ranged from 2,200 to 2,600 µg/kg at remote reference locations in the Sound.
A large number of surface sediment and sediment core samples were collected at various locations in lower Narragansett Bay in 1993 (Battelle, 1994). The total PAH in the surface sediment ranged from below 1,000 µg/kg at the reference locations to approximately 30,000 µg/kg for locations with no

identified impact from PAH point source contamination; 58,000 µg/kg was measured at a location near a known source of PAH input. Surface sediment total PAH concentrations ranging from 1,700 to 40,700 µg/kg were recently measured at 18 sites throughout Presque Isle Bay, in Erie, Pennsylvania (Battelle, 1997).

PAH concentrations in sediment cores tend to increase with depth to a maximum concentration at depths corresponding to the 1960s to 1970s, and then decrease as the sediment represents earlier deposition (Gustafsson *et al*., 1997; Simcik *et al*., 1996). It is widely accepted that the dramatic increase in PAH fluxes observed in sediment in the North American aquatic environment from the early to mid 1900's is a direct result of the acceleration of industrial activities and other increases in the use of fossil fuels. Several studies have shown that anthropogenic inputs of PAH in urban areas of North America generally peaked some time between 1950 and 1980 (Gustafsson *et al*., 1997; Simcik *et al*., 1996; Furlong, *et al*., 1987), although there are clearly regional differences. In a detailed study of the characteristics of PAH deposition in Lake Michigan sediment, cores were collected from the northern part of the lake to the south (Simcik *et al*., 1996). The data showed that the accumulation of PAH increased sharply starting around 1900, reached a maximum and a plateau between 1940 and 1970, and has since begun a gradual decline. However, the decline in PAH input is not dramatic, and a change is still undetectable in many systems. In a similar study of sediment cores from the Upper Mystic Lake (a small lake near Boston, Massachusetts), inputs of pyrogenic PAH were determined to have peaked around 1960, leveled off, and began and slow decline around 1970 (Gustafsson *et al*., 1997). The dramatic increase in PAH is generally attributed to the onset of coal combustion and later use of other fossil fuels, while a slight decline in recent years is thought to have resulted from a shift from coal to oil and gas use, and to implementation of various pollution control measures. Recent significant improvements in source control include better removal of particulate matter from stack gases and more effective control of sewerage discharges, and combined sewerage overflow and storm water systems.

Sediment contaminant data can be compared to the NS&T/MW (National Status and Trends/Mussel Watch) “high” values, which are useful reference values determined statistically using the NS&T/MW monitoring program dataset (Table 4-1; Daskalakis and O’Connor, 1995). The listed reference values were set as the geometric mean plus one standard deviation, using the NS&T U.S. coastal monitoring program sediment site data. Daskalakis and O’Connor (1995) compiled a comprehensive Coastal Sediment Database (COSED) of chemical contaminant concentrations in US sediments, and this is a useful reference for contaminant concentrations measured around the country and what would typically be considered elevated concentrations.

The NS&T/MW “high” value for Total PAH is 2,180 µg/kg, and is based on the same 24 PAH compounds that were measured in the LSJR and COR study. NS&T/MW “high” values for low MW PAH (LMW, 2- and 3-ring PAH) and high MW PAH (HMW, 4- through 6-ring PAH) are 450 µg/kg and 1,730 µg/kg, respectively. These values reflect the greater abundance and persistence of pyrogenic PAH (from combustion products, mostly HMW) than petrogenic PAH (from petroleum products, mostly lower molecular weight PAH). Table 4-1 indicates that between 2 and 14% of coastal sediments monitored in various U.S. monitoring programs (NST&MW sites, EMAP sites, and all COSED sites; 14%, 2%, and 6%, respectively) contain concentrations of total PAH equal to or greater than the corresponding NS&T/MW “high” value. In comparison, approximately 25% of the 77 Lower St. Johns River sites (Table 4-1) sampled in LSJR study had total PAH concentrations that exceeded the NS&T/MW “high” value, and most of these were within a factor of two the NS&T/MW reference value. The PAH concentrations for the LSJR sites appear to, on average, be slightly higher than in a typical cross-section of the country. However, the St. Johns River is somewhat more impacted by industry and urban environments than your “average” U.S. water body, and the parts of the river with elevated concentrations are, geographically, fairly limited (the northern section near Jacksonville and a small area near Rice Creek).

Table 4-1. Number of Sites with Surface Sediment NS&T/MW “High” Value Exceedances

	NS&T/MW ‘High’ Value [a]	Number of Exceedances				
		% NS&T/MW ‘High’ Exceedances in COSED Dataset			% NS&T/MW ‘High’ Exceedances in This Study	
		NS&T/MW Sites	EMAP Sites	All COSED Sites	LSJR Sites	COR Sites
Study/Site Information						
Random		No [b]	Yes			
Total sites		224	500	3878	77	51
Parameter						
Ag	0.52	16	8	22	14	65
As	13	13	8	18	1	4
Cd	0.54	16	12	31	38	86
Cr	125	14	3	11	0	0
Cu	42	18	10	25	3	41
Hg	0.22	15	12	30	48	90
Ni	42	13	5	11	0	0
Pb	45	13	12	23	12	80
Sb	2.1	15	1	8	0	0
Se	0.92	14	16	15	71	92
Sn	4	12	17	20	8	57
Zn	135	15	17	22	16	73
High MW PAH	1730	18	9	23	30	86
Low MW PAH	450	17	12	22	17	39
Total PAH	2180	14	2	6	25	82
Total Chlordane	4.5	14	2	8	0	53
Total Dieldrin	2.9	13	1	6	0	0
Total DDT	22	18	9	23	1	25
Total PCBs	80	15	5	15	32	88

[a] “High” concentrations values are in µg/kg for organic contaminants and mg/kg for metals. Data from Daskalakis and O’Connor (1995).

[b] Not random, but representative sites. Percentages are based on number of sites analyzed for the particular chemical, a number usually less than the total number of sites. EMAP: Environmental Monitoring and Assessment Program; NS&T/MW: National Status and Trends, Mussel Watch Program.

The relative composition of the different PAH compounds in the LSJR sites varied some from site-to-site, but the dominant PAH at most locations were the four- and five-ring PAH. These PAH are mostly associated with pyrogenic sources, although lower molecular weight PAH, with likely petrogenic origin, are present at lower concentrations. The pyrogenic PAH (HMW) constitute between 60 and 80% of the total PAH at most locations (Figure 4-4); the average relationship was about 3 times more HMW than LMW. The relatively consistent proportion of pyrogenic and petrogenic PAH in the surface sediment indicate a similarity in the sources, or types of sources, of the PAH contamination. Figure 4-5 shows the PAH composition of selected samples. The PAH composition of selected reference samples and petroleum products are compiled in Appendix I.

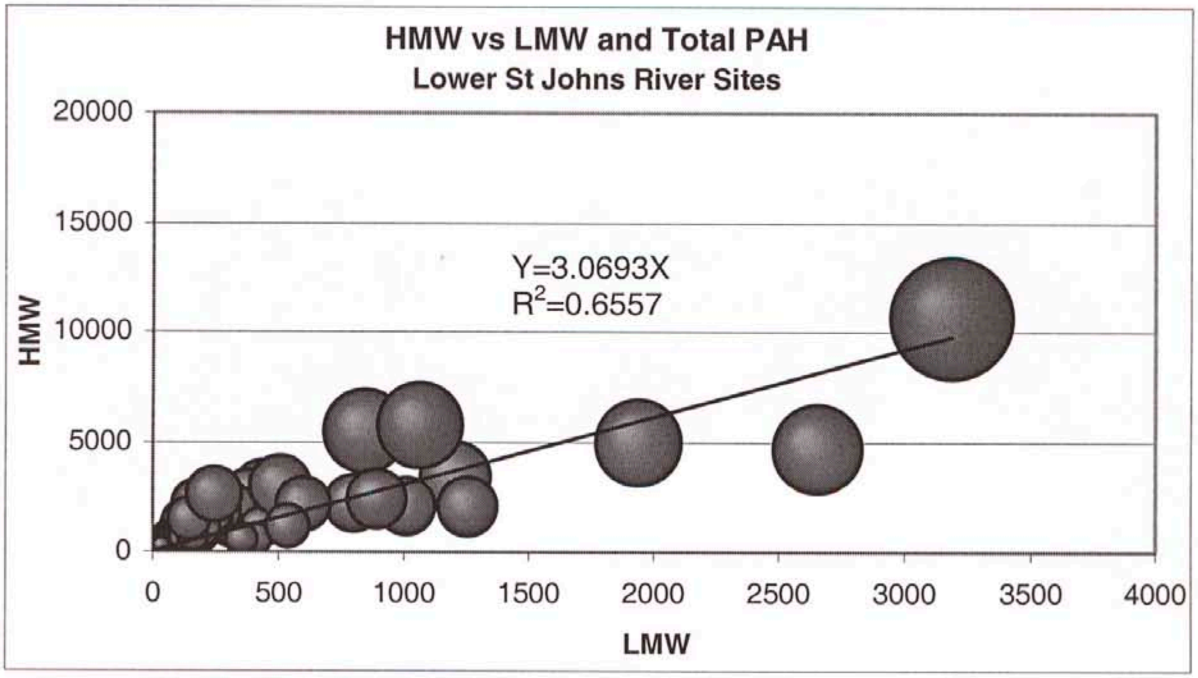


Figure 4-4. Lower St. Johns River — Relative Composition of HMW, LMW and Total PAH Concentrations

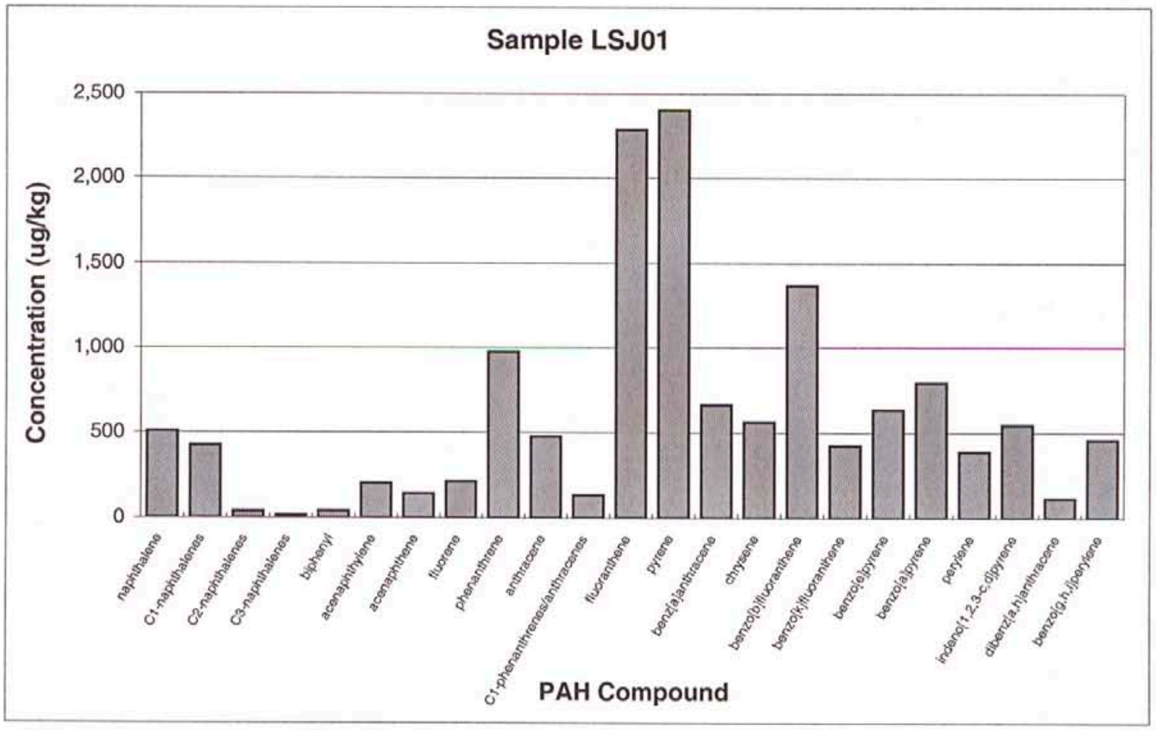
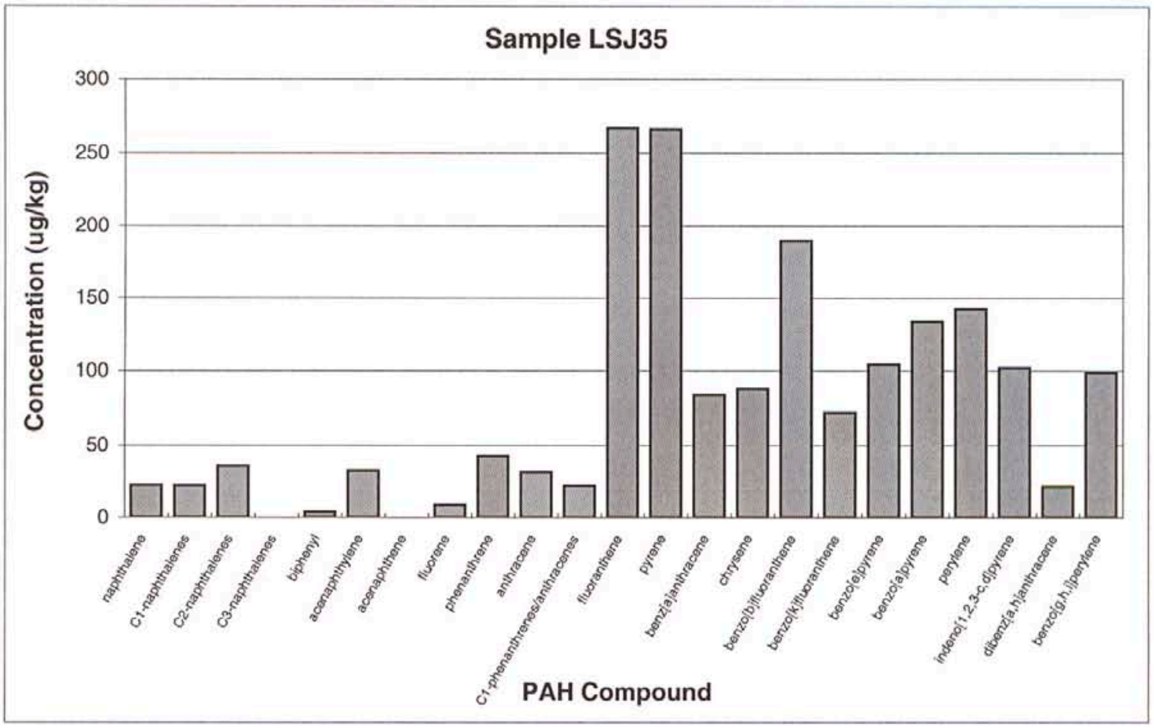


Figure 4-5. Lower St. Johns River — PAH Composition of Selected Samples



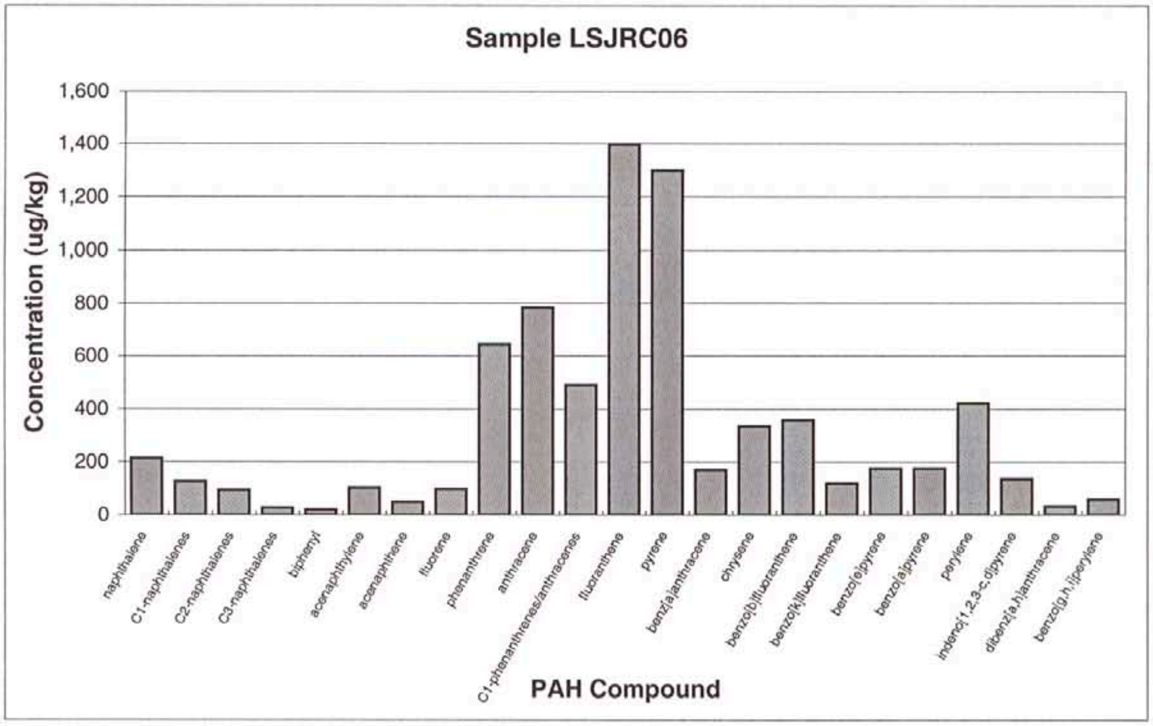
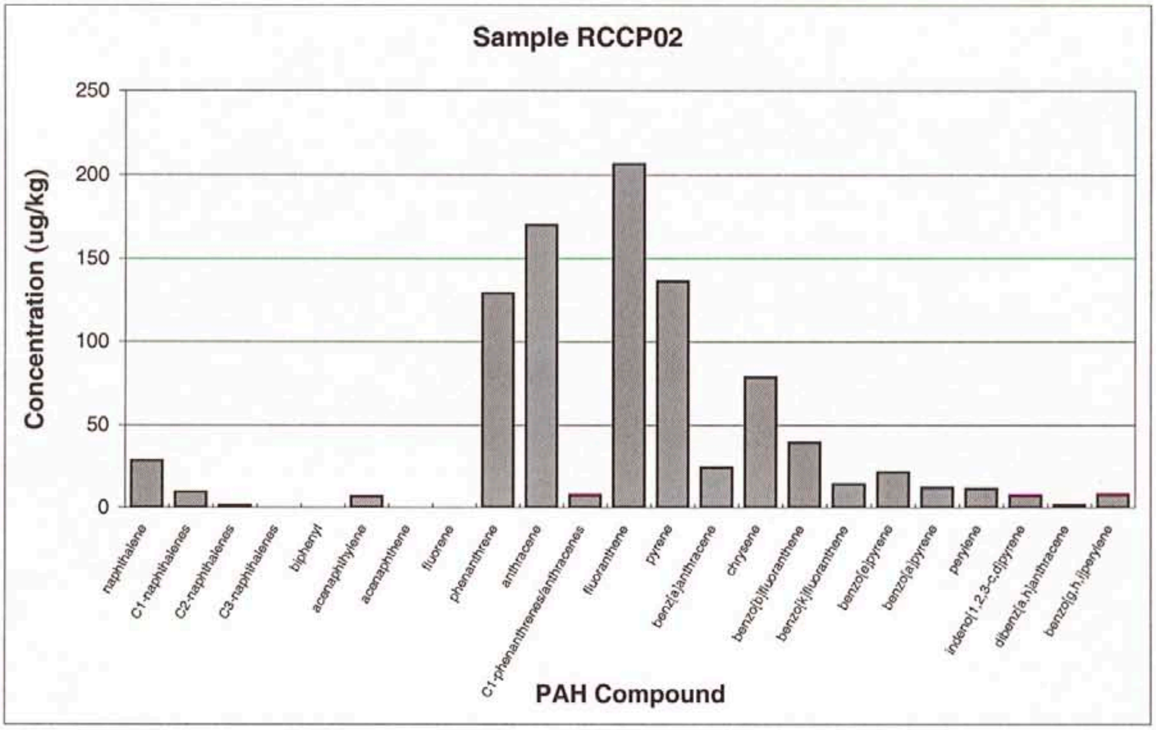


Figure 4-5 (cont.). Lower St. Johns River — PAH Composition of Selected Samples



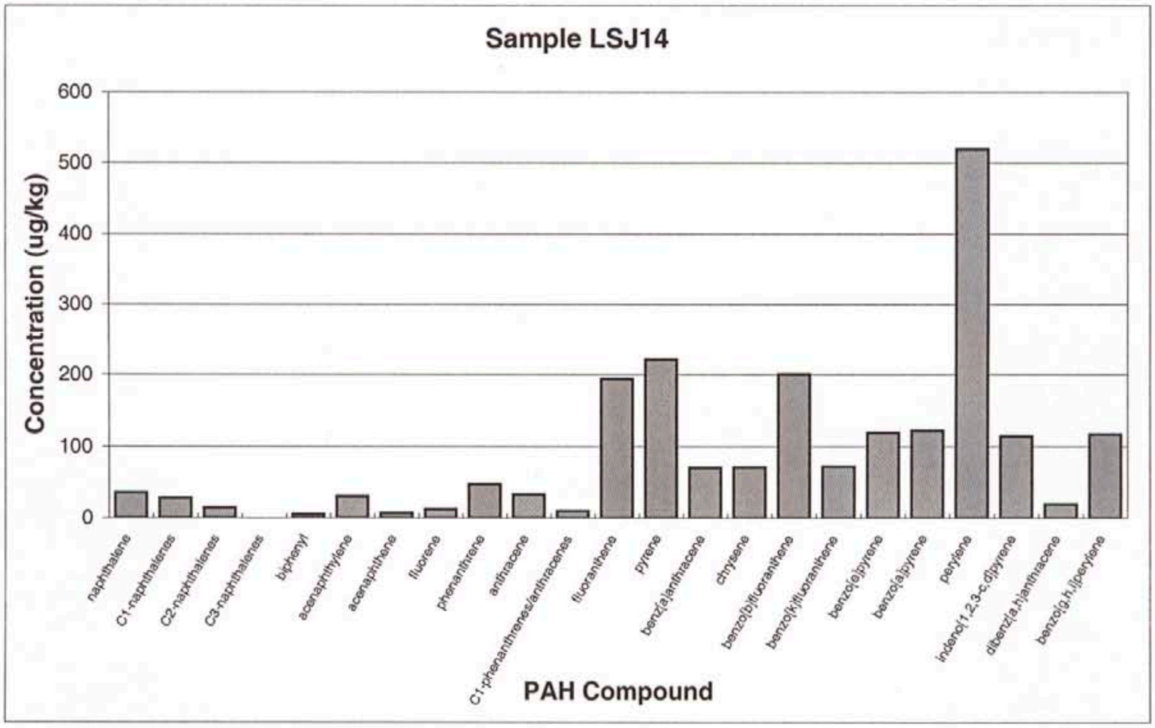


Figure 4-5 (cont.). Lower St. Johns River — PAH Composition of Selected Samples

Most samples had a PAH composition similar to those of LSJ01 or LSJ35 (Figure 4-5), which are comparable to the PAH composition in the NIST SRM 1941 sediment and soot (Appendix I). The SRM sediment is a reference material that was collected in an East Coast estuarine environment and is considered to be a good representation of typical background PAH derived primarily from pyrogenic sources. Sites LSJRC02 and LSJRC06 (and the surrounding sites near the mouth of Rice Creek) had relatively high non-normalized PAH concentrations and, proportionately, less of the high-molecular weight PAH than other sites; they were dominated by mid-molecular weight PAH (Figure 4-5). The sample from RCCP02 (up stream of Rice Creek), although not high in PAH, had a similar less common PAH composition, and these samples from the Rice Creek area appear to have a source of the PAH that is different from the PAH in other parts of the river.

The data were also analyzed using an exploratory principal component analysis (PCA)[1] to elucidate patterns of PAH composition and to differentiate among sites with similar and dissimilar PAH composition. Like the PAH composition histogram analysis, the PCA analysis indicated that the majority of the LSJR sites had similar PAH composition (Figure 4-6), except for the samples collected near Rice Creek which had a composition that, relatively, more closely resembled that of petroleum products than the other LSJR sites.

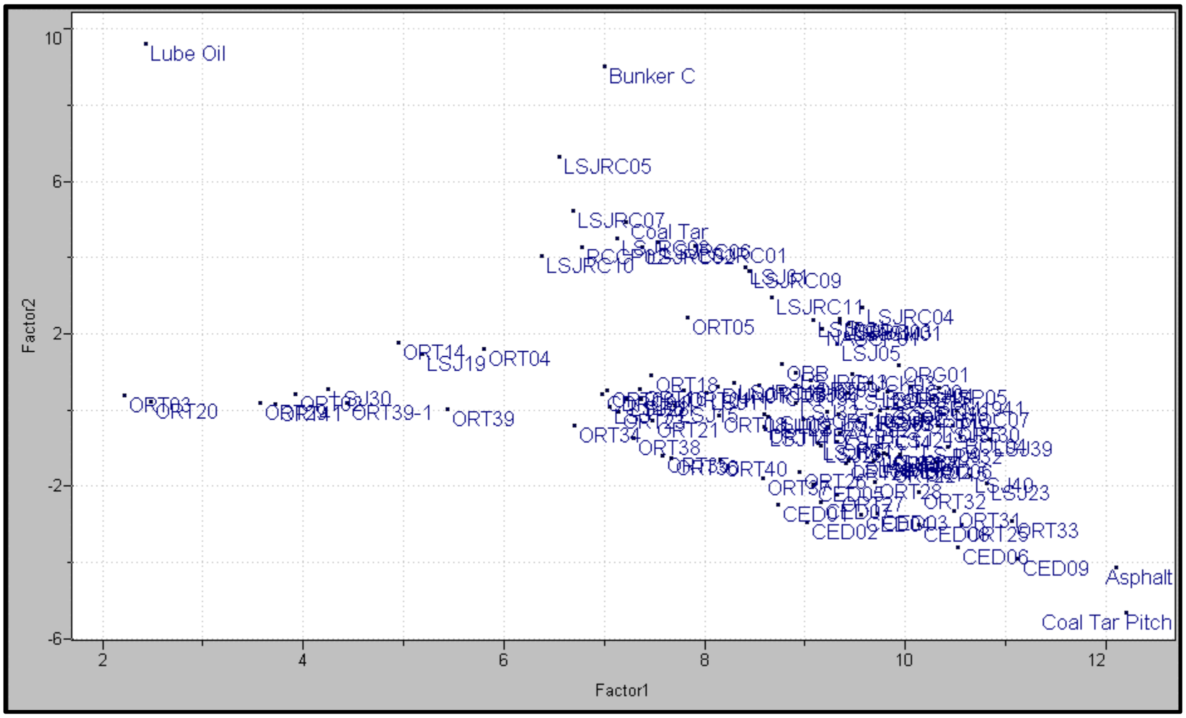


Figure 4-6. Principal Component Analysis (PCA) of PAH Composition of the Sediment Samples

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[1] Principal component analysis (PCA) analysis is a data exploratory and analysis tools designed to explore large data sets, focusing on the variability between samples. PCA produces graphical depictions of relationships between samples and variables (e.g. PAH compounds or PCB congeners) based on pattern recognition. These exploratory techniques were used to help recognize groups of samples that share similar contaminant composition (i.e., similar relative PAH and PCB compound concentrations) and those that have clearly different composition. Samples which visually “cluster” are chemically similar, and may have similar source(s) of the tested contamination.

Perylene is the dominant PAH in some of the low PAH concentration samples (e.g., site LSJ14; Figure 4-5), particularly in samples that also have relatively high amounts of organic matter. Perylene is not primarily derived from petrogenic or pyrogenic sources; most is formed through the natural decay of plant material in anoxic layers of the sediment, and therefore perylene is not considered an important environmental contaminant.

The HMW distribution in most sediment samples is characteristic of PAH inputs primarily from combustion sources, or hydrocarbon materials containing a mixture of high molecular weight pyrogenic and petrogenic PAHs (e.g., coal and coke tar, coal gasification tars, creosote, and, to some degree, asphalt). Low concentrations of petrogenic PAH (e.g., alkylated naphthalenes, phenanthrenes) are also present in many of the samples, suggesting some contribution from weathered petroleum products.

Phthalate Esters

The phthalate data showed no clear geographic trend in concentrations; elevated phthalate concentrations were measured at mostly scattered sites, with possibly some general elevations in the northern parts of the St. Johns River (e.g., LSJ01, HSP05, and BOL04) and near Rice Creek. Other sites with elevated phthalate concentrations were MOC07 and PA32. Only two sites had total phthalate concentrations in excess of 1,000 µg/kg, and the highest was just above 2,000 µg/kg (BOL04). The TOC-normalized data indicate that the five sites identified with the highest non-normalized phthalate concentrations are indeed likely near potential sources of these contaminant because the concentrations remained similarly elevated relative to the rest of the sites, both non- and TOC-normalized.

Industrial Chlorinated Compounds

The contaminant pattern observed for other chlorinated industrial compounds (i.e., the chlorinated benzene) is significantly moderated by TOC-normalizing the data, indicating that the elevated concentrations, although geographically focused in the Rice Creek area, are primarily associated with high TOC samples. These are among the most water-soluble and mobile of the chlorinated compounds, and tend to be transported in the water column and concentrate in areas of high TOC more than discretely near the source. The TOC-normalized data for the other chlorinated compounds show relatively little concentration difference along the river.

PCB

The PCB concentrations were highest at the sites in the northern part of the St. Johns River (e.g., sites LSJ01, LSJ04, and HSP05) and some of the locations near Rice Creek (e.g., LSJRC06 and LSJRC11), when considering both the non-normalized and TOC-normalized data (Figure 4-7, and Appendices C and H). The sum of the target PCB congener concentrations was between 50 and 250 µg/kg for 18 of the 77 sites, and below 50 µg/kg for the rest of the sites. These data can be compared with sediment concentrations from 66 to 233 µg/kg for three Boston Harbor/Massachusetts Bay sites sampled in the NOAA Mussel Watch Program in the late 1980’s, and a range of 9 to 80 µg/kg for five Massachusetts sites outside Massachusetts Bay (Battelle, 1990, 1991b, 1992). As discussed in Section 3.1.2, a detailed analysis of the PCB composition of the study samples revealed that this congener set, on average, represented 42% of the total PCB. The total PCB in these samples can therefore be estimated by multiplying the sum of the PCB congener concentrations by 2.4. A total of 25 (32%) of the 77 Lower St. Johns River sites had PCB concentrations higher than the NOAA “high” concentration of 80 µg/kg, and most of these were within a factor of two of the NOAA value. In comparison, 15% of the NS&T/MW sites and 15% of all COSED sites exceeded this reference value. The PCB concentrations appear to, like PAH, be a little higher in the St. Johns River than a typical cross-section of the country, but the elevated levels are relatively localized.

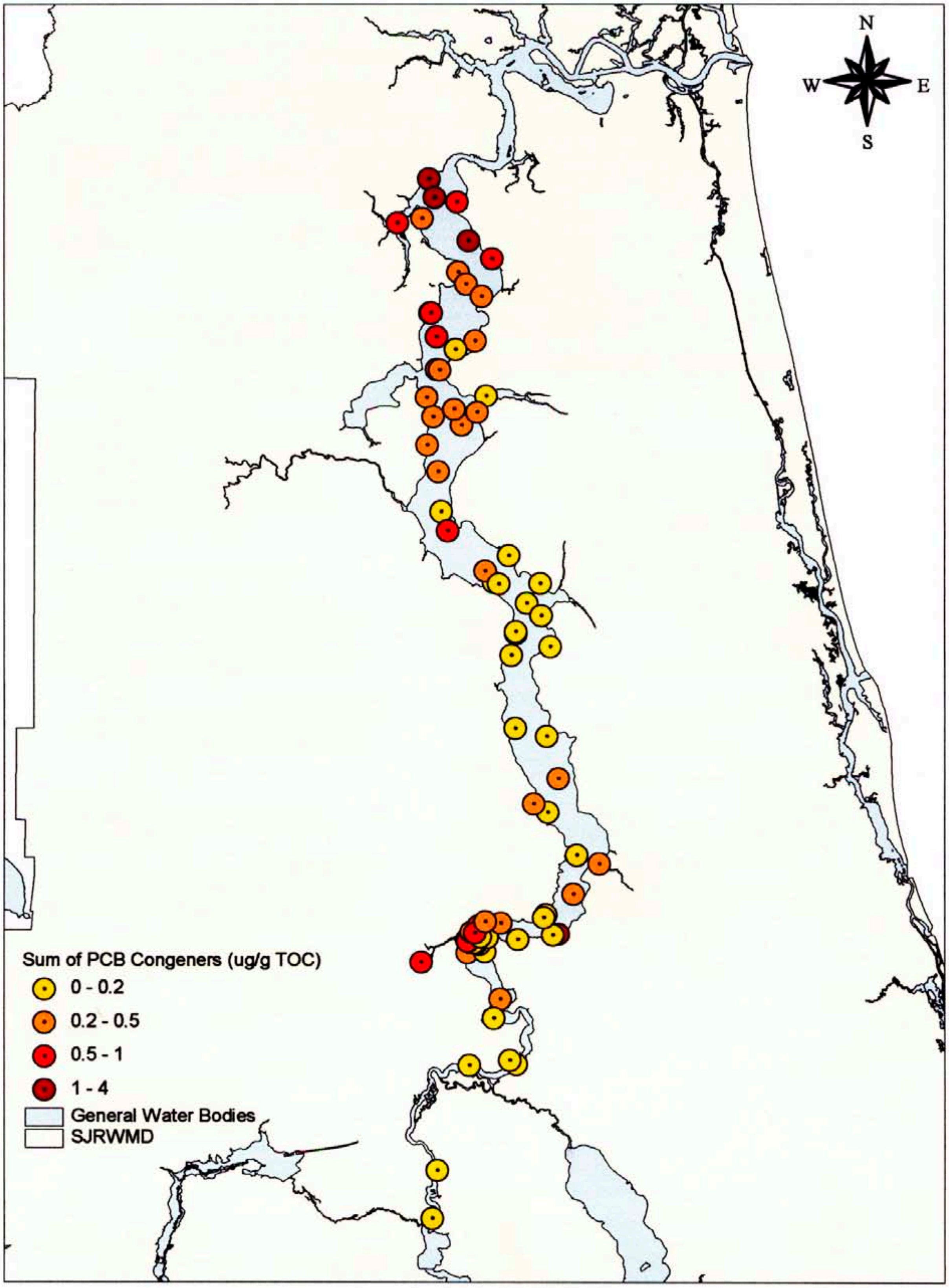
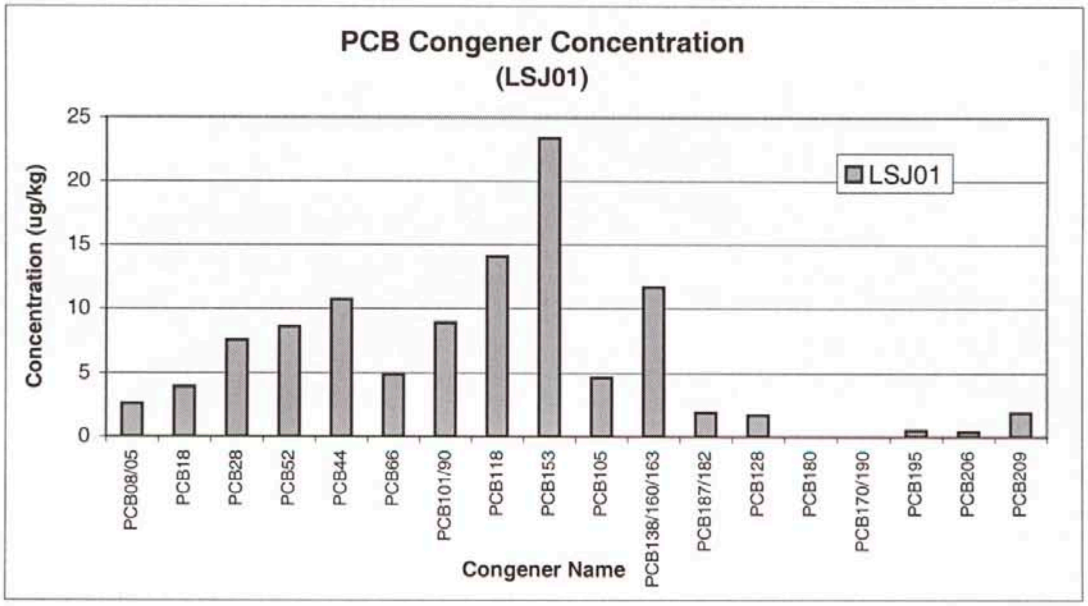


Figure 4-7. Lower St. Johns River — Map Displaying TOC Normalized Sum of PCB Congener Concentrations



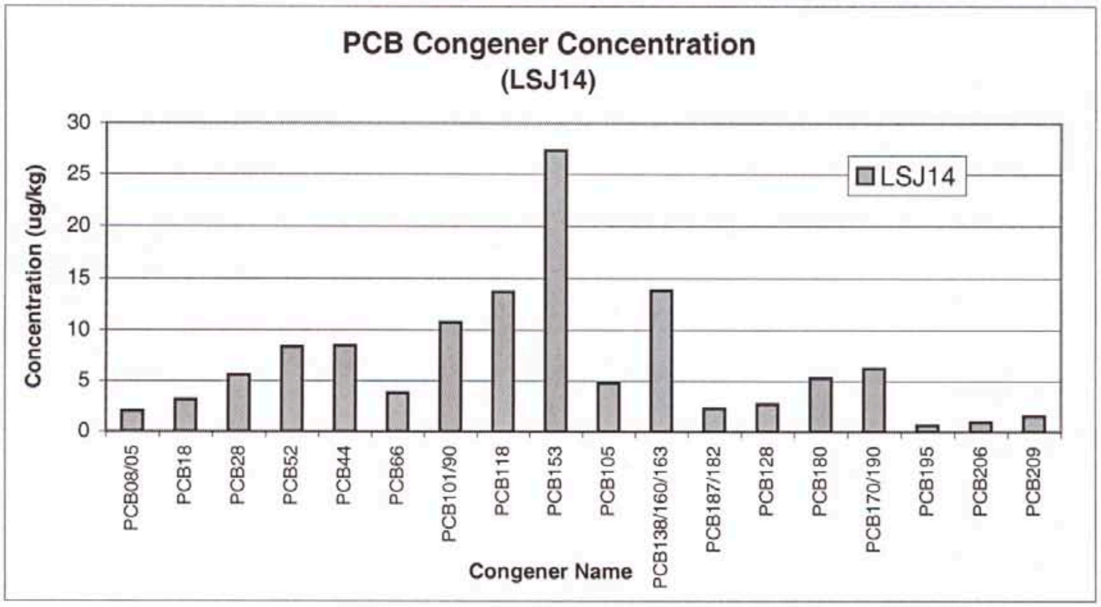
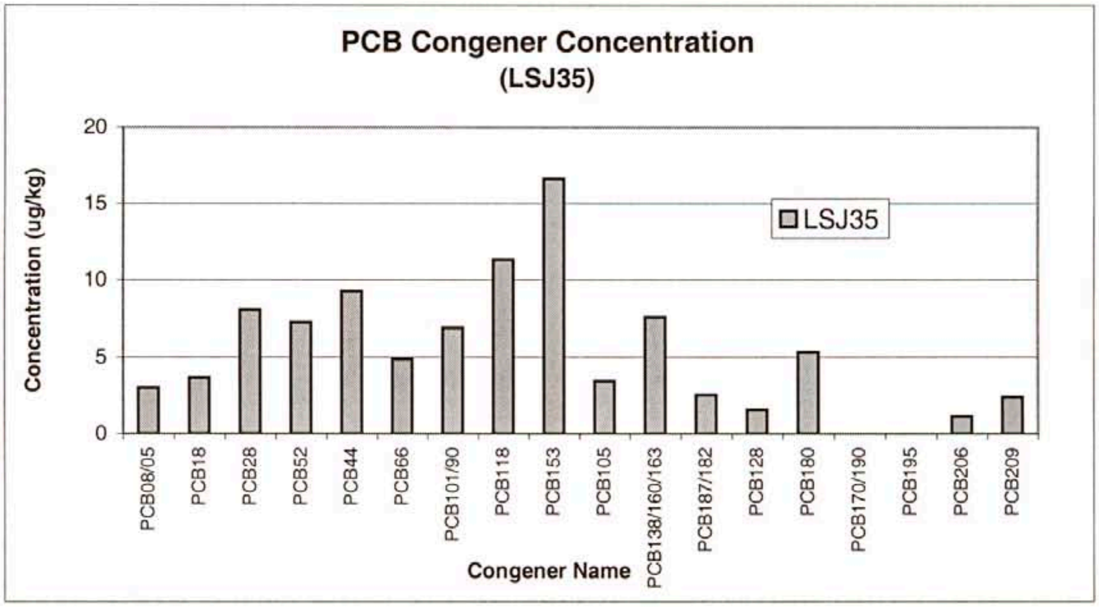


Figure 4-8. Lower St. Johns River — PCB Composition of Selected Samples



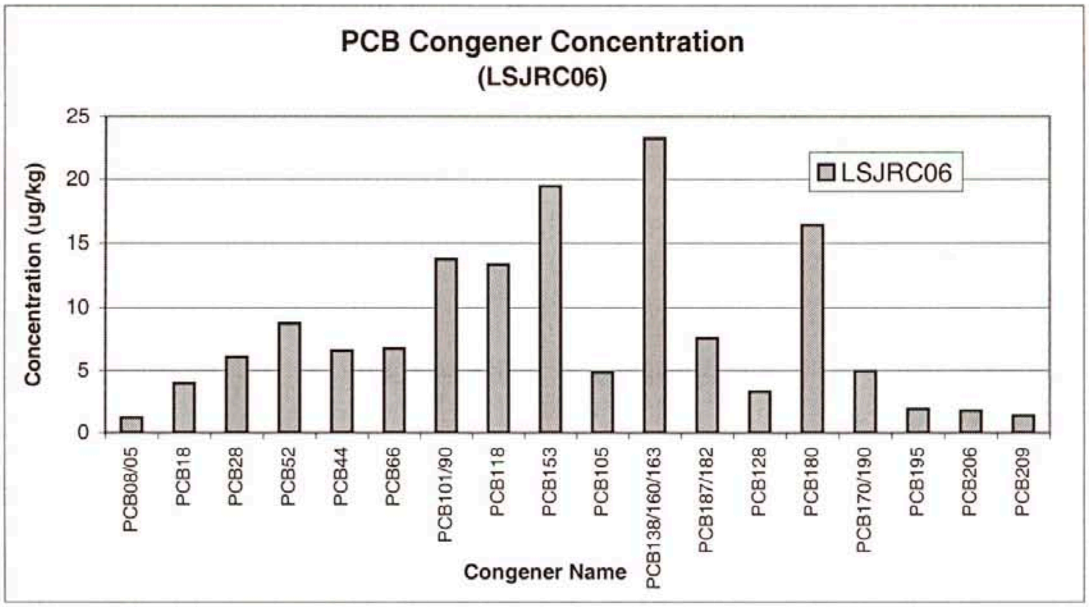


Figure 4-8 (cont.). Lower St. Johns River — PCB Composition of Selected Samples

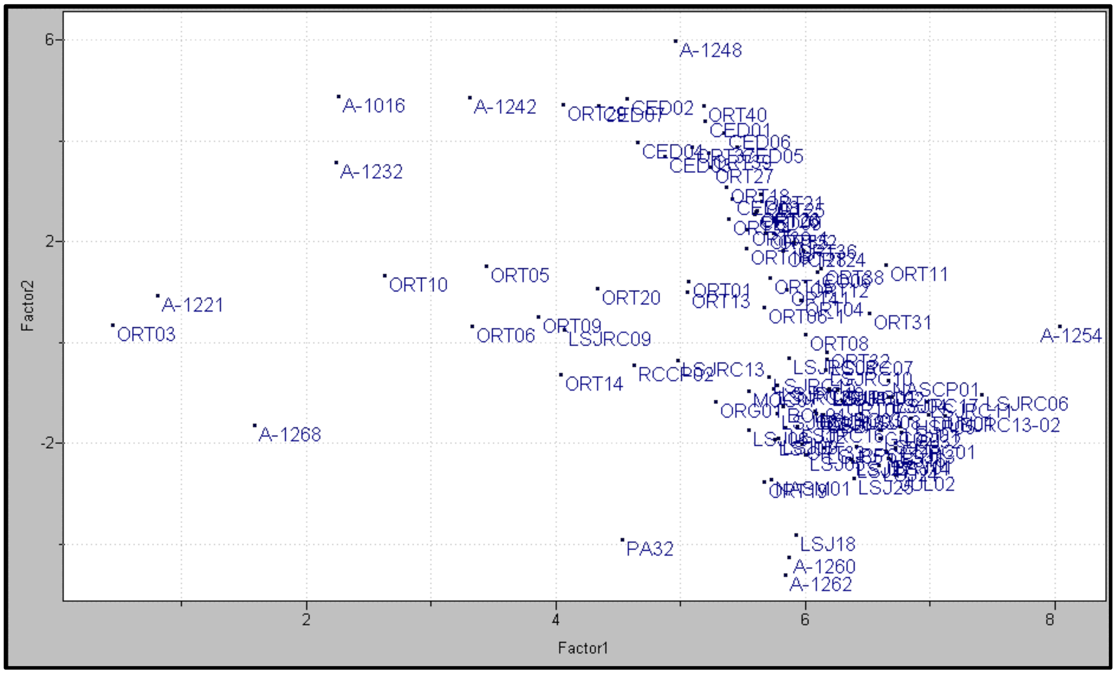


Figure 4-9. Principal Component Analysis (PCA) of PCB Composition of the Sediment Samples

The PCB composition was fairly uniform within the Lower St. Johns River (Figure 4-8), and can be compared to those of the original PCB source material (Aroclor formulations; Appendix J). The PCB composition most closely resembles a combination of mid-molecular weight Aroclor formulations (e.g., Aroclors 1248 and 1254), with some contribution of higher molecular weight material (e.g., Aroclor 1260). PCA analysis was also performed using the individual PCB congener data to discern compositional differences (Figure 4-9). This analysis also showed the relative similarity in the PCB composition of the LSJR samples, with a composition that was mainly in the mid-molecular weight range (e.g., Aroclor 1254), with some contributions from higher and lower molecular weigh formulations, all of which have undergone some level of environmental weathering. These were the most widely used PCB formulations, and this is a fairly typical PCB composition for aquatic environments that have large drainage basins and a number of potential sources of PCB. The manufacture and new use of PCB was banned in the mid-70’s, and most of the PCB detected in the environment today are broad “blends” of historic PCB that may have been transported significant distances. Unique PCB patterns are generally only observed close to existing point sources.

Pesticides - DDTs

The chlorinated pesticide concentrations have a somewhat different geographic distribution than the more urban and industrial-linked compounds discussed so far, which is consistent with their more focused use and distribution (Figure 4-10 and Appendices C and H). In addition, the contamination pattern varied somewhat from pesticide to pesticide compound. Only 2 of the 77 sites had a concentration of the sum of the DDT class of compounds (DDT and its degradation products DDD and DDE) higher than 20 µg/kg, and the highest concentration was just above 30 µg/kg (LSJ01). The sites that had somewhat elevated concentrations of the DDT compounds, as compared to the rest of the sites, include sites in the northern parts of the St. Johns River (e.g., LSJ01, LSJ02, HSP05, and BOL04), and, to a lesser degree, some of the sites near Rice Creek. The DDT compound concentrations measured in this study can be compared to 24 to 58 µg/kg for three NOAA Massachusetts sites located near urban areas and to between 1 and 9 µg/kg for the more rural sites (Battelle, 1990, 1991b, 1992). The DDT concentrations at the LSJR sites were lower than what has been observed in many national monitoring programs, with only one site (LSJ01) exceeding the NS&T/MW "high" value of 22 µg/kg (Table 4-1), while 18% of the NS&T/MW and 23% of the COSED sites exceeded this value.

The concentrations of DDT and its degradation products DDD and DDE are listed in Table 3-6, along with the total concentration of these DDT compounds. Various environmental conditions (primarily oxygen supply) dictate the rate of DDT degradation, and the relative amounts of DDD and DDE that are formed. Figure 4-11 shows the relative concentrations of DDT, DDD, and DDE at selected sites. The concentration of DDD was higher than both the DDE and DDT concentrations in most samples, as it is in many sediments around the US, as determined in the NOAA Mussel Watch Project (Battelle, 1990, 1991b, 1992). However, some of the northern-most sites (and the ones with the highest overall DDT concentration) had proportionately slightly higher concentrations of DDT than what was found in most sediments nationwide. Some sites near the mouth of Rice Creek (e.g., LSJRC10 and LSJRC11) actually had higher concentrations of DDT than either of the degradation products, suggesting more recent inputs of DDT and/or slower DDT degradation.

Pesticides - Other Chlorinated Pesticides

Chlordane concentrations were lower than DDT concentrations, were below 5 µg/kg in all samples, and were between 2 and 5 µg/kg at 11 of the 77 sites. The pesticide chlordane was determined to be, relatively, elevated at some of the sites that also had elevated DDT (LSJ01 and LSJ02, and to some degree near Rice Creek), but also at the one site that is in the Cedar-Ortega River Basin (CO06). The apparently elevated chlordane concentration at LSJ23 is entirely due to one of the chlordane isomers, which suggests this may be a false positive caused by analytical interference (the chlordane isomers are typically detected concurrently). The chlordane concentrations were lower than what has been observed in national monitoring programs; no sites exceeded the NS&T/MW "high" value of 4.5 µg/kg (Table 4-1), while 14% of the NS&T/MW and 8% of all COSED sites exceeded this value.

The BHCs and endosulfan concentrations were, on average, similar to, or slightly higher than, the chlordane concentrations. BHC concentrations were between 2 and 6 µg/kg at 9 of the sites, with the rest having concentrations below 2 µg/kg (the highest was LSJRC06). The BHC concentrations were among the highest in the middle of the study region (e.g., LSJ17) and at sites in the Palatka reach (e.g., LSJRC06 and LSJRC10). The endosulfan concentrations were, generally, quite low at the LSJR sites, ranging from ND to 16.6 µg/kg, but clearly elevated levels were measured at a few northern sites (LSJ01, LSJ02, HSP05, and BOL04). Eight sites (LSJRC02, LSJRC06, LSJRC08, LSJRC10, LSJRC11, LSJRC13, LSJRC17, and LSJR20) located near the confluence with Rice Creek also had relatively elevated endosulfan concentrations (between 4 and 16.6 µg/kg).

Chlorophenolic Compounds

The chlorophenolic compound concentrations varied greatly across the study area, and it was difficult to distinguish a clear geographical pattern (Figure 4-12). Some of the northern most locations appeared to have elevated concentrations of some of the chlorophenolics, as did the area near Rice Creek. However, the elevated concentrations were not always consistent across the chlorophenolic compound classes (i.e., chlorinated phenols, anisoles, catechols, guaiacols), and scattered sites in the central part of the study area also had sporadic elevated chlorophenolic compound concentrations.

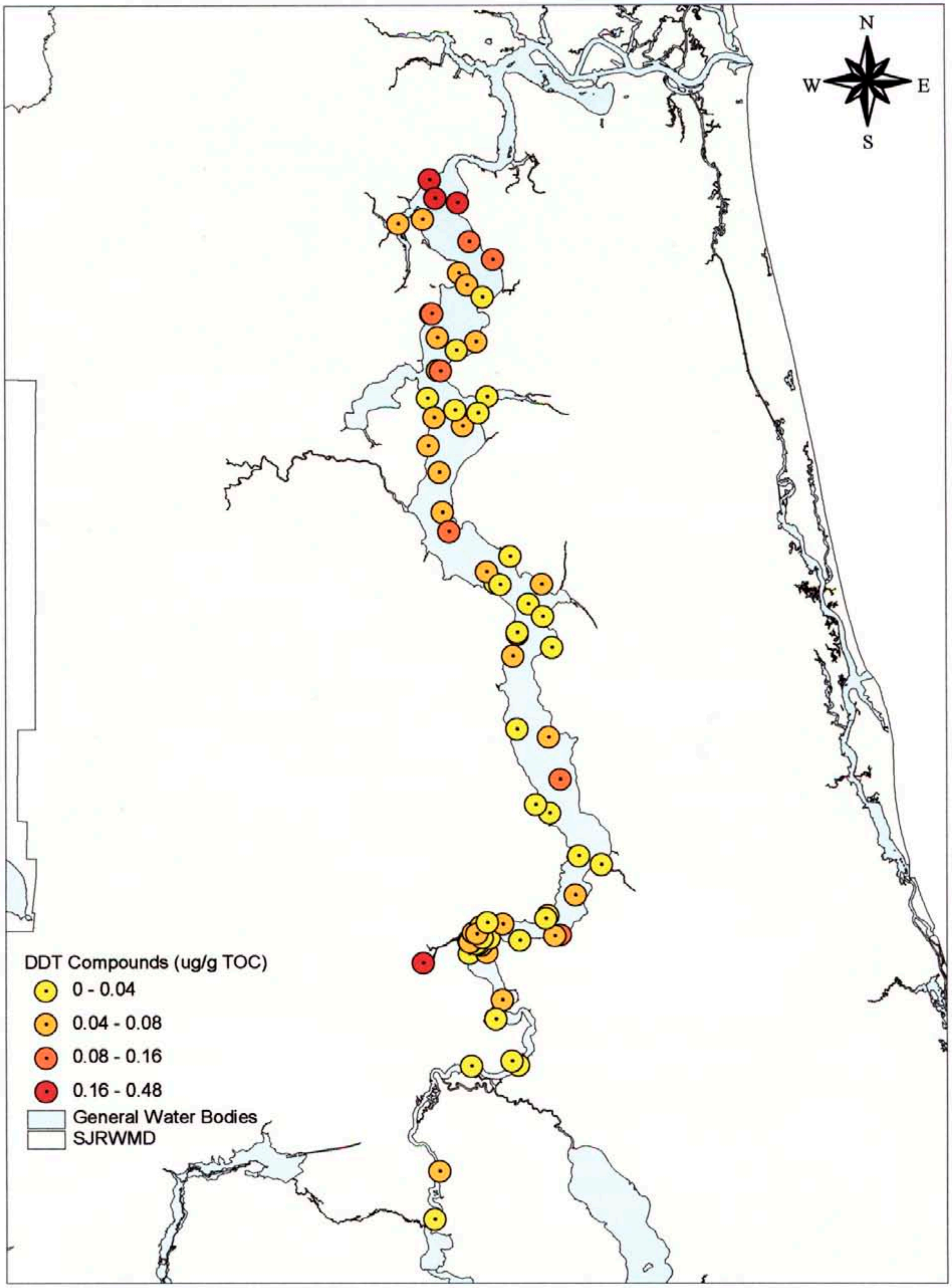


Figure 4-10. Lower St. Johns River — Map Displaying TOC Normalized Total DDT Compound Concentrations

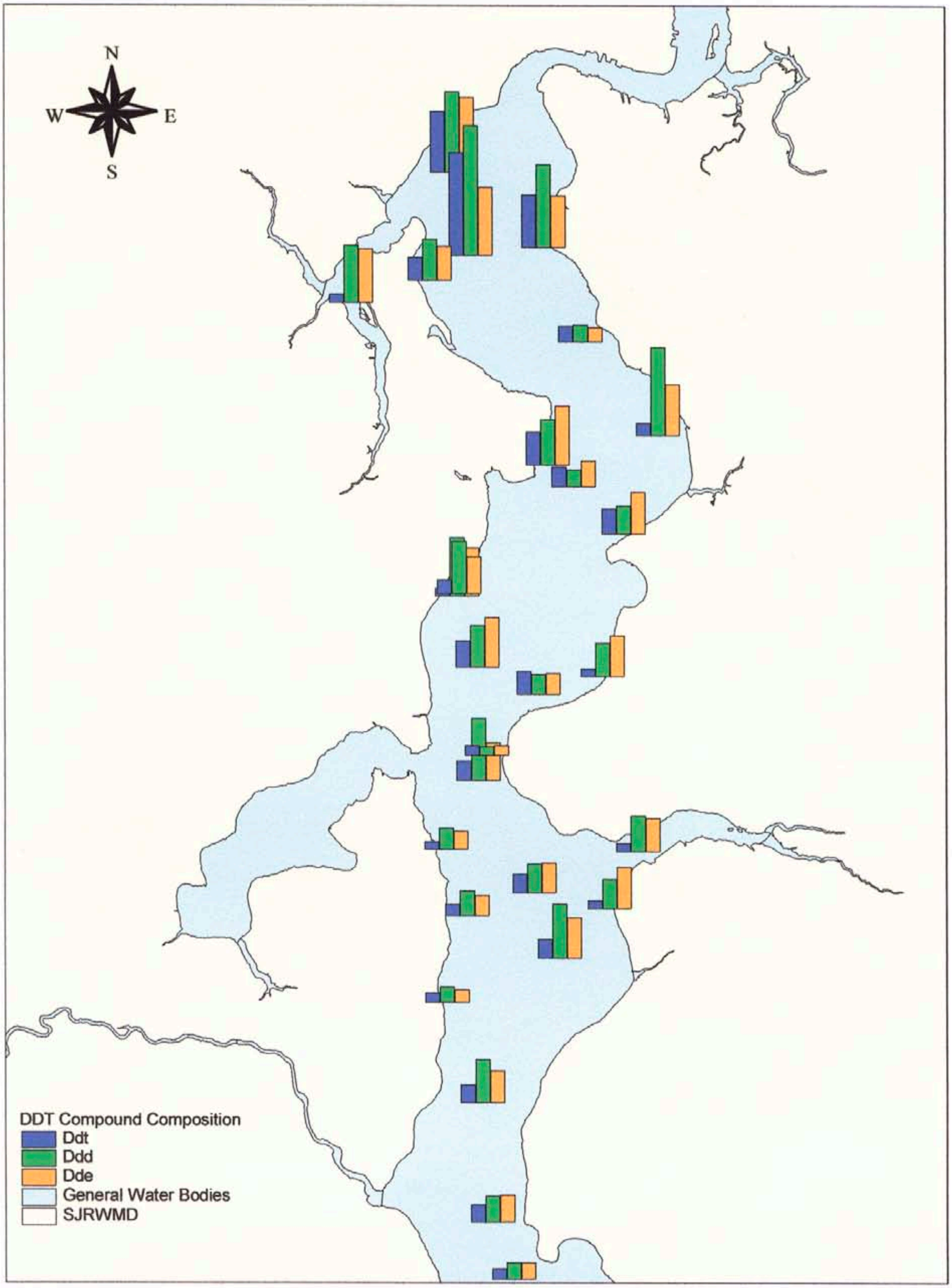


Figure 4-11. Lower St. Johns River — Map Displaying Relative Composition of DDT and its Key Degradation Products for Selected Sites

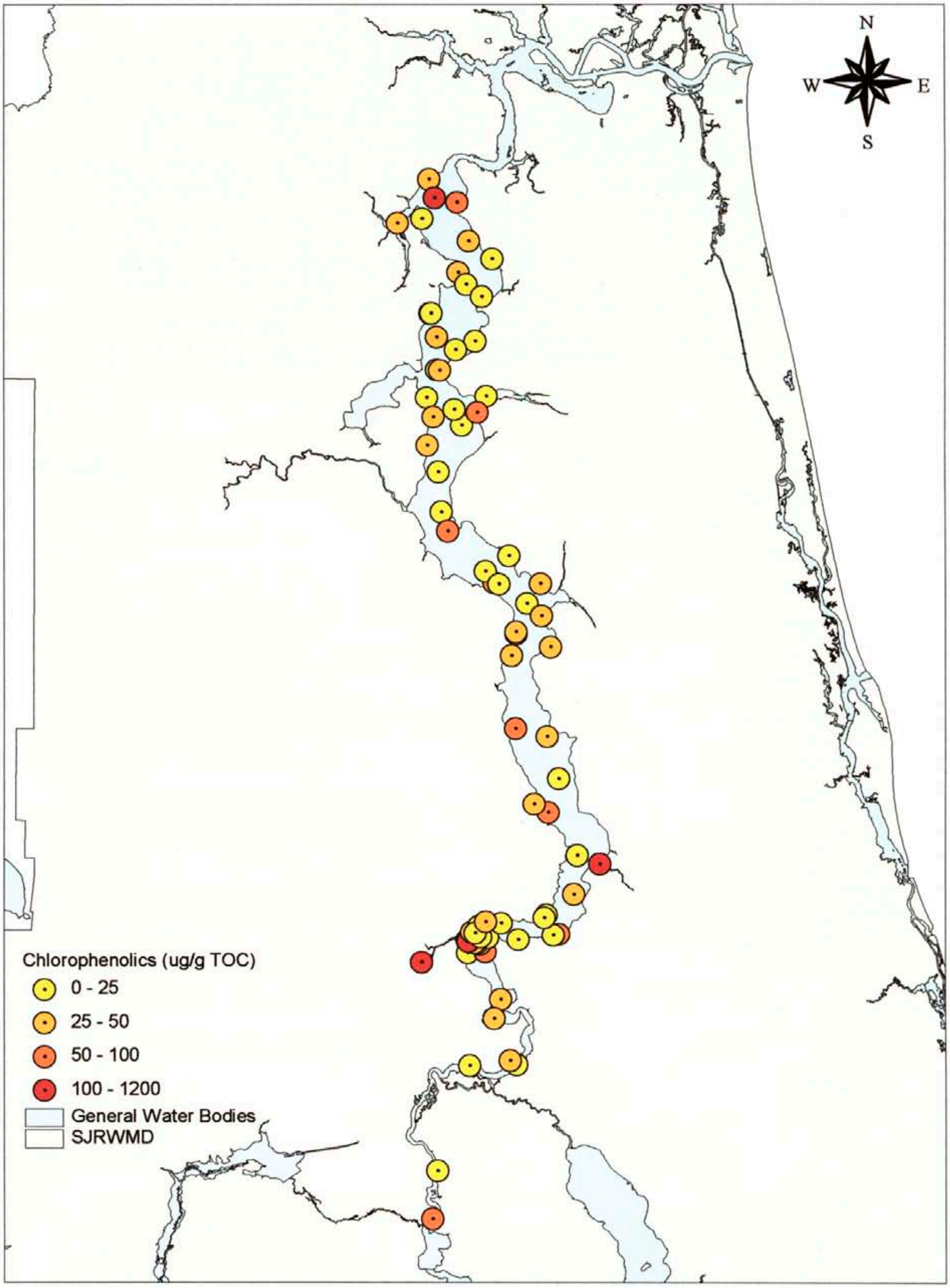


Figure 4-12. Lower St. Johns River — Map Displaying TOC Normalized Sum of Chlorophenolic Compound Concentrations

As discussed in Section 3.1.3, the analytical method that was developed for the chlorophenolic compound analysis in this project was intended to provide a first-level screening analysis of a broad range of compounds simultaneously, with the intent to identify locations and/or compounds that may warrant more detailed investigation. Battelle's quality assurance and quality control program results demonstrated adequate recoveries of these chlorophenolic compounds, and Battelle is confident in the analytical methods used and the reported results as intended screening level data. However, since the method accommodated chlorinated phenolic compounds with highly varying chemical characteristics, it could not be optimized for a specific narrow class of compounds and there was a significant potential for matrix contributions (i.e., non-analyte matrix contribution to measured target compounds, and even false positives). Therefore, to improve the reliability for most chlorophenolic group, Battelle and the SJRWMD agreed to modify the list of analytes requested for some of the sediment samples. This resulted in a modification in the data reports. Some data reports contained the full-suite of chlorophenolic analytes as present in Tables 1-1 and 3-7, while others lacked the results for the tetrachlorocatechol, and 3,4,6-trichlorocatechol compounds. The chlorophenolic data should therefore be used with caution, keeping in mind the intended use of these results.

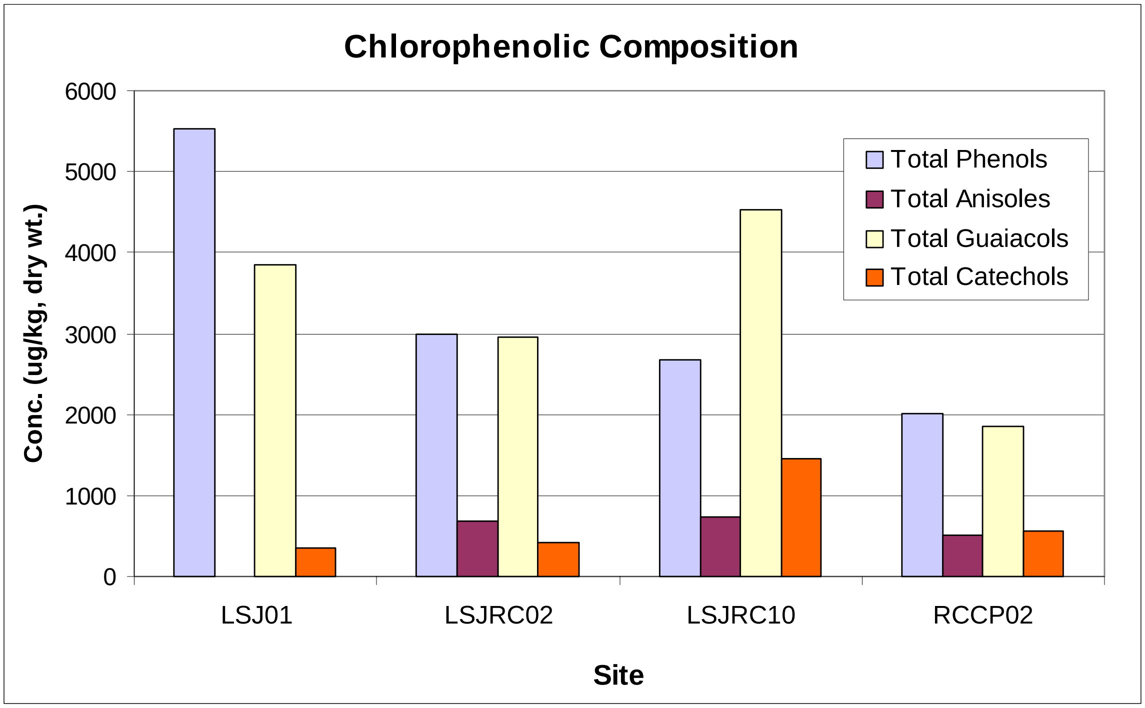


Figure 4-13. Lower St. Johns River — Chlorophenolic Compound Class Composition at Selected Sites

Nevertheless, after accounting for the sometimes sporadic chlorophenolic compound detections (e.g., detection of only one of the four classes of compounds), there appears to be a subtle pattern of elevated total chlorophenolic compounds in the northern parts of the St. Johns River and in and around Rice Creek. The chlorophenolic compound composition (Figure 4-13 and Appendices D and H) was dominated by 2-chlorophenol and selected di-, tri-, and tetrachlorphenols at most locations. The presence of these broadly used (and highly mobile) chlorinated phenol class of compounds was wide spread. Anisoles were detected at greater frequency at the sites near Rice Creek than any other area, but also at several geographically scattered sites. The guaiacol and catechol compounds were detected broadly, with a relatively consistent detection of guaiacols in the northern parts of the St. Johns River and of both guaiacols and catechols near Rice Creek. Both were also detected at several other isolated locations. The lack of correlation between guaiacols and catechols in the northern part of the river is surprising, considering that these classes of compounds will most often co-exist in environmental contamination, such as in environments exposed to pulp and paper industrial activities. Site LSJ23, which was near the shore at the center of the study area, had elevated detections of, particularly, chlorinated phenols, anisoles, and guaiacols; site BAY01, which was located next to LSJ23, had only low levels of chlorinated phenols and anisoles, no guaiacols, and significant levels of catechols. This inconsistency in results for sites so close to each other indicates the complexity of a) environmental factors influencing the distribution of the chemicals, and b) the sediment sample matrix and the analytical difficulties with resolving specific analytes at very low levels from associated interferences, and confounds the data interpretation. Site RCCP02 (located in the Rice Creek), and a few St. Johns River sites near the mouth of Rice Creek, appear to consistently have somewhat elevated concentrations of all chlorophenolic compound classes. These data suggest that this area may warrant further investigation using more specific analytical protocols, particularly when considering the potential relationship between these contaminants and the pulp and paper industry activity in the Rice Creek area.

***Organic Compounds — Potential Hot Spots*.**

This particular study can be used as the primary frame of reference when discussing potential hot spots, or one can include data from other comparable locations throughout the country to put the entire study area into perspective. Contaminant concentrations were earlier in this section compared to data generated in various other national monitoring programs (Table 4-1), but because there are limited data from other studies and locations that can be considered truly comparable, this section will focus on data generated in this study. The reader should be aware that significantly elevated concentrations relative to other study sites do not necessarily indicate environmental concern — it could simply mean that most sites have relatively low contaminant concentrations.

The organic compound contaminant concentrations are clearly higher at several of the northern-most St. Johns River sites, and at some of the sites near Rice Creek. Elevated concentrations of PAH, PCB, some phthalates, some pesticides (particularly DDT, chlordane, and endosulfans), and some chlorinated phenolic compounds, were measured in the northern parts of the St. Johns River; sites located between LSJ05 and HSP05, with the sites closest to Jacksonville typically having the highest concentrations (e.g., HSP05, LSJ01, and LSJ02). This suggests that most of the contamination in this area comes from urban activities in and around Jacksonville, and the PAH composition in this area was indicative of typical urban runoff/discharge/deposition.

Several of the sites near Rice Creek also had elevated concentrations of PAH, PCBs, some pesticides (particularly chlordane and endosulfans, but also, to a lesser degree, DDT), chlorinated phenolic compounds, and other chlorinated industrial compounds. The PAH composition was different in this area than in other parts of the river, indicating a local origin of some of these, and potentially other, contaminants. The proximity to Palatka and the nearby pulp and paper industry present possible local sources. The site in Rice Creek itself (RCCP02) had DDT contamination that was more “fresh” than most other location, and had a consistent signal of the different chlorinated phenolic compounds.

Site NASCP01 was another location that had somewhat elevated concentrations of several contaminants, including PAH, PCB, and DDT. This is a site that is located fairly far north in the study area (which, as discussed, meant increasingly high contaminant levels anyway) and is also close to the Naval Air Station. The one site in this LSJR subset of sites that was located in the Cedar-Ortega River Basin (CO06) had notably elevated levels of chlordane, and somewhat elevated concentrations of PCB, DDT, and some chlorophenol compounds.

Organic Compounds — Indicators of Potential Effects.

In the following section concentrations of contaminants in sediments are compared to effects-based sediment quality guideline values. Effects range-low (ERL) and effects range-median (ERM) values are the most commonly used and referenced sediment quality guidelines. They were initially developed by scientists at NOAA (Long and Morgan, 1990) and were later revised after compiling additional data (Long *et. al*., 1995). These are scientifically derived values of potential for biological effects from sediment-sorbed contaminants.

The degree of confidence in the representativeness of the ERL and ERM values is sometimes hotly debated. There is, for instance, typically more confidence in the PAH guidance values than in those for PCB or most toxic metals. These reference values are screening tools that were developed to evaluate the potential for biological impact. However, although these values were not intended as sediment quality criteria, and should not be used as such, they can be useful as a semiquantitative point of reference for reviewing sediment data.

The ERL and ERM guideline values delineate three concentration ranges for a particular chemical (Long *et. al*., 1995). The concentration below the ERL value represents a minimal-effect range; a range representing conditions in which effects would rarely be observed. Concentrations between the ERL and ERM represent a possible-effects range within which effects would occasionally occur, and the concentrations above the ERM value represent a probable-effects range where effects would be expected to frequently occur.

Guidelines similar to the more widely accepted and used ERL and ERM values have also been published specifically for sediments in Florida systems (MacDonald *et al*., 1996; FDEP, 1994). MacDonald published threshold effects levels (TEL) and probable effect levels (PEL) for Florida coastal water sediments using a weight-of-evidence approach. These TELs and PELs were determined similarly to the ERLs and ERMs, and, like ERLs and ERMs, were developed based on coastal/salt-water sediment data. The three ranges of contaminant concentrations represent sediment levels that rarely, occasionally, and frequently are associated with adverse biological effects, but the TEL/PEL values are typically lower than the ERL/ERM values because the testing regime used in their development to generate actual sediment quality guidelines. The marine/coastal sediment ERL, ERM, TEL, and PEL values are summarized in Table 4-2. Organic contaminant ERL, ERM, TEL, and PEL values are based on non-normalized concentration data.

An additional set of sediment quality guidelines has been developed for the freshwater systems in the province of Ontario (Persaud *et al*., 1993); it uses lowest effects levels (LELs), which indicate a level of contamination which has an effect on less than 5% of the sediment-dwelling organisms studied. A more comprehensive set of freshwater sediment guidelines were recently developed (Smith, *et. al*., 1996; CCME, 1995), and these are increasingly being used for sediment quality evaluation. These guidelines were based on much of the approach taken by MacDonald for developing sediment quality guidelines for Florida, and they are also referred to as TEL and PEL values. The freshwater LEL, TEL, and PEL values are summarized in Table 4-3. Organic contaminant freshwater TEL, PEL, and LEL values are based on non-normalized concentrations.

Table 4-2. Marine Sediment ERL, ERM, TEL, and PEL Values

Contaminant	ERL[a] (mg/kg for metals and µg/kg for organics)	ERM[b] (mg/kg for metals and µg/kg for organics)	TEL[c] (mg/kg for metals and µg/kg for organics)	PEL[d] (mg/kg for metals and µg/kg for organics)
As	8.2	70	7.24	41.6
Cd	1.2	9.6	0.68	4.21
Cr	81	370	52.3	160
Cu	34	270	18.7	108
Pb	46.7	218	30.2	112
Hg	0.15	0.71	0.13	0.7
Ni	20.9	51.6	15.9	42.8
Ag	1	3.70	0.73	1.77
Zn	150	410	124	271
Total PCB	22.7	180	21.6	189
Total DDT	1.58	46.1	3.89	51.7
p,p'-DDE	2.2	27	2.07	374
p,p'-DDD	2	20	1.22	7.81
p,p'-DDT	1	7	1.19	4.77
Dieldrin	0.02	8	0.72	4.3
Lindane	NA[e]	NA	0.32	0.99
Chlordane	0.5	6	2.26	4.79
Low PAH	552	3,160	312	1,442
High PAH	1,700	9,600	655	6,676
Total PAH	4,022	44,792	1,684	16,770
Acenaphthene	16	500	6.71	88.9
Acenaphthylene	44	640	5.87	128
Anthracene	85.3	1100	46.9	245
Fluorene	19	540	21.2	144
Naphthalene	160	2,100	34.6	391
2-Methylnaphthalene	70	670	20.2	201
Phenanthrene	240	1,500	86.7	544
Benz(a)anthracene	261	1,600	74.8	693
Benzo(a)pyrene	430	1,600	88.8	763
Chrysene	384	2,800	108	846
Dibenzo(a,h)anthracene	63.4	260	6.22	135
Fluoranthene	600	5,100	113	1,494
Pyrene	665	2,600	153	1,398
Bis(2-ethylhexyl)phthalate	NA	NA	182	2,647

[a] ERL: Effects Range Low (Long *et al.*, 1995; Long & Morgan, 1990, for DDD, DDT, dieldrin and chlordane).
[b] ERM: Effects Range Median (Long *et al.*, 1995; Long & Morgan, 1990, for DDD, DDT, dieldrin and chlordane).
[c] TEL: Threshold Effect Level (MacDonald *et al.*, 1996; FDEP, 1994)
[d] PEL: Probable Effect level (MacDonald *et al.*, 1996; FDEP, 1994)
[e] NA: not applicable. There is no ER-L or ER-M for this parameter.

Table 4-3. Freshwater Sediment TEL, PEL, and LEL Values

Contaminant	TEL[a] (mg/kg for metals and μg/kg for organics)	PEL[b] (mg/kg for metals and μg/kg for organics)	LEL[c] (mg/kg for metals and μg/kg for organics)
As	5.9	17	6
Cd	0.6	3.5	0.6
Cr	37.3	90	26
Cu	35.7	197	16
Pb	35	91.3	31
Hg	0.17	0.49	0.2
Ni	18	35.9	16
Zn	123	315	120
Total PCB	34.1	277	70
Total DDT	6.98	4,450	7
p,p'-DDE	1.42	6.75	5
p,p'-DDD	3.54	8.51	8
Chlordane	4.5	8.9	7
Dieldrin	2.85	6.67	NA [d]
Endrin	2.67	62.4	NA
Lindane	0.94	1.38	3
Heptachlor epoxide	0.6	2.74	NA
Total PAH	NA	NA	4,000
Anthracene	NA	NA	220
Fluorene	NA	NA	190
Phenanthrene	41.9	515	560
Benz(a)anthracene	31.7	385	320
Benzo(a)pyrene	31.9	782	370
Chrysene	57.1	862	340
Dibenzo(a,h)anthracene	NA	NA	60
Fluoranthene	111	2,355	750
Pyrene	53	875	490

[a] TEL: Threshold Effect Level (Smith *et al*., 1996)
[b] PEL: Probable Effect level (Smith *et al*., 1996; CCME, 1995)
[c] LEL: Lowest Effect level, (Persaud *et al*., 1993)
[d] NA: not applicable. There is no TEL, PEL, or LEL for this parameter.

The ERL/ERM and TEL/PEL values in Table 4-2 were developed for coastal sediments, and it is unclear how they translate to fresh water systems. However, the TEL/PEL values in Table 4-3, which were developed by the Canadian regulatory agencies for assessing freshwater sediment quality in Canada, compare quite well with ERL/ERM values, although the TEL/PEL values generally are slightly lower than the ERL/ERM values when differences were observed. Long and MacDonald (1998) have concluded that saltwater sediment quality guidelines are comparable to those derived with similar empirical methods, but different databases, for freshwater sediments. These data suggest there is relatively little impact on effects from sediment residing contaminants due to differences between coastal and freshwater sediments. In addition, these sediment quality guidelines were developed base on data from toxicity testing with a wide range of testing scenarios and systems, and a significant degree of broad based general application was incorporated; a significant "error margin" should therefore be used in the application of the values. Another note of caution in applying ERL and ERMs is that these sediment quality guidelines may not satisfactorily account for multiple contaminants, or contaminant interactions, that may affect biota that are exposed to a complex suite of contaminants simultaneously.

It is clear that there can be differences in the contaminant assessment conclusions depending on which sediment quality guidelines one uses. Additionally, the high TOC concentrations in many of these samples actually contributes to "holding" the organic contaminants, making them less available to cause environmental harm. However, simultaneously considering both TOC- and non-normalized data, and the ERL/ERM and TEL/PEL values, is most useful for an overall contaminant assessment.

Table 4-4 summarizes the number of sites that exceeded the ERL and ERM values (marine/coastal guidelines), the State of Florida TEL and PEL values (marine/coastal guidelines), and the Canadian TEL and PEL values (freshwater guidelines). The assessment of sediment quality guideline exceedances focuses on the ERL/ERM values (the most widely applied sediment quality guidelines) and the freshwater TEL/PEL values (the most comprehensive freshwater guidelines). Graphs with total PAH, total PCB, and sum of the DDT compound concentrations are presented in Figures 4-14, 4-15, and 4-16, respectively, along with the ERL, ERM, reference values. Additional plots with ERL/ERM and *freshwater* TEL/PEL references are presented in Appendix M. Non-normalized data are used for all organic and metals sediment quality guideline comparisons.

Table 4-4. Number of Sites with Surface Sediment ERL, ERM, TEL, and PEL Exceedances

Contaminant	**Number of Sediment Quality Guideline Exceedances** [a]					
	Marine Guidelines				**Freshwater Guidelines**	
	ERL	**ERM**	**TEL**	**PEL**	**TEL**	**PEL**
Lower St. Johns River Sites						
As	7 (9%) [a]	0 (0%)	15 (19%)	0 (0%)	26 (34%)	0 (0%)
Cd	2 (3%)	0 (0%)	17 (22%)	0 (0%)	21 (27%)	0 (0%)
Cr	3 (4)	0 (0%)	21 (27%)	0 (0%)	39 (51%)	1 (1%)
Cu	4(5%)	0 (0%)	22 (29%)	0 (0%)	4 (5%)	0 (0%)
Pb	8 (10%)	0 (0%)	19 (25%)	0 (0%)	18 (23%)	1 (1%)
Hg	49 (64%)	1 (1%)	51 (66%)	1 (1%)	45 (58%)	2 (3%)
Ni	2 (3%)	0 (0%)	25 (32%)	0 (0%)	9 (12%)	0 (0%)
Ag	1 (1%)	0 (0%)	4 (5%)	0 (0%)	NA	NA
Zn	9 (12%)	0 (0%)	13 (17%)	0 (0%)	13 (17%)	0 (0%)
Total PCB	58 (75%)	10 (13%)	58 (75%)	8 (10%)	52 (68%)	4 (5%)
Total DDT	64 (83%)	0 (0%)	50 (65%)	0 (0%)	30 (39%)	0 (0%)
p,p'-DDE	33 (43%)	0 (0%)	33 (43%)	0 (0%)	42 (55%)	1 (1%)
p,p'-DDD	40 (52%)	0 (0%)	36 (47%)	1 (1%)	NA	NA
p,p'-DDT	45 (58%)	4 (5%)	32 (42%)	3 (4%)	NA	NA
Dieldrin	53 (69%)	0 (0%)	20 (26%)	0 (0%)	0 (0%)	0 (0%)
Endrin	NA	NA	NA	NA	0 (0%)	0 (0%)
Lindane	NA	NA	39 (51%)	19 (25%)	20 (26%)	11 (14%)
Chlordane	33 (43%)	0 (0%)	8 (10%)	0 (0%)	0 (0%)	0 (0%)
Heptachlor epoxide	NA	NA	NA	NA	10 (13%)	3 (4%)
Low PAH	11 (14%)	1 (1%)	20 (26%)	3 (4%)	NA	NA
High PAH	23 (30%)	1 (1%)	55 (71%)	1 (1%)	NA	NA
Total PAH	6 (8%)	0 (0%)	29 (38%)	0 (0%)	NA	NA
Acenaphthene	10 (13%)	0 (0%)	24 (31%)	4 (57%)	NA	NA
Acenaphthylene	10 (13%)	0 (0%)	63 (82%)	1 (1%)	NA	NA
Anthracene	14 (18%)	0 (0%)	20 (26%)	7 (9%)	NA	NA
Fluorene	18 (23%)	0 (0%)	15 (19%)	2 (3%)	NA	NA
Naphthalene	2 (3%)	0 (0%)	27 (35%)	1 (1%)	NA	NA
2-Methylnaphthalene	4 (5%)	0 (0%)	19 (25%)	1 (1%)	NA	NA

Contaminant	**Number of Sediment Quality Guideline Exceedances** [a]					
	Marine Guidelines				**Freshwater Guidelines**	
	ERL	**ERM**	**TEL**	**PEL**	**TEL**	**PEL**
Phenanthrene	6 (8%)	0 (0%)	18 (23%)	3 (4%)	37 (48%)	3 (4%)
Benz(a)anthracene	3 (4%)	0 (0%)	26 (34%)	0 (0%)	55 (71%)	1 (1%)
Benzo(a)pyrene	1 (1%)	0 (0%)	33 (43%)	1 (1%)	60 (78%)	1 (1%)
Chrysene	2 (3%)	0 (0%)	18 (23%)	0 (0%)	48 (62%)	0 (0%)
Dibenzo(a,h)anthracene	1 (1%)	0 (0%)	56 (73%)	0 (0%)	NA	NA
Fluoranthene	8 (10%)	0 (0%)	47 (61%)	3 (4%)	47 (61%)	0 (0%)
Pyrene	6 (8%)	0 (0%)	43 (56%)	3 (4%)	62 (81%)	5 (6%)
Bis(2-ethylhexyl)phthalate	NA	NA	15 (19%)	0 (0%)	NA	NA
Cedar-Ortega River Basin Sites						
As	4 (8%) [a]	0 (0%)	7 (14%)	0 (0%)	18 (35%)	1 (2%)
Cd	24 (47%)	0 (0%)	39 (76%)	0 (0%)	41 (80%)	2 (4%)
Cr	2 (4%)	0 (0%)	39 (76%)	0 (0%)	47 (92%)	2 (4%)
Cu	24 (47%)	0 (0%)	42 (82%)	0 (0%)	24 (47%)	0 (0%)
Pb	41 (80%)	4 (8%)	43 (84%)	10 (20%)	42 (82%)	14 (27%)
Hg	47 (92%)	23 (45%)	47 (92%)	23 (45%)	46 (90%)	42 (82%)
Ni	3 (6%)	0 (0%)	17 (33%)	0 (0%)	8 (17%)	0 (0%)
Ag	12 (24%)	2 (4%)	21 (41%)	3 (6%)	NA	NA
Zn	32 (63%)	9 (18%)	40 (78%)	15 (29%)	40 (78%)	11 (22%)
Total PCB	50 (98%)	42 (82%)	50 (98%)	42 (82%)	48 (94%)	31 (40%)
Total DDT	49 (96%)	2 (4%)	49 (96%)	1 (2%)	43 (84%)	0 (0%)
p,p'-DDE	43 (84%)	1 (2%)	44 (86%)	0 (0%)	45 (88%)	19 (37%)
p,p'-DDD	44 (86%)	2 (4%)	44 (86%)	4(8%)	NA	NA
p,p'-DDT	46 (90%)	7 (14%)	39 (76%)	9 (18%)	NA	NA
Dieldrin	41 (80%)	0 (0%)	28 (55%)	3 (6%)	5 (10%)	1 (2%)
Endrin	NA	NA	NA	NA	1 (2%)	0 (0%)
Lindane	NA	NA	33 (65%)	24 (47%)	24 (47%)	19 (37%)
Chlordane	44 (86%)	22 (43%)	37 (73%)	26 (51%)	27 (53%)	15 (29%)
Heptachlor epoxide	NA	NA	NA	NA	2 (4%)	0 (0%)
Low PAH	12 (24%)	0 (0%)	29 (57%)	0 (0%)	NA	NA
High PAH	45 (88%)	8 (16%)	50 (98%)	12 (24%)	NA	NA
Total PAH	29 (57%)	0 (0%)	47 (92%)	1 (2%)	NA	NA
Acenaphthene	20 (39%)	0 (0%)	42 (82%)	0 (0%)	NA	NA
Acenaphthylene	13 (26%)	0 (0%)	47 (92%)	0 (0%)	NA	NA
Anthracene	15 (29%)	0 (0%)	30 (59%)	1 (2%)	NA	NA
Fluorene	28 (55%)	0 (0%)	23 (45%)	0 (0%)	NA	NA
Naphthalene	3 (6%)	0 (0%)	38 (75%)	0 (0%)	NA	NA
2-Methylnaphthalene	1 (2%)	0 (0%)	26 (51%)	0 (0%)	NA	NA
Phenanthrene	7 (14%)	0 (0%)	28 (55%)	2 (4%)	43 (84%)	2 (4%)
Benz(a)anthracene	18 (35%)	0 (0%)	42 (82%)	2 (4%)	45 (88%)	9 (18%)
Benzo(a)pyrene	14 (28%)	1 (2%)	38 (75%)	7 (14%)	46 (90%)	7 (14%)
Chrysene	16 (31%)	0 (0%)	40 (78%)	5 (10%)	44 (86%)	5 (10%)
Dibenzo(a,h)anthracene	22 (43%)	2 (4%)	47 (92%)	8 (16%)	NA	NA
Fluoranthene	18 (35%)	0 (0%)	45 (88%)	3 (6%)	45 (88%)	1 (2%)
Pyrene	21 (41%)	0 (0%)	44 (86%)	3 (6%)	49 (96%)	11 (22%)
Bis(2-ethylhexyl)phthalate	NA	NA	26 (51%)	0 (0%)	NA	NA

[a] The percentage of all 77 Lower St. Johns River and the 51 broadly assessed Cedar-Ortega River sites that exceeded the guidance values are listed in parenthesis.

[b] NA: not applicable. There is no ERL, ERM, TEL, or PEL value for this parameter in this sediment type.

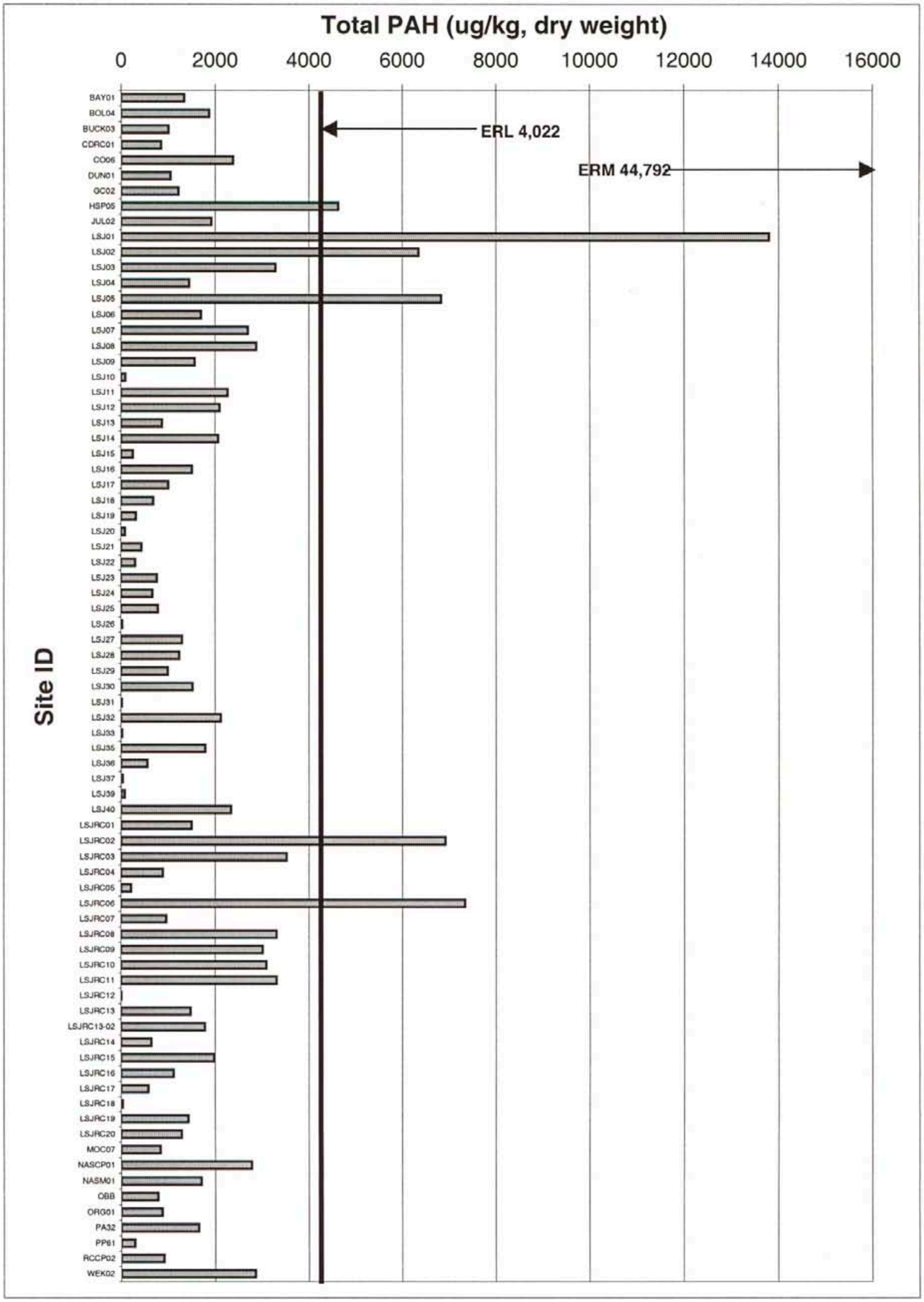


Figure 4-14. Lower St. Johns River — Total PAH Concentrations and ERL/ERM Values

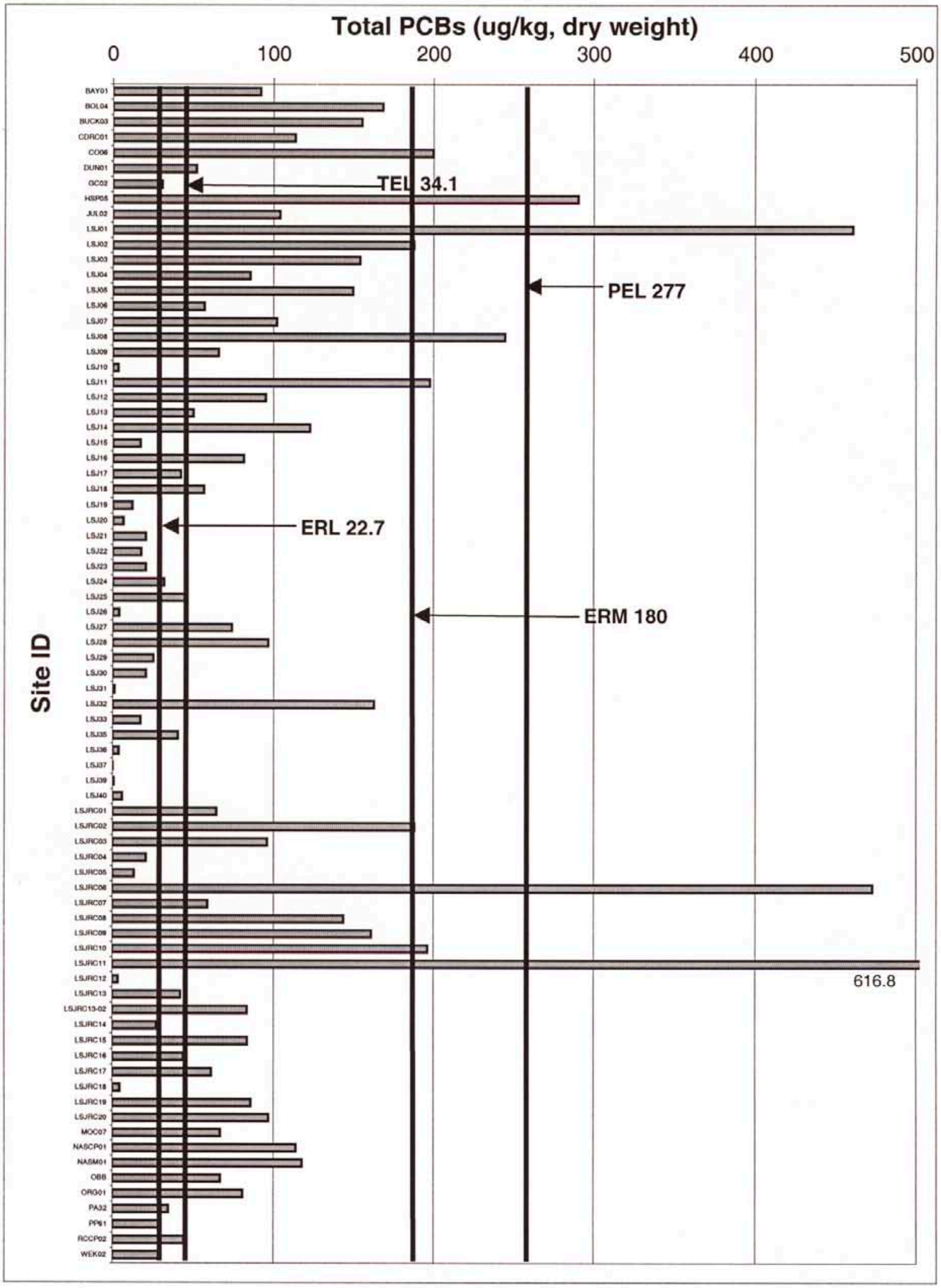


Figure 4-15. Lower St. Johns River — Total PCB Concentrations and ERL/ERM and TEL/PEL Values

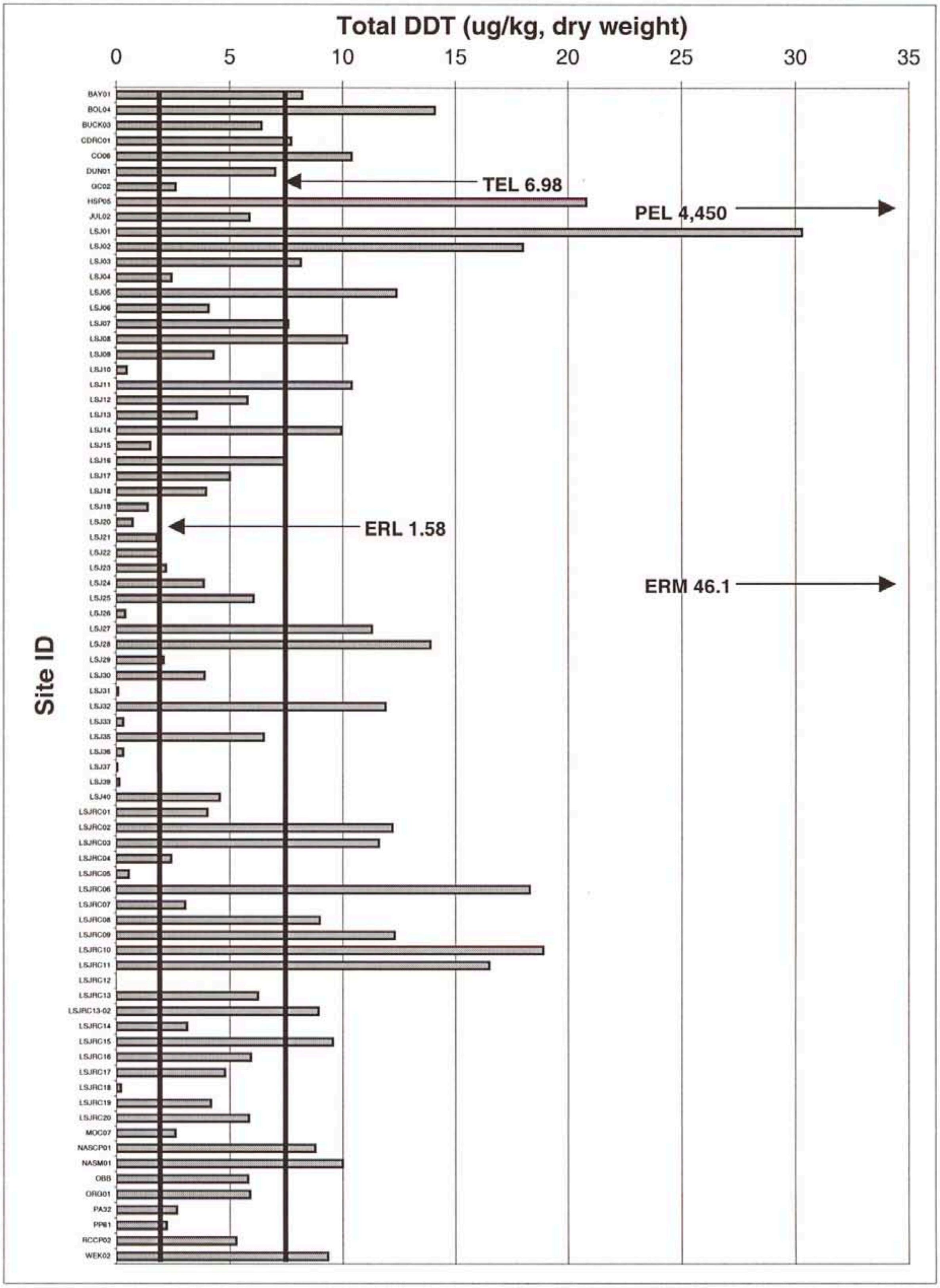


Figure 4-16. Lower St. Johns River — Sum of DDTs Concentrations and ERL/ERM and TEL/PEL Values

PAH

There were several ERL, ERM, and marine TEL exceedances for the PAH concentrations in the LSJR sites. Eight percent, 30%, and 14% of the LSJR sites (Table 4-4) exceed the Total PAH ERL, High PAH ERL, and Low PAH ERL values, respectively. Total PAH concentrations did not exceed the ERM, but the High PAH ERM value and Low PAH ERM value were exceed at 1 site (LSJ01). Since there are no *freshwater* TEL or PEL values for PAH, the LSJR PAH data were compared with the marine TEL/PEL values. The LSJR sites exceeded the marine TELs for Total PAH, High PAH, and Low PAH at 38%, 71% and 26% of the sites, respectively. Marine PELs were exceeded for High PAH and Low PAH at 1 and 4% of the sites respectively, but did not exceed the Total PAH PEL.

Note that the PAH compounds used to compute the low- and high-molecular weight PAH ERL/ERM values (Long *et. al*., 1995) are slightly different from what is commonly used for similar summations, and from what is used in this report (see Table 3-1). However, the differences are small and have no impact on the overall exceedance rate or conclusions.

PCB

The total PCB ERL was exceeded at 58 (or 75%) of the 77 LSJR sites and total PCB concentrations exceed the ERM value at 10 (or 13%; sites CO06, HSP05, LSJ01, LSJ02, LSJ08, LSJ11, LSJRC02, LSJRC06, LSJRC10, LSJRC11) of the LSJR sites. Note that the total PCB concentration used for this assessment was calculated by multiplying the sum of the target PCB congener concentrations by 2.4, as discussed in Section 3.1.2. The freshwater Total PCB TEL was exceeded at 52 (68%) of the 77 LSJR sites, and there were 4 freshwater Total PCB PEL exceedances. The PEL exceedances were for sites HSP05, LSJ01, LSJRC06, and LSJRC11.

Pesticides - DDTs

The ERL for total DDT was exceeded at 64 (83%) of the 77 LSJR sites and the freshwater TEL was exceeded at 30 (39%) of the LSJR sites; there were no ERM or freshwater PEL exceedances for total DDT. The individual p,p'-DDT, p,p'-DDD, and p,p'-DDE compound concentrations exceed the ERL values at 45 (58%), 40 (52%), and 33 (43%) of the 77 LSJR sites respectively. The p,p'-DDD and p,p'-DDE concentrations did not exceed the ERM but the p,p'-DDT concentrations exceeded the ERM at 4 (5%) of the 77 LSJR sites. The freshwater TEL value was exceed for p,p'-DDE at 42 (55%) of the 77 LSJR sites and the freshwater PEL value for p,p'-DDE was exceeded at 1 (1%, HSP05) of LSJR sites.

Pesticides – Other Chlorinated Pesticides

There were also a fairly large number of sites with chlordane and dieldrin concentrations that exceeded the most conservative sediment quality guideline values, but the concentrations of pesticides does not appear to present a notable risk. Chlordane exceeded the ERL at 33 (43%) of the 77 LSJR sites, but did not exceed the ERM, freshwater TEL, or freshwater PEL values. Dieldrin did not exceed the ERM, freshwater TEL, or freshwater PEL values but did exceed the ERL at 53 (69%) of the 77 LSJR sites. However, the referenced ERL value for dieldrin is described as being a number with "low" confidence by Long and Morgan (1990), and should not be considered a reliable value for potential effects assessment. This listed ERL value for dieldrin is a factor of 100 lower than the dieldrin TEL value, even though the ERL and TEL values are comparable for most other organic contaminants. The concentrations of lindane in the LSJR sites were above both the TEL and PEL values at a number of sites; 20 (26%) of the 77 sites exceeded the TEL, while 11 (14%) of the 77 sites exceed the PEL. The lindane PEL exceedances were mostly observed at sites near Rice Creek (e.g., LSJRC02, LSJRC03, LSJRC06, LSJRC08, LSJRC09, LSJRC10), and some sites several miles up and down-stream of this area (e.g., LSJ02, LSJ27, LSJ30, LSJ32, and LSJ35).

4.1.2 Metal Contaminant Levels

Metals — Contaminant Concentration, Distribution, and Composition.

The important relationships between metals (e.g., toxic metals and major metals), the general physico-chemical characteristics of sediments (e.g., TOC and grain size), and how those relate to the interpretation of metals data, were discussed in Section 3.2. The physico-chemical data analyses described in Section 3.2 indicated that, for these samples, the metals contamination can be assessed through the concurrent use of non-normalized and aluminum normalized metals contaminant data.

There was a broad range in the metal concentrations of the St. Johns River sediments, and the levels were also spatially variable. An example of this range and variability was seen in the aluminum concentrations (Figure 4-17). Aluminum is a major metal primarily associated with mineral components of sediments. It is frequently used to normalize variability in metals concentrations that arise from differences in the grain size composition and geology of sediments. Through normalization, naturally occurring metal concentrations can often be separated from those resulting from anthropogenic activities. Bar charts depicting the non-normalized and aluminum- and grain size-normalized metals data are compiled in Appendix K.

Aluminum concentrations in the sediments ranged from a low of 637 mg/kg to a high of 54,500 mg/kg, or a 100-fold difference between the lowest and highest concentrations. A range like this is typical of systems that have highly variable grain size distributions, as found in this set of samples. As observed in the aluminum distribution, the other major metals associated with crustal materials (minerals) also displayed a large range in concentration. Manganese concentrations, for instance, ranged from 20.8 to 485 mg/kg and lithium from 1.4 to 45 mg/kg. There was a 23- and 32-fold difference, respectively, between the maximum and minimum concentrations of these two elements.

As shown in Tables 3-10 and 3-11, the toxic metals concentrations were also quite variable in the Lower St. Johns River. Differences between high and low values ranged from 20 fold for antimony to 300 fold for lead. Variability in the relative difference between the high and low values can be related to many factors including the proximity to sources, subtle differences in the factors controlling concentrations (e.g., TOC, grain size), and the redox state of the sediments. Generally speaking, samples with low toxic metals concentrations tended to be associated with sediments that were sandier in nature. However, there were also subtle geographical patterns to some metal profiles that may be attributable to potential sources; the percent mud did not exhibit a discernable geographical pattern (Appendix L).

There were less discrete contaminant signals and patterns for metals than for organic contaminants, and most metals followed a very similar contaminant distribution trend. The concentrations of most metals, including antimony, arsenic, beryllium, cadmium, chromium, cobalt, copper, lead, lithium, tin, silver, and zinc appeared to be slightly elevated in the northern, more urban and industrial, parts of the St. Johns River (Figures 4-18 through 4-20, and Appendices E and K). However, the magnitude of the elevation was generally small, and when the data were normalized to aluminum to better discern anthropogenic enrichment of the sediments the apparent contaminant elevation was generally not evident. The aluminum-normalized data for some of these metals indicated elevations at a few sites, but these were primarily due to low aluminum concentrations (i.e., coarse sediments), and when viewed together — non-normalized and aluminum-normalize data — there did not appear to be a contamination issue (e.g., antimony, chromium, cobalt, lithium, and tin at LSJ31, LSJ33, LSJ37, and LSJRC12).

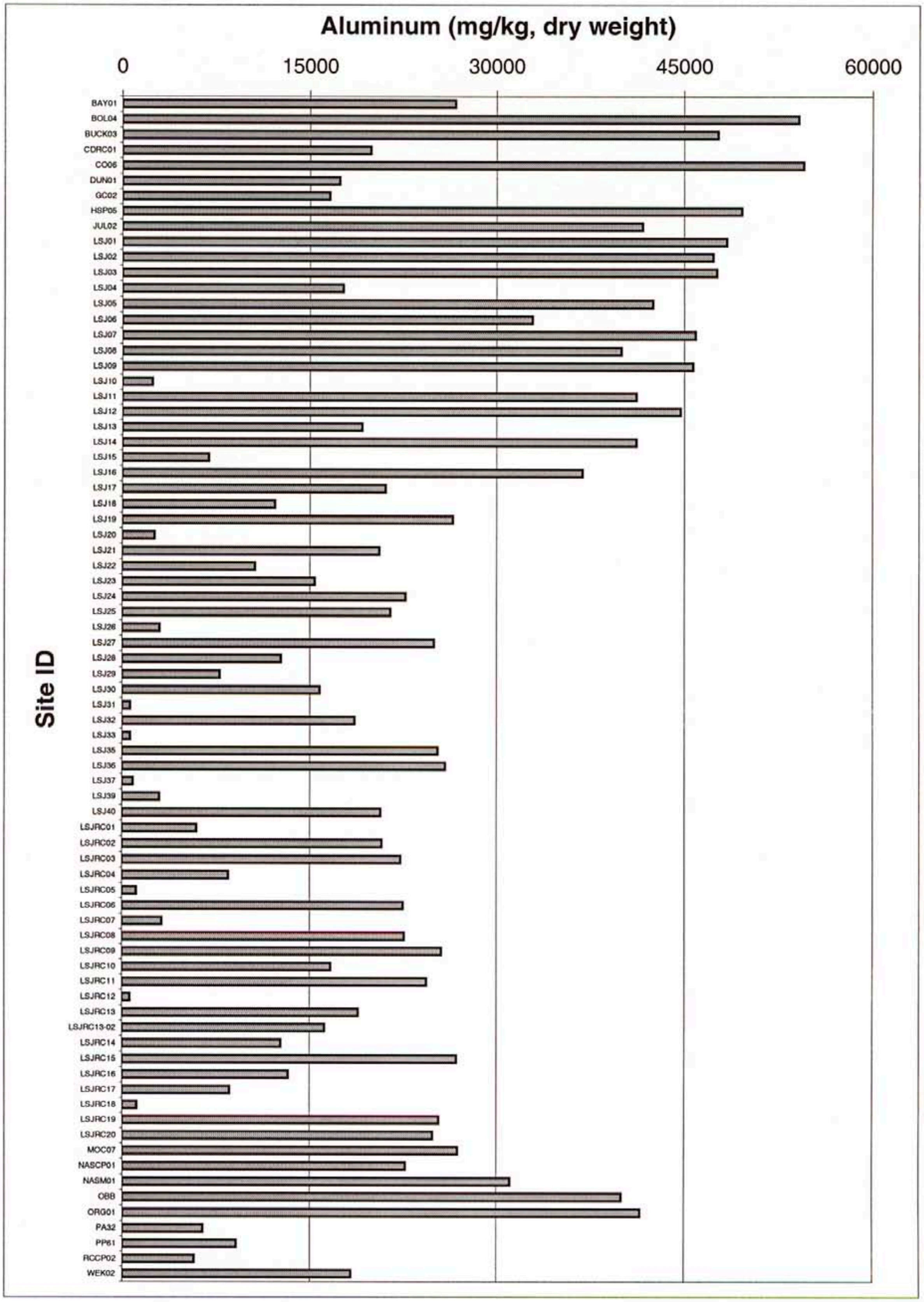


Figure 4-17. Lower St. Johns River — Aluminum Concentrations of Sediments

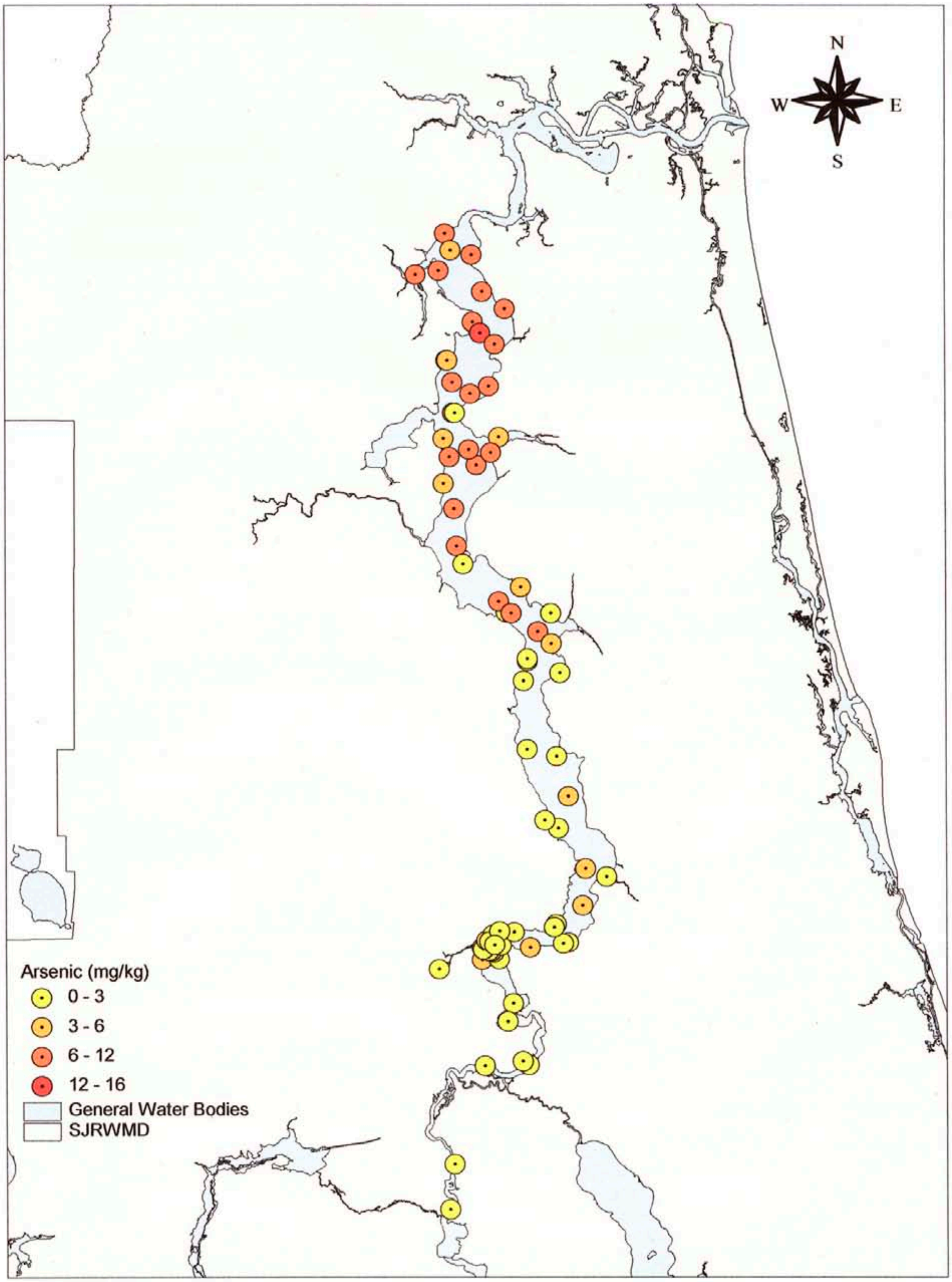


Figure 4-18. Lower St. Johns River — Map Displaying Arsenic (As) Concentrations (a) Non-Normalized

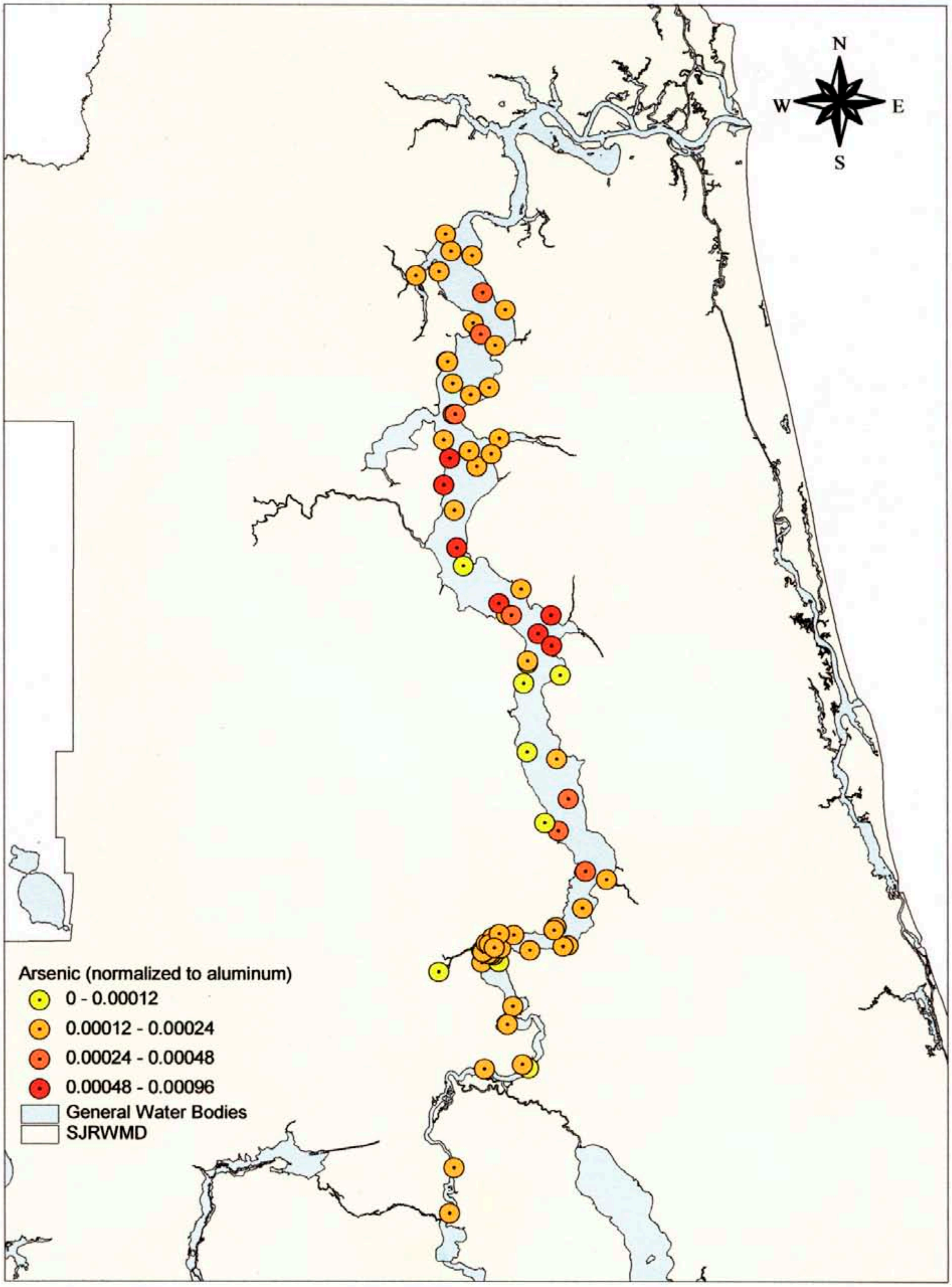


Figure 4-18. Lower St. Johns River — Map Displaying Arsenic (As) Concentrations (b) Normalized to Aluminum

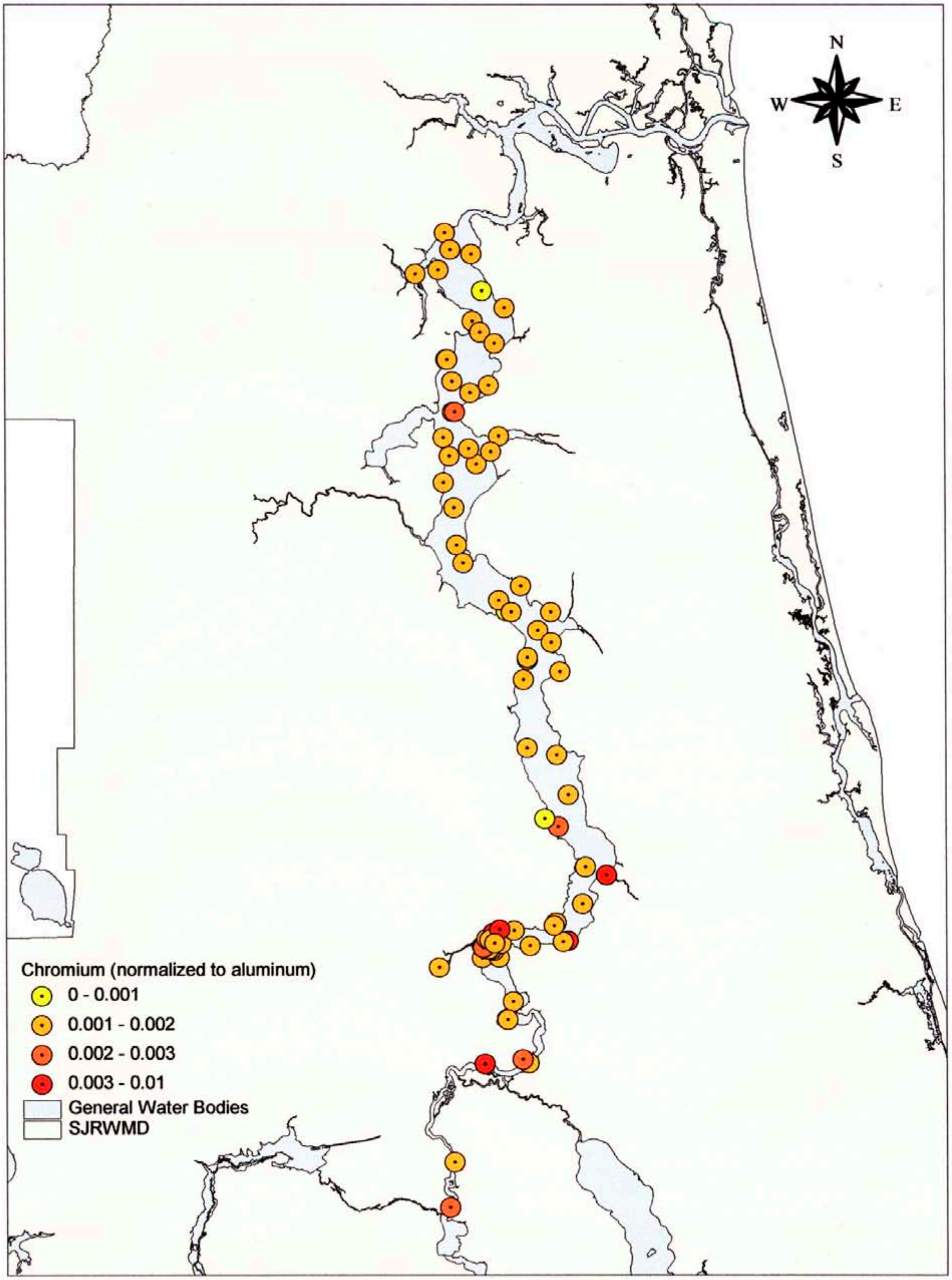


Figure 4-19. Lower St. Johns River — Map Displaying Chromium (Cr) Concentrations Normalized to Aluminum

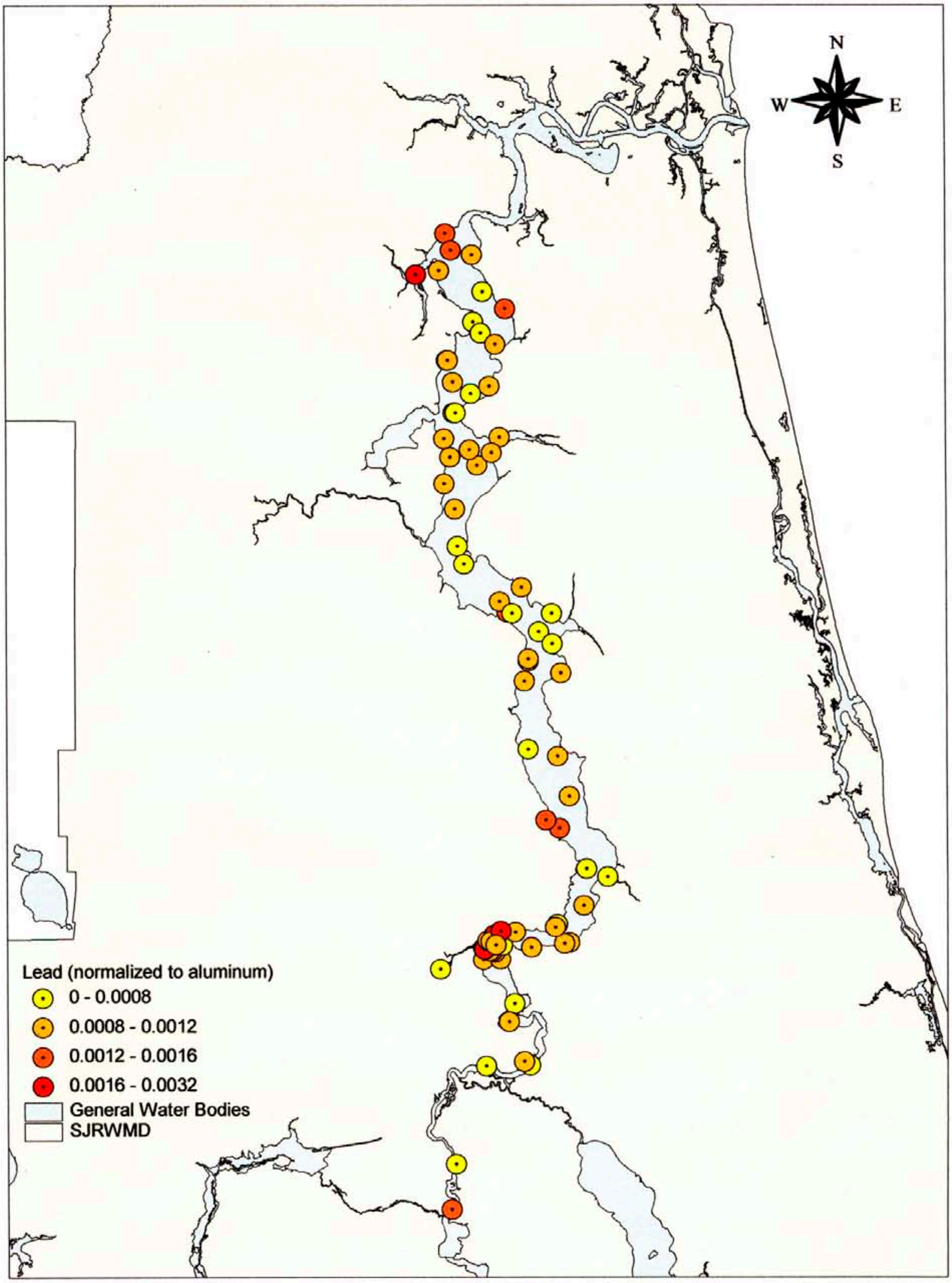


Figure 4-20. Lower St. Johns River — Map Displaying Lead (Pb) Concentrations Normalized to Aluminum

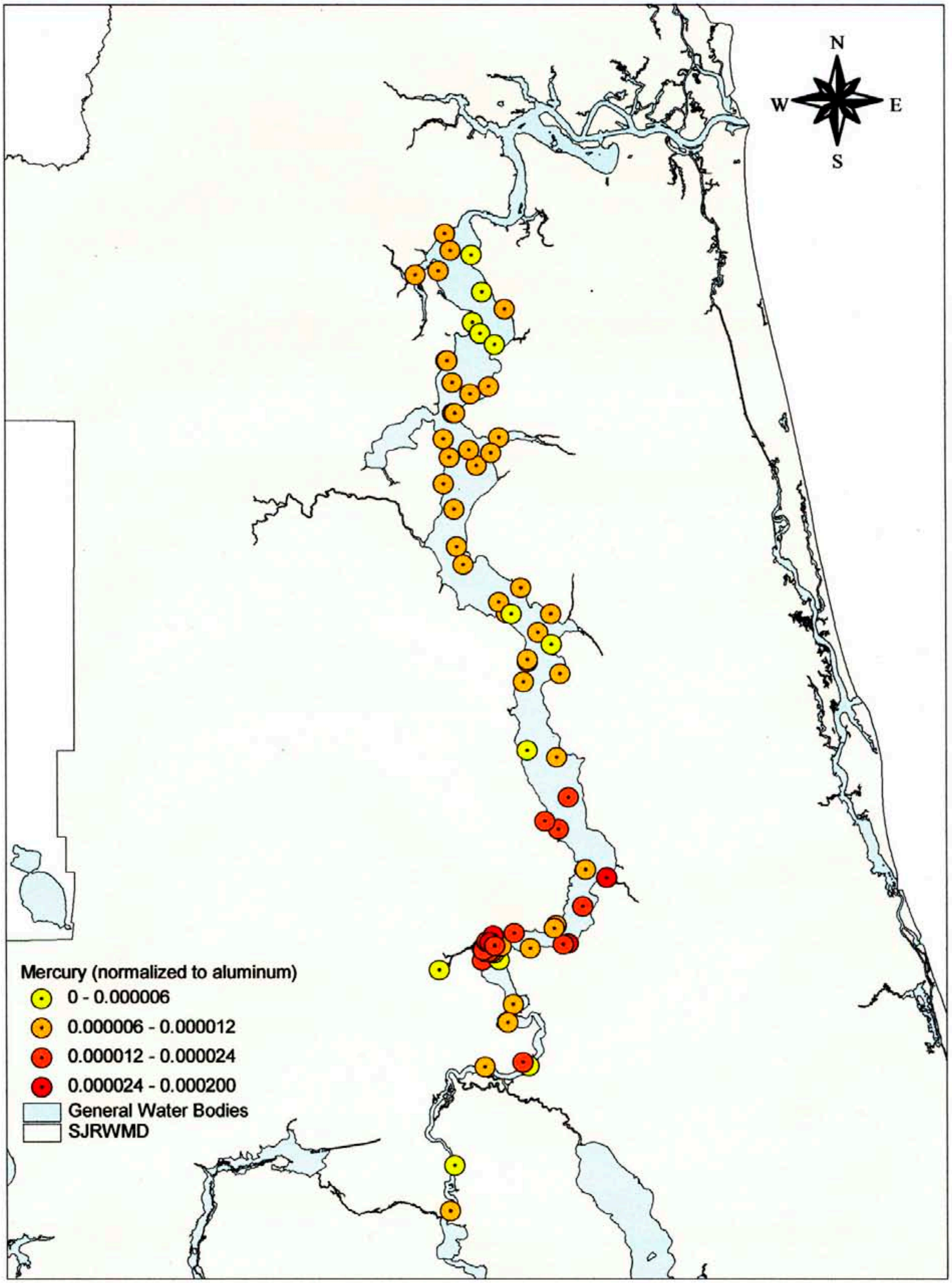


Figure 4-21. Lower St. Johns River — Map Displaying Mercury (Hg) Concentrations Normalized to Aluminum

Other metals, such as mercury (Figure 4-21), nickel, selenium, thallium, and vanadium were detected at concentrations that were more variable along the river, but with contaminant concentrations varying within a fairly small concentration range. These metals exhibited, for the most part, no relationship to location, whether the data were reviewed normalized to aluminum or not (i.e., the metals concentrations were mostly driven by grain size/geology).

A few, though mostly subtle, contaminant signals were evident when both the normalized and non-normalized data had been reviewed. The arsenic concentrations appeared to be slightly elevated in the middle section of the main stem of the river (from sites LSJ13 to LSJ22), and the selenium concentrations of the sediments at WEK02, DUN01, LSJ30, and LSJ40 appeared to be a little higher than at other locations. Beryllium was clearly elevated at site LSJ39, which was one of the southern most sites, and was located in a relatively rural and narrow part of the river. Cadmium appears to be elevated at site GC02, but at two adjacent sites (LSJ18 and LSJ19) the cadmium levels were below the average for the river. Similarly, the silver concentrations appeared to be somewhat higher at site LSJ11 than in most parts of the river, but at the adjacent LSJ10 site the concentrations were less than at most locations. These contaminant signals may be due to local input, but no obvious land use characteristics, or local point sources, were identified that can account for the observations. Additionally, most of these potentially elevated concentrations were still within a factor of 2 of the average contaminant loadings.

The concentrations of mercury and nickel appeared to be slightly elevated in the St. Johns River sediments near Rice Creek. For instance, the concentrations of mercury were higher at LSJRC06, LSJRC11, LSJRC12, and LSJRC18 than at most other locations, and nickel was slightly elevated at sites LSJRC06 through LSJRC11. These sites were all close to the confluence of Rice Creek and the St. Johns River, and there were no elevated concentrations measured downstream in the St. Johns River, suggesting that Rice Creek may be contributing mercury and zinc. Elevated concentrations of zinc, and vanadium (but not mercury), was also measured at the Rice Creek site (RCCP02). However, these potentially elevated concentrations were, for the most part, relatively subtle and the concentrations were mostly within a factor of 2 of the average concentration in the St. Johns River.

The concentrations of metals were, for the most part, lower in the St. Johns River sediments than what have been measured in other national monitoring programs (Table 4-1). A relatively small proportion of the sediment sites had arsenic, copper, lead, silver, tin, or zinc concentrations that exceeded the NS&T/MW “high” value, and the concentrations of antimony, chromium, and nickel did not exceed these reference values for any site. Each of these nine metals had a lower rate of NS&T/MW “high” value exceedances for the St. Johns River sites than both the NS&T/MS and COSED sites. For instance, the NOAA “high” concentrations for lead and tin were exceeded at 12% and 8% of the St. Johns River sites, respectively, compared to 13% and 12% of the NS&T/MW sites and 23% and 20% of the COSED sites. Cadmium, mercury, and selenium concentrations, on the other hand, exceeded the NOAA reference value at a greater proportion of the St. Johns River sites than did the NS&T/MW and COSED sites. Selenium had the highest rate of exceedances (71% of the St. Johns River sites). These higher rate of exceedances may, partly, be due to differences in the geology of the sediments; the St. Johns River sediments may be naturally more enriched in these metals than the average U.S. coastal sediment. Another factor could be the relatively fine grain size of the St. Johns River sediment, as compared to most coastal sediment (the NOAA “high” values are based on non-normalized data), resulting in a naturally elevated metals concentrations as compared to coarser grain size sediments. Mercury results are difficult to reliably compare with historical data because significantly more reliable analytical methods were used in this study than were available for most historical monitoring programs. Variable, and often significantly elevated, background concentrations of mercury were, in the past, typically subtracted from measured concentrations, resulting in artificially low reported sediment concentrations.

Metals — Potential Hot Spots.

The metals data evaluation suggests that there are no broad, contiguous areas with dramatically elevated metals concentrations, compared to other parts of the Lower St. Johns River study area, when viewing the data set as a whole. Some metals were clearly present at higher concentrations in the northern part of the river than other parts. Because these sediments are proximal to Jacksonville, the data suggests that anthropogenic activity may be causing them to differentiate from the more general relationships observed in the river. However, although the northern part of the river appears, at first glance, to be somewhat more contaminated with metals than most other parts of the river, much of this can be attributed to finer sediment grain size. There appears to be slightly elevated concentrations of mercury near Rice Creek, and high concentrations of zinc and vanadium at the Rice Creek sites, as discussed above. There were also isolated occurrences of the occasional metal being elevated at individual sites, as mentioned. Determination of whether or not these locations constitute hot spots of concern depends on an evaluation of other factors, such as proximity to localized specific sources, and sediment transport and depositional characteristics, information on which were not available to this assessment.

Metals — Indicators of Potential Effects.

Figure 4-22 presents the lead data relative to the ERL/ERM and freshwater TEL/PEL values and Figure 4-23 presents this information for mercury. Similar figures for the other seven metals that are typically of environmental concern, and for which there are published ERL/ERM and freshwater TEL/PEL values, are compiled in Appendix M. The numerical values of the ERL, ERM, freshwater TEL and PEL indicators vary with the metal. Comparing the sediment contaminant data to these sediment quality guidelines can be useful for identifying areas that potentially should be examined further to determine whether or not there are environmentally detrimental impacts. The metals concentrations were, like the organic contaminant data, compared to both the marine ERL/ERM and the freshwater TEL/PEL indicators (Tables 4-2 and 4-3). A summary of the results of this data comparison is presented in Table 4-4, and the data are presented graphically in Appendix M.

There was only one ERM exceedance (mercury at LSJRC11) and only four PEL exceedances (mercury at CO06 and LSJRC11, chromium at BOL04, and lead at CO06), among all metals and for all sites. The data were also assessed relative to the more conservative (i.e., lower) ERL and TEL values, with the TEL typically being the lowest reference threshold. Mercury had the largest number of ERL and TEL exceedances (Table 4-4 and Figure 4-23), with approximately 60% of the sites exceeding these sediment quality evaluation guidelines. Lead exceeded the ERL value at eight locations and the TEL at 18 locations (Figure 4-22), and zinc exceeded these guidelines with a similar rate (nine and 13 ERL and TEL exceedances, respectively). The TEL is clearly a more conservative risk measure than the, already recognized to be low, ERL value. The percentage of sites with ERL exceedances for the remaining metals in Table 4-4 — arsenic, cadmium, chromium, copper, and nickel — ranged from 3% to 9% (2 to 7 sites), while the TEL values were exceeded between 5% and 51% of the sites for these same metals.

The sites with the most ERL exceedances were CO06 and BOL04 (exceeded the ERL for six of the nine metals that have ERL values), HSP05 (five exceedances), LSJ01, LSJ03, and BUCK03 (four exceedances), and LSJRC06 (three exceedances). With the exception of mercury (the ERL which was exceeded at 49 of the 77 sites), only 17 of the 77 sites exceeded any ERL for any metal. Other than mercury, the data set shows a remarkable lack of notable ERL exceedances and leaves the impression of relatively limited, or geographically focused, potential for biological impact from metals in the Lower St. Johns River. The reliability of using the mercury ERL (or PEL) value to assess potential risk is often hotly debated at scientific gatherings; among all the metals, mercury has the sediment quality guideline value that is most often being questioned as potentially non-representative.

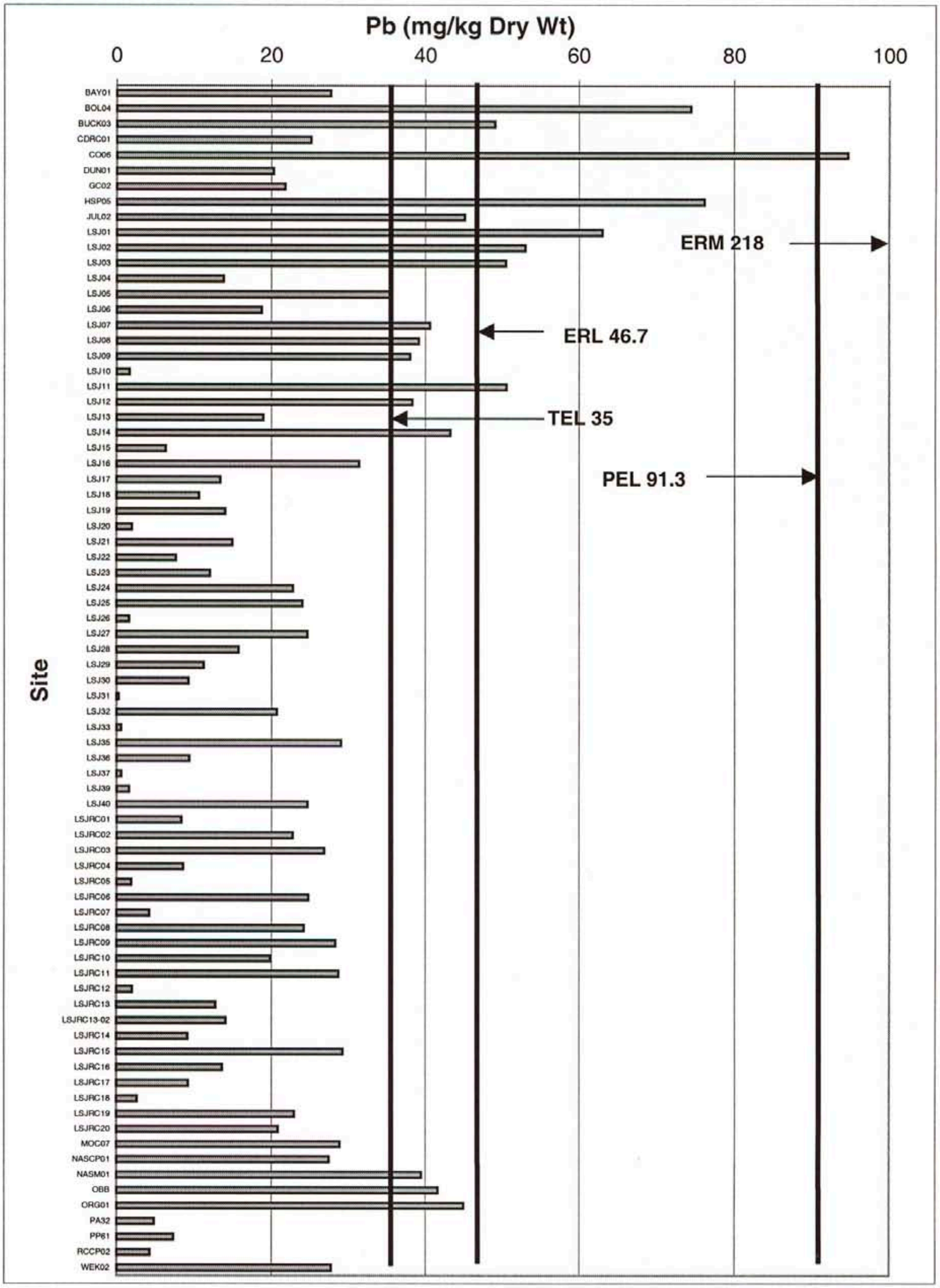


Figure 4-22. Lower St. Johns River — Sediment Lead (Pb) Concentrations and ERL/ERM and TEL/PEL Values

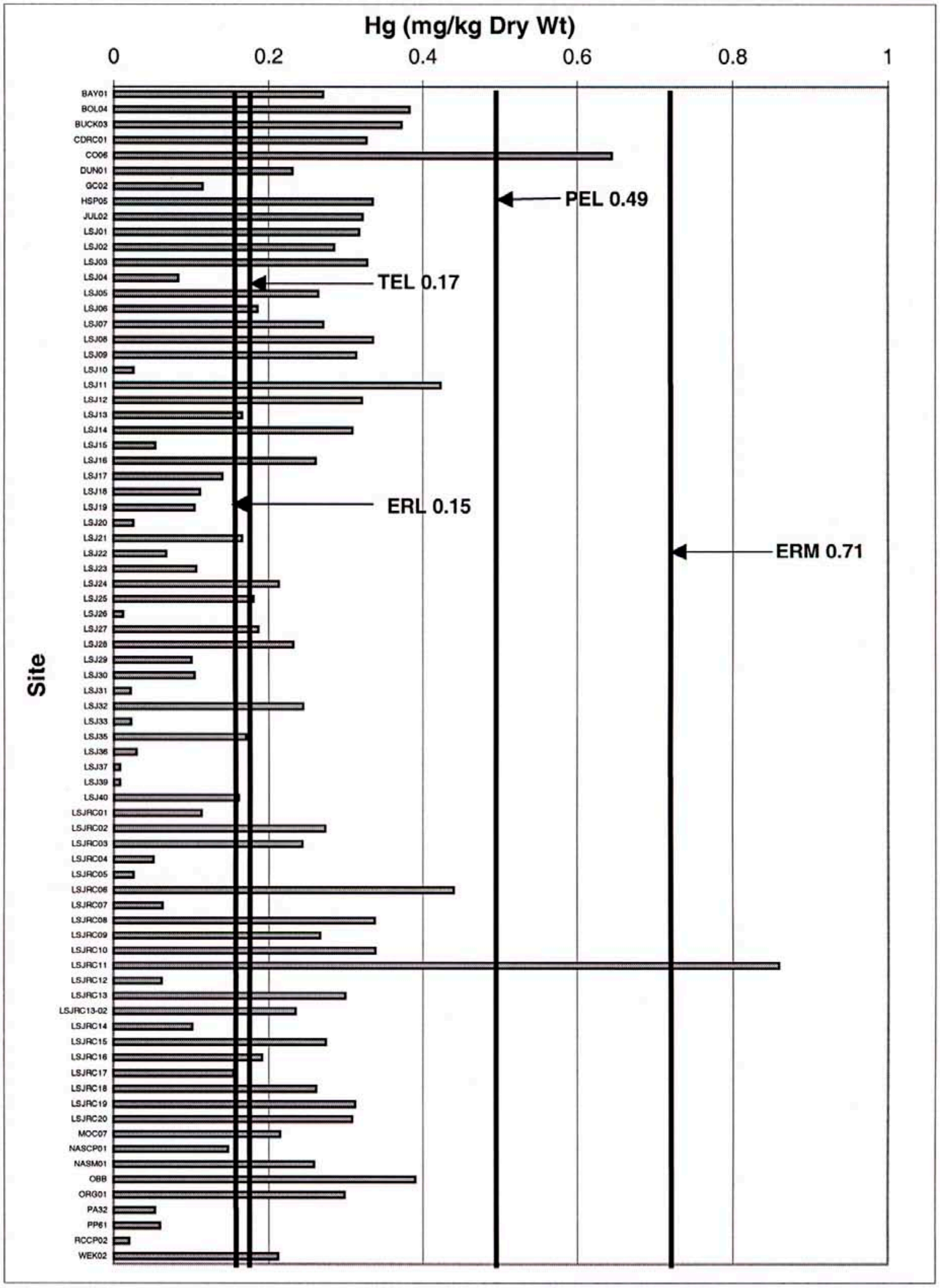


Figure 4-23. Lower St. Johns River — Sediment Mercury (Hg) Concentrations and ERL/ERM and TEL/PEL Values

The application of these sediment quality guidelines should be made with caution, particularly for toxic metals. Firstly, most of the guidelines were developed for individual parameters and do not incorporate additive or interactive effects due to multiple toxic components. Secondly, the potential of metals to cause adverse biological effects depends greatly on the characteristics of the sediment and how the metals are associated with the sediment (i.e., how available the metals are to possible receptors). The bioavailability of the metals depends on the grain size and the amount of TOC in the sediment — finer grain sediment and high TOC typically bind the metals more tightly making them less available. A high acid volatile sulfide (AVS) concentration in the sediment also appears to reduce the bioavailability of certain toxic metals, including cadmium, copper, nickel, lead, and zinc (DiToro *et al*.; 1990 and 1992).

4.2 Cedar-Ortega River Basin Contaminant Levels

4.2.1 Organic Compound Contaminant Levels

Organic Compounds — Contaminant Concentration, Distribution, and Composition.

The organic contaminant concentrations were, generally, less variable in the Cedar-Ortega River Basin than in the Lower St. Johns River (Tables 3-3, 3-6, 3-9, Appendices B, C, and D). However, the sediments in the Cedar-Ortega River Basin had higher concentrations of many organic contaminants than the Lower St. Johns River, and the levels were often higher than the most impacted parts of the St. Johns River (e.g., the northern part of the River, such as sites HSP05, LSJ01, and LSJ02).

PAH

The total PAH concentrations in the sediments are presented in Figures 4-24 (non-normalized) and 4-25 (TOC-normalized), and are also displayed on a map in Figure 4-26. Additional supplemental bar charts of organic contaminant concentrations are compiled in Appendix H, and maps illustrating the general geographical distribution of the contaminants can be found in Appendix N. The sites in the bar graph are sorted alphabetically by site name, as indicated in Figures 4-24 and 4-25.

The highest PAH concentrations were measured at sites CED09 (29,800 µg/kg total PAH), the nearby sites in the middle segment of the Cedar River, and ORT33 (15,200 µg/kg total PAH). The PAH concentrations were, generally, much higher at the Cedar-Ortega River Basin sites than at the Lower St. Johns River sites; the median total PAH concentrations was 4,840 µg/kg for COR (Table 3-2), which is about three times higher than the median value for the LSJR sites. A total of 44 of the 51 COR sites (86% of the sites) had a total PAH above 2,000 µg/kg dry weight, while only 22 of the 77 LSJR sites (29% of the sites) had a PAH concentration that exceeded 2,000 µg/kg.

As discussed earlier, it is often useful to also normalize organic contaminant data to the TOC content of the sediment, and review both the non-normalized and TOC-normalized data, to help determine if elevated levels of organic contaminants may be from nearby sources. A review of both the non-normalized and TOC-normalized concentrations can also provide information related to the bioavailability of the organic contaminant (i.e., organic contaminants tightly bound to organic matter, or particulates, are less bioavailable than less tightly bound compounds).

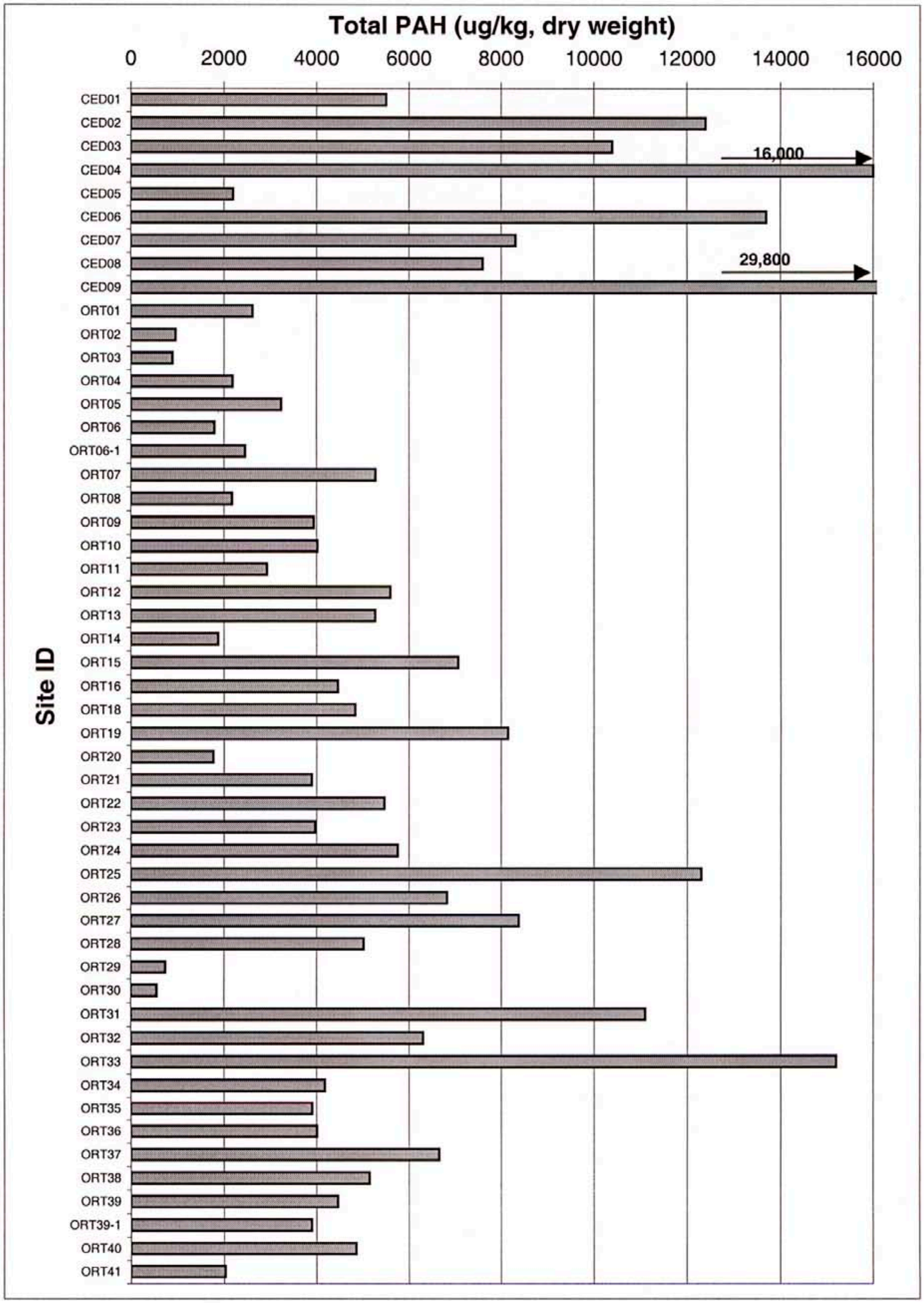


Figure 4-24. Cedar-Ortega River Basin — Total PAH Concentrations

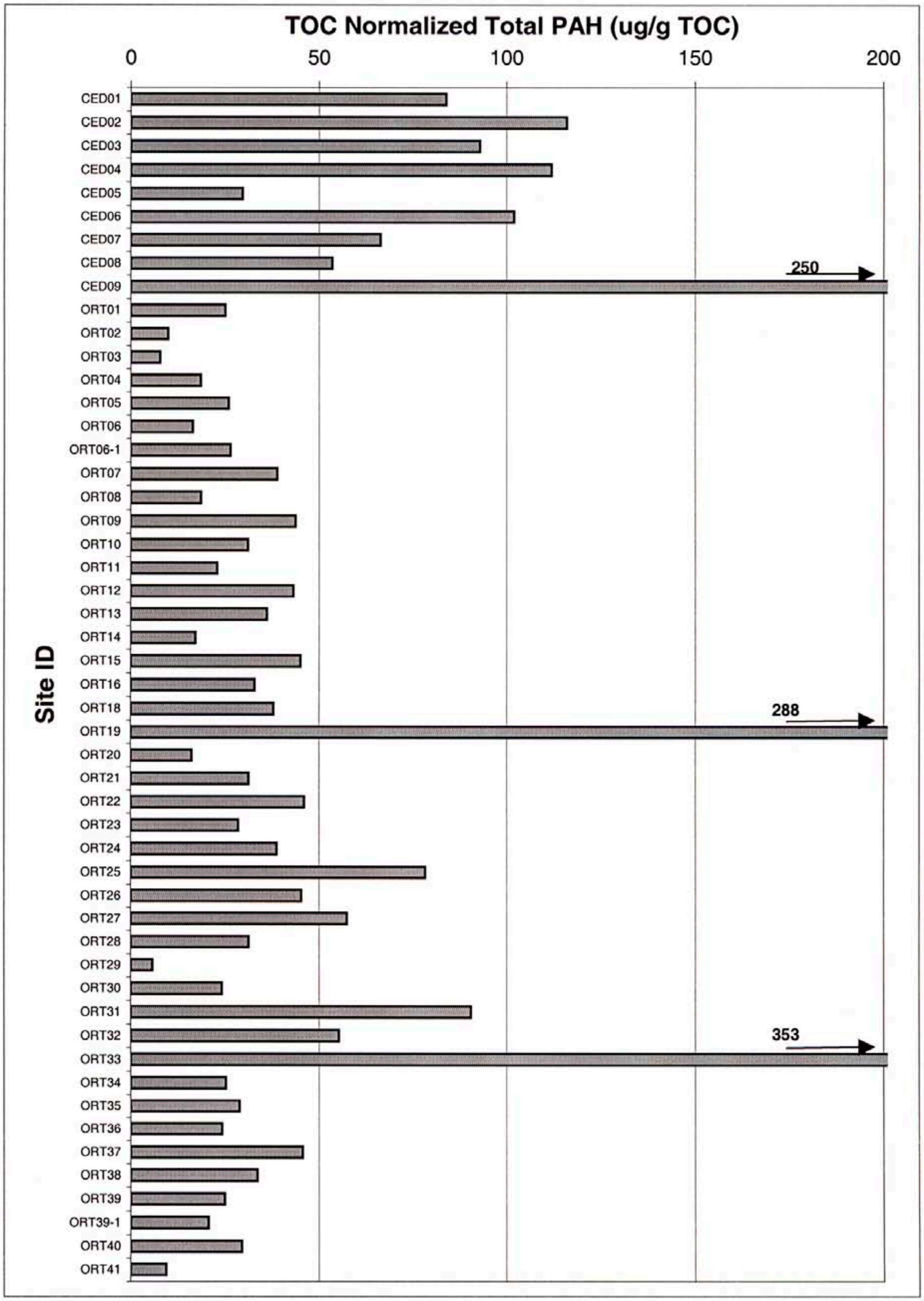


Figure 4-25. Cedar-Ortega River Basin — TOC-Normalized Total PAH Concentrations

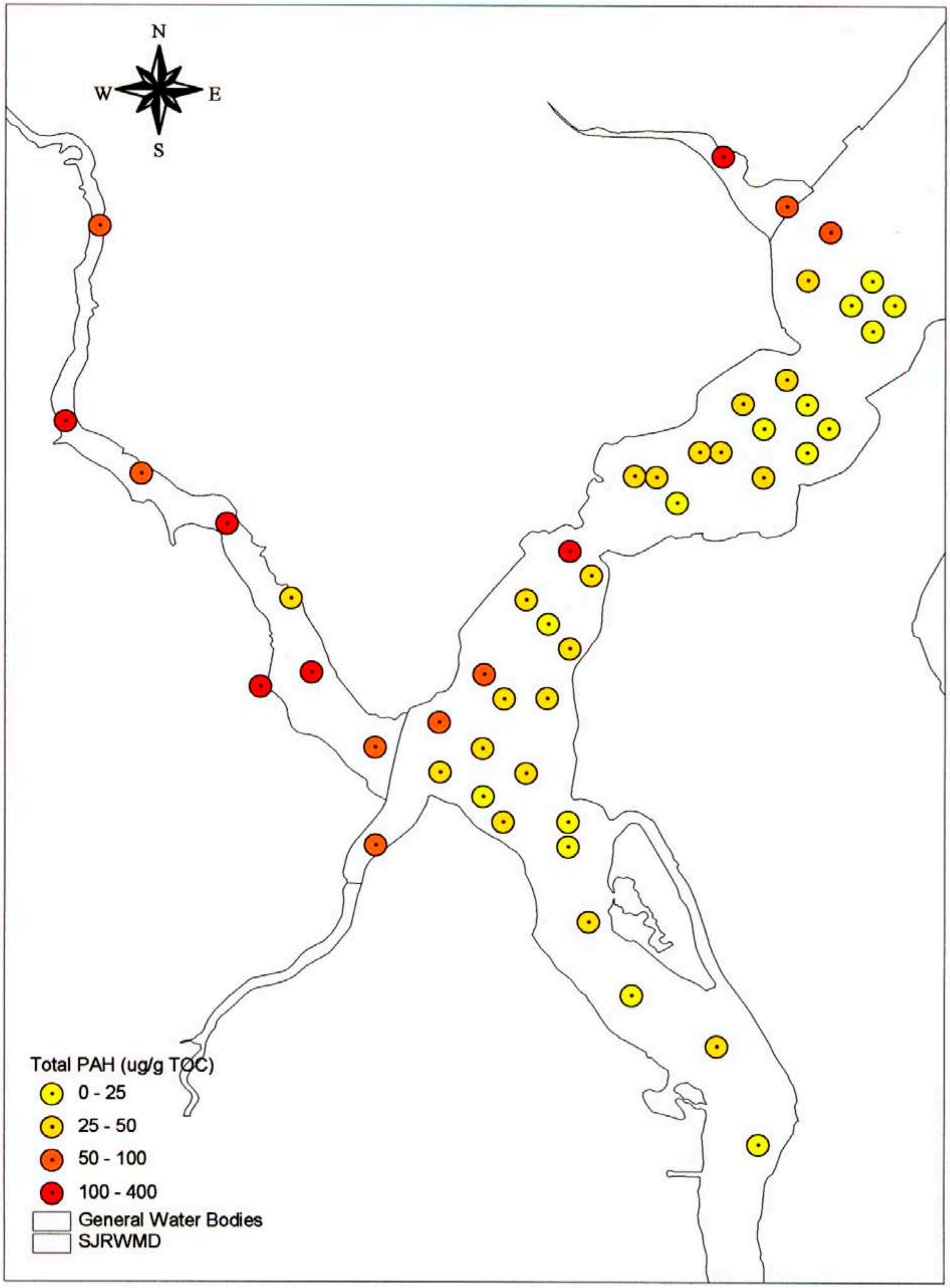


Figure 4-26. Cedar-Ortega River Basin — Map Displaying TOC-Normalized Total PAH Concentrations

The TOC normalized PAH concentration distribution (Figures 4-25 and 4-26) was fairly similar to the non-normalized distribution, with only a few sites appearing elevated even though their non-normalized concentrations were more moderate (e.g., site ORT19). This similarity in contaminant pattern is a reflection of the TOC content being fairly similar in these sediments. After considering all the PAH and sediment characteristics data, the sites and areas that appear to have the most significant concentrations of PAH are CED09, ORT33 and ORT31, ORT19, and, generally, the Cedar River.

The PAH concentrations measured in this study were generally towards the higher end of a range one may expect as being "typical" for most urban or near-urban locations. Section 4.1 discusses in detail the ranges of PAH contaminant concentrations that have been measured at various locations around the country and therefore provide a useful point of reference for comparing the COR site data to data from other areas around the country. That information is not repeated in this section.

As with the LSJR sites, the contaminant concentrations for the COR sites were compared to the NS&T/MW "high" values (Table 4-1) established from national sediment data. Approximately 82% of the Cedar-Ortega River Basin sites sampled in this study had Total PAH concentrations that exceeded the NOAA "high" concentration of 2,180 µg/kg — this is an exceedance rate that is clearly much higher than observed in any of the sediment monitoring program data sets listed in Table 4-1 (NS&T, EMAP, COSED, which had exceedances rates from 2 to 14%), and the observed exceedances are wide-spread, geographically. However, the Cedar-Ortega River Basin is also likely more impacted by industry and urban environments than the average U.S. coastal location. In addition, approximately 39% and 86% of the COR sites exceed the NS&T/MW "high" values for Low MW PAH and High MW PAH, respectively, which is also well above the 9 to 23% observed for the other listed programs.

The relative composition of the different PAH compounds varied some from site-to-site, but the dominant PAH at most locations were the four- and five-ring PAH. These PAH are mostly associated with pyrogenic sources, although lower molecular weight PAH, with likely petrogenic origin, are present at significantly lower concentrations. This predominance of high-molecular weight PAH was even more apparent in the Cedar-Ortega River than it was in the St. Johns River, and was very striking. The pyrogenic PAH (HMW) constituted over 90% of the total PAH at most locations (Figure 4-27), and the proportion of pyrogenic PAH was generally highest at sites with the highest overall PAH concentrations. The average relationship was about 14 times more HMW than LMW (as compared to an average ratio of 3:1 for the Lower St. Johns River sites). The relatively consistent proportion of pyrogenic to petrogenic PAH in the surface sediment indicate a similarity in the sources, or types of sources, of the PAH contamination, at least for most of the locations. Site ORT19 is one location that had, proportionately, more LMW than other locations (a high:low PAH ratio of 7:1), suggesting there may be a local source of some of the PAH. However, the data suggests that there is another, more significant, source of the PAH for most of the Basin.

Figure 4-28 shows the PAH composition of selected samples. The PAH composition of selected reference samples and petroleum products are compiled in Appendix I. Most samples had a PAH composition similar to those of CED09, ORT15, and ORT33 (Figure 4-28). The composition of CED02 (also in Figure 4-28) is actually very similar to the composition of most other samples, except for the greater contributions of perylene. Perylene is a relatively significant PAH in, particularly, some of the lower concentration, high organic content, samples. Perylene is not primarily derived form petrogenic or pyrogenic sources; most is formed through the natural decay of plant material in anoxic layers of the sediment, and perylene is not considered an important environmental contaminant.

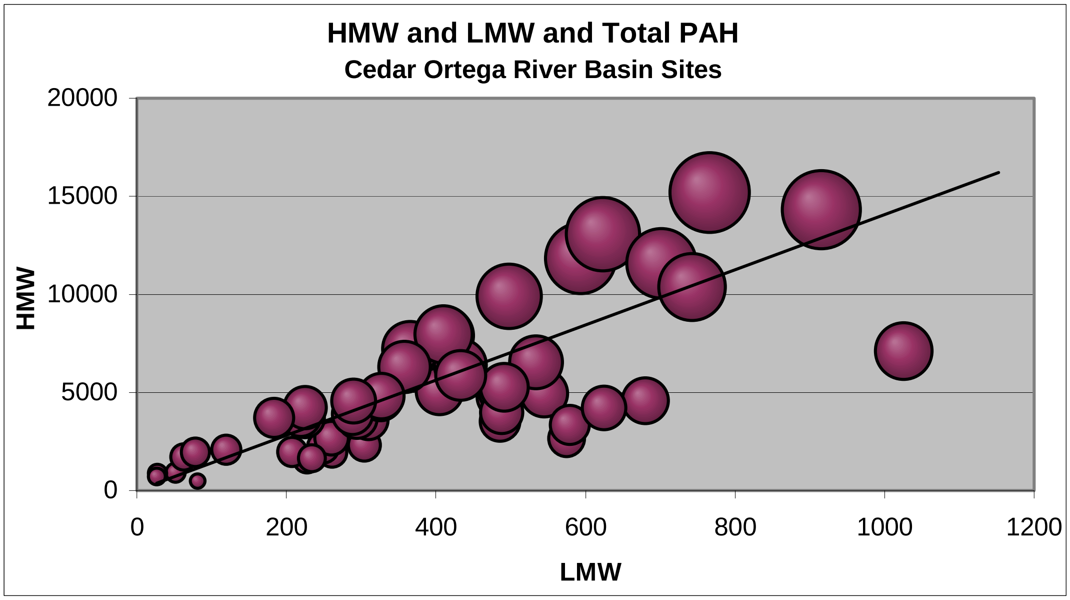
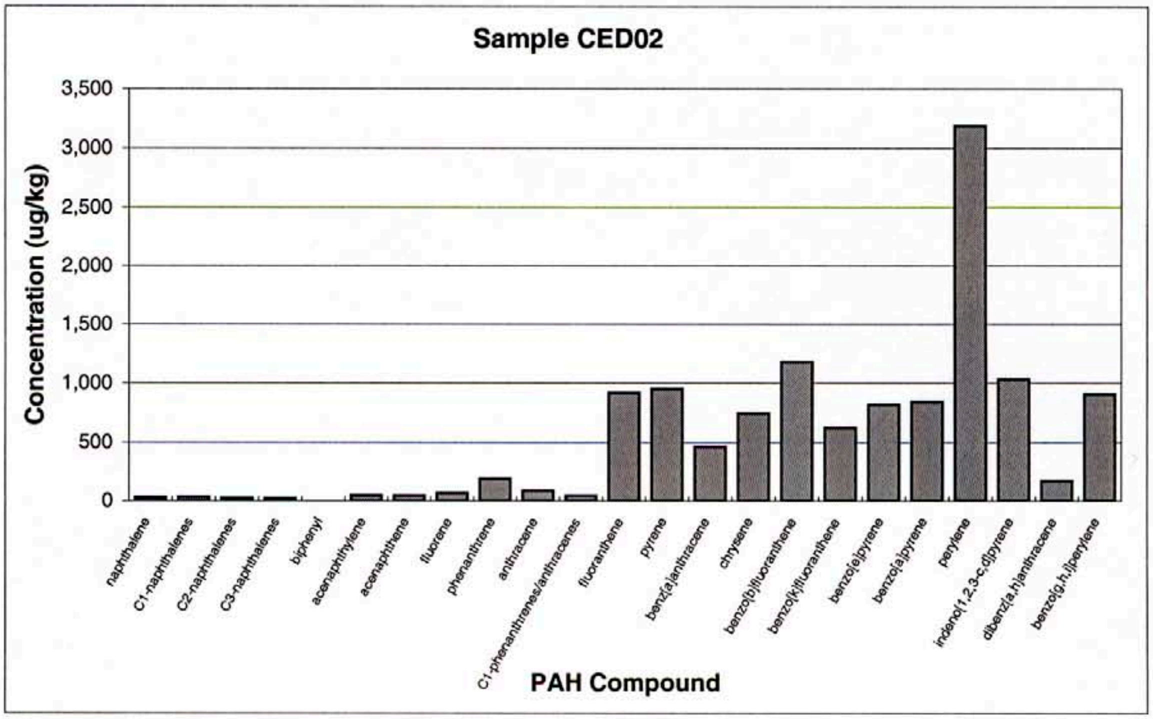


Figure 4-27. Cedar-Ortega River Basin — Relative Composition of HMW, LMW and Total PAH Concentrations

The PAH composition of most samples is unlike what is most commonly observed for urban sediments. The relatively unique PAH composition of the COR samples was also confirmed with the PCA analysis (Figure 4-6). The PAH composition of the NIST SRM 1941 sediment and soot (Appendix I) are common urban signatures, and considered to be a good representation of typical background PAH derived primarily from pyrogenic sources, including atmospheric deposition, stormwater runoff and other urban discharges. The unique HMW distribution in most of the COR sediment samples, as indicated by the compositional plots and the PCA analysis, is characteristic of PAH inputs primarily from hydrocarbon materials containing predominantly HMWs (e.g., coal and coke tar, coal gasification tars, carbon black, creosote, and, to some degree, asphalt; Appendix I). Coal tar and gasification tar processing by-product (e.g., coal tar pitch), have a PAH composition that is similar to what was observed in much of the Cedar-Ortega River Basin. A more detailed study of the PAH composition of the area, and of potential sources and source materials, would further the understanding of the significant PAH contamination in this area.

Phthalates

The phthalate data showed a range in concentrations that, on average, were about twice as high as in the Lower St. Johns River. Elevated phthalate concentrations were measured at sites from CED01 through CED05 in the Cedar River and at ORT33 — a geographical distribution of the contamination that was similar to that of PAH. Eight of the 51 COR sites had total phthalate concentrations over 1,000 µg/kg (only two of the 77 LSJR exceeded 1,000 µg/kg), and the highest was just above 2,500 µg/kg (CED04). The TOC-normalized data indicate that the six sites identified with the highest non-normalized phthalate concentrations are indeed likely near potential sources of these contaminants because the concentrations remained similarly elevated relative to the rest of the sites, both non- and TOC-normalized.



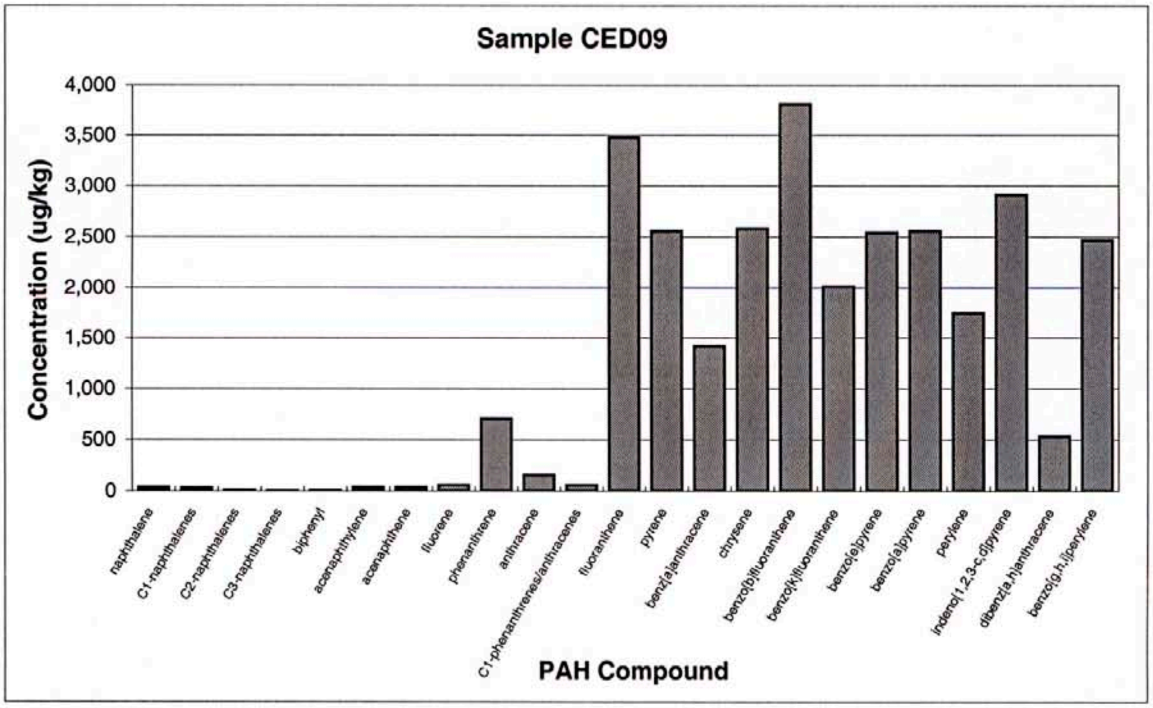
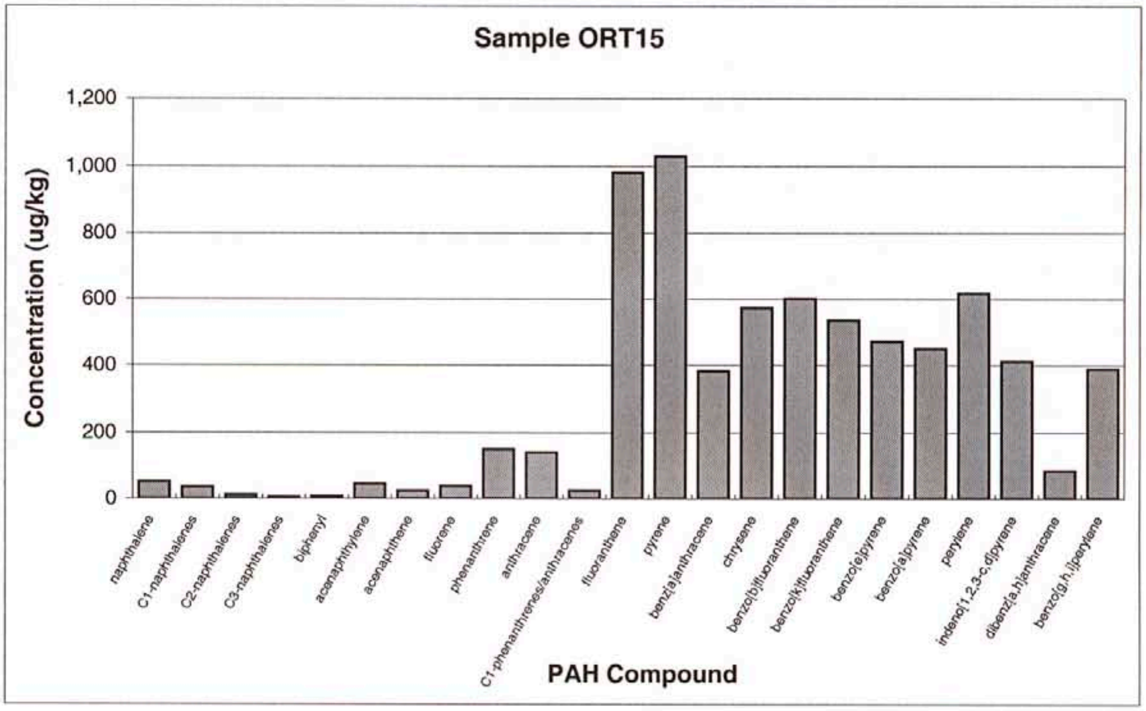


Figure 4-28. Cedar-Ortega River Basin — PAH Composition of Selected Samples



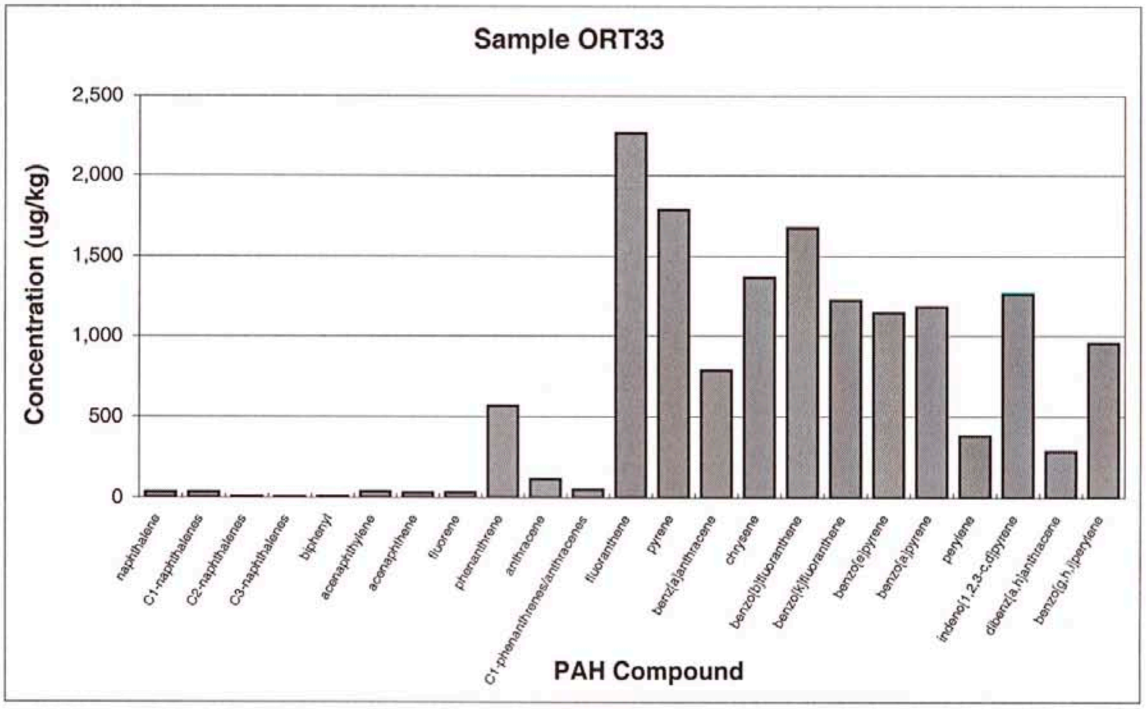


Figure 4-28 (cont.). Cedar-Ortega River Basin — PAH Composition of Selected Samples

Industrial Chlorinated Compounds

The other chlorinated industrial compounds (i.e., the chlorinated benzene) show a much more variable contaminant distribution, with no clear geographical relationship. One of the highest concentrations were measured at a site in the southern branch of the Ortega River (site ORT40), but the two sites closest to ORT40 had among the lowest chlorinated industrial compound concentrations of all sites. These compounds are among the most water-soluble and mobile of the chlorinated compounds determined in this project, and tend to be transported away from sources to a greater degree than most of the other compounds, potentially causing less predictable and more variable data.

PCB

The PCB concentrations were, generally, much higher at the COR sites than at the LSJR sites; the median concentration was five times higher (Table 3-5), and 13 of the 51 COR sites had higher PCB concentrations than the site with the highest PCB concentration in the LSJR. The PCB concentrations were highest in the Cedar River (e.g., sites CED01, CED02, CED03), and there was a clear trend of gradually decreasing PCB concentrations down the Cedar River (Figure 4-29, and Appendices C and H). Seven samples were collected for only PCB analysis as part of this project (e.g., at CED12), mostly to better characterize the PCB in the Cedar River. An increase in PCB loading was observed moving up stream to site CED12, which was the site farthest up the river. This clearly suggests that there is a significant source of PCB upstream from CED01.

The sum of the target PCB congener concentrations was below 50 µg/kg for only eight of the 51 widely analyzed sites, between 50 and 250 µg/kg for 30 sites, and above 250 µg/kg for 13 of the sites. These data can be compared with concentrations from 66 to 233 µg/kg for three Boston Harbor/Massachusetts Bay sediment sites sampled in the NOAA Mussel Watch Program in the late 1980's, and a range of 9 to 80 µg/kg for five Massachusetts sites outside Massachusetts Bay (Battelle, 1990, 1991b, 1992). As discussed in Section 3.1.2, a detailed analysis of the PCB composition of the study samples revealed that this congener set, on average, represented 42% of the total PCB in these samples. The total PCB in these samples can therefore be estimated by multiplying the sum of the PCB congener concentrations by 2.4. A total of 45 (88%) of the 51 Cedar-Ortega River sites had PCB concentrations higher than the NOAA "high" concentration of 80 µg/kg (Table 4-1); 15% of the NS&T and 15% of all COSED sites exceeded this reference value. The PCB concentrations appear to, like PAH, be significantly higher in the Cedar-Ortega River Basin than can be expected in a typical cross-section of the country.

The PCB composition was relatively uniform across the COR sites (Figure 4-30), and can be compared to those of the original PCB source material (Aroclor formulations; Appendix J). The PCB composition most closely resembled that of a combination of mid-molecular weight Aroclor formulations (e.g., Aroclors 1248 and 1254), and, at first glance, the composition appears to be relatively similar to what was observed in the St. Johns River. However, there appears to be less contribution from high molecular weight Aroclor(s), and a composition of most samples that could be differentiated from the LSJR samples using PCA analysis (Figure 4-9). A more detailed study of the PCB composition of the area, and of potential sources, would further the understanding of this significant contamination.

Pesticides - DDTs

The chlorinated pesticide concentrations had a somewhat different geographic distribution than the more urban and industrial-linked PAH, phthalate, and PCB compounds (Figure 4-31). In addition, the contaminant pattern varied somewhat between different pesticides. A total of 17 of the 51 COR sites had a concentration of the sum of DDT compounds above 20 µg/kg (two of the 77 LSJR sites exceeded this concentration), and the highest concentration was just above 80 µg/kg (CED01). Sites CED01 and ORT33 were the two sites with significantly elevated concentrations of the DDT compounds, as compared to the rest of the sites, and the concentrations decreased notably away from these location. Nonetheless, the overall concentrations of DDT in the COR were significantly higher than in the LSJR.

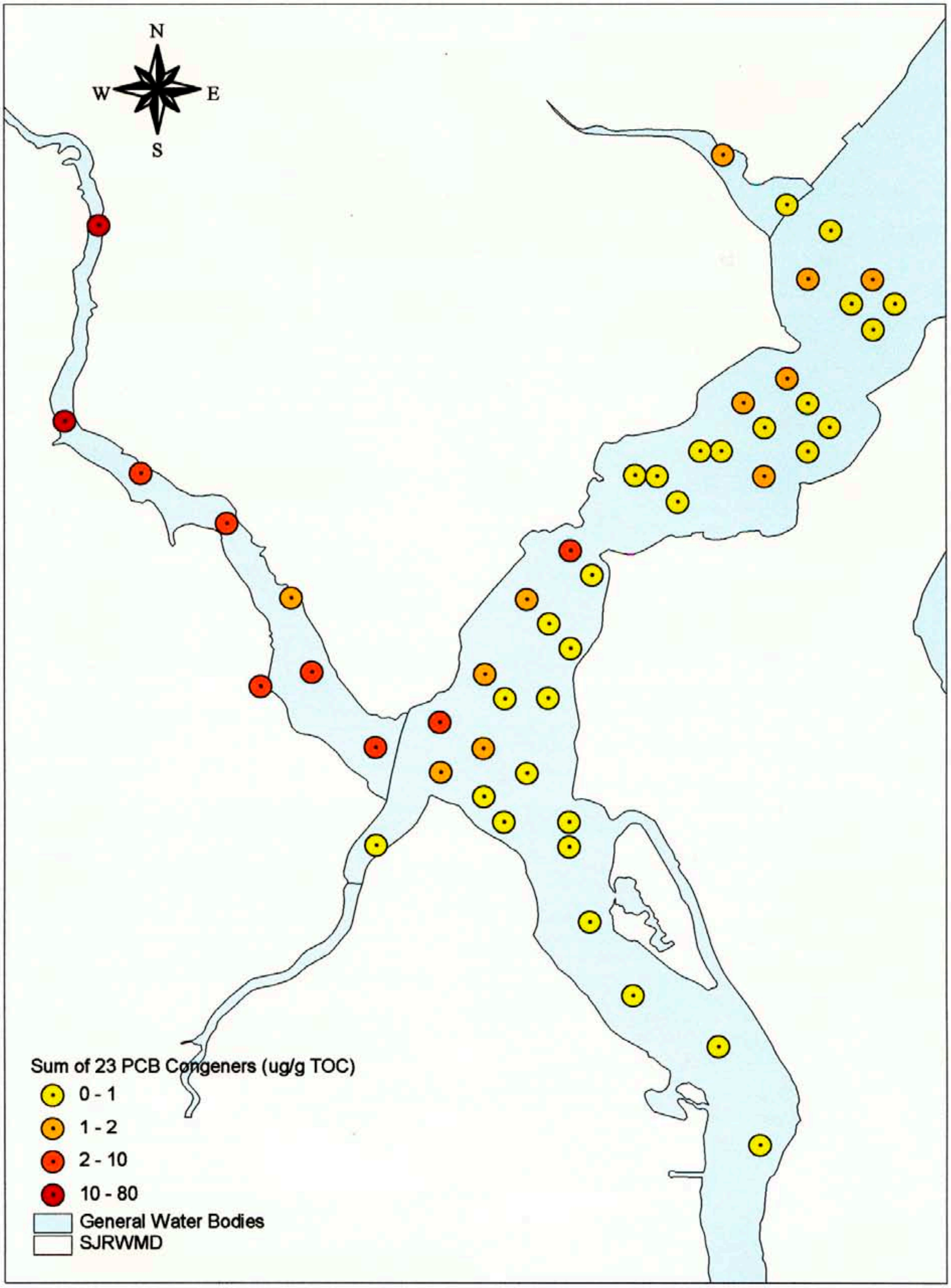
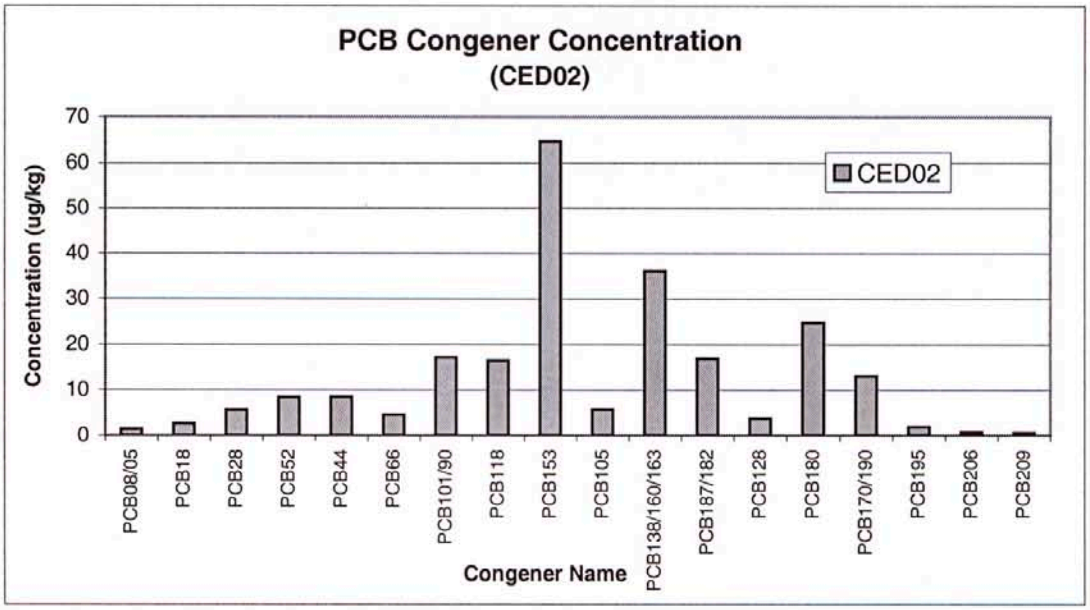


Figure 4-29. Cedar-Ortega River Basin — Map Displaying TOC Normalized Sum of PCB Congener Concentrations



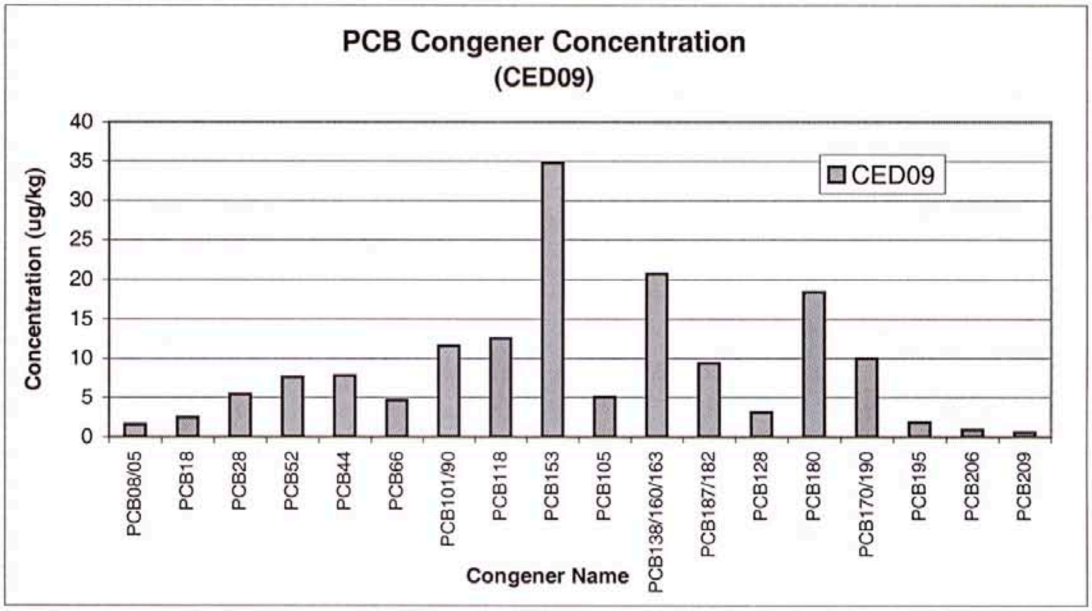
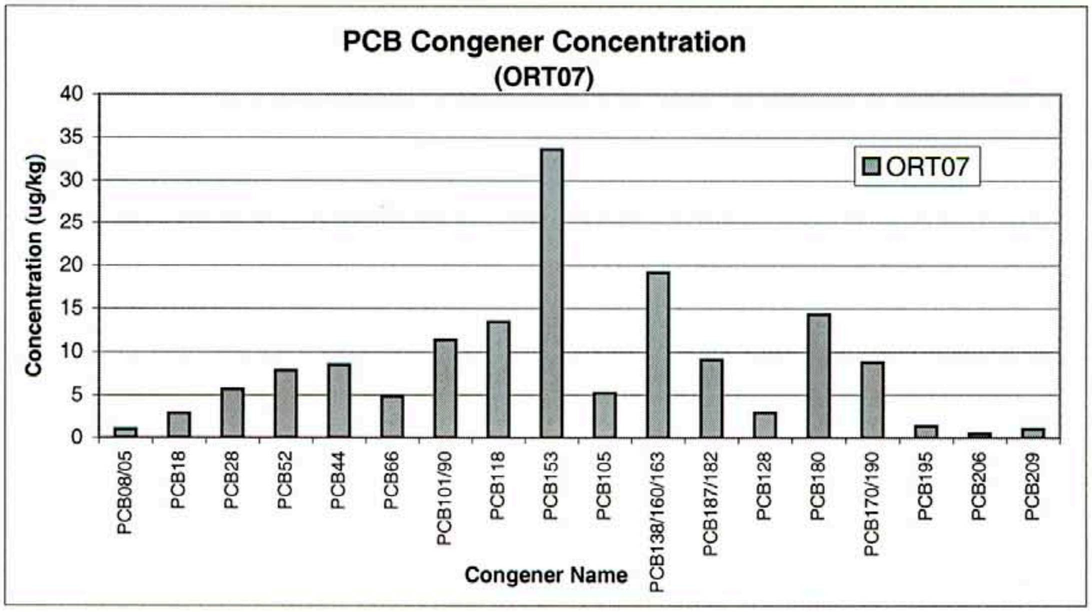


Figure 4-30. Cedar-Ortega River Basin — PCB Composition of Selected Samples



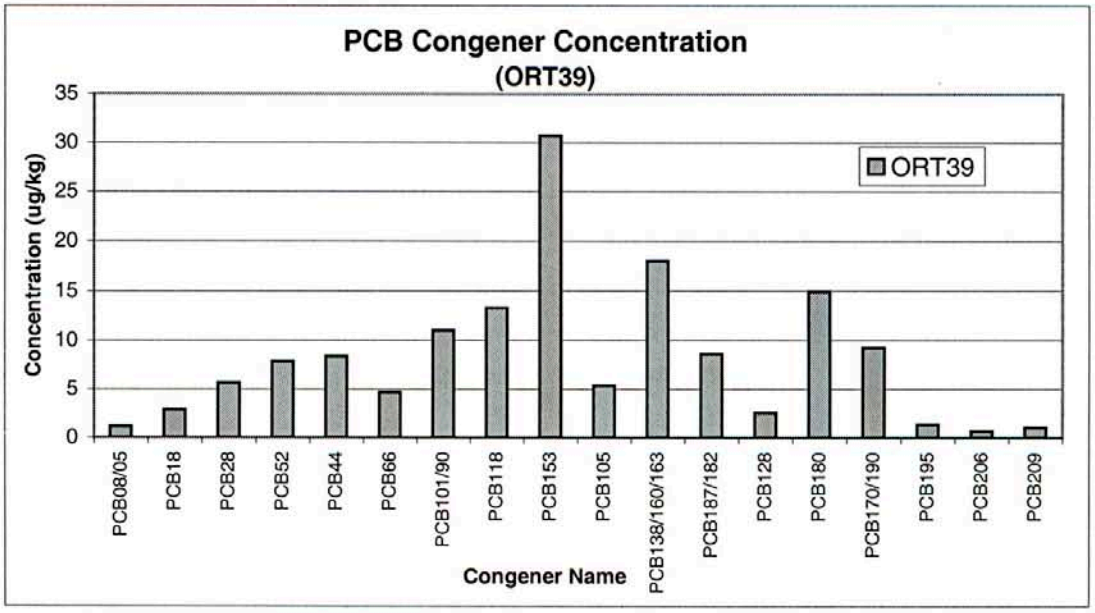


Figure 4-30 (cont.). Cedar-Ortega River Basin — PCB Composition of Selected Samples

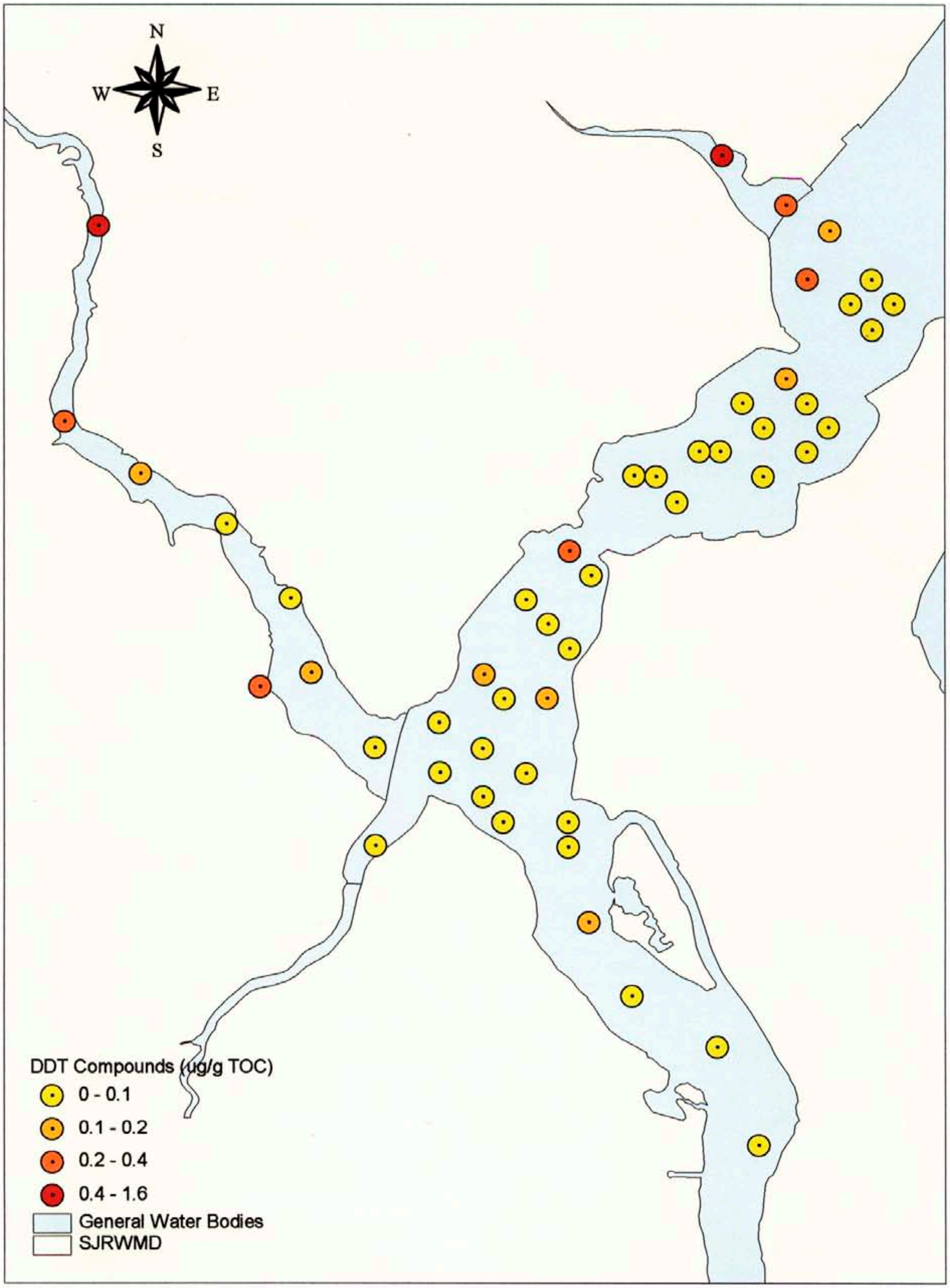


Figure 4-31. Cedar-Ortega River Basin — Map Displaying TOC Normalized Total DDT Compound Concentrations

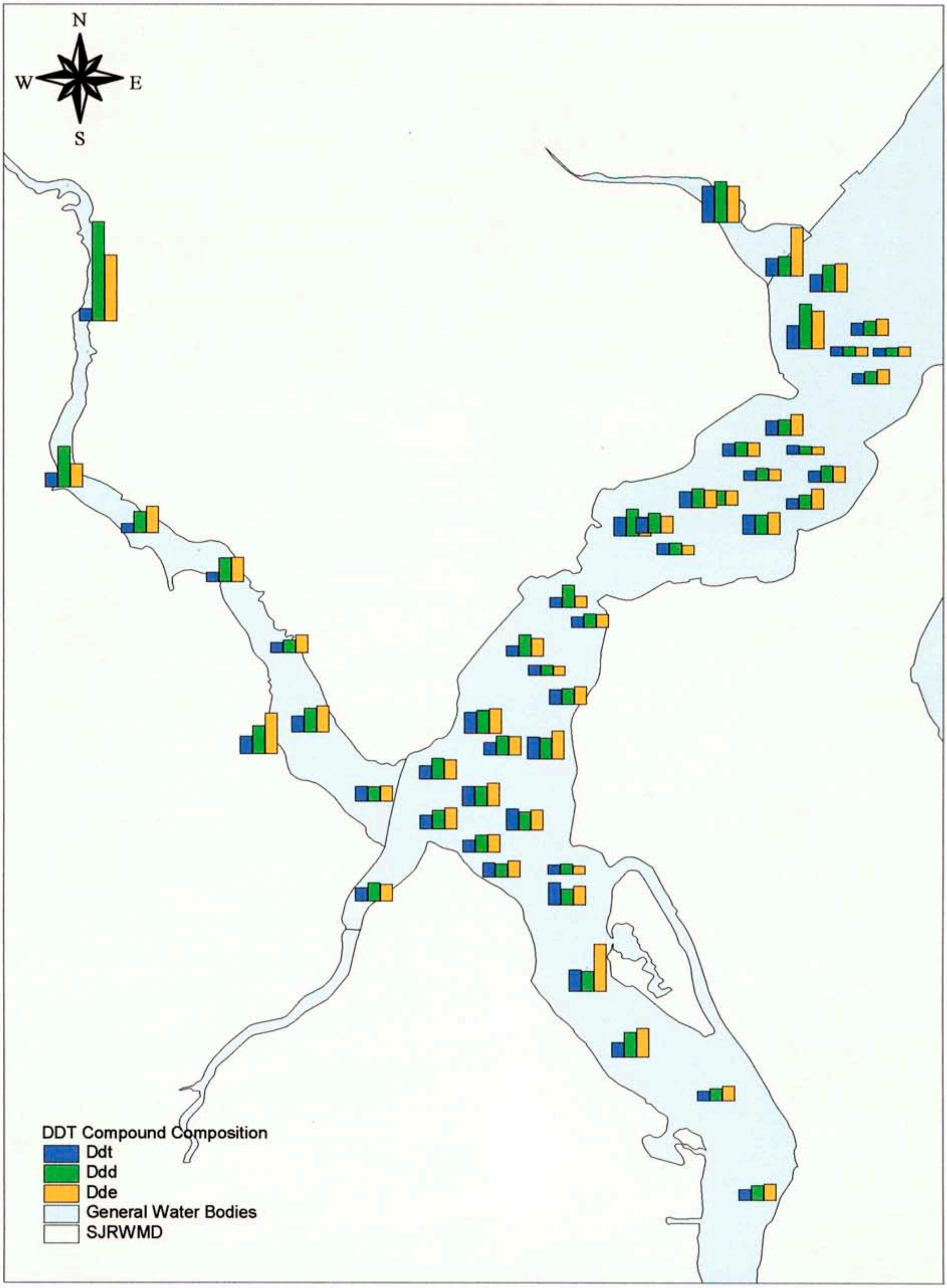


Figure 4-32. Cedar-Ortega River Basin — Map Displaying Relative Composition of DDT and its Key Degradation Products for Selected Sites

The DDT compound concentrations measured at the COR sites can be compared to the 24 to 58 µg/kg range for three NOAA Massachusetts sites located near urban areas and from 1 to 9 µg/kg for the more rural sites (Battelle, 1990, 1991b, 1992). The DDT concentrations were comparable to, or slightly higher than, what has been observed in many national monitoring programs. For example, 25% of the COR sites had DDT concentrations that exceeded the NS&T/MW "high" value of 22 µg/kg (Table 4-1), while only 18% of the NS&T/MW and 23% of the COSED sites exceeded this value.

The concentrations of DDT, and its degradation products DDD and DDE, are listed in Table 3-6, along with the total concentration of these DDT compounds. Various environmental conditions (primarily oxygen supply) dictate the rate of DDT degradation, and the relative amounts of DDD and DDE that are formed. Figure 4-32 shows the relative concentrations of DDT, DDD, and DDE at selected sites. The concentration of DDD was higher than both the DDE and DDT concentrations in most samples, just as it is in many sediments around the US (Battelle, 1990, 1991b, 1992), but there were also a number of sites at which DDE was most abundant, suggesting varying oxygen supply conditions of the sediments (aerobic versus anaerobic conditions). In addition, site ORT33, and some of the sites towards the middle part of the study area (the main Basin area), had proportionately higher concentrations of DDT than what was found in most sediments, and very similar concentrations of all three components, suggesting more recent inputs of DDT (possibly at site ORT33) and/or slower DDT degradation (possibly at main basin sites and maybe ORT33).

Pesticides – Other Chlorinated Pesticides

The chlordane concentrations were, generally, a little lower than the DDT concentrations, but they were significantly higher in the COR than in the LSJR. The median chlordane concentration was more than 10 times higher in the COR, and the highest concentrations measured (85.4 µg/kg at ORT31) was 20 times higher than the highest concentration measured in the St. Johns River; 29 of the 51 COR sites had chlordane concentrations that were higher than the highest concentration measured in the LSJR. The chlordane concentration was elevated at several of the sites that also had elevated DDT (ORT33 and some Cedar River sites), but the contaminant distribution was more similar to what was observed for PAH; high concentrations at ORT33 and nearby (e.g., ORT31) and high concentrations at CED09 and elevated, though slightly lower, up the Cedar River. The chlordane concentrations at the COR sites were notably higher than what has typically been observed in national monitoring programs; 53% of the sites exceeded the NS&T/MW "high" value of 4.5 µg/kg (Table 4-1), while 14% of the NS&T/MW and 8% of all COSED sites exceeded this value.

The BHCs and endosulfan concentrations were lower than the chlordane and DDT concentrations. The BHC concentrations were similar to what they were in the St. Johns River; the concentration range was between 2 and 6 µg/kg at 9 of the sites, with the rest having concentrations below 2 µg/kg (the highest was measured for site ORT23). There was no distinct geographical pattern to the BHC concentrations. The endosulfan concentrations were higher than the BHC concentrations, and the concentrations at the COR sites were higher than in the LSJR. Clearly elevated levels of endosulfan were measured in the Cedar River, and also at sites CED09 and ORT25 in the Ortega River.

Chlorophenolic Compounds

The chlorophenolic compound concentrations varied greatly across the Cedar-Ortega River Basin, and it was difficult to distinguish a clear geographical pattern (Figure 4-33). The two Cedar River sites (CED03 and CED04) appeared to have elevated concentrations of some of the chlorophenolics, while the central basin sites seemed to have higher concentrations of other, related, compounds. The elevated concentrations were not always consistent across chlorophenolic compound classes (i.e., chlorinated phenols, anisoles, catechols, guaiacols), and scattered sites across the study area had sporadic elevated chlorophenolic compound concentrations.

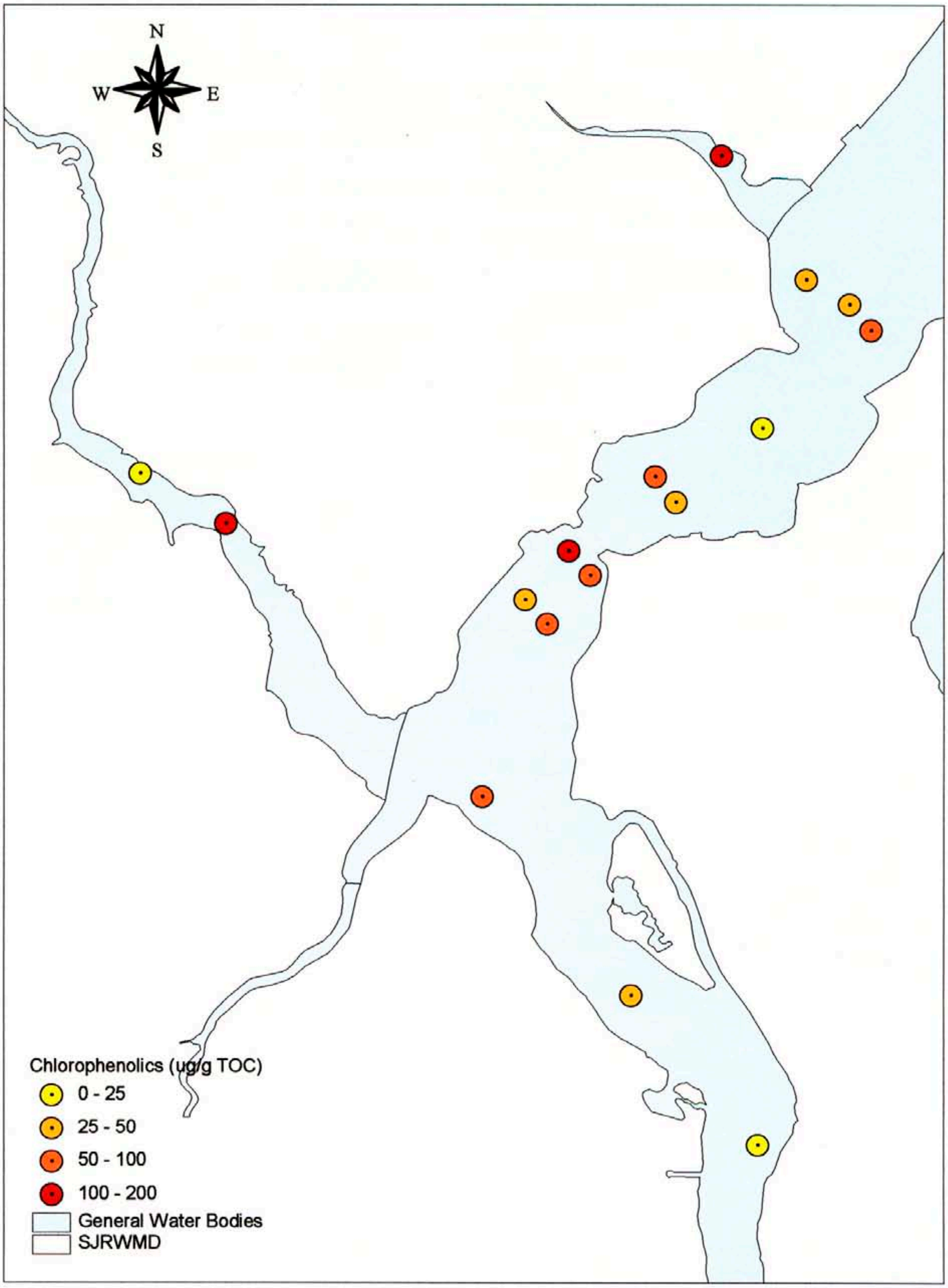


Figure 4-33. Cedar-Ortega River Basin — Map Displaying TOC Normalized Sum of Chlorophenolic Compound Concentrations

As discussed in Section 3.1.3 and 4.1.1, the analytical method that was developed for the chlorophenolic analysis for this project was intended to provide a first-level screening analysis of a broad range of compounds simultaneously, with the intent to identify locations and/or compounds that may warrant more detailed investigation. The method was not optimized for a specific class of compounds and there was a significant potential for matrix contributions. The chlorophenolic data should therefore be used with caution, keeping in mind the intended use of these results.

The chlorinated phenols were detected at all locations, and this broadly used (and highly mobile) class of compounds was wide spread. Anisoles and guaiacols were detected at approximately 63% of the sites, and catechols were detected at approximately 88% of the sites. The lack of correlation between guaiacols and catechols detections was surprising, considering that these classes of compounds most often co-exist in areas exhibiting environmental contamination from pulp and paper industry.

***Organic Compounds — Potential Hot Spots*.**

The data generated in this study were inter-compared for the purposes of identifying potential hot spots, rather than using data from similar locations from other parts of the country. The data were also put into national perspective by comparing to NS&T "high" values (Table 4-1), and this assessment was discussed earlier in this section.

The contaminant profiles vary from contaminant-to-contaminant, but there are a few clear geographical distribution characteristics. Following a review of the data, three general areas emerge as the primary potential hot spots: (1) the area around ORT33/ORT31, (2) the lower part of the Cedar River near CED09, and (3) the upper part of the Cedar River.

The concentrations of chlordane, PAH, phthalates, and DDT are significantly elevated at site ORT33, and to a lesser degree at ORT31, relative to the rest of the Cedar-Ortega River Basin. There appears to be a contaminant gradient towards the south for this area, with most measured contaminant concentrations decreasing from ORT33 to ORT31 to ORT32. These data suggest that the small water body that enters the mouth of the Ortega River by sites ORT31 and ORT32 receive elevated amounts of these contaminants from local source(s). Several small creeks (Big Fish Weir Creek and Little Fish Weir Creek) and other urban/residential runoff discharges enter into this water body (Little Fish Weir Creek enters near ORT33 from the north).

Site ORT19, near the north shore of the central part of the main Basin area and below an automobile (Roosevelt Blvd) and railroad bridge, was one site that had somewhat elevated concentrations of several contaminants, and may be impacted by a local relatively small source. The PAH concentrations are particularly elevated at this location, and the composition of the PAH is slightly different at this location, suggesting there may be local source(s).

The PAH (Figure 4-26) and chlordane concentrations were elevated at site CED09, and the surrounding area. The DDT (Figure 4-31) and endosulfan concentrations were also somewhat higher around site CED09 than most parts of the COR area. The PAH and chlordane concentrations were also elevated, but to a lesser degree, up the Cedar River, particularly up to site CED02. This suggests that the source of these contaminants is (1) in the lower part of the river (e.g., at/near CED09) or (2) the contamination is primarily historic from upstream source(s) and has been deposited in these lower parts of the Cedar River. A contaminant transport *up* the Cedar River (e.g., from CED09 to CED02) would be unlikely, and the source(s) of, particularly the PAH contamination, could be more wide spread. This is consistent with the generally high levels of PAH in the Cedar-Ortega River Basin, and the overall similarity in PAH composition. However, the area around CED09 appears to be an area that warrants additional study. There is a small creek (Butcher Pen Creek) that discharges into the Cedar River at CED09, and the potential for this contributing contaminants, and potential upstream sources, would be worth investigating more closely, in addition to a determination of the transport/depositional mechanisms associated with other parts of the Basin.

The Cedar River in general has elevated concentrations of a number of organic contaminants, as compared to the rest of the Cedar-Ortega River Basin. This is particularly the case for PCB contamination (Figure 4-29), but also DDT and phthalates. The high phthalate concentrations are fairly wide spread across the central part of the Cedar River, with a subtle increase in concentration going downstream, suggesting the input may be historic (or episodic) and the measure concentrations are mostly related to depositional characteristics. The PCB and DDT concentrations increase upstream, suggesting there may be a current source of these contaminants upstream of site CED01. The PCB contamination is high throughout most of the Basin, and the contaminant concentrations increase dramatically up the Cedar River. The overall PCB contamination levels, and PCB composition, that was observed for the Cedar-Ortega River Basin suggests that the primary source of this contaminant for the entire basin may be somewhere up the Cedar River.

***Organic Compounds — Indicators of Potential Effects*.**

The background on the development, and a discussion on the appropriate use, of the ERL/ERM, TEL/PEL, and LEL values was described in Section 4.1.1. The ERL/ERM and TEL/PEL values in Table 4-2 were developed based on U.S. coastal sediments and the TEL/PEL values in Table 4-3 were developed by the Canadian regulatory agencies for assessing freshwater sediment quality in Canada. Long and MacDonald (1998) concluded that saltwater sediment quality guidelines are comparable to those derived with similar empirical methods, but different databases, for freshwater sediments.

Table 4-4 summarizes the number of sites that exceeded the ERL and ERM values, the State of Florida TEL and PEL values (marine/coastal guidelines), and the Canadian TEL and PEL values (freshwater guidelines). Graphs with total PAH, total PCB, and sum of the DDT compound concentrations are presented in Figures 4-34, 4-35, and 4-36, respectively, along with the ERL/ERM reference values. Additional plots with ERL/ERM and *freshwater* TEL/PEL reference values are presented in Appendix M. Non-normalized data are used for all organic and metals sediment quality guideline comparisons. As discussed in the *Indicators of Potential Effects* part of Section 4.1.1, there could clearly be some differences in the contaminant assessment conclusions depending on which sediment quality guidelines one uses. Furthermore, the significant TOC concentrations in many of these samples may make them less bioavailable. It is therefore important to consider both TOC- and non-normalized data, and the ERL/ERM and TEL/PEL values, for an overall contaminant assessment.

PAH

This assessment of sediment quality guideline exceedances focuses on the ERL/ERM values (the most widely applied sediment quality guidelines) and the freshwater TEL/PEL values (the most comprehensive freshwater guidelines). ERL exceedances for Total PAH, High PAH, and Low PAH occurred at 29 (57%), 45 (88%), and 12 (24%) of the 51 COR sites, respectively (Table 4-4). The ERM values for Total PAH and Low PAH were not exceeded at any of the COR sites, however the ERM value for High PAH was exceed at 8 (16%, CED02, CED03, CED04, CED06, CED09, ORT25, ORT31, and ORT33) of the 51 COR sites. These HMW PAH (e.g., benzo(a)pyrene) are the PAH generally considered to have the greatest potential for adverse chronic effects (e.g., carcinogens, teratogens), but they are generally less acutely toxic than lower molecular weight PAH and less mobile in the environment. Note that the PAH compounds used to compute the low- and high-molecular weight PAH ERL/ERM values (Long *et. al*., 1995) are slightly different from what is commonly used for similar summations, and from what is used in this report (see Table 3-1), but the differences are small and have no impact on the overall exceedance rate or conclusions.

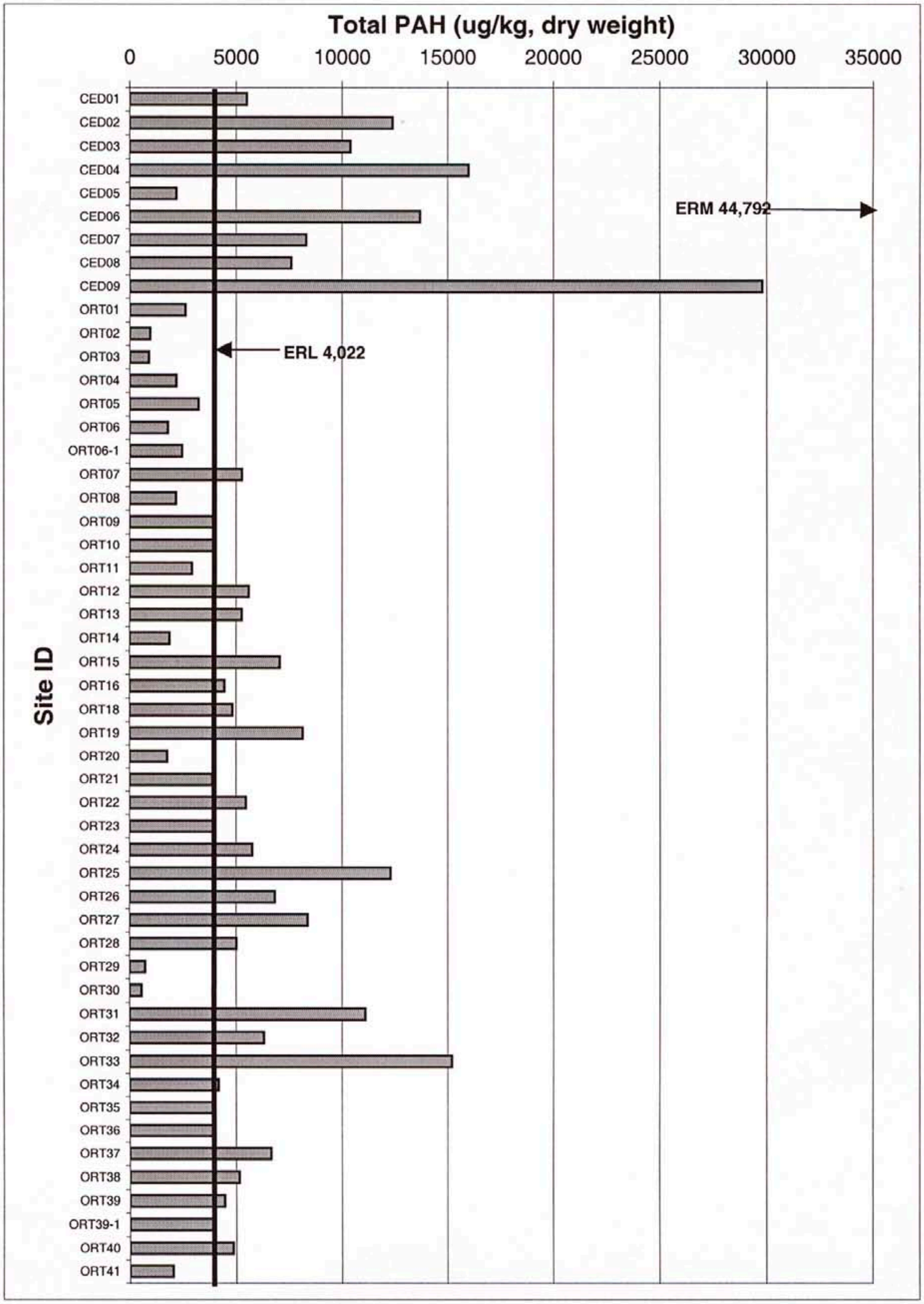


Figure 4-34. Cedar-Ortega River Basin — Total PAH Concentrations and ERL/ERM Values

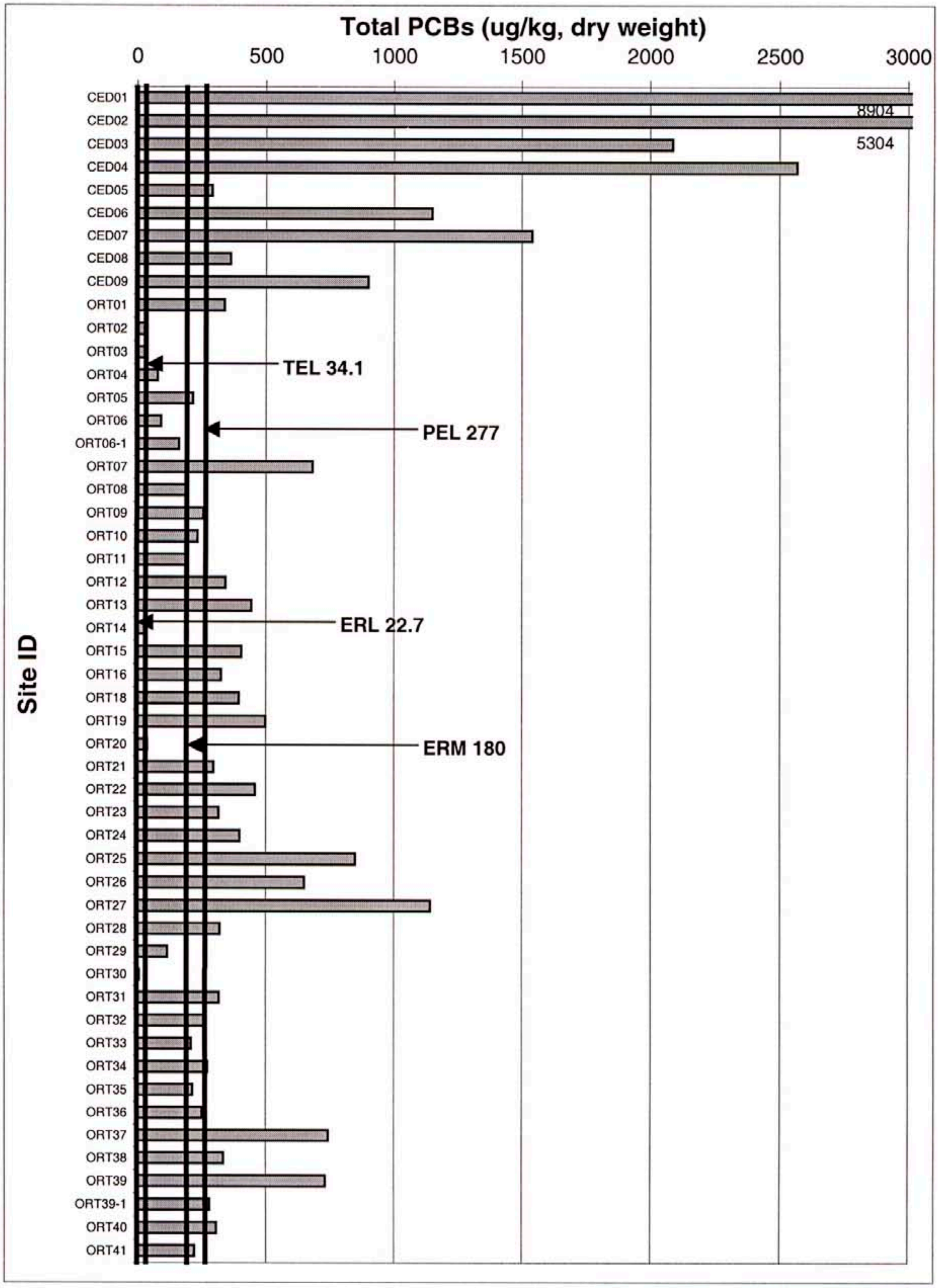


Figure 4-35. Cedar-Ortega River Basin — Total PCB Concentrations and ERL/ERM and TEL/PEL Values

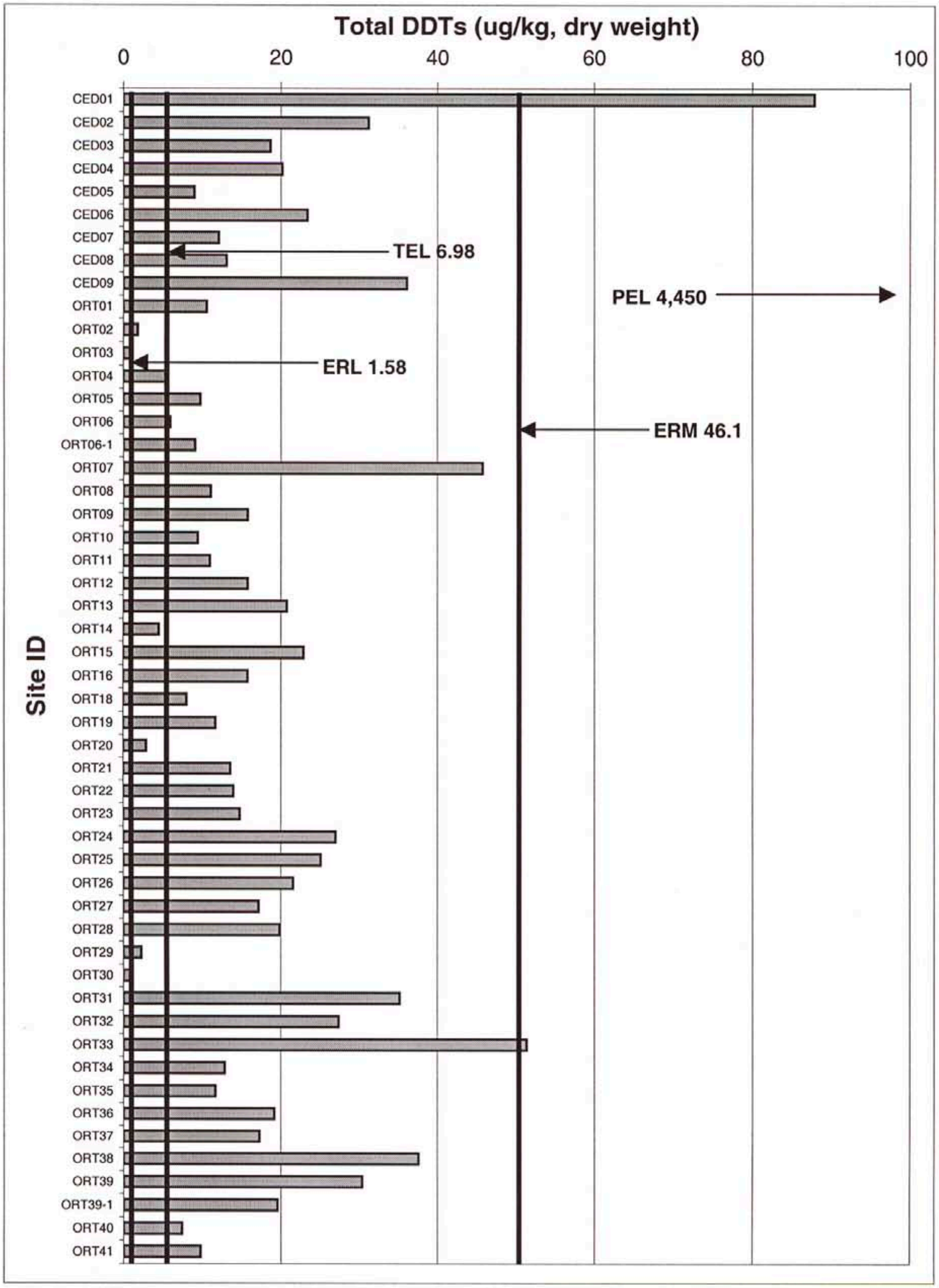


Figure 4-36. Cedar-Ortega River Basin — Sum of DDTs Concentrations and ERL/ERM and TEL/PEL Values

Since there are no *freshwater* TEL or PEL values for PAH, as with the LSJR data set these COR basin data were compared to the marine TEL/PEL values. Marine TEL exceedances for Total PAH, High PAH, and Low PAH occurred at 47 (92%), 50 (98%), and 29 (57%) of the COR sites, respectively (Table 4-4). The marine PEL value for Low PAH was not exceeded at any of the COR sites, however the marine PEL values for Total PAH and High PAH were exceeded at 1 (2%) and 12 (24%) of the COR sites, respectively.

PCB

The Total PCB concentration used for this assessment was calculated by multiplying the sum of the target PCB congener concentrations by 2.4, as discussed in Section 3.1.2. There were numerous ERL/ERM and freshwater TEL/PEL Total PCB exceedances. The total PCB ERL and ERM values were exceeded at 50 (98%) and 42 (82%) of the 51 COR sites, respectively. Freshwater TEL and PEL values were exceeded at 48 (94%) and 31 (40%) of the COR sites, respectively. The total PCB concentration at CED01 exceeded the ERM value by a factor of 49, and the ERL was exceeded by a factor of 392. PCB was clearly the organic contaminant with the greatest potential for environmental effects in the Cedar-Ortega River Basin, based on these sediment quality guidelines.

Pesticides - DDTs

The ERL for total DDT was exceeded at 49 (96%) sites and the freshwater TEL was exceeded at 43 (84%) of the 51 sites. The ERM for total DDT was exceeded at 2 (4%, CED01 and ORT33) of the 51 COR sites and the freshwater PEL was not exceeded at any of the COR sites. Sites CED01 and ORT33 exceeded these sediment quality guideline values by the greatest amounts; the sediment DDT concentrations for site CED01 exceeded the ERM value by about a factor of 2. The individual p,p'-DDE, p,p'-DDD, and p,p'-DDT compound concentrations exceed the ERL values at 43 (84%), 44 (86%), and 46 (90%) of the COR sites, respectively. ERM values for the p,p'-DDE, p,p'-DDD, and p,p'-DDT compound were exceeded at 1 (2%), 2 (4%), and 7 (14%) of the COR sites, respectively. Freshwater TEL and PEL values were exceeded for p,p'-DDE were exceeded at 45 (88%) and 19 (37%) of the COR sites, respectively. CED01 and ORT33 were clearly the sites in the Cedar-Ortega River Basin with the most significant DDT compound contamination, from a sediment quality perspective.

Pesticides – Other Chlorinated Pesticides

There were a number of chlordane, dieldrin, and lindane sediment quality guideline exceedances in the Cedar-Ortega River Basin. Chlordane concentrations exceeded the ERL value at 44 (86%) of the 51 sites and the freshwater TEL value was exceeded at 27 (53%) of the sites. The chlordane ERM value was exceed at 22 (43%) of the COR sites and the freshwater PEL value was exceeded at 15 (29%) of the sites. The most significant sediment quality guideline exceedances for chlordane were observed at sites ORT33, ORT31, and CED09.

Dieldrin concentrations exceeded the ERL value at 41 (80%) of the 51 sites and the freshwater TEL value was exceeded at 5 (10%) of the sites. The dieldrin ERM value was not exceeded at any of the COR sites, however the freshwater PEL was exceeded at 1 (ORT33) of the COR sites. The ERL reference value is, as described in Section 4.1.1, considered less reliable than most other.

The concentration of lindane was above both the freshwater TEL and PEL values at a number of sites; 19 (37%) of the 51 sites exceeded the PEL, and they were, geographically, distributed throughout the Basin. The concentrations of lindane at these 19 sites with PEL exceedances were, generally, within a factor of 2 of the reference value. There are no ERL or ERM reference values for lindane.

4.2.2 Metal Contaminant Levels

Metals — Contaminant Concentration, Distribution, and Composition.

The important relationships between metals, the general physico-chemical characteristics of sediments (e.g., TOC and grain size), and how those relate to the interpretation of metals data, were discussed in Section 3.2. The physico-chemical data analyses described in Section 3.2 was also performed with the COR sample data, with analogous general findings as with the LSJR data, and the data were therefore handled similarly for interpretation and presentation purposes.

There was a fairly broad range in the metal concentrations of the Cedar-Ortega River Basin sediments and the levels were also spatially variable. An example of this range and variability, which was not as great as in the St. Johns River, was seen in the aluminum concentrations (Figure 4-37). Aluminum is a major metal primarily associated with mineral components of sediments. It is frequently used to normalize variability in metals concentrations that arise from differences in the grain size composition and geology of sediments. Through normalization, naturally occurring metal concentrations can often be separated from those resulting from anthropogenic activities. Bar charts depicting the non-normalized and aluminum- and grain size-normalized metals data are compiled in Appendix K.

Aluminum concentrations ranged from 11,600 mg/kg to 60,600 mg/kg, or about a 5-fold difference between the lowest and highest sediment concentrations (as compared to a 100-fold difference in the St. Johns River). A range like this is typical of systems that have fairly variable grain size distributions but of similar geological origin, as found in this set of samples. The other major metals associated with crustal materials (minerals) also displayed a similar range in concentration. Manganese concentrations, for instance, ranged from 96 to 270 ppm and lithium from 11.5 to 54 ppm. There was a 3- and 5-fold difference between the maximum and minimum concentrations of these elements, respectively.

As shown in Tables 3-10 and 3-11, the toxic metals concentrations were quite variable in the Cedar-Ortega River Basin. Differences between high and low values ranged from four fold for thallium and vanadium to 100 fold for silver and 400 fold for beryllium. Variability in the relative difference between the high and low values can be related to many factors including the proximity to sources, subtle differences in the factors controlling concentrations (e.g., TOC, grain size), and the redox state of the sediments. Generally speaking, samples with low toxic metals concentrations tended to be associated with sediments that were sandier in nature. However, there were also subtle geographical patterns to some of the metal contaminant profiles that could be attributable to potential sources; the percent mud did not exhibit a discernable geographical pattern (Appendix L).

There were less discrete contaminant signals and patterns for metals than for organic contaminants, and most metals followed a very similar contaminant distribution trend. The concentrations of several metals, including antimony, arsenic, chromium, copper, lead, silver, tin, and zinc appeared to be somewhat elevated in the upper parts of the Cedar River, with declining concentrations closer to the confluence with the Ortega River (Figures 4-38 through 4-40, and Appendices E and K). Some of these metals (lead, silver, and zinc) were also elevated at sites ORT33/31. The magnitude of the elevation varied by metals, but was fairly small for most metals, although the geographical pattern was evident.

Other metals, were detected at concentrations that were either more constant throughout the area (e.g., cadmium, cobalt, lithium, nickel, selenium, and thallium) or somewhat more variable but with contaminant concentrations varying within a fairly small concentration range [e.g., beryllium, copper, mercury (Figure 4-41), and vanadium]. These metals exhibited, for the most part, no clear geographical pattern, whether the data were reviewed normalized to aluminum or not (i.e., the metals concentrations were mostly driven by grain size/geology).

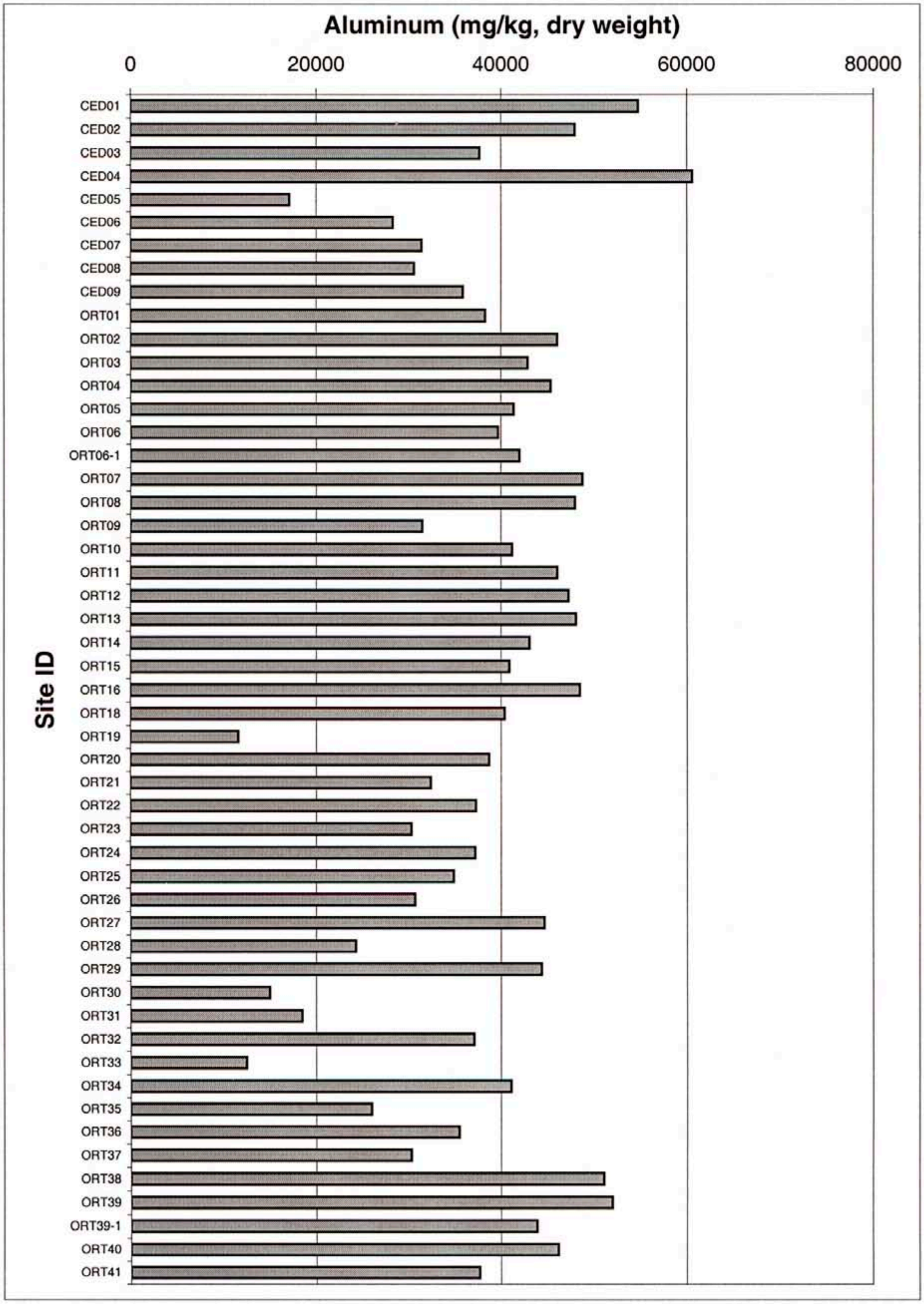


Figure 4-37. Cedar-Ortega River Basin — Aluminum Concentrations of Sediments

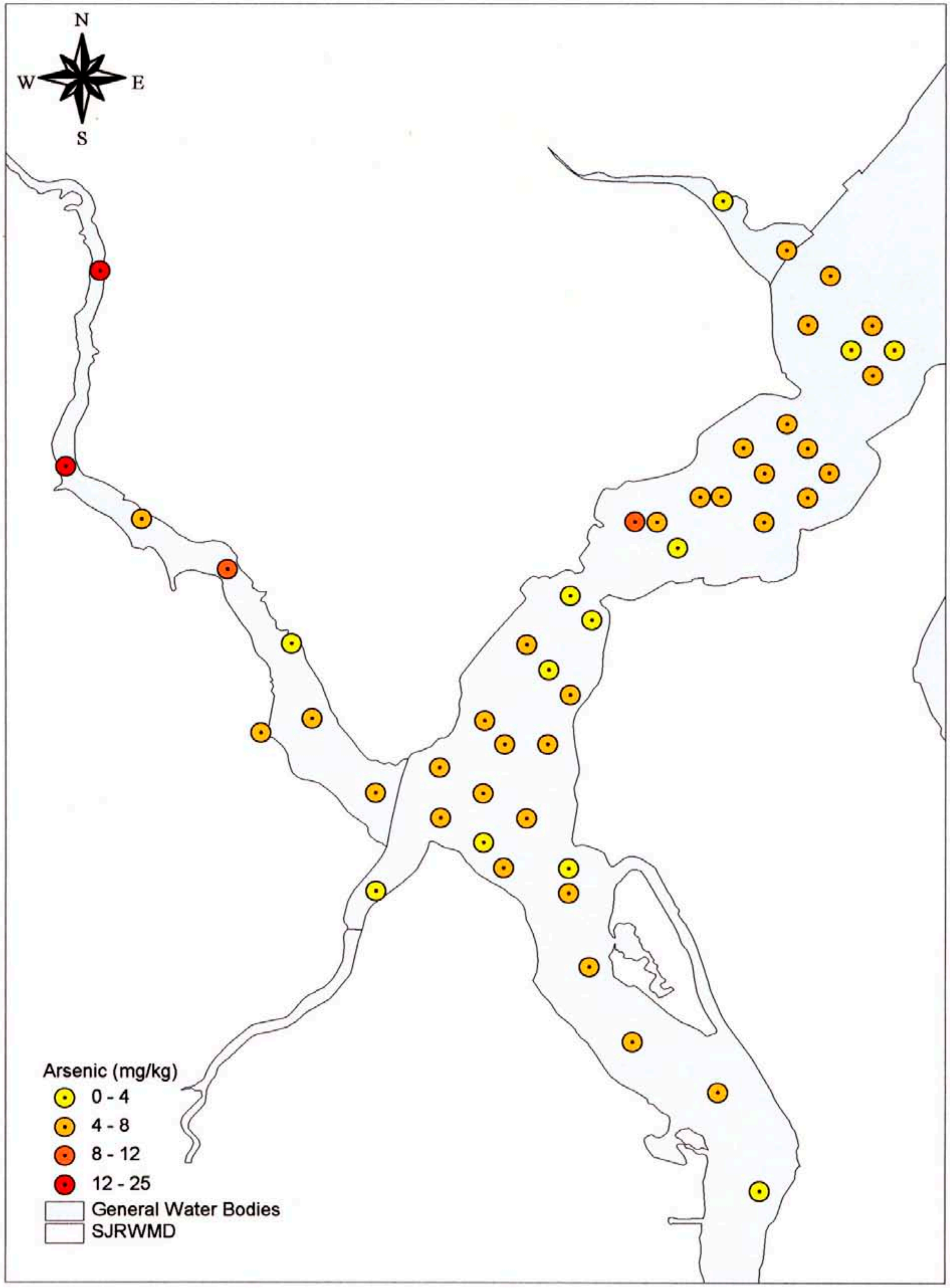


Figure 4-38. Cedar-Ortega River Basin — Map Displaying Arsenic (As) Concentrations (a) Non-Normalized

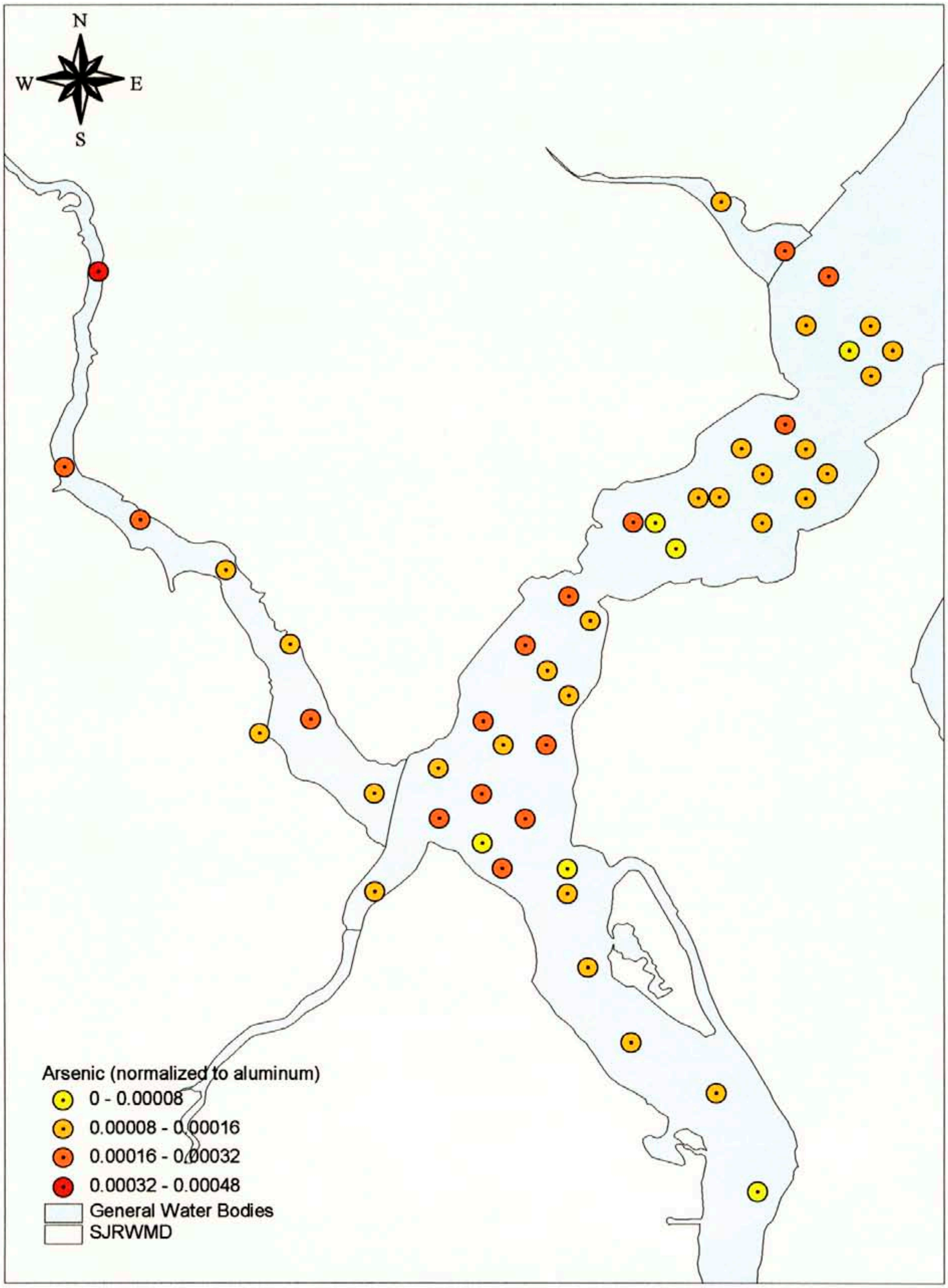


Figure 4-38. Cedar-Ortega River Basin — Map Displaying Arsenic (As) Concentrations (b) Normalized to Aluminum

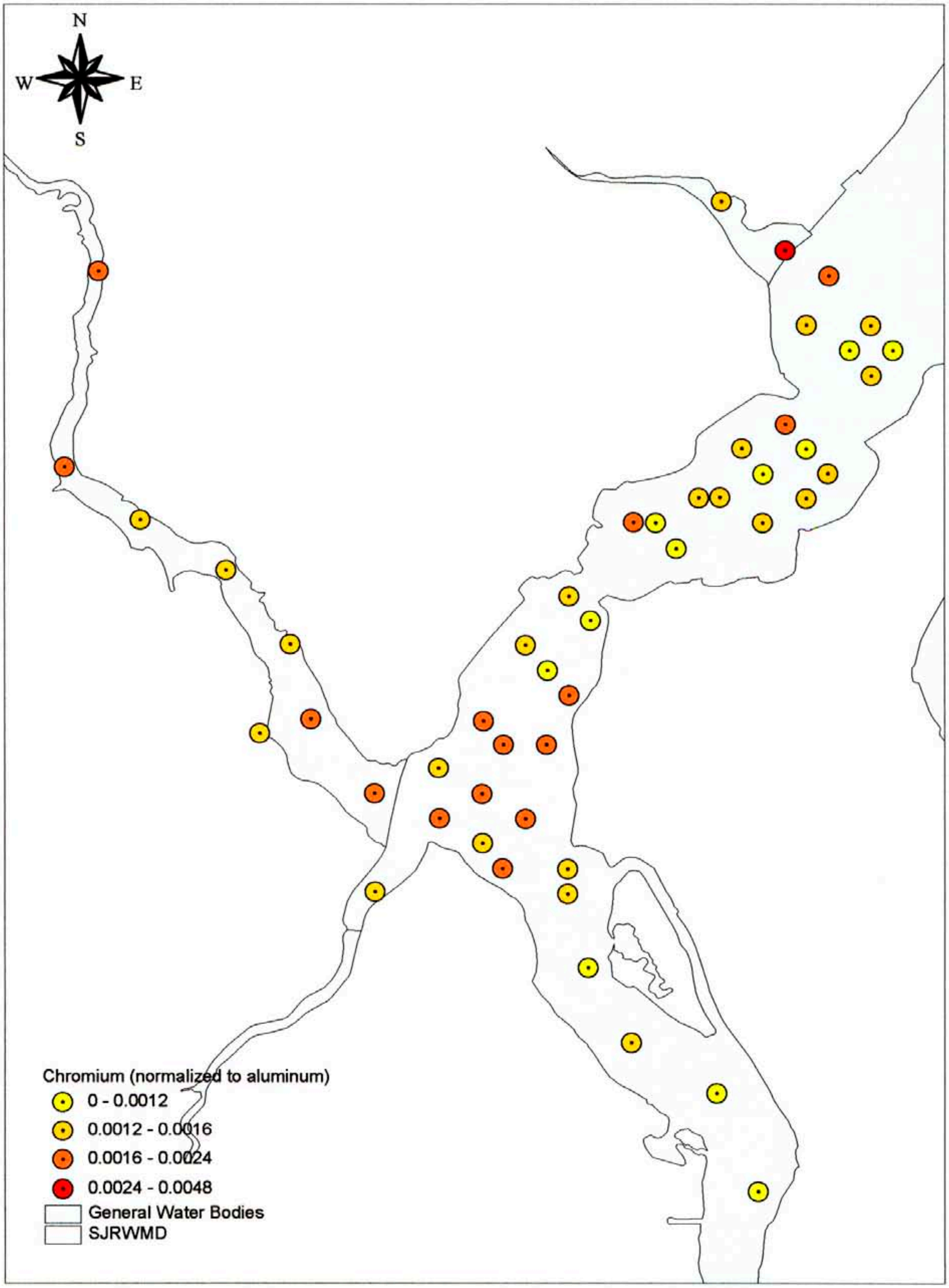


Figure 4-39. Cedar-Ortega River Basin — Map Displaying Chromium (Cr) Concentrations Normalized to Aluminum

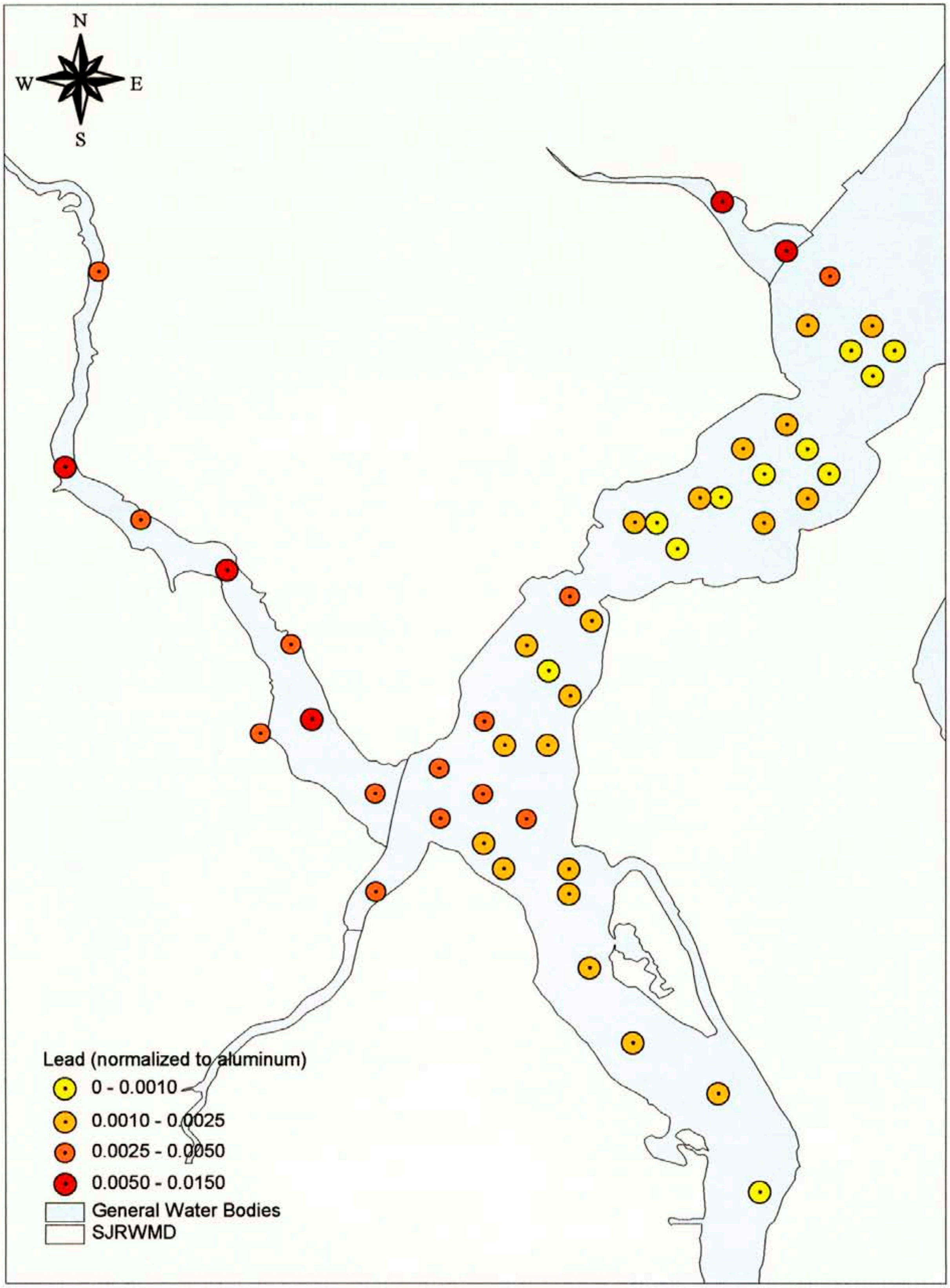


Figure 4-40. Cedar-Ortega River Basin — Map Displaying Lead (Pb) Concentrations Normalized to Aluminum

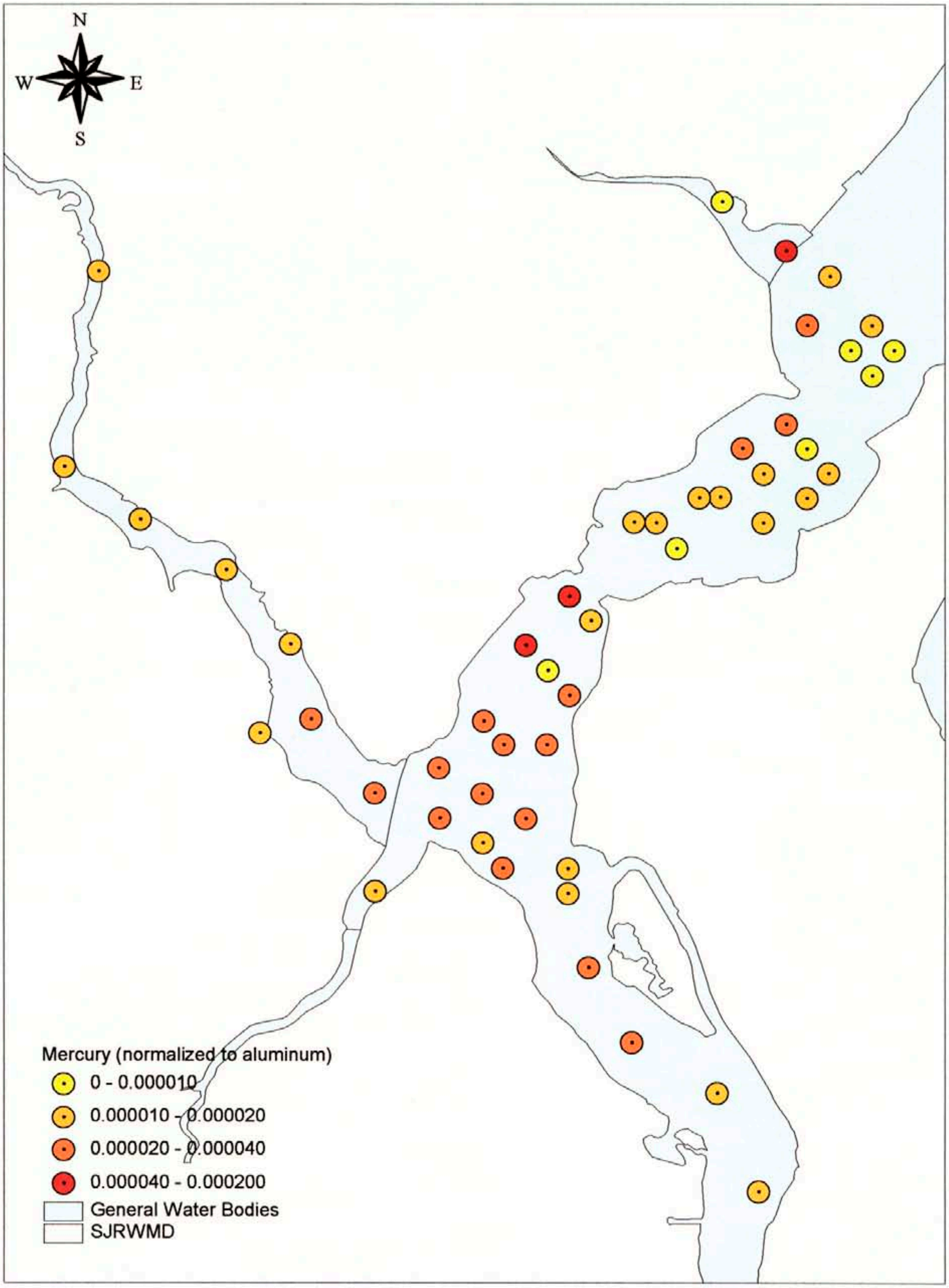


Figure 4-41. Cedar-Ortega River Basin — Map Displaying Mercury (Hg) Concentrations Normalized to Aluminum

Some contaminant signals were evident when both the normalized and non-normalized data had been reviewed. The copper, lead, silver, and zinc concentrations appear to be significantly elevated in the northern section of the Cedar River (e.g., sites CED01 and CED02), and the lead, silver, and zinc concentrations were elevated at sites ORT31 and/or ORT33. These Cedar and Ortega River locations were also identified to have elevated concentrations of several organic contaminants. Copper and mercury appear to also be elevated at site ORT19, which is a site along the northern shore of the main section of the Basin that also had a PAH contamination profile that was different from most sites.

Several of the metals measured in this study, were present at higher concentrations in the Cedar-Ortega River Basin than in other national monitoring programs (Table 4-1). A relatively large proportion of the sediment sites had cadmium, copper, lead, mercury, selenium, silver, tin, and zinc concentrations that exceeded the NS&T/MW "high" value; these metals exceeded the reference value at 86%, 41%, 80%, 90%, 92%, 65%, 57%, and 73% of the COR sites, respectively, compared to 31%, 25%, 23%, 30%, 15%, 22%, 20%, and 22%, respectively, for all COSED sites. There were fewer exceedances for the NS&T/MW sediment sites (between 12% and 18%, for these metals) than the COSED sites. There were no, or fewer, NS&T/MW "high" value exceedances for arsenic, chromium, nickel, antimony for the COR sites than there were in the NS&T/MW and COSED data sets. The fairly high rate of exceedances may, partly, be due to differences in the geology of the sediments; the Cedar-Ortega River sediments may be naturally more enriched in these metals than the average U.S. coastal sediment. Another factor could be the relatively fine grain size of these sediment, as compared to most coastal sediment (the NOAA "high" values are based on non-normalized data), resulting in a naturally elevated metals concentrations as compared to coarser grain size sediments. Additionally, as discussed earlier, mercury results are difficult to dependably compare with historical data because significantly more reliable analytical methods were used in this study than were available for most historical monitoring programs. However, the very high rate of exceedance for many metals, in addition to the significantly higher rate of exceedance as compared to the St. Johns River, clearly suggests that the Cedar-Ortega River Basin has notably elevated concentrations of these toxic metals (i.e. Hg, Pb, Cd, and Cr).

Metals — Potential Hot Spots.

The contaminant concentration evaluations suggest that there are, similar to the organic compound contamination, parts of the Cedar-Ortega River Basin that have elevated concentrations of selected metals, as compared to other parts of the study area. These include areas in the Cedar River and around sites ORT31, ORT33, and ORT19. The northern parts of the Cedar River had higher concentrations of several metals (copper, lead, silver, and zinc), and these concentrations declined down stream. The PCB and DDT concentrations had a similar contaminant distribution, suggesting there may be a current source of these metals and organic contaminants upstream of site CED01.

The area around ORT31 and ORT33 also had significantly higher concentrations of selected metals (lead, silver, and zinc) that other parts of the area, but more so at site ORT31 than at the northern-most site (ORT33) where the most significant elevation of organic contaminants was observed. These data suggest that this small water body that enters the mouth of the Ortega River by ORT31/ORT32 receives elevated amounts of these contaminants from local source(s). Several small creeks (e.g., Big Fish Weir Creek and Little Fish Weir Creek) and other urban/residential runoff discharges enter into this water body; Little Fish Weir Creek enters near ORT33 from the north.

Site ORT19, near the north shore of the central part of the main Basin area, had elevated concentrations of copper and mercury, and may be impacted by a local source. These metals are not dramatically elevated at other locations, so there is clearly a site-specific signal to this contamination. The PAH concentrations were also elevated at this location, and the composition of the PAH was different at this location, all suggesting that there may be local source(s) of PAH, copper, and mercury contamination.

Metals — Indicators of Potential Effects.

The metal contaminant data were compared to sediment quality guidelines to identify areas that potentially should be examined further to determine whether or not there could be environmentally detrimental impacts. For this evaluation, the sediment metals concentrations were compared to both the marine ERL/ERM and the freshwater TEL/PEL indicators (Tables 4-2 and 4-3). The results of this data comparison are summarized in Table 4-4, and in Appendix M. Figure 4-42 presents the lead data relative to the ERL/ERM and freshwater TEL/PEL values, and Figure 4-43 presents this information for mercury. Similar figures for the other seven metals that are typically of environmental concern, and for which there are published ERL/ERM and freshwater TEL/PEL values, are compiled in Appendix M.

There were many more metals sediment quality guideline exceedances in the Cedar-Ortega River Basin than the St. Johns River. There were a relatively limited number of ERM exceedances; the ERM for lead was exceeded at four sites (CED01, CED02, CED04, and ORT31), silver at two sites (CED01, and CED02), zinc at nine sites (mostly in the Cedar River), and mercury at many sites. There were no ERM exceedances for arsenic, cadmium, chromium, copper, or nickel. There were significantly more exceedances of the more conservative, and lower, ERL and TEL values, as is evident from the figures in Appendix M and the summary data in Table 4-4; all metals had ERL and TEL exceedances. Mercury had the largest number of ERL (and ERM) exceedances; 92% of the sites exceeded the mercury ERL, followed by lead (80% of the sites), zinc (63% of the sites), cadmium and copper (47% of the sites), and silver (24% of the sites). The reliability of using the mercury ERL (or TEL) value to assess potential risk is often hotly debated at scientific meetings, and it should certainly only be used as a general guideline and only as a component of a more comprehensive environmental quality assessment. The TEL is a more conservative risk measure than the, already recognized to be low, ERL value, and there were, consequently, even more TEL exceedances.

The sites with the most metals ERL exceedances were CED01 and CED02 (all nine metals with ERL values exceeded this measure) followed by CED04 and ORT15 (eight metals). Many sites had five or six ERL metals exceedances. The sediment quality guideline exceedances were concentrated in or near the Cedar River, and also the Big Fish Weir Creek and Little Fish Weir Creek area, for several of the metals with a large number of exceedances (e.g., copper, lead, silver, and zinc), indicating that the sediment quality issues may be originating in sources upstream of these locations. There were also a large number of sediment quality guideline exceedances for mercury and cadmium, but the contaminant concentrations and sediment quality exceedances were more broadly distributed throughout the Cedar Ortega River Basin for these two metals. This data set shows a significant amount of sediment quality guideline exceedances for the Cedar-Ortega River Basin, resulting in an impression of a fairly wide spread potential for biological impact from metals in the study area.

As mentioned previously, the application of these sediment quality guidelines should be made with caution, particularly for toxic metals. Most of the guidelines were developed for individual parameters and do not incorporate additive or interactive effects due to multiple toxic components. In addition, the potential of metals to cause adverse biological effects depends greatly on the characteristics of the sediment and how the metals are associated with the sediment (i.e., how available the metals are to possible receptors). The bioavailability of the metals depends on the grain size and the amount of TOC in the sediment — finer grain sediment and high TOC typically bind the metals more tightly making them less available. A high acid volatile sulfide (AVS) concentration in the sediment also appears to reduce the bioavailability of certain toxic metals, including cadmium, copper, nickel, lead, and zinc (DiToro *et al*.; 1990 and 1992).

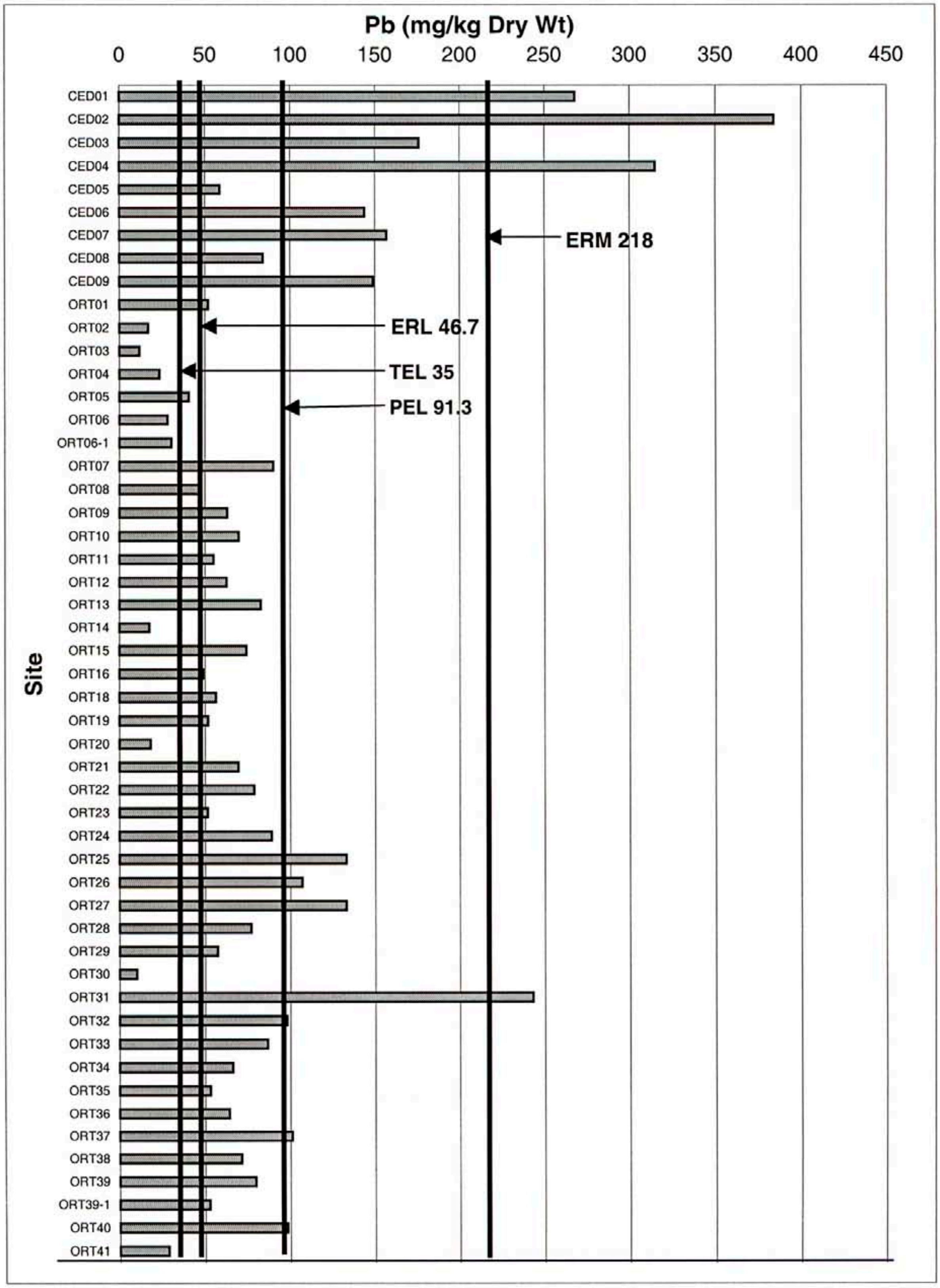


Figure 4-42. Cedar-Ortega River Basin — Sediment Lead (Pb) Concentrations and ERL/ERM and TEL/PEL Values

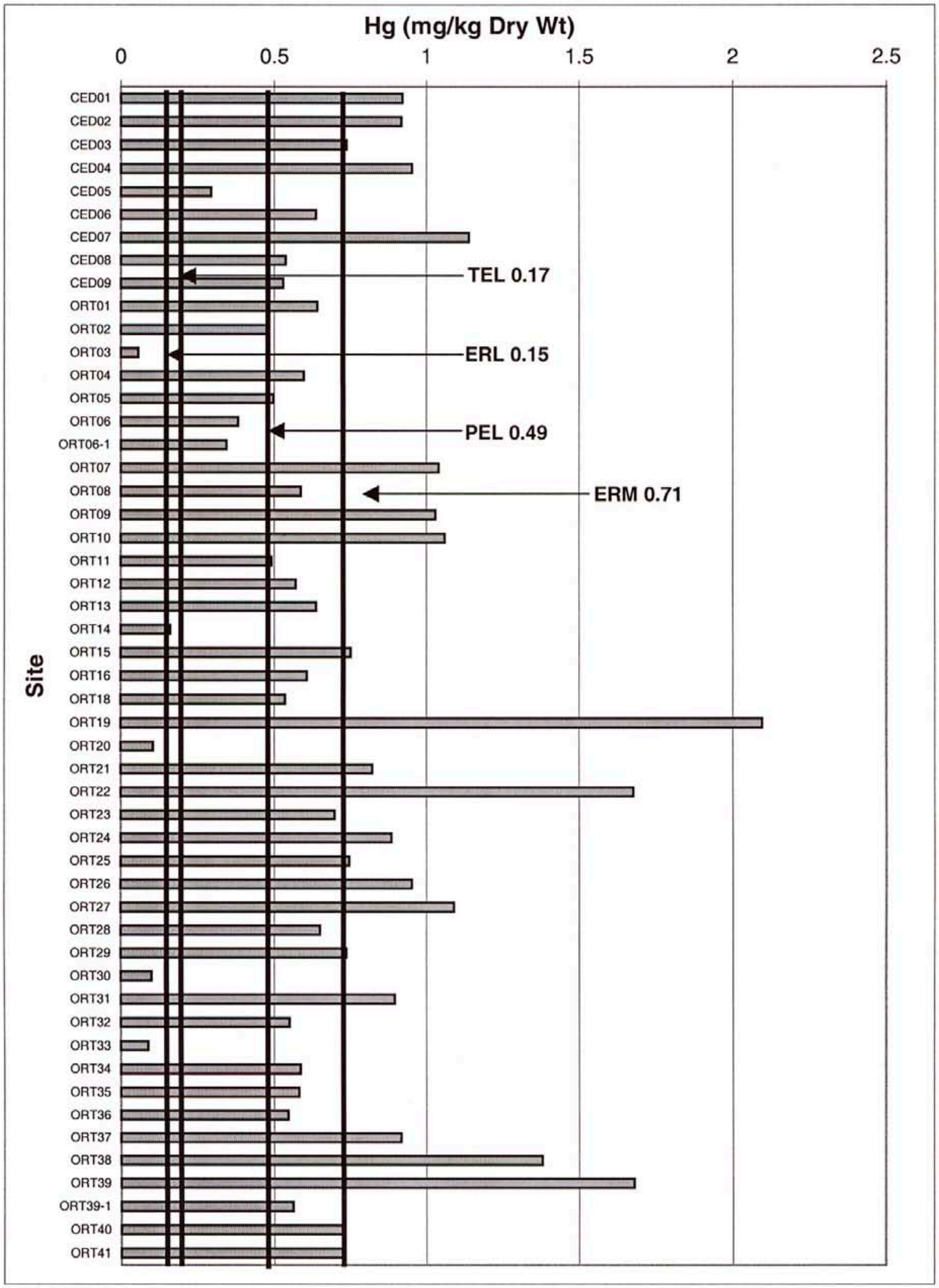


Figure 4-43. Cedar-Ortega River Basin — Sediment Mercury (Hg) Concentrations and ERL/ERM and TEL/PEL Values

5. CONCLUSION

This study is the most complete sediment quality assessment to date of the Lower St. Johns River and the Cedar-Ortega River Basin. A wealth of data were generated on the sediment contaminant characteristics of the area, and this provides a broad and solid foundation for future environmental management decisions. Some contaminant characteristics that had previously been reported (e.g., elevated PAH in the St. Johns River near Jacksonville) were confirmed, but an abundance of new contaminant data were generated. These new data included information on a large number of organic and metals contaminants that had previously not been measured, and the spatial coverage and resolution was significantly greater than any previous sediment study in Lower St. Johns River Basin. The wealth of new data allow for 1) the identification of new locations with potential contamination issues, 2) the identification of new contaminants of concern, and 3) the demonstration of locations and contaminants that do not appear to be of environmental concern.

The quality of the sediments in Lower St. Johns River and the Cedar-Ortega River were quite variable; particularly in the Lower St. Johns River. The Lower St. Johns River had a few locations that had notably elevated concentrations, as compared to the rest of the River and suitable environmental guidelines. However, the sediments of the Lower St. Johns River appears to, for the most part, be of relatively good environmental quality from a chemical contaminant load perspective, considering the large drainage area and the relative proximity to industry and urban areas. The sediments of the Cedar-Ortega River Basin, on the other hand, are widely contaminated with a variety of organic and metal contaminants, and the data analysis suggests this is an area that warrants environmental action.

Figures 5-1 through 5-4 present a *very* general summary of the relative contaminant “rankings” of the Lower St. Johns River and Cedar-Ortega River sites, for organic and metals contamination. This ranking is based on ordering the sites from highest to lowest contaminant concentration (using both non-normalized and normalized data separately), for the major classes of organic contaminants (PAH, PCB, pesticide) and the major toxic metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc), assigning each of the sites a rank value for each parameter (1=most and 77=least contaminated of the 77 LSJR sites, for instance), and then summing the individual parameter rankings to generate the sums presented in the figures. This ranking should only be used as a very general barometer, and does in no way address the magnitude of any individual contaminant. Additionally, a site may, for instance, be among the most contaminated with two or three metals, and of significant environmental concern, but have low concentrations of the other metals, and end up with an average overall contaminant load ranking.

Lower St. Johns River

The contaminant data were quite variable, indicating differences in contaminant concentrations and also in the natural composition of the sample matrix. Differences among the sources of these contaminants, including their proximity to the sampling locations, certainly accounts for some of the differences in the contaminant distribution patterns. Some contaminants, such as PAH and mercury, have a large atmospheric source component in addition to being in runoff and other discharges that also must be considered. In contrast, most other metals, PCB, and pesticides are introduced to the environment primarily through point sources, or local non-point runoff. Contaminants with substantial atmospheric sources will tend to be spread more uniformly within a watershed when contrasted to pollutants with more localized and less distributed source functions.

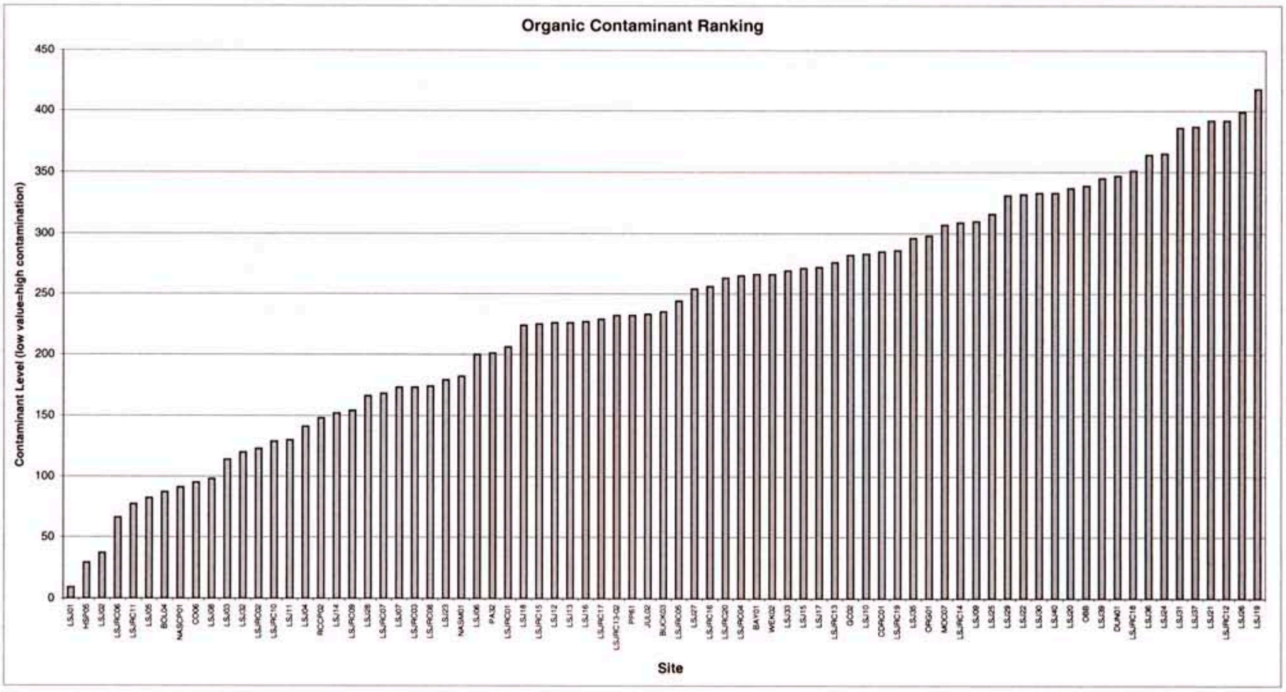


Figure 5-1. Lower St. Johns River — General Organic Contaminant Rankings of Sites

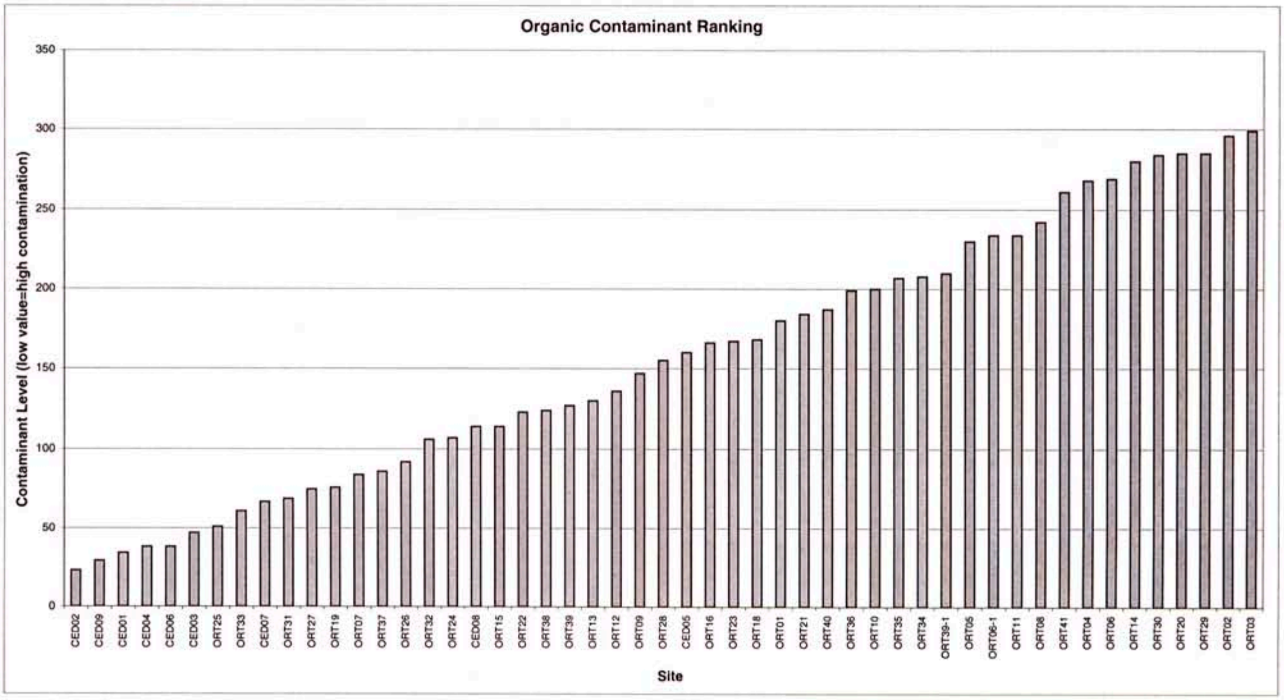


Figure 5-2. Cedar-Ortega River Basin — General Organic Contaminant Rankings of Sites

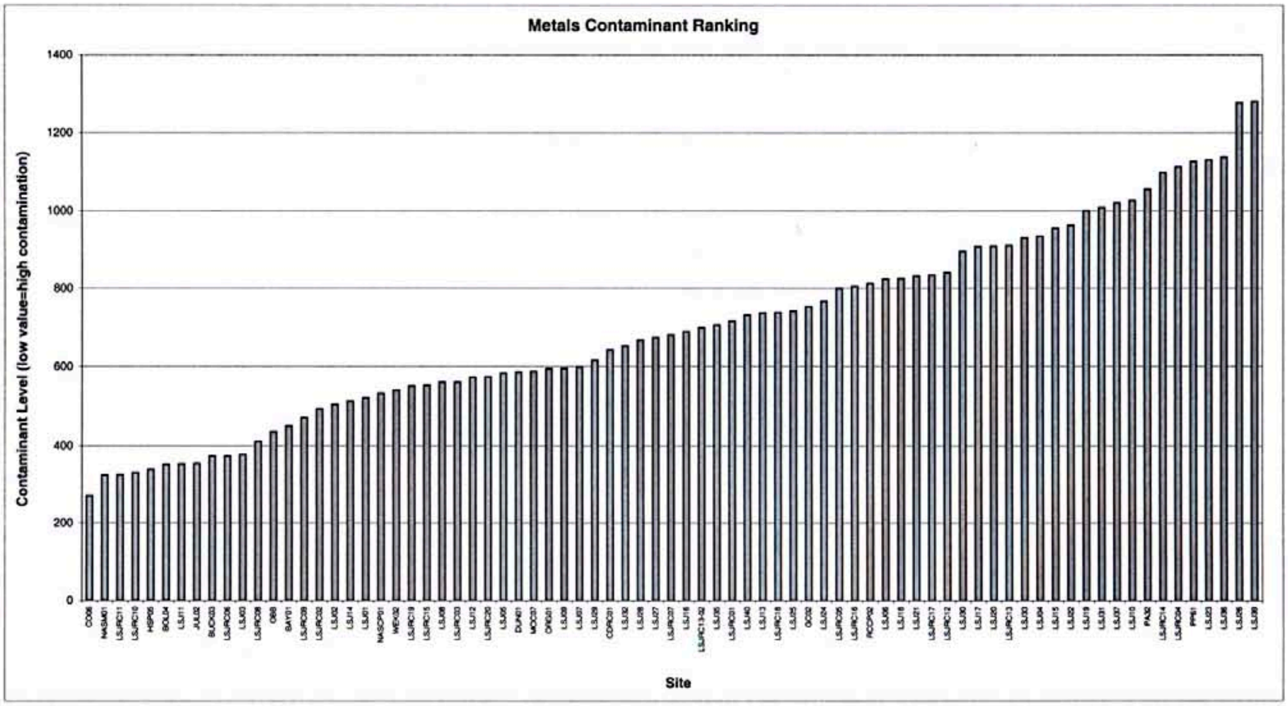


Figure 5-3. Lower St. Johns River — General Metals Contaminant Rankings of Sites

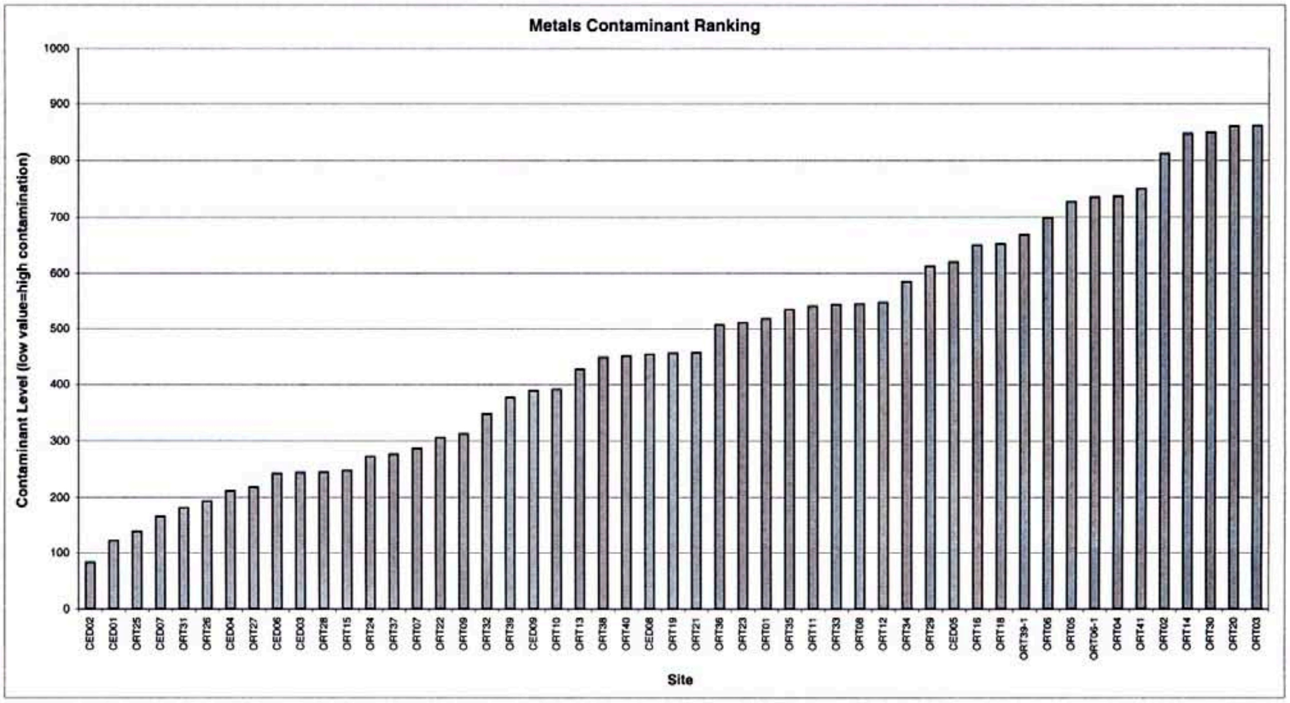


Figure 5-4. Cedar-Ortega River Basin — General Metals Contaminant Rankings of Sites

Generally, the quality of the sedimentary environment in the Lower St. Johns River appears to be quite good, based on this chemical contaminant assessment, but a few parts of the River clearly had elevated concentrations of contaminants when compared to the rest of the area, and contaminant profiles. Considerations that may be of environmental quality interest include the following:

- The northern-most part of the Lower St. Johns River, near Jacksonville (represented by sites LSJ01, LSJ02, and HSP05), was clearly the most contaminated part of the St. Johns River study area, with significantly elevated concentrations of a number of organic contaminants. The elevated contaminant signals were particularly evident for PAH, PCB, and some pesticides, such as DDT, chlordane, and endosulfan. There appeared to also be elevated levels of certain metals in this area, but the relative magnitude of this elevation was smaller than for the organic contaminants.

- The Lower St. Johns River by Rice Creek (e.g., sites LSJRC06, LSJRC10, LSJRC11, LSJRC02) had elevated concentrations of several sediment contaminants. This area had elevated concentrations of PAH, PCB, and some pesticides, including chlordane and endosulfan, and some metals. There also appeared to be an elevated signal of selected industrial chlorinated compounds, including chlorinated phenolics. Some of the contaminant profiles [e.g., the PAH compound composition, chlorinated phenolics, elevated mercury and zinc] were different in this area than in most other parts of the River, indicating local source(s).

- Selected individual sites had elevated concentrations of one or several contaminants, suggesting the possible presence of a localized source of contaminants. This included site NASCP01, which is by the Naval Air Station (elevated PAH, PCB, and DDT), and CO06, which is inside the Cedar-Ortega River Basin, confirming the overall contamination issues of this that area.

Large urbanized areas, and potentially also some specific industrial activities, appear to be exerting some influence on the contaminant concentrations in the sediments of parts of the Lower St. Johns River. These locations described above had concentrations of several of the organic and metal contaminants that were greater than what would be considered typical, based on data from different national environmental monitoring programs. A series of general sediment quality guideline value exceedances were also observed for these locations, suggesting there may be a potential for adverse biological impact from some of the measured contaminants.

Cedar-Ortega River Basin

The Cedar-Ortega River Basin is widely contaminated with different organic and metals contaminants, and within the Basin there are locations with clearly elevated concentrations, compared to the rest of the Basin.

- The upper parts of the Cedar River has very high concentrations of PCB, and also significantly elevated concentrations of phthalates and DDT, and several metals (copper, lead, silver, and zinc). There was a sharp increase in the contaminant signals up the river, suggesting there is a significant source(s) of these contaminants upstream of site CED01.

- The lower part of the Cedar River, near the confluence with the Ortega River (as represented by site CED09 at the mouth of Butcher Pen Creek), had significantly elevated concentrations of PAH and selected pesticides (particularly chlordane).

- The small water body in which sites ORT33 and ORT31 were located, by the mouth of Big Fish Weir Creek and Little Fish Weir Creek and near the mouth of the Ortega River, had elevated concentrations of chlordane, PAH, phthalates, DDT, and selected metals (lead, silver, zinc), indicating the presence of a local source(s).

- Elevated contaminant concentrations, although to a lesser degree than the other three locations, were also measure at site ORT19. The slightly elevated concentrations of PAH, mercury, and copper, in combination with the relatively site-specific composition of these contaminants, suggests there may be a small local source of contamination.

The areas around the Cedar-Ortega River Basin are clearly exerting significant influence on the contaminant concentrations in the sediments. Although much of the contamination may be historic, the data clearly suggest that there also appear to be significant current sources of contamination. The concentrations of PCB, PAH, some of the pesticides (particularly chlordane and DDT), and several metals (particularly lead, silver, zinc, copper, mercury, and cadmium) are high in this area, whether they are compared to the Lower St. Johns River, other national monitoring programs, or widely used sediment quality guidelines. The PAH and PCB compound composition is also relatively unique in the Cedar-Ortega River Basin, suggesting there may be a fairly limited number of sources. These sediments are of poor quality, from a chemical contaminant perspective, throughout the lower parts of the Cedar-Ortega River Basin, and much of the Cedar River, and there is significant potential for adverse biological impact from the measured contaminants.

Recommendations

- A few areas of potential and likely concern have been identified, and some of the findings may warrant additional investigations of these locations. Site-focused studies should include a sound sampling and analysis plan that will ensure that the data can be confidently used for contaminant characterization, source location, and other interpretive analyses. The analysis can be focused to effectively address the issues at any particular location.

  1. The contamination of the northern Lower St. Johns River has been studied in the past, and it is fairly well established that much/most of the contamination is from urban activities in Jacksonville. Given the significant contamination of the Cedar-Ortega River Basin, it is not unreasonable to question if some of the elevated contamination in the northern part of the Lower St. Johns River could be originating in the Cedar-Ortega River Basin. It would probably be best to gain a better understanding of the Cedar-Ortega River contaminant issues before more efforts are exerted on the Lower St. Johns River near the confluence with the Ortega River.

  2. The Cedar-Ortega River Basin is clearly the location described in this report that is of greatest environmental concern that warrants additional data analysis and interpretation. The PCB contamination is significant, and detailed PCB congener characterization of the sediments up the Cedar River could provide valuable information on the nature, fate, transport, and source of this contamination. A detailed PAH characterization (with extensive PAH alkyl homologue measurements) of the Basin, with particular focus on the identified “hot spot” areas, can provide crucial information on the hydrocarbon material that is contaminating the Basin, the nature, fate, transport, and source of this material. The other major contaminants (specific pesticides and metals) should be co-investigated further.

     This additional, more site-focused, analysis and interpretation of all existing Cedar-Ortega River Basin data would support any proposed contaminant source track-down and control activity, and remediation plan, because it would provide a more specific spatial and temporal characterization of the contamination in this basin. An investigation of the contamination of the Cedar-Ortega River Basin should also include extensive records research, in addition to further field and laboratory-based work. Investigation of past and present industrial activities in the area, local drainage and discharge systems (including permitted and non-permitted discharges), and general commercial and recreational use of the area, should all be part of a thorough investigation of the contamination of the Cedar-Ortega River Basin.

3. The sediments of the St. Johns River by the confluence with Rice Creek had elevated contaminant concentrations, and a unique contaminant profile that indicates the presence of a source that is different from other parts of the river. Rice Creek itself, and any discharges and drainage to Rice Creek, warrants additional investigation. This study indicates the potential presence of environmentally significant chlorinated phenolic compounds. These compounds are potentially highly relevant, from an environmental quality perspective, and additional survey of these compounds should be performed using a more targeted and specific analytical approach (e.g., GC/MS or LC/MS), to obtain more reliable and high quality data for these specific contaminants.

- Sediment contamination is generally associated with sediment deposition areas and knowledge of the hydrodynamic characteristics of the area, including locations of depositional areas and other sediment transport patterns, would be valuable for future contamination assessments and remediation activities. Typically, sediment transport models provide a cost effective method to determine patterns of sediments and contaminant movement and zones of deposition.

- Additional contaminant assessment should be made to enhance our understanding of the potential effects of sediment bound contaminant to biota, since the existing comparisons to sediment quality guidelines have indicated the potential for organic and metal toxicity.

- Follow-up assessment to determine the trends in the environmental contaminant loadings at selected sites may be very useful to support environmental management decisions. However, sediment contaminants concentrations do not change rapidly (and the rate of change depends on a number of factors, such a rate of deposition, bioturbation etc.), so large-scale follow-up trends monitoring may not be useful for another 3-5 years.

- This report provides a wealth of quality environmental monitoring and assessment data that could be a valuable resource for environmental planers and scientist around the country. It would therefore be good if this information could become more widely distributed and available, such as by publishing the results in technical journals, presenting it at technical and non-technical meetings, and possibly by making it available over the Internet (e.g., though Web-based mapping or other interactive Web-based data access and interface).

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