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SEDIMENT QUALITY IN THE ST. JOHNS RIVER WATER MANAGEMENT DISTRICT:

PHYSICAL AND CHEMICAL CHARACTERIZATION OF NEW SITES AND DETAILED ASSESSMENT OF PREVIOUSLY SAMPLED LOCATIONS

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EXECUTIVE SUMMARY

Background

The St. Johns River Water Management District (SJRWMD) comprises 12,400 square miles in northeastern Florida — almost 21% of the total area of the state. The SJRWMD includes several major urban centers, many smaller cities, and large tracts of agriculture and forestry land. The region's population is growing rapidly, and currently is just under four million.

The SJRWMD was created in 1972 to protect and preserve the water resources, which are critical to many regional economies. The mission of the SJRWMD is to manage water resources to ensure their continued availability while maximizing both environmental and economic benefits.

In 1996-1997 the SJRWMD conducted a District-wide baseline monitoring project to assess the current status of the freshwater sediment quality at 86 selected sites in the region. This earlier work was published as District Special Publication SJ 98-SP5, "*Sediment Quality in the St. Johns River Water Management District: Physical and Chemical Characteristics*" (SJRWMD, 1998), and indicated that the general quality of the fresh water sediments in the District was quite good. A few locations, however, had elevated concentrations of a number of organic and metal contaminants, and were therefore recommended for further study. The work reported in this document was performed based on findings and recommendations from the 1996-1997 study and included the following components:

- An investigation of sediments from an additional 40 sites was performed to increase the overall coverage and representativeness of the District-wide Assessment.
- A Detailed Assessment study was performed to further improve the understanding of sediment quality at 10 locations identified as areas of particular concern due to elevated contaminant levels.

Methods

It is widely recognized that the analytical methods used in most priority pollutant tracking programs nationwide are not sufficiently sensitive to detect low, but environmentally relevant, levels of contaminants. Additionally, application of "standard" analyte lists are not always effective in addressing specific, or even broad-based, contaminant issues. Therefore, to meet the objectives of this program, analytical methods were used that could provide trace-level data for highly relevant toxic and/or persistent compounds.

The objective was to measure trace organic and trace metal contaminants in sediments from 40 new freshwater sites across the SJRWMD for the District-wide Assessment and 63 sites from 10 locations for the Detailed Assessment. The analytes were consistent with the 1996-1997 baseline monitoring study and included a wide range of environmentally relevant organic compounds and metals. A smaller, more targeted, set of analytes was selected for the Detailed Assessment sites, for which specific contaminant issues had been identified in the 1996-1997 study.

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 the 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

District-wide Assessment - 40 New Sites

In general, the contaminant concentration ranges were narrower and the median concentrations were lower for the 40 new sites than for sites in the 1996 –1997 baseline monitoring study. In addition, there were no polycyclic aromatic hydrocarbon (PAH) or polychlorinated biphenyl (PCB) concentrations that exceeded the NOAA NS&T nationally derived reference value for "high" sediment concentrations. Three of the 40 sites, however, exceeded the NOAA NS&T "high" concentration for the pesticide DDT. The pesticide (e.g., DDT and chlordane) concentrations followed no broad geographic pattern, and were likely related to localized sources and uses. The sediments from the mid-Florida region sites had among the highest DDT and chlordane concentrations. Similar organic contaminant composition was observed for the 40 new sites as for the 1996-1997 original sites. For instance, the PAH appeared to mostly originate with petroleum combustion products and the predominant DDT compounds were generally the DDT degradation products DDE and DDD, with much less parent DDT.

The metal contaminant concentration ranges were, in general, also narrower and the median concentrations were lower for the 40 new sites than those found in the 1996 –1997 baseline monitoring study. The metals concentrations exceeded the NOAA NS&T "high" concentration more often than the organic contaminant concentrations. Specifically, NOAA NS&T "high" concentrations were exceeded at 5 of the 40 new sites for mercury, 4 of the 40 new sites for lead, 2 of the 40 new sites for cadmium, 1 of the 40 new sites for silver and copper, and 13 of the 40 new sites for selenium. The higher metal concentrations were consistently found at several of the mid-Florida site locations (e.g., sites CHARLES, HALFMOON, HELENA, MAITL) and at the Newnans Lake sites.

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 value was exceeded for DDT compounds at site NORRIS. The freshwater PEL value for p,p'-DDE was exceeded at site NORRIS and 3 other sites.
- The ERL and freshwater TEL values were exceeded at between 2 and 15 sites for total PCB, total DDT, p,p'-DDE, p,p'-DDD, p,p'-DDT, dieldrin, heptachlor epoxide, and/or chlordane.

Metals Contaminants

- There were no ERM metal exceedances, but site INDUSPL exceeded the freshwater PEL for lead.
- There were ERL and freshwater TEL exceedances at between 1 and 8 sites for cadmium, copper, lead, mercury, and/or silver.

Detailed Assessment Sites – 63 Sites from 10 Locations

The organic and metal contaminant concentrations at the detailed assessment sites had similar concentration ranges as those found in the 1996 –1997 baseline monitoring study. However, the median contaminant concentrations were generally higher in this detailed assessment, which is a reflection of the prevalence of locations expected to be contaminated.

The Detailed Assessment study focused on PCB, chlorinated pesticide, and metal contaminants in the Gainesville and mid-Florida Lakes areas, and also on PCB and chlorinated pesticide contaminants in Lakes Disston and George. In general, the organic contaminant concentrations tended to be the highest at the mid-Florida lakes and Gainesville area sites, while the metal contaminants consistently were highest at the Gainesville area sites. Specifically, chlorinated pesticide concentrations were highest at Lake Dora/Beauclair and PCBs were highest at the Bivens Arm sites in Gainesville. Lakes Disston and George had the lowest contaminant concentrations of the detailed assessment locations. When concentrations of organic and metal contaminants for the 63 detailed assessment sites were compared to NOAA NS&T "high" concentrations, many exceedances were observed. The NOAA NS&T "high" concentrations for total chlordane, total dieldrin, total DDT, and total PCBs were exceeded at 10, 9, 20, and 9 of the 63 study sites, respectively. The NOAA NS&T "high" concentrations for silver, arsenic, cadmium, chromium, copper, mercury, and lead were exceeded at 8, 5, 10, 2, 2, 22, and 12 of the 63 study sites, respectively.

The sediment contaminant concentrations determined in the Detailed Assessment component of this study 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, and dieldrin were exceeded at 2, 11, and 2 of the 63 study sites, respectively. The freshwater PEL values were exceeded at 1 and 2 sites for total PCB and dieldrin, respectively.
- The ERL values for total PCB, total DDT, and dieldrin were exceeded at 28, 49, and 37 sites, respectively. The freshwater TEL concentrations for total PCB, total DDT and dieldrin were exceeded at 23, 35, and 9 sites, respectively.

Metals Contaminants

- The lead concentrations exceeded the ERM and the freshwater PEL at 3 and 8 sites, respectively.
- The arsenic and chromium concentrations exceeded the freshwater PELs at 1 and 4 sites, respectively.
- There were ERL and TEL exceedances for arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and/or zinc at between one and 29 of the 63 sites. Arsenic and mercury had the greatest number of exceedances.

Conclusions

Generally, quality of the fresh water sediment in the SJRWMD varied. The most contaminated locations appear to have contaminant levels that are comparable to typical U.S. urban coastal sediments. Some additional locations with elevated concentrations of some contaminants were identified in the new District-wide Assessment work that was performed. The Detailed Assessment study further characterized specific locations where contaminants issues were of potential concern.

New District-wide Assessment

- In general, the contamination that was measured at the 40 new District-wide Assessment sites was of no or low environmental concern. However, a few areas with potentially elevated contaminant signals were identified.
    - Lake Norris had elevated concentrations of DDT. The DDT concentrations at this site were several times higher than at any other location, and this was the only new District-wide Assessment site and contaminant that exceeded an ERM reference value. The DDT

concentration at Lake Norris was as high as the highest concentrations measured at Lake Dora in the Detailed Assessment study.

- Some sites north or west of Orlando (e.g., sites MAITL, HOWELL, BEAR, LOUISA) had slightly elevated concentrations of most contaminants, relative to the other study sites, most notably PAH, PCB, pesticides, and some toxic metals.

- Some scattered mid-Florida lakes, central region, or Newnans Lake area sites had slightly elevated concentrations of selected metals (e.g., sites HELENA, SILRV, HALFMOON, MILD, CHARLES, INDUSPL, PCR-PL) and/or some chlorinated industrial compounds.

Detailed Assessment

- The Detailed Assessment study sampling in the Gainesville area indicated that the organic contaminant concentrations were typically highest in the Sweetwater Branch samples, followed by the Bivens Arm West samples, and much lower at the Hogtown Creek sites. The sediments collected downstream in the Sweetwater Branch and Bivens Arm West locations had PCB, DDT, and chlordane concentrations that appeared to be of significant concern. Much of the organic contamination appeared to be originating upstream, which was then transported and deposited at the downstream locations. The metal contaminant concentrations were typically highest in the Bivens Arm West samples, but also high in the downstream Sweetwater Branch samples. Concentrations of lead, cadmium, and zinc were particularly elevated, and are of environmental concern. Metal contaminant concentrations were generally low at the Hogtown Creek sites.

- The Detailed Assessment of the sites located in the mid-Florida lakes region revealed that organic contaminant concentrations varied greatly for the five lakes (Dora/Beauclair, Eustis, Griffin, Harris, and Monroe) although the sediment characteristics were fairly similar. The organic contaminant concentrations (most notably the pesticide DDT, but also chlordane and BHC) were generally highest at Lakes Dora/Beauclair, followed by somewhat lower concentrations at sites in Lake Eustis, and lower yet in the other three lakes; there was a clear decline in concentration with the flow of the water through the different parts of Lake Dora and to Lake Eustis, suggesting that the contamination may be originating with the water flowing into Lake Beauclair from the south.

- In the original base-line study it appeared that Lake Disston and Lake George may have high concentrations of selected chlorinated pesticides, including DDT, chlordane, and BHC. However, the detailed assessment study indicated that the relatively modest contamination that was identified in parts of these lakes was quite spotty, and was focused in a few areas with high organic carbon containing sediment, and is not of significant concern.

Overall, the potential for biological impact from the measured contaminants at the 40 new sites of the District-wide Assessment study generally appears to be low, based on the sediment quality guideline comparison approach, and is consistent with the generally low to moderate organic contaminant and metals concentrations measured in most of the sediments. One exception may be the DDT contamination at Lake Norris. However, the potential for biological impact from the contaminants measured at the 63 sites of the Detailed Assessment study appears to be moderate to high at some locations, based on the reported results, including assessments versus sediment quality guidelines. Locations in the Bivens Arm West, lower Sweetwater Branch, and Lake Dora/Beauclair (and, to a lesser degree, parts of Lake Eustis) continue to be of concern.

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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
ERL	Effects Range-Low
ERM	Effects Range-Medium
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
HPLC	High Performance Liquid Chromatography
ICP/MS	Inductively Coupled Plasma/Mass Spectroscopy
LCS	Laboratory Control Sample
LEL	Lowest Effect Level
LPAH	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
OP	Ortho-Phosphate (Soluble Reactive Phosphorus)
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
TKN	Total Kjeldahl Nitrogen
TOC	Total Organic Carbon
TP	Total Phosphorus
TS	Total Solids
TVS	Total Volatile Solids

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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 SJRWMD comprises 12,400 square miles in northeastern Florida, or about 21 percent of the state's total area. The SJRWMD includes all or parts of 19 counties. The region comprises several major urban centers; numerous smaller cities, towns, and residential developments; and large tracts of rural land in agriculture and forestry. Nine percent of the SJRWMD's area is water. The SJRWMD has a population of just under four million, or about 25 percent of the state's total population. The SJRWMD's population has grown rapidly in recent decades and is expected to continue growing at a comparable rate in the future. The population 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. The SJRWMD contains about one-third of the state's citrus acreage and produces 10% percent of Florida's fresh winter vegetables. Half of the state's pulp mills are located in the SJRWMD. Many regional economies depend on the SJRWMD's water resources. A generalized land use distribution is shown in Figure 1-1.

To facilitate the planning and management of surface water, the SJRWMD is divided into ten hydrologic units or surface water basins (Figure 1-2). The boundaries of these basins approximate drainage basins delineated by the U.S. Geological Survey. The St. Johns River and its tributaries drain approximately 70 percent of the SJRWMD. The St. Johns River and its principal tributary, the Ocklawaha River, drain about one-sixth of the total area of Florida. The remainder of the SJRWMD is drained by the Nassau and St. Mary's rivers in the north and by various streams in the coastal area along the Atlantic Ocean. The SJRWMD includes a major portion of Florida's lake region. The chain of interconnected lakes in the Ocklawaha River basin, including Lakes Apopka, Harris, Eustis, Griffin, and Dora, are important recreational assets. Large, shallow lakes along the main stem of the St. Johns River, such as Lakes George, Harney, and Monroe, are also distinctive features of the SJRWMD.

The mission of the SJRWMD is to manage water resources to ensure their continued availability while maximizing both environmental and economic benefits. The responsibilities of the SJRWMD have expanded greatly since its inception. 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. Since 1987, the SJRWMD has been required by Florida Statute (Chap. 373.451-373.4595 F.S.) to develop and implement Surface Water Improvement and Management (SWIM) Plans. 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.

Surface water quality monitoring began at the SJRWMD in 1979 as a component of the Upper St. Johns River Basin Project. A district-wide monitoring program, known as the Permanent Monitoring Network Project, began in 1983 with the objectives of locating polluted surface waters and creating a long-term water quality database for analyzing temporal trends in water quality. The project was renamed Surface Water Quality Monitoring Program (SWQMP) in 1988 to more specifically reflect project activities and is managed by the Environmental Assessment Section (EAS) within the Environmental Sciences (ES) division at the SJRWMD.

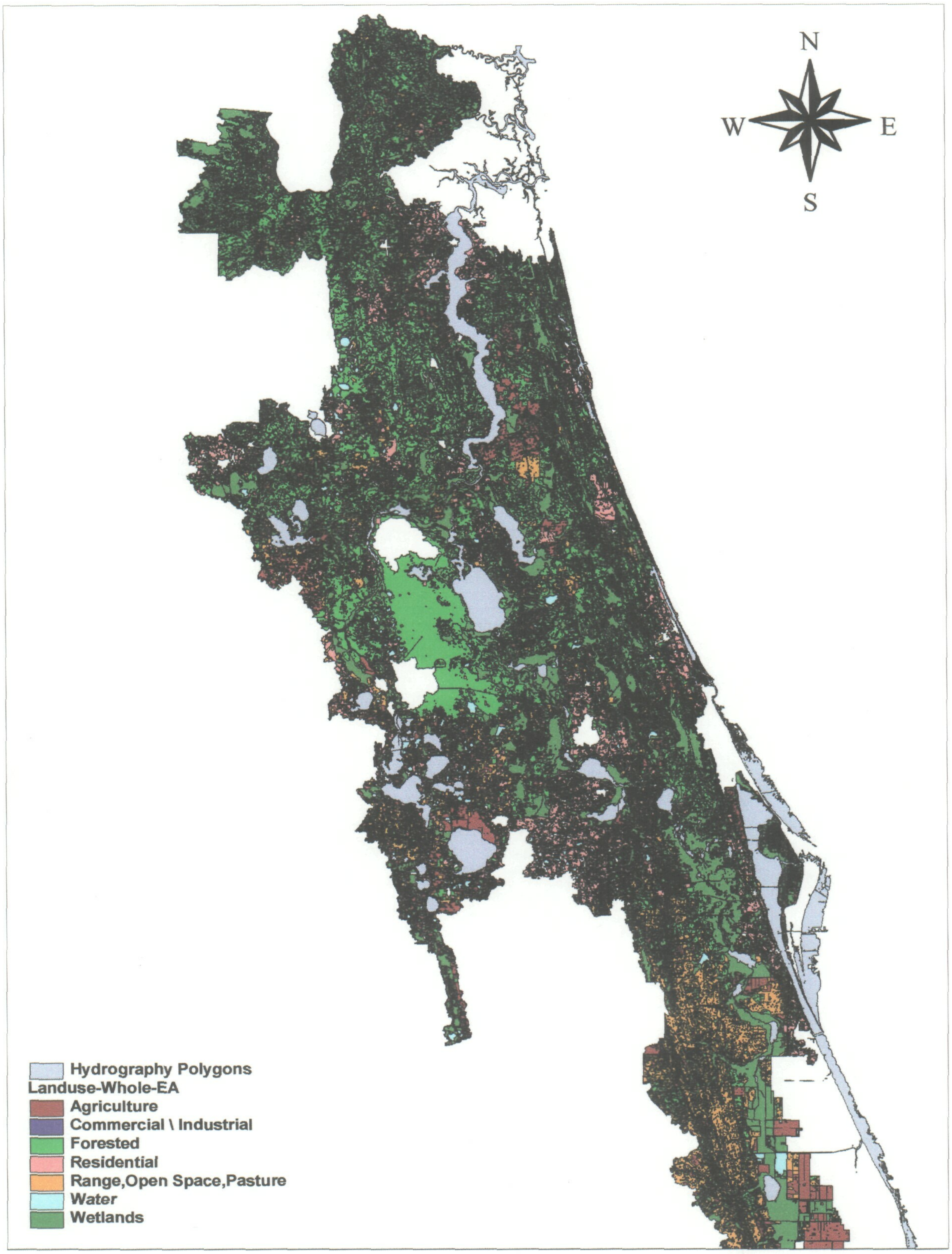

Figure 1-1. Land Uses in the St. Johns River Water Management District

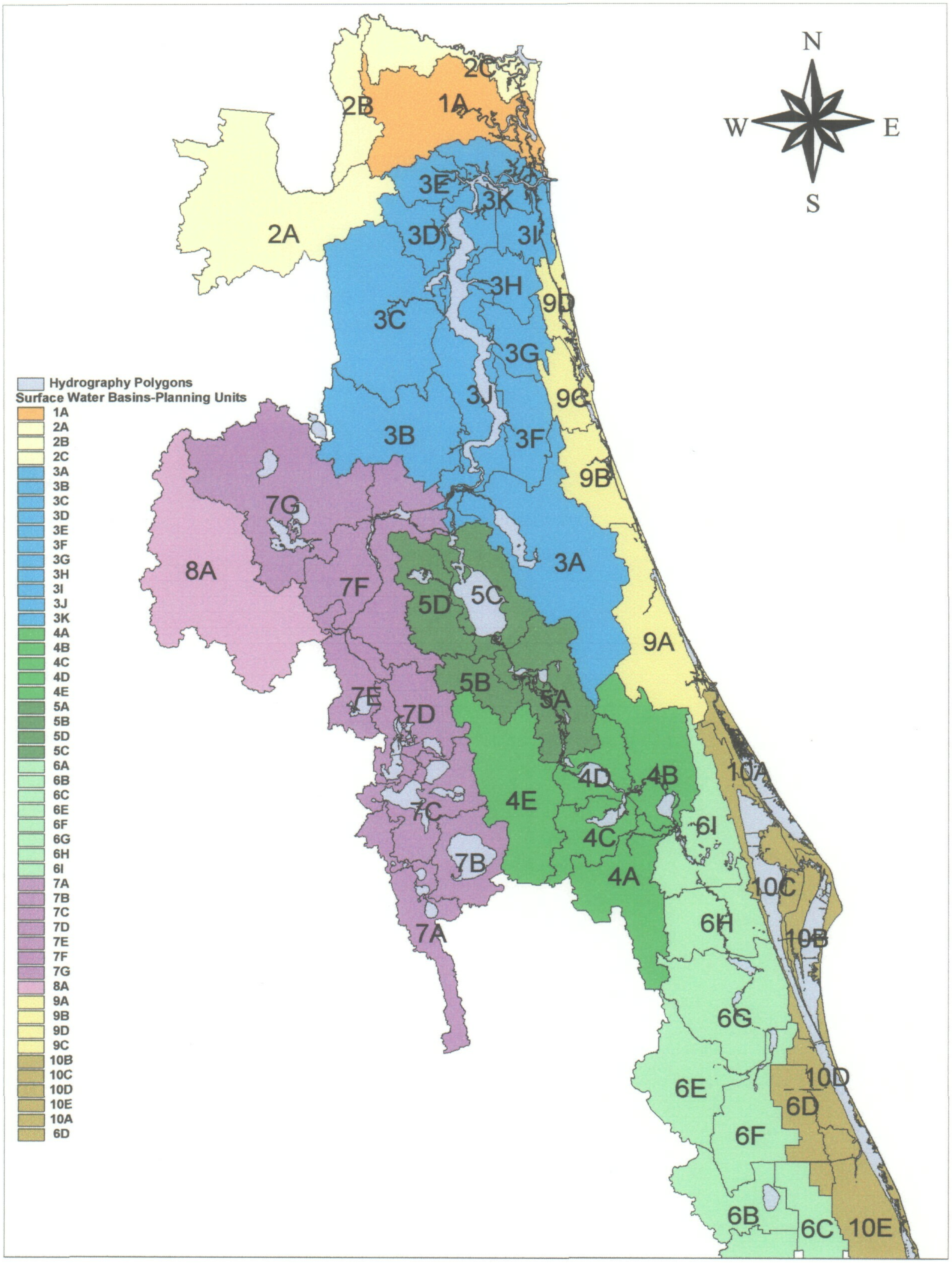

Figure 1-2. Hydrological Units in the St. Johns River Water Management District

Originally the SJRWMD's only surface water quality monitoring project, the SWQMP is now one of five equivalently sized monitoring programs (including Upper St. Johns Basin non-SWIM, Lower St. Johns River Basin SWIM, Apopka/Upper Ocklawaha SWIM, and Indian River Lagoon SWIM Programs) in the ES division. In 1990, the SWQMP started monitoring sediments for priority pollutants. Priority pollutants include metals, hydrocarbons, pesticides and industrial chemicals known to be acutely or chronically toxic. All data collected under this program have been uploaded to the EPA's National Water Quality Data Base (STORET) and are used by the FDEP for the State biennial assessment of water quality — the 305(b) report.

The District-wide survey of toxic compounds in sediments was initiated in FY 89-90 following several studies that documented the prevalence of toxic organic compounds in sediments of the Lower St. Johns River (Dames and Moore, 1983; Shropp and Windom, 1987; Pierce *et al.*, 1988; FDER, 1988). Sediment studies continued under the SWQMP during FY 90-93. More than half of the stations surveyed indicated widespread contamination from polycyclic aromatic hydrocarbons (Delfino *et al.*, 1991 and 1993).

A district-wide base-line monitoring project was performed in the winter of 1996-1997 to assess the current status of freshwater sediments at 86 selected stations with the District. The stations were selected to provide a representative cross-section of the District. The objectives of the 1996-1997 project were to measure trace organic and trace metal contaminants in sediments, compare them to effects-based sediment quality guideline values, and to identify general problem areas and specific potential "hot spots" that may warrant further investigation.

A district-wide sediment assessment report was prepared based on the data gathered in this base-line monitoring project, and was published as a District Special Publication SJ 980SP5, "*Sediment Quality in the St. Johns River Water Management District: Physical and Chemical Characteristics*" (SJRWMD, 1998). This report indicated that the general quality of the fresh water sediments in the District were quite good. The most contaminated locations appeared to have contaminant levels that were comparable to typical U.S. urban coastal sediments. A few general locations, however, with elevated concentrations of a number of organic and metal contaminants were identified, and were recommended for further study. The 1996-1997 base-line monitoring study generated valuable information and also identified some information gaps that needed to be addressed with additional analytical and data interpretive work.

1.2 Objectives

The work reported in this document was performed primarily based on finding and recommendations from the 1996-1997 study (SJRWMD, 1998), and included the following components:

- An investigation of sediments from an additional 40 sites was performed to increase the overall coverage and representativeness of the District-wide Assessment.
- A Detailed Assessment study was performed to further improve the understanding of sediment quality at 10 locations identified as areas of particular concern due to elevated contaminant levels.

The general objective of the study described in this report was to further improve the understanding of sediment quality within the District by sampling 40 new water body locations and perform a more detailed assessment of 10 locations identified in the previous study (SJRWMD, 1998) as potentially being areas of concern. Specific objectives were to determine the presence and concentration of potentially toxic organic compounds and metals in sediments from 40 new sites and 63 detailed assessment sites (10 general locations) in order 1) to increase the spatial data coverage and reduce the information gaps, 2) to better characterize the magnitude and geographical extent of any potential environmentally significant contamination, and 3) possibly identify the general and approximate origins of the contamination at those locations that exhibited elevated contaminant levels during the 1996-1997 study.

To accomplish this task, additional sampling and analysis activities were performed. To reduce the information gap on sediment quality, 40 new sites from key water bodies within the District were identified for baseline monitoring. The 40 new sites were sampled and analyzed for organic and metal contaminants. In addition, three general areas within the District that had elevated concentrations of selected organic and metal contaminants identified in the 1996-1997 study were revisited and sampled in more detail (63 individual sites in 10 water bodies). Detailed sampling and analysis was performed in the Gainesville region (Bivens Arm West, Sweetwater Branch, and Hogtown Creek), mid-Florida Lakes region (Lake Harris, Lake Eustis, Lake Griffin, Lake Dora, and Lake Monroe), and in Lake Disston and Lake George.

This report describes (1) a general assessment of the sediment quality at the 40 new District-wide assessment sites, (2) a detailed contaminant assessment of the10 locations at which a detailed assessment was performed, and (3) recommendations for further studies.

1.3 Scope of Work

Battelle and the SJRWMD jointly developed an analytical program in which Battelle would assist with the measurement and assessment of organic and trace metal contaminants in sediments from water bodies throughout the SJRWMD. Sediment sampling locations were selected and sampled by SJRWMD staff following appropriate procedures, and the samples were shipped to the laboratory for chemical and physical-chemical analysis. A total of 103 samples (40 sediments for the District-wide assessment and 63 sediments for the detailed assessment) were collected and submitted for analysis. Table 1-1 summarizes the sampling and analysis scheme for the detailed assessment study. The target analytical parameters, and the method detection limits, are listed in Table 1-2. All of these parameters were measured for the 40 new sites and, as indicated in Table 1-1, a sub-set were measured for the detailed assessment, based on the contamination that had in the 1996-1997 study been determined to potentially be of concern at these locations (SJRWMD, 1998).

Table 1-1. Sample Analysis Plan for the Detailed Assessment Task

Location	# Stations (samples)	PCB/Pesticide Analysis	Metals Analysis (10 key metals)[a]
Gainesville Area Sites			
Bivens Arm West	6	Yes	Yes
Sweetwater Branch	5	Yes	Yes
Hogtown Creek	4	Yes	Yes
Mid-Florida Lakes Sites			
Lake Dora	7	Yes	Yes
Lake Eustis	7	Yes	Yes
Lake Griffin	6	Yes	Yes
Lake Harris	6	Yes	Yes
Lake Monroe	7	Yes	Yes
Other Lakes Sites			
Lake George	10	Yes	
Lake Disston	5	Yes	

[a] The metals analysis was for Al, As, Cd, Cr, Cu, Pb, Hg, Ni, Ag, and Zn.

Table 1-2. 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
Organic Compounds - Pesticide		
Chlordecone (Kepone)	0.10	8270M
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

Table 1-2 (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 - Pesticides		
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
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

Table 1-2 (continued). Analytical Parameters and Method Detection Limits

TARGET ANALYTE	Sediment MDL (µg/kg, dry weight)	Analysis Method [a]
Organic Compounds - Pesticides (cont.)		
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
Metals	(mg/kg, dry weight)	
Aluminum (Al)	14.3	200.8M
Arsenic (As)	1.03	200.9M
Cadmium (Cd)	0.074	200.8M
Chromium (Cr)	1.0	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
Tin (Sn)	0.056	200.8M
Zinc (Zn)	3.26	200.8M
Nutrients		
Total Kjeldahl Nitrogen (TKN)	5	
Total Phosphorus (TP)	5	
Orthophosphate (OP)	0.5	
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)
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)

Battelle was responsible for determining the sediment concentrations of the target organic compounds and major and trace metals, and Battelle's subcontracting laboratory (Mote Marine) performed the analysis for the nutrient and physical-chemical parameters identified as Ancillary Measurements.

The target contaminants and ancillary measures list was developed based on the following considerations:

- Identification of the most important and persistent organic and metal contaminants found in sediments, as documented by major monitoring programs conducted in this country over the last 10-15 years (e.g., EPA EMAP, NOAA National Status and Trends Program). 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 parameters and methods for their measurement.
- Comparability with the target analyte list that was used in the 1996-1997 district-wide assessment (SJRWMD, 1998) and the list that is currently being used by the LSJRB project for the St. Johns River mainstem work, so as to ensure comparability, continuity in methods, detection limits, and appropriate quality control measures.
- The contaminants for the detailed assessment were based on potential contamination issues identified for those locations in the 1996-1997 district-wide assessment (SJRWMD, 1998; Table 1-1).

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 sediment analyses of the 40 new district-wide assessment sites and the 63 detailed assessment study sites. The report format and content were finalized through discussions between Battelle and SJRWMD staff. The report includes the following:

- Study background information
- Study objectives and scope
- The field sampling and laboratory analytical methods used
- The Quality Control program
- Analytical results in tabular and, where applicable, graphical form
- Analysis of relationships among chemical contaminant burdens and physical-chemical composition of the sediments
- Intercomparison of contaminant burdens among sampling sites
- A comparison of measured sediment burdens with concentrations observed nationally in sediment monitoring programs and with sediment quality guideline values as first-level indicators of possible risks that in-place contaminants might pose to the benthic ecological systems
- Conclusions and recommendations

2. TECHNICAL APPROACH

2.1 Site Selection — Rationale and Objectives

The locations investigated in the 1996-1997 district-wide assessment (SJRWMD, 1998) consisted of 71 Surface Water Quality Monitoring Program (SWQMP) sites from throughout the District and 15 Lower St. Johns River Basin sites. The study sites included in this report are 40 new district-wide assessment study sites as well as 63 sites (from 10 locations) for the detailed assessment study.

The 40 new sites were selected to provide an assessment of water bodies that were not included in the 1996-1997 study, but warrant investigation due to the lack of information for these locations and a desire to have more complete and representative geographical coverage. Sediment samples from the 40 new sites required analysis of the same organic and inorganic contaminants measured in the 1996-1997 base-line monitoring study, which were all parameters in Table 1-2.

Ten locations within the District were chosen for detailed assessment as a result of the 1996-1997 study (SJRWMD, 1998). The study identified these areas of potential concern because they had notable chemical contaminant concentrations. There was a need to better characterize the magnitude and geographical extent of any potential environmentally significant contamination and possibly identify the potential sources of the contamination at these locations. A total of 63 individual sampling sites were established at the 10 locations within the three general areas (Gainesville, Mid-Florida Lakes, and Lakes Disston and George). The sediment analyses at these locations focused on the contamination issues identified during the 1996-1997 study (see Table 1-1). As indicated in Table 1-1, the 63 sediment samples from the detailed assessment locations required analysis of either selected organic contaminants (pesticide and PCB) or a combination of selected organic contaminants (pesticide and PCB) and metals analysis. Metals analysis for the detailed assessment locations required only a subset of the metals analyzed in the base-line monitoring study (the metals in Table 1-2 *except* iron, manganese, lithium, selenium, and tin were determined).

The locations of the 40 new district-wide assessment sites are shown in Figures 2-1a and 2-1b. The 63 detailed assessment sites that were sampled in this study are shown in Figures 2-2a through 2-2e. Additional detailed site maps for each individual site are presented in Appendix A, as are maps with information on population density, land use, 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, empty 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 of the 40 new sampling sites, as illustrated in Figure 2-3. These three site replicates were placed in separate glass jars, chilled and shipped to each of the laboratories (Battelle Duxbury and Mote Marine) for analysis. At each of the laboratories, the sediments were mixed thoroughly and equal amounts from each of the three site replicates were removed and placed in a new jar, mixed, and used for the subsequent analyses. Individual site grabs were not analyzed separately for the 40 new sites in the District-wide assessment study. Discrete grab samples were collected and analyzed separately for the detailed assessment study (i.e., no sample compositing was performed).

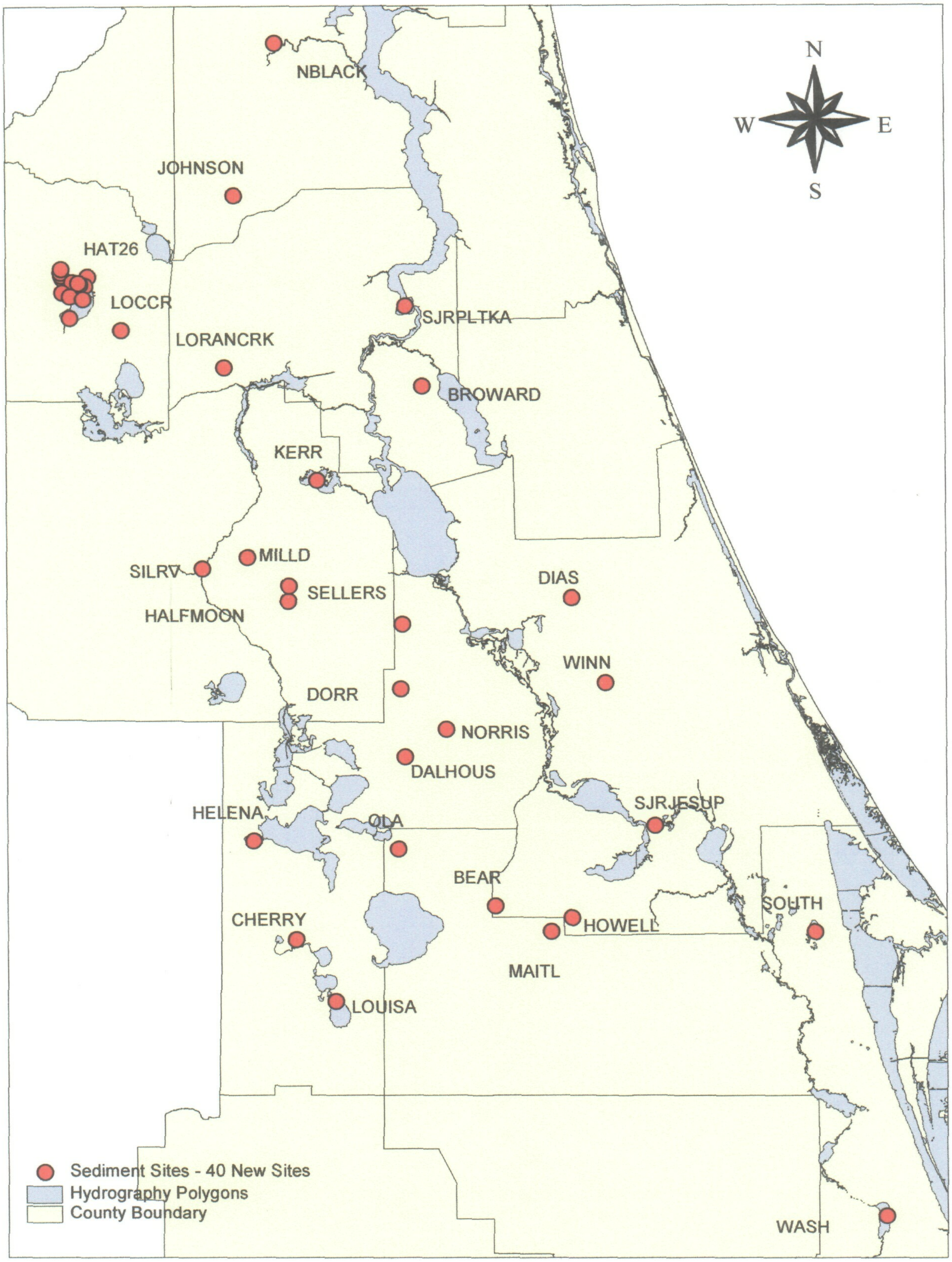


Figure 2-1a. Locations of the 40 New Sampling Sites

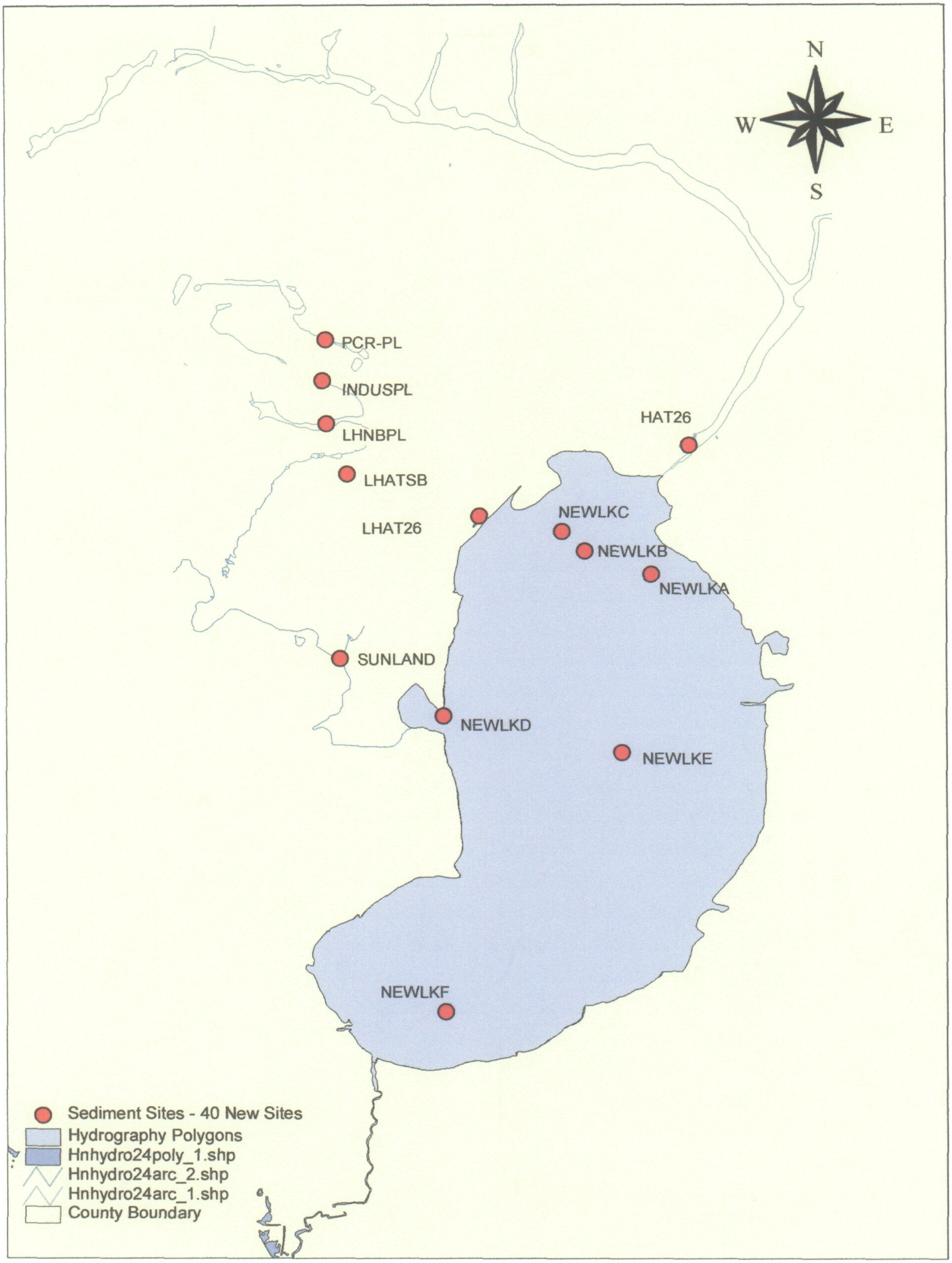


Figure 2-1b. Locations of the 40 New Sampling Sites (Newnans Lake Area Sites)

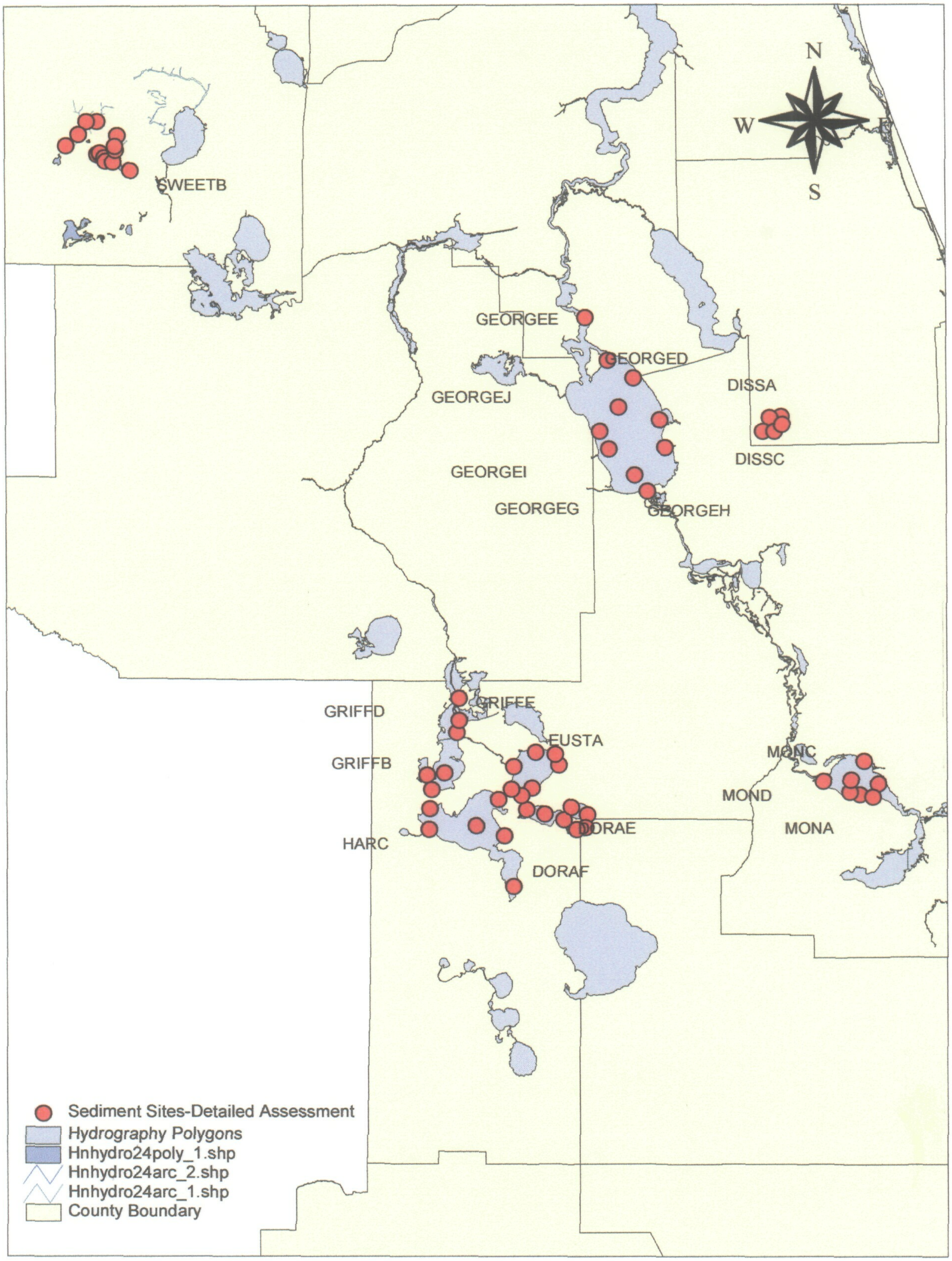


Figure 2-2a. Locations of the Detailed Assessment Sites

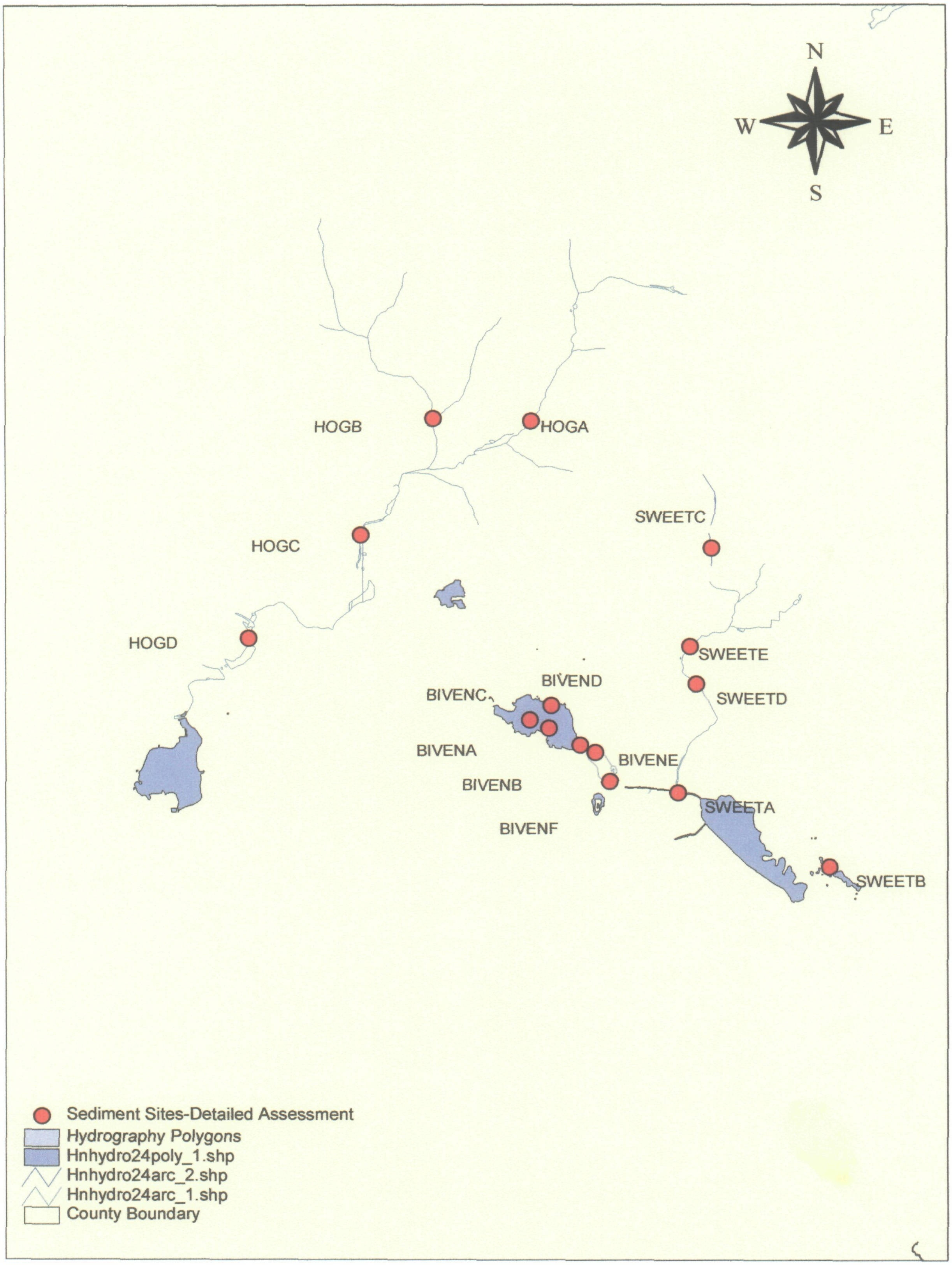


Figure 2-2b. Locations of the Detailed Assessment Sites (Gainesville Area Sites)

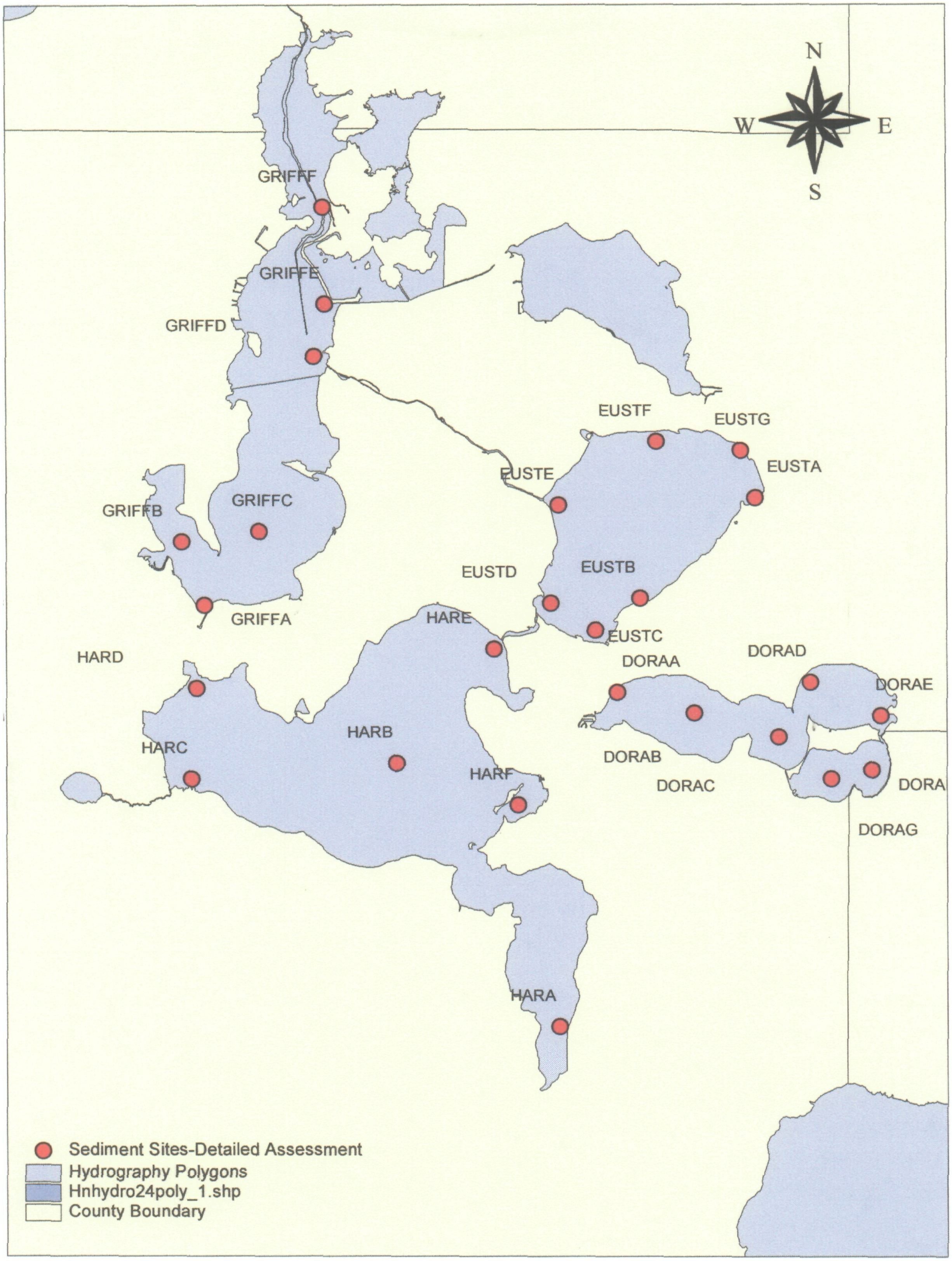


Figure 2-2c. Locations of the Detailed Assessment Sites (Mid-Florida Lakes Sites)

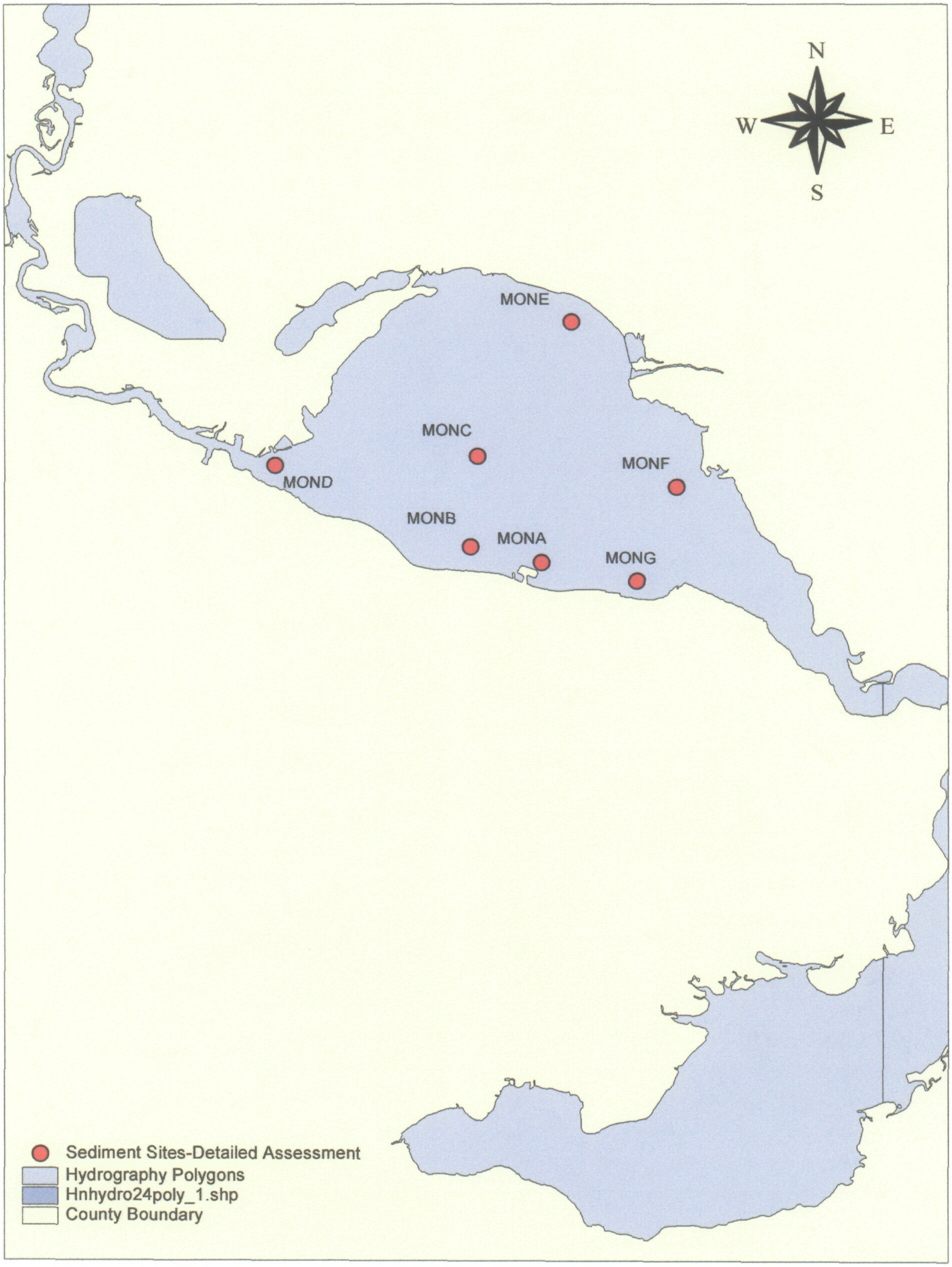


Figure 2-2d. Locations of the Detailed Assessment Sites (Mid-Florida /Lake Monroe Sites)

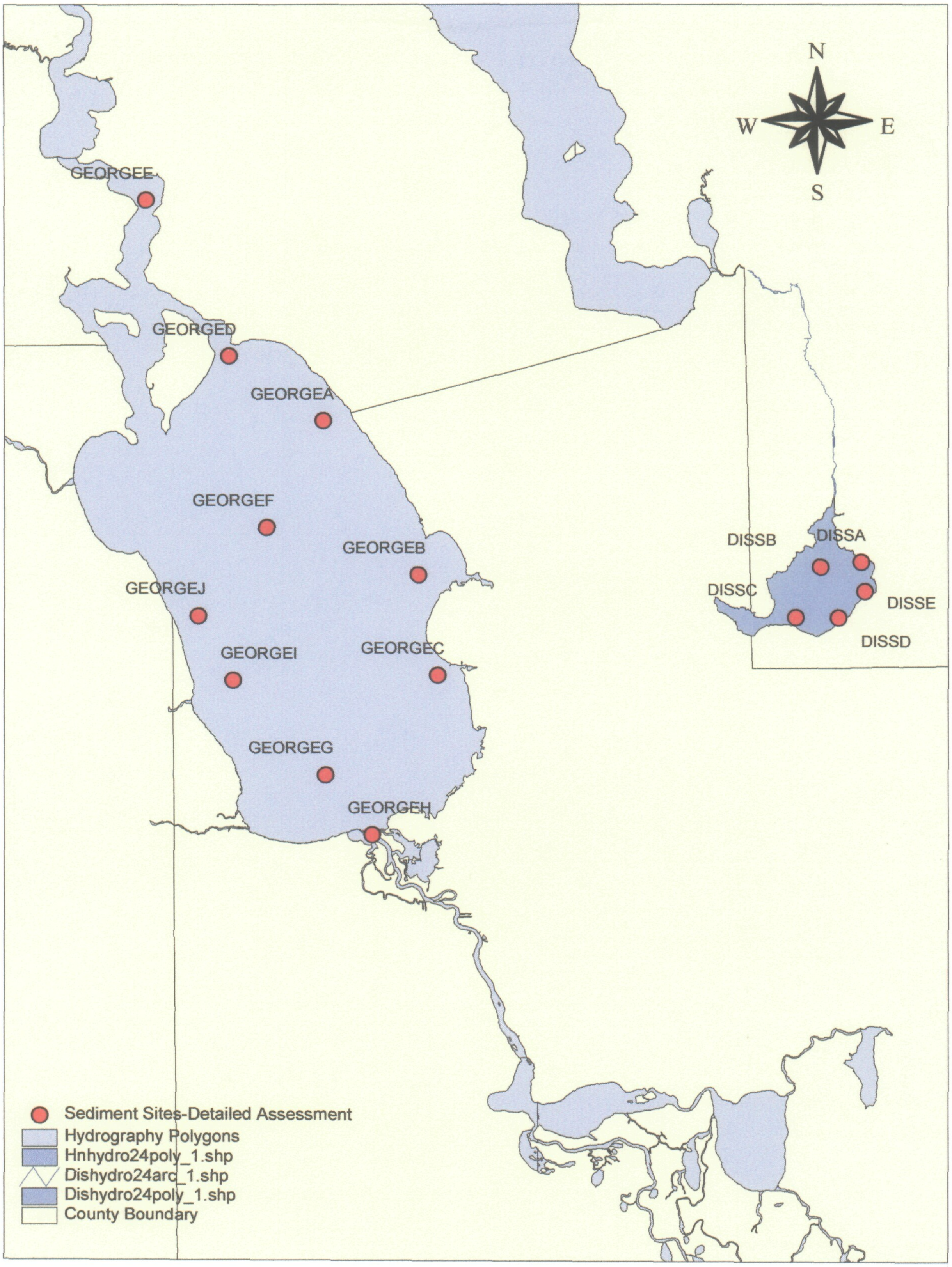


Figure 2-2e. Locations of the Detailed Assessment Sites (Lakes Disston and George Sites)

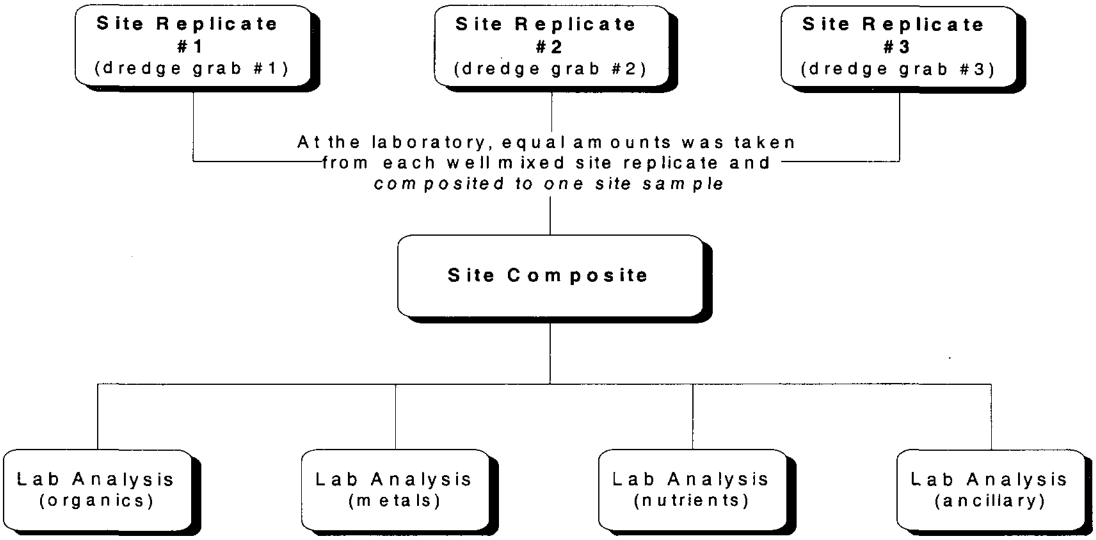


Figure 2-3. Sampling and Compositing Regime for Samples Collected at the 40 New Sites

The SJRWMD Environmental Assessment staff collected the sediment samples from December 1998 to February 1999. The SJRWMD staff followed Quality Assurance/Quality Control procedures in compliance with the SJRWMD's Comprehensive Quality Assurance Plan (CompQAP). 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; NOAA, 1998; NOAA, 1993).

2.2.1 Sample Collection Containers

The sample containers were 500 mL pre-cleaned glass jars with Teflon lined caps obtained from Battelle for the organic compound and metal analyses, and 120 mL glass and 250 mL plastic jars obtained from Mote Marine for total organic carbon, nutrient and other ancillary analyses. The contract laboratories were responsible for shipping these containers, which had been cleaned in a manner that was consistent with the analysis at hand, to the SJRWMD.

2.2.2 Sample Collection Equipment

SJRWMD staff used pre-cleaned stainless steel petite Ponar dredges and/or Eckman dredges to collect all sediment samples. 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 laboratory staff in accordance with the CompQAP.

2.2.3 Sample Collection Procedures

Sediment collection procedures involved using boats, bridges, and wading apparel. Most of the lake, river, and estuarine sites were sampled using a boat. SJRWMD field personnel collected samples from smaller streams and rivers by sampling from accessible bridges or by carefully wading into the river, ensuring that the sediment to be collected was not disturbed.

Upon arrival at the site, an Eckman or Ponar dredge was chosen. SJRWMD staff employed the following protocol for dredge usage and sediment collection:

1. Unwrapped aluminum foil from the dredge.
2. Lowered the dredge into the water body until it reached the sediment. A messenger was then sent down the line to trip the spring mechanism and close the jaws of the dredge.
3. Retrieved the sample.
4. Deposited the entire sample into a glass mixing tray
5. Used a stainless steel spoon to thoroughly mix the sample in the mixing tray.
6. Promptly partitioned the mixed sample into the appropriate sample containers in order to prevent oxidation of metal ions or volatilization of organic compounds from the sample.
7. Stored the samples immediately in a cooler with wet ice. No chemical preservative was required. FDEP and EPA sample handling, storage, and holding times were adhered to (Table 2-1).

At each of the 40 new District-wide assessment sites, SJRWMD staff collected three separate dredge samples (Figure 2-3) that were composited. At each of the 63 detailed assessment sites, SJRWMD staff collected discrete sediment samples. In each instance, the spoon and glass dish were rinsed with de-ionized water between successive samples. The sample containers were near filled at each site and immediately placed into a cooler with wet ice.

Sample collection and shipment was coordinated with the analytical laboratories (Battelle and Mote Marine) to ensure that sample holding times were met. The preservation and maximum holding times of sediment samples for laboratory analysis were, as outlined in the FDEP SOPs, as follows:

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 Kjeldahl Nitrogen	Cool at 4°C	28 days
Total Phosphorus	Cool at 4°C	28 days
Total Organic Carbon	Cool at 4°C	28 days
Orthophosphate	Cool at 4°C	48 hours

Field blanks comprised of water were collected at various intervals as required by SJRWMD's CompQAP. Deionized water was poured over the sampling equipment (spoons, dredges, and dishes) and collected into clean containers for analysis. The SJRWMD laboratory analyzed the field blank samples, as per the SJRWMD Field 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, nutrient parameters, and various physical and chemical ancillary measures to support the monitoring program objectives of this study. The targeted analytical parameters are listed in Table 1-2. This target analyte list was jointly derived by Battelle and SJRWMD staff and includes most of the applicable contaminants from 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. Several compounds were added to the SJRWMD standard monitoring list to complete the suite of contaminants (e.g., addition of certain compounds ensured that all the important 2-, 3-, 4-, and 5- ring polycyclic aromatic hydrocarbons (PAH) were represented) and to improve comparability between the SWQMP monitoring efforts and the LSJRB project. Alkylated PAHs were added to provide more complete data on the type of PAH contamination and assist in the identification of petrogenic contamination (e.g., methylated naphthalenes and phenanthrenes). Polychlorinated biphenyls (PCBs — as individual congeners) were added as target parameter because these remain ubiquitous and environmentally important compounds. Several other persistent and environmentally relevant chlorinated pesticides that were not on the base list (e.g., δ-BHC, γ-BHC (Lindane), methoxychlor, trans-nonachlor, a-chlordane, and g-chlordane) were added to improve the representation, data usability, and data comparability.

The contaminants determined in this project include the most 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 National Status and Trends, 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 monitoring projects being conducted by the SJRWMD.

All the parameters listed in Table 1-2 were determined for the 40 new sites, just like in the 1996-1997 district-wide assessment study (SJRWMD, 1998). The analysis for the detailed assessment sites were based on potential contaminant issues that had been identified in the 1996-1997 study, as outlined in Table 1-1 and discussed earlier in this report.

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. 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 (e.g., impact to the benthic community structure), 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, other analytical procedures were needed to achieve the method performance goals required for environmental quality monitoring.

Achieving meaningful detection limits for organic and trace metal contaminants for environmental quality monitoring has been of special concern to the National Oceanic and Atmospheric Administration (NOAA) and the U.S. EPA. Through the NOAA National Status and Trends (NS&T) Program and the EPA Environmental Monitoring and Assessment Program (EMAP), a set of analytical methods have been developed specifically to meet the low level detection limit requirements necessary for successful environmental quality monitoring. Developed over the last 10 years, these methods are modifications and improvements upon the 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 National Status and Trends Program, by EPA in the National 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.* The methods are used in 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 methods have been published in a NOAA Technical Memorandum in which Battelle scientists were principal authors (NOAA, 1998; NOAA, 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) ensure 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). These are the same methods that were used by Battelle in the 1996-1997 district-wide study (SJRWMD, 1998). Battelle obtained FDEP approval for the application of these specialized methods, which have been incorporated into Battelle's FDEP CompQAP, and are also being used to provide analytical support to the SJRWMD for monitoring studies in the St. Johns River and the Cedar-Ortega River Basin. 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.

The general scheme that was used for the laboratory analyses of organic contaminants and metals is shown in Figure 2-4. The laboratory procedures are further described below.

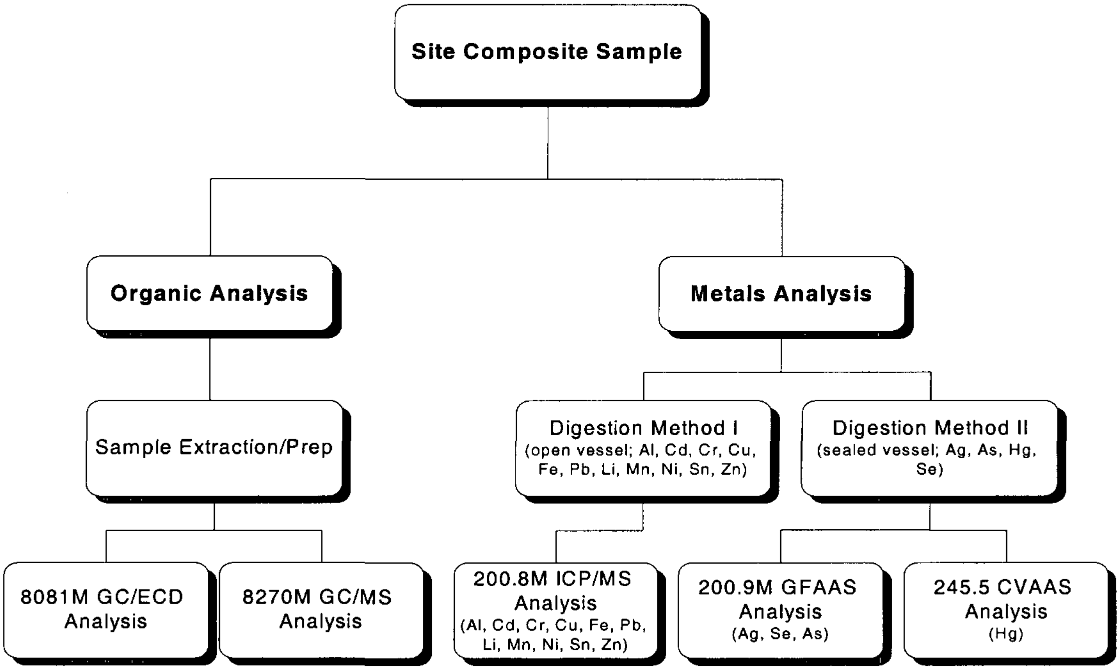


Figure 2-4. Laboratory Scheme for Organic Contaminant and Metals Analysis

2.3.1 Sample Analysis for Organic Analytes

Sample Preparation

The sediment samples were kept refrigerated at approximately 4 °C 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, phenanthrene-d_{10}, and chrysene-d_{12} for the 8270M analysis; PCB congeners $Cl_3(34)$ and $Cl_5(112)$ for the 8081M analysis)] in order to monitor procedural efficiency and for sample quantification. The sample was then 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 x 21.2 mm Phenogel (100 Å pore size, 10 µm particle size) semipreparative GPC column (Phenomenex Corp.), with a 50 mm x 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 cleanup process far exceeds what can be obtained with traditional, open, gravity-fed liquid chromatography columns.

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 hexane, 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.

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 or 6890 GC equipped with an electronic pressure controlled (EPC) inlet and a H-P 5972 or H-P 5973 MSD operating in the selected ion monitoring (SIM) mode to achieve the needed sensitivity and specificity. Analyte separation was carried out on a 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:	20 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 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 0.15 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.

8270M and 8081M — 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, as was also performed for the report on the 1996-1997 study (SJRWMD, 1998). Surrogate corrected data typically provide a much 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 National Status and Trends 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 15 metals (MDLs are listed in Table 1-2): aluminum (Al), arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), lithium (Li), manganese (Mn), mercury (Hg), nickel (Ni), selenium (Se), silver (Ag), tin (Sn), and zinc (Zn). All 15 metals were determined for the 40 new sites. Iron, lithium, manganese, selenium, and tin were not determined for the detailed assessment sites. The general laboratory sample analysis scheme is summarized in Figure 2-4, 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, Cd, Cr, Cu, Fe, Pb, Li, Mn, Ni, Sn, 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 quantification 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. 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 were 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, Cd, Cr, Cu, Fe, Pb, Li, Mn, Ni, Sn, 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. 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 Nutrients and 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 °C 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. TOC measurements were 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, and dried at 103-105°C 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, 17^th Edition (APHA, 1989). Dried sediments from the total solids determinations were ashed for 1 hour at 550°C ± 50°C. 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 (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, which 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:

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

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

φ Size	μm
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

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.

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 Appendix E.

The 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.

Soluble Reactive Phosphorus (orthophosphate)

Soluble reactive phosphorus (EPA/CE-81-1, p.3-223) for sediments was determined by an operationally defined procedure in which a 10 g wet weight aliquot of sediment was passively extracted overnight with a fixed volume of laboratory water. The resultant solution was filtered, digested with dilute acid and heat, and analyzed for reactive phosphate (also commonly referred to as ortho-phosphate).

Total Phosphorus and Total Kjeldahl Nitrogen

Both total phosphorus and total Kjeldahl nitrogen were determined on a single sample digest (EPA/CE-81-1, p.3-227 [e], p.3-201,2), using a digestion block and sulfuric acid-persulfate-mercuric oxide solution. The resulting clear or pale yellow digestate was analyzed with an automated segmented flow analyzer.

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 the Florida State DEP, Commonwealth of Massachusetts DEP, New Jersey 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 extraction and analysis of sediments and tissues for PCBs, pesticides, and PAHs.

Several components of this 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 (or Triplicate)
- 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 at concentrations near the project MDLs 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) [also referred to as 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 or certified 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 matrix interference.

- *Matrix Spikes/Matrix Spike Duplicate* (MS/MSD) samples were processed and analyzed with each batch of trace metals and organic compound samples. 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 possible 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 processed with each batch of samples for trace metal, TOC, grain size, and nutrient analysis. Field duplicates incorporated the precision in the field sampling with the analytical precision.

- *Standard Reference Materials* (SRMs) were processed and analyzed with each analytical batch of trace metals and organic contaminant analyses (two different 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 procedural blank exceedances are considered minor due to the extremely low detection limits (100 to 100-fold lower than standard EPA solids methods, such as Method 8081, and Method 8270) that are achieved using the modified methodologies. 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 in SRM analyses 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)		Deviations will be documented.
Procedural blank	1 per 20 samples	<3 × MDL (qualify if < MDL)	Reextraction or reanalysis, and/or justification documented.
BS (LCS)	1 per 20 samples	30-130% recovery[2]	Reextraction or reanalysis and/or justification documented.
MS/MSD	1 per 20 samples	30-130% recovery[1], <30% RPD[1]. Applies to parameters with spikes >5 × background.	Reextraction or reanalysis and/or justification documented.
SRM[3]	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.
Surrogate recovery	8270M: 3 per sample 8081M: 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: 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 and NUTRIENTS			
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	90-110% recovery for TOC 85-110% recovery for OP 75-115% recovery for TP and TKN	Reanalysis and/or justification documented.
Duplicates	1 per 20 samples	<20% RPD if conc. <0.20 %TOC <10% RPD if conc. >0.20 %TOC <30% RPD for OP <25% RPD for TP and TKN	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 and/or justification documented.

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.
BS (LCS)	1 per 20 samples	70-130% recovery; <30% RPD	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[2]	Reextraction or reanalysis and/or justification documented
SRM	1 per 20 samples	70-130% recovery versus certified value	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] % recovery (MS/MSD) = [((MS concentration – Background concentration) × (MS dry weight)) / spike amount] × 100. MS/MSD criteria apply when spiking level >5 × background level.

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

[3] Certified values for sediment SRM are available for selected PAH, PCB, pesticides, and metals. DQO apply when the consensus/certified value 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 [polycyclic aromatic hydrocarbons (PAH), phthalate esters, polychlorinated biphenyl (PCB), pesticides, other chlorinated compounds], metals, and nutrient analyses, along with the data from the geophysical (ancillary) analyses [total organic carbon (TOC), grain size, moisture content, total solids (TS), and total volatile solids (TVS)]. Complete field sample sediment chemistry results are reported in Appendices B through H. 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 40 new sites and followed by the detailed assessment sites.

All chemistry data presented and discussed in this section 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. Sample moisture content is also reported, and allows for conversion to wet weight based results.

3.1 Results for Organic Compound Analysis

Individual concentrations for a total of 94 organic compounds were determined for the 40 new sites and 52 compounds were determined for the detailed assessment sites (Tables 1-1 and 1-2). The analytical data for each individual compound are listed in Appendix B (Method 8270M analytes for new sites) and Appendices C and F (Method 8081M analytes for the new and detailed assessment sites, respectively). All individual compound data have been 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 this report. A few individual organic compounds are also discussed, when the data revealed them to be of particular interest.

3.1.1 PAH and Phthalate Compound Results

The sediment samples from the 40 new sites were analyzed for 34 aromatic compounds by method 8270M; 24 individual polycyclic aromatic hydrocarbons (PAHs), 6 phthalate esters, 2 chlorinated naphthalenes, isophorone, and kepone. Method 8270M analysis was not performed on the detailed assessment site samples because in the original study it was determined that PAH concentrations were not compounds of concern at these specific locations. For presentation and discussion purposes this report focuses on the 30 individual PAH and phthalate compounds, which are categorized as (1) low molecular weight PAH (LPAH), (2) high molecular weight PAH (HPAH), (3) total PAH, and (4) total phthalate. Table 3-1 lists the analytes that comprise each group.

Low molecular weight PAH are frequently associated with refined and unrefined petroleum products (i.e., of petrogenic origin). High molecular weight PAH are primarily derived from the combustion of fossil fuels or as principal components of creosote-type formulations (i.e., of pyrogenic origin). 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

Low Molecular Weight PAH (Σ of)	High Molecular Weight PAH (Σ of)	Total PAH (Σ of)	Total Phthalate (Σ of)
Naphthalene	Fluoranthene	LPAH	Dimethylphthalate
2-Methylnaphthalene	Pyrene	HPAH	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 presented in Table 3-2. Table 3-2 includes the summary data for the 40 new district-wide assessment sites, as well as the data from the original 1996-1997 district-wide study. The summary concentration data for each of the 40 new sites are presented in Table 3-3. These data are presented both non-normalized and normalized to percent total organic carbon (TOC).

Table 3-2. Concentration Ranges for PAH and Phthalates

Aromatic Hydrocarbon and Phthalate Groups	Not Normalized (μg/kg dry weight)			Normalized to %TOC (μg/kg/%TOC)		
	Median	Min	Max	Median	Min	Max
Original Study Sites						
Total PAH	413	2.70	13,800	89.8	5.10	10,000
Low PAH	63.7	0.71	5,540	16.6	1.31	634
High PAH	310	0.78	10,600	69.8	2.38	9,530
Total Phthalate	105	6.09	1,840	37.4	2.08	3,890
40 New Sites						
Total PAH	94.0	2.29	1,070	40.0	5.72	1,190
Low PAH	13.4	1.36	153	8.30	1.38	93.5
High PAH	62.2	0.32	1,010	28.9	4.34	1,090
Total Phthalate	25.9	5.35	585	18.5	1.18	1,340

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

FIELD ID	Not Normalized (raw) (µg/kg dry weight)				Normalized to %TOC (µg/kg dry weight/%TOC)			
	Total PAH	Low PAH	High PAH	Total Phthalates	Total PAH	Low PAH	High PAH	Total Phthalates
40 New Sites								
BEAR	132	10.9	121	11.6	213	17.6	196	18.8
BROWARD	11.3	2.78	8.50	5.66	33.8	8.32	25.4	16.9
CHARLES	587	78.3	509	341	17.2	2.29	14.9	9.96
CHERRY	46.9	6.22	40.7	7.02	25.3	3.36	22.0	3.79
DALHOUS	18.2	5.12	13.1	7.93	40.3	11.3	29.0	17.5
DIAS	198	17.8	181	57.0	47.6	4.27	43.3	13.7
DORR	8.96	2.08	6.88	5.48	33.3	7.74	25.6	20.4
HALFMOON	515	129	386	39.7	20.0	5.02	15.0	1.55
HAT26	2.81	1.36	1.45	9.90	63.9	30.9	32.9	225
HELENA	581	153	428	273	17.1	4.49	12.6	8.02
HOWELL	751	26.5	724	212	695	24.5	671	197
INDUSPL	363	51.0	312	77.8	14.9	2.09	12.8	3.19
JOHNSON	84.1	26.0	58.1	9.07	37.2	11.5	25.7	4.01
KERR	12.3	3.34	8.96	5.35	42.1	11.4	30.7	18.3
LHAT26	5.72	1.46	4.26	12.5	25.1	6.41	18.7	54.8
LHATSB	10.9	3.60	7.30	40.8	43.1	14.2	28.9	161
LHNBPL	57.8	6.38	51.5	21.0	325	35.8	289	118
LOCCR	5.38	1.92	3.47	16.1	26.1	9.30	16.8	78.4
LORANCRK	2.29	1.97	0.32	37.4	81.7	70.4	11.3	1,340
LOUISA	335	26.4	309	111	1,190	93.5	1,090	391
MAITL	1,060	55.1	1,010	25.3	606	31.5	575	14.5
MILLD	25.2	6.10	19.1	8.20	5.72	1.38	4.34	1.86
NBLACK	151	19.7	132	54.1	111	14.4	96.1	39.5
NEWLKA	10.2	2.44	7.77	25.8	32.3	7.71	24.6	81.6
NEWLKB	15.9	2.34	13.5	17.8	46.8	6.89	39.9	52.5
NEWLKC	515	71.2	443	585	19.9	2.75	17.1	22.6
NEWLKD	821	83.7	737	195	22.5	2.29	20.2	5.35
NEWLKE	310	51.2	259	239	10.5	1.73	8.75	8.07
NEWLKF	523	69.7	454	265	20.5	2.73	17.8	10.4
NORRIS	888	46.2	842	27.1	38.6	2.01	36.6	1.18
OLA	31.9	4.21	27.6	7.96	47.9	6.32	41.6	12.0
PCR-PL	104	37.6	66.3	142	44.6	16.1	28.5	61.0
SELLERS	15.6	4.03	11.5	6.27	66.5	17.2	49.3	26.8
SILRV	256	16.0	240	79.2	36.9	2.30	34.6	11.4
SJRJESUP	11.3	2.35	8.92	16.9	39.8	8.29	31.5	59.8
SJRPLTKA	1,070	103	969	163	335	32.0	303	50.8
SOUTH	131	55.4	75.2	26.0	178	75.5	102	35.4
SUNLAND	5.13	2.28	2.84	11.0	94.9	42.3	52.7	205
WASH	292	43.4	249	32.8	10.9	1.62	9.28	1.22
WINN	34.8	6.04	28.8	7.08	66.3	11.5	54.8	13.5

40 New Sites

The ranges of total PAH, low PAH, high PAH, and total phthalate concentrations at the 40 new sites were not as broad as was observed for the 86 sites the original district-wide study (SJRWMD, 1998). Median PAH and phthalate concentrations were lower (about a factor of 4 lower for non-normalized data and a factor of 2 lower for TOC normalized data) for the 40 new sites compared to the original study sites. In general, the maximum total PAH, low PAH, high PAH, and total phthalate concentration were a factor of 13, 36, 10, and 3 lower, respectively, than in the original study. Total PAH ranged from 2.29 µg/kg [site LORANCRK (Little Orange Creek)] to 1070 µg/kg [site SJRPLTKA (SJR at Palatka)]. The median total PAH concentration for the 40 new sites was 94.0 µg/kg, compared to 413 µg/kg in the original study.

The concentration of low molecular weight PAH (Low PAH) ranged from 1.36 [site HAT26 (Hatchet Creek)] to 153 µg/kg [site HELENA (Helena Run)] at the 40 new sites, and the high molecular weight PAH (High PAH) ranged from 0.32 [site LORANCRK (Little Orange Creek)] to 1,010 µg/kg [site MAITL (Lake Maitland)]. Median values for low PAH and high PAH were 13.4 µg/kg and 62.2 µg/kg, respectively. The concentration of high PAH was, on average, approximately 6.6 times higher than the concentration of low PAH at the 40 new sites, although there were a number of site-specific differences. Total phthalate concentrations ranged from 5.35 [site KERR (Lake Kerr)] to 585 µg/kg [site NEWLKC (Mouth of Little Hatchet Creek)]. The phthalate concentrations were mostly relatively low, with only 7 sites having concentrations above 100 µg/kg. The median total phthalate concentration was 25.9 µg/kg.

The variability in the sediment PAH and phthalate concentrations was fairly high even after the data were normalized to sediment TOC content (Tables 3-2 and 3-3). The TOC normalized total PAH median concentration was 40.0 µg/kg/%TOC and the concentration ranged from 5.72 [site MILLD (Mill Dam Lake)] to 1,190 µg/kg/%TOC [site LOUISA (Lake Louisa)]. TOC normalized low PAH concentrations ranged of 1.38 [site MILLD (Mill Dam Lake)] to 93.5 µg/kg/%TOC [site LOUISA (Lake Louisa)] and the high PAH ranged from 4.34 [site MILLD (Mill Dam Lake)] to 1,090 µg/kg/% [site LOUISA (Lake Louisa)]. The median TOC normalized low PAH and high PAH concentration was 8.30 µg/kg/%TOC and 28.9 µg/kg/%TOC, respectively. TOC normalized total phthalate concentrations ranged from 1.18 [site NORRIS (Lake Norris)] to 1,340 µg/kg/%TOC [site LORANCRK (Little Orange Creek)], with a median concentration of 18.5 µg/kg/%TOC.

3.1.2 PCB, Pesticide, and Other Chlorinated Compound Results

The sediment samples from the 40 new sites were analyzed for a total of 60 individual chlorinated compounds (23 individual PCB congeners, 29 pesticides, and 8 other chlorinated industrial compounds) using Method 8081M. The PCB and chlorinated pesticide compounds, but not the 8 "other chlorinated compounds", were determined for the detailed assessment sites, based on the findings in the 1996-1997 study. 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) sum of 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. The total DDT, DDE, and DDD compound concentrations, each as sums of their 4,4'- and 2,4'-isomers, were also determined to further characterize the DDT contamination.

Table 3-5 presents the median concentrations and the concentration ranges of chlorinated compounds measured for the original district-wide study sites, the 40 new district-wide sites, and the 63 detailed assessment sites. Summaries of the concentration data for the 40 new sites and the 63 detailed assessment sites are presented in Table 3-6.

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. Concentration Ranges for Selected Chlorinated Organic Compounds

Chlorinated Organic Compound Groups	Not Normalized (µg/kg, dry weight)			Normalized to %TOC (µg/kg/%TOC)		
	Median	Min	Max	Median	Min	Max
Original Study Sites						
ΣPCBs	9.30	0.10	198	3.05	0.203	39.1
ΣDDT Compounds	2.70	ND	118	0.56	ND	6.48
DDTs	0.17	ND	15.5	0.06	ND	2.73
DDDs	0.77	ND	52.9	0.21	ND	4.45
DDEs	0.69	ND	103	0.18	ND	3.81
ΣChlordanes	0.12	ND	5.83	0.05	ND	9.05
ΣBHCs	ND	ND	8.94	ND	ND	0.38
ΣChloros	3.93	ND	127	1.56	ND	94.3
40 New Sites						
ΣPCBs	1.13	ND	42.2	0.53	ND	39.1
ΣDDT Compounds	1.07	ND	104	0.39	ND	5.19
DDTs	ND	ND	1.93	ND	ND	0.69
DDDs	0.04	ND	35.9	0.01	ND	1.56
DDEs	0.57	ND	65.7	0.22	ND	4.10
ΣChlordanes	0.01	ND	4.07	0.02	ND	2.32
ΣBHCs	ND	ND	0.83	ND	ND	0.30
ΣChloros	2.71	ND	36.1	1.69	ND	31.1
ΣEndosulfans	0.03	ND	9.03	0.02	ND	0.84
Detailed Assessment Sites						
ΣPCBs	8.47	0.01	130	0.71	0.02	95.1
ΣDDT Compounds	10.4	ND	203	1.02	ND	37.6
DDTs	1.15	ND	14.8	0.10	ND	6.53
DDDs	2.72	ND	46.9	0.29	ND	27.0
DDEs	5.52	ND	157	0.54	ND	8.20
ΣChlordanes	1.34	ND	25.7	0.09	ND	24.8
ΣBHCs	0.96	ND	7.83	0.11	ND	3.71
ΣEndosulfans	0.37	ND	11.6	0.03	ND	7.13

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

FIELD ID	Not Normalized (raw) (ug/kg dry weight)									Normalized to %TOC (ug/kg dry weight/%TOC)								
	Sum PCBs	Sum DDTs	DDT	DDE	DDD	Chlordanes	BHCs	Endosulfans	Other Chloros	Sum PCBs	Sum DDTs	DDT	DDE	DDD	Chlordanes	BHCs	Endosulfans	Other Chloros
40 New Sites																		
BEAR	3.01	1.79	0.24	1.17	0.38	0.51	ND	ND	1.57	4.86	2.89	0.39	1.89	0.61	0.83	ND	ND	2.54
BROWARD	0.17	0.30	0.02	0.17	0.11	0.02	ND	0.06	2.15	0.52	0.90	0.07	0.50	0.33	0.05	ND	0.17	6.43
CHARLES	7.88	24.9	0.25	11.8	12.8	0.45	ND	0.81	0.89	0.23	0.73	0.01	0.35	0.37	0.01	ND	0.02	0.03
CHERRY	0.65	5.46	ND	3.96	1.51	0.24	0.06	0.08	1.16	0.35	2.95	ND	2.14	0.82	0.13	0.03	0.05	0.63
DALHOUS	0.27	0.49	0.02	0.33	0.14	0.01	0.04	0.07	1.56	0.59	1.07	0.05	0.72	0.30	0.03	0.08	0.16	3.44
DIAS	3.07	1.56	ND	0.97	0.59	0.14	0.09	0.67	10.7	0.74	0.37	ND	0.23	0.14	0.03	0.02	0.16	2.56
DORR	0.25	0.50	ND	0.34	0.16	0.01	0.01	0.03	1.61	0.92	1.88	ND	1.28	0.60	0.05	0.04	0.10	5.98
HALFMOON	9.45	26.4	ND	16.1	10.3	1.04	ND	0.78	23.8	0.37	1.03	ND	0.63	0.40	0.04	ND	0.03	0.93
HAT26	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HELENA	1.90	3.68	ND	3.68	ND	ND	ND	ND	22.3	0.06	0.11	ND	0.11	ND	ND	ND	ND	0.66
HOWELL	42.2	1.07	0.16	0.56	0.35	0.43	0.07	0.49	2.72	39.1	0.99	0.15	0.52	0.32	0.40	0.06	0.46	2.52
INDUSPL	9.71	3.34	ND	3.34	ND	0.63	0.83	ND	8.59	0.40	0.14	ND	0.14	ND	0.03	0.03	ND	0.35
JOHNSON	2.61	2.41	ND	0.99	1.42	0.26	ND	0.18	3.11	1.15	1.07	ND	0.44	0.63	0.11	ND	0.08	1.38
KERR	0.02	0.18	ND	0.09	0.09	ND	0.01	0.02	0.87	0.08	0.63	ND	0.30	0.32	ND	0.05	0.06	2.99
LHAT26	ND	ND	ND	ND	ND	ND	ND	ND	0.91	ND	ND	ND	ND	ND	ND	ND	ND	3.97
LHATSB	ND	ND	ND	ND	ND	ND	ND	ND	2.55	ND	ND	ND	ND	ND	ND	ND	ND	10.1
LHNBPL	0.61	0.13	ND	0.13	ND	0.07	ND	ND	5.54	3.44	0.72	ND	0.72	ND	0.38	ND	ND	31.1
LOCCR	ND	ND	ND	ND	ND	ND	ND	0.17	ND	ND	ND	ND	ND	ND	ND	ND	0.84	ND
LORANCRK	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LOUISA	0.34	1.08	0.07	0.78	0.23	0.12	0.08	0.18	1.67	1.20	3.81	0.26	2.76	0.79	0.42	0.30	0.62	5.91
MAITL	4.67	9.09	0.22	7.17	1.70	4.07	ND	ND	8.17	2.67	5.19	0.13	4.1	0.97	2.32	ND	ND	4.67
MILLD	0.11	0.31	ND	0.18	0.13	0.04	ND	0.03	1.43	0.02	0.07	ND	0.04	0.03	0.01	ND	0.01	0.33
NBLACK	1.61	ND	ND	ND	ND	0.19	0.23	0.96	3.84	1.18	ND	ND	ND	ND	0.14	0.17	0.70	2.80
NEWLKA	0.19	ND	ND	ND	ND	ND	ND	ND	3.15	0.60	ND	ND	ND	ND	ND	ND	ND	9.96
NEWLKB	0.32	ND	ND	ND	ND	ND	ND	ND	4.13	0.93	ND	ND	ND	ND	ND	ND	ND	12.2
NEWLKC	11.7	4.24	ND	4.24	ND	ND	0.51	9.03	12.5	0.45	0.16	ND	0.16	ND	ND	0.02	0.35	0.48
NEWLKD	3.56	5.03	ND	5.03	ND	ND	ND	ND	28.5	0.10	0.14	ND	0.14	ND	ND	ND	ND	0.78
NEWLKE	1.38	1.20	ND	1.20	ND	ND	ND	ND	34.4	0.05	0.04	ND	0.04	ND	ND	ND	ND	1.16
NEWLKF	1.10	1.45	ND	1.45	ND	ND	ND	ND	36.1	0.04	0.06	ND	0.06	ND	ND	ND	ND	1.41

FIELD ID	Not Normalized (raw) (ug/kg dry weight)									Normalized to %TOC (ug/kg dry weight/%TOC)								
	Sum PCBs	Sum DDTs	DDT	DDE	DDD	Chlordanes	BHCs	Endosulfans	Other Chloros	Sum PCBs	Sum DDTs	DDT	DDE	DDD	Chlordanes	BHCs	Endosulfans	Other Chloros
NORRIS	12.8	104	1.93	65.7	35.9	0.71	ND	0.41	3.40	0.56	4.50	0.08	2.86	1.56	0.03	ND	0.02	0.15
OLA	1.16	2.09	ND	1.74	0.35	0.10	0.01	0.10	2.09	1.74	3.14	ND	2.62	0.53	0.14	0.02	0.15	3.14
PCR-PL	12.2	2.37	1.61	0.26	0.50	4.01	ND	0.25	0.71	5.23	1.02	0.69	0.11	0.22	1.72	ND	0.11	0.30
SELLERS	0.17	0.13	ND	0.05	0.08	0.01	ND	0.01	2.70	0.73	0.54	ND	0.20	0.34	0.04	ND	0.06	11.6
SILRV	3.71	1.80	ND	1.80	ND	ND	ND	ND	8.20	0.54	0.26	ND	0.26	ND	ND	ND	ND	1.18
SJRJESUP	ND	ND	ND	ND	ND	ND	ND	ND	1.96	ND	ND	ND	ND	ND	ND	ND	ND	6.93
SJRPLTKA	4.90	1.30	0.29	1.01	ND	0.16	0.42	0.25	3.90	1.53	0.41	0.09	0.32	ND	0.05	0.13	0.08	1.22
SOUTH	1.68	0.56	ND	0.56	ND	ND	ND	0.28	1.44	2.28	0.77	ND	0.77	ND	ND	ND	0.38	1.97
SUNLAND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
WASH	8.08	5.68	0.15	4.17	1.36	0.43	ND	0.51	12.0	0.30	0.21	0.02	0.16	0.05	0.02	ND	0.02	0.45
WINN	0.83	0.79	ND	0.58	0.21	0.09	ND	0.05	2.89	1.57	1.50	ND	1.10	0.40	0.18	ND	0.10	5.50
Detailed Assessment Sites																		
BIVENA	56.0	27.1	2.62	14.1	10.5	8.38	2.23	3.64	NA	2.18	1.06	0.10	0.55	0.41	0.33	0.09	0.14	NA
BIVENB	74.0	47.2	3.70	35.2	8.35	3.20	ND	1.82	NA	3.02	1.93	0.15	1.44	0.34	0.13	ND	0.07	NA
BIVENC	39.8	15.9	ND	10.2	5.76	3.45	0.38	2.43	NA	1.38	0.55	ND	0.35	0.20	0.12	0.01	0.08	NA
BIVEND	110	73.0	3.62	34.6	34.8	25.7	ND	11.6	NA	3.80	2.52	0.13	1.19	1.20	0.89	ND	0.40	NA
BIVENE	130	94.3	2.04	80.1	12.2	4.26	1.20	5.04	NA	2.97	2.14	0.05	1.82	0.28	0.10	0.03	0.12	NA
BIVENF	0.54	0.55	ND	0.39	0.17	0.12	0.12	ND	NA	1.28	1.33	ND	0.93	0.40	0.29	0.29	ND	NA
DISSA	1.22	2.40	0.22	1.35	0.84	0.07	0.10	0.21	NA	1.50	2.94	0.26	1.65	1.03	0.08	0.13	0.25	NA
DISSB	0.10	0.29	ND	0.19	0.10	ND	ND	ND	NA	0.23	0.69	ND	0.45	0.25	ND	ND	ND	NA
DISSC	15.4	54.2	2.15	36.2	15.8	0.82	0.87	1.53	NA	0.68	2.40	0.10	1.61	0.70	0.04	0.04	0.07	NA
DISSD	0.16	0.23	ND	0.14	0.09	ND	ND	ND	NA	0.71	0.99	ND	0.60	0.39	ND	ND	ND	NA
DISSE	0.85	0.50	ND	0.21	0.29	ND	ND	0.06	NA	3.73	2.18	ND	0.91	1.28	ND	ND	0.26	NA
DORAA	0.39	0.23	0.03	0.07	0.13	0.04	0.02	0.04	NA	2.72	1.57	0.20	0.47	0.90	0.24	0.14	0.25	NA
DORAB	8.47	64.5	4.51	47.6	12.4	2.82	3.48	0.39	NA	0.24	1.80	0.13	1.33	0.35	0.08	0.10	0.01	NA
DORAC	11.1	78.5	4.03	64.5	9.95	3.58	5.05	ND	NA	0.33	2.34	0.12	1.93	0.30	0.11	0.15	ND	NA
DORAD	14.6	93.0	6.02	75.3	11.7	7.90	7.61	0.60	NA	0.41	2.59	0.17	2.10	0.33	0.22	0.21	0.02	NA
DORAE	22.7	115	7.45	86.1	21.9	9.98	7.83	ND	NA	0.56	2.83	0.18	2.11	0.54	0.25	0.19	ND	NA
DORAF	15.2	203	11.8	157	34.2	7.01	4.99	ND	NA	0.39	5.24	0.31	4.05	0.88	0.18	0.13	ND	NA
DORAG	21.9	200	13.1	140	46.9	7.15	3.98	0.44	NA	0.81	7.41	0.49	5.18	1.74	0.27	0.15	0.02	NA
EUSTA	45.9	37.3	5.37	23.3	8.55	14.8	3.90	1.95	NA	1.28	1.03	0.15	0.65	0.24	0.41	0.11	0.05	NA
EUSTB	1.63	1.10	0.17	0.25	0.68	0.03	0.09	0.11	NA	9.82	6.64	1.04	1.49	4.11	0.16	0.52	0.66	NA

FIELD ID	Not Normalized (raw) (ug/kg dry weight)									Normalized to %TOC (ug/kg dry weight/%TOC)								
	Sum PCBs	Sum DDTs	DDT	DDE	DDD	Chlordanes	BHCs	Endosulfans	Other Chloros	Sum PCBs	Sum DDTs	DDT	DDE	DDD	Chlordanes	BHCs	Endosulfans	Other Chloros
EUSTC	53.2	72.3	3.02	58.7	10.5	3.05	3.43	1.77	NA	1.63	2.22	0.09	1.80	0.32	0.09	0.11	0.05	NA
EUSTD	29.3	22.1	1.99	16.9	3.21	2.38	4.96	0.95	NA	0.83	0.62	0.06	0.48	0.09	0.07	0.14	0.03	NA
EUSTE	3.84	4.09	0.51	2.57	1.02	0.64	1.07	0.09	NA	0.34	0.36	0.04	0.22	0.09	0.06	0.09	0.01	NA
EUSTF	14.9	19.6	2.52	11.6	5.52	2.11	4.05	0.36	NA	0.51	0.67	0.09	0.39	0.19	0.07	0.14	0.01	NA
EUSTG	1.66	0.87	0.11	0.57	0.19	0.17	0.50	ND	NA	1.84	0.96	0.12	0.63	0.21	0.19	0.55	ND	NA
GEORGEA	0.02	ND	ND	ND	ND	ND	0.05	ND	NA	0.09	ND	ND	ND	ND	ND	0.24	ND	NA
GEORGEB	5.63	3.13	1.17	1.19	0.77	0.08	1.37	0.39	NA	0.48	0.27	0.10	0.10	0.07	0.01	0.12	0.03	NA
GEORGEC	4.40	3.53	1.06	1.56	0.91	0.16	0.85	0.41	NA	0.41	0.33	0.10	0.15	0.09	0.02	0.08	0.04	NA
GEORGED	0.77	0.62	0.24	0.14	0.24	ND	0.43	0.04	NA	0.19	0.15	0.06	0.03	0.06	ND	0.10	0.01	NA
GEORGEE	0.01	ND	ND	ND	ND	ND	ND	ND	NA	0.02	ND	ND	ND	ND	ND	ND	ND	NA
GEORGEF	8.87	7.25	2.58	3.02	1.65	0.22	4.54	0.64	NA	0.29	0.24	0.09	0.10	0.05	0.01	0.15	0.02	NA
GEORGEG	12.3	6.96	2.60	2.95	1.41	1.52	2.81	0.53	NA	0.59	0.33	0.12	0.14	0.07	0.07	0.13	0.03	NA
GEORGEH	1.16	0.70	0.26	0.15	0.29	0.31	0.36	0.07	NA	0.21	0.13	0.05	0.03	0.05	0.06	0.06	0.01	NA
GEORGEI	1.41	1.33	0.31	0.59	0.43	0.06	0.23	0.09	NA	0.39	0.37	0.09	0.16	0.12	0.02	0.06	0.02	NA
GEORGEJ	8.12	10.4	1.45	6.35	2.60	0.08	0.96	0.43	NA	0.50	0.65	0.09	0.40	0.16	0.01	0.06	0.03	NA
GRIFFA	18.9	16.8	2.89	9.93	3.96	1.15	5.40	0.87	NA	0.48	0.43	0.07	0.25	0.10	0.03	0.14	0.02	NA
GRIFFB	11.9	22.3	1.28	14.7	6.28	0.31	3.11	ND	NA	0.36	0.68	0.04	0.45	0.19	0.01	0.09	ND	NA
GRIFFC	2.58	6.35	1.15	5.20	ND	0.46	4.12	ND	NA	0.06	0.15	0.03	0.12	ND	0.01	0.10	ND	NA
GRIFFD	30.1	14.2	6.80	5.52	1.87	3.28	1.60	0.82	NA	1.15	0.54	0.26	0.21	0.07	0.13	0.06	0.03	NA
GRIFFE	12.2	33.1	ND	21.8	11.3	3.54	3.89	0.37	NA	0.31	0.83	ND	0.55	0.29	0.09	0.10	0.01	NA
GRIFFF	4.25	11.1	ND	8.35	2.72	1.68	3.70	0.26	NA	0.10	0.25	ND	0.19	0.06	0.04	0.08	0.01	NA
HARA	2.42	13.5	ND	9.08	4.39	0.27	2.17	ND	NA	0.06	0.35	ND	0.23	0.11	0.01	0.06	ND	NA
HARB	18.1	44.8	ND	33.7	11.0	2.18	3.09	ND	NA	0.64	1.58	ND	1.19	0.39	0.08	0.11	ND	NA
HARC	4.33	4.25	0.23	3.03	0.99	0.34	0.84	0.14	NA	0.49	0.48	0.03	0.34	0.11	0.04	0.10	0.02	NA
HARD	6.85	16.4	1.54	11.4	3.49	1.34	3.16	0.19	NA	0.20	0.49	0.05	0.34	0.10	0.04	0.09	0.01	NA
HARE	14.0	9.29	ND	7.28	2.01	1.05	2.73	0.61	NA	0.54	0.36	ND	0.28	0.08	0.04	0.11	0.02	NA
HARF	7.45	27.4	4.28	19.9	3.25	1.91	5.56	2.09	NA	0.20	0.74	0.12	0.54	0.09	0.05	0.15	0.06	NA
HOGA	5.34	2.12	0.12	0.14	1.86	2.03	0.05	0.58	NA	65.2	25.8	1.43	1.69	22.7	24.8	0.63	7.13	NA
HOGB	4.88	4.12	ND	0.21	3.91	2.94	0.84	1.72	NA	12.3	10.4	ND	0.53	9.87	7.42	2.12	4.35	NA
HOGC	10.5	11.5	0.90	2.35	8.26	6.27	0.40	1.85	NA	34.3	37.6	2.93	7.69	27.0	20.5	1.30	6.05	NA
HOGD	5.07	2.20	0.09	0.90	1.21	1.22	0.45	0.62	NA	3.53	1.53	0.06	0.63	0.84	0.85	0.31	0.43	NA
MONA	7.55	2.00	0.46	0.76	0.79	0.69	0.41	0.23	NA	3.83	1.02	0.23	0.38	0.40	0.35	0.21	0.12	NA
MONB	32.3	24.0	6.20	9.41	8.44	7.90	1.00	2.41	NA	1.96	1.46	0.38	0.57	0.51	0.48	0.06	0.15	NA

FIELD ID	Not Normalized (raw) (ug/kg dry weight)									Normalized to %TOC (ug/kg dry weight/%TOC)								
	Sum PCBs	Sum DDTs	DDT	DDE	DDD	Chlordanes	BHCs	Endosulfans	Other Chloros	Sum PCBs	Sum DDTs	DDT	DDE	DDD	Chlordanes	BHCs	Endosulfans	Other Chloros
MONC	16.1	14.9	2.61	7.79	4.47	1.93	1.67	0.46	NA	0.91	0.84	0.15	0.44	0.25	0.11	0.09	0.03	NA
MOND	1.31	0.89	0.25	0.39	0.24	0.20	0.27	0.10	NA	1.23	0.82	0.23	0.37	0.23	0.19	0.25	0.09	NA
MONE	15.6	14.8	2.19	8.73	3.89	1.36	4.67	0.27	NA	1.15	1.10	0.16	0.65	0.29	0.10	0.35	0.02	NA
MONF	2.10	1.40	0.40	0.57	0.43	0.23	0.52	0.11	NA	0.43	0.28	0.08	0.12	0.09	0.05	0.11	0.02	NA
MONG	6.50	7.05	1.33	3.68	2.04	0.87	0.87	0.10	NA	1.22	1.32	0.25	0.69	0.38	0.16	0.16	0.02	NA
SWEETA	77.8	39.1	14.8	9.79	14.5	19.1	3.06	5.94	NA	13.2	6.62	2.51	1.66	2.45	3.23	0.52	1.01	NA
SWEETB	54.7	17.6	2.97	9.74	4.84	8.43	0.89	1.42	NA	4.20	1.35	0.23	0.75	0.37	0.65	0.07	0.11	NA
SWEETC	11.7	5.83	1.22	1.53	3.08	3.97	0.69	1.15	NA	62.7	31.2	6.53	8.20	16.5	21.3	3.71	6.16	NA
SWEETD	19.1	2.16	1.02	ND	1.14	1.02	0.02	0.81	NA	95.1	10.8	5.10	ND	5.67	5.10	0.11	4.01	NA
SWEETE	3.78	2.64	1.05	0.40	1.20	3.00	0.10	0.20	NA	21.2	14.8	5.87	2.22	6.74	16.9	0.58	1.11	NA

The 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 are generally approximately two times the sum of these congeners), as determined in the NOAA NS&T program. The total PCB in these samples can therefore be estimated by multiplying the sum of the PCB congener concentrations by 2.

The data for the 40 new sites, as well as the 63 detailed assessment sites, indicate that concentrations of PCB, pesticides, and other chlorinated compounds are quite variable in these sediments. This is consistent with data from the original district-wide study sites. Some general similarities in the data were observed for the 40 new sites and the 63 detailed assessment sites. These include that (1) the DDT and PCB concentrations were greater than the concentrations of other chlorinated compounds (e.g., the pesticides chlordanes, BHCs, and endosulfans) and (2) DDE was the DDT compound that was typically detected with the highest concentration. The DDT concentrations were generally lower than the PCBs concentrations for most sites sampled in the original 1996-1997 study, compared to the 40 new district-wide sites and the detailed assessment sites, possibly because a greater proportion of the 1996-1997 study sites were near urban locations than the recently sampled sites. Higher concentrations of other chlorinated compounds were also measured at many of the original study sites than at the new sites, also most likely because there were more urban/industrial locations (e.g., a number of Lower St. Johns River sites) sampled in the earlier work.

40 New Sites

The sum of the PCB congeners at the 40 new sites ranged from not detected (ND) to 42.2 µg/kg [site HOWELL (Lake Howell)] and total DDT compound concentrations ranged from ND to 104 µg/kg [site NORRIS (Lake Norris)]. The median concentrations of PCB and DDT were 1.13 µg/kg and 1.07 µg/kg, respectively, at the 40 newly sampled district-wide sites. The concentrations of the individual DDT, DDD, and DDE compounds at the 40 new sites ranged from ND to 1.93 µg/kg [site NORRIS (Lake Norris)], ND to 35.9 µg/kg [site NORRIS (Lake Norris)], and ND to 65.7 µg/kg [site NORRIS (Lake Norris)], respectively. The concentrations of the other major pesticides, chlordane, BHC, and endosulfan, were significantly lower and spanned a much smaller concentration range. Total chlordane concentrations ranged from ND to 4.07 µg/kg [site MAITL (Lake Maitland)], total BHC concentrations were from ND to 0.83 µg/kg [site INDUSPL (Airport Industrial Park)], and total endosulfans ranged from ND to 9.03 µg/kg [site NEWLKC (Mouth of Little Hatchet Creek)]. Other chlorinated compounds ranged from ND to 36.1 µg/kg [site NEWLKF (South end of Newnans Lake)].

The variability in the sediment concentrations of chlorinated compounds at the 40 new sites was moderated when the data were normalized to sediment TOC content (Tables 3-5 and 3-6). The TOC normalized PCB concentrations at the 40 new sites ranged from ND to 39.1 µg/kg/%TOC [site HOWELL (Lake Howell)]. The TOC normalized total DDT concentrations ranged from ND to a high of 5.19 µg/kg/%TOC [site MAITL (Lake Maitland)], while the median TOC normalized total PCB and total DDT concentrations were 0.525 and 0.39 µg/kg/%TOC, respectively, for the 40 new sites. The range in TOC normalized individual pesticide compound (e.g., DDT, chlordane, BHC, and endosulfan) and other chlorinated industrial chemicals were similarly reduced upon TOC normalization.

Detailed Assessment Sites

The data for the 63 detailed assessment sites indicate that concentrations of PCB, pesticides, and other chlorinated compounds were also quite variable in the sediment samples, with notable concentrations at several sites. This wider range, including some relatively elevated concentrations, was not surprising since the detailed assessment study was conducted to better study locations that had been identified to potentially have specific contaminant issues (SJRWMD, 1998). However, no sites were investigated because they were contaminated with all target analytes, and low contaminant concentrations were therefore also measured in this phase of the project.

The sum of the PCB congener concentrations at the 63 detailed assessment sites ranged from 0.01 µg/kg [site GEORGEE (Lake George)] to 130 µg/kg [site BIVENE (Bivens Arm)], and the total DDT compound concentrations ranged from ND to 203 µg/kg [site DORAF (Lake Beauclair)]. Median concentrations for total PCB and total DDT were 8.47 µg/kg and 10.4 µg/kg, respectively. Similarly to the original study, Lake Dora/Lake Beauclair was the location with the highest concentrations of DDT compounds. Of the three classes of DDT compounds, the degradation product DDE was, with few exceptions, generally detected at the highest concentrations. The concentrations of the individual DDT, DDD, and DDE compounds ranged from ND to 14.8 µg/kg [site SWEETA (Sweetwater Branch)], from ND to 46.9 µg/kg [site DORAG (Lake Beauclair)], and from ND to 157 µg/kg [site DORAF (Lake Beauclair)], respectively.

Total chlordane, BHC, and endosulfan concentrations were generally much lower than the DDT concentrations. Total chlordane concentrations ranged from ND to 25.7 µg/kg [site BIVEND (Bivens Arm)], total BHC concentrations from ND to 7.83 µg/kg [site DORAE (Lake Dora)], and total endosulfan from ND to 11.6 µg/kg [site BIVEND (Bivens Arm)].

The variability of the chlorinated compound concentrations in the sediment from the 63 detailed assessment sites was, as expected, reduced when the data were normalized to sediment TOC content (Table 3-6). TOC normalized PCB concentrations ranged from 0.02 [site GEORGEE (Lake George) to 95.1 µg/kg/%TOC [site SWEETD (Sweetwater Branch)] and the total DDT concentrations ranged from ND to 37.6 µg/kg/%TOC [site HOGC (Hogtown Creek); a site with low TOC, not notably high overall DDT concentrations]. Median TOC normalized concentrations of total PCB and DDT were 0.710 and 1.02 µg/kg/%TOC, respectively.

3.2 Results for Metals Analysis

Sediment metals concentrations were determined for 15 elements for the 40 new sites in the district wide assessment (just like in the original 1996-1997 study) and for 10 elements for the 63 sites in the detailed assessment study (based on results from the original 1996-1997 study). Three of the metals (aluminum, iron, and manganese) are considered major metals and are naturally abundant in most geological formations. The other metals are typically considered contaminants of environmental concern. The three 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. The individual site metals data for each of the 40 new and the 63 detailed assessment sites are presented in Tables 3-8a through 3-8c. The metals data are also summarized in Appendices D (40 new sites) and G (detailed assessment sites).

40 New Sites and District Wide Assessment Sites

The ranges of major and trace metal concentrations varied widely (see Table 3-7). The nonanthropogenic, crustal major metals, Al, Fe, and Mn, were, as expected, present at the highest concentrations in the sediments, whereas the toxic trace metals, such as As, Cd, Cr, Cu, Pb, Li, Hg, Ni, Se, Ag, Sn, and Zn, were detected at significantly lower concentrations (Tables 3-7 and 3-8a). The sediment metals concentrations were less variable when normalized to the aluminum concentration (Tables 3-7 and 3-8b). For instance, the Al-normalized Cu concentration in the sediment samples from the 40 new sites ranged from 0.000146 to 0.00685 (unitless), a factor of approximately 47 in concentration range, as compared to the raw Cu data which varied by a factor of approximately 280 between the high and the low concentrations. Notable reductions in variability, by normalizing to Al, were also observed for Pb, Ni, and Ag for the 40 new sites. Normalizing the metal concentrations to aluminum resulted in fewer and less reductions in concentration ranges for the detailed assessment sites (reductions were only noteworthy for Cr and Cu).

Table 3-7. Concentration Ranges for Major and Trace Metals

Major and Trace Metals	Not Normalized (raw) (mg/kg dry weight)			Normalized to Al		
	Median	Min	Max	Median	Min	Max
Original Study Sites						
Major Metals						
Aluminum (Al)	8,840	239	48,400	1	1	1
Iron (Fe)	4,670	111	29,400	5.96E-1	0.130	4.19
Manganese (Mn)	69.9	2.72	425	8.72E-3	0.002	0.213
Trace Metals						
Arsenic (As)	1.19	ND	15.2	1.40E-4	ND	2.22E-3
Cadmium (Cd)	0.16	ND	1.33	1.63E-5	ND	1.52E-4
Chromium (Cr)	14.1	0.51	139	1.63E-3	6.35E-4	1.58E-2
Copper (Cu)	3.95	0.26	59.7	6.37E-4	1.46E-4	2.88E-2
Lead (Pb)	13.4	0.66	343	1.35E-3	5.20E-4	3.60E-2
Lithium (Li)	6.45	1.31	50.0	7.51E-4	4.09E-4	7.66E-3
Mercury (Hg)	0.08	ND	0.44	9.92E-6	ND	7.63E-5
Nickel (Ni)	3.98	0.12	29.8	4.22E-4	1.02E-4	1.33E-3
Selenium (Se)	0.76	ND	5.51	6.74E-5	ND	6.66E-2
Silver (Ag)	0.04	ND	0.96	5.10E-6	ND	9.10E-5
Tin (Sn)	0.74	0.07	8.35	8.67E-5	3.13E-5	2.53E-3
Zinc (Zn)	19.5	0.90	361	2.41E-3	6.57E-4	7.89E-2
40 New Sites						
Major Metals						
Aluminum (Al)	2,580	454	27,400	NA	NA	NA
Iron (Fe)	1,095	63.6	30,200	3.66E-01	4.75E-02	2.80
Manganese (Mn)	28.0	1.78	216	7.84E-03	1.46E-03	4.15E-02
Trace Metals						
Arsenic (As)	0.77	ND	7.91	2.92E-04	ND	3.26E-03
Cadmium (Cd)	0.07	ND	2.26	1.79E-05	ND	1.59E-03
Chromium (Cr)	5.04	1.23	30.9	1.61E-03	8.54E-04	6.81E-02
Copper (Cu)	2.41	0.39	112	7.52E-04	1.46E-04	6.85E-03
Lead (Pb)	8.99	0.61	128	2.46E-03	7.17E-04	3.95E-02
Lithium (Li)	1.79	ND	18.3	5.26E-04	ND	2.42E-03
Mercury (Hg)	0.02	ND	0.30	8.05E-06	ND	8.72E-05
Nickel (Ni)	1.23	0.14	14.4	3.58E-04	1.72E-04	9.01E-03
Selenium (Se)	0.33	ND	6.26	1.10E-04	ND	5.81E-03
Silver (Ag)	0.07	0.01	1.55	1.86E-05	4.23E-06	3.02E-04
Tin (Sn)	0.39	0.16	1.67	1.49E-04	3.54E-05	5.75E-04
Zinc (Zn)	14.8	5.15	67.7	4.68E-03	1.61E-03	2.93E-02
Detailed Assessment Sites						
Major Metals						
Aluminum (Al)	10,400	277	44,300	NA	NA	NA
Trace Metals						
Arsenic (As)	6.86	ND	21.3	5.84E-04	ND	1.41E-03
Cadmium (Cd)	0.33	ND	1.92	2.89E-05	ND	2.10E-04
Chromium (Cr)	18.7	0.76	187	1.98E-03	9.89E-04	1.32E-02
Copper (Cu)	16.7	0.40	46.0	1.57E-03	4.16E-04	5.47E-03
Lead (Pb)	30.3	ND	367	3.20E-03	ND	6.66E-02
Mercury (Hg)	0.20	ND	0.43	1.80E-05	ND	7.76E-05
Nickel (Ni)	6.94	ND	22.8	5.88E-04	ND	3.52E-03
Silver (Ag)	0.16	ND	2.35	1.94E-05	ND	1.99E-04
Zinc (Zn)	38.0	1.55	279	4.09E-03	1.21E-03	2.66E-02

Table 3-8a. Metals Data — Non-Normalized

FIELD ID	Non-Normalized Metals Concentrations (mg/kg, dry weight)														
	Al	As	Cd	Cr	Cu	Fe	Pb	Li	Mn	Hg	Ni	Se	Ag	Sn	Zn
40 New Sites															
BEAR	2,380	1.20	ND	3.52	2.60	506	11.7	1.15	8.73	ND	0.909	0.259	0.052	0.337	10.5
BROWARD	1,810	0.540	ND	4.18	2.02	599	14.0	1.50	27.6	0.010	0.575	0.298	0.100	0.344	10.7
CHARLES	10,800	5.32	0.357	12.3	4.91	8,620	17.5	1.30	138	0.283	9.29	2.69	0.052	0.382	24.0
CHERRY	2,040	0.632	0.069	2.94	3.63	1,020	5.85	2.13	16.9	0.018	1.00	0.429	0.028	0.206	9.47
DALHOUS	2,390	0.516	0.027	7.16	3.08	1,170	7.48	1.34	55.1	ND	0.676	0.346	0.177	0.586	12.2
DIAS	6,680	6.39	0.045	7.06	3.91	5,580	7.06	2.21	86.5	0.040	2.68	1.16	0.073	0.317	16.6
DORR	1,090	0.202	ND	2.55	1.10	343	4.05	0.847	14.0	ND	0.336	0.222	0.055	0.241	5.15
HALFMOON	11,500	5.86	0.453	17.9	11.3	9,590	48.3	5.51	173	0.304	7.58	4.16	0.143	1.14	39.9
HAT26	757	ND	0.032	1.98	0.394	175	0.791	1.83	7.06	0.014	0.136	ND	0.012	0.160	11.1
HELENA	1,420	2.19	2.26	11.6	9.73	1,780	8.26	ND	44.0	0.118	9.33	6.26	0.037	0.388	26.7
HOWELL	2,770	0.857	0.035	4.88	5.88	681	9.12	1.59	18.1	0.014	1.07	0.303	0.187	0.431	24.0
INDUSPL	5,130	1.51	0.274	8.49	12.8	1,430	128	2.43	17.5	0.115	5.14	0.209	1.55	1.04	27.8
JOHNSON	6,020	0.892	0.065	6.71	4.20	1,320	14.2	3.43	31.4	0.021	2.06	1.16	0.106	0.530	43.0
KERR	2,120	4.8	ND	3.96	1.49	862	10.3	2.66	28.5	ND	0.546	0.345	0.063	0.239	8.45
LHAT26	7,070	0.61	0.083	15.1	1.03	1,660	6.61	3.46	13.0	0.022	1.66	ND	0.067	0.461	12.6
LHATSB	1,350	0.47	0.037	2.33	0.801	1,010	1.12	2.46	6.96	0.016	0.383	ND	0.030	0.326	7.39
LHNBPL	3,640	0.4	0.111	4.82	1.09	874	2.61	1.70	12.6	0.016	1.12	ND	0.055	0.316	10.0
LOCCR	927	ND	ND	3.13	0.475	172	1.04	1.27	4.55	0.014	0.219	ND	0.044	0.430	8.77
LORANCRK	1,980	ND	0.175	7.65	1.75	2,620	3.57	4.18	82.2	0.013	0.500	ND	0.139	0.634	58.1
LOUISA	1,670	0.383	ND	3.21	1.96	629	19.1	1.50	16.1	0.006	0.538	0.258	0.075	0.320	6.74
MAITL	23,500	6.34	0.347	22.6	112	3,070	61.2	9.75	34.4	0.172	7.72	0.940	0.119	1.18	67.2
MILLD	1,340	0.299	ND	1.45	0.833	63.6	52.9	1.68	12.9	0.005	0.553	0.304	0.046	0.256	14.5
NBLACK	9,750	1.51	0.187	11.4	2.53	3,470	9.40	4.74	40.0	0.032	2.05	ND	0.106	0.663	38.8
NEWLKA	650	ND	0.038	1.23	1.53	129	0.610	1.01	1.78	0.012	0.273	ND	0.012	0.155	5.96
NEWLKB	710	ND	0.031	1.39	1.04	153	0.707	1.35	3.24	0.010	0.196	ND	0.021	0.156	6.24
NEWLKC	4,810	1.45	0.218	4.81	3.68	3,950	22.1	0.997	36.3	0.105	2.50	0.512	0.063	0.920	29.3
NEWLKD	16,700	6.45	0.592	22.4	9.89	8,840	26.8	3.95	47.0	0.275	11.3	2.13	0.097	1.32	67.7
NEWLKE	16,900	5.42	0.390	24.6	12.5	10,500	21.3	4.67	51.3	0.233	11.2	2.66	0.090	0.796	47.6
NEWLKF	15,400	6.19	0.362	23.5	8.30	9,950	16.7	4.37	45.0	0.199	10.6	1.98	0.096	0.724	35.7
NORRIS	27,400	7.91	0.403	23.4	11.1	30,200	43.1	18.3	216	0.284	14.4	1.85	0.116	1.01	44.1
OLA	3,170	1.14	0.025	4.65	5.66	562	6.97	1.71	21.3	0.008	1.35	0.352	0.081	0.406	10.5

FIELD ID	Non-Normalized Metals Concentrations (mg/kg, dry weight)														
	Al	As	Cd	Cr	Cu	Fe	Pb	Li	Mn	Hg	Ni	Se	Ag	Sn	Zn
PCR-PL	1,280	0.63	0.262	6.81	2.27	420	6.50	ND	15.3	0.064	2.17	ND	0.071	0.407	21.5
SELLERS	1,700	0.387	ND	3.90	2.28	960	5.30	1.74	32.1	0.005	0.411	0.274	0.080	0.363	16.0
SILRV	454	1.48	0.434	30.9	1.49	690	2.21	ND	11.9	0.040	4.09	2.64	0.087	0.261	8.68
SJRJESUP	4,590	0.59	0.076	5.20	0.943	1,520	3.62	2.35	38.9	0.013	0.79	ND	0.068	0.269	14.0
SJRPLTKA	6,790	2.05	0.158	9.98	3.64	3,980	8.86	2.17	61.5	0.044	1.87	0.692	0.117	1.67	25.5
SOUTH	1,790	1.56	0.023	4.10	1.60	5,020	5.69	1.05	38.1	0.051	2.40	1.41	0.025	0.164	15.2
SUNLAND	1,180	ND	0.036	2.63	0.610	307	33.6	1.94	9.19	0.010	0.352	ND	0.023	0.307	9.13
WASH	19,800	0.490	0.250	20.2	8.83	11,800	22.3	8.72	102	0.190	7.41	1.55	0.139	0.789	46.1
WINN	3,820	0.672	0.029	3.76	2.15	571	9.75	1.30	20.0	0.013	0.973	0.458	0.039	0.199	9.67
Detailed Assessment Sites															
BIVENA	12,500	4.02	0.925	93.6	32.9	NA	112	NA	NA	0.259	13.7	NA	0.386	NA	161
BIVENB	22,200	4.12	1.46	187	39.7	NA	324	NA	NA	0.380	19.1	NA	0.643	NA	229
BIVENC	14,300	7.55	0.956	89.4	31.3	NA	118	NA	NA	0.302	13.7	NA	0.363	NA	161
BIVEND	11,800	8.24	1.32	122	42.2	NA	246	NA	NA	0.426	15.3	NA	0.467	NA	279
BIVENE	26,600	12.1	1.65	163	46.0	NA	367	NA	NA	0.424	22.8	NA	0.531	NA	220
BIVENF	277	ND	ND	2.11	0.801	NA	2.38	NA	NA	0.022	ND	NA	0.055	NA	2.43
DORAA	383	ND	ND	0.758	0.400	NA	ND	NA	NA	ND	ND	NA	ND	NA	1.55
DORAB	13,400	12.6	0.230	17.6	13.3	NA	23.4	NA	NA	0.199	6.25	NA	0.143	NA	36.3
DORAC	16,700	21.3	0.391	21.1	28.2	NA	48.7	NA	NA	0.272	8.15	NA	0.235	NA	64.9
DORAD	11,300	15.9	0.400	17.1	33.6	NA	43.5	NA	NA	0.221	7.37	NA	0.152	NA	75.6
DORAE	11,700	13.0	0.430	17.8	35.1	NA	37.2	NA	NA	0.193	7.29	NA	0.141	NA	76.5
DORAF	13,100	14.1	0.349	20.2	31.3	NA	19.4	NA	NA	0.167	7.53	NA	0.158	NA	49.9
DORAG	10,000	10.3	0.239	17.0	26.3	NA	13.8	NA	NA	0.140	5.62	NA	0.125	NA	37.8
EUSTA	14,100	10.8	0.627	22.2	28.2	NA	93.1	NA	NA	0.332	8.47	NA	0.264	NA	116
EUSTB	300	ND	ND	1.56	0.738	NA	1.46	NA	NA	ND	ND	NA	0.034	NA	1.67
EUSTC	17,700	16.3	0.428	23.3	23.0	NA	60.0	NA	NA	0.297	7.73	NA	0.289	NA	61.8
EUSTD	13,900	11.5	0.347	18.6	19.9	NA	42.9	NA	NA	0.267	7.23	NA	0.183	NA	54.0
EUSTE	2,790	2.88	0.050	4.67	4.63	NA	9.13	NA	NA	0.067	1.58	NA	0.061	NA	12.1
EUSTF	15,000	9.21	0.416	19.5	15.4	NA	35.0	NA	NA	0.273	7.42	NA	0.314	NA	52.4
EUSTG	725	ND	ND	2.05	1.33	NA	2.24	NA	NA	0.016	ND	NA	0.050	NA	3.46
GRIFFA	9,460	8.99	0.495	20.1	27.5	NA	42.8	NA	NA	0.301	7.50	NA	0.679	NA	84.8
GRIFFB	9,640	9.78	0.256	18.8	10.0	NA	16.7	NA	NA	0.193	6.87	NA	0.218	NA	25.2
GRIFFC	8,230	10.0	0.371	16.5	18.4	NA	33.2	NA	NA	0.275	6.82	NA	0.380	NA	49.5
GRIFFD	10,700	6.66	0.154	23.1	8.46	NA	19.6	NA	NA	0.124	4.84	NA	0.152	NA	25.8

FIELD ID	Non-Normalized Metals Concentrations (mg/kg, dry weight)														
	Al	As	Cd	Cr	Cu	Fe	Pb	Li	Mn	Hg	Ni	Se	Ag	Sn	Zn
GRIFFE	14,500	15.0	0.350	28.7	17.8	NA	46.8	NA	NA	0.260	9.04	NA	0.195	NA	46.6
GRIFFF	7,960	11.0	0.239	16.6	11.7	NA	28.3	NA	NA	0.215	6.53	NA	0.123	NA	25.8
HARA	6,400	7.86	0.223	14.8	8.92	NA	12.8	NA	NA	0.196	4.99	NA	0.057	NA	24.8
HARB	14,800	10.9	0.342	24.4	14.1	NA	33.5	NA	NA	0.254	8.39	NA	0.172	NA	32.0
HARC	2,730	1.51	0.088	5.38	4.67	NA	9.26	NA	NA	0.063	1.72	NA	0.065	NA	9.64
HARD	15,700	10.6	0.430	24.5	21.7	NA	43.6	NA	NA	0.287	9.06	NA	0.134	NA	46.1
HARE	7,070	4.91	0.274	15.1	15.9	NA	28.2	NA	NA	0.166	5.40	NA	0.123	NA	38.8
HARF	8,980	10.1	0.324	16.7	17.4	NA	34.0	NA	NA	0.226	7.01	NA	0.098	NA	37.1
HOGA	1,220	ND	0.235	4.66	1.24	NA	4.15	NA	NA	0.027	1.21	NA	0.060	NA	12.1
HOGB	4,570	ND	0.318	40.4	25.0	NA	7.21	NA	NA	0.03	16.1	NA	0.158	NA	15.1
HOGC	3,630	ND	0.266	13.8	1.51	NA	10.1	NA	NA	0.027	1.84	NA	0.049	NA	16.7
HOGD	1,540	ND	0.075	5.00	2.08	NA	6.92	NA	NA	0.037	1.00	NA	0.060	NA	10.9
MONA	8,410	1.49	0.117	13.0	11.2	NA	13.0	NA	NA	0.032	3.88	NA	0.158	NA	21.8
MONB	37,200	5.48	0.686	50.3	38.8	NA	43.5	NA	NA	0.313	15.0	NA	0.868	NA	109
MONC	44,300	7.72	0.606	57.2	24.3	NA	32.3	NA	NA	0.331	18.4	NA	0.671	NA	71.3
MOND	8,810	ND	ND	8.71	3.87	NA	7.71	NA	NA	0.018	1.65	NA	0.123	NA	10.7
MONE	43,000	7.05	0.459	55.6	31.0	NA	35.4	NA	NA	0.275	19.3	NA	0.670	NA	58.5
MONF	9,860	ND	0.061	13.8	6.26	NA	7.22	NA	NA	0.034	2.38	NA	0.218	NA	14.8
MONG	21,500	2.39	0.164	21.8	12.8	NA	15.1	NA	NA	0.092	5.22	NA	0.263	NA	27.1
SWEETA	14,400	4.32	1.92	52.3	27.5	NA	97.6	NA	NA	0.259	13.3	NA	0.947	NA	176
SWEETB	17,000	3.19	1.16	71.2	21.3	NA	54.0	NA	NA	0.274	10.8	NA	2.35	NA	112
SWEETC	1,650	ND	0.118	4.58	4.03	NA	20.8	NA	NA	0.034	1.52	NA	0.061	NA	28.5
SWEETD	3,500	ND	0.384	11.2	2.46	NA	15.1	NA	NA	0.050	1.96	NA	0.126	NA	22.7
SWEETE	1,430	1.16	0.300	18.9	3.66	NA	95.3	NA	NA	0.040	1.68	NA	0.106	NA	38.1

Table 3-8b. Metals Data — Normalized to Aluminum

FIELD ID	Aluminum Normalized Metals Concentrations											
	As	Cd	Cr	Cu	Pb	Li	Hg	Ni	Se	Ag	Sn	Zn
40 New Sites												
BEAR	5.04E-04	ND	1.48E-03	1.09E-03	4.92E-03	4.83E-04	ND	3.82E-04	1.09E-04	2.20E-05	1.42E-04	4.41E-03
BROWARD	2.98E-04	ND	2.31E-03	1.12E-03	7.73E-03	8.29E-04	5.36E-06	3.18E-04	1.65E-04	5.52E-05	1.90E-04	5.91E-03
CHARLES	4.93E-04	3.31E-05	1.14E-03	4.55E-04	1.62E-03	1.20E-04	2.62E-05	8.60E-04	2.49E-04	4.81E-06	3.54E-05	2.22E-03
CHERRY	3.10E-04	3.36E-05	1.44E-03	1.78E-03	2.87E-03	1.04E-03	8.77E-06	4.90E-04	2.10E-04	1.39E-05	1.01E-04	4.64E-03
DALHOUS	2.16E-04	1.15E-05	3.00E-03	1.29E-03	3.13E-03	5.61E-04	ND	2.83E-04	1.45E-04	7.41E-05	2.45E-04	5.10E-03
DIAS	9.57E-04	6.66E-06	1.06E-03	5.85E-04	1.06E-03	3.31E-04	5.96E-06	4.01E-04	1.74E-04	1.09E-05	4.75E-05	2.49E-03
DORR	1.85E-04	ND	2.34E-03	1.01E-03	3.72E-03	7.77E-04	ND	3.08E-04	2.04E-04	5.00E-05	2.21E-04	4.72E-03
HALFMOON	5.10E-04	3.94E-05	1.56E-03	9.83E-04	4.20E-03	4.79E-04	2.64E-05	6.59E-04	3.62E-04	1.24E-05	9.91E-05	3.47E-03
HAT26	ND	4.17E-05	2.62E-03	5.20E-04	1.04E-03	2.42E-03	1.82E-05	1.80E-04	ND	1.61E-05	2.11E-04	1.47E-02
HELENA	1.54E-03	1.59E-03	8.17E-03	6.85E-03	5.82E-03	ND	8.31E-05	6.57E-03	4.41E-03	2.62E-05	2.73E-04	1.88E-02
HOWELL	3.09E-04	1.27E-05	1.76E-03	2.12E-03	3.29E-03	5.74E-04	4.98E-06	3.86E-04	1.09E-04	6.75E-05	1.56E-04	8.66E-03
INDUSPL	2.94E-04	5.34E-05	1.65E-03	2.50E-03	2.50E-02	4.74E-04	2.24E-05	1.00E-03	4.07E-05	3.02E-04	2.03E-04	5.42E-03
JOHNSON	1.48E-04	1.08E-05	1.11E-03	6.98E-04	2.36E-03	5.70E-04	3.49E-06	3.42E-04	1.93E-04	1.76E-05	8.80E-05	7.14E-03
KERR	2.26E-03	ND	1.87E-03	7.03E-04	4.86E-03	1.25E-03	ND	2.58E-04	1.63E-04	2.96E-05	1.13E-04	3.99E-03
LHAT26	8.63E-05	1.18E-05	2.14E-03	1.46E-04	9.35E-04	4.89E-04	3.14E-06	2.35E-04	ND	9.42E-06	6.52E-05	1.78E-03
LHATSB	3.48E-04	2.76E-05	1.73E-03	5.93E-04	8.30E-04	1.82E-03	1.21E-05	2.84E-04	ND	2.24E-05	2.41E-04	5.47E-03
LHNBPL	1.10E-04	3.05E-05	1.32E-03	2.99E-04	7.17E-04	4.67E-04	4.37E-06	3.08E-04	ND	1.51E-05	8.68E-05	2.75E-03
LOCCR	ND	ND	3.38E-03	5.12E-04	1.12E-03	1.37E-03	1.50E-05	2.36E-04	ND	4.71E-05	4.64E-04	9.46E-03
LORANCRK	ND	8.84E-05	3.86E-03	8.84E-04	1.80E-03	2.11E-03	6.46E-06	2.53E-04	ND	7.02E-05	3.20E-04	2.93E-02
LOUISA	2.29E-04	ND	1.92E-03	1.17E-03	1.14E-02	8.98E-04	3.59E-06	3.22E-04	1.54E-04	4.47E-05	1.92E-04	4.04E-03
MAITL	2.70E-04	1.48E-05	9.62E-04	4.77E-03	2.60E-03	4.15E-04	7.32E-06	3.29E-04	4.00E-05	5.06E-06	5.02E-05	2.86E-03
MILLD	2.23E-04	ND	1.08E-03	6.22E-04	3.95E-02	1.25E-03	3.51E-06	4.13E-04	2.27E-04	3.42E-05	1.91E-04	1.08E-02
NBLACK	1.55E-04	1.92E-05	1.17E-03	2.59E-04	9.64E-04	4.86E-04	3.23E-06	2.10E-04	ND	1.09E-05	6.80E-05	3.98E-03
NEWLKA	ND	5.85E-05	1.89E-03	2.35E-03	9.38E-04	1.55E-03	1.80E-05	4.20E-04	ND	2.42E-05	2.38E-04	9.17E-03
NEWLKB	ND	4.41E-05	1.96E-03	1.46E-03	9.96E-04	1.90E-03	1.45E-05	2.76E-04	ND	2.90E-05	2.20E-04	8.79E-03
NEWLKC	3.01E-04	4.53E-05	1.00E-03	7.65E-04	4.59E-03	2.07E-04	2.18E-05	5.20E-04	1.06E-04	1.31E-05	1.91E-04	6.09E-03
NEWLKD	3.86E-04	3.54E-05	1.34E-03	5.92E-04	1.60E-03	2.37E-04	1.65E-05	6.77E-04	1.28E-04	5.80E-06	7.90E-05	4.05E-03
NEWLKE	3.21E-04	2.31E-05	1.46E-03	7.40E-04	1.26E-03	2.76E-04	1.38E-05	6.63E-04	1.57E-04	5.34E-06	4.71E-05	2.82E-03
NEWLKF	4.02E-04	2.35E-05	1.53E-03	5.39E-04	1.08E-03	2.84E-04	1.29E-05	6.88E-04	1.29E-04	6.26E-06	4.70E-05	2.32E-03
NORRIS	2.89E-04	1.47E-05	8.54E-04	4.05E-04	1.57E-03	6.68E-04	1.04E-05	5.26E-04	6.75E-05	4.23E-06	3.69E-05	1.61E-03
OLA	3.60E-04	7.76E-06	1.47E-03	1.79E-03	2.20E-03	5.39E-04	2.56E-06	4.26E-04	1.11E-04	2.56E-05	1.28E-04	3.31E-03
PCR-PL	4.92E-04	2.05E-04	5.32E-03	1.77E-03	5.08E-03	ND	5.02E-05	1.70E-03	ND	5.55E-05	3.18E-04	1.68E-02

FIELD ID	Aluminum Normalized Metals Concentrations											
	As	Cd	Cr	Cu	Pb	Li	Hg	Ni	Se	Ag	Sn	Zn
SELLERS	2.28E-04	ND	2.29E-03	1.34E-03	3.12E-03	1.02E-03	3.12E-06	2.42E-04	1.61E-04	4.68E-05	2.14E-04	9.41E-03
SILRV	3.26E-03	9.56E-04	6.81E-02	3.28E-03	4.87E-03	ND	8.72E-05	9.01E-03	5.81E-03	1.91E-04	5.75E-04	1.91E-02
SJRJESUP	1.29E-04	1.66E-05	1.13E-03	2.05E-04	7.89E-04	5.12E-04	2.83E-06	1.72E-04	ND	1.47E-05	5.86E-05	3.05E-03
SJRPLTKA	3.02E-04	2.33E-05	1.47E-03	5.36E-04	1.30E-03	3.20E-04	6.51E-06	2.75E-04	1.02E-04	1.72E-05	2.46E-04	3.76E-03
SOUTH	8.72E-04	1.26E-05	2.29E-03	8.94E-04	3.18E-03	5.87E-04	2.87E-05	1.34E-03	7.88E-04	1.42E-05	9.16E-05	8.49E-03
SUNLAND	ND	3.03E-05	2.23E-03	5.17E-04	2.85E-02	1.64E-03	8.98E-06	2.98E-04	ND	1.97E-05	2.60E-04	7.74E-03
WASH	2.47E-05	1.26E-05	1.02E-03	4.46E-04	1.13E-03	4.40E-04	9.60E-06	3.74E-04	7.83E-05	7.02E-06	3.98E-05	2.33E-03
WINN	1.76E-04	7.67E-06	9.84E-04	5.63E-04	2.55E-03	3.40E-04	3.32E-06	2.55E-04	1.20E-04	1.02E-05	5.21E-05	2.53E-03
Detailed Assessment Sites												
BIVENA	3.22E-04	7.40E-05	7.49E-03	2.63E-03	8.96E-03	NA	2.07E-05	1.10E-03	NA	3.09E-05	NA	1.29E-02
BIVENB	1.86E-04	6.58E-05	8.42E-03	1.79E-03	1.46E-02	NA	1.71E-05	8.60E-04	NA	2.90E-05	NA	1.03E-02
BIVENC	5.27E-04	6.67E-05	6.23E-03	2.19E-03	8.26E-03	NA	2.11E-05	9.53E-04	NA	2.53E-05	NA	1.12E-02
BIVEND	6.98E-04	1.12E-04	1.03E-02	3.58E-03	2.08E-02	NA	3.61E-05	1.30E-03	NA	3.96E-05	NA	2.36E-02
BIVENE	4.55E-04	6.20E-05	6.13E-03	1.73E-03	1.38E-02	NA	1.59E-05	8.57E-04	NA	2.00E-05	NA	8.27E-03
BIVENF	ND	ND	7.62E-03	2.89E-03	8.59E-03	NA	7.76E-05	ND	NA	1.99E-04	NA	8.77E-03
DORAA	ND	ND	1.98E-03	1.04E-03	ND	NA	ND	ND	NA	ND	NA	4.05E-03
DORAB	9.40E-04	1.72E-05	1.31E-03	9.93E-04	1.75E-03	NA	1.49E-05	4.66E-04	NA	1.07E-05	NA	2.71E-03
DORAC	1.28E-03	2.34E-05	1.26E-03	1.69E-03	2.92E-03	NA	1.63E-05	4.88E-04	NA	1.41E-05	NA	3.89E-03
DORAD	1.41E-03	3.53E-05	1.51E-03	2.96E-03	3.84E-03	NA	1.95E-05	6.50E-04	NA	1.34E-05	NA	6.68E-03
DORAE	1.11E-03	3.68E-05	1.52E-03	3.00E-03	3.18E-03	NA	1.65E-05	6.23E-04	NA	1.21E-05	NA	6.54E-03
DORAF	1.08E-03	2.66E-05	1.54E-03	2.39E-03	1.48E-03	NA	1.27E-05	5.75E-04	NA	1.21E-05	NA	3.81E-03
DORAG	1.03E-03	2.39E-05	1.70E-03	2.63E-03	1.38E-03	NA	1.40E-05	5.62E-04	NA	1.25E-05	NA	3.78E-03
EUSTA	7.66E-04	4.45E-05	1.57E-03	2.00E-03	6.60E-03	NA	2.35E-05	6.01E-04	NA	1.87E-05	NA	8.23E-03
EUSTB	ND	ND	5.20E-03	2.46E-03	4.87E-03	NA	ND	ND	NA	1.12E-04	NA	5.57E-03
EUSTC	9.21E-04	2.42E-05	1.32E-03	1.30E-03	3.39E-03	NA	1.68E-05	4.37E-04	NA	1.63E-05	NA	3.49E-03
EUSTD	8.27E-04	2.50E-05	1.34E-03	1.43E-03	3.09E-03	NA	1.92E-05	5.20E-04	NA	1.32E-05	NA	3.88E-03
EUSTE	1.03E-03	1.79E-05	1.68E-03	1.66E-03	3.28E-03	NA	2.39E-05	5.66E-04	NA	2.20E-05	NA	4.36E-03
EUSTF	6.14E-04	2.77E-05	1.30E-03	1.03E-03	2.33E-03	NA	1.82E-05	4.95E-04	NA	2.09E-05	NA	3.49E-03
EUSTG	ND	ND	2.83E-03	1.83E-03	3.09E-03	NA	2.25E-05	ND	NA	6.84E-05	NA	4.77E-03
GRIFFA	9.51E-04	5.23E-05	2.12E-03	2.90E-03	4.53E-03	NA	3.18E-05	7.93E-04	NA	7.18E-05	NA	8.96E-03
GRIFFB	1.01E-03	2.66E-05	1.95E-03	1.04E-03	1.73E-03	NA	2.00E-05	7.13E-04	NA	2.26E-05	NA	2.61E-03
GRIFFC	1.22E-03	4.51E-05	2.00E-03	2.24E-03	4.03E-03	NA	3.34E-05	8.29E-04	NA	4.62E-05	NA	6.01E-03
GRIFFD	6.22E-04	1.44E-05	2.16E-03	7.91E-04	1.83E-03	NA	1.16E-05	4.52E-04	NA	1.42E-05	NA	2.41E-03
GRIFFE	1.03E-03	2.41E-05	1.98E-03	1.23E-03	3.23E-03	NA	1.79E-05	6.23E-04	NA	1.34E-05	NA	3.21E-03
GRIFFF	1.38E-03	3.00E-05	2.09E-03	1.47E-03	3.56E-03	NA	2.70E-05	8.20E-04	NA	1.55E-05	NA	3.24E-03

FIELD ID	Aluminum Normalized Metals Concentrations											
	As	Cd	Cr	Cu	Pb	Li	Hg	Ni	Se	Ag	Sn	Zn
HARA	1.23E-03	3.48E-05	2.31E-03	1.39E-03	2.00E-03	NA	3.06E-05	7.80E-04	NA	8.91E-06	NA	3.88E-03
HARB	7.36E-04	2.31E-05	1.65E-03	9.53E-04	2.26E-03	NA	1.72E-05	5.67E-04	NA	1.16E-05	NA	2.16E-03
HARC	5.53E-04	3.23E-05	1.97E-03	1.71E-03	3.39E-03	NA	2.29E-05	6.30E-04	NA	2.38E-05	NA	3.53E-03
HARD	6.74E-04	2.73E-05	1.56E-03	1.38E-03	2.77E-03	NA	1.83E-05	5.76E-04	NA	8.52E-06	NA	2.93E-03
HARE	6.94E-04	3.88E-05	2.14E-03	2.25E-03	3.99E-03	NA	2.35E-05	7.64E-04	NA	1.74E-05	NA	5.49E-03
HARF	1.12E-03	3.61E-05	1.86E-03	1.94E-03	3.79E-03	NA	2.52E-05	7.81E-04	NA	1.09E-05	NA	4.13E-03
HOGA	ND	1.93E-04	3.82E-03	1.02E-03	3.40E-03	NA	2.18E-05	9.92E-04	NA	4.88E-05	NA	9.92E-03
HOGB	ND	6.96E-05	8.84E-03	5.47E-03	1.58E-03	NA	6.59E-06	3.52E-03	NA	3.46E-05	NA	3.30E-03
HOGC	ND	7.33E-05	3.80E-03	4.16E-04	2.78E-03	NA	7.49E-06	5.07E-04	NA	1.34E-05	NA	4.60E-03
HOGD	ND	4.90E-05	3.25E-03	1.35E-03	4.50E-03	NA	2.43E-05	6.52E-04	NA	3.92E-05	NA	7.07E-03
MONA	1.77E-04	1.39E-05	1.55E-03	1.33E-03	1.55E-03	NA	3.75E-06	4.61E-04	NA	1.88E-05	NA	2.59E-03
MONB	1.47E-04	1.84E-05	1.35E-03	1.04E-03	1.17E-03	NA	8.41E-06	4.03E-04	NA	2.33E-05	NA	2.93E-03
MONC	1.74E-04	1.37E-05	1.29E-03	5.49E-04	7.28E-04	NA	7.46E-06	4.15E-04	NA	1.52E-05	NA	1.61E-03
MOND	ND	ND	9.89E-04	4.39E-04	8.75E-04	NA	2.07E-06	1.87E-04	NA	1.40E-05	NA	1.21E-03
MONE	1.64E-04	1.07E-05	1.29E-03	7.21E-04	8.23E-04	NA	6.40E-06	4.49E-04	NA	1.56E-05	NA	1.36E-03
MONF	ND	6.17E-06	1.40E-03	6.35E-04	7.32E-04	NA	3.42E-06	2.41E-04	NA	2.21E-05	NA	1.50E-03
MONG	1.11E-04	7.63E-06	1.01E-03	5.95E-04	7.02E-04	NA	4.27E-06	2.43E-04	NA	1.22E-05	NA	1.26E-03
SWEETA	3.00E-04	1.33E-04	3.63E-03	1.91E-03	6.78E-03	NA	1.80E-05	9.24E-04	NA	6.58E-05	NA	1.22E-02
SWEETB	1.88E-04	6.82E-05	4.19E-03	1.25E-03	3.18E-03	NA	1.61E-05	6.35E-04	NA	1.38E-04	NA	6.59E-03
SWEETC	ND	7.11E-05	2.77E-03	2.43E-03	1.26E-02	NA	2.08E-05	9.17E-04	NA	3.71E-05	NA	1.72E-02
SWEETD	ND	1.10E-04	3.20E-03	7.03E-04	4.31E-03	NA	1.43E-05	5.60E-04	NA	3.60E-05	NA	6.49E-03
SWEETE	8.11E-04	2.10E-04	1.32E-02	2.56E-03	6.66E-02	NA	2.76E-05	1.17E-03	NA	7.41E-05	NA	2.66E-02

Table 3-8c. Metals Data — Normalized to Grain Size (% Mud)

FIELD ID	Grain Size Normalized Metals Concentrations (mg/kg/%Mud)											
	As	Cd	Cr	Cu	Pb	Li	Hg	Ni	Se	Ag	Sn	Zn
40 New Sites												
BEAR	0.103	ND	0.303	0.224	1.01	0.099	ND	0.078	0.022	4.51E-03	0.029	0.905
BROWARD	0.064	ND	0.492	0.238	1.65	0.176	1.14E-03	0.068	0.035	1.18E-02	0.041	1.26
CHARLES	0.070	4.67E-03	0.161	0.0642	0.229	0.017	3.70E-03	0.121	0.035	6.80E-04	0.005	0.314
CHERRY	0.036	3.92E-03	0.168	0.207	0.334	0.122	1.02E-03	0.057	0.025	1.62E-03	0.012	0.541
DALHOUS	0.068	3.61E-03	0.942	0.405	0.984	0.176	ND	0.089	0.046	2.33E-02	0.077	1.61
DIAS	0.281	1.96E-03	0.311	0.172	0.311	0.097	1.75E-03	0.118	0.051	3.21E-03	0.014	0.731
DORR	0.061	ND	0.773	0.333	1.23	0.257	ND	0.102	0.067	1.65E-02	0.073	1.56
HALFMOON	0.087	6.70E-03	0.265	0.167	0.714	0.082	4.50E-03	0.112	0.062	2.12E-03	0.017	0.590
HAT26	NA[a]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HELENA	0.116	1.20E-01	0.614	0.515	0.437	ND	6.24E-03	0.494	0.331	1.97E-03	0.021	1.41
HOWELL	0.054	2.23E-03	0.309	0.372	0.577	0.101	8.73E-04	0.068	0.019	1.18E-02	0.027	1.52
INDUSPL	0.080	1.45E-02	0.449	0.677	6.77	0.129	6.08E-03	0.272	0.011	8.20E-02	0.055	1.47
JOHNSON	0.028	2.05E-03	0.210	0.132	0.445	0.108	6.58E-04	0.065	0.036	3.32E-03	0.017	1.35
KERR	1.41	ND	1.16	0.438	3.03	0.782	ND	0.161	0.101	1.85E-02	0.070	2.49
LHAT26	0.127	1.74E-02	3.15	0.215	1.38	0.721	4.63E-03	0.346	ND	1.39E-02	0.096	2.63
LHATSB	0.115	9.07E-03	0.568	0.195	0.273	0.600	4.00E-03	0.093	ND	7.37E-03	0.080	1.80
LHNBPL	0.133	3.70E-02	1.61	0.363	0.870	0.567	5.30E-03	0.373	ND	1.84E-02	0.105	3.33
LOCCR	ND	ND	0.948	0.144	0.315	0.385	4.21E-03	0.066	ND	1.32E-02	0.130	2.66
LORANCRK	NA[a]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
LOUISA	0.101	ND	0.845	0.516	5.03	0.395	1.58E-03	0.142	0.068	1.97E-02	0.084	1.77
MAITL	0.252	0.014	0.897	4.44	2.43	0.387	0.0068	0.306	0.037	0.005	0.047	2.67
MILLD	0.093	ND	0.453	0.260	16.5	0.525	1.47E-03	0.173	0.095	1.43E-02	0.080	4.53
NBLACK	0.057	7.00E-03	0.427	0.095	0.352	0.178	1.18E-03	0.077	ND	3.97E-03	0.025	1.45
NEWLKA	ND	3.17E-02	1.03	1.280	0.508	0.842	9.75E-03	0.228	ND	1.31E-02	0.129	4.97
NEWLKB	ND	2.61E-02	1.16	0.867	0.589	1.13	8.58E-03	0.163	ND	1.72E-02	0.130	5.20
NEWLKC	0.191	2.87E-02	0.633	0.484	2.91	0.131	1.38E-02	0.329	0.067	8.32E-03	0.121	3.86
NEWLKD	0.141	1.30E-02	0.490	0.216	0.586	0.086	6.02E-03	0.247	0.047	2.12E-03	0.029	1.48
NEWLKE	0.104	7.46E-03	0.470	0.239	0.407	0.089	4.46E-03	0.214	0.051	1.72E-03	0.015	0.910
NEWLKF	0.129	7.52E-03	0.488	0.172	0.347	0.091	4.13E-03	0.220	0.041	2.00E-03	0.015	0.741
NORRIS	0.134	6.82E-03	0.396	0.188	0.729	0.310	4.81E-03	0.244	0.031	1.96E-03	0.017	0.746
OLA	0.055	1.18E-03	0.222	0.271	0.333	0.082	3.88E-04	0.065	0.017	3.89E-03	0.019	0.502
PCR-PL	0.031	1.27E-02	0.331	0.110	0.316	ND	3.12E-03	0.105	ND	3.45E-03	0.020	1.04

FIELD ID	Grain Size Normalized Metals Concentrations (mg/kg/%Mud)											
	As	Cd	Cr	Cu	Pb	Li	Hg	Ni	Se	Ag	Sn	Zn
SELLERS	0.073	ND	0.736	0.430	1.00	0.328	1.00E-03	0.078	0.052	1.50E-02	0.069	3.02
SILRV	0.066	1.95E-02	1.39	0.067	0.099	ND	1.78E-03	0.183	0.118	3.90E-03	0.012	0.389
SJRJESUP	0.053	6.79E-03	0.464	0.084	0.323	0.210	1.16E-03	0.071	ND	6.04E-03	0.024	1.25
SJRPLTKA	0.105	8.10E-03	0.512	0.187	0.454	0.111	2.27E-03	0.096	0.036	6.00E-03	0.086	1.31
SOUTH	0.080	1.16E-03	0.210	0.082	0.292	0.054	2.64E-03	0.123	0.072	1.30E-03	0.008	0.779
SUNLAND	ND	7.16E-02	5.26	1.220	67.2	3.88	2.12E-02	0.704	ND	4.64E-02	0.614	18.3
WASH	0.009	4.60E-03	0.372	0.163	0.411	0.161	3.50E-03	0.136	0.029	2.56E-03	0.015	0.849
WINN	0.042	1.83E-03	0.235	0.134	0.609	0.081	7.94E-04	0.061	0.029	2.43E-03	0.012	0.604
Detailed Site Assessment												
BIVENA	0.094	2.17E-02	2.20	0.772	2.63	NA	6.08E-03	0.322	NA	9.06E-03	NA	3.78
BIVENB	0.082	2.90E-02	3.71	0.788	6.43	NA	7.54E-03	0.379	NA	1.28E-02	NA	4.54
BIVENC	0.200	2.53E-02	2.36	0.828	3.13	NA	7.99E-03	0.361	NA	9.60E-03	NA	4.26
BIVEND	0.310	4.96E-02	4.59	1.59	9.25	NA	1.60E-02	0.575	NA	1.76E-02	NA	10.5
BIVENE	0.343	4.67E-02	4.62	1.30	10.4	NA	1.20E-02	0.646	NA	1.50E-02	NA	6.23
BIVENF	ND	ND	0.603	0.229	0.680	NA	6.14E-03	ND	NA	1.58E-02	NA	0.694
DORAA	ND	ND	0.842	0.444	ND	NA	ND	ND	NA	ND	NA	1.72
DORAB	0.667	1.22E-02	0.931	0.704	1.24	NA	1.05E-02	0.331	NA	7.57E-03	NA	1.92
DORAC	0.789	1.45E-02	0.781	1.04	1.80	NA	1.01E-02	0.302	NA	8.70E-03	NA	2.40
DORAD	0.612	1.54E-02	0.658	1.29	1.67	NA	8.50E-03	0.283	NA	5.84E-03	NA	2.91
DORAE	0.473	1.56E-02	0.647	1.28	1.35	NA	7.02E-03	0.265	NA	5.13E-03	NA	2.78
DORAF	0.455	1.13E-02	0.652	1.01	0.626	NA	5.39E-03	0.243	NA	5.10E-03	NA	1.61
DORAG	0.320	7.42E-03	0.528	0.817	0.429	NA	4.35E-03	0.175	NA	3.88E-03	NA	1.17
EUSTA	0.374	2.17E-02	0.768	0.976	3.22	NA	1.15E-02	0.293	NA	9.13E-03	NA	4.01
EUSTB	ND	ND	1.73	0.820	1.62	NA	ND	ND	NA	3.72E-02	NA	1.86
EUSTC	0.442	1.16E-02	0.631	0.623	1.63	NA	8.05E-03	0.209	NA	7.83E-03	NA	1.67
EUSTD	0.449	1.36E-02	0.727	0.777	1.68	NA	1.04E-02	0.282	NA	7.15E-03	NA	2.11
EUSTE	0.119	2.05E-03	0.192	0.190	0.376	NA	2.74E-03	0.065	NA	2.52E-03	NA	0.499
EUSTF	0.482	2.18E-02	1.02	0.806	1.83	NA	1.43E-02	0.388	NA	1.64E-02	NA	2.74
EUSTG	ND	ND	0.103	0.067	0.113	NA	8.19E-04	ND	NA	2.49E-03	NA	0.174
GRIFFA	0.272	1.49E-02	0.606	0.829	1.29	NA	9.09E-03	0.226	NA	2.05E-02	NA	2.56
GRIFFB	0.420	1.10E-02	0.807	0.429	0.717	NA	8.28E-03	0.295	NA	9.36E-03	NA	1.08
GRIFFC	0.284	1.05E-02	0.469	0.523	0.943	NA	7.81E-03	0.194	NA	1.08E-02	NA	1.41
GRIFFD	0.376	8.70E-03	1.31	0.478	1.11	NA	7.01E-03	0.273	NA	8.59E-03	NA	1.46
GRIFFE	0.354	8.25E-03	0.677	0.420	1.10	NA	6.13E-03	0.213	NA	4.60E-03	NA	1.10
GRIFFF	0.262	5.69E-03	0.395	0.279	0.674	NA	5.12E-03	0.155	NA	2.93E-03	NA	0.614

FIELD ID	Grain Size Normalized Metals Concentrations (mg/kg/%Mud)										
	As	Cd	Cr	Cu	Pb	Li	Hg	Ni	Se	Ag	Sn	Zn
HARA	0.313	8.88E-03	0.590	0.355	0.510	NA	7.81E-03	0.199	NA	2.27E-03	NA	0.988
HARB	0.480	1.51E-02	1.07	0.621	1.48	NA	1.12E-02	0.370	NA	7.58E-03	NA	1.41
HARC	0.063	3.66E-03	0.223	0.194	0.384	NA	2.59E-03	0.071	NA	2.70E-03	NA	0.400
HARD	0.473	1.92E-02	1.09	0.966	1.94	NA	1.28E-02	0.404	NA	5.97E-03	NA	2.05
HARE	0.220	1.23E-02	0.677	0.713	1.26	NA	7.44E-03	0.242	NA	5.52E-03	NA	1.74
HARF	0.616	1.98E-02	1.02	1.06	2.07	NA	1.38E-02	0.427	NA	5.98E-03	NA	2.26
HOGA	ND	2.35E-01	4.66	1.24	4.15	NA	2.66E-02	1.21	NA	5.95E-02	NA	12.1
HOGB	ND	3.74E-02	4.75	2.94	0.848	NA	3.54E-03	1.89	NA	1.86E-02	NA	1.78
HOGC	ND	4.59E-02	2.38	0.260	1.74	NA	4.69E-03	0.317	NA	8.36E-03	NA	2.88
HOGD	ND	7.87E-03	0.523	0.217	0.724	NA	3.90E-03	0.105	NA	6.31E-03	NA	1.14
MONA	0.076	6.00E-03	0.667	0.574	0.667	NA	1.62E-03	0.199	NA	8.10E-03	NA	1.12
MONB	0.093	1.16E-02	0.851	0.657	0.736	NA	5.30E-03	0.254	NA	1.47E-02	NA	1.84
MONC	0.118	9.24E-03	0.873	0.371	0.492	NA	5.05E-03	0.280	NA	1.02E-02	NA	1.09
MOND	ND	ND	0.314	0.140	0.278	NA	6.57E-04	0.060	NA	4.44E-03	NA	0.386
MONE	0.104	6.79E-03	0.822	0.459	0.524	NA	4.07E-03	0.286	NA	9.91E-03	NA	0.865
MONF	ND	1.83E-03	0.416	0.189	0.217	NA	1.02E-03	0.072	NA	6.57E-03	NA	0.446
MONG	0.071	4.85E-03	0.645	0.379	0.447	NA	2.72E-03	0.154	NA	7.78E-03	NA	0.802
SWEETA	0.135	6.00E-02	1.63	0.859	3.05	NA	8.09E-03	0.416	NA	2.96E-02	NA	5.50
SWEETB	0.111	4.04E-02	2.48	0.742	1.88	NA	9.55E-03	0.376	NA	8.19E-02	NA	3.90
SWEETC	ND	6.91E-02	2.69	2.37	12.2	NA	2.02E-02	0.892	NA	3.60E-02	NA	16.7
SWEETD	ND	3.56E-02	1.04	0.228	1.40	NA	4.65E-03	0.181	NA	1.17E-02	NA	2.10
SWEETE	0.504	1.30E-01	8.22	1.59	41.4	NA	1.72E-02	0.730	NA	4.61E-02	NA	16.6

[a] The HAT26 and LORANCRK sediments consisted of 100% sand, and %mud normalized data could therefore not be calculated.

Normalization of the metals data to sediment grain size (% Mud, which is defined as the sum of the % silt and % clay) (Table 3-8c) lowered the variability in sediment concentrations for a subset of metals. For example, the grain-size normalized Cu concentration in the 40 new sediment samples ranged from 0.064 to 4.44 mg/kg/% mud, a factor of about 70 difference in the concentration between the high and the low sites. The raw (not normalized) Cu results showed a low-to-high site concentration difference of a factor of about 280. Additional reductions in variability, by normalizing to grain size, were also observed for Fe, Cu, and Ni for the 40 new sites. Notable reductions in variability, by normalizing to grain size, were observed for Al, Cr, Cu, and Zn for the detailed assessment sites.

3.3 Results for Nutrients Analysis

The nutrient analysis results are summarized in Tables 3-9 and 3-10, and are also compiled in Appendix E. Total Kjeldahl nitrogen (TKN), total phosphorus (TP), and soluble reactive phosphorus (orthophosphate; OP) are reported in mg/kg dry weight. Nutrient analysis was only performed for the 40 new district-wide assessment sites, to generate a dataset consistent with the original district-wide assessment study (SJRWMD, 1998).

Table 3-9. Concentration Ranges for Nutrients

Nutrients	Concentration (mg/kg dry weight)		
	Median	Min	Max
Original Study Sites			
TKN	1,570	ND	49,000
TP	355	ND	8,070
OP	0.8	ND	68
40 New Sites			
TKN	968	30	27,900
TP	196	14	4,260
OP	0.9	ND	8.0

TKN, TP, and OP concentrations were highly variable throughout the study area. Median concentrations of nutrients in the 40 new sites were generally lower than in the original study sites. The TKN concentrations measured in this study ranged from 30 mg/kg [site LORANCRK (Little Orange Creek)] to 27,900 mg/kg [site NEWLKD (Mouth of Lake Forest Creek)], while the TP concentrations ranged from 14 mg/kg [site HAT26 (Hatchet Creek)] to 4,260 mg/kg [site NEWLKD (Mouth of Lake Forest Creek)]. Median concentrations for TKN and TP were 968 mg/kg and 196 mg/kg, respectively. The OP concentrations were somewhat less variable, than the TKN and TP concentrations, ranging from ND to 8 mg/kg [site HELENA (Helena Run)]. The median OP concentration was 0.9 mg/kg. Approximately 23% of the sediments analyzed (9 of 40 sites) had no detectable concentrations of OP.

Table 3-10. Nutrient Data

FIELD ID	TKN (mg/kg dry wt.)	TP (mg/kg dry wt.)	OP (mg/kg dry wt.)
40 New Sites			
BEAR	568	154	0.6
BROWARD	369	58	0.5
CHARLES	19,600	818	4.5
CHERRY	1,100	79	ND
DALHOUS	401	55	ND
DIAS	5,110	252	2.0
DORR	176	30	0.6
HALFMOON	18,900	759	4.5
HAT26	41	14	ND
HELENA	23,300	2,730	8.0
HOWELL	900	157	0.9
INDUSPL	7,350	717	1.9
JOHNSON	1,960	179	ND
KERR	294	33	0.7
LHAT26	262	1,230	3.1
LHATSB	238	33	ND
LHNBPL	143	2,290	1.5
LOCCR	267	27	0.5
LORANCRK	30	34	ND
LOUISA	217	29	ND
MAITL	2,090	1,260	1.9
MILLD	503	39	ND
NBLACK	1,140	457	0.6
NEWLKA	367	51	1.1
NEWLKB	406	45	2.5
NEWLKC	11,800	915	2.2
NEWLKD	27,900	4,260	7.8
NEWLKE	27,400	3,900	6.7
NEWLKF	22,000	3,520	5.8
NORRIS	13,300	2,020	4.4
OLA	995	63	ND
PCR-PL	1,630	819	1.1
SELLERS	281	22	0.6
SILRV	3,250	865	0.8
SJRJESUP	374	212	0.9
SJRPLTKA	1,860	1,140	1.1
SOUTH	7,250	409	0.8
SUNLAND	57	47	1.1
WASH	17,700	729	1.3
WINN	941	120	0.6

3.4 Results for Ancillary Measurements

Tables 3-11 and 3-12 present the results of the ancillary measurement analyses [total organic carbon (TOC), grain size, moisture content, total solids (TS), and total volatile solids (TVS)] for the 40 new sites and the 63 detailed assessment sites. These data are also presented in more detail in Appendix E (40 new sites) and Appendix H (detailed assessment sites). The TOC and TVS data are presented as percent dry weight. Moisture and TS data are presented on a 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 the percent mud value is used for normalizing the metals concentrations to grain size. Table 3-11 presents the median values and the ranges of concentrations for these ancillary measurements, and Table 3-12 summarizes the data for each individual site. As shown in Table 3-11, the ancillary measurements results obtained for the 40 new sites and the 63 detailed assessment sites have very similar minimum and maximum values as those measured in the original study sites, but the median concentrations are quite different for several measures.

Table 3-11. Ranges for Ancillary Measurements

Ancillary Measurement	Median	Min	Max
Original Study Sites			
%Moisture	62.6	16.1	96.6
%TOC	3.12	0.02	45
%TS (wet weight)	37.4	3.4	83.9
%TVS (dry weight)	9.45	ND	71.2
%Sand	75.6	21	100
%Silt	21.5	ND	72
%Clay	2.0	ND	13
%Mud	24.4	ND	80
40 New Sites			
%Moisture	37.4	19.0	94.8
%TOC	0.91	0.03	36.5
%TS (wet weight)	62.6	5.2	81.0
%TVS (dry weight)	21.5	ND	56.8
%Sand	84.2	23.6	100
%Silt	14.3	ND	66.1
%Clay	1.2	ND	10.4
%Mud	15.9	ND	76.5
Detailed Assessment Sites			
%Moisture	85.3	17.5	96.8
%TOC	16.1	0.1	44.5
%TS (wet weight)	14.7	3.2	82.5
%TVS (dry weight)	26.3	ND	73.3
%Sand	73.4	32.4	99.0
%Silt	25.5	0.9	65.2
%Clay	0.9	ND	5.2
%Mud	26.6	0.9	67.6

[a] Median values not available for original study sites.

Table 3-12. Ancillary Measurement Summary Data

FIELD ID	%Moisture	%TOC	%TS (wet wt)	%TVS (dry wt)	%Sand	%Silt	%Clay	%Mud
40 New Sites								
BEAR	31.0	0.6	69.0	1.0	88.4	9.6	2.0	11.6
BROWARD	26.3	0.3	73.7	0.9	91.5	6.9	1.6	8.5
CHARLES	86.8	34.2	13.2	46.6	23.6	66.1	10.4	76.5
CHERRY	31.8	1.9	68.2	2.6	82.5	15.4	2.1	17.5
DALHOUS	27.5	0.5	72.5	0.8	92.5	6.3	1.3	7.6
DIAS	72.2	4.2	27.8	16.0	77.3	21.2	1.5	22.7
DORR	20.5	0.3	79.5	0.7	96.7	2.5	0.8	3.3
HALFMOON	86.3	25.7	13.7	47.9	32.3	62.4	5.2	67.6
HAT26	20.0	0.04	80.0	ND	100.0	ND	ND	ND
HELENA	94.5	34.0	5.5	52.5	81.1	18.3	0.6	18.9
HOWELL	40.2	1.1	59.8	1.5	84.3	14.8	1.0	15.8
INDUSPL	76.0	24.4	24.0	30.9	81.1	17.4	1.5	18.9
JOHNSON	37.3	2.3	62.7	4.6	68.1	26.9	5.0	31.9
KERR	22.1	0.3	77.9	0.6	96.6	2.6	0.8	3.4
LHAT26	20.5	0.2	79.5	0.8	95.1	2.3	2.5	4.8
LHATSB	27.3	0.3	72.7	0.8	95.9	3.6	0.5	4.1
LHNBPL	20.4	0.2	79.6	0.5	97.1	2.1	0.9	3.0
LOCCR	25.4	0.2	74.6	1.0	96.7	2.8	0.5	3.3
LORANCRK	20.2	0.03	79.8	ND	99.5	ND	ND	ND
LOUISA	23.6	0.3	76.4	0.6	96.3	2.6	1.2	3.8
MAITL	53.7	1.8	46.3	4.8	74.8	23.6	1.6	25.2
MILLD	25.8	4.4	74.2	1.1	96.8	2.7	0.5	3.2
NBLACK	47.7	1.4	52.3	4.6	73.2	22.9	3.8	26.7
NEWLKA	25.7	0.3	74.3	0.6	98.6	1.2	ND	1.2
NEWLKB	24.1	0.3	75.9	1.2	98.7	1.2	ND	1.2
NEWLKC	87.1	25.9	12.9	50.0	92.0	7.6	ND	7.6
NEWLKD	94.6	36.5	5.4	56.8	54.2	44.7	1.0	45.7
NEWLKE	94.8	29.6	5.2	46.7	47.7	51.1	1.2	52.3
NEWLKF	93.6	25.5	6.4	42.2	51.8	47.1	1.1	48.2
NORRIS	83.8	23.0	16.2	32.4	40.8	51.4	7.7	59.1
OLA	43.0	0.7	57.0	2.0	79.1	19.7	1.2	20.9
PCR-PL	48.1	2.3	51.9	7.9	79.4	16.2	4.4	20.6
SELLERS	22.8	0.2	77.2	0.7	94.7	4.5	0.8	5.3
SILRV	65.9	7.0	34.1	8.8	77.7	20.7	1.6	22.3
SJRJESUP	31.0	0.3	69.0	0.9	88.9	8.8	2.4	11.2
SJRPLTKA	53.3	3.2	46.7	5.9	80.5	18.1	1.4	19.5
SOUTH	84.6	0.7	15.4	15.6	80.2	19.5	ND	19.5
SUNLAND	19.0	0.1	81.0	ND	99.3	0.5	ND	0.5
WASH	85.6	26.8	14.4	39.5	45.7	50.0	4.3	54.3
WINN	37.5	0.5	62.5	2.3	84.0	13.8	2.2	16.0

FIELD ID	%Moisture	%TOC	%TS (wet wt)	%TVS (dry wt)	%Sand	%Silt	%Clay	%Mud
Detailed Assessment Sites								
BIVENA	91.9	25.7	8.1	37.9	57.4	41.1	1.5	42.6
BIVENB	88.4	24.5	11.6	33.0	49.6	48.6	1.8	50.4
BIVENC	93.4	28.9	6.6	37.5	62.1	36.4	1.5	37.8
BIVEND	89.9	29.0	10.1	38.4	73.4	25.2	1.4	26.6
BIVENE	93.8	44.0	6.2	49.9	64.7	34.0	1.3	35.3
BIVENF	23.0	0.4	77.0	0.5	96.3	3.5	ND	3.5
DISSA	27.3	0.8	72.7	1.7	83.9	14.0	2.2	16.2
DISSB	22.5	0.4	77.5	1.1	86.8	9.1	4.1	13.2
DISSC	86.5	22.6	13.5	33.5	40.0	54.8	5.2	60.0
DISSD	22.2	0.2	77.8	0.5	95.3	4.0	0.7	4.7
DISSE	22.3	0.2	77.7	0.8	96.9	2.5	0.6	3.1
DORAA	17.5	0.1	82.5	ND	99.0	0.9	ND	0.9
DORAB	95.3	35.9	4.7	51.4	80.8	18.9	ND	18.9
DORAC	96.0	33.5	4.0	58.8	73.1	26.5	0.5	27.0
DORAD	96.8	35.9	3.2	56.0	74.0	25.5	0.5	26.0
DORAE	96.7	40.8	3.3	60.7	72.5	26.8	0.7	27.5
DORAF	96.2	38.7	3.8	59.5	69.0	30.3	0.7	31.0
DORAG	93.4	27.0	6.6	42.5	67.8	31.3	0.9	32.2
EUSTA	95.1	36.0	4.9	62.0	70.6	28.9	ND	28.9
EUSTB	17.9	0.2	82.1	ND	99.0	0.9	ND	0.9
EUSTC	94.7	32.6	5.3	50.7	63.1	36.3	0.6	36.9
EUSTD	94.3	35.5	5.7	48.5	74.1	25.6	ND	25.6
EUSTE	80.7	11.5	19.4	14.4	75.5	24.3	ND	24.3
EUSTF	95.2	29.4	4.8	54.6	80.6	19.1	ND	19.1
EUSTG	41.1	0.9	58.9	2.1	79.9	19.9	ND	19.9
GEORGEA	21.4	0.2	78.6	ND	96.6	3.0	ND	3.0
GEORGEB	83.8	11.7	16.2	20.9	41.7	56.8	1.5	58.3
GEORGEC	82.8	10.7	17.2	18.7	41.3	57.2	1.5	58.7
GEORGED	47.3	4.1	52.7	4.0	69.9	29.1	1.0	30.1
GEORGEE	21.5	0.6	78.5	ND	96.6	3.0	0.5	3.5
GEORGEF	92.4	30.4	7.6	42.5	38.8	59.8	1.4	61.2
GEORGEG	86.5	20.9	13.5	32.3	50.0	47.9	2.1	50.0
GEORGEH	43.4	5.6	56.6	5.6	71.5	26.7	1.8	28.5
GEORGEI	68.5	3.6	31.5	7.0	47.2	51.5	1.3	52.8
GEORGEJ	86.1	16.1	13.9	26.3	40.6	57.7	1.7	59.4
GRIFFA	95.9	39.5	4.2	61.6	66.9	32.4	0.7	33.1
GRIFFB	95.6	32.9	4.4	59.5	76.4	23.3	ND	23.3
GRIFFC	95.3	42.1	4.7	64.3	64.8	34.5	0.7	35.2
GRIFFD	84.3	26.2	15.7	41.5	82.3	16.8	0.9	17.7
GRIFFE	94.5	39.7	5.5	60.1	57.7	41.4	1.0	42.4
GRIFFF	94.1	44.5	5.9	73.3	58.0	41.0	1.0	42.0
HARA	95.1	39.0	4.9	67.8	74.9	24.5	0.6	25.1
HARB	95.8	28.4	4.2	55.7	77.0	22.7	ND	22.7
HARC	75.8	8.8	24.2	11.6	75.5	24.1	ND	24.1
HARD	95.6	33.6	4.4	61.1	77.2	22.4	ND	22.4
HARE	92.2	25.9	7.8	35.7	77.3	22.3	ND	22.3
HARF	95.9	36.9	4.1	65.5	83.4	16.4	ND	16.4

FIELD ID	%Moisture	%TOC	%TS (wet wt)	%TVS (dry wt)	%Sand	%Silt	%Clay	%Mud
HOGA	17.6	0.1	82.4	ND	98.8	1.0	ND	1.0
HOGB	24.4	0.4	75.6	2.8	91.6	6.8	1.7	8.5
HOGC	21.6	0.3	78.4	2.3	94.1	4.5	1.3	5.8
HOGD	31.5	1.4	68.5	7.4	90.5	8.3	1.3	9.6
MONA	44.9	2.0	55.1	12.4	80.5	18.1	1.4	19.5
MONB	86.7	16.5	13.3	27.4	40.9	57.1	2.0	59.1
MONC	89.4	17.7	10.6	29.5	34.5	63.7	1.8	65.5
MOND	41.3	1.1	58.7	2.6	72.3	25.5	2.2	27.7
MONE	85.3	13.5	14.7	22.5	32.4	65.2	2.4	67.6
MONF	53.0	4.9	47.0	3.2	66.8	31.4	1.8	33.2
MONG	73.8	5.3	26.2	11.2	66.2	32.3	1.5	33.8
SWEETA	58.0	5.9	42.0	12.8	68.0	27.7	4.3	32.0
SWEETB	77.3	13.0	22.7	20.0	71.3	26.8	1.9	28.7
SWEETC	17.5	0.2	82.5	0.6	98.2	1.3	0.4	1.7
SWEETD	19.6	0.2	80.4	0.7	89.1	7.7	3.1	10.8
SWEETE	19.4	0.2	80.6	1.0	97.8	1.7	0.6	2.3

3.4.1 TOC Results

40 New Sites

The TOC content of the sediment varied greatly for both the 40 new sites and the 63 detailed assessment sites (Figures 3-1 and 3-2). The TOC content at the 40 new sites ranged from 0.03% [site SJRJESUP (Mid SRJ at East Barge Canal)] to 36.5% [site NEWLKD (Mouth of Lake Forest Creek)]. The median TOC content for the 40 new sites was 0.91%, which is significantly lower than for the original 1196-1997 study and the detailed assessment study. Low TOC concentrations are generally associated with coarse, sandy sediments (>90% sand). The TOC concentrations was less than 0.5% at all except two of the 40 new sites samples that consisted of more than 90% sand. However, NEWLKC and MILLD, had uncharacteristically high TOC content, 25.9% and 4.4% respectively, considering their high proportion of sand. Some of this apparently high coarser "sand" content could have been the result of plant debris remaining in the sample, which would also contribute significant amounts of TOC.

Detailed Assessment Sites

The TOC content at the 63 detailed assessment sites ranged from 0.1% [site HOGA (Hogtown Creek)] to 44.5% [site GRIFFF (Lake Griffin)]. The median TOC content at these 63 sites was 16.1%. The TOC concentrations averaged 0.4% at the detailed assessment sites with more than 90% sand, and at these sites the TOC ranged from 0.1% to 1.4%.

However, there was still *not* a good correlation between TOC and the sediment grain size (Figures 3-3 and 3-4); many of the samples in both the 40 new sites and the 63 detailed assessment sites were highly non-homogeneous and significant amounts of plant debris was observed in many samples, resulting in an atypical TOC/grain size relationships. Three (HELENA, INDUSPL, and NEWLKC) of the 40 new sites had significantly elevated TOC concentrations (>20%) with relatively high sand content (>80%). Several of the detailed assessment sites, including BIVEND, DORAB, DORAC, DORAD, DORAE, EUSTA, EUSTE, GRIFFB, GRIFFD, HARA, HARD, HARE, and HARF, also had high TOC concentrations (>25%) and a relatively high proportion of sand (>70%).

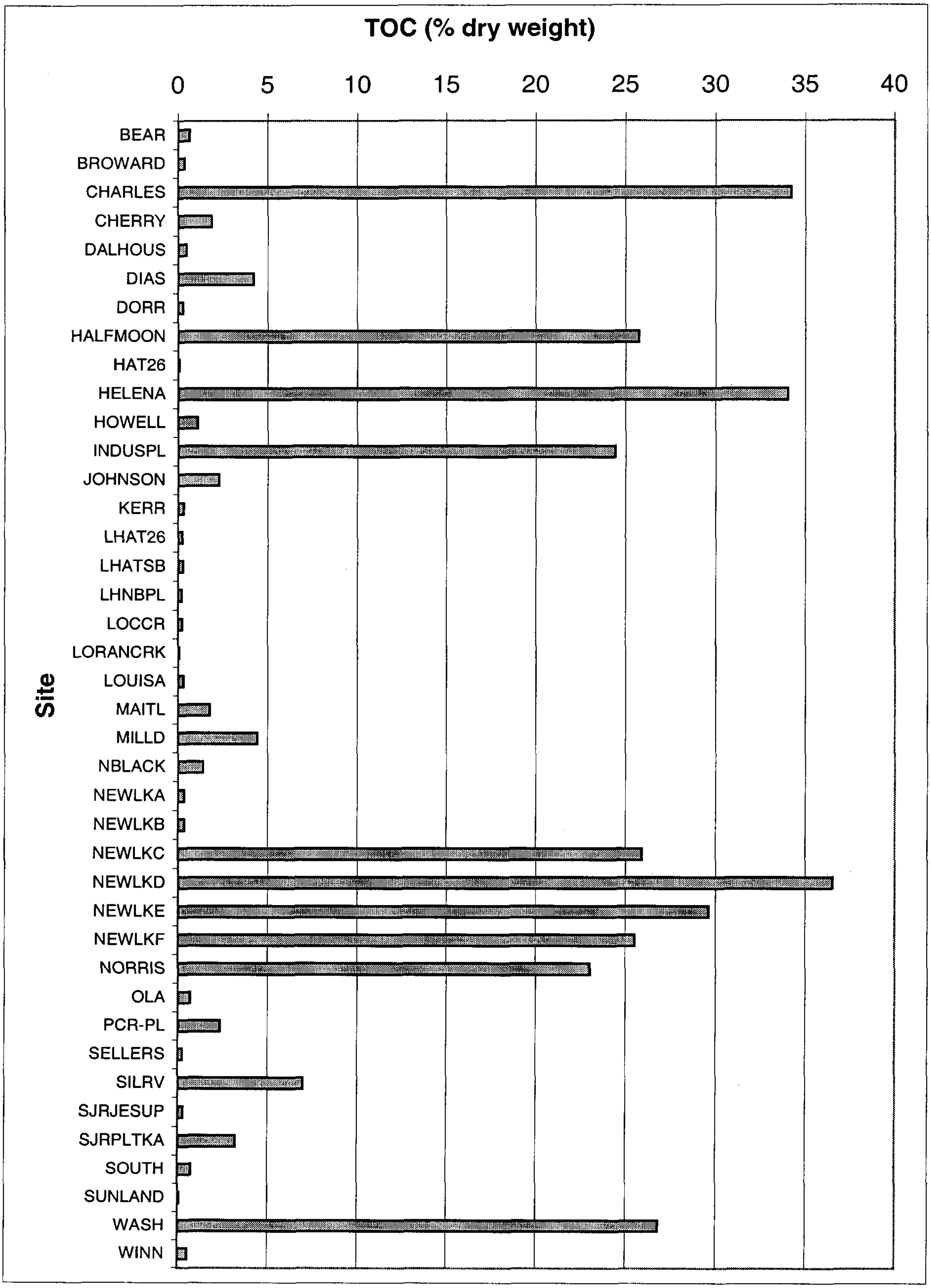


Figure 3-1. 40 New Sites — Total Organic Carbon (%TOC) of Sediments

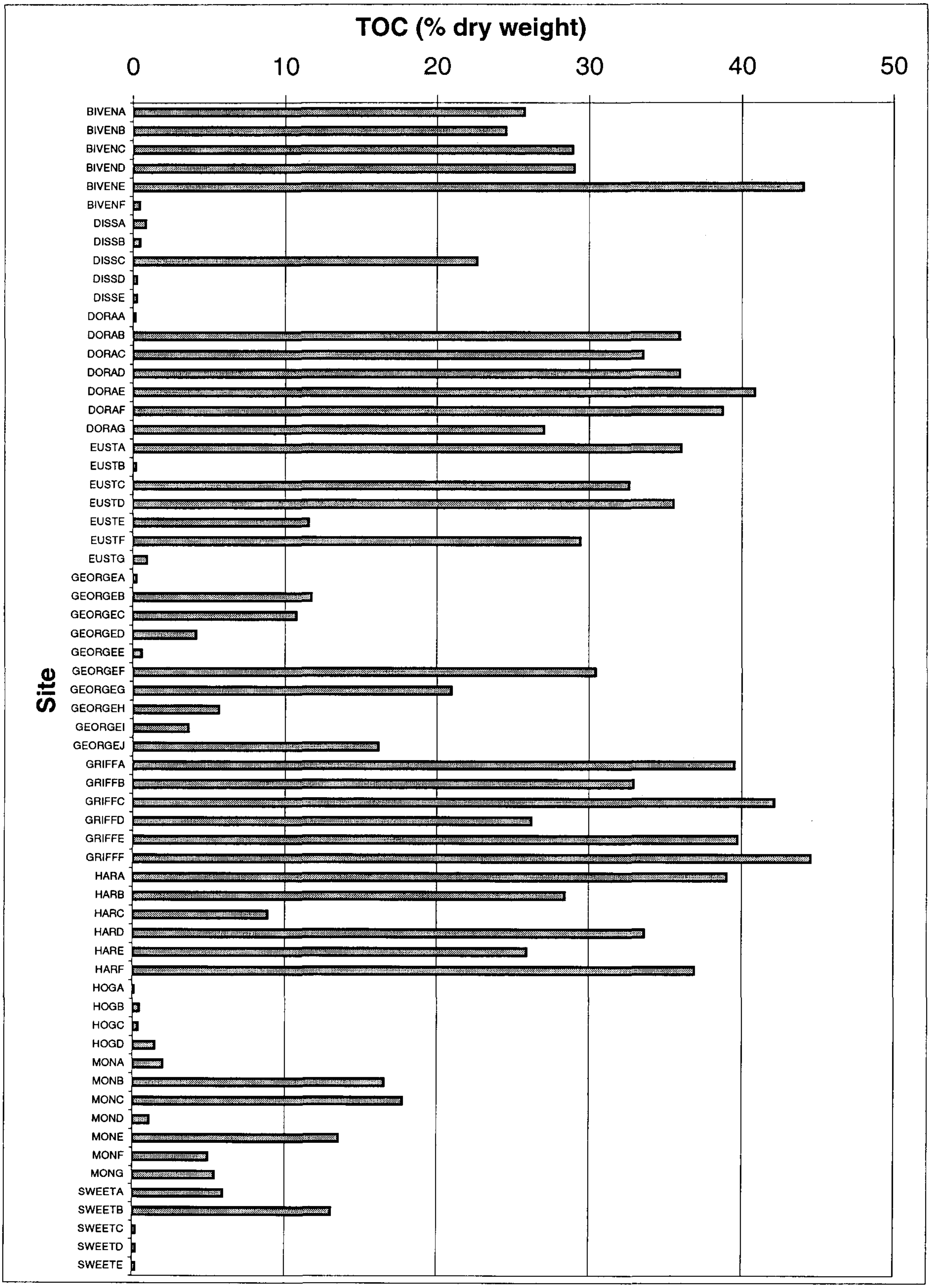


Figure 3-2. Detailed Assessment Sites — Total Organic Carbon (%TOC) of Sediments

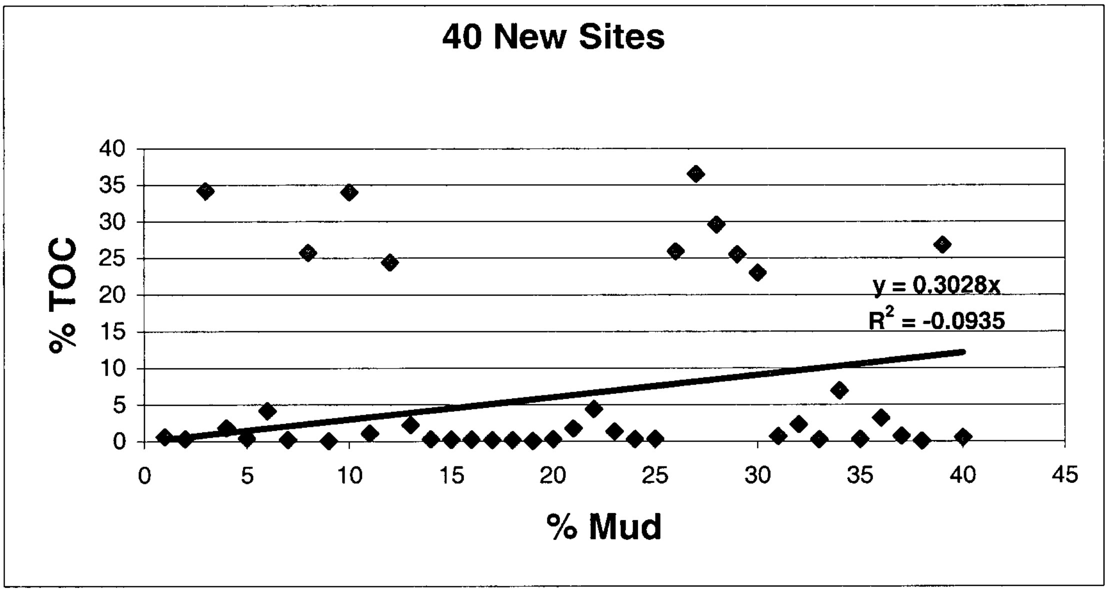


Figure 3-3. 40 New Sites — %TOC versus %Mud

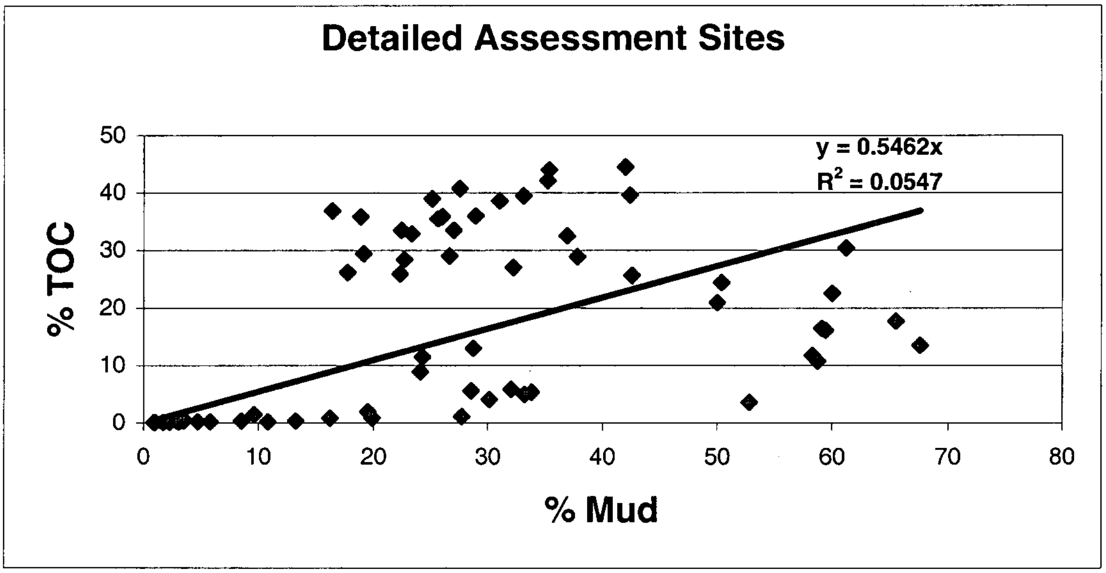


Figure 3-4. Detailed Assessment Sites — %TOC versus %Mud

3.4.2 Grain Size Results

The sediment grain-size distributions were variable and complex (Table 3-12). The sites included areas dominated by muddy (fine-grained, silty) sediments and others dominated by coarse sediments (primarily sand). Approximately 43% of the samples from the new sites (17 of the 40 sites) consisted of <10% mud (mud is defined as the silt plus clay fraction) and approximately 21% of the 63 detailed assessment site samples were <10% mud.

The ternary grain size plots presented in Figures 3-5 and 3-6 shows the grain size composition of each sample from the 40 new sites of the district wide assessment and the 63 sites from the detailed assessment study, respectively, as characterized by a continuum of grain-size distributions. Other than the fact that all samples have <10% clay, no distinct grouping(s) of sediment grain size are apparent from this analysis in either the 40 new sites or the 63 detailed assessment sites.

40 New Sites
The grain size composition of the samples from the 40 new sites is variable throughout the area and ranged from 0% to 76.5% mud [site CHARLES (Lake Charles)] and from approximately 23.6% [site CHARLES (Lake Charles)] to 100% sand [site HAT26 (Hatchet Creek)]. Percent silt and percent clay at the 40 new sites ranged from 0% to 66.1% [site CHARLES (Lake Charles)] and 0% to 10.4% [site CHARLES (Lake Charles)], respectively. Median concentrations for % sand, % silt, % clay, and % mud were 84.2%, 14.3%, 1.2%, and 15.9% respectively, from the 40 new sites.

Detailed Assessment Sites
The grain size composition at the 63 detailed assessment sites was also variable throughout the study area and ranged from 0.9% [site EUSTB (Lake Eustis)] to 67.6% mud [site MONE (Lake Monroe)] and from approximately 32.4% [site MONE (Lake Monroe)] to 99% sand [site EUSTB (Lake Eustis)]. Percent silt and percent clay for the detailed assessment sites range from 0.9% [site EUSTB (Lake Eustis)] to 65.2% [site MONE (Lake Monroe)] and 0% to 5.2% [site DISC (Lake Disston)], respectively. Median concentrations for % sand, % silt, % clay, and % mud were 73.4%, 25.5%, 0.9%, and 26.6% respectively, in the sediments from the 63 detailed assessment sites.

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

40 New Sites
Sediment moisture content, total solids (TS), and total volatile solids (TVS) also varied greatly for the different sediment samples. Moisture, TS, and TVS content were characterized by a range of distributions, with no obvious groupings of sediment types. The moisture content of the sediment collected at the 40 new sites ranges from 19% [site SUNLAND (Newnans Lake)] to 94.8% [site NEWLKE (Newnans Lake)]. The TS of the 40 new sites ranged from 5.2% [site NEWLKE (Newnans Lake)] to 81% [site SUNLAND (Newnans Lake)], and the TVS ranged from ND to 56.8% [site NEWLKD (Mouth of Lake Forest Creek)]. The median percent moisture, total solids, and total volatile solids were 37.4%, 62.6%, and 21.5% respectively for the 40 new sites.

Detailed Assessment Sites
The moisture content of the sediment from the 63 detailed assessment sites ranges from 17.5% [site DORAA (Lake Dora)] to 96.8% [site DORAD (Lake Dora)]. The TS and TVS of these sediments ranged from 3.2% [site DORAD (Lake Dora)] to 82.5% [site SWEETC (Sweetwater Branch)], and ND to 73.3% [site GRIFFF (Lake Griffin)], respectively. The median moisture content, total solids and total volatile solids were 85.3%, 14.7%, and 26.3% respectively for the 63 detailed assessment sites.

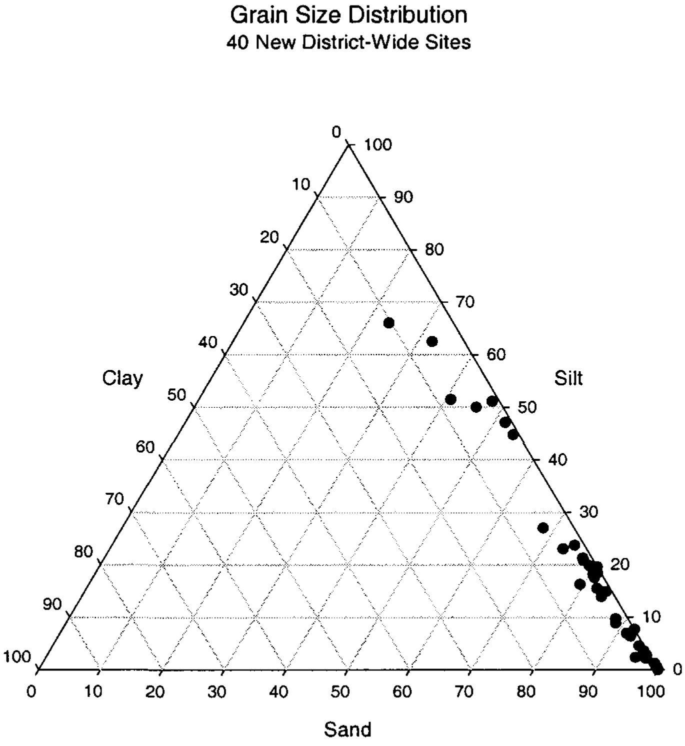


Figure 3-5. 40 New Sites — Grain Size Distribution

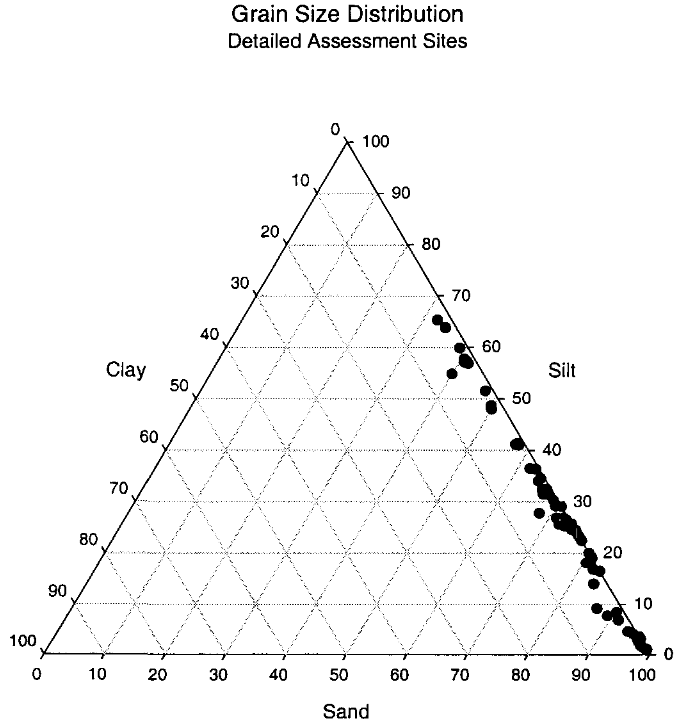


Figure 3-6. Detailed Assessment Sites — Grain Size Distribution

4. DISCUSSION

The samples collected in this study cover a range of water body types. The 40 new sites that were sampled for the district-wide assessment were collected from creeks, lakes, and rivers (Figures 2-1a and b, and Appendix A). The majority of the sites (7 of the 10 locations) that were sampled for the detailed assessment study were lakes, including Lake Dora, Lake Eustis, Lake Griffin, Lake Harris, and Lake Monroe in the mid-Florida lakes region, and Lake George and Lake Disston. The other 3 locations sampled for the detailed assessment were mostly creeks and shallow water bodies in and around Gainesville (Bivens Arm, Sweetwater Branch, and Hogtown Creek; Figures 2-2a - e, and Appendix A).

The land use in the areas sampled for the two studies is dominated by forests, wetlands, and agriculture (Figure 1-1, Appendix A), but a number of sites were also located near urban/residential areas (e.g., the Gainesville area sites). The majority of sampling sites were located in predominately rural settings, however, selected sites are located in the vicinity of urban areas such as around Gainesville, south of Jacksonville, and northern parts of Orlando.

The data assessment is separated by the two main studies that were performed; the district-wide assessment study and the detailed assessment study. The first part of the discussion section focuses on three aspects of the sediment contamination measured at the 40 new sites for the district-wide assessment. These include: 1) the general contaminant loading, distribution, and composition in the study area, and how the contaminant levels compare to those measured in other aquatic systems, 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 second part of the discussion focuses on the specific contaminant issues in the three general areas investigated for the detailed assessment; the Gainesville area sites, the mid-Florida lakes sites, and the Lake Disston and Lake George sites. The discussion focuses on 1) contaminant levels relative to those measured at these locations in the 1996-1997 study, 2) observations of any apparent geographical and contaminant distribution trends in the sediment contaminant levels at the locations in the detailed assessment study, 3) relationships of contaminant distribution to possible transport mechanisms and potential sources of the contamination, and 4) the potential impact of the contamination to the water bodies.

4.1 Contaminant Levels at 40 New District-Wide Assessment Sites

4.1.1 Organic Compound Contaminant Levels

Organic Contaminants Investigated. The major classes of organic compounds analyzed were polycyclic aromatic hydrocarbons (PAH), phthalates, polychlorinated biphenyls (PCBs), a group of other chlorinated organic compounds, and a series of chlorinated pesticides (e.g., DDTs, BHCs, endosulfans, and chlordane). These groups of compounds were categorized in Sections 3.1.1 and 3.1.2.

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 compounds from two-ring (naphthalene) to six-ring [e.g., benzo(g,h,i)perylene] PAH 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_3 and C_4 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 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 origin 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 tar-derived products seem to have a behavior intermediate between those of pyrogenic and petrogenic PAH (Hugget *et al.*, 1987).

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 compounds that were analyzed, but they are among the most widely used industrial chemicals (e.g., major components of most plastics), are part of our daily life and, therefore, are introduced into the environment from countless sources. They are also common laboratory contaminants, particularly di-N-butylphthalate and bis(2-ethylhexyl)phthalate. The "other industrial chlorinated compounds" are a group of chlorinated, relatively low molecular weight, organic compounds (e.g., chlorinated benzenes) that are also widely used in many industrial processes and applications.

PCBs are used less today than they were in the past, but are a very 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 Distribution and Composition

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

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

PAH

The highest PAH concentrations were most often found in the central region, just north of Orlando (sites MAITL, HOWELL, and NORRIS). Two other locations further north (SJRPLTKA, and NEWLK sites NEWLKC, NEWLKD, NEWLKE, and NEWLKF) also had notably higher PAH concentrations than most sites. However, all of the 40 sites had total PAH concentrations below 1,100 μg/kg; 35 sites had total PAH concentrations below 600 μg/kg and the remaining 5 sites, listed above, had concentrations between 600 and 1,100 μg/kg. All of the sites had high molecular weight PAH below 1,010 μg/kg and all sites had low molecular weight PAH below 155 μg/kg.

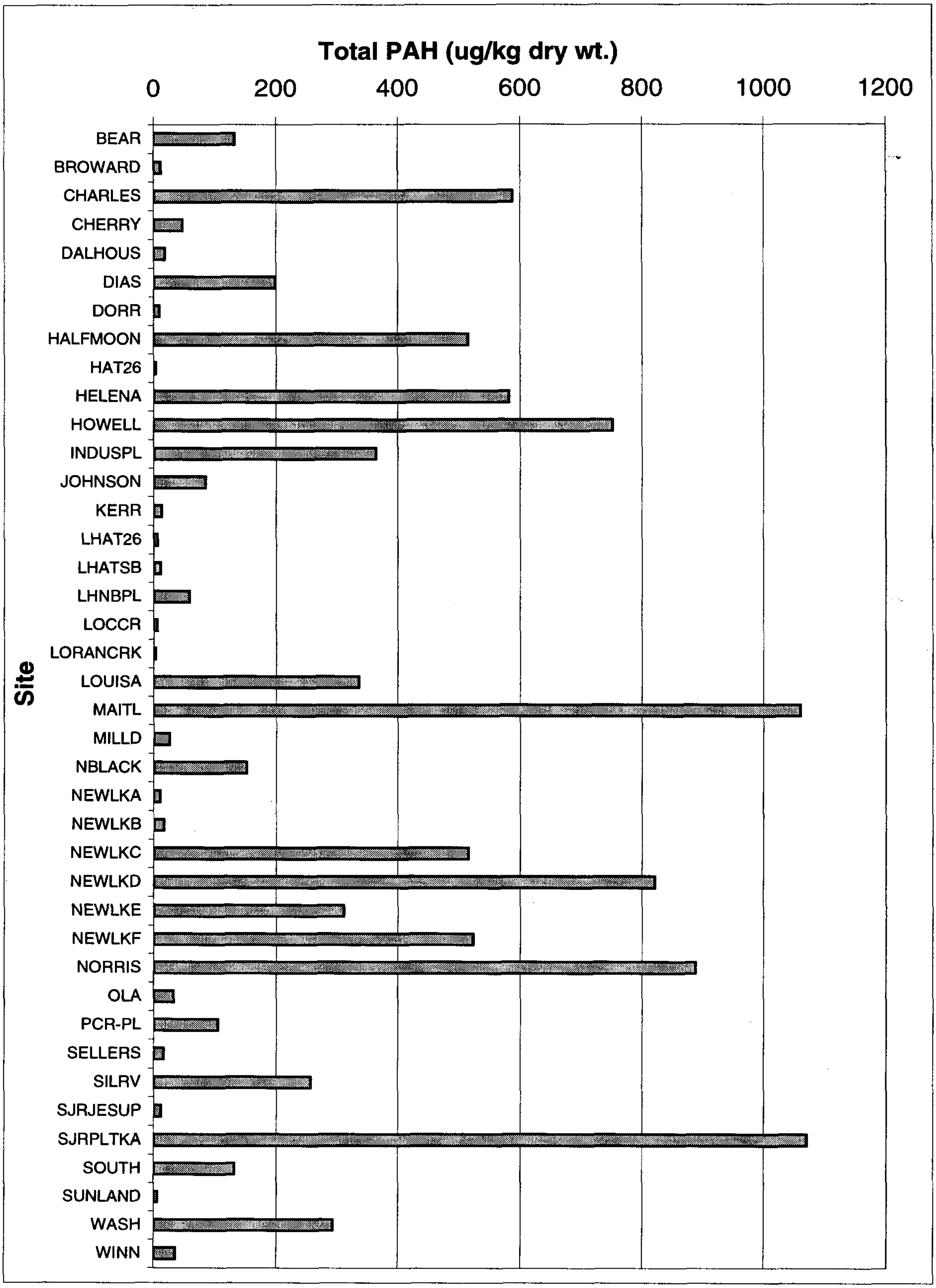


Figure 4-1a. 40 New Sites — Total PAH Concentrations

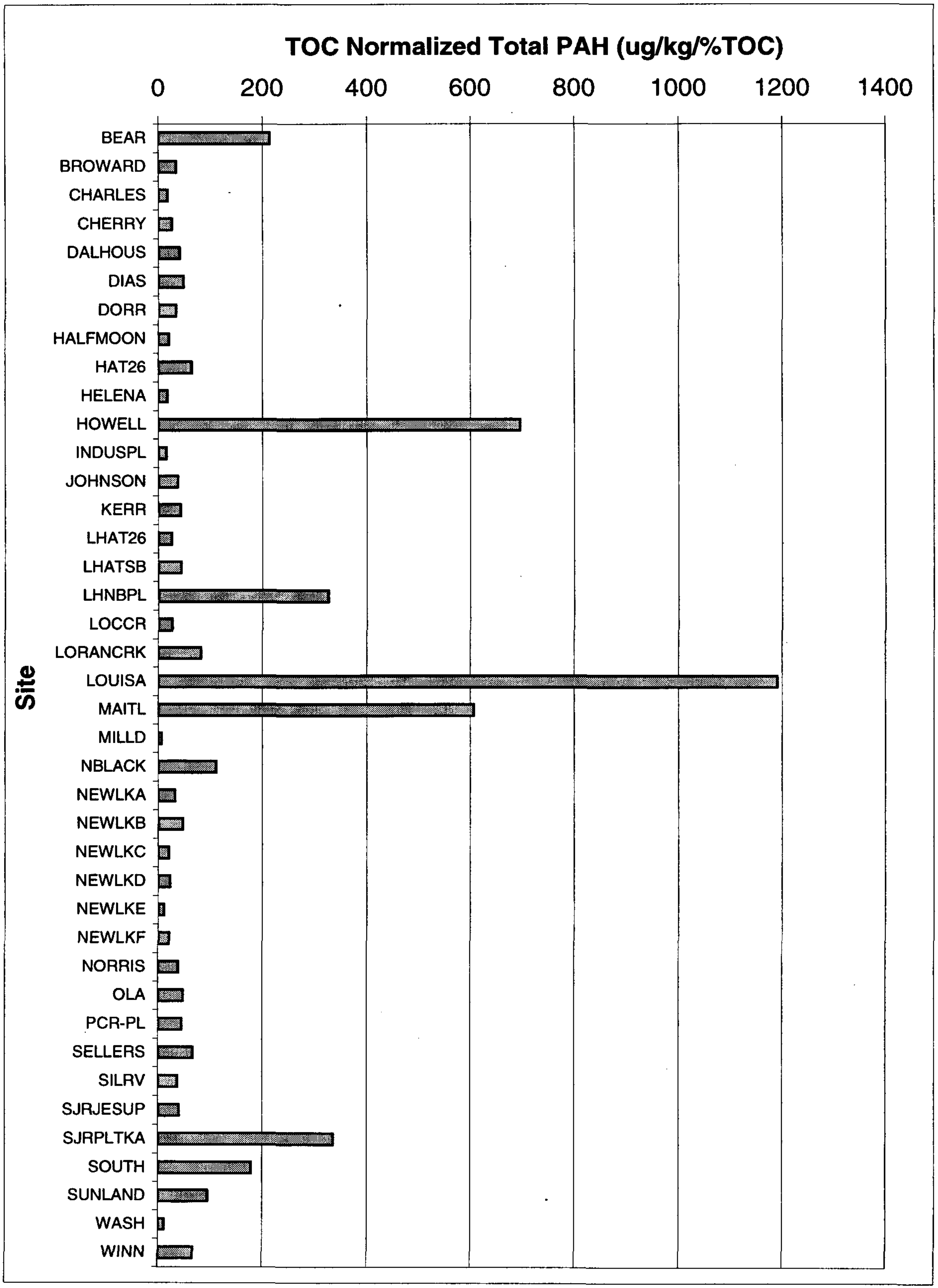


Figure 4-1b. 40 New Sites — TOC Normalized Total PAH Concentrations

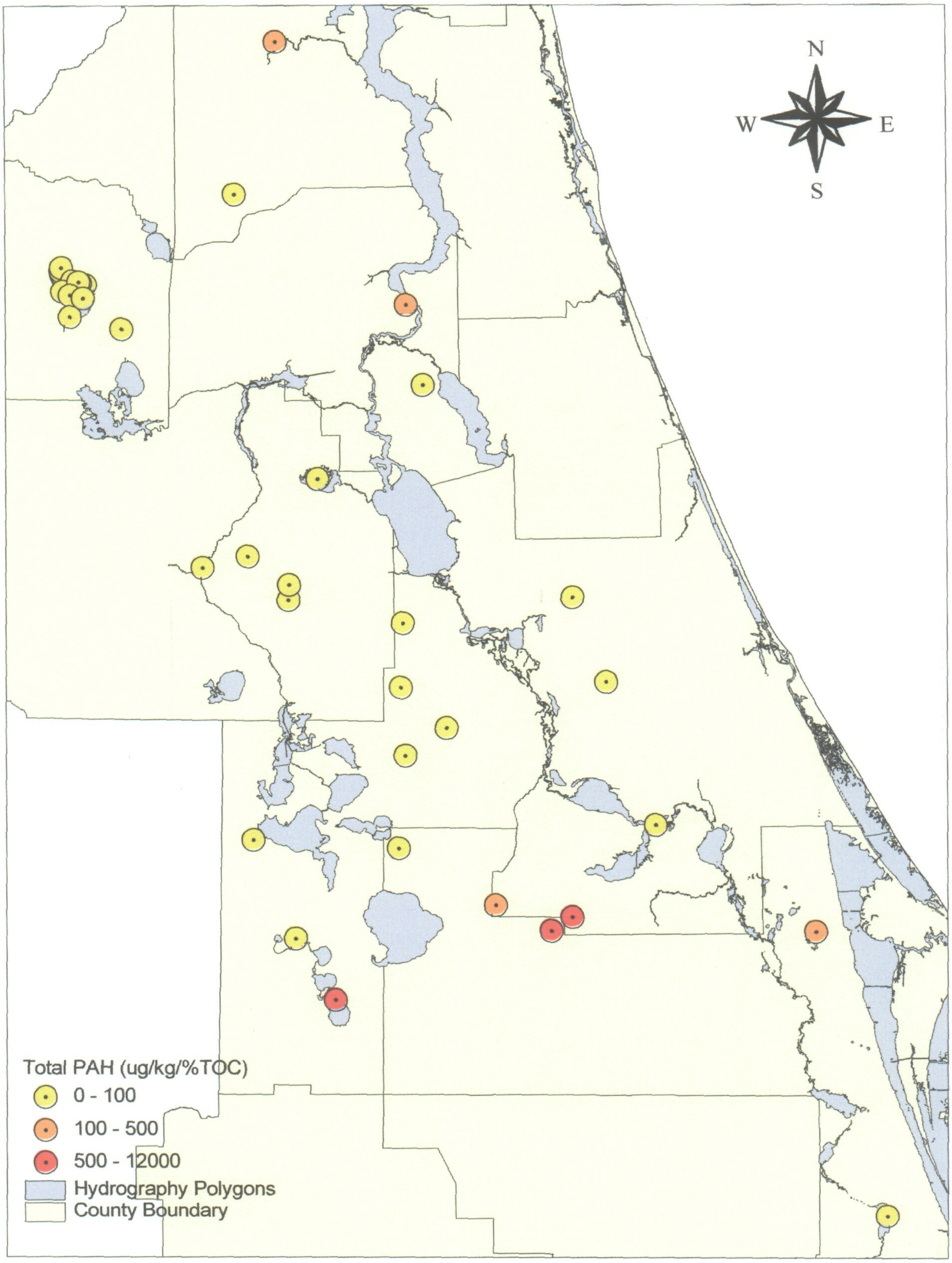


Figure 4-2. 40 New Sites — Map Displaying TOC normalized Total PAH Concentrations

When comparing the total PAH concentrations for samples from the 40 new sites to the concentrations determined for the 71 original sites sampled in the 1996-1997 district-wide assessment study, it appears that the PAH concentrations at the 40 new sites are similar or slightly lower than at similar locations in the earlier study. However, the same general regions that appeared to have more elevated levels of PAH in the 1997 study, were also elevated in this study (e.g., area just north of Orlando, Gainesville area, and the St. Johns River).

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. 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 contaminants (i.e., organic contaminants tightly bound to organic matter, or particulates, are less bioavailable than less bound compounds).

The non-normalized PAH concentration distribution (Figure 4-1a) has a slightly different appearance than the TOC normalized distribution (Figure 4-1b), with some sites appearing elevated even though their non-normalized concentrations were low [e.g., LOUISA (Lake Louisa)]. This is clearly a reflection of a low TOC content of these sediments and not of PAH concentrations that are 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. After considering all the PAH and sediment characteristics data, the sites that appear to have the most significant concentrations of PAH include MAITL (Lake Maitland), HOWELL (Lake Howell), SJRPLTKA (SJR at Palatka), and LOUISA (Lake Louisa).

The PAH concentrations measured in this study (from 2 to 1,070 µg/kg total PAH) were generally lower than what would be expected for urban or near-urban locations. The "near-urban sites" located near Gainesville, Palatka, and northern Orlando suburbs had PAH concentrations comparable to or lower than concentrations measured for urban coastal sediments elsewhere in the U.S. However, the majority of sites 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). The total PAH concentrations in the resampled surface sediment ranged from 500 to 128,000 µg/kg, and for 12 of the 14 stations the concentrations were between 700 and 40,000 µg/kg. 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. At remote reference locations in Long Island Sound the total PAH concentrations ranged from 2,200 to 2,600 µg/kg. 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. 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 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 (soot) from stack gases and more effective control of sewerage discharges, and combined sewerage overflow and storm water systems.

The "high" concentration (geometric mean plus one standard deviation of National Status and Trends (NS&T) Program site average concentrations) of total PAH in sediments from U.S. National Status and Trends monitoring sites, including the Great Lakes, is 2,180 µg/kg (Table 4-1; Daskalakis and O'Connor, 1995) based on the same 24 PAH compounds that were measured in this study. "High" concentrations for low molecular weight PAH (2- and 3-ring PAH) and high molecular weight PAH (4- through 6-ring PAH) are set at 450 µg/kg and 1,730 µg/kg, respectively, based on the NS&T data set, reflecting the greater abundance and persistence of pyrogenic PAH (from combustion products, mostly high molecular weight PAH) than petrogenic PAH (from petroleum products, mostly lower molecular weight PAH). Approximately 23% of coastal sediments monitored in various U.S. monitoring programs, including some in the Great Lakes (identified as all COSED sites in Table 4-1), contain concentrations of total PAH equal to or greater than the corresponding National Status and Trends "high" values, and 18% of the NS&T/MW sediment sites exceeded this reference value. The Coastal Sediment Database (COSED) contains data from various NOAA and EPA sources, including NS&T Program data from San Francisco and Tampa Bays, EPA sources from the Storage and Retrieval of US Waterways Parametric Data (STORET), the Ocean Data Evaluation System (ODES), EPA Region 4 complied data (REGION4), and the Environmental Monitoring and Assessment Program Estuarine Component (EMAP/EC). None (0%) of the 40 District-wide assessment sites sampled in this study had total PAH, high PAH, or low PAH concentrations that exceeded the NOAA "high" concentrations.

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

Contaminant and Contaminant Group	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	63 DTA Sites	40 DWA Sites
Study/Site Information						
Random		No[a]	Yes			
Total sites		224	500	3,878	63	40
Parameter						
Ag	0.52	16	8	22	13	3
As	13	13	8	18	8	0
Cd	0.54	16	12	31	16	5
Cr	125	14	3	11	3	0
Cu	42	18	10	25	3	3
Hg	0.22	15	12	30	35	13
Ni	42	13	5	11	0	0
Pb	45	13	12	23	19	10
Sb	2.1	15	1	8	NA	NA
Se	0.92	14	16	15	NA	33
Sn	4	12	17	20	NA	0
Zn	135	15	17	22	10	0
High MW PAH	1,730	18	9	23	NA	0
Low MW PAH	450	17	12	22	NA	0
Total PAH	2,180	14	2	6	NA	0
Total Chlordane	4.5	14	2	8	17	0
Total Dieldrin	2.9	13	1	6	14	8
Total DDT	22	18	9	23	30	8
Total PCBs	80	15	5	15	14	0

[a] "High" concentration values are in µg/kg for organic contaminants and mg/kg for metals. 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 varied somewhat 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 (combustion-related) sources, although lower molecular weight PAH, with likely petrogenic origin (petroleum- and/or oil-related), are present at lower concentrations. The pyrogenic PAH (high molecular weight PAH) constitute between 70 and 90% of the total PAH at most locations (Figure 4-3); the average relationship was about 6 times more high molecular weight PAH than low molecular weight PAH. The relatively consistent proportion of petrogenic to pyrogenic PAH in the surface sediment indicate a similarity in the sources, or types of sources, of the PAH contamination. Figure 4-4 shows the PAH composition of selected samples. The PAH composition of selected reference samples and petroleum products are compiled in Appendix J.

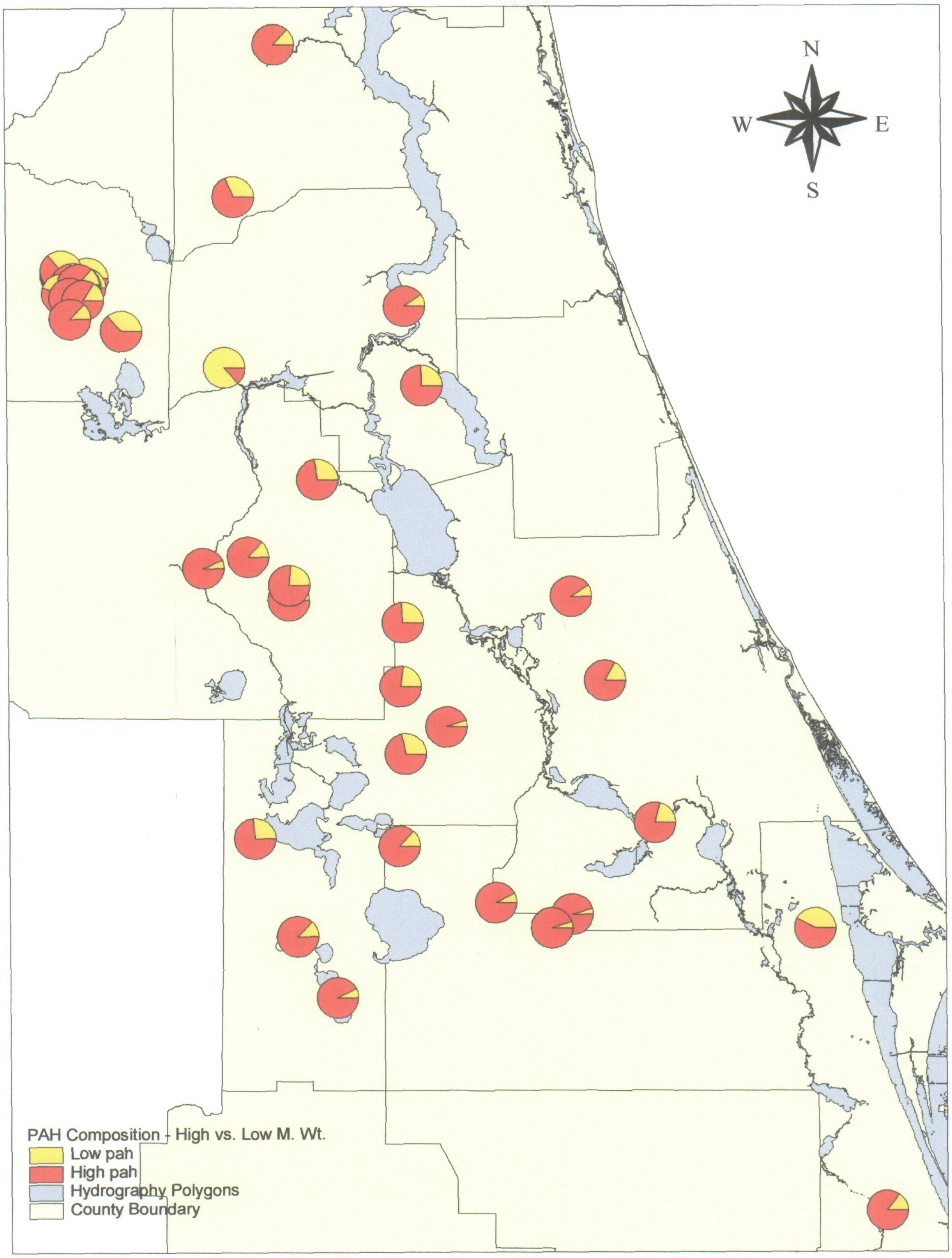
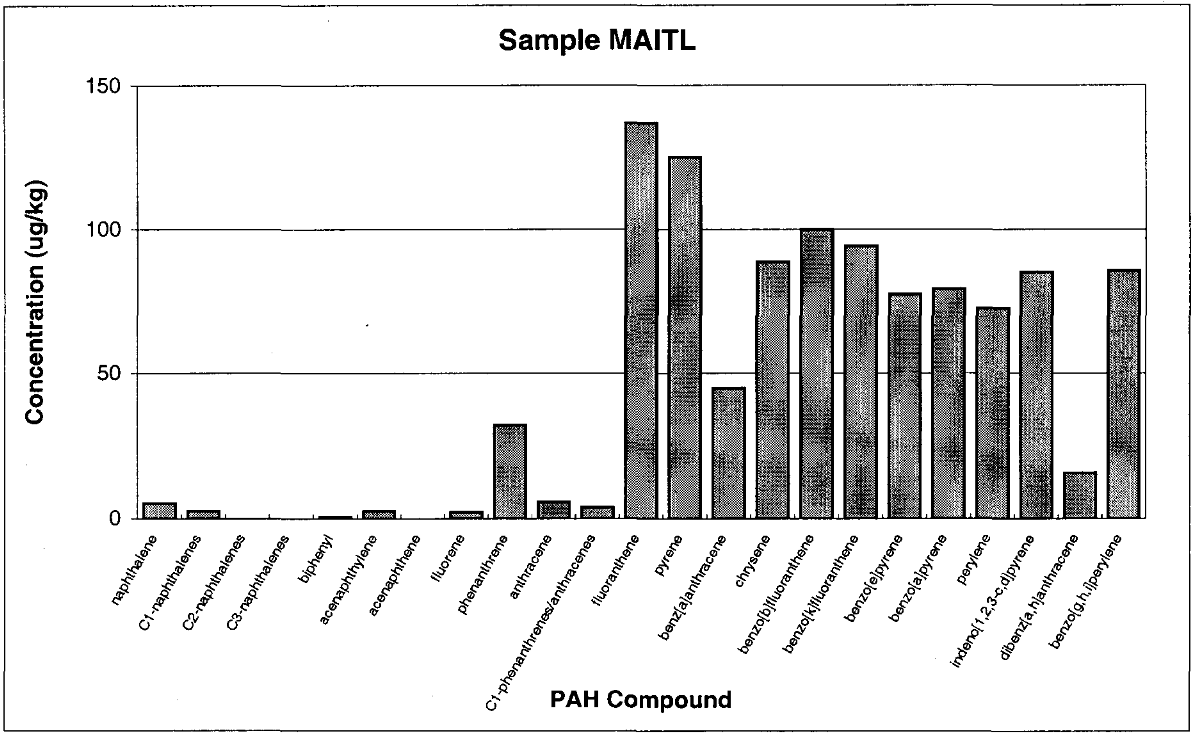


Figure 4-3. 40 New Sites — Map Displaying Relative Composition of High- and Low-Molecular Weight PAH



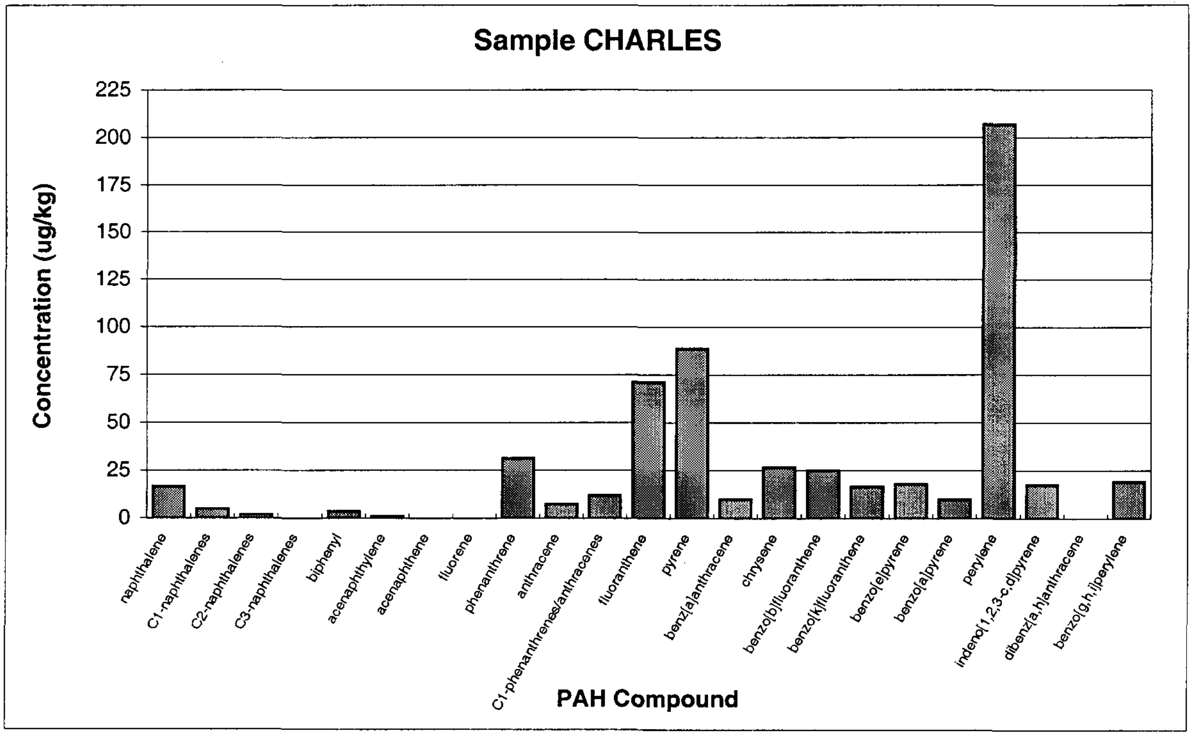
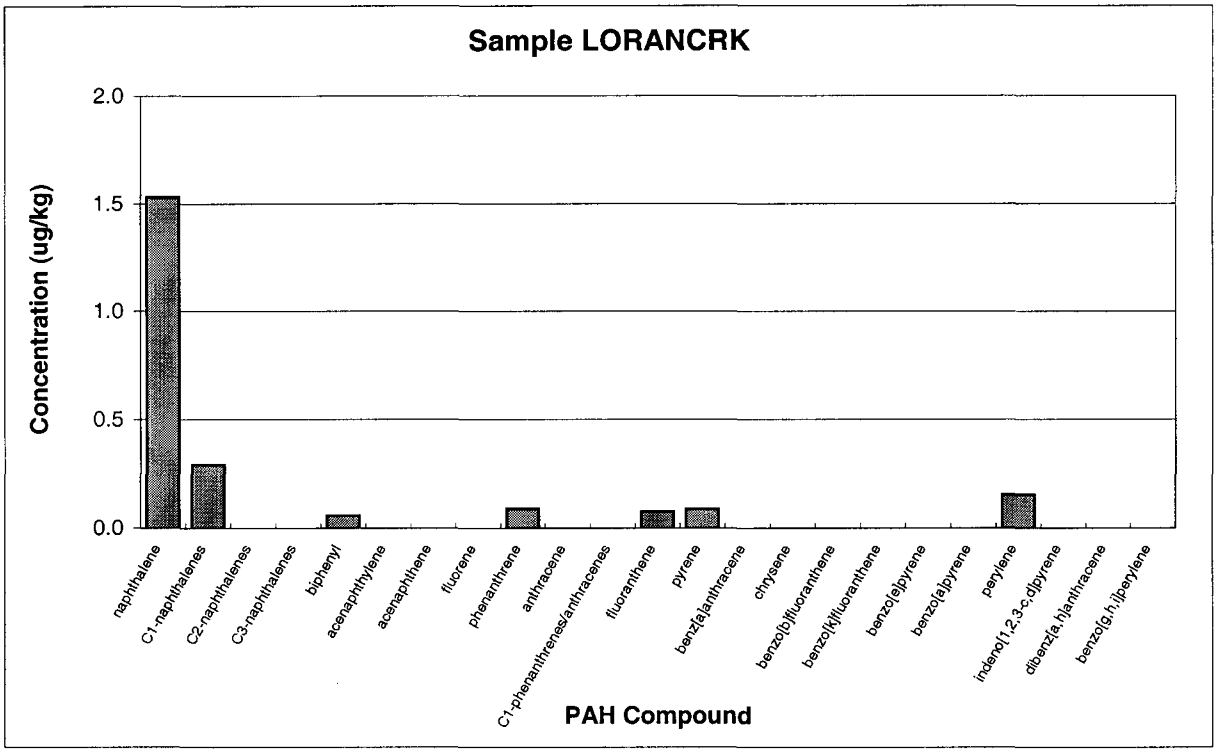


Figure 4-4. 40 New Sites — PAH Composition of Selected Samples



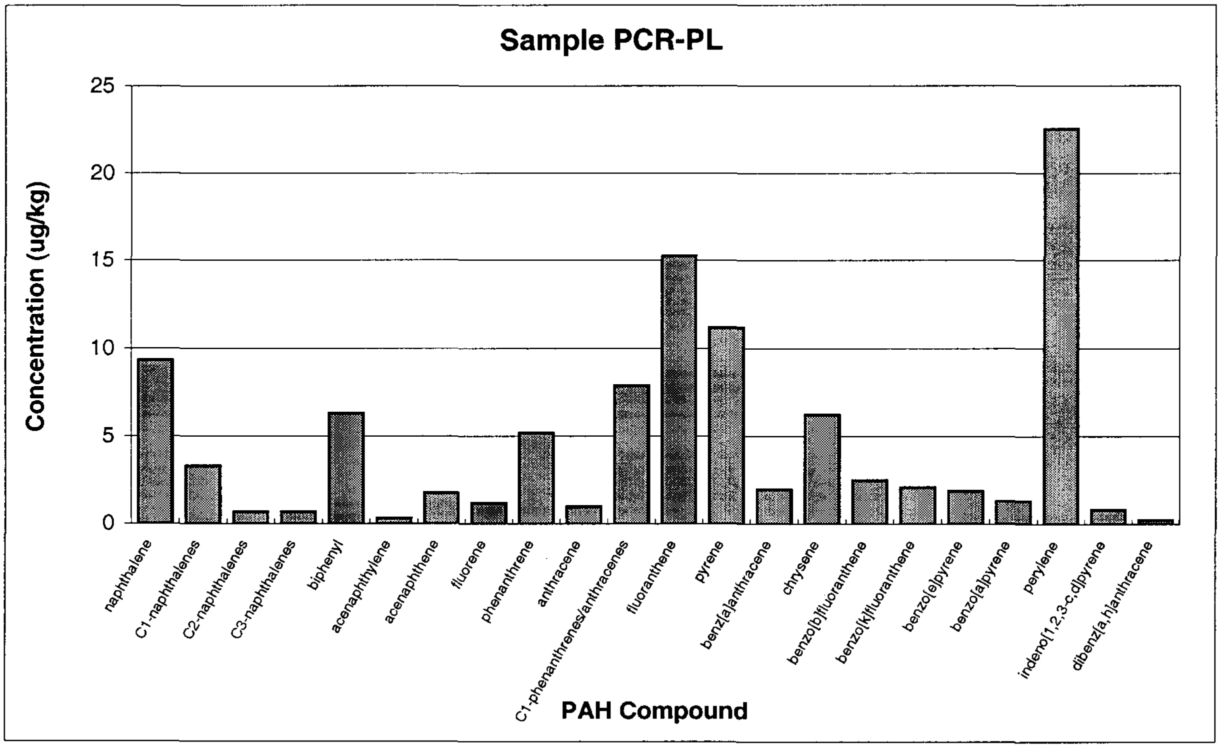


Figure 4-4 (cont). 40 New Sites — PAH Composition of Selected Samples

Most samples had a PAH composition similar to that of MAITL (Lake Maitland), or some combination of the composition of MAITL and CHARLES (Lake Charles; Figure 4-4), which is comparable to the PAH composition in the NIST SRM 1941 sediment (Appendix J). 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.

The PAH composition of the sample from CHARLES (Lake Charles; Figure 4-4), is an example of several sites that had significant biogenic contribution to the PAH composition, with a proportionately high concentration of perylene. Perylene is the dominant PAH in some of the samples with fairly low PAH concentrations, 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 perylene is not considered an important environmental contaminant

The high molecular weight PAH distribution in most sediment samples is characteristic of PAH inputs primarily from combustion sources, or hydrocarbon materials containing a mixture of high molecular weight of pyrogenic and petrogenic PAHs (e.g., coal and coke tar, coal gasification tars, carbon black, creosote, and, to some degree, asphalt). It is likely that the majority of the PAH measured at most sites originate with combustion of fossil fuels, and are transported and dispersed through atmospheric deposition, runoff, and minor local discharges.

Low concentrations of petrogenic PAH (e.g., alkylated naphthalenes, phenanthrenes) were also present in many of the samples, suggesting some contribution from weathered petroleum products. A few sites (e.g., PCR-PL and SOUTH) had a greater proportion of low molecular weight PAH than most other sites, indicating that there may be a small-scale local source of petroleum contributing to the PAH contamination. The Airport Industrial complex within the Little Hatchet Creek watershed may be a possible source of this contamination. There has been a history of hazardous waste spills in this area, which may contribute to the low molecular weight PAH at site PCR-PL, as well as elevated levels of other organic and inorganic contaminants in this area.

Phthalates

The phthalate data showed no clear geographic trend in concentrations, other than possibly some elevations in Newnans Lake; elevated phthalate concentrations were measured at mostly scattered sites. Sites with the highest phthalates were NEWLKC (Mouth of Little Hatchett Creek, 585 µg/kg; phthalates were also elevated at NEWLKD through NEWLKF) and CHARLES (Lake Charles, 341 µg/kg). The TOC normalized data indicate that sites HOWELL (Lake Howell) and LOUISA may be near potential sources of this contaminant because the concentrations remained similarly elevated relative to the rest of the sites, both non- and TOC normalized. However, the total phthalate concentrations (non-normalized and TOC normalized) at the 40 new sites were generally lower than what was measured for the 71 sites in the 1996-1997 district-wide study.

Other Chlorinated Compounds

The contaminant pattern observed for other chlorinated industrial compounds (i.e., the chlorinated benzene) was significantly moderated by TOC-normalizing the data, indicating that the elevated concentrations, although geographically focused in the Newnans Lake area, were primarily associated with high TOC samples. Chlorinated benzenes are among the most water-soluble and mobile of the chlorinated compounds, and tend to be transported in the water column and concentrated in areas of high TOC more than discretely near the source.

PCB

The sum of the PCB congener concentrations appear to be highest at HOWELL (Lake Howell), and at PCR-PL (PCR stream), when considering both the non-normalized (Figure 4-5a) and TOC normalized data (Figure 4-5b). However, on closer examination it is clear that the apparent PCB measured for HOWELL is primarily due to *non-PCB* signal, and not actual PCB. Two PCB congeners alone are contributing the vast majority of the reported value for HOWELL; environmental PCB contamination does not exist in such proportions and two phthalates that frequently interfere with these two congeners in the analysis are likely causing false positive identifications. The slightly elevated PCB concentrations at PCR-PL may be associated with the airport activities discussed earlier.

The PCB congener concentrations were between 4.90 and 12.8 µg/kg for 7 of the 40 sites (excluding site HOWELL) and below 4.9 µg/kg for the remaining 33 sites (including HOWELL). 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, the congener set that was determined in this study represent about half the total PCB in most environmental samples, and the total PCB in these samples can therefore be estimated by multiplying the sum of the PCB congener concentrations by 2. None of the 40 new district-wide assessment sites had PCB concentrations higher than the NOAA "high" concentration of 80 µg/kg, after excluding the HOWELL site, as discussed earlier; 15% of the NS&T and 15% of all COSED sites exceeded this reference value. Total PCB concentrations (non-normalized and TOC normalized) at the 40 new sites, like the other organic compounds previously mentioned, were generally detected at lower concentrations than what was measured for the sites in the 1996-1997 district-wide study.

The PCB composition was relatively uniform for the few samples that had clear PCB patterns (e.g., sites MAITL and NORRIS; Figure 4-6) and can be compared to those of the original PCB source material (Aroclor formulations; Appendix L). The PCB composition most closely resembled that of 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). 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 (through water systems and air deposition). The manufacture and new use of PCB was banned in the mid-70's, and most PCB detected today are broad "blends" of historic PCB that may have been transported significant distances. Unique and discrete PCB patterns are generally only observed very close to existing point sources.

Chlorinated Pesticides

The chlorinated pesticide concentrations had 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 4-7 and Appendix O). In addition, the contaminant distribution pattern varied somewhat from pesticide to pesticide compound. Three of the 40 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; the highest concentration was just above 100 µg/kg (NORRIS) and the other 2 sites (HALFMOON and CHARLES) had concentrations just above 25 µg/kg. The other 37 samples had concentrations that were between 0 and 10 µg/kg. Investigation of non-normalized and TOC normalized DDT concentrations, revealed that the sites that had relatively elevated concentrations of the DDT compounds were generally located in the central region (e.g., MAITL, CHERRY, OLA, NORRIS, HALFMOON, and CHARLES).

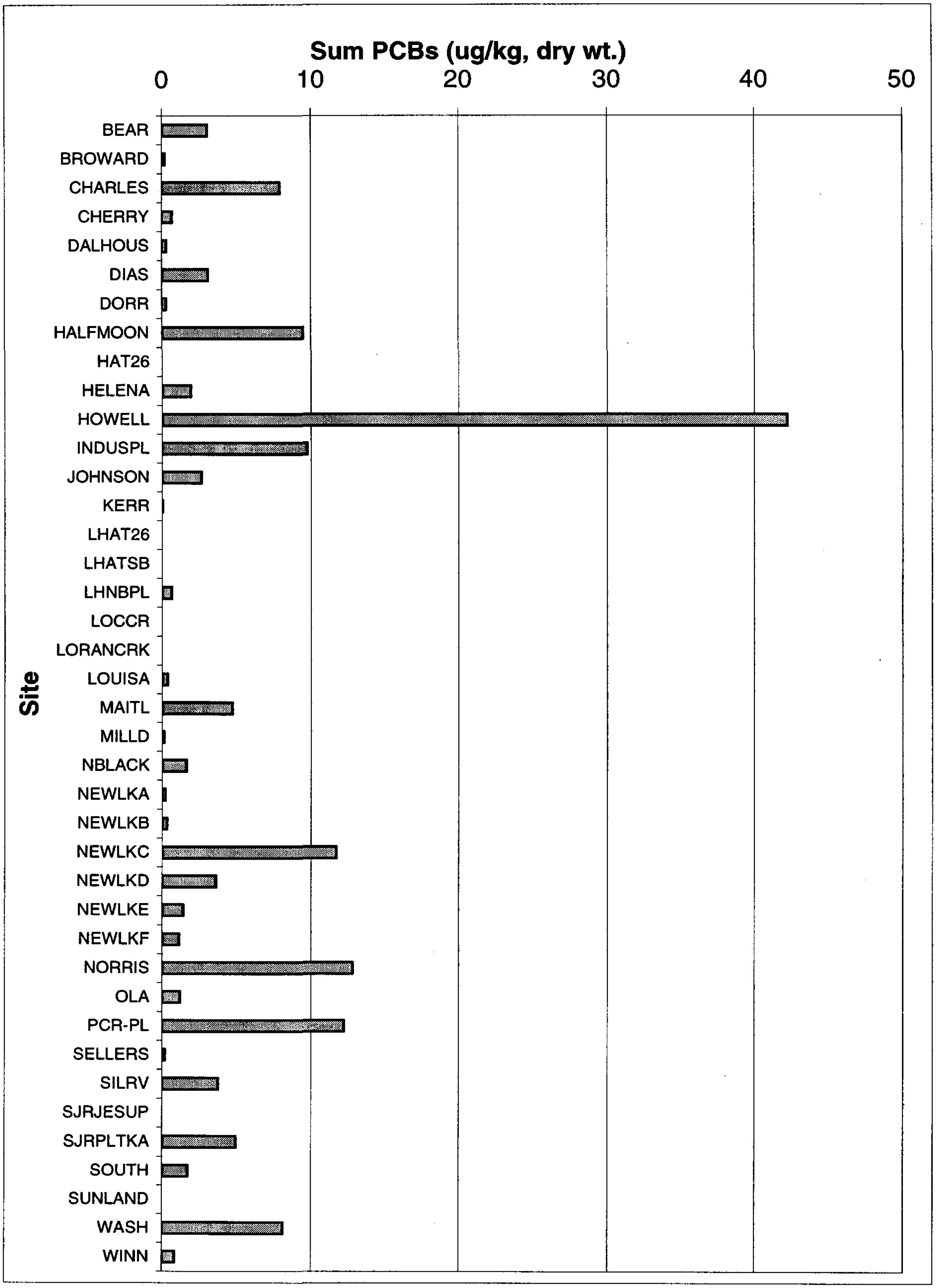


Figure 4-5a. 40 New Sites — Sum of PCB Congener Concentrations

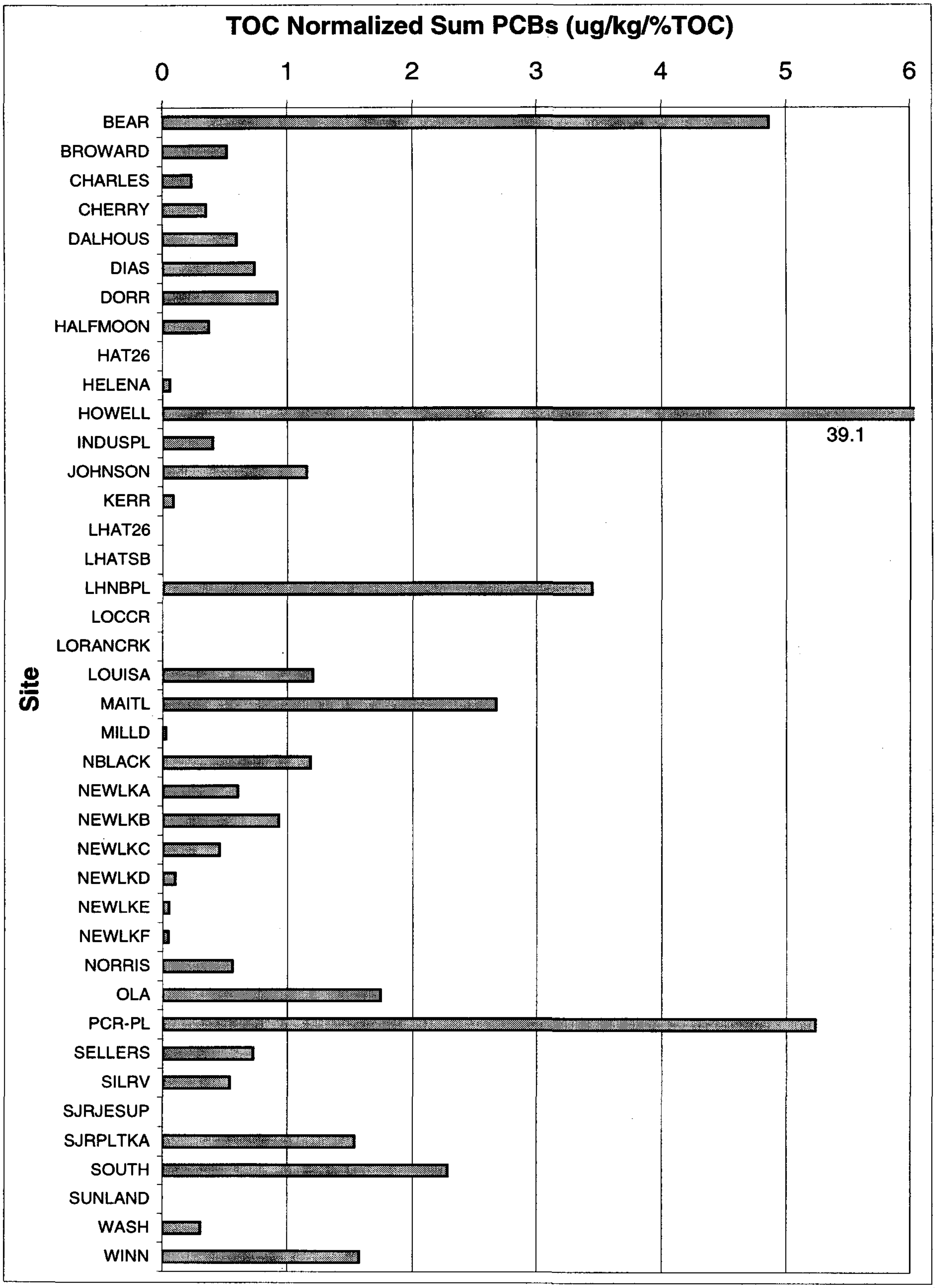
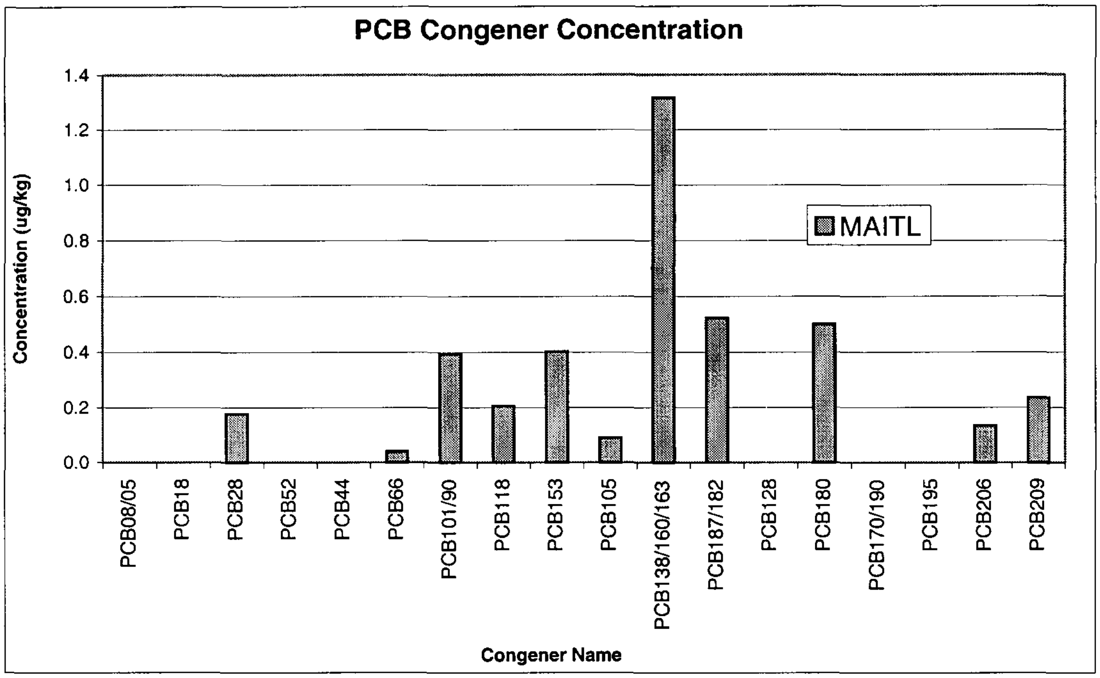


Figure 4-5b. 40 New Sites — TOC Normalized Sum of PCB Congener Concentrations



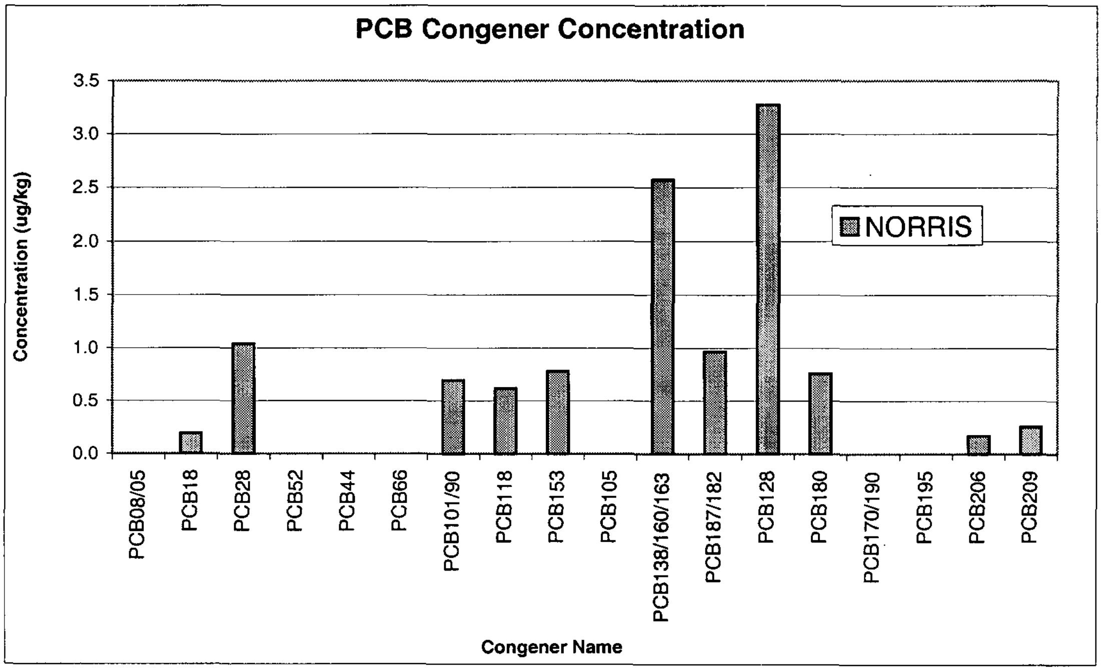
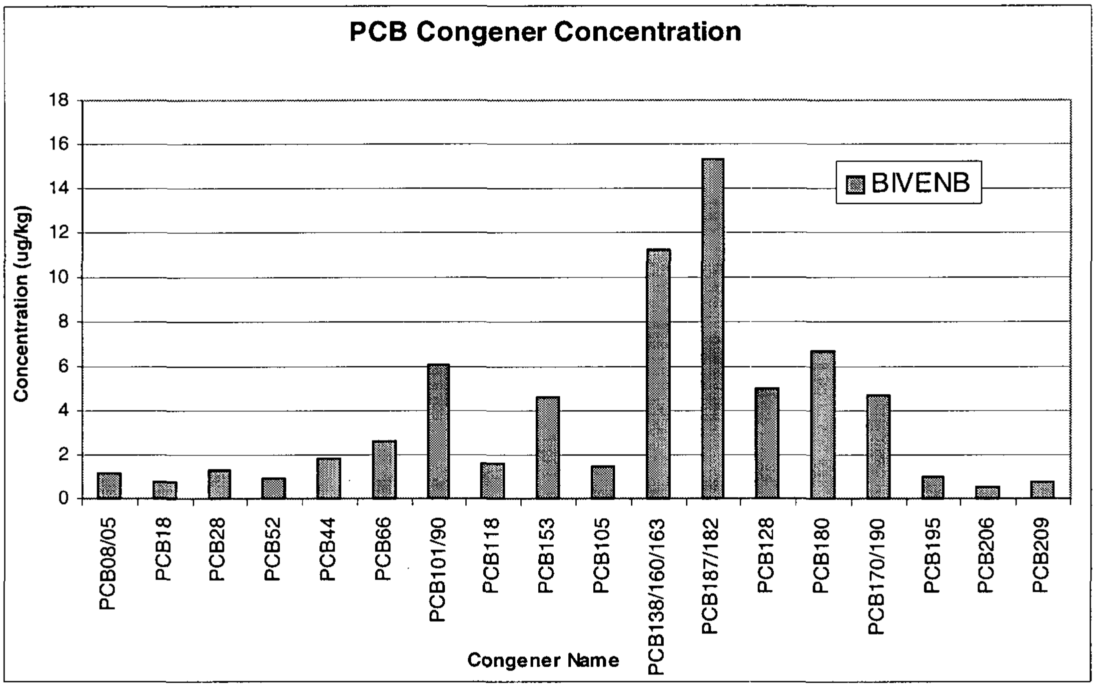


Figure 4-6. PCB Congener Composition of Selected Samples



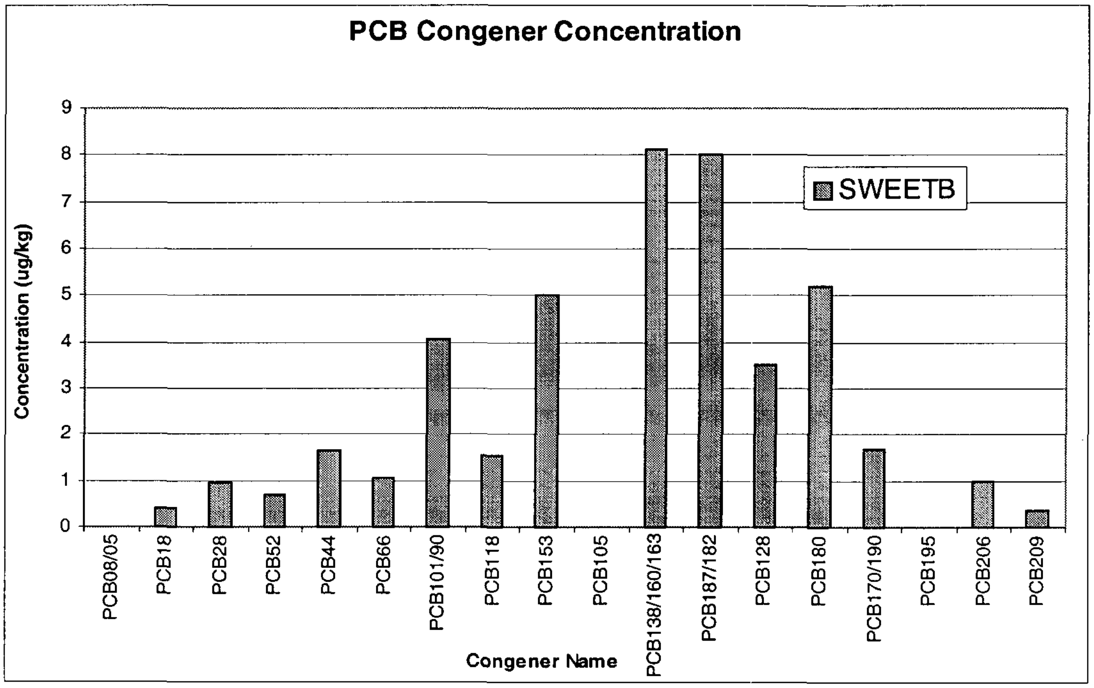


Figure 4-6 (cont). PCB Congener Composition of Selected Samples

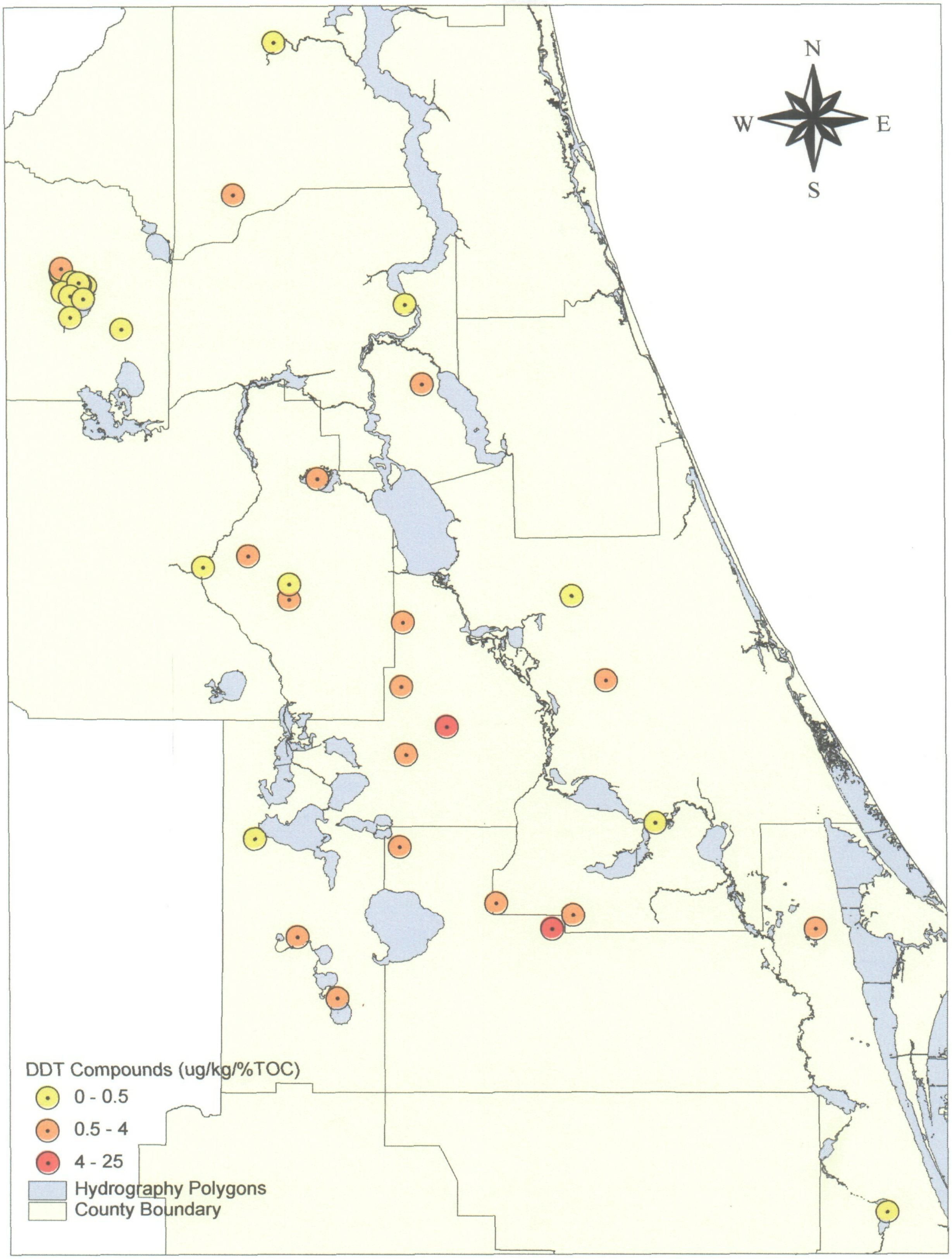


Figure 4-7. 40 New Sites — Map Displaying TOC Normalized Sum DDT Concentrations

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 district-wide assessment sites were lower than what has been observed in many national monitoring programs, with only three sites (8%) exceeding the NS&T/MW "high" value of 22 μg/kg (Table 4-1), while 15% of the NS&T/MW and COSED sites exceeded this value. However, the three sites with the highest DDT concentrations had levels that were comparable to those measured for some of the most contaminated sites in the 1996-1997 district-wide study, while most of the other sites had relatively low concentrations of DDT.

The concentrations of DDT and its degradation products DDD and DDE are presented 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 4-8 shows the relative composition of DDT, DDD, and DDE at selected sites. The concentration of DDE was higher than both the DDD and DDT concentrations in most samples, just as it is in most sediments around the US, as determined in the NOAA Mussel Watch Project (Battelle, 1990, 1991b, 1992) and as was observed in the 1996-1997 district-wide study. Site PCR-PL was an exception, however, with a ratio of DDT:DDE of approximately 6:1, suggesting there may be an active source of DDT near this site, and/or environmental conditions that retards DDT degradation.

The chlordane concentrations were generally lower than the DDT concentrations, were below 5 μg/kg in all samples, and were between 0 and 1 μg/kg at 37 of the 40 new sites. Of these, sites MAITL and PCR-PL had the highest concentrations of chlordane (about 4 μg/kg). The chlordane concentrations were lower than what has commonly 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 BHC concentrations were generally very low; consistently below 1 μg/kg. BHCs were detected in samples from less than half the sites. Examination of non- and TOC-normalized BHCs concentrations (which include the pesticide lindane) indicated that sites SJRPLTKA (SJR at Palatka), NBLACK (North fork of Black Creek), and INDUSPL had somewhat higher BHC loadings than other sites. This appears to be consistent with data from the 1996-1997 base-line study where elevated concentrations of BHC were detected in the St. Johns River and near Gainesville. Endosulfan concentrations were also very low; from not detected to 1 μg/kg for all samples except at one of the Newnans Lake sites (NEWLKC; Mouth of Little Hatchett Creek) where the concentration of endosulfan was 9.03 μg/kg.

Organic Compounds — Potential Hot Spots

When discussing potential hot spots, this particular study can be used as the primary frame of reference, or one can include data from other comparable locations throughout the country. Because there are limited data from other studies and locations that can be considered truly comparable, this assessment focused on data generated in this study. The reader should be aware that significantly elevated concentrations relative to other study sites does not necessarily indicate environmental concern — it could simply mean that most sites have relatively low contaminant concentrations.

Very few of the 40 new sites appear to have elevated concentrations of PAH, PCB, phthalates, or pesticides when compared to major national monitoring programs (Table 4-1). Some locations around the mid-Florida lakes and north of Orlando, however, appear to have mostly small elevations of some organic contaminants (e.g., DDTs and/or PAH at MAITL, LOUISA, HOWELL, and NORRIS), suggesting that these contaminants may be coming from a combination of agricultural and/or urban activities north of Orlando. The most significant potential organic contamination issue identified in the new district-wide assessment study appears to be the high DDT concentrations at Lake Norris.

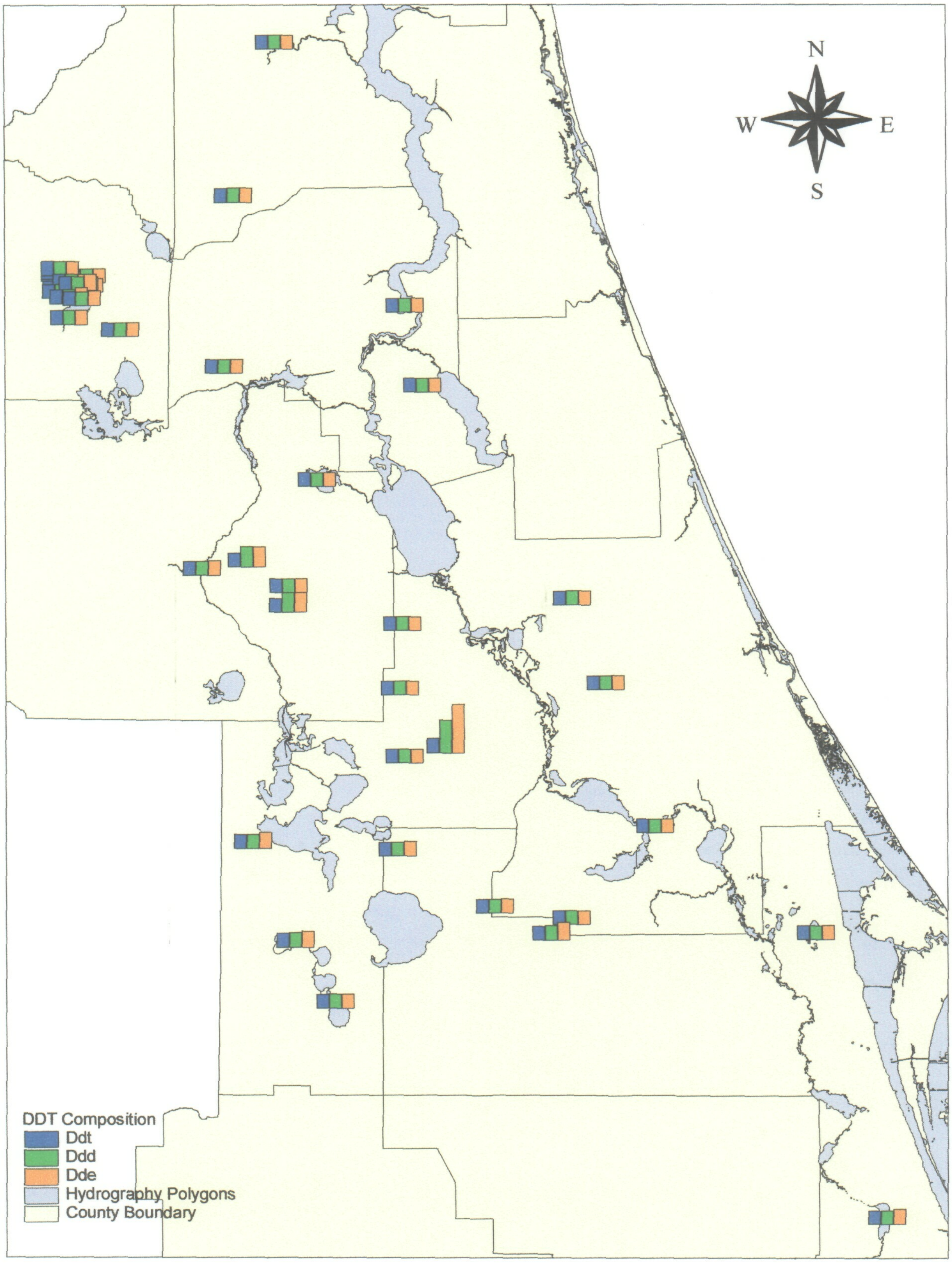


Figure 4-8. 40 New Sites — Map Displaying Relative Composition of DDT and its Key Degradation Products

Organic Compounds — Indicators of Potential Effects

One useful way to evaluate concentrations of contaminants in sediments is to compare the concentrations to effects-based sediment quality guideline values. Effects range-low (ERL) and effects range-medium (ERM) values are the most commonly used and referenced sediment quality guidelines. ERL and ERM values were initially developed by scientists at NOAA (Long *et. al.*, 1991), and were later revised after compiling additional data (Long *et. al.*, 1995). These are scientifically derived values of potential for biological effects due to sediment-sorbed contaminants.

The degree of confidence in the representativeness of the ERL and ERM values is sometimes 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 should be considered 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 general ecological and toxicological 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 and PEL values are typically a little lower than the ERL/ERM values because of 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. These sediment quality reference values are all based on non-normalized concentration data (i.e., the data have not been adjusted for TOC content).

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. LEL values are generally comparable to ERLs. 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 were based on much of the approach taken by MacDonald for developing sediment quality guidelines for Florida, and these numerical guidelines are also referred to as TEL and PEL values. The freshwater LEL, TEL, and PEL values are summarized in Table 4-3. The organic contaminant TEL, PEL, and LEL values are, like ERL and ERM values, based on non-normalized contaminant 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	60	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, 1992, for DDD, DDT, dieldrin and chlordane).
[b] ERM: Effects Range Median (Long *et al.*, 1995; Long & Morgan, 1992, 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 ERM 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
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, with the TEL/PEL values generally being a little lower (i.e., a little more conservative/protective) 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 based 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 these values. Another note of caution in applying ERL and ERMs is that these sediment quality guidelines may not satisfactorily describe or account for multiple contaminants or contaminant interactions that may affect the biota that are exposed to a complex suite of contaminants simultaneously.

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). Graphs with total PAH, total PCB, and sum of the DDT compound concentrations are presented in Figures 4-9, 4-10, and 4-11, respectively, along with the ERL, ERM, freshwater TEL, and freshwater PEL reference values, as available. Additional plots with ERL/ERM and freshwater TEL/PEL references are presented in Appendix N.

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
40 New Sites – DWA						
As	0 (0%)	0 (0%)	1 (3%)	0 (0%)	5 (13%)	0 (0%)
Cd	1 (3%)	0 (0%)	1 (3%)	0 (0%)	1 (3%)	0 (0%)
Cr	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Cu	1 (3%)	0 (0%)	1 (3%)	1 (3%)	1 (3%)	0 (0%)
Pb	4 (10%)	0 (0%)	6 (15%)	1 (3%)	5 (13%)	1 (3%)
Hg	8 (20%)	0 (0%)	8 (20%)	0 (0%)	8 (20%)	0 (0%)
Ni	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Ag	1 (3%)	0 (0%)	1 (3%)	0 (0%)	NA	NA
Zn	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Total PCB	3 (8%)	0 (0%)	5 (13%)	0 (0%)	0 (0%)	0 (0%)
Total DDT	15 (38%)	1 (3%)	8 (20%)	1 (3%)	4 (10%)	0 (0%)
p,p'-DDE	10 (25%)	1 (3%)	10 (25%)	0 (0%)	13 (33%)	4 (10%)
p,p'-DDD	3 (8%)	1 (3%)	6 (15%)	3 (8%)	NA	NA
p,p'-DDT	2 (5%)	0 (0%)	2 (5%)	0 (0%)	NA	NA
Dieldrin	29 (73%)	0 (0%)	10 (25%)	0 (0%)	3 (8%)	0 (0%)
Endrin	NA	NA	NA	NA	0 (0%)	0 (0%)
Lindane	NA	NA	2 (5%)	0 (0%)	0 (0%)	0 (0%)
Chlordane	6 (15%)	0 (0%)	2 (5%)	0 (0%)	0 (0%)	0 (0%)
Heptachlor epoxide	0 (0%)	0 (0%)	NA	NA	3 (8%)	0 (0%)
Low PAH	0 (0%)	0 (0%)	0 (0%)	0 (0%)	NA	NA
High PAH	0 (0%)	0 (0%)	5 (13%)	0 (0%)	NA	NA
Total PAH	0 (0%)	0 (0%)	0 (0%)	0 (0%)	NA	NA
Acenaphthene	0 (0%)	0 (0%)	0 (0%)	0 (0%)	NA	NA
Acenaphthylene	0 (0%)	0 (0%)	2 (5%)	0 (0%)	NA	NA
Anthracene	0 (0%)	0 (0%)	0 (0%)	0 (0%)	NA	NA
Fluorene	0 (0%)	0 (0%)	0 (0%)	0 (0%)	NA	NA
Naphthalene	0 (0%)	0 (0%)	0 (0%)	0 (0%)	NA	NA
2-Methylnaphthalene	0 (0%)	0 (0%)	1 (3%)	0 (0%)	NA	NA
Phenanthrene	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (3%)	0 (0%)
Benz(a)anthracene	0 (0%)	0 (0%)	1 3%)	0 (0%)	3 (8%)	0 (0%)
Benzo(a)pyrene	0 (0%)	0 (0%)	0 (0%)	0 (0%)	5 (13%)	0 (0%)
Chrysene	0 (0%)	0 (0%)	1 (3%)	0 (0%)	3 (8%)	0 (0%)
Dibenzo(a,h)anthracene	0 (0%)	0 (0%)	3 (8%)	0 (0%)	NA	NA
Fluoranthene	0 (0%)	0 (0%)	2 (5%)	0 (0%)	2 (5%)	0 (0%)
Pyrene	0 (0%)	0 (0%)	2 (5%)	0 (0%)	11 (28%)	0 (0%)
Bis(2-ethylhexyl)phthalate	NA	NA	1 (3%)	0 (0%)	NA	NA

Contaminant	Number of Sediment Quality Guideline Exceedances [a]					
	Marine Guidelines				Freshwater Guidelines	
	ERL	ERM	TEL	PEL	TEL	PEL
Detailed Assessment Sites						
As	20 (32%) [a]	0 (0%)	23 (37%)	0 (0%)	25 (40%)	1 (2%)
Cd	4 (6%)	0 (0%)	8 (13%)	0 (0%)	10 (16%)	0 (0%)
Cr	5 (8%)	0 (0%)	8 (13%)	2 (3%)	11 (17%)	4 (6%)
Cu	5 (8%)	0 (0%)	21 (33%)	0 (0%)	4 (6%)	0 (0%)
Pb	12 (19%)	3 (5%)	24 (38%)	4 (6%)	19 (30%)	8 (13%)
Hg	29 (46%)	0 (0%)	30 (48%)	0 (0%)	27 (43%)	0 (0%)
Ni	1 (2%)	0 (0%)	5 (8%)	0 (0%)	4 (6%)	0 (0%)
Ag	1 (2%)	0 (0%)	3 (5%)	1 (2%)	NA	NA
Zn	6 (10%)	0 (0%)	6 (10%)	1 (2%)	6 (10%)	0 (0%)
Total PCB	28 (44%)	2 (3%)	30 (48%)	2 (3%)	23 (37%)	1 (2%)
Total DDT	49 (78%)	11 (17%)	41 (65%)	10 (16%)	35 (56%)	0 (0%)
p,p'-DDE	38 (60%)	12 (19%)	39 (62%)	0 (0%)	41 (65%)	30 (48%)
p,p'-DDD	31 (49%)	2 (3%)	36 (57%)	9 (14%)	NA	NA
p,p'-DDT	32 (51%)	4 (6%)	27 (43%)	7(11%)	NA	NA
Dieldrin	37(59%)	2 (3%)	23 (37%)	4 (6%)	9 (14%)	2 (3%)
Endrin	NA	NA	NA	NA	0 (0%)	0 (0%)
Lindane	NA	NA	38 (60%)	21 (33%)	22 (35%)	10 (16%)
Chlordane	40 (63%)	0 (0%)	23 (37%)	11 (17%)	11 (17%)	4 (6%)
Heptachlor epoxide	NA	NA	NA	NA	2 (3%)	1 (2%)

[a] The percentage of all 40 new District-wide Assessment Sites and the 63 Detailed Assessment 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.

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). None of the total PAH, low PAH, or high PAH concentration measured at the 40 new district-wide sites exceeded the ERL or ERM values. There are no *freshwater* TEL or PEL values for PAH. 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 most 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 and conclusions.

The total PCB ERL was exceeded at three of the 40 sites, but all sites had PCB concentrations well below the ERM (the false positive PCB results for HOWELL have been considered, as discussed earlier). The ERL exceedances for the 3 sites were very minor (concentrations of 23.4 to 25.6 μg/kg versus an ERL of 22.7 μg/kg). Note that the total PCB concentration used for this assessment was calculated by multiplying the sum of the target PCB congener concentrations by two, as discussed in Section 3.1.2. All sites had PCB concentrations that were below the TEL and, consequently, also the PEL.

The ERL was exceeded for total DDT at 15 of the 40 sites and the TEL was exceeded at four sites. There was 1 ERM and no PEL exceedances for DDT. Sites NORRIS, CHARLES, HALFMOON, and MAITL exceeded both the ERL and TEL values for DDT, and NORRIS also exceeded the ERM by a factor of about two. There were two individual DDT compound ERL exceedances, three DDD compound ERL exceedances, and 10 DDE compound ERL exceedances.

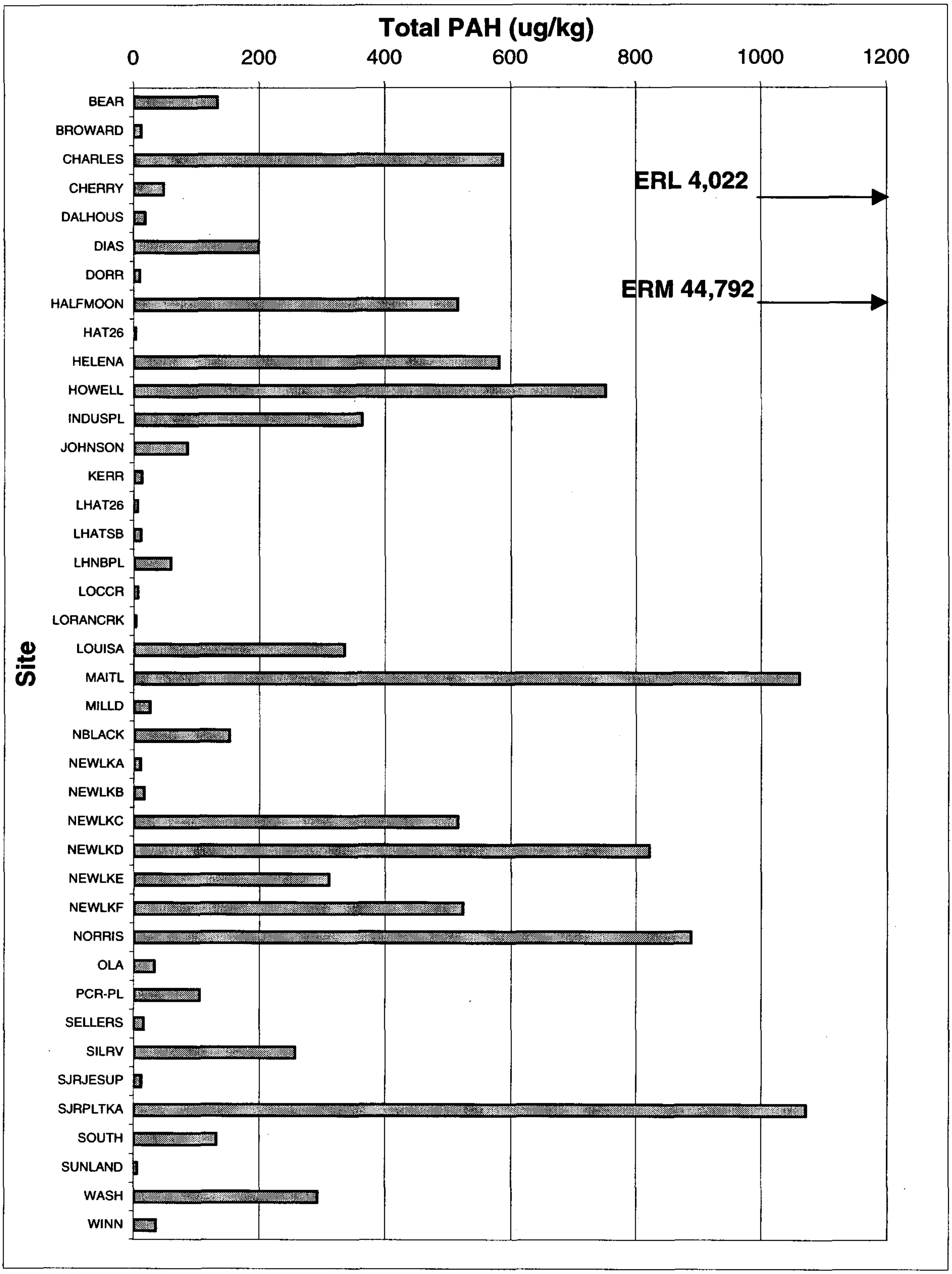


Figure 4-9. 40 New Sites — Total PAH Concentrations and ERL/ERM Values

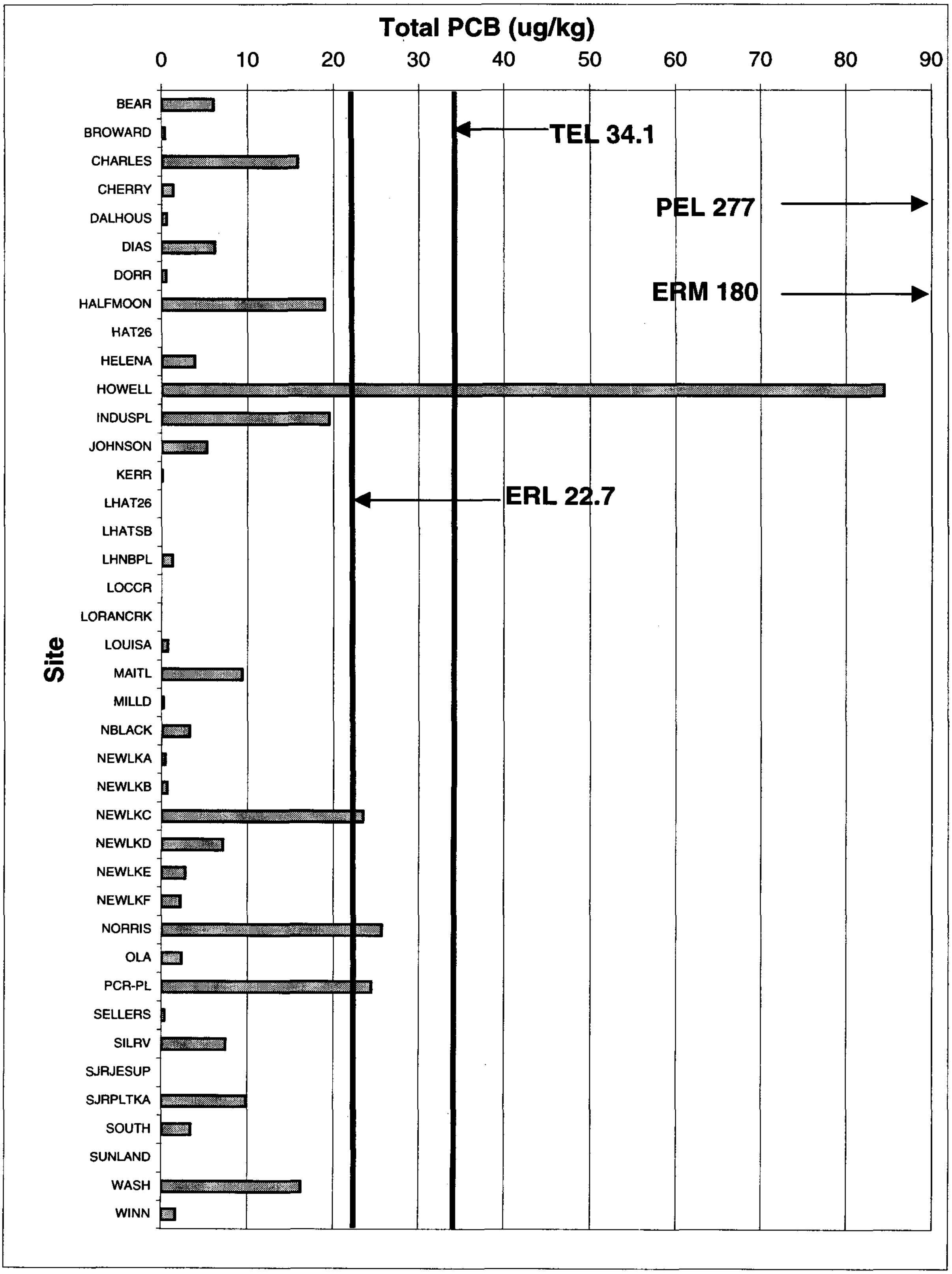


Figure 4-10. 40 New Sites — Total PCB Concentrations and ERL/ERM and Freshwater TEL/PEL Values

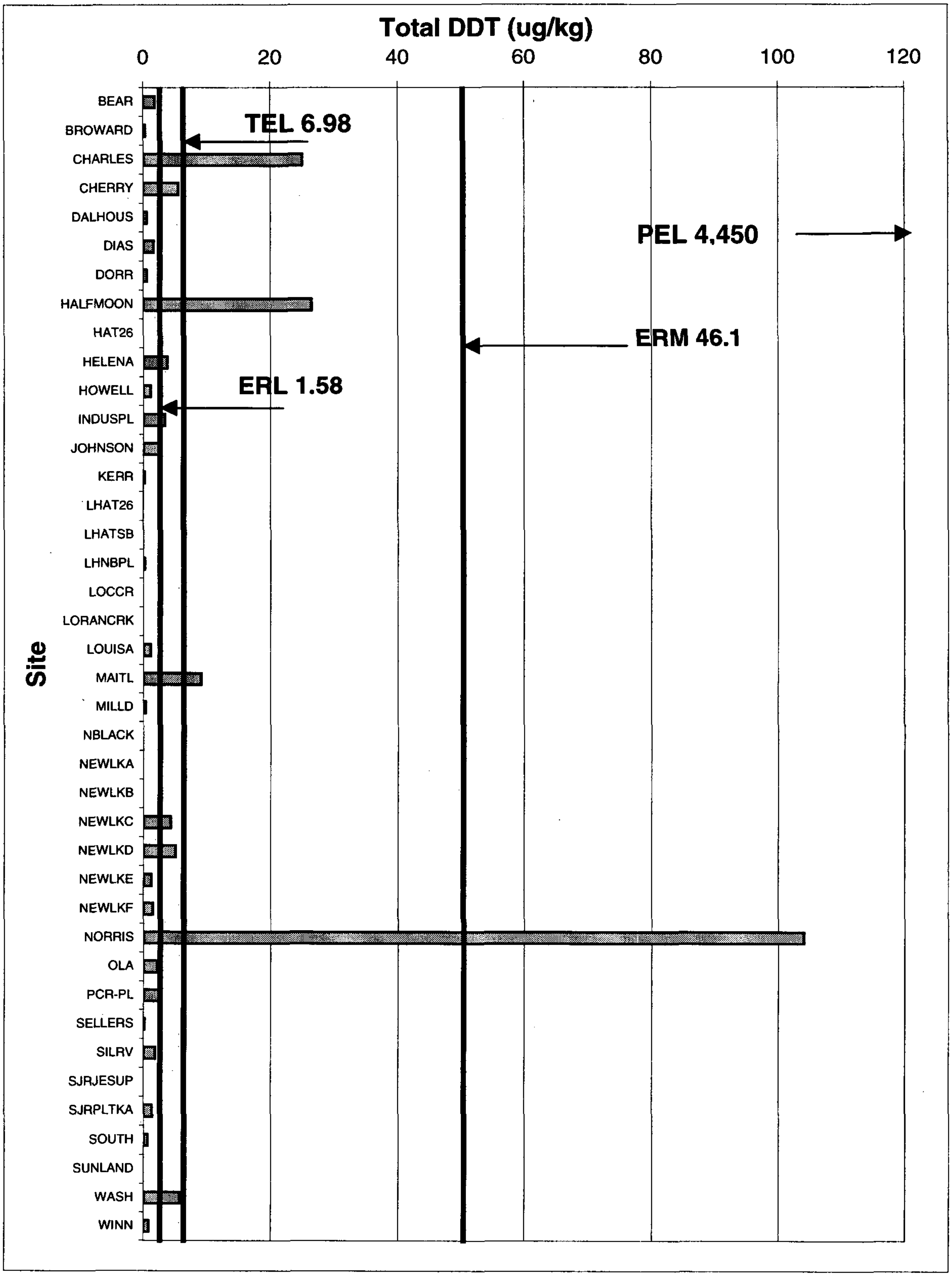


Figure 4-11. 40 New Sites — Sum of DDTs Concentrations and ERL/ERM and Freshwater TEL/PEL Values

The sediment concentrations of DDD and DDE at NORRIS exceeded the higher ERM values, and these sediment quality guideline exceedances were only observed for this site, suggesting it may be a location of particular concern with respect to DDT contamination. Elevated levels of DDT, and its degradation product DDE, were predominantly found in the mid-Florida lakes region, which coincides with the land use in this area (mostly of agricultural and forest area) and with earlier observations (SJRWMD, 1998).

The chlordane concentrations exceeded the ERL value at six of the 40 new sites, with MAITL, and PCR-PL having the most significant exceedances (about eight times above the ERL). The total chlordane concentrations did not exceed the TEL, ERM, or PEL at any of the sites, although sites MAITL (4.07 µg/kg) and PCR-PL (4.01 µg/kg) had total chlordane concentrations fairly close to the TEL value of 4.5 µg/kg. There were a number of dieldrin ERL (a total of 29) and TEL (three total) exceedances. However, the referenced ERL value for dieldrin is described as being a number with "low" confidence by Long and Morgan (1992), 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 TEL value, even though the ERL and TEL values are comparable for most other organic contaminants. The concentration of lindane was below the TEL and PEL values at all sites.

There could clearly be some differences in the contaminant assessment conclusions depending on which sediment quality guidelines one uses. Because of the significant TOC levels in many of these samples, and because the sediment quality guidelines and these assessments are based on non-normalized data, this analysis can be considered to be a quite conservative approach as a component of a risk "screen" assessment. This is because the significant TOC concentrations in many samples actually contributes to "holding" the organic contaminants, making them less available to cause environmental harm.

4.1.2 Metal Contaminant Levels

Correspondence Among Metals.
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 sediment major metals concentrations, the grain size, and the 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. Normalizing to grain size (using the fine fraction, such as %mud) is also frequently done to determine anthropogenic contamination. Grain size normalization accounts for the natural geological abundance differences and for the fact that metals typically 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 (Figures 4-12a and 4-12b) to the fine-grained, or mud, fraction of the sediments revealed a general, but fairly weak, correspondence in this system (Figures 4-13a and 4-13b). Some of the variability may relate to the very high amount of TOC in many of the sediment samples (>20% TOC at about 25% of the sites); many of these sediments were clearly comprised of significant proportions of non-geological material. The other metals concentrations also generally increased with the aluminum content (or mud fraction), but the correspondence was more variable than one might expect (Figures 4-14a and 4-14b and 4-15a and 4-15b). Similar analyses were performed using the other major metals instead of aluminum.

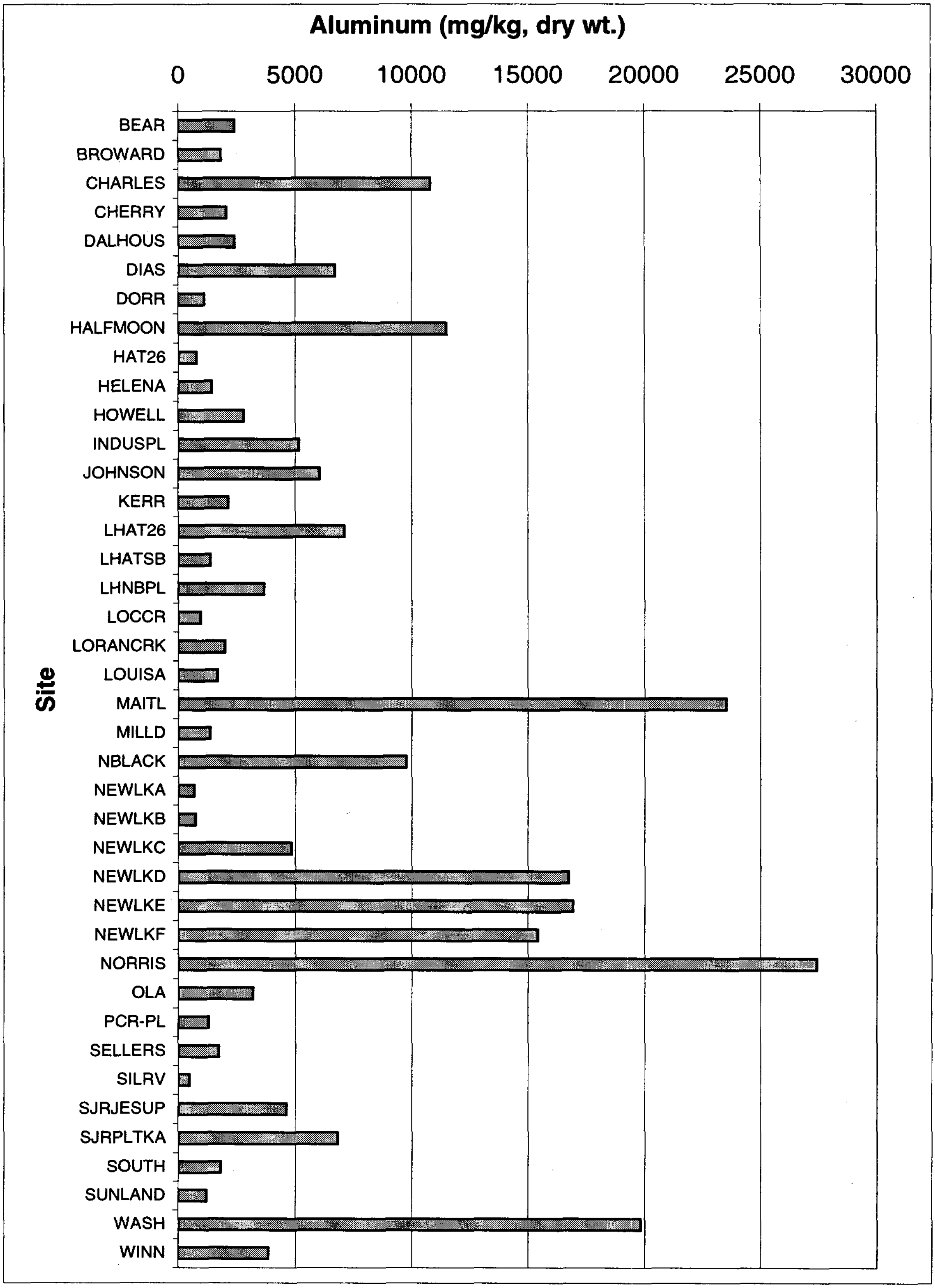


Figure 4-12a. 40 New Sites — Aluminum Concentrations of Sediments

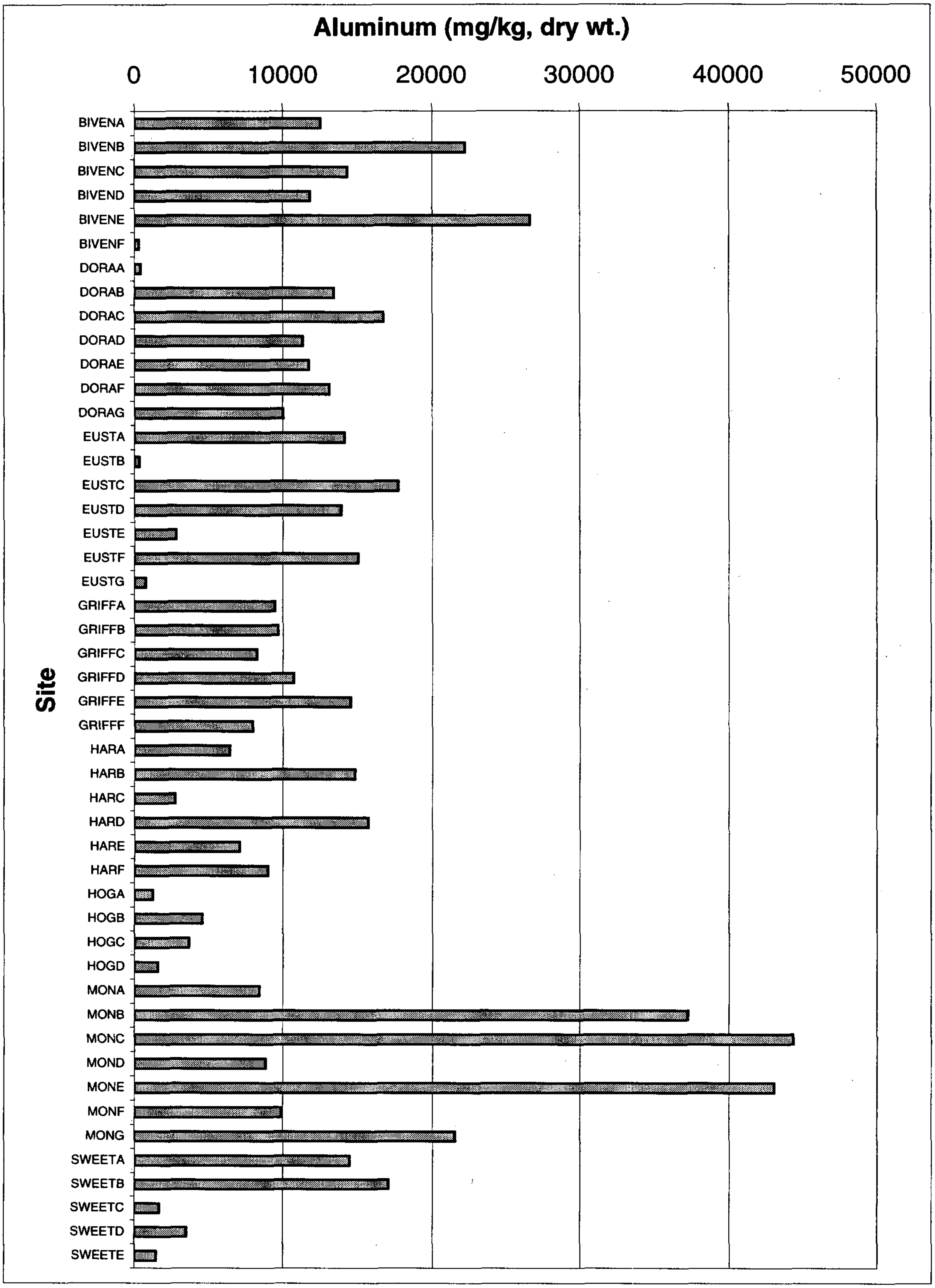


Figure 4-12b. Detailed Assessment Sites — Aluminum Concentrations of Sediments

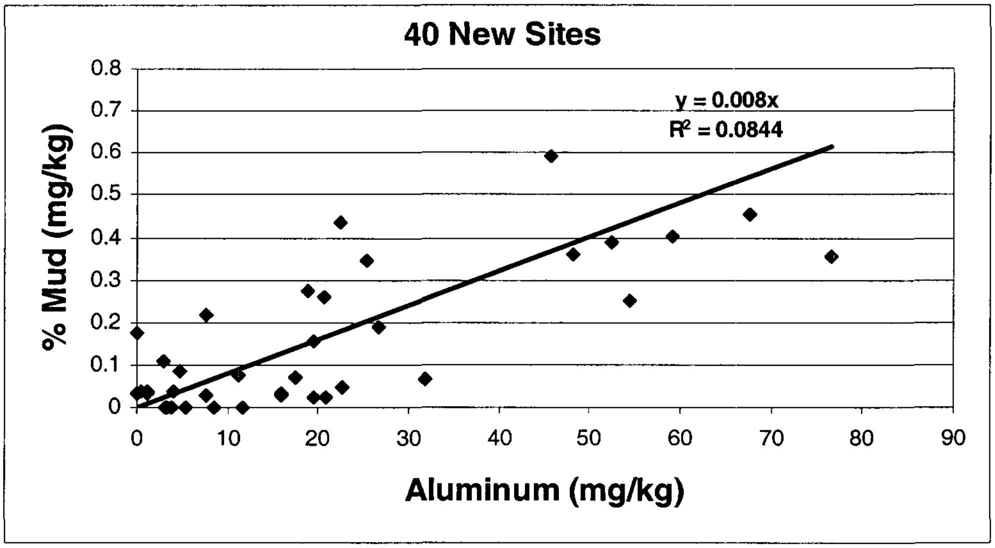


Figure 4-13a. 40 New Sites — Grain Size (% Mud) versus Aluminum Concentration of Sediments

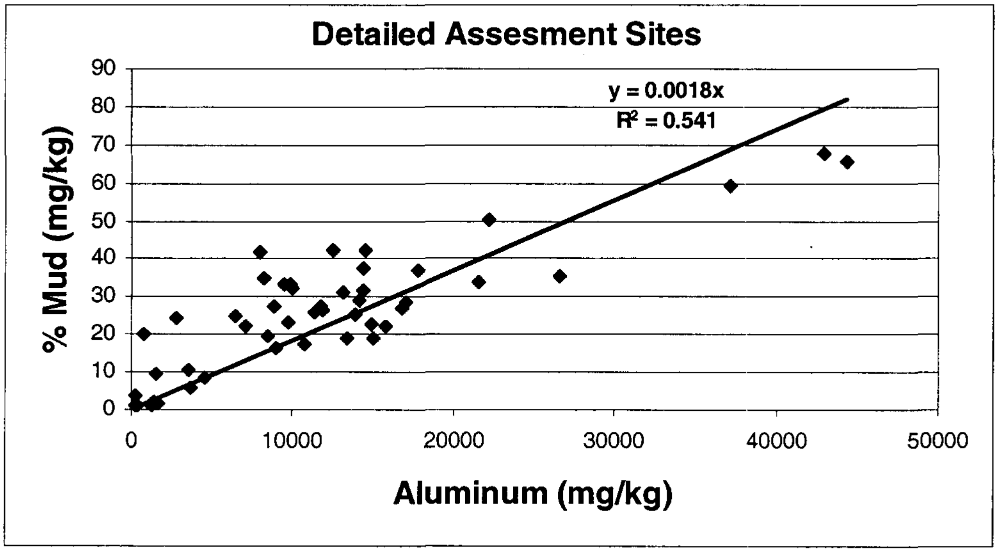
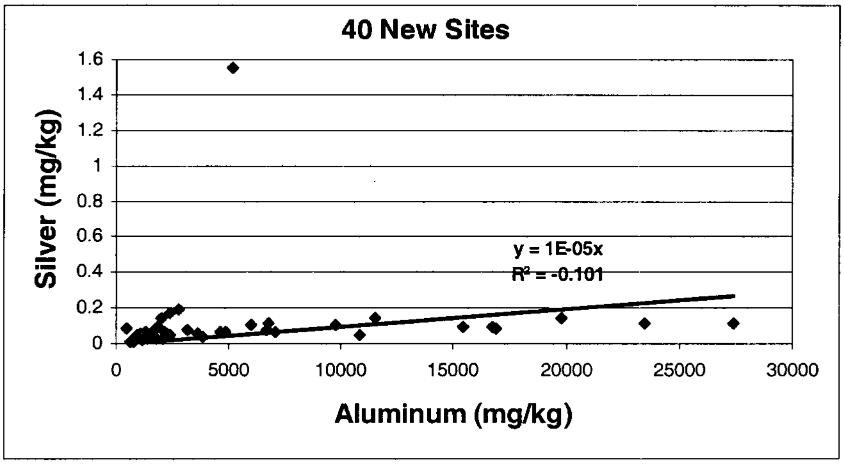
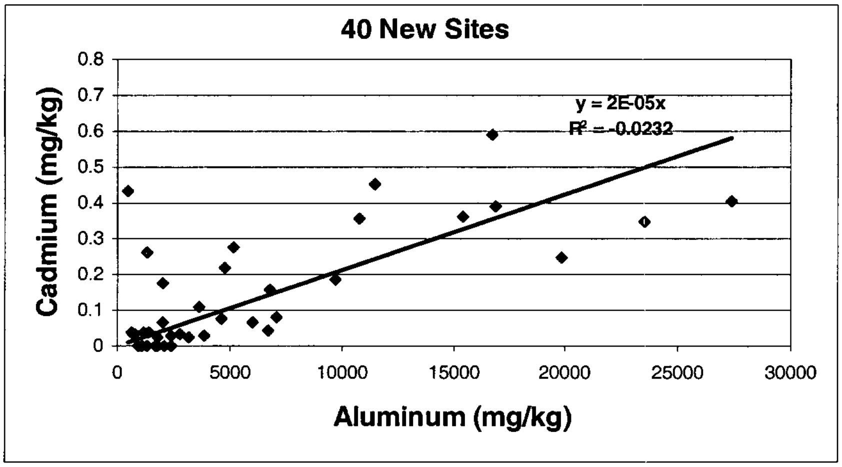


Figure 4-13b. Detailed Assessment Sites — Grain Size (% Mud) versus Aluminum Concentration of Sediments





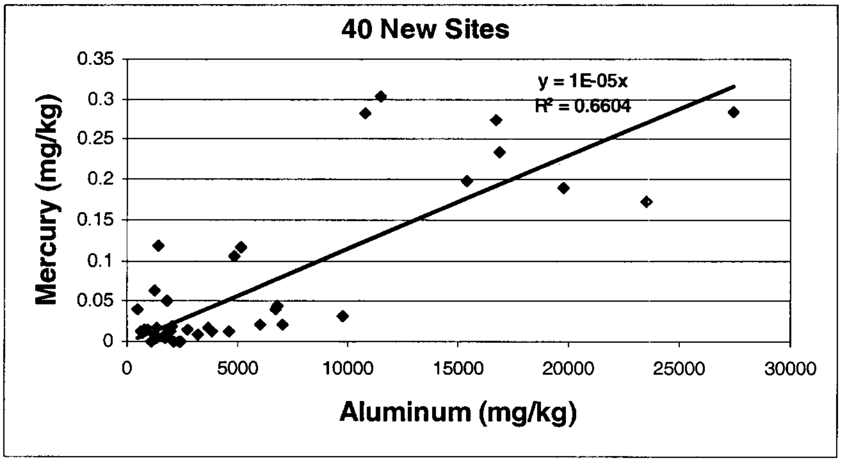
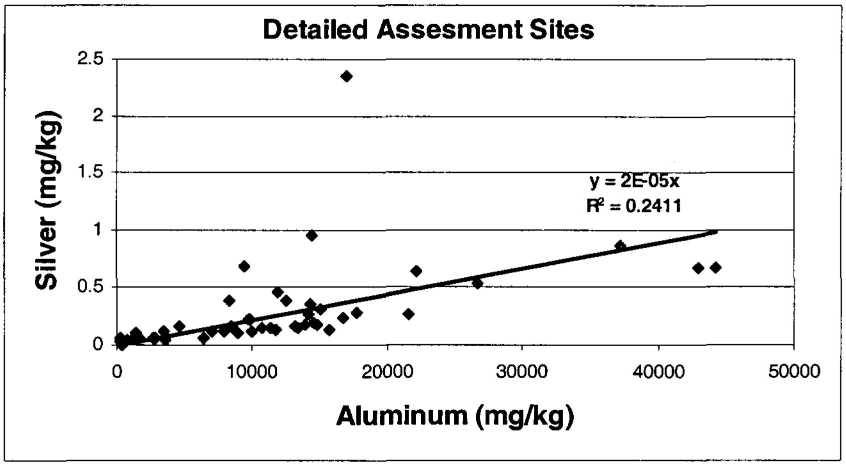
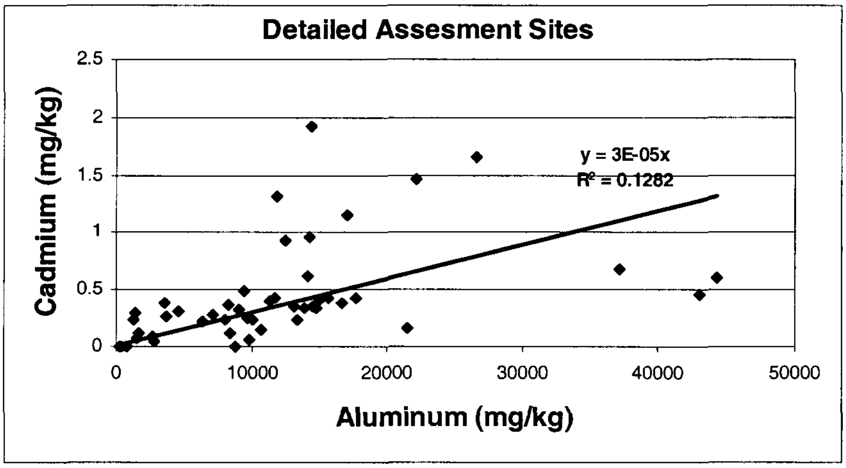


Figure 4-14a. 40 New Sites — Silver, Cadmium, and Mercury versus Aluminum Concentration of Sediments





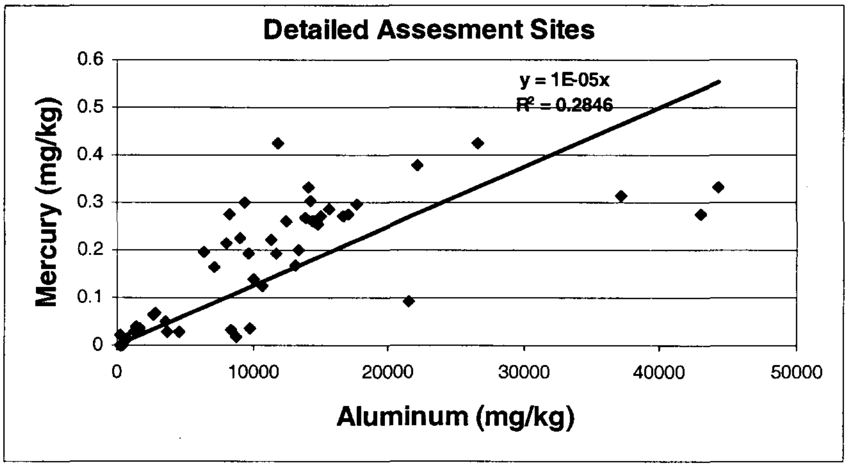


Figure 4-14b. Detailed Assessment Sites — Silver, Cadmium, and Mercury versus Aluminum Concentration of Sediments

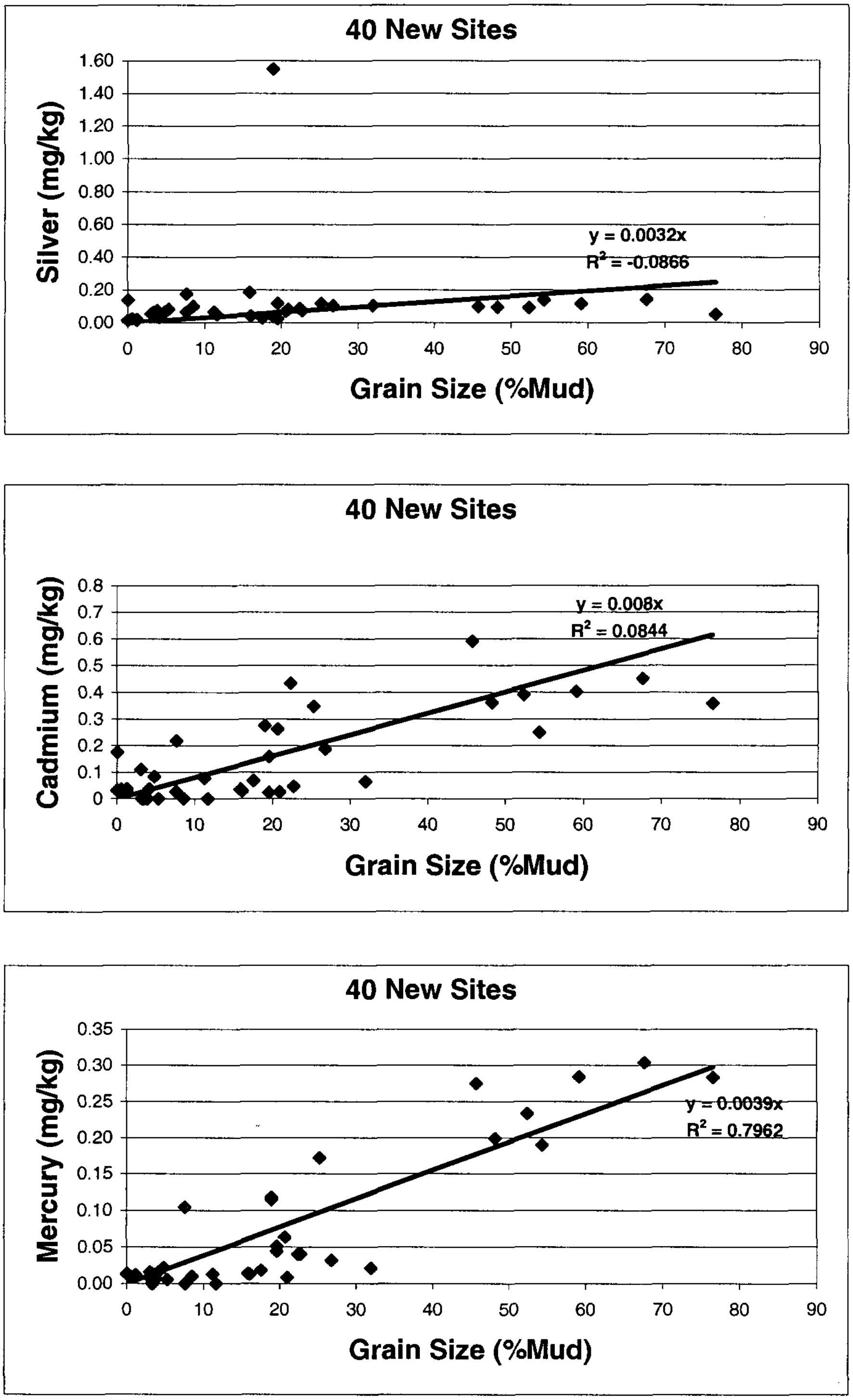
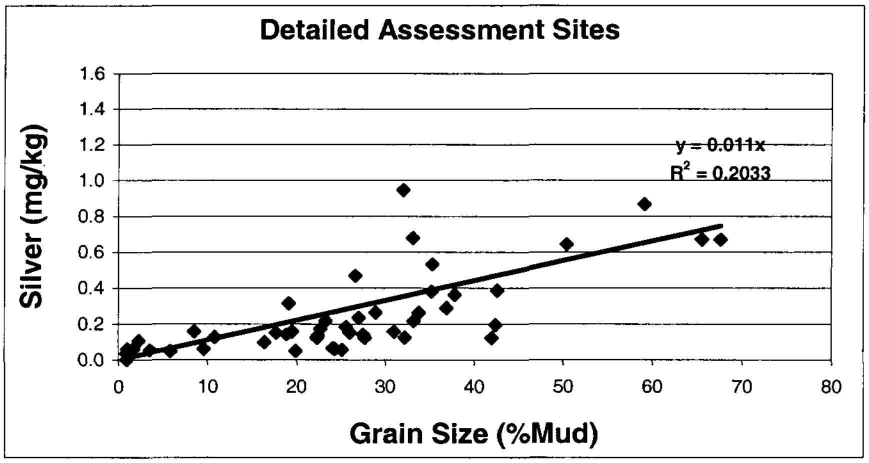
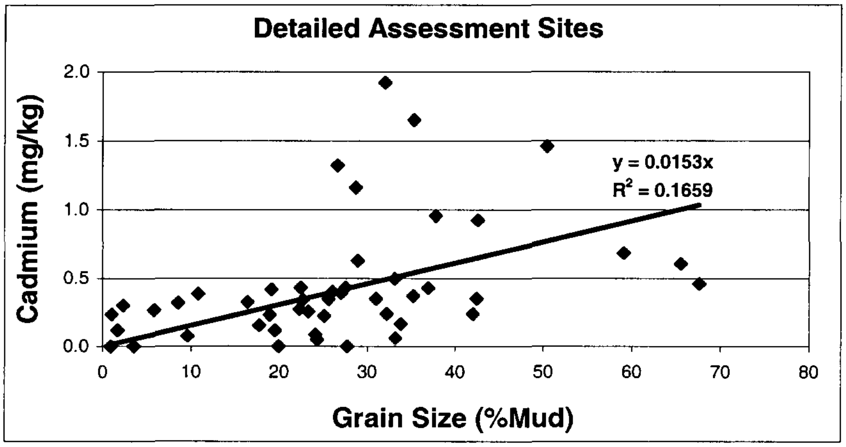


Figure 4-15a. 40 New Sites — Silver, Cadmium, and Mercury Concentration versus Grain Size (%Mud) of Sediments





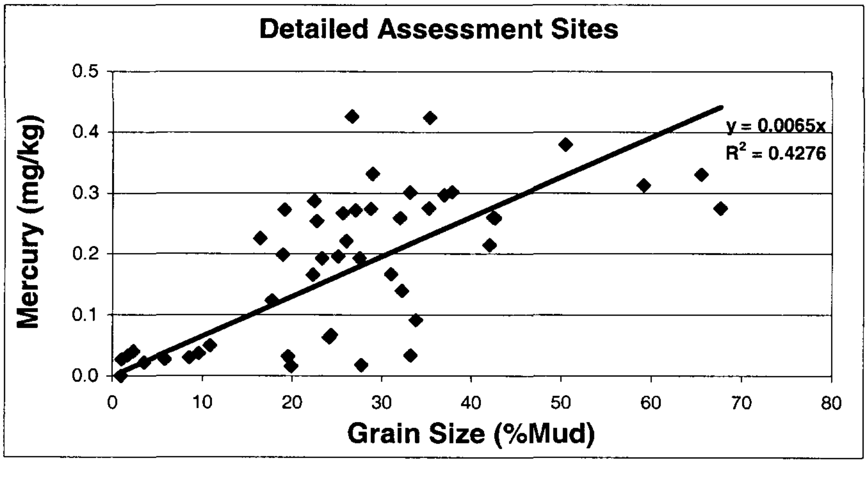


Figure 4-15b. Detailed Assessment Sites — Silver, Cadmium, and Mercury Concentration versus Grain Size (%Mud) of Sediments

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* (Figure 3-3). Similarly, the correspondence between aluminum and TOC was weak. Figure 3-3 demonstrates the lack of correspondence between TOC and mud fraction in sediments with a TOC content of less than 5% (which typically correlate in many sedimentary environments), as well as the lack of correspondence between these two parameters in sediments with higher TOC. This demonstrates that many of the sediments were 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 many high TOC 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.

The toxic metals concentration relationship to common data normalizers was particularly weak with TOC, and was often similar with crustal elements and grain size. It became evident that metal contamination co-varied most consistently with aluminum — aluminum normalization provided somewhat better correlation to the other metal concentrations than grain size or TOC normalization and also better than what the other major metals provided — aluminum was therefore chosen as the primary data normalizer for the metals data assessment.

Metals — Contaminant Distribution and Composition.

Fifteen metals were investigated for the 40 new sites of the District-wide assessment. These metals were Al, As, Cd, Cr, Cu, Fe, Li, Pb, Mn, Hg, Ni, Se, Ag, Sn, and Zn. There was a broad range in the metal concentrations at the 40 new sediment sites, and the levels were also spatially variable. An example of this range and variability is illustrated by the aluminum concentrations (Figure 4-12). Aluminum is a major metal primarily associated with mineral components of sediments, and is frequently used to normalize variability in metals concentrations resulting from differences in the grain size composition and geology of sediments. Through normalization, naturally occurring metal concentrations can often be separated from those originating with anthropogenic activity. Charts depicting the non-normalized, aluminum-normalized, and grain size-normalized concentrations of the measured metals are compiled in Appendix L.

The aluminum concentrations in the sediments ranged from a low of 454 to a high of 27,400 mg/kg, or a 60-fold difference between the lowest and highest concentrations. A range like this is typical of systems that have variable grain size distributions and differing geological origin, as is the case with these 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 1.78 to 216 mg/kg and iron from 63.6 to 30,200 mg/kg. There was a 120- and 475-fold difference between the maximum and minimum concentrations of manganese and iron, respectively.

The toxic metals concentrations were also quite variable in the 40 new sites, as shown in Tables 3-8 and 3-9. Differences between high and low values ranged from 10 fold for tin to a 284 fold for copper. 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. Sites exhibiting higher metal concentrations were most often associated with sites with relatively higher percent mud.

There were even fewer and less discrete contaminant signals and patterns for metals than for organic contaminants, and many metals followed a similar contaminant distribution trend. The concentrations of most metals, including arsenic, chromium, copper, lead, lithium, mercury, and selenium appeared to be slightly higher at some of the sites in the central lakes region (at sites such as CHARLES, HALFMOON, SILRV, MAITL, and NORRIS) and in the Newnans Lake area (NEWLK sites and INDUSPL). However, the magnitude of the elevation was generally relatively small, and when the data were normalized to aluminum to better discern anthropogenic enrichment of the sediments the apparent contaminant elevation was generally moderated. The aluminum-normalized data for some of these metals indicated elevations at a few sites that did not appear to be contaminated when the non-normalized data were reviewed, but these were primarily due to low aluminum concentrations (i.e., coarse sediments). It is important to view the data together — non-normalized and aluminum-normalized — to obtain an overall understanding of possible metal contamination issues.

A few, though mostly subtle, contaminant signals were evident when both the normalized and non-normalized data had been reviewed. The arsenic and mercury concentrations appear to be slightly elevated some sites in the central region (e.g., sites KERR, HELENA, DIAS, NORRIS, MAITL, and SILRV), as well as in the Newnans Lake area near Gainesville (NEWLKD and NEWLKF). Cadmium, chromium, copper, nickel, selenium appear to be slightly elevated at sites HELENA, SILRV, and/or MAITL (copper was particularly high at MAITL), as well as the sites located in the Gainesville region. The lead concentrations may be of significance at sites INDUSPL and SUNLAND, which are near Gainesville where significant lead contamination was identified in the 1996-1997 study. However, these new sites, INDUSPL and SUNDLAND, would have an entirely different, although also urban, source than the sites sampled in the 1996-1997 study. Silver was also relatively high at INDUSPL. Slightly elevated lead levels were also identified at two sites in nearly adjoining small lakes in the central part of the District (sites MILLD and HALFMOON).

The concentrations of metals were, for the most part, lower in the 40 new district-wide assessment sediments than what was measured in the 1996-1997 district-wide study (Table 3-7) and lower than what has been measured in other national monitoring programs (Table 4-1). A relatively small proportion of the sediment sites had cadmium, copper, mercury, lead, and silver concentrations that exceeded the NS&T/MW "high" value. The concentrations of arsenic, chromium, nickel, tin, and zinc did not exceed these reference values for any site. Of the six metals (Cd, Cu, Hg, Pb, Se, and Ag), concentrations that exceed the NS&T/MW "high" value, only selenium had a higher rate of exceedance than both the NS&T/MS and COSED sites. For instance, the NOAA "high" concentrations for silver and cadmium were exceeded at 3% and 5% of the 40 new sites, respectively, compared to 16% and 16% of the NS&T/MW sites and 22% and 31% of the COSED sites. Selenium concentrations, on the other hand, exceeded the NOAA reference value at a greater proportion of the 40 new sites than did the NS&T/MW and COSED sites, with an exceedances rate of 33% for the 40 new sites. This higher rate of exceedances may, partly, be due to differences in the geology of the sediments; the sediments from the 40 new sites may be naturally more enriched in selenium than average U.S. coastal sediments. Another factor could be the relatively fine grain size of the sediments from the 40 new sites, 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 sediments. Mercury data are difficult to reliably compare with historical data because more reliable analytical methods were used in this study than were available for most older programs. Variable and often significantly elevated background mercury concentrations were typically subtracted from measured sample concentrations in the past, often resulting in artificially low measured sediment concentrations.

Metals — Potential Hot Spots

The above evaluation suggests that there are no broad, contiguous areas with dramatically elevated metals concentrations. Some metals were present at higher concentrations in the Gainesville area and in different lakes in the central region than in other areas. As discussed, the contamination profile varied somewhat for the different metals, but the contamination appears to be more localized, and almost more site-specific, than regional. Upon review of the metals concentrations at the 40 new sites, site INDUSPL may appear as a hot spot for metals; the concentrations of several individual metals are higher for site INDUSPL than other sites. Newnans Lake, and tributaries and other water bodies flowing into this lake, such as Silver River, Helena Run, Lake Maitland, are locations that potentially have elevated levels of selected toxic metals. 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, which are not available to this assessment.

Metals — Indicators of Potential Effects

Mercury and lead concentrations data are presented relative to the ERL, ERM (Long *et al.*, 1995), and freshwater TEL and PEL values in Figures 4-16 and 4-17. Similar figures for the other 7 metals that are typically of environmental concern, and for which there are published ERL, ERM, TEL, and PEL values, are compiled in Appendix N. The ERL, ERM, TEL and PEL sediment quality guidelines are summarized in Tables 4-2 and 4-3 for the metals with such reference values. 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. For this evaluation, the metals concentrations in the sediments were compared to both the marine ERL/ERM and the freshwater TEL/PEL indicators. A summary of the results of this data comparison is presented in Table 4-4, and the data are presented graphically in Appendix N.

There were very few sediment quality guideline exceedances for metals at the sampled sites. There were no ERM exceedances, only one PEL exceedance, and relatively few ERL and TEL exceedances. No metal exceeded the sediment guideline value at more than eight sites (20% of the sites). In addition, there were no exceedances for the chromium, nickel or zinc.

The one PEL exceedance was for lead at site INDUSPL. The data were also assessed relative to the more conservative (i.e., lower) ERL and TEL values, with the TEL reference value typically being the lowest. Mercury, followed by lead and arsenic, had the largest number of ERL and TEL exceedances (Table 4-4 and Figures 4-16 and 4-17). Eight of the sites exceeded the mercury ERL/TEL sediment quality evaluation guidelines, there were four (ERL) and five (TEL) exceedances for lead, and five (TEL) exceedances for arsenic. The ERL and/or TEL was exceeded at one site for cadmium (HELENA), copper (MAITL), and silver (INDUSPL). There were more (but relatively minor) TEL and ERL exceedances for mercury, and it should be noted that the reliability of using the mercury ERL (or PEL) value to assess potential risk is often hotly debated in the scientific community; among all the metals, mercury has the sediment quality guideline value that is most often being questioned as potentially non-representative.

The site with the most ERL exceedances was MAITL (exceeded the TEL for four of the eight metals that have TEL values). NORRIS had three TEL exceedances and a few sites had two TEL exceedances (INDUSPL, HALFMOON, NEWLKD, and NEWLKF). Except for possibly the lead exceedances at INDUSPL, the data set shows a remarkable lack of notable sediment quality exceedances and leaves the impression of relatively limited, or geographically focused, potential for biological impact from metals at the study sites.

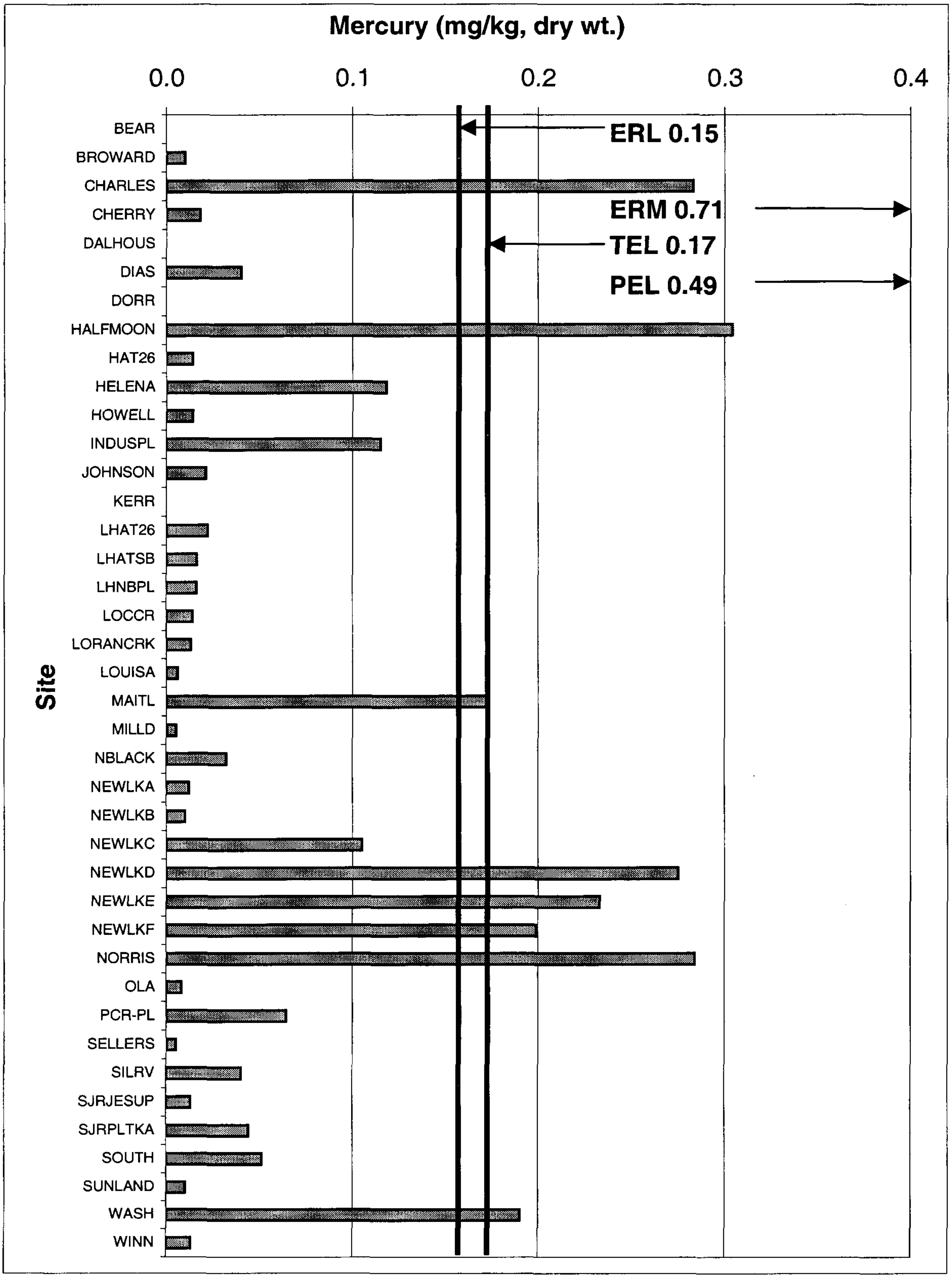


Figure 4-16. 40 New Sites — Sediment Mercury Concentrations and ERL/ERM and Freshwater TEL/PEL Values

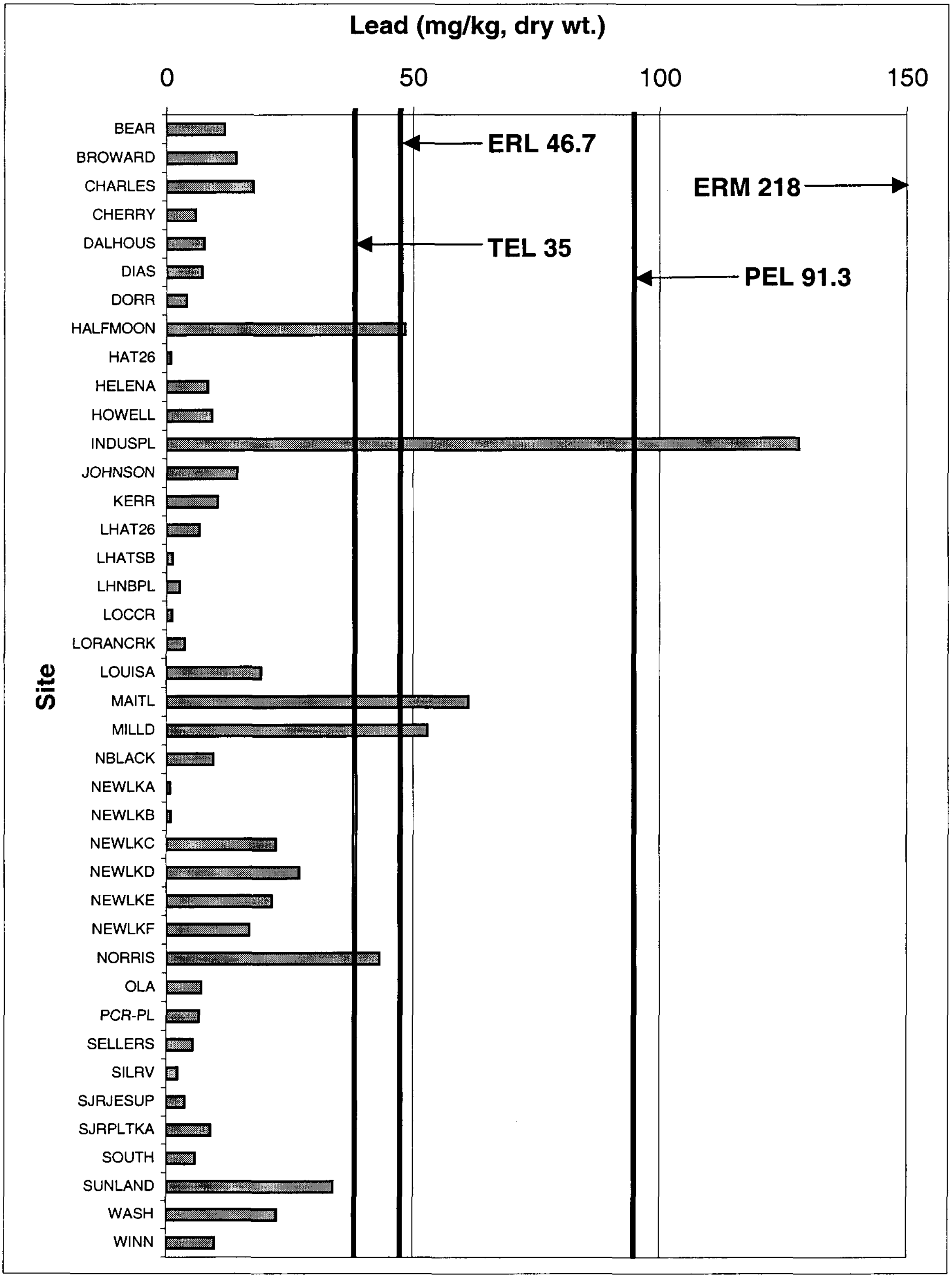


Figure 4-17. 40 New Sites — Sediment Lead Concentrations and ERL/ERM and Freshwater TEL/PEL Values

The application of these sediment quality guidelines should be made with caution, particularly for toxic metals. First, most of the guidelines were developed for individual parameters and do not incorporate additive or interactive effects due to multiple toxic components. Second, 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). The analysis of AVS was considered for this project, but it was not included because this was primarily a broad-based general assessment investigation that was not focused on specific metals toxicity issues.

4.1.3 Nutrient Levels

Nutrient (TKN, TP, and OP) concentrations were generally highest in the lake samples (Appendices M and O) although considerable variability was evident within each sediment type. There was also a very good correlation between the TKN and TOC content of the sediments (Figure 4-18) — no such relationship was observed for TP or OP versus TOC, or for any of the nutrients when plotted versus grain size. The TKN to TOC relationship suggests that the majority of the nitrogen originates with the organic material in the sediments, and not as anthropogenic inputs of nutrients. However, because of the large amounts of organic matter in some of these sediments, smaller anthropogenic contributions might not be discerned. The maximum TKN concentrations reached in the lakes was generally at least two times, and often more than 10 times, as high as the TKN concentrations measured in the stream sediments. It should be noted that 14 of the 40 samples (35%) were collected from streams and the remaining 26 samples (65%) were collected at lakes. A similar general pattern was observed for TP (Appendices E and M). Stream sediment samples had, in general, lower total phosphorus concentrations than the lake samples.

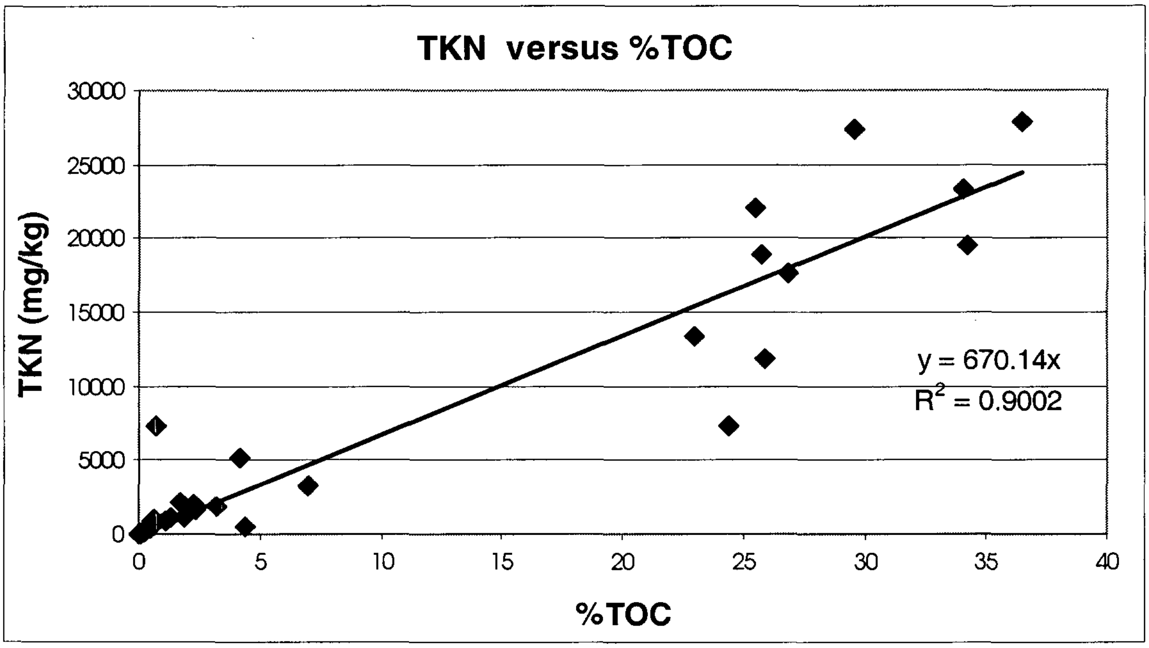


Figure 4-18. 40 New Sites — TKN versus TOC Concentrations

Although orthophosphate was a small fraction of the total phosphorus (OP/TP) in these sediments, the distribution pattern was similar to that observed for the other nutrient measurements; the highest concentrations were observed in the lake sediments. The OP concentrations (Appendix M) were uniformly low in other sites (less than 2 mg/kg, dry weight), and were generally less than 1 percent of the TP measured in the samples (Figure 4-19). Occasionally, OP contributed 1 to 2%, and as much as 5% in one sample (NEWLKB), of the total phosphorus in the samples. There was low variability in the total-nitrogen to total-phosphorus relationship across the different sediment types (Figure 4-20). Many samples collected from lake sites had nitrogen to phosphorus ratios that were similar to those observed for samples from other water bodies. However, there were a number of lake samples that had TKN/TP ratios greater than 10, indicating that the nitrogen per unit phosphate was often higher in the lake sediments, as compared to the stream sediment.

4.2 Contaminant Levels at Detailed Assessment Sites

The detailed assessment study consisted of the collection of four to 10 samples (63 samples total) from each of ten locations that were identified in the 1996-1997 study to potentially have contamination issues. A more detailed characterization was performed to gain a better understanding of the different characteristics of the potential contamination (Section 1 and Table 1-1). The 10 locations that were studied further can be divided into three general areas; Gainesville area, mid-Florida Lakes area, and Other Lakes (Lake Disston and Lake George), and the data presentation in Section 4.2 is divided into three sub-sections by these general areas.

Site replicates were collected and analyzed at one site from each of the 10 detailed assessment locations to determine the precision and representativeness of the field data; triplicate samples were collected and analyzed from sites BIVENC, DISSC, DORAD, GEORGEB, HARD, HOGD, MONC, and SWEETC and duplicate samples were collected at sites EUSTE and GRIFFA. The replicate data were then averaged before performing any data interpretation and presentation; the data at the above mentioned sites were averaged for the presentation in the summary tables, graphs, and maps in this report. The data for the individual site replicates are presented in Appendix F (PCB and pesticide data) and Appendix G (metals data), including the relative standard deviations (RSD) and relative percent differences (RPD) for the triplicate and duplicate measurements, respectively.

Figures 4-21a and 4-21b present the average site total PCB and total DDT concentrations for selected sites, along with the one standard deviation error bars for site replicates. Similar data are presented in Figures 4-22a and 4-22b for lead and mercury. The precision was generally very good for the majority of the organic and metals contaminants measured at concentrations well above the limit of detection. As expected, there were instances where elements detected at very low concentrations (e.g., Hg and individual organic compounds) were susceptible to lower precision (i.e., higher RSDs or RPDs). Review of the TOC and grain size data revealed that in some instances the lower precision in normalized contaminant data results were attributable to difference in grain size (%mud) or TOC content between the replicate samples — lack of sample homogeneity at the site. It should be pointed out that these precision measurements primarily reflect the representativeness of samples collected separately in the field — laboratory analytical precision (as measured through duplicate analysis of the same sediment sample) was consistently very good.

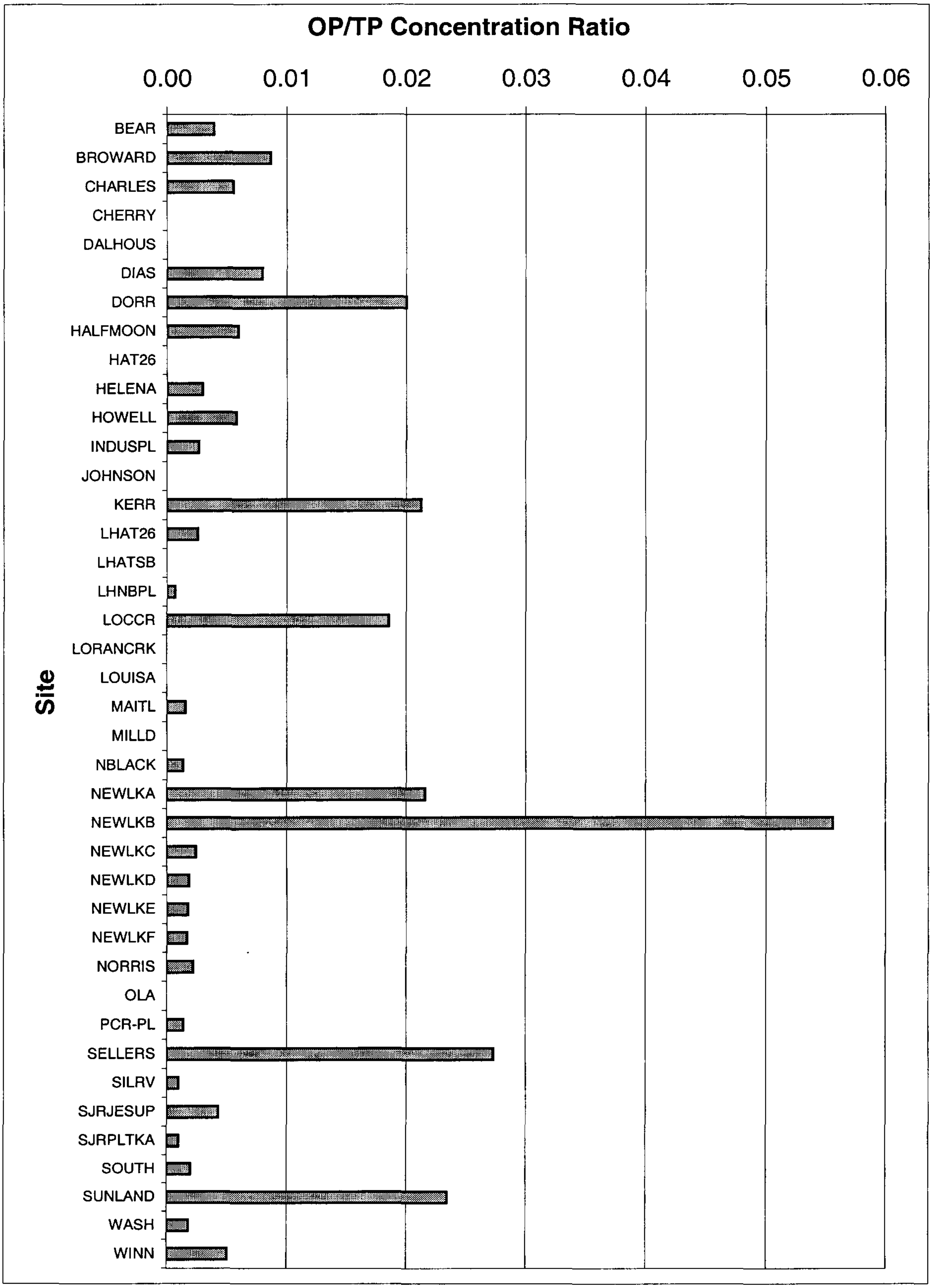


Figure 4-19. 40 New Sites — OP/TP Concentration Ratio

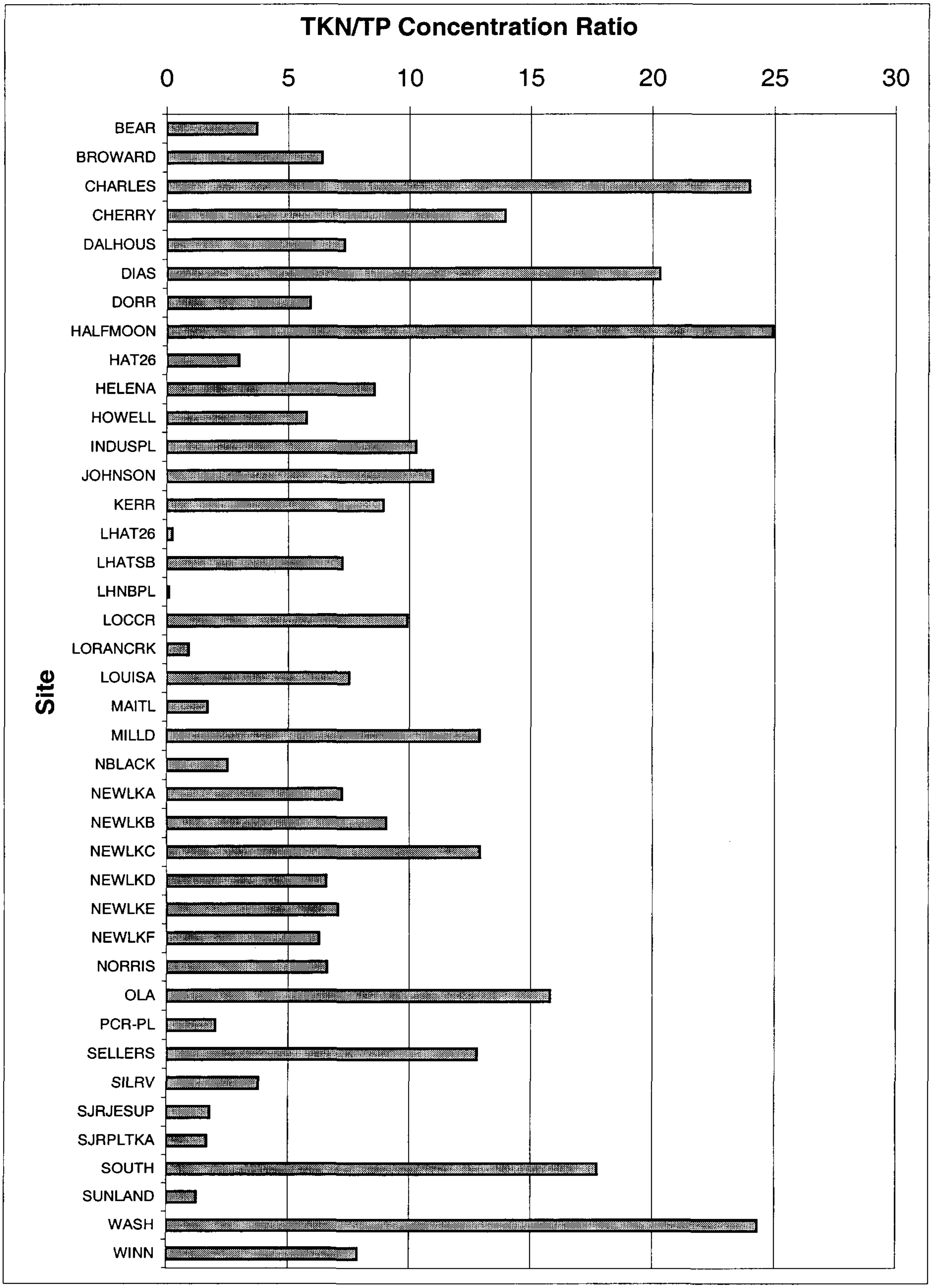


Figure 4-20. 40 New Sites — TKN/TP Concentration Ratio

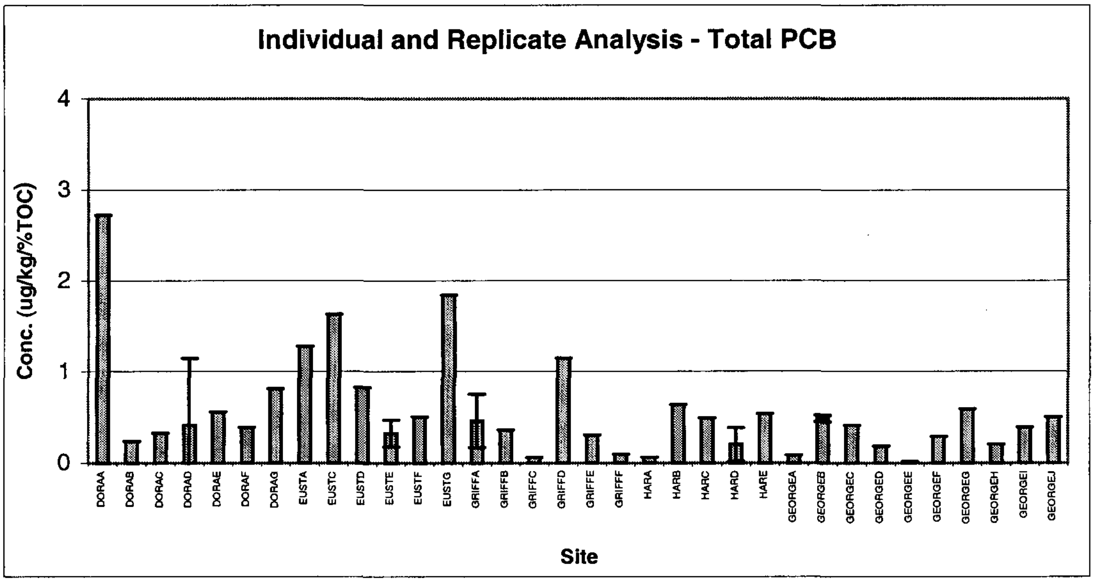


Figure 4-21a. Detailed Assessment Sites — Example Individual and Replicate Site PCB Data

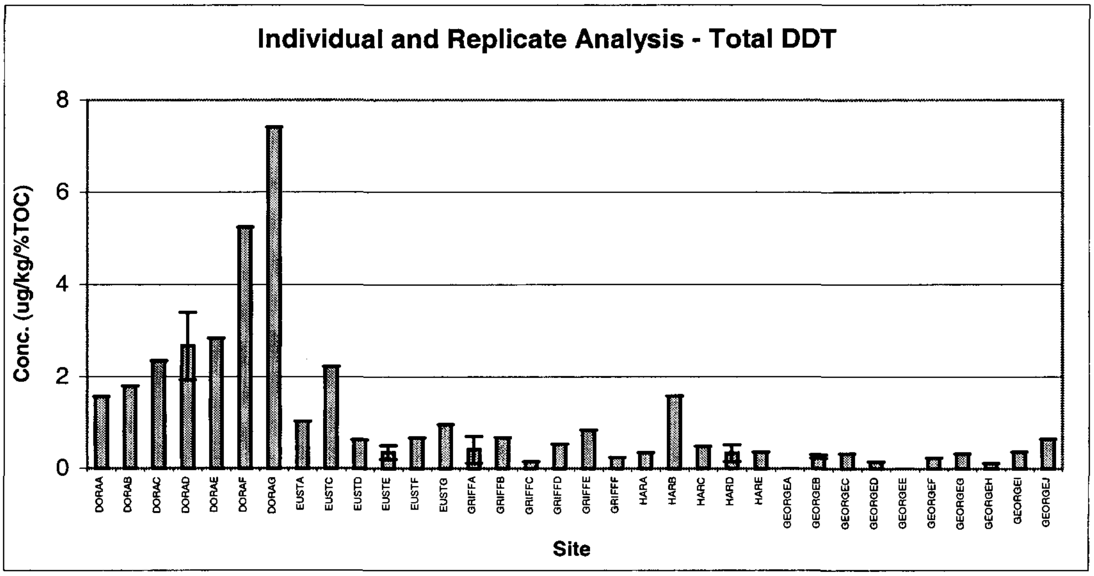


Figure 4-21b. Detailed Assessment Sites — Example Individual and Replicate Site DDT Data

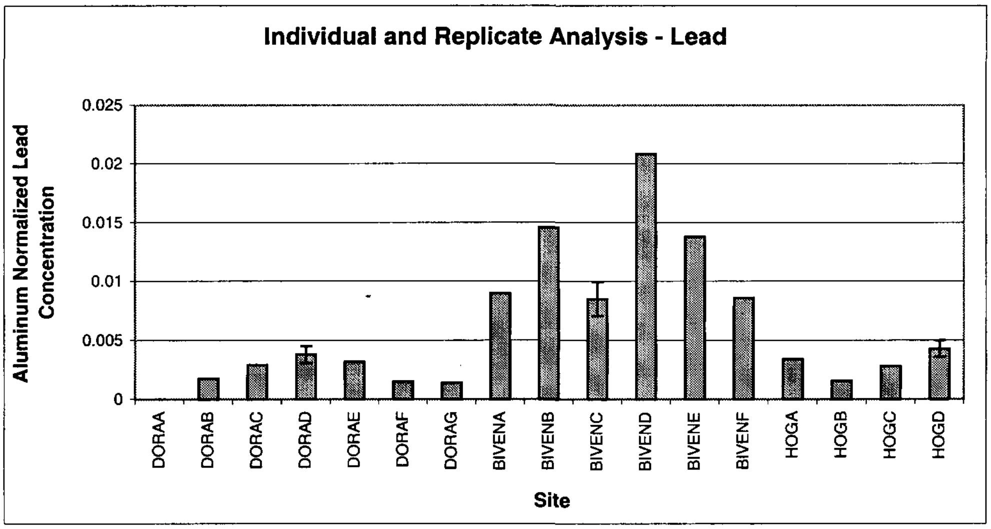


Figure 4-22a. Detailed Assessment Sites — Example Individual and Replicate Site Lead Data

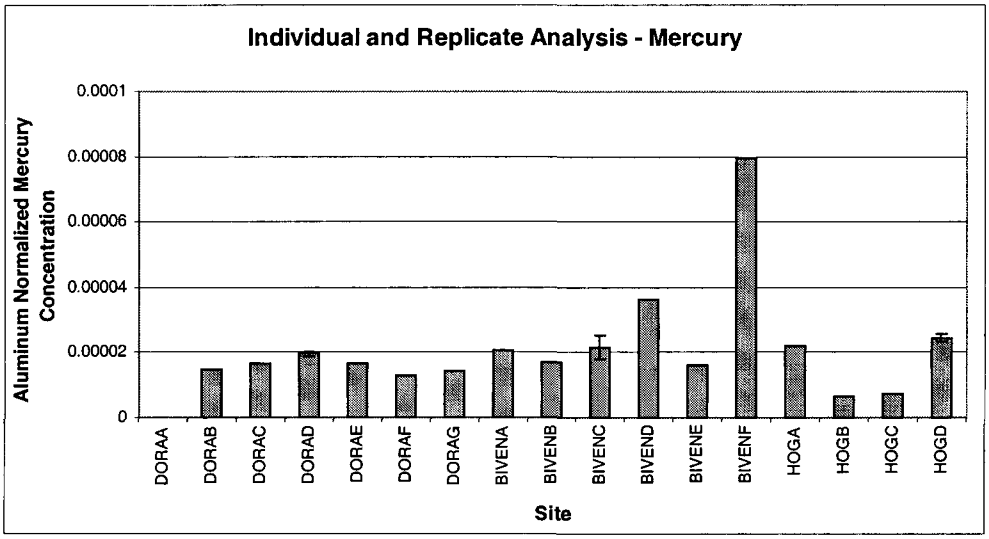


Figure 4-22b. Detailed Assessment Sites — Example Individual and Replicate Site Mercury Data

The error bars provide an aid to estimating which sites at a general location can, with a reasonable degree of confidence, be considered to be different from each other or, at a minimum, from the sample that was collected in replicate. For instance, considering the error bar for DORAD in Figure 4-21b, it can be assumed that the DDT concentrations at DORAA and DORAB are likely lower than at DORAC, DORAD, and DORAE (while those three locations may not have significantly different concentrations from each other), and that the DDT concentrations at DORAF and DORAG are higher than the rest of the DORA location sites, with DORAG being the highest. However, true ANOVA analysis, or other more statistically rigorous similarity/dissimilarity analysis, can only be performed with replicate data from *each* site.

There were two cases in the metals analysis where one of the replicate values was so different than its peers that it was removed due to it being an outlier and not used in calculating the site average for the rest of this section. Specifically, the copper value of 100 mg/kg in SWEETC, replicate 3, was removed from the average. Similarly, the high lead value (300 mg/kg) detected in SWEETC, replicate 2, was removed from the average prior to data presentation and plotting. The reason for the variability in the replicates for these two metals is not understood but may be due to sample non-homogeneity issues.

Organic Contaminants Investigated. The 1996-1997 district-wide base-line monitoring study identified several site locations as areas of potential concern that warranted further, and more detailed, investigation. This detailed assessment study allowed for additional sample collection at each of the specified areas to assist in further characterization. The major classes of organic compounds determined in the detailed assessment study were a series of chlorinated pesticides (DDTs, BHCs, chlordane, and endosulfan) and polychlorinated biphenyls (PCBs; Tables 1-1 and 1-2). These groups of compounds were categorized in Sections 3.1.2.

Pesticides, and to a lesser degree PCBs, were the organic contaminants that in the 1996-1997 study had been identified as potential issues in the Gainesville area. Chlorinated pesticides were the major organic contaminant of concern in the mid-Florida lakes region and at Lakes Disston and George, but PCBs were also quantified in these samples because the data could be generated concurrently. The PCB and pesticide concentrations (non- and TOC-normalized) are reported in Table 3-6, and are also compiled as tables in Appendix F, as Figures in Appendix I, and on maps in Appendix O.

Metals Contaminants Investigated. The 1996-1997 district-wide base-line monitoring study identified two general areas with potential metals contaminant issues that warranted further, and more detailed, investigation. These were the Gainesville area and the mid-Florida lakes area. The 1996-1997 study identified several metals, including cadmium, chromium, copper, mercury, and, most notably, lead, as contaminants of potential concern at the Gainesville area sites, and some metals including arsenic, mercury, and silver, as contaminants of potential concern at the mid-Florida lakes sites. The detailed assessment study allowed for additional sample collection in these areas to further characterize the metals contaminants. Ten metals (Al, As, Cd, Cr, Cu, Pb, Hg, Ni, Ag, and Zn) were analyzed in the detailed assessment study. The metal concentrations (non-, aluminum-, and grain size-normalized) are reported in Tables 3-8a, b, and c, respectively, and are also compiled as tables in Appendix G, as Figures in Appendix L, and on maps in Appendix O.

4.2.1 Gainesville Area Sites

The 1996-1997 base-line study identified PCB, DDT, chlordane, and metals (most notably lead) as being of potential concern at the Gainesville sites, specifically at the Bivens Arm and the Sweetwater Branch locations (Figures 2-2a and 2-2b). As a result, a detailed assessment was performed in this area. Six sites in Bivens Arm, 5 sites in Sweetwater Branch, and 4 sites in the adjacent Hogtown Creek were sampled and analyzed for PCB, chlorinated pesticides, and metals.

Organic Contaminants — Distribution, Composition and Assessment.

The organic contaminant concentrations (PCB and various chlorinated pesticides) varied within this cluster of sites (Table 3-6 and Appendices F, I, and O). PCB concentrations, however, were less variable within the three sampling areas (Bivens Arm, Sweetwater Branch, and Hogtown Creek).

PCB

Figure 4-23 displays the TOC normalized PCB concentrations for the sites in the Gainesville area. In general, the Bivens Arm samples had the highest *non-normalized* PCB concentrations, followed by Sweetwater Branch and Hogtown Creek. The Bivens Arm sediments had higher percent mud and correspondingly higher TOC content than the other locations. The resulting TOC normalized sum of the PCB congener concentrations ranged from 1.3 to 3.8 µg/kg/%TOC at the Bivens Arm sites. The Sweetwater Branch and the Hogtown Creek sediments had higher TOC normalized PCB concentrations because of the lower TOC content of the sediments from these locations; the concentrations ranged from 1.2 to 9 µg/kg/%TOC, and 3.5 to 65 µg/kg/%TOC, respectively. TOC normalized sum of PCB concentrations from the Gainesville area sites sampled during the 1996-1997 base-line monitoring study (OR908, SWBPP1, TUBPP1, and HOG30) were generally between 10 and 15 µg/kg/%TOC.

The PCB composition at these locations (Figure 4-6) most closely resembles a combination of mid to high molecular weight Aroclor formulations (e.g. Aroclors 1254 and 1260), with some contribution of lower molecular weight material (e.g. Aroclor 1242 or 1248). These were the most widely used PCB formulations, and this is a fairly typical PCB composition for aquatic environments. The manufacture and use of PCB was banned in the mid 70's, and most PCB detected today are broad "blends" of historic PCB that may have been transported significant distances. Unique and discrete PCB patterns are generally only observed very close to existing point sources.

As discussed earlier, the total PCB can be estimated by multiplying the sum of the PCB congener concentrations by two. A review of the non-normalized total PCB data indicate that the Gainesville area sites generally had much higher PCB concentrations than most sites sampled in other national monitoring programs (Table 4-5). Seven of the 15 sites (about half the sites) sampled in the Gainesville area had a total PCB concentration greater than the NOAA "high" concentration of 80 µg/kg, compared to exceedance rates of 15% for the NS&T/MW sites and COSED sites. Five of the six Bivens Arm sites and two of the five Sweetwater Branch sites had PCB concentrations that exceeded this reference value.

The PCB concentrations at the Gainesville area sites were also evaluated versus ERL, ERM, and freshwater TEL and PEL values (Tables 4-2 and 4-3). The total PCB concentration exceed the ERL and TEL at eight of the 15 sites (at five Bivens Arm and three Sweetwater Branch sites). The sediment PCB concentrations exceeded the ERM at two of the Bivens Arm sites (BIVEND and BIVENE). The PCB concentrations at the Hogtown Creek sites did not exceed any of the sediment quality guideline values.

It is clear that there are PCB contaminant issues at the locations sampled in the Gainesville area, and particularly in Bivens Arm and Sweetwater Branch. The PCB concentrations were high at most of the Bivens Arm sites (BIVEN A through E), with the last site (BIVENF) being the only site with a significant drop in concentration relative to the rest. The TOC normalized data suggest that there may be a significant source of the PCB towards the city of Gainesville (high TOC-normalized PCB concentrations at HOGA, SWEETC, SWEETD, and SWEETE), but most of the PCB is depositing and accumulating in the more organic rich sediments downstream, as indicated by the non-normalized data (high non-normalized concentrations at BIVENA through BIVENE and SWEETA and SWEETB).

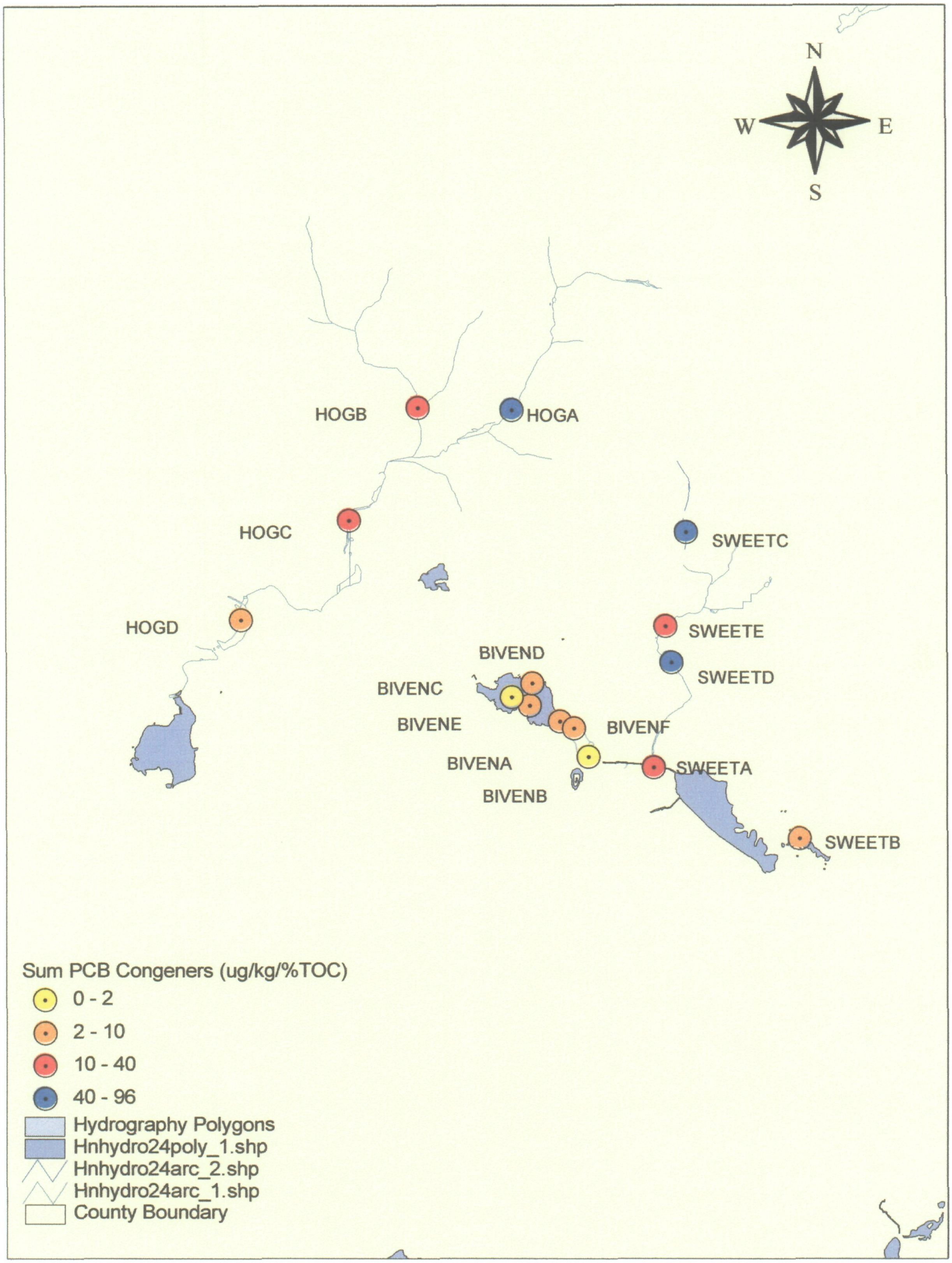


Figure 4-23. Detailed Assessment Sites — Map of TOC Normalized PCB Concentration at Gainesville Area Sites

Table 4-5. Number of Detailed Assessment Sites with Surface Sediment NS&T/MW "High" Value Exceedances

Contaminant and Contaminant Group	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	Gainesville Lakes Region	Mid-Florida Lakes Region	Other Lakes (Disston and George)
Study/Site Information							
Random		No[b]	Yes				
Total sites		224	500	3,878	15	33	15
Parameter							
Ag	0.52	16	8	22	27	12	NA
As	13	13	8	18	0	15	NA
Cd	0.54	16	12	31	47	9	NA
Cr	125	14	3	11	13	0	NA
Cu	42	18	10	25	13	0	NA
Hg	0.22	15	12	30	47	45	NA
Ni	42	13	5	11	0	0	NA
Pb	45	13	12	23	53	12	NA
Zn	135	15	17	22	40	0	NA
Total Chlordane	4.5	14	2	8	33	18	0
Total DDT	22	18	9	23	33	39	7
Total PCBs	80	15	5	15	47	6	0

[a] "High" concentration values are in µg/kg for organic contaminants and mg/kg for metals. 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.

Chlorinated Pesticides

The concentrations of DDT and its degradation products DDD and DDE are presented in Table 3-6, along with the total concentration of these compounds. Figure 4-24 displays the TOC normalized total DDT concentrations at each of the Gainesville area sites. In general, the total DDT concentrations were lower than the PCB concentrations at the Gainesville sites, but the contaminant trends and distributions were similar to what was observed for PCBs. The higher non-normalized DDT concentrations were detected at the depositional Bivens Arm and the lower Sweetwater Branch sites, and the higher TOC-normalized concentrations were at the up-stream Sweetwater Branch and Hogtown Creek sites. The TOC normalized DDT concentrations for the Bivens Arm sites ranged from 0.6 to 2.5 µg/kg/%TOC, whereas TOC normalized DDT concentrations ranged from 1.5 to 38 µg/kg/%TOC at the Hogtown Creek sites, and 1.4 to 31 µg/kg/%TOC at Sweetwater Branch sites. The TOC normalized DDT concentrations from the Gainesville area sites (OR908, SWBPP1, TUBPP1, and HOG30) sampled during the 1996-1997 base-line monitoring study were generally between 1 and 3 µg/kg/%TOC. It is clear that this additional sampling has identified new up-stream locations with higher TOC-normalized DDT (and PCB) concentrations than had been measured previously.

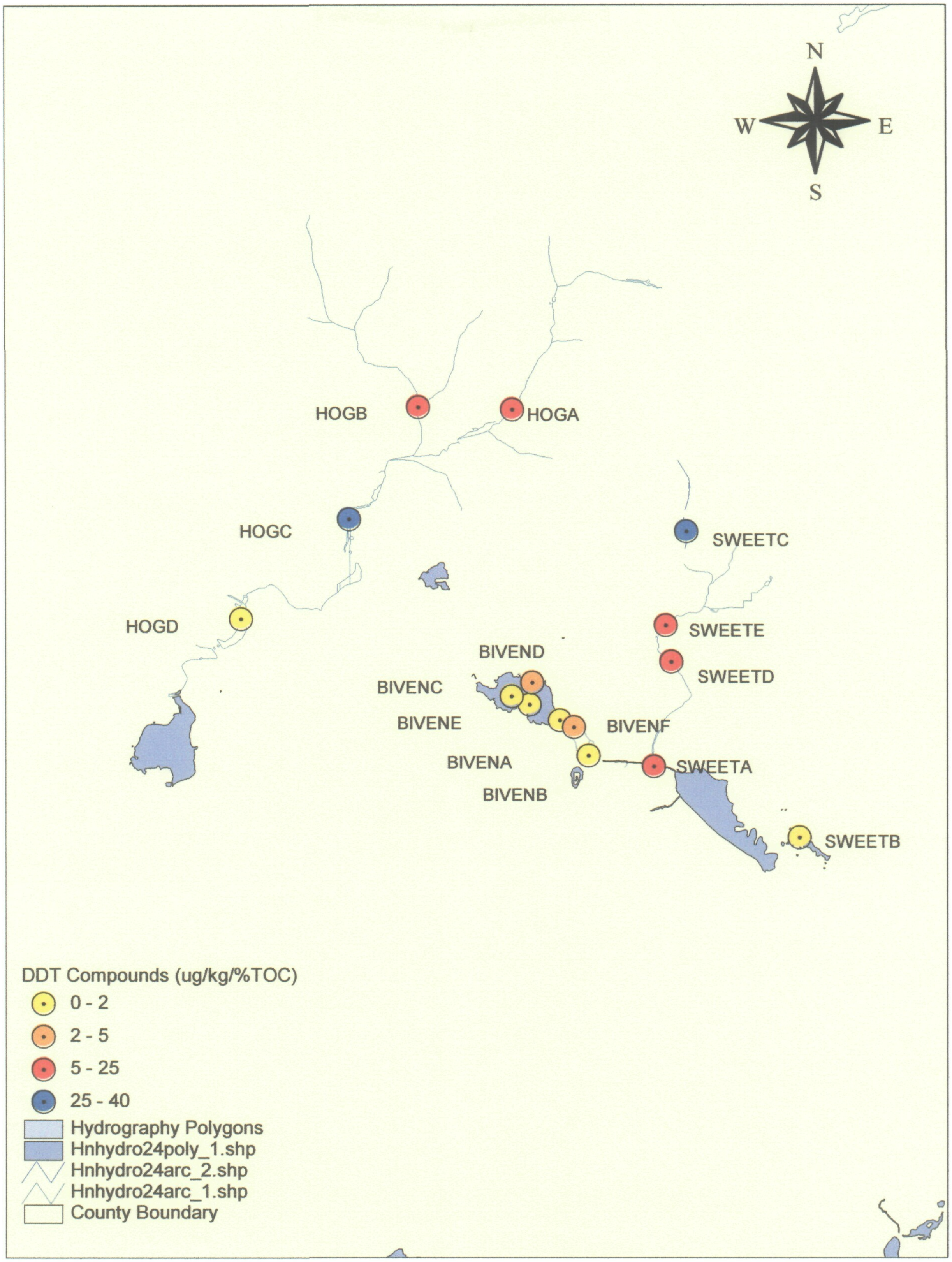


Figure 4-24. Detailed Assessment Sites — Map of TOC Normalized DDT Concentration at Gainesville Area Sites

Various environmental conditions (primarily oxygen supply) dictate the rate of DDT degradation, and the relative amounts of DDD and DDE that are formed. Figure 4-25 shows the relative composition of DDT, DDD, and DDE at selected sites. The concentration of DDE was higher than both the DDD and DDT concentrations in most of the Bivens Arm samples, just as it is in most sediments around the US, as determined in the NOAA Mussel Watch Project (Battelle, 1990, 1991b, 1992). A closer review of the data revealed that concentrations of DDD, and in some instances DDT, were higher than DDE concentrations at several Hogtown Creek (HOGA and HOGC) and Sweetwater Branch sites (SWEETC and SWEETE), suggesting that the DDT has been in an environment less conducive for DDT degradation, *or* closer to an active source of DDT.

The sediments from the Gainesville area sites had total DDT concentrations that resulted in a higher rate of NOAA "high" reference value exceedances than other national monitoring programs (Table 4-5). Five of the 15 sites (33%) sampled in the Gainesville area (four Bivens Arm and one Sweetwater Branch site) had total DDT concentrations greater than the NOAA "high" concentration of 22 µg/kg. Rates of exceedance for total DDT in the NS&T/MW and all COSED sites were 18% and 23% respectively.

The DDT concentrations at the Gainesville area sites were also evaluated versus ERL, ERM, and freshwater TEL and PEL values (Tables 4-2, 4-3, and 4-4). The total DDT concentrations exceeded the ERL at 14 of the 15 sites and the TEL at eight of the 15 sites (five Bivens Arm sites, two Sweetwater Branch sites, and one Hogtown site). There were three ERM exceedances for DDT at the 15 Gainesville area sites; all three were Bivens Arm sites.

The combination of assessments versus typical national sediment concentrations, the ERL/ERM and TEL/PEL sediment quality guidelines, and overall DDT distribution in the Gainesville area suggests that all three locations (Bivens Arm, Hogtown Creek, and Sweetwater Branch) may have DDT concentrations of potential environmental concern. As was observed for the PCB contamination, the DDT data suggest that there may be a significant source(s) of the DDT in the city of Gainesville; there were high TOC-normalized concentrations at upstream sites, and the DDT had a more "fresh" composition upstream than downstream. However, most of the DDT appears to be depositing and accumulating in the more organic rich sediments downstream, as indicated by the non-normalized data (high non-normalized concentrations at BIVENA through BIVENE and SWEETA and SWEETB).

Total chlordane, BHC, and endosulfan concentrations were significantly lower than both PCB and DDT concentrations at the Gainesville area sites. The concentrations of these pesticides are summarized in Table 3-6, and are also presented, along with other pesticide data, in Appendix F. The total chlordane, BHC, and endosulfan concentrations were less variable among the three areas than the PCB and DDT concentrations. Figure 4-26 displays the TOC normalized total chlordane concentrations geographically. The TOC normalized total chlordane concentrations for the Bivens Arm sites ranged from 0.097 to 0.89 µg/kg/%TOC, from 0.85 to 25 µg/kg/%TOC at the Hogtown Creek sites, and at the Sweetwater Branch sites they ranged from 0.65 to 17 µg/kg/%TOC. The TOC normalized total chlordane concentrations at the Gainesville area sites sampled during the 1996-1997 base-line study (OR908, SWBPP1, TUBPP1, and HOG30) were generally between 0.2 and 2 µg/kg/%TOC. The BHC concentrations for the Bivens Arm sites ranged from ND to 0.29 µg/kg/%TOC, they ranged from 0.31 to 2.1 µg/kg/%TOC at the Hogtown Creek sites, and from 0.068 to 3.7 µg/kg/%TOC at the Sweetwater Branch sites. In the 1996-1997 study the BHC concentrations at the Gainesville area sites were generally between ND and 0.33 µg/kg/%TOC. The endosulfan concentrations followed similar trends; the Bivens Arm sites had the lowest TOC-normalized concentrations, from ND to 0.40 µg/kg/%TOC, followed by the Hogtown Creek and Sweetwater Branch sites, ranging from 0.43 to 7.1 µg/kg/%TOC and 0.11 to 6.2 µg/kg/%TOC, respectively.

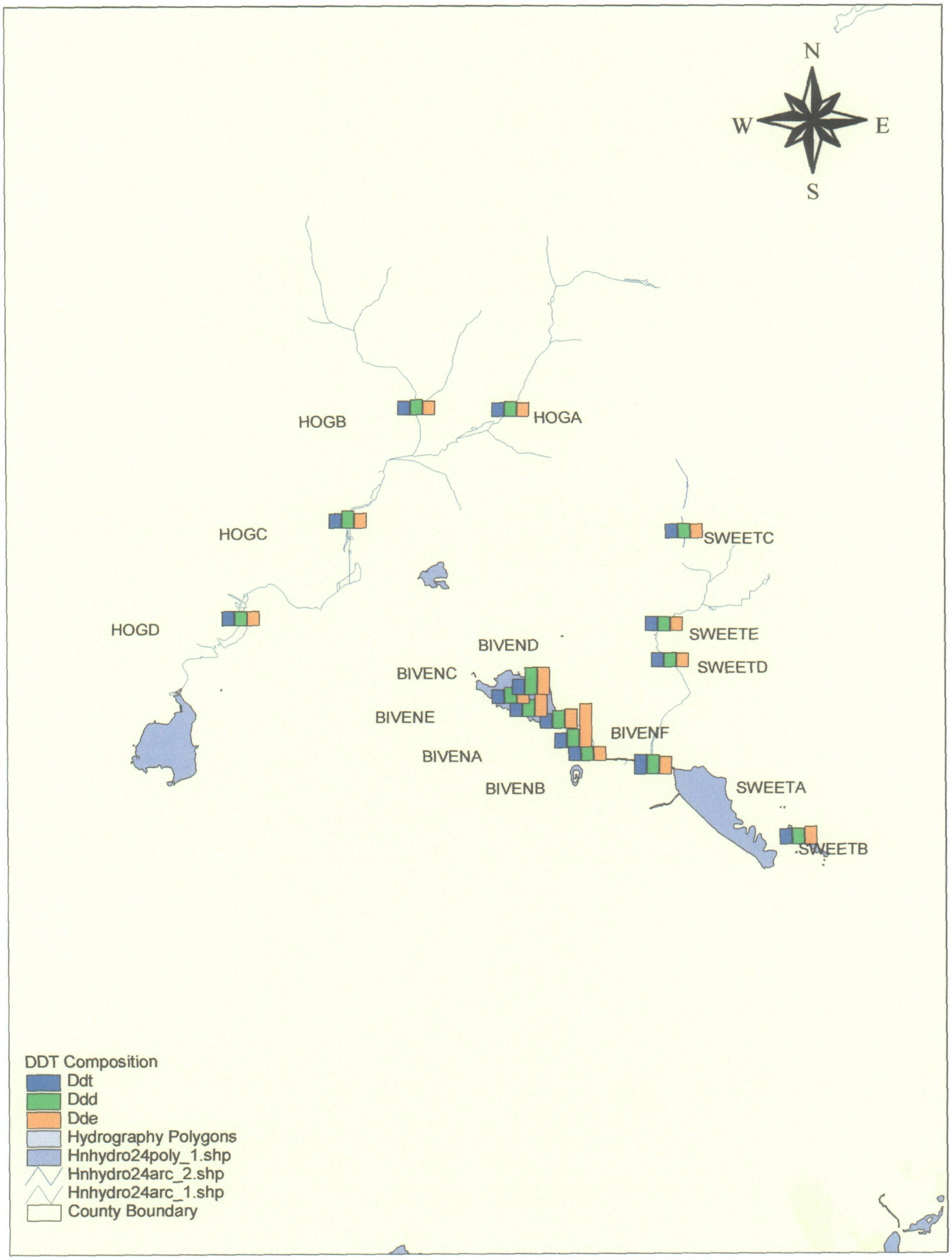


Figure 4-25. Detailed Assessment Sites — Map of DDT Composition at Gainesville Area Sites

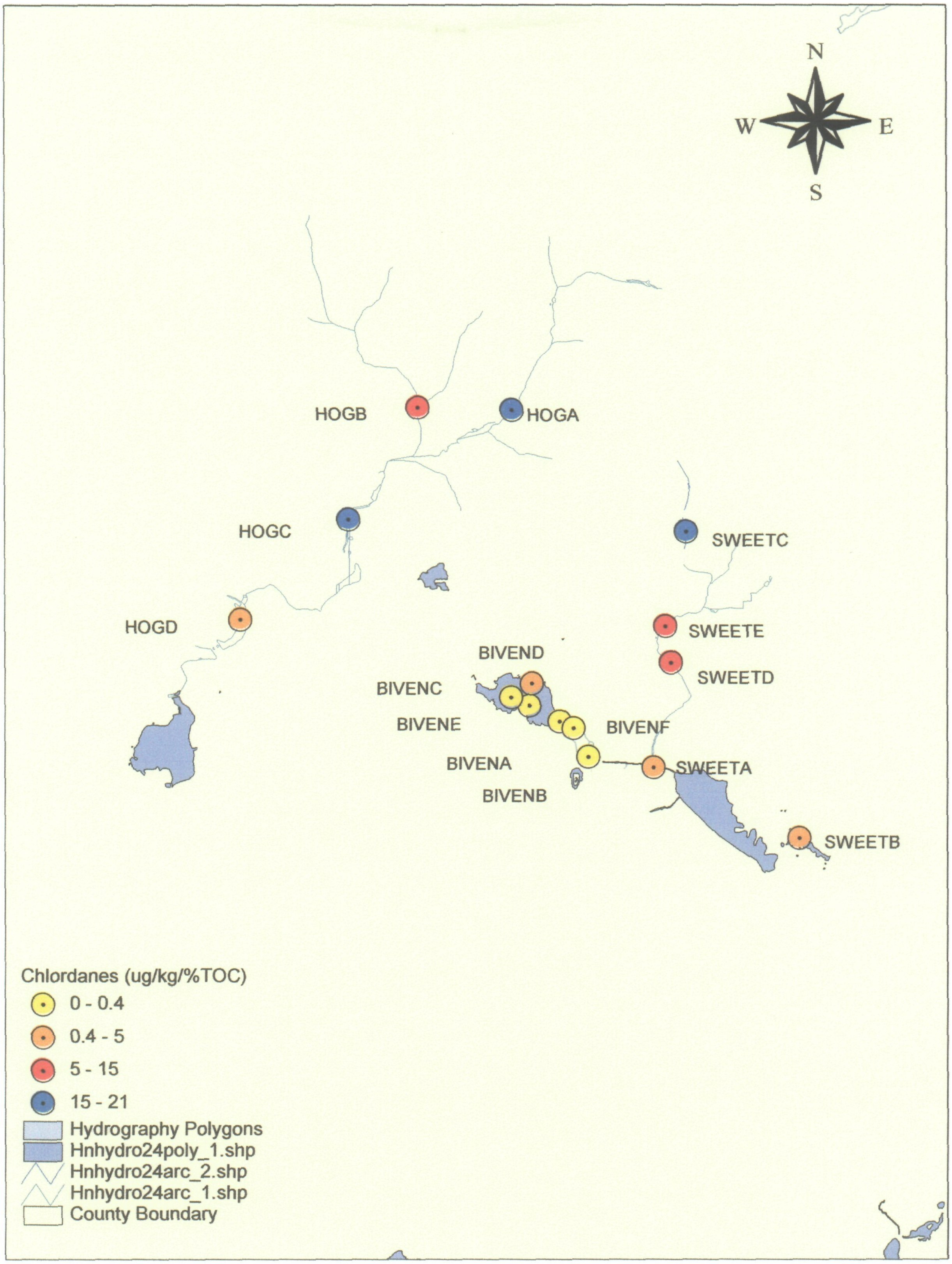


Figure 4-26. Detailed Assessment Sites — Map of TOC Normalized Total Chlordane Concentrations at Gainesville Area Sites

A review of the non-normalized total chlordane concentrations indicate that the Gainesville area sites have a higher rate of NS&T/MW "high" value exceedances than the referenced national monitoring programs (Table 4-5). Five of the 15 sites sampled in the Gainesville area had total chlordane concentrations greater than the NOAA "high" concentration of 4.5 µg/kg (2 Bivens Arm, 2 Sweetwater Branch, and 1 Hogtown Creek site); 33% of the Gainesville area sites had exceedances. Rates of exceedance for total chlordane in the NS&T/MW and all COSED sites were only 14% and 8% respectively. NS&T/MW "high" values are not available for BHCs and endosulfans.

The chlordane concentrations for the Gainesville area sites were evaluated versus ERL, ERM, freshwater TEL, and PEL values (Tables 4-2 and 4-3). The chlordane concentrations exceeded the ERL at 14 of the 15 Gainesville area sites, the TEL at five of the 15 sites, and the PEL at two of the sites. The TEL exceedances were for two Bivens Arm sites, two Sweetwater Branch sites, and one Hogtown Creek site. The PEL exceedances were for BIVEND and SWEETA. Chlordane concentrations exceeded the ERL at 1 of the 6 Bivens Arm sites, whereas the ERL was exceeded at all 4 of the Hogtown Creek sites, and at all 5 Sweetwater Branch sites. There were no chlordane ERM exceedances at the Gainesville area sites.

Sediment quality guideline values are not available for total BHCs or for endosulfans, but freshwater TEL and PEL values are available for lindane (γ-BHC). The lindane concentrations exceeded the TEL at three of the 15 sites; BIVENA, BIVENE, and SWEETA. There were no PEL exceedances for lindane at any of the Gainesville sites.

The chlordane and endosulfan contamination is in many ways similar to the PCB and DDT contamination in the Gainesville area, indicating that all three locations (Bivens Arm, Hogtown Creek, and Sweetwater Branch) have concentrations of potential concern. The BHC concentrations were more variable and appeared to be of lower concern. The non-normalized chlordane and endosulfan concentrations were highest at the Bivens Arm and Sweetwater Branch sites, while after TOC normalizing the data the Sweetwater Branch and Hogtown Creek sites emerged as the highest in concentration. As for PCB and DDT, these data suggest that there may be a significant source(s) of chlordane and endosulfan upstream (e.g., high TOC-normalized concentrations at HOGA, HOGB, SWEETC and SWEETE), while the bulk of the pesticides are accumulating downstream (e.g., SWEETA and BIVEND).

Metals Contaminants — Distribution, Composition and Assessment

The metals composition and concentrations varied from metal-to-metal for the three different Gainesville area locations that were sampled, suggesting that some metals may have similar sources while others may have more contaminant-specific origins. The aluminum-normalized lead concentrations at the Gainesville area sites are shown in Figure 4-27 (lead was a metal that was found to be of particular concern in the Gainesville area during the 1996-1997 study). Detailed maps depicting the concentrations of other metals are can be found in Appendix O. These maps help to visually identify the areas with elevated metal concentrations, and can be used in conjunction with the non-normalized and normalized plots in Appendix L to assess the contaminant characteristics of the area. Elevated concentrations of arsenic, cadmium, chromium, lead, mercury, silver, and zinc were observed at one or more of the three Gainesville sampling locations, while the copper and nickel concentrations were close to what can be expected for this type of environment. The metals concentrations were highest at the Bivens Arm or Sweetwater Branch sites, and there does not appear to be metals contamination at any environmentally significant levels at the Hogtown Creek sites. The metals contamination is discussed further below.

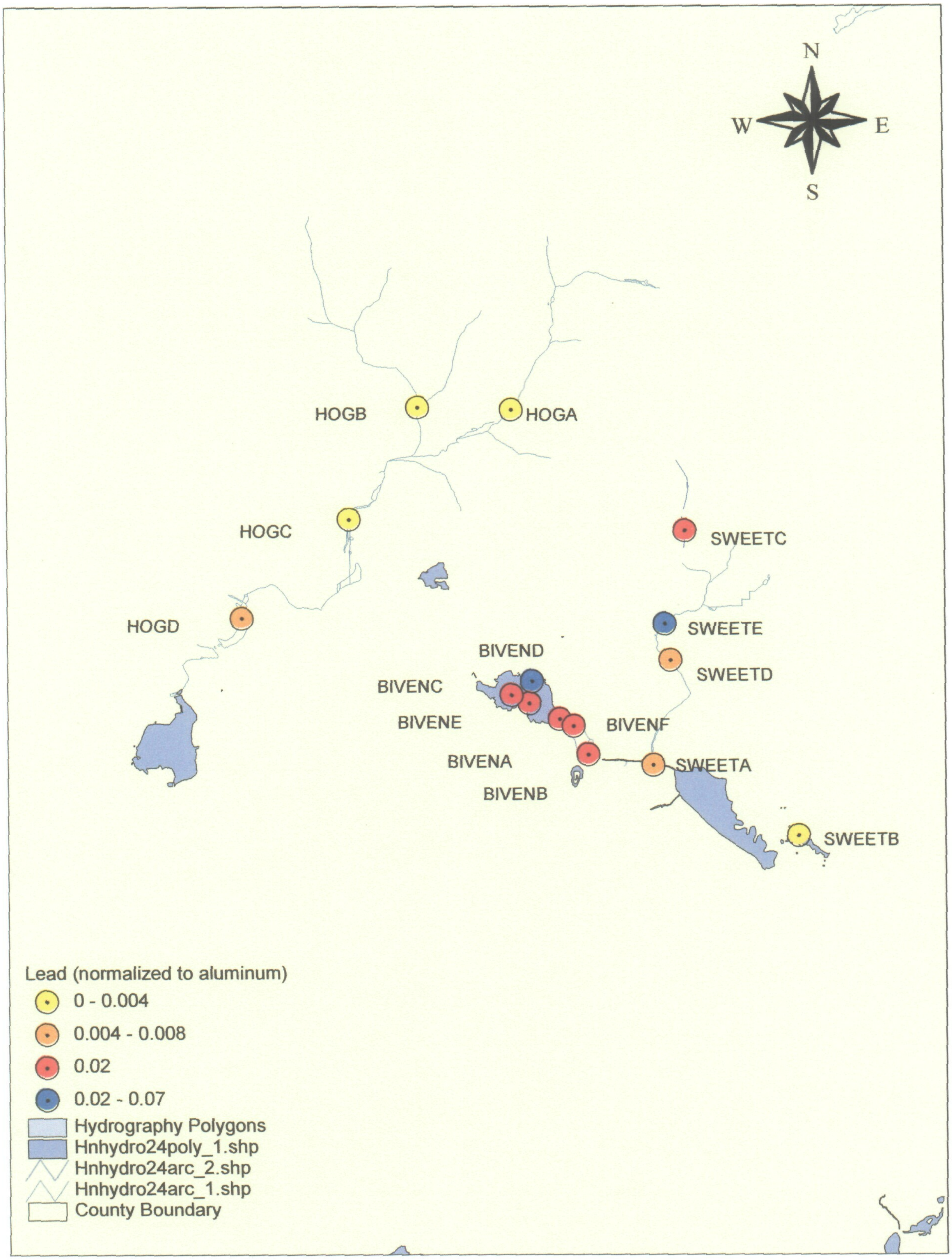


Figure 4-27. Detailed Assessment Sites — Map of Aluminum Normalized Lead Concentrations at Gainesville Area Sites

The arsenic concentrations ranged from ND to 12.1 mg/kg at the Bivens Arm sites (it was not detected at BIVENF), and were lower or not detected at the other locations; they were from ND to 4.32 mg/kg at Sweetwater Branch sites and there was no arsenic detected in the sediments from the Hogtown Creek sites. Arsenic concentrations were less than 4 mg/kg at the Gainesville area sites in the 1996-1997 study (OR908, SWBPP1, TUBPP1, and HOG30), and the NS&T/MW "high" reference value (Table 4-5) for arsenic is 13 mg/kg, which was not exceeded for any of the Gainesville are sediment samples.

The cadmium, chromium, lead, mercury and zinc concentrations had similar contamination characteristics for the three locations; the non-normalized concentrations were highest at the Bivens Arm sites, but the concentrations were still notable and of significance at the Sweetwater Branch sites. The cadmium concentrations ranged from not detected to 1.7 µg/kg at the Bivens Arm sites and from 0.075 mg/kg to 0.32 µg/kg at Hogtown Creek sites, compared to a range of 0.1 mg/kg to 1.4 mg/kg in the 1996-1997 study. Chromium concentrations were substantially higher than arsenic and cadmium concentrations, and spanned the largest concentration range; from 2.1 mg/kg to 190 mg/kg at the Bivens Arm sites, compared to a range from 3 mg/kg to a high of 140 mg/kg at OR908 (Bivens Arm) in the 1996-1997 study. The lead concentrations ranged from 2.4 mg/kg to 370 mg/kg at the Bivens Arm sites and from 15 mg/kg to 98 mg/kg at Sweetwater Branch sites; similar ranges were observed in the 1996-1997 base-line monitoring study, with ranges from about 11 to a high of 260 mg/kg at OR908 (Bivens Arm) and 343 mg/kg at SWBPP1 (Sweetwater Branch). The mercury concentrations measured in this study were similar to those measured in the 1996-1997 study; from 0.022 mg/kg to 0.43 mg/kg at the Bivens Arm sites (up to 0.27 mg/kg at Sweetwater Branch sites), compared to a high of 0.39 mg/kg at OR908 (Bivens Arm) in the previous study.

The aluminum-normalized concentrations of these metals were similar at the Bivens Arm and Sweetwater Branch sites, which is an indication that the coarser sediments in the Sweetwater Branch sites may be exposed to similar or higher concentrations from the water column, but they appear to be accumulating in the downstream sediments (sites SWEETA, SWEETB, and BIVENA through BIVENE). Silver was distributed slightly differently, with the downstream Sweetwater Branch sites (SWEETA and SWEETB) having, comparatively, higher concentrations than other locations, suggesting there may be less current input from upstream sources or there could be downstream source(s) of silver.

A review of the non-normalized metals concentrations indicate that the Gainesville area sites, in general, had a higher rate of NS&T/MW "high" value exceedances for several metals than the listed national monitoring programs (Table 4-5). Cadmium, mercury, lead, silver, and zinc had notably higher rates of exceedance (47%, 47%, 53%, 27%, and 40% respectively) that the NS&T/MW sites and COSED sites. Chromium and copper concentrations had similar rates of exceedances as the NS&T/MW sites and COSED sites. None of the 15 Gainesville area sites sampled had arsenic or nickel concentrations that were greater than the NOAA "high" concentrations of 13 µg/kg. The majority of the metals concentration exceedances were for the Bivens Arm sites, followed by the Sweetwater Branch sites.

The metals concentrations at the Gainesville area sites were also evaluated versus ERL, ERM, and freshwater TEL, and PEL values (Tables 4-2 and 4-3, and Appendix N). The metal ERL, ERM, TEL, and PEL exceedances at each of the 3 sets of Gainesville area sites are summarized in Table 4-6. The Bivens Arm sites had the highest total number of exceedances (a total of 74 ERL/ERM/TEL/PEL), followed by the Sweetwater Branch sites (20 exceedances). There were no ERL, ERL, TEL, or PEL exceedances at the Hogtown Creek sites.

Table 4-6. Metal ERL, ERM, Freshwater TEL and PEL Exceedances at Gainesville Area Sites

Site	SQG Indicator	As	Cd	Cr	Cu	Pb	Hg	Ni	Ag	Zn	Total Exceedances
Bivens Arm	ERL	2	3	5	3	5	5	1	0	5	29
	ERM	0	0	0	0	3	0	0	0	0	3
	TEL	3	5	5	3	5	5	2		5	33
	PEL	0	0	4	0	5	0	0		0	9
Exceedances at Bivens Arm		5	8	14	6	18	10	3	0	10	74
Sweetwater Branch	ERL	0	1	0	0	3	2	0	1	1	8
	ERM	0	0	0	0	0	0	0	0	0	0
	TEL	0	2	2	0	3	2	0		1	10
	PEL	0	0	0	0	2	0	0		0	2
Exceedances at Sweetwater Branch		0	3	2	0	8	4	0	1	2	20
Hogtown Creek	ERL	0	0	0	0	0	0	0	0	0	0
	ERM	0	0	0	0	0	0	0	0	0	0
	TEL	0	0	0	0	0	0	0		0	0
	PEL	0	0	0	0	0	0	0		0	0
Exceedances at Hogtown Creek		0	0	0	0	0	0	0	0	0	0

Lead was the metal contaminant with the highest number, and most significant type, of sediment quality guideline exceedances; 18 at the Bivens Arm sites and eight at the Sweetwater Branch sites. Most notable were the lead levels (Figure 4-28), which exceeded the ERL and TEL at five of the six Bivens Arm sites and at three of the five Sweetwater Branch sites. The higher PEL was exceeded at the same five Bivens Arm sites and at two Sweetwater Branch sites, and the ERM was exceeded at three of the Bivens Arm sites. Chromium was the metal with the second most significant sediment quality guideline exceedances. There were 14 chromium exceedances overall at the Bivens Arm sites and two at the Sweetwater Branch sites; four of the exceedances at Sweetwater Branch sites were PEL exceedances.

The ERL and/or the TEL were exceeded for arsenic, cadmium, copper, mercury, nickel, and zinc at one or more Bivens Arm sites, and they were exceeded for cadmium, mercury, silver, and zinc at one or more of the Sweetwater Branch sites (Table 4-6 and Appendix N). Although the Bivens Arm sites had the greatest number of metals exceedances, there were none for the site BIVENF. This site had the lowest TOC content (0.4% compared to 30% on average for the 5 other sites) and the lowest percent mud (3.5% compared to 39% on average for the 5 other sites) of the 6 Bivens Arm sites, which likely accounts for the low metals concentrations found at this particular farthest downstream site. The Hogtown Creek sites, which had no sediment quality guideline exceedances, were similarly sandy and low in organic carbon.

Based on the metals distribution, and their concentrations relative to reference values and sediment quality guidelines, it appears that there may be a potential for impact from toxic metals to the aquatic environment in the Gainesville area. The primary areas of concern appear to be the Bivens Arm and Sweetwater Branch locations. The metals that appear to be elevated the most, and/or contributing the greatest risk, are lead, cadmium, chromium, and zinc, followed by mercury and silver. The data suggest that there may be a significant source(s) of these contaminants in the vicinity of the upstream Sweetwater Branch sites. The contaminants are then carried downstream and deposited at the lower Sweetwater Branch locations (e.g., SWEETA and SWEETB).

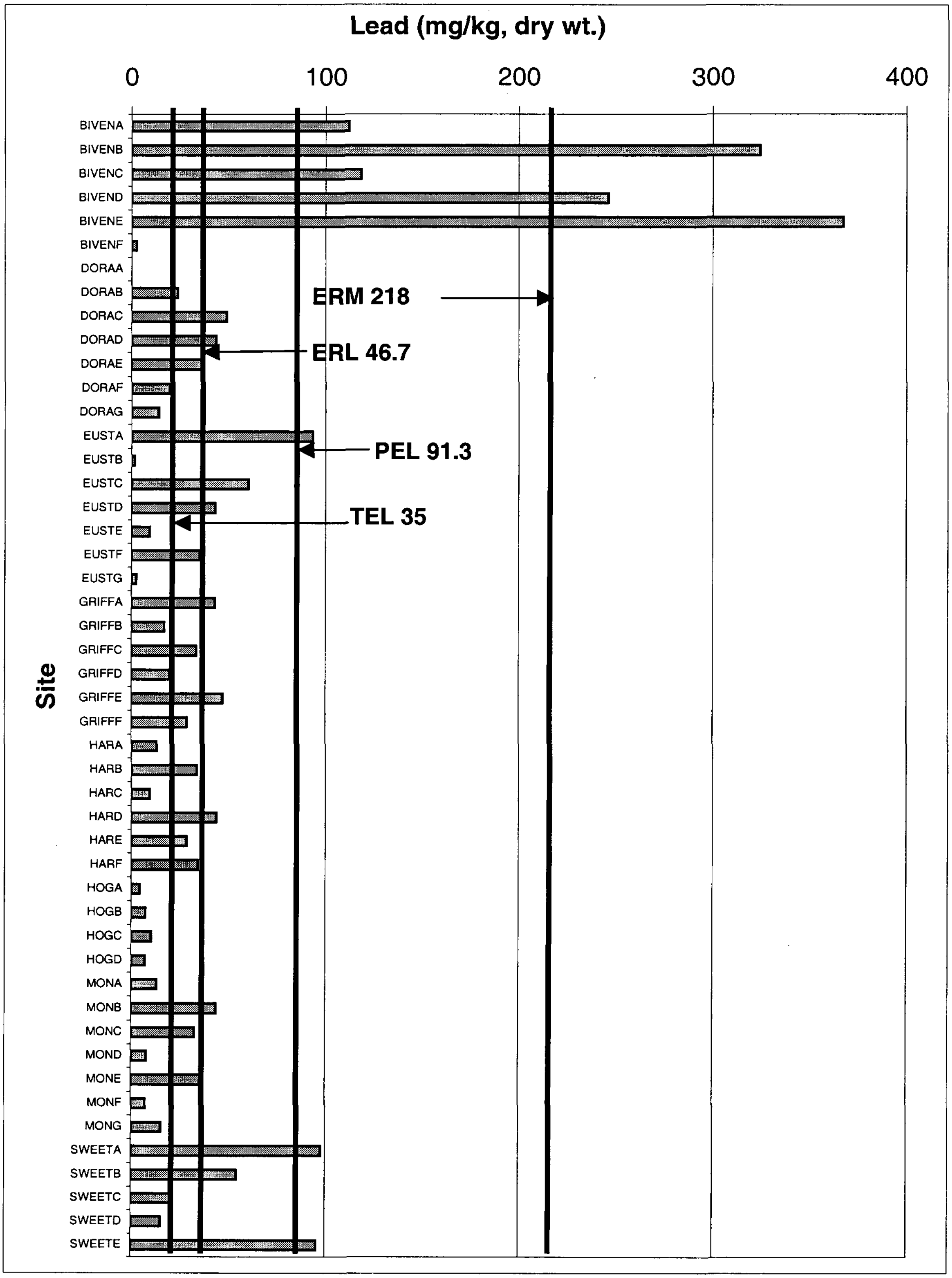


Figure 4-28. Detailed Assessment Sites — Sediment Lead Concentrations and ERL/ERM and Freshwater TEL/PEL Values

There is an abundance of potential sources of metals for the Sweetwater Branch. These sources including urban runoff from an older section of downtown Gainesville and the City's main wastewater treatment facility which discharges effluent directly into the Sweetwater Branch. Although it may appear that Bivens Arm could be a source of some of the metals contamination observed at the lower Sweetwater Branch sites, it is very unlikely, as the flows of these two creeks (Sweetwater and Bivens Arm) are confined to different channels and enter the prairie at discrete and different point. The Bivens Arm metals contamination is more uniformly distributed, suggesting there may be more of a chronic non-point source of the contamination. Alternatively the contamination may be more historic in origin and has distributed itself with time, or there may be sources of contamination to this area that have not been identified. A better understanding of the water inputs to the Bivens Arm, and the flow characteristics of the area, would be valuable for better predicting the origin of these contaminants.

4.2.2 Mid-Florida Lakes Sites

The 1996-1997 base-line study identified potential PCB, DDT, and metals contaminant issues at the mid-Florida lakes sites, including Lake Harris, Lake Eustis, Lake Griffin, Lake Dora and Lake Monroe. As a result, a detailed assessment at these locations was performed. Six sites in Lake Harris, seven sites in Lake Eustis, six sites in Lake Griffin, seven sites in Lake Dora, and seven sites in Lake Monroe were sampled and analyzed for PCB, chlorinated pesticides, and metals.

Organic Contaminants — Distribution, Composition and Assessment.
The organic contaminant concentrations (PCB and pesticide) within these lakes were somewhat variable (Table 3-6 and Appendices F and I). Maps displaying the non-normalized and TOC normalized PCB and pesticide concentrations are compiled in Appendix O. Please note that Lake Monroe is located East of the four other mid-Florida sites and is not linked to the four-lake system.

PCB
The non-normalized PCB concentrations at the mid-Florida lakes were similar to those in parts of the Gainesville area and other lake sites. However, the TOC normalized PCB concentrations at the mid-Florida lakes sites are substantially lower due to the high organic nature of the mid-Florida lake sediments (Appendices I and O). The TOC content of the mid-Florida lakes sediments ranged from 0.1% to 44.5%, and averaged approximately 25%. The average non-normalized PCB concentration was 14 μg/kg and the average TOC normalized PCB concentration was 1.1 μg/kg/%TOC. In comparison, somewhat higher PCB concentrations were observed for the mid-Florida lakes sites (20020381, 20020377, 02238000, 20020368, HAR, DOR, LMAC, and 20010003) that were sampled during the 1996-1997 base-line monitoring study, with average non- and TOC normalized PCB concentrations of approximately 55 μg/kg and 3.5 μg/kg/%TOC, respectively.

The PCB concentrations of the sampled mid-Florida lakes sites have a much lower rate of exceedance of the NS&T/MW "high" reference value than other national monitoring programs (Table 4-5). Two of the 33 sites (six percent of the sites) sampled in the mid-Florida lakes had total PCB concentrations greater than the NOAA "high" concentration of 80 μg/kg, compared to rates of exceedance of 15% for the NS&T/MW sites and COSED sites.

The PCB concentrations at the mid-Florida lakes sites were evaluated versus ERL, ERM, freshwater TEL, and PEL values (Tables 4-2 and 4-3). There were 15 ERL and nine TEL PCB exceedances for the 33 mid-Florida Lakes sites. There were no PCB ERM or PEL exceedances at any of the mid-Florida lake sites. The exceedances were scattered among the different lakes, with no obvious geographic pattern or relationship; with two of the nine TEL exceedances being at Lake Dora sites, three at Lake

Eustis, two at Lake Griffin, one at Lake Harris, and one at Lake Monroe. These data from this more detailed assessment of the mid-Florida lakes area suggest that PCB is likely not a contaminant of significant concern in these lakes.

Chlorinated Pesticides

The DDT concentrations, on the other hand, appear to be of significant environmental concern at several mid-Florida lakes locations. The concentrations of DDT, and its degradation products DDD and DDE, are listed in Table 3-6. Figure 4-29a shows the total DDT concentrations for all of the sites sampled in the detailed assessment study, and Figure 4-29b displays the TOC normalized DDT concentrations for the mid-Florida lakes (with Lake Monroe excluded). The average non-normalized and TOC-normalized DDT concentrations were 36 µg/kg and 1.5 µg/kg/%TOC, respectively, for the mid-Florida lakes sites. Similar concentrations were detected in the mid-Florida lakes sites sampled during the 1996-1997 base-line monitoring study (20020381, 20020377, 02238000, 20020368, HAR, DOR, LMAC, and 20010003); average non- and TOC-normalized total DDT concentrations were approximately 34 µg/kg and 1.8 µg/kg/%TOC, respectively. Lake Dora (consisting of sites from Lake Dora and Lake Beauclair) had the highest DDT concentrations of the mid-Florida lakes; the average total DDT concentration for Lake Dora/Beauclair was 3.4 µg/kg/%TOC, compared to 1.8 µg/kg/%TOC for Lake Eustis, 0.67 µg/kg/%TOC for Lake Harris, and 0.48 µg/kg/%TOC for Griffin Lake. The average concentration at Lake Monroe was 0.98 µg/kg/%TOC. Sites DORAF and DORAG, located in Lake Beauclair, were the sites with the highest concentrations of DDT; 203 and 200 µg/kg, respectively (the TOC-normalized concentrations were 5.2 and 7.4 µg/kg/%TOC).

Figure 4-30 shows the relative composition of DDT, DDD, and DDE at the sites in Lakes Dora/Beauclair, Lake Eustis, Lake Harris, and Lake Griffin. The concentration of DDE was higher than both the DDD and DDT concentrations at the majority of the mid-Florida lake sites, just as it is in most sediments around the US, as determined in the NOAA Mussel Watch Project (Battelle, 1990, 1991b, 1992). There was no evidence of significant proportions of undegraded or "fresh" DDT at any of the locations.

A review of non-normalized total DDT concentrations indicate that the mid-Florida lakes sites have a significantly higher rate of NS&T/MW "high" value exceedance than sediments analyzed in other national monitoring programs (Table 4-5). Fourteen of the 33 sites (42%) sampled in the Mid-Florida Lakes had total DDT concentrations greater than the NOAA "high" concentration of 22 µg/kg. The rates of exceedance for total DDT and the NS&T/MW and all COSED sites were 18% and 23% respectively. The highest rate of exceedance occurred at Lake Dora with six of the seven sites exceeding the NOAA "high" value. The lowest rate of exceedance occurred at Lake Monroe with only one of the seven sites exceeding this reference value.

The DDT data were also evaluated versus sediment quality guideline values (Tables 4-2 and 4-3). The total DDT concentration exceed the ERL at 28 of the 33 sites (Figure 4-31); it was exceeded at six of the seven Lake Dora/Beauclair sites, at five of the seven Lake Eustis sites, at all six Lake Harris sites, at all six Lake Griffin sites, and at five of the seven Lake Monroe sites. The total DDT TEL was exceeded at 24 of the 33 sites and the ERL was exceeded at eight sites. The ERL exceedances were most notable for Lake Dora/Beauclair; all six Lake Dora/Beauclair sites that exceeded the ERL and TEL also exceeded the ERM for DDT. One Lake Eustis site (the southernmost EUSTC) and one Lake Harris (HARB – the site in the middle of Lake Harris) also exceeded the ERL for DDT.

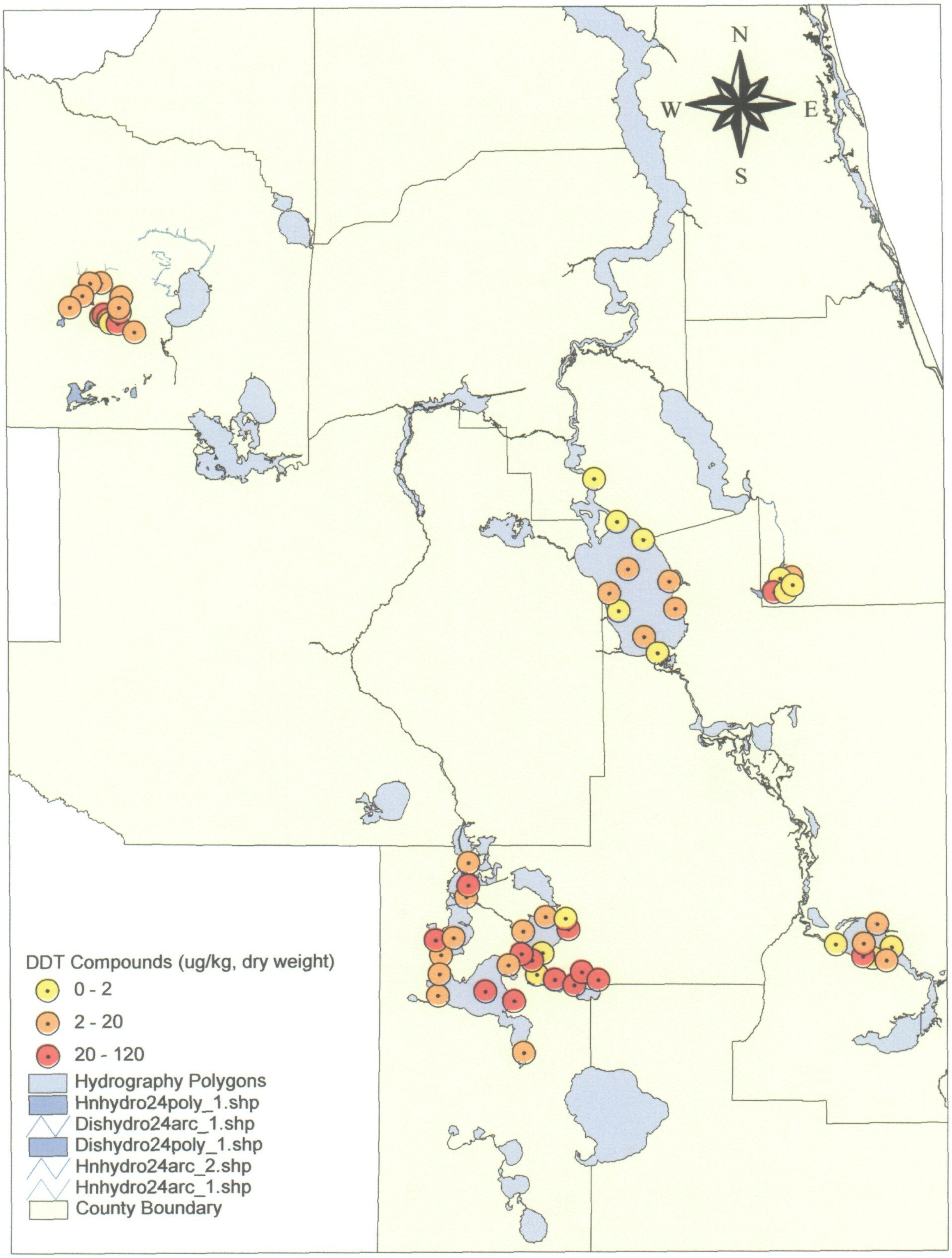


Figure 4-29a. Detailed Assessment Sites — Map of Sum of DDT Concentrations

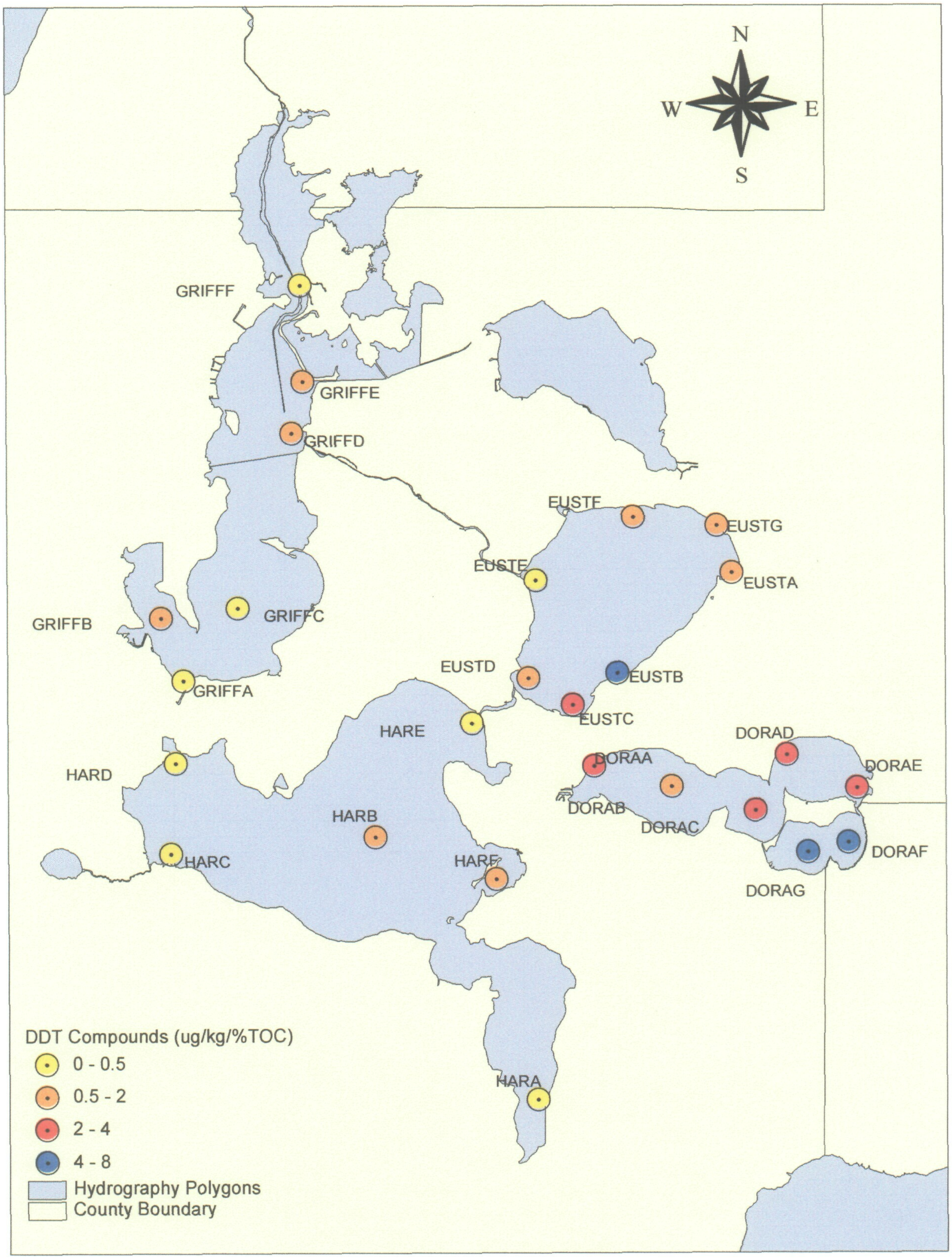


Figure 4-29b. Detailed Assessment Sites — Map of TOC Normalized DDT Concentrations at Mid-Florida Lakes Sites (Lake Monroe not included)

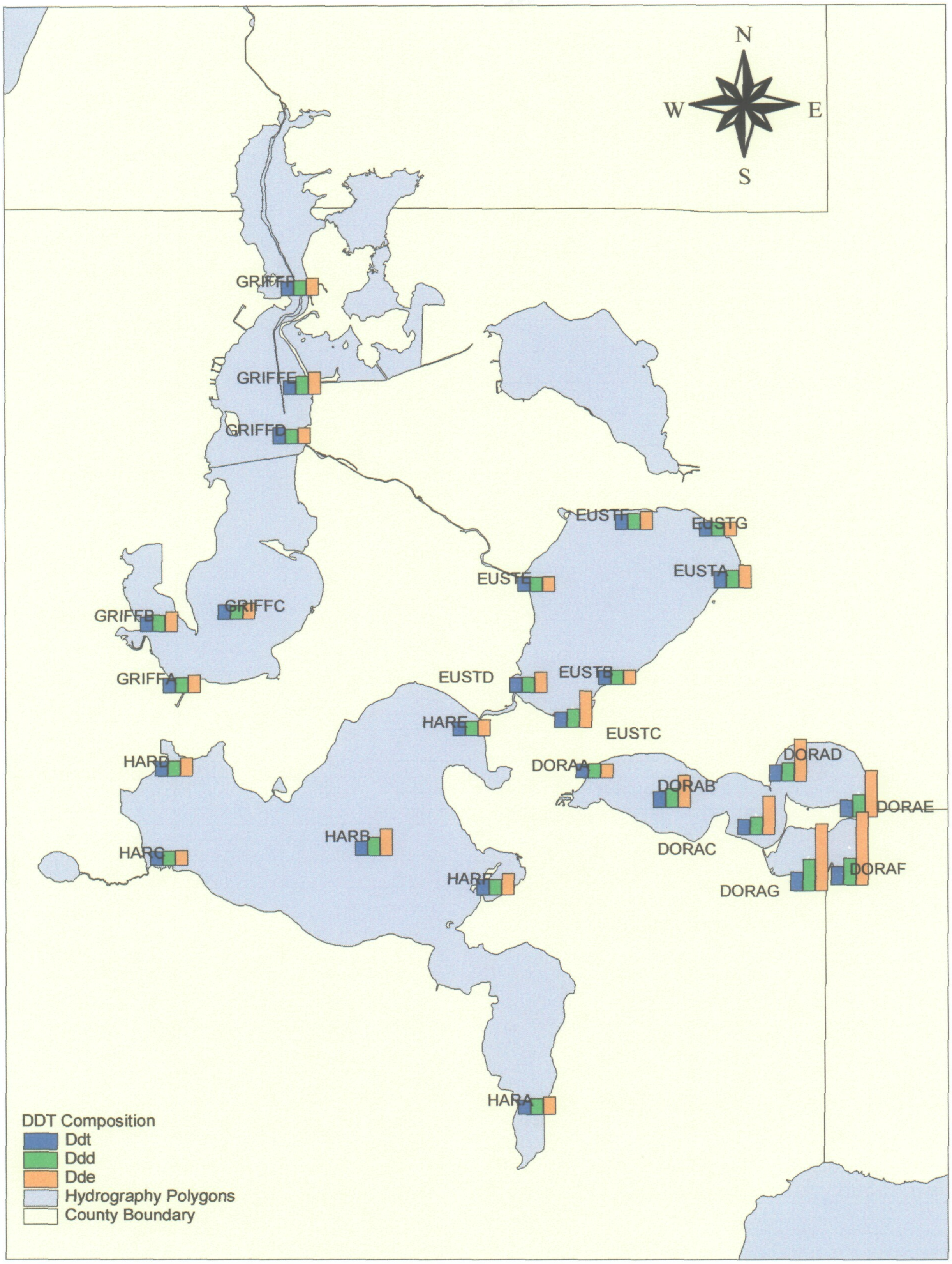


Figure 4-30. Detailed Assessment Sites — Map of DDT Composition at Mid-Florida Lakes Sites

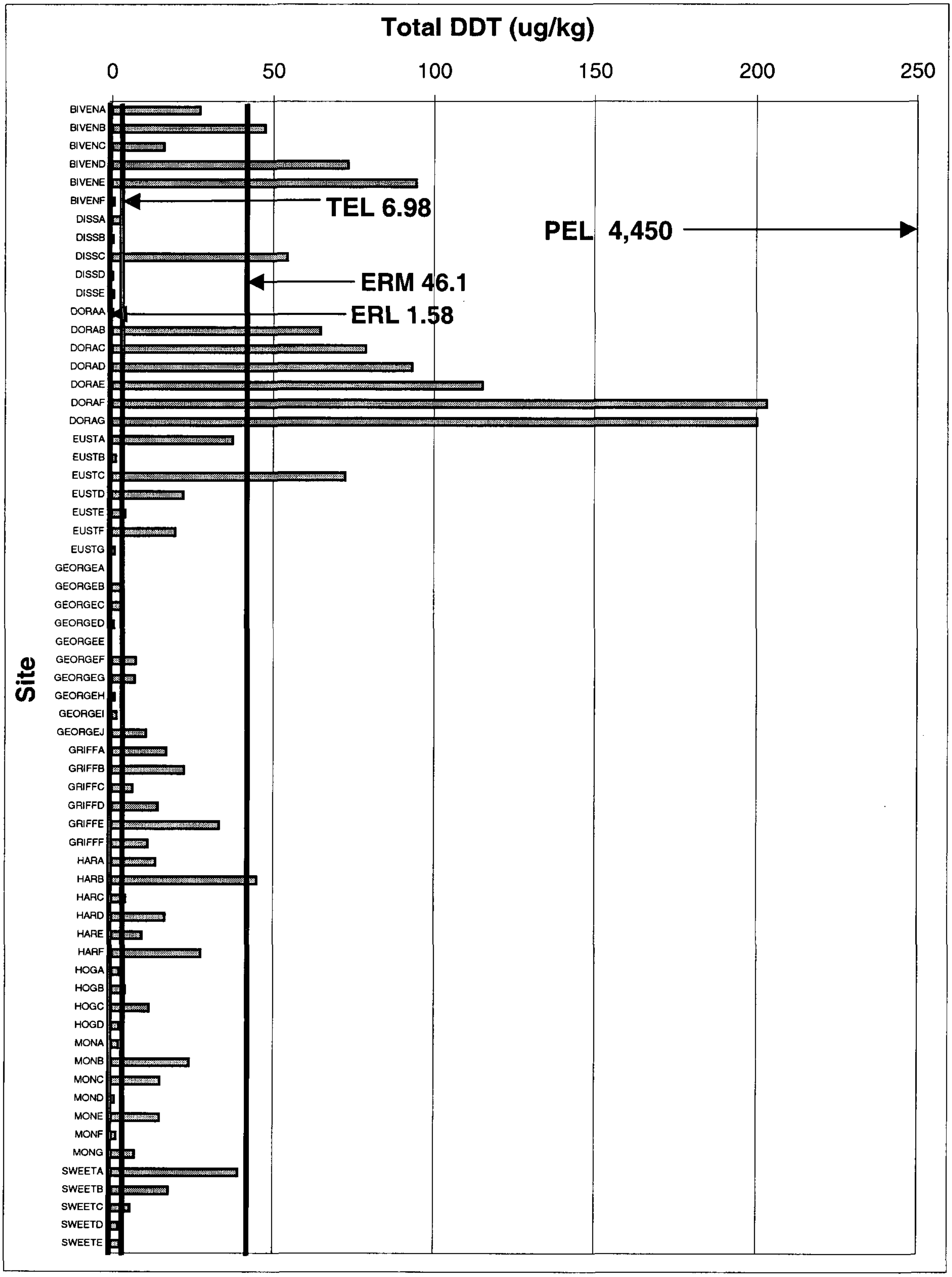


Figure 4-31. Detailed Assessment Sites — Sum of DDT Concentrations and ERL/ERM and Freshwater TEL/PEL Values

The DDT concentrations are clearly very high in Lakes Dora and Beauclair, and several other locations. The concentrations are most elevated in Lake Beauclair (sites DORAF and DORAG), which receives water from the south; the primary source of the DDT in these interconnected lakes appears to be the bodies of water that are feeding the south-eastern parts of Lake Dora, such as Lake Apopka. An earlier SJRWMD publication also reported high DDx concentrations in Lakes Beauclair and Dora, and attributed them as most likely resulting from discharges from Lake Apopka, which has historically had large agricultural areas adjacent to the lake, as well as an extensive pesticide spill at a chemical company adjacent to the lake. (Fulton 1996). Much of the DDT appears to be transported to Lake Eustis, which has significantly elevated concentrations at several locations (e.g., EUSTC, closest to the flow from Lake Dora). Lower, although still fairly high compared to most environments, are the DDT concentrations in Lake Harris and Lake Griffin, further downstream. The DDT contamination in Lake Monroe appears to be comparable to that of Lake Harris and Lake Griffin.

The chlordane and BHC concentrations were significantly lower than PCB and DDT concentrations at the mid-Florida lake sites, and there were no or minimal amounts of endosulfan measured (Table 3-6 and Appendix I). The chlordane concentrations followed a similar distribution as the DDT concentrations, with relatively high concentrations being measured at six of the seven Lake Dora sites, and also relatively high concentrations at a few Lake Eustis (EUSTA actually had the highest concentration of all sites), Lake Monroe, and Lake Griffin sites. The average non-normalized and TOC-normalized chlordane concentrations were 2.8 μg/kg and 0.13 μg/kg/%TOC, respectively. Lower concentrations (approximately 0.5 μg/kg and 0.08μg/kg/%TOC, respectively) were generally measured at the mid-Florida lakes sites (20020381, 20020377, 02238000, 20020368, HAR, DOR, LMAC, and 20010003) sampled during the 1996-1997 base-line monitoring study. The BHC concentrations were more uniform across the region, with similar concentrations being measured in most of the lakes. The average non-normalized and TOC normalized BHC concentrations were 3.02 and 0.16 μg/kg/%TOC, respectively, again with the highest concentrations of BHCs, on average, detected at Lake Dora. Lower concentrations were measured for the 1996-1997 study sites; average concentrations of approximately 0.89 μg/kg and 0.05μg/kg/%TOC, respectively.

The mid-Florida lakes sites had a higher rate of NS&T/MW "high" values exceedances for chlordane than other national monitoring programs (Table 4-5); six of the 33 mid-Florida lakes sites (18% of the sites) exceeded the NOAA "high" concentration for chlordane of 4.5 μg/kg, versus an exceedance rate of 14% and 8% for the NS&T/MW and COSED sites, respectively.

There were a number of sediment quality guideline value exceedances for chlordane and lindane (one of the BHC compounds) at the mid-Florida lakes sites (Tables 4-4 through 4-4 and Appendix N). Chlordane concentrations exceeded the ERL at 24 of the 33 sites, the TEL at six of the sites, and the PEL at two sites (DORAE and EUSTA). The lindane concentrations exceeded the TEL at 16 of the 33 sites and the PEL at nine sites (five Lake Dora sites, three Lake Griffin sites, and one Lake Monroe site); there are no ERL or ERM values for lindane.

There could clearly be some difference in the organic contaminant assessment conclusions depending on which sediment quality guidelines one uses. Because of the significant TOC concentrations of many of the sediments from these sites, the conservative approach is clearly to use the ERL/TEL value (which are based on non-normalized data) as the primary risk "screen"; much of the organic compound contamination may be bound by the organic carbon of the sediments, and be less available to cause harm than had the sediments been of lower organic content. Additionally, the ERL/TEL is often considered to be lower than needed for environmental risk assessment of sediment contamination. Nonetheless, it is evident that the location with the highest organic contaminant concern is Lake Dora/Beauclair, with significant concentrations of DDT that appear to be distributed to the other inter-connected lakes (first Lake Eustis, then Lake Harris and Lake Griffin) from Lake Dora. Lake Dora also has relatively high chlordane and lindane concentrations, as do several sites in the other lakes. The chlordane appears to be distributed much like the DDT contamination, but additional local sources appear to be contributing chlordane to Lake Eustis (e.g., high concentrations at EUSTA). The lindane contamination is more widespread, with evidence of other local sources and/or historic contamination (e.g., high concentrations at scattered sites in Lake Monroe, Lake Griffin, and Lake Harris, as well as Lake Dora).

Metals Contaminants — Distribution, Composition and Assessment

The metals concentrations were, on a whole, less variable at the mid-Florida lakes sites than in the Gainesville area, and were less variable than the pesticide concentrations in this area. In general, there appears to be much less of a metals than pesticide contamination issue, and the metals concentrations appear to, for the most part, warrant little concern. Some of the consistency in metals concentrations was likely due the fact that the sediments were more homogenous in this area; the sediments have similar percent mud and TOC content. However, there also appears to be less input from anthropogenic sources.

The metals data are summarized in Table 3-8, and are presented graphically in Appendix L (bar charts) and Appendix O (maps). Arsenic was the only metal that appeared to have a clearly distinguishable elevated concentration, with Lake Dora having the highest concentrations (averaged 14.5 mg/kg), followed by concentrations at Lakes Eustis, Griffin, and Harris that were similar fir these three lakes. Lead (with Lake Eustis having the highest average concentration of 34.8 mg/kg) and mercury (with Lake Griffin having the highest average concentration of 0.23 mg/kg) were present at concentrations that, at first glance, may appear to be slightly elevated at some of the sites at each lake, and the chromium and nickel signals appear to be slightly higher at Lake Monroe than at comparable locations, although these all appear to be quite subtle elevations. The concentrations of cadmium, copper, nickel, and zinc were consistently low, as was chromium and silver at the four inter-connected lakes.

The metals concentrations were reviewed against the NS&T/MW "high" reference values to better put them into perspective (Table 4-5). None of the 33 mid-Florida lake sites sampled had chromium, copper, nickel, or zinc concentrations that were greater than the NOAA "high" concentrations of 125, 42, 42, or 135 mg/kg, respectively. Cadmium, lead, and silver had slightly lower rates of exceedance (9%, 12%, and 12% respectively) in comparison to the NS&T/MW sites and COSED sites. The exceedance rates for arsenic were comparable to other monitoring programs, with a rate of exceedance of 15%, compared to 13% and 18% for the NS&T/MW sites and COSED sites, respectively. Mercury had a higher rate of exceedance than the other national programs; 12 of the 33 sites (36% of the sites) exceeded the reference value, compared to 15% and 30% for the NS&T/MW sites and COSED sites, respectively. However, it should be noted that mercury is one element for which the analytical methods have improved dramatically in the past 10 years, and it can therefore often be difficult to reliably compare results from today's more reliable analyses to those from the past.

The metals concentrations in the sediments from the mid-Florida lake sites were evaluated against ERL, ERM, and freshwater TEL and PEL values (Tables 4-2 and 4-3). The metal ERL, ERM, TEL, and PEL exceedances at each of the 5 mid-Florida lakes are summarized in Table 4-7. The Lake Dora sites had the highest total number of sediment quality guideline exceedances (a total of 28), followed by Lake Griffin with 24 total exceedance, Lake Eustis with 23, Lake Monroe with 19, and Lake Harris with 18 total exceedances. Among all the mid-Florida lakes, mercury and arsenic were the metal contaminants with the highest number of threshold limit exceedances. Mercury had a total of 43 threshold limit exceedances, followed closely by arsenic with a total of 42 threshold limit exceedances. Mercury was the metal at Lakes Harris and Monroe that exceeded the threshold limits most frequently compared to other metals. Lake Eustis had the same number of mercury and arsenic threshold limit exceedances. However, arsenic was the metal at Lakes Dora and Griffin that exceeded the threshold limits most frequently compared to other metals. The majority of the sediment quality guideline exceedances were of the lower ERL and TEL values; there were no ERM exceedances for any metals at any of the mid-Florida lakes sites, and there were only two PEL exceedances (for arsenic at two Lake Dora sites).

Mercury was one of the two metals with the most ERL/TEL exceedances. The reliability of using the mercury ERL (or TEL) 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.

Table 4-7. Metal ERL, ERM, Freshwater TEL and PEL Exceedances at Mid-Florida Lake Sites

Site	SQG Indicator	As	Cd	Cr	Cu	Pb	Hg	Ni	Ag	Zn	Total Exceedances
Lake Dora	ERL	6	0	0	1	1	5	0	0	0	13
	ERM	0	0	0	0	0	0	0	0	0	0
	TEL	6	0	0	0	3	4	0		0	13
	PEL	2	0	0	0	0	0	0		0	2
Exceedances at Lake Dora		14	0	0	1	4	9	0	0	0	28
Lake Eustis	ERL	4	0	0	0	2	4	0	0	0	10
	ERM	0	0	0	0	0	0	0	0	0	0
	TEL	4	1	0	0	4	4	0		0	13
	PEL	0	0	0	0	1	0	0		0	0
Exceedances at Lake Eustis		8	1	0	0	7	8	0	0	0	24
Lake Griffin	ERL	5	0	0	0	1	5	0	0	0	11
	ERM	0	0	0	0	0	0	0	0	0	0
	TEL	6	0	0	0	2	5	0		0	13
	PEL	0	0	0	0	0	0	0		0	0
Exceedances at Lake Griffin		11	0	0	0	3	10	0	0	0	24
Lake Harris	ERL	3	0	0	0	0	5	0	0	0	8
	ERM	0	0	0	0	0	0	0	0	0	0
	TEL	4	0	0	0	1	5	0		0	10
	PEL	0	0	0	0	0	0	0		0	0
Exceedances at Lake Harris		7	0	0	0	1	10	0	0	0	18
Lake Monroe	ERL	0	0	0	1	0	3	0	0	0	4
	ERM	0	0	0	0	0	0	0	0	0	0
	TEL	2	2	3	1	2	3	2		0	15
	PEL	0	0	0	0	0	0	0		0	0
Exceedances at Lake Monroe		2	2	3	2	2	6	2	0	0	19

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). AVS was, as discussed earlier, not determined in this project because such specific information was not within the scope and objectives of this study.

The observed concentration of metals, and frequency of threshold limit exceedances at the mid-Florida lakes sites, may indicate that there could be a potential for impact at some locations. When looking at these data as a whole, it appears that the arsenic concentrations at Lake Dora, and a few other sites in the inter-connected lakes, may be the metal contamination that poses the greatest, although probably a fairly modest, risk. With the knowledge that these sediments are generally very fine in consistency, and fairly high in TOC, it is probably valid to assume that, in general, the metal contaminants in the mid-Florida lakes do not pose a noteworthy risk to the surrounding environment.

4.2.3 Other Lake Sites – Lake Disston and Lake George

The 1996-1997 base-line monitoring study identified the potential for chlorinated pesticide contamination issues at Lakes George and Disston. As a result, detailed assessments at these locations were performed. Five sites in Lake Disston and 10 sites in Lake George were sampled to better understand the organic contaminant issues in these two lakes.

Organic Contaminants — Distribution, Composition and Assessment.
The organic contaminant concentrations (PCB and pesticide) were generally lower at the Lake George and Lake Disston sites than at the other detailed assessment sites (Gainesville and mid-Florida lakes). The organic contaminant concentration are summarized in Table 3-6 and Appendix F. They are also presented graphically in Appendices I (bar charts) and O (maps).

PCB
The average non-and TOC-normalized sum of the PCB congener concentrations at Lake Disston were 3.5 µg/kg and 1.4 µg/kg/%TOC, respectively. Average non- and TOC-normalized PCB concentrations at Lake George were approximately 4.3 µg/kg and 0.32 µg/kg/%TOC, respectively. The PCB concentrations from the Lake Disston/George area sites sampled during the 1996-1997 base-line monitoring study (CLD, LSJ070, LAG, LEO, and 20030373) were higher than measured this time, with average non- and TOC-normalized concentrations of 12.3 µg/kg and 1.7 µg/kg /%TOC, respectively. More low-PCB containing sites were included in the study this time, and of the Lake Disston sites one (DISSC) had a concentration of 15.4 µg/kg, while the other four had PCB concentrations of 1.2 µg/kg, or less. The concentrations at Lake George were more variable, with five sites having PCB levels between 4 and 12 µg/kg and the other five having concentrations below 2 µg/kg.

The Lake Disston/George area sites had a much lower rate of NS&T/MW "high" PCB value exceedance than the referenced other national monitoring programs (Table 4-5). None of the 15 sites sampled in the Lake George/Disston area had total PCB concentrations greater than the NOAA "high" concentration of 80 µg/kg. Furthermore, when PCB concentrations at the Lake Disston and Lake George sites were evaluated versus ERL, ERM, freshwater TEL, and PEL values (Tables 4-2 and 4-3) there was only one minor ERL exceedances noted for each of the two lakes, and no TEL, ERL, or PEL exceedances. PCBs do not appear to be a contaminant of concern in Lake Disston/George area.

Chlorinated Pesticides
Total DDT concentrations were generally lower at the Lake Disston/George area sites than the Gainesville and mid-Florida lakes sites (Figures 4-29 and 4-31). 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. Generally, concentrations of the degradation product, DDE, were higher than both the DDD and DDT concentrations in most of the Lake Disston and Lake George sites. The non-normalized

total DDT concentrations at Lake Disston ranged from 0.23 μg/kg to a high of 54.2 μg/kg (at DISSC). However, the average total DDT concentration, excluding site DISSC, was only 0.85 μg/kg — the relatively elevated concentration measured at DISSC is clearly a reflection of contaminants being concentrated at this organic carbon rich location (22.6% TOC, compared to less than 1% TOC at the other four Lake Disston sites). The TOC-normalized total DDT concentrations at Lake Disston ranged from 0.69 μg/kg/%TOC to 2.9 μg/kg/%TOC.

The total DDT concentrations at the Lake George sites were generally higher than at Lake Disston, with non-normalized total DDT concentrations ranging from ND to 10.4 μg/kg, and averaging 3.4 μg/kg. TOC normalized total DDT concentrations at Lake George ranged from ND to 0.65 μg/kg/%TOC. Much higher DDT concentrations were detected at the Lake Disston/George area sites that were sampled during the 1996-1997 base-line monitoring study (CLD, LSJ070, LAG, LEO, and 20030373). Average non- and TOC-normalized DDT concentrations measured in the earlier study were approximately 26 μg/kg and 1.4 μg/kg/%TOC, respectively. This suggests that the concentrations may be quite variable at these two lakes, which was confirmed in the detailed assessment, but also that, for the most part, the DDT concentrations are not notably elevated.

The Lake Disston/George area sites had a fairly low rate of "high" reference value exceedances, when compared to data from other national monitoring programs (Table 4-5). Only one of the 15 sites sampled in the Lake Disston/George area (site DISSC) had total DDT concentrations greater than the NOAA "high" value of 22 μg/kg. Rates of exceedance for total DDT in the NS&T/MW and all COSED sites were 18% and 23%, respectively.

The DDT concentrations at the Lake Disston/George area sites also compared favorably when evaluated against ERL, ERM, freshwater TEL, and PEL values (Tables 4-2 and 4-3, and Appendix N). Although there were several exceedances of the very low (1.58 μg/kg) ERL value (seven of the 15 sites), only three of the 15 sites exceeded the TEL value for DDT. There was one DDT ERM exceedance (site DISSC) and no PEL exceedances. The Lake George and Lake Disston sediments that did have minor sediment quality guideline exceedances also had a high percent mud and TOC content, suggesting that the DDT contamination may be mostly "unavailable" to cause environmental harm due to binding to these sediments.

The chlordane, BHC, and endosulfan concentrations were also, for the most part, relatively low at the Lake Disston and Lake George sites (Table 3-6). The chlordane and endosulfan concentrations were particularly low, while slightly higher BHC concentrations were measured at some of the Lake George sites. The concentration of these compounds were also very low relative to the other detailed area sites, except for some of the BHC concentrations at Lake George that were comparable to those at other mid-Florida lakes sites (which were quite low to begin with).

None of the 15 Lake Disston/George area sites had chlordane concentrations that exceeded the NS&T/MW "high" value of 4.5 μg/kg; 14% and 8% for the NS&T/MW and COSED sites, respectively, exceeded this value. Additionally, only one of the Lake George sites (GEORGEG) and one of the Lake Disston sites (DISSC) had a chlordane concentration that exceeded the low ERL value of 0.5 μg/kg; there were no chlordane TEL, PEL, or ERM exceedances. Three of the 10 Lake George sites had lindane concentrations that exceeded the TEL (they were all within a factor of two of the TEL), and one Lake George site exceeded the lindane PEL value (site GEORGEF). However, the high organic nature of the Lake George sediments that exceeded the TEL/PEL values (GEORGEF had 30.4% TOC) may cause this compound, like other organic compounds, to bind tightly to the sediment particles, making the contaminant minimally available to cause adverse biological effects. It appears that the organic contaminant levels detected at the Lake Disston/George area sites pose less of an environmental risk to their surrounding areas than the contamination at the other detailed assessment areas.

5. CONCLUSION

District Wide Assessment

A review of the data from the 40 new sites for the District Wide Assessment (DWA) provided similar findings to those observed in the original study of 86 sites in 1996-1997 (SJRWMD, 1998). In general, the organic contaminant and metals data did not broadly or unequivocally point to substantial anthropogenic signals in these samples. A few selected sites exhibited elevated concentrations of contaminants when compared to the rest of the new sites, the 1996-1997 survey data, and key contaminant reference data. However, the concentration ranges and contaminant elevations detected in the 40 new sites were typically lower than those found in the earlier district-wide study. The quality of the sedimentary environment in the areas surveyed appears to be quite good.

Similar to the findings of the 1996-1997 study, the data for the 40 new sites were quite variable, indicating differences in contaminant concentrations and also in the natural composition of the sample matrices. The metals, for instance, generally showed an increase in concentration as the grain size of the sediments decreased, but the nature of these sediments made it difficult to apply standard data normalization procedures. Once again, many of the sediments in the DWA were very high in organic carbon, but much of this was undegraded plant debris that is not completely available as an organic source for "binding" contaminants. This plant debris also contributed disproportionately to the coarser fractions in the grain size determinations, and the grain size data did therefore not always provide reliable information on the grain size of the mineral component of the sediment.

Although the 40 sites cannot be directly compared because they represent many different environments, with different geology and natural processes, they were, generally, compared to the 86 sites of the baseline assessment study. They were also compared to data from other monitoring programs, and to sediment quality guideline values. A review of the data for the 40 new DWA sites, in conjunction with these other reference data, assisted in confirming contaminant concerns in certain areas as well as reaffirming that the urbanized areas tend to have higher contaminant concentrations than non-urban areas. Some of the sites in the DWA are located in similar locations to sites sampled in the earlier study and show similar contaminant trends. For instance, new DWA sites located in the Gainesville area (INDUSPL and PCR-PL) and north of Orlando (MAITL and HOWELL) tended to show elevated levels of PAH, some pesticides, and metals relative to the other 40 sites. As discussed in the 1996-1997 study, large urbanized areas appear to be exerting some influence on the contaminant concentrations in the sediments, although the differences between urban and rural areas were mostly relatively subtle. In addition, there were few, if any, pure "urban" sites among these 40 new sites.

Specific water body type "signals" were, as discussed, evident in some of the data, but it was not possible to develop a specific classification of environmental quality based on the water body type. The 40 new sites were mainly composed of lakes and creeks. Similar to what was observed in the 1996-1997 study, it appears that the lakes had collected the greatest concentrations of most contaminants, which is consistent with common understanding of contaminant transport and deposition. However, 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 primarily 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 sources.

Figures 5-1a and 5-1b present a summary of the concentrations of key organic (PAH, PCB, and pesticides) and metals (lead, mercury, and arsenic) contaminants for the 40 new sites. The majority of the sites clearly "cluster", with similarly low concentrations, with a few relative outlier sites evident. Figures 5-2a and 5-2b present a *very* general summary of the relative contaminant "rankings" of the 40 new 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), 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=least and 40=most contaminated of the 40 new DWA sites), 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 contamination. 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.

In general, the contamination that was measured for the 40 new sites was of low environmental concern. The sites, as a whole, had lower levels of contaminants than the sites sampled in 1996-1997, and can, for the most part, be considered to be in good condition. A few specific locations and general areas with elevated concentrations of some organic and metal contaminants were identified within the 40 new sites of the DWA.

- Lake Norris had significantly elevated concentrations of DDT. The DDT concentrations at this site were several times higher than at any other location, and was the only site and contaminant that exceeded an ERM reference value. The DDT concentration at Lake Norris was about as high as the highest concentrations measured at Lake Dora.

- Some sites north or west of Orlando (e.g., sites MAITL, HOWELL, BEAR, LOUISA) had somewhat elevated concentrations of most contaminants, relative to the other study sites, most notably PAH, PCB, pesticides, and some toxic metals.

- Some scattered mid-Florida lakes, central region, or Newnans Lake area sites had somewhat elevated concentrations of selected metals (e.g., sites HELENA, SILRV, HALFMOON, MILD, CHARLES, INDUSPL, PCR-PL) and/or some chlorinated industrial compounds.

Detailed Assessment

The Detailed Assessment Study helped to determine which of the potential contaminant problem that were identified in the baseline 1996-1997 study appear to be true issues and which appear to be of little or no concern.

Extensive sampling in the Gainesville area revealed that the contaminant concentrations varied substantially due to the varying sediment characteristics and the water flow and sediment depositional characteristics in the area. The organic contaminant concentrations were typically highest in the Sweetwater Branch samples, followed by the Bivens Arm West samples, and much lower at the Hogtown Creek sites. The sediments collected downstream in the Sweetwater Branch and Bivens Arm West locations had PCB, DDT, and chlordane concentrations that appeared to be of significant concern. Much of the organic contamination appeared to be originating upstream, and then being transported and deposited at the downstream locations.

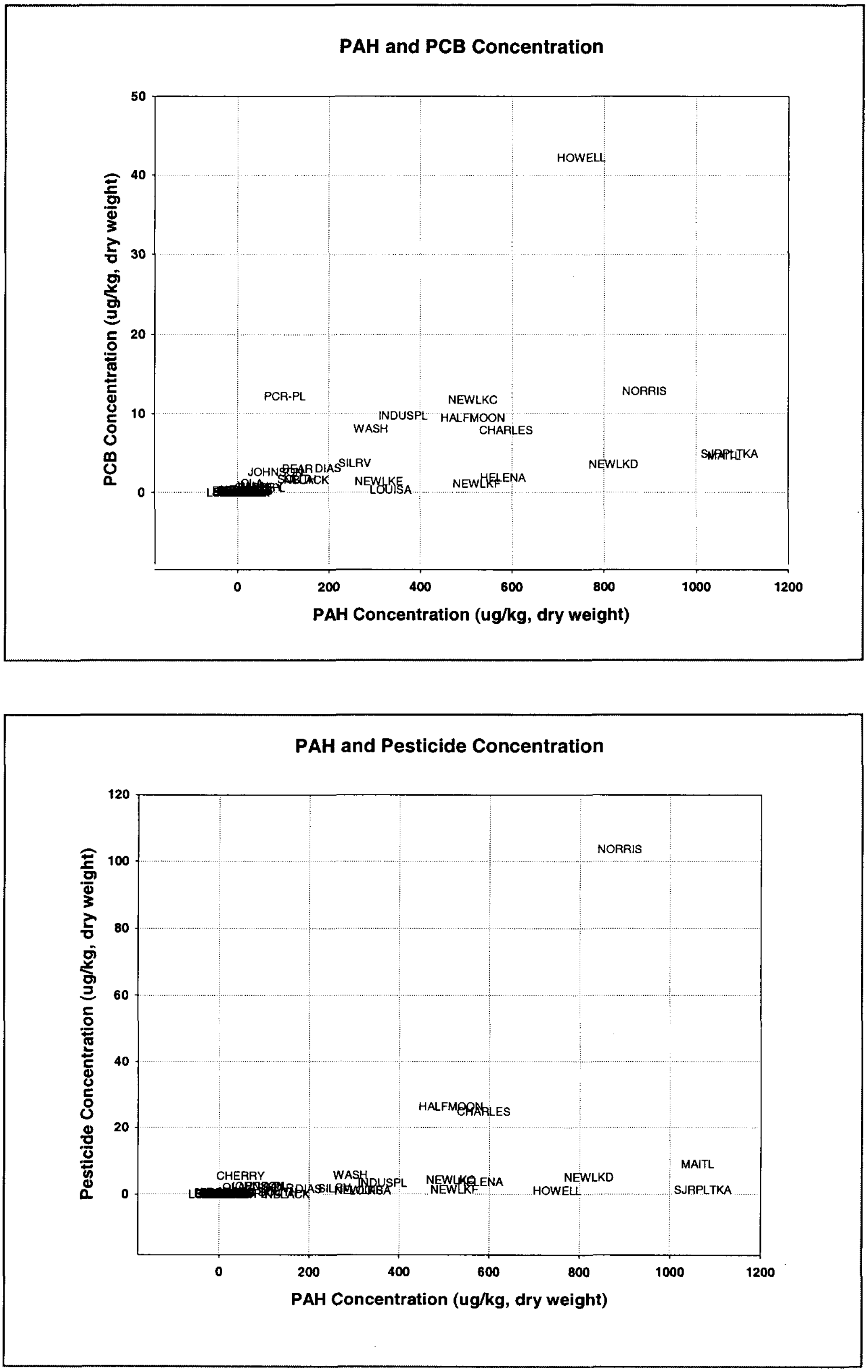


Figure 5-1a. 40 New Sites — Distribution of Sites by Organic Compound Contamination (PAH, PCB, and Pesticides)

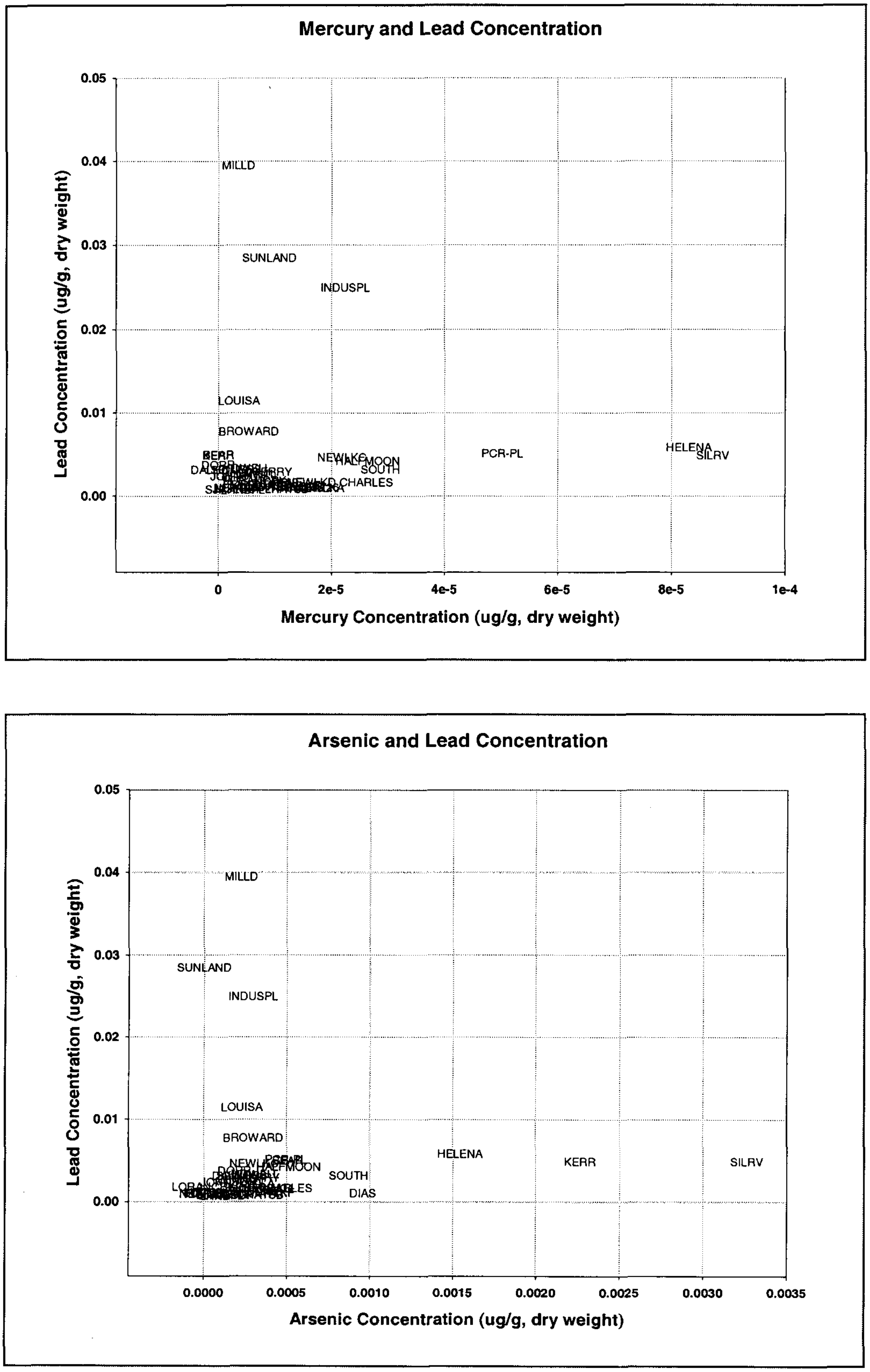


Figure 5-1b. 40 New Sites — Distribution of Sites by Metals Contamination (Lead, Mercury, and Arsenic)

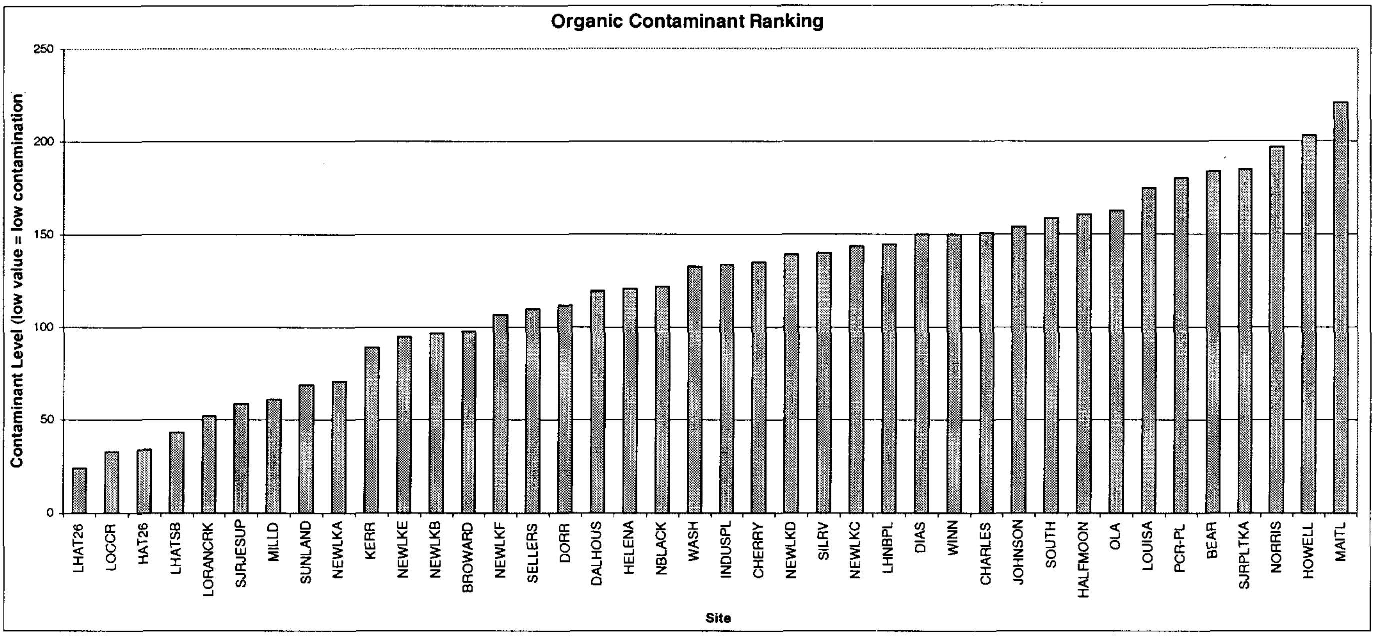


Figure 5-2a. 40 New Sites — General Organic Contaminant Rankings of Sites

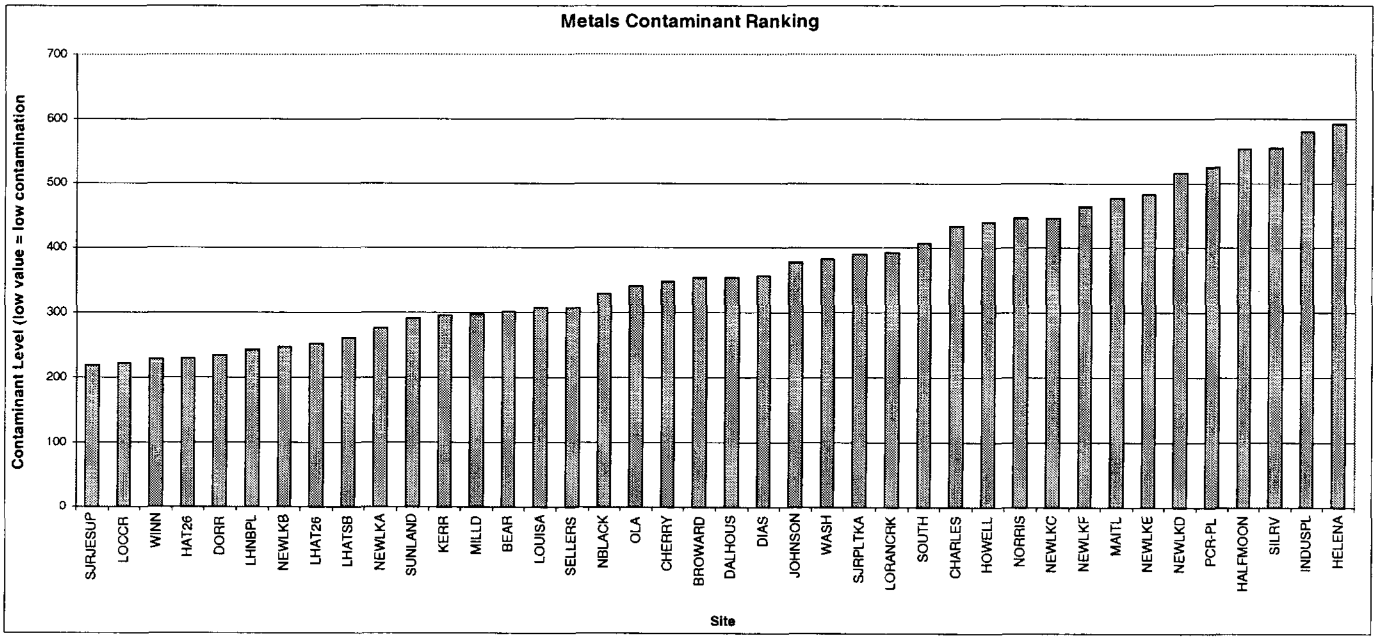


Figure 5-2b. 40 New Sites — General Metals Contaminant Rankings of Sites

The metal contaminant concentrations were typically highest in the Bivens Arm West samples, but also high in the downstream Sweetwater Branch samples. Concentrations of lead, cadmium, and zinc were particularly elevated, and appear to pose a notable environmental concern. The origin of the elevated metals concentrations may be similar to that of the organic compounds, but this was difficult to clearly determine with the existing information. Metal contaminant concentrations were generally low at the Hogtown Creek sites

The detailed investigation of the sites located in the mid-Florida lakes region revealed that organic contaminant concentrations varied for the five lakes (Dora/Beauclair, Eustis, Griffin, Harris, and Monroe) although the sediment characteristics (%TOC and % mud) were fairly similar. The organic contaminant concentrations (most notably DDT, but also chlordane and BHC) were generally highest at Lakes Dora/Beauclair, followed by somewhat lower concentrations at sites in Lake Eustis, and lower yet in the other three lakes. The pesticide concentrations were highest in Lake Beauclair, with a clear decline in concentration with the flow of the water through the different parts of Lake Dora and in to Lake Eustis, suggesting that the contamination may be originating with the water flowing into Lake Beauclair from the south.

In the original base-line study it appeared that Lake Disston and Lake George may have high levels of chlorinated pesticides, including DDT, chlordane, and BHC. However, the detailed assessment study indicated that the relatively modest contamination that was identified in parts of these lakes was quite spotty, and was focused in a few areas with high organic carbon containing sediment, and, as a whole, of no significant concern.

Overall, the potential for biological impact from the measured contaminants at the 40 new sites of the district-wide assessment study generally appears to be low, based on the ERL and TEL comparison approach, and is consistent with the generally low to moderate organic contaminant and metals concentrations measured in most of the sediments. One exception may be the DDT contamination at Lake Norris. However, the potential for biological impact from the contaminants measured at the 63 sites of the detailed assessment study appears to be moderate to high at some location, based on the reported results, including assessments versus sediment quality guidelines. Locations in the Bivens Arm West, lower Sweetwater Branch, and Lake Dora/Beauclair (and, to a lesser degree, parts of Lake Eustis) continue to be of concern.

Recommendations

- This report provides information on the chemical contamination of sediments. It would be valuable to consolidate, and further interpret, these results along with (1) the benthic ecology assessment and (2) the water quality assessment data and reports that have been generated for these locations. This could provide a more thorough understanding of the environmental status of these sediments and water bodies, and could provide even more valuable and helpful information for environmental decision makers.

- It may also be advantageous to have sediment toxicity data available for selected locations of particular concern, to aid the overall, consolidated, evaluation of the environmental quality at key sites. Sediment toxicity testing could therefore be performed with sediment from selected locations, and the results also used in the above suggested consolidated report.

- One area of potential concern was identified in the study of the 40 new district-wide sites; Lake Norris, which had high DDT concentration. This may warrant a more rigorous investigation of this location. The target analyte list can be reduced to efficiently address this potential issue.

- Additional site-focused studies may be warranted at the Gainesville area and mid-Florida lakes locations that had the previously identified contamination confirmed through the detailed assessment study. Such work could be focused on providing more definitive information on the magnitude and extent of the contamination, and the sources, by:

    - Determining the hydrodynamics and sediment transport/deposition characteristics of Bivens Arm West, Sweetwater Branch, Lake Dora, and Lake Eustis, to provide valuable information for better understanding the observed contaminant patterns.

    - Performing a more detailed analysis of the land use and point-source and non-point sources of Bivens Arm West, Sweetwater Branch, Lake Dora, and Lake Eustis, in an attempt to better understand the contamination that was observed, and potential sources.

    - With a better understanding of the hydrodynamics, contaminants transport, land uses and potential contaminant sources, it should be possible to determine the primary origins of the contamination, the significance of current inputs versus historic contamination, and develop appropriate source control measures.

    - Perform sediment core sampling and analysis to determine the depth of the contamination for a given concentration of concern, and determine the mass of the critically contaminated sediment in areas where the contamination may warrant consideration of different remediation options (e.g., natural attenuation, capping, removal and disposal, removal-treatment-replacement, etc.). Three-dimensional sub-surface visualization and calculations of the contaminant concentrations, risks, distribution, and mass can conveniently and effectively be performed with data analysis using EarthVision™. Such coring work should also include the determination of the sedimentation rate of the area of interest.

    - An optimum study may also include benthic community structure analysis to determine current effects to this community, and sampling of resident fish and freshwater bivalves to determine the potential for contaminant bioaccumulation, should this be an important driver in environmental management decisions for the SJRWMD. Additionally, the target analyte list can be reduced and focused to efficiently and effectively address the issues at each location.

- Follow-up monitoring to determine the trends in the environmental contaminant loadings at the sites may be very useful to support environmental management. 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 until about 5 years after the original sampling.

- 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 by making it available over the Internet (e.g., though an interactive Web-based database that would include map-based interfaces).

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