Toxic Contamination Sources Assessment:

Sources of Sediment Contaminants of Concern and Recommendations for Prioritization of Hillsborough and Boca Ciega Sub-Basins

FINAL

Prepared for:

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LIST OF ACRONYMS AND ABBREVIATIONS

COC(s)	contaminant(s) of concern
COPC(s)	contaminant(s) of potential concern
EPC	Hillsborough County Environmental Protection Commission
EMAP	Environmental Monitoring and Assessment Program
FDEP	Florida Department of Environmental Protection
FLUCCS	Florida Land Use, Cover, and Forms Classification System
HPAH	high molecular weight polycyclic aromatic hydrocarbons
LPAHs	low molecular weight polycyclic aromatic hydrocarbons
NCPDI	National Coastal Pollutant Discharge Inventory (NOAA)
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System (USEPA)
NPL	National Priority List (USEPA)
NURP	National Urban Runoff Program (USEPA)
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PCS	Permit Compliance System (USEPA)
SCS	Soil Conservation Service
SWFWMD	Southwest Florida Water Management District
TBNEP	Tampa Bay National Estuary Program (USEPA)
TRI	Toxic Release Inventory (USEPA)
USCG	U.S. Coast Guard
USDA	U.S. Department of Agriculture
USDOT	U.S. Department of Transportation
USEPA	U.S. Environmental Protection Agency

EXECUTIVE SUMMARY

The Tampa Bay National Estuary Program (TBNEP) Toxic Contamination Sources Assessment project was initiated to identify specific sources of contaminants and to prioritize management actions based on risks associated with the contaminants in areas of Tampa Bay. Task 1 of this project included an evaluation of ecological and human health risks associated with sediment contaminants in areas of Tampa Bay, and development of a methodology for specific source identification. Areas evaluated for Task 1 included upper and lower Hillsborough Bay, McKay Bay, Boca Ciega Bay, Bayboro Harbor, and western Old Tampa Bay.

Based on previous studies evaluated by TBNEP and the results of Task 1 of this project, the lower Hillsborough River, coastal Hillsborough, and Boca Ciega drainage basins were considered priority areas for evaluation of toxic contaminant releases. The focus of Task 2 of this project was to identify specific sources of contaminants of concern (COCs) in the priority drainage basins, to estimate loadings by these sources where possible, and to prioritize sub-basins for management actions.

Hillsborough Bay

Sediment contaminants identified as COCs for Hillsborough Bay based on a significant potential for adverse ecological or human health effects include: four metals (chromium, copper, mercury, and nickel), polynuclear aromatic hydrocarbons (PAHs) (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, fluoranthene, pyrene, and total PAHs), five chlorinated pesticides (chlordane, DDT/DDD, endrin, heptachlor/heptachlor epoxide, and lindane), and total polychlorinated biphenyls (PCBs).

The priority sub-basins based on total COC load included: Delaney Creek for point sources of chromium, copper, and nickel, and nonpoint sources of metals and pesticides; Lower Hillsborough River No. 1 for nonpoint sources of metals and PAHs; Lower Hillsborough River No. 2 for nonpoint sources of metals, PAHs, and pesticides; Ybor Channel for point sources of copper and nickel, and nonpoint sources of metals; and Tampa Bypass Canal for nonpoint sources of metals and pesticides.

Land uses associated with stormwater runoff containing metals identified as COCs included low density residential and commercial-retail for chromium and copper; and high density residential, light industrial, agricultural, commercial-office, and highway/utility for copper. Major sources of PAH loading included permitted stormwater outfalls from industrial facilities within the Palm River and Ybor Channel sub-basins, and stormwater runoff in all sub-basins. Stormwater runoff accounted for 99-100 percent of the total pesticide loadings. One PCB cogener was detected in atmospheric deposition samples; PCBs were not detected in point source discharges or stormwater.

Boca Ciega Bay

Sediment contaminants identified as COCs for Boca Ciega Bay based on a significant potential for adverse ecological or human health effects include: PAHs and PCBs. The priority sub-basins based on total COC load (including O&G) include: Long Bayou, Direct Runoff to Bay, St. Joe's Creek, Cross Canal, and Lake Seminole. The primary source for PAHs was stormwater runoff, with one permitted discharger in the Long Bayou sub-basin. As for upper Hillsborough Bay, PCB loadings were associated with atmospheric deposition.

General Recommendations for Reduction of COC Loading

Stormwater was identified as the dominant current source for most of the sediment COCs evaluated for this assessment. Stormwater treatment is an effective management because it can capture the portion of atmospheric deposition that occurs within drainage basins, as well as reduce pollutant runoff from other types of sources. Stormwater control methods may be selected for specific sub-basins based on total impact reduction (i.e., COCs + nutrients + total suspended solids). Additional potential benefits of stormwater management actions include general water quality improvements, creation or restoration of wildlife habitats, and the opportunity for public education on the importance of reducing pollutants.

Best management practices (BMPs) to control stormwater runoff of contaminants may be structural or nonstructural. Historically, structural BMPs have consisted of small treatment facilities associated with individual development projects. This has resulted in increased long-term operation and maintenance costs, and limited possibilities for additional environmental benefits such as habitat improvement. For these reasons, interest in regional stormwater treatment facilities is increasing. Regional stormwater facilities can provide water quality treatment, flow attenuation, and compensatory volume for existing uses (retrofit), as well as planned or uncertain future development.

Although stormwater runoff was identified as the dominant source for most current loadings of COCs, point source discharges accounted for a significant portion of loads for several COCs (particularly chromium and nickel) in the upper Hillsborough Bay drainage basin. Contaminant releases from facilities with wastewater or stormwater permits allowing discharge of specific COCs should be examined to identify opportunities for contaminant load reduction. For some of the COCs that are no longer in common use, such as chlorinated pesticides, the sediments themselves should be considered a primary source. Because direct or food web exposures to these sediment contaminants may present significant risks to fish and wildlife in portions of the bay, this source should be considered in the development of a sediment contamination action plan.

1.0 INTRODUCTION

Recent assessments in Hillsborough and Boca Ciega Bays suggest that the relatively high sediment concentrations of several groups of toxicants may contribute to adverse ecological effects (Long et al. 1994; Grabe et al. 1995; McConnell et al. 1996) or potential human health risks (Frithsen et al. 1995; McConnell et al. 1996). Previous studies (Brooks and Doyle 1992; Doyle et al. 1989; Long et al. 1991, 1994; Zarbock et al. 1996) have demonstrated that concentrations of contaminants in water, sediment, and biota are elevated, and in certain areas exceed regulatory or guidance levels designed to protect ecological resources. Sediment contaminant concentrations toxic to laboratory test organisms have also been found in several areas of the bay (Long et al. 1994). The distribution of contaminants in areas of Tampa Bay suggests that contaminants originate from both localized point sources and diffuse nonpoint sources.

The Tampa Bay National Estuary Program (TBNEP) Toxic Contamination Sources Assessment Project was initiated to identify specific sources of contaminants and to prioritize management actions based on risks associated with the contaminants in areas of Tampa Bay. Task 1 of this project (McConnell et al. 1996) included an evaluation of ecological and human health risks associated with sediment contaminants in areas of Tampa Bay, and development of a methodology for specific source identification. Areas evaluated for Task 1 included upper and lower Hillsborough Bay, McKay Bay, Boca Ciega Bay, Bayboro Harbor, and western Old Tampa Bay.

Based on previous studies evaluated by TBNEP, and the results of Task 1 of this project, the lower Hillsborough River, coastal Hillsborough Bay, and Boca Ciega Bay drainage basins were considered priority areas for evaluation of toxic contaminant releases. Task 2 of the Toxic Contamination Sources Assessment project was developed to identify specific sources of contaminants of concern (COCs) in the priority drainage basins, to estimate loadings by these sources where possible, and to prioritize sub-basins for management actions. The locations of Tampa Bay segments (based on Lewis and Whitman 1985) and major drainage basins of the Tampa Bay watershed (from Zarbock et al. 1994) are provided in Figure 1.1.

The results of this study will be used as input for a separate TBNEP project to develop a sediment contamination management action plan to reduce risks associated with COCs. Types of management strategies to be considered may include: reduction of loadings by point sources where feasible, and treatment of runoff/inflow from basins discharging to Tampa Bay.

This report, Sources of Sediment Contaminants of Concern and Recommendations for Prioritization of Sub-Basins in Hillsborough and Boca Ciega Bay Drainage Basins, presents the methods and findings for Task 2 of this project.

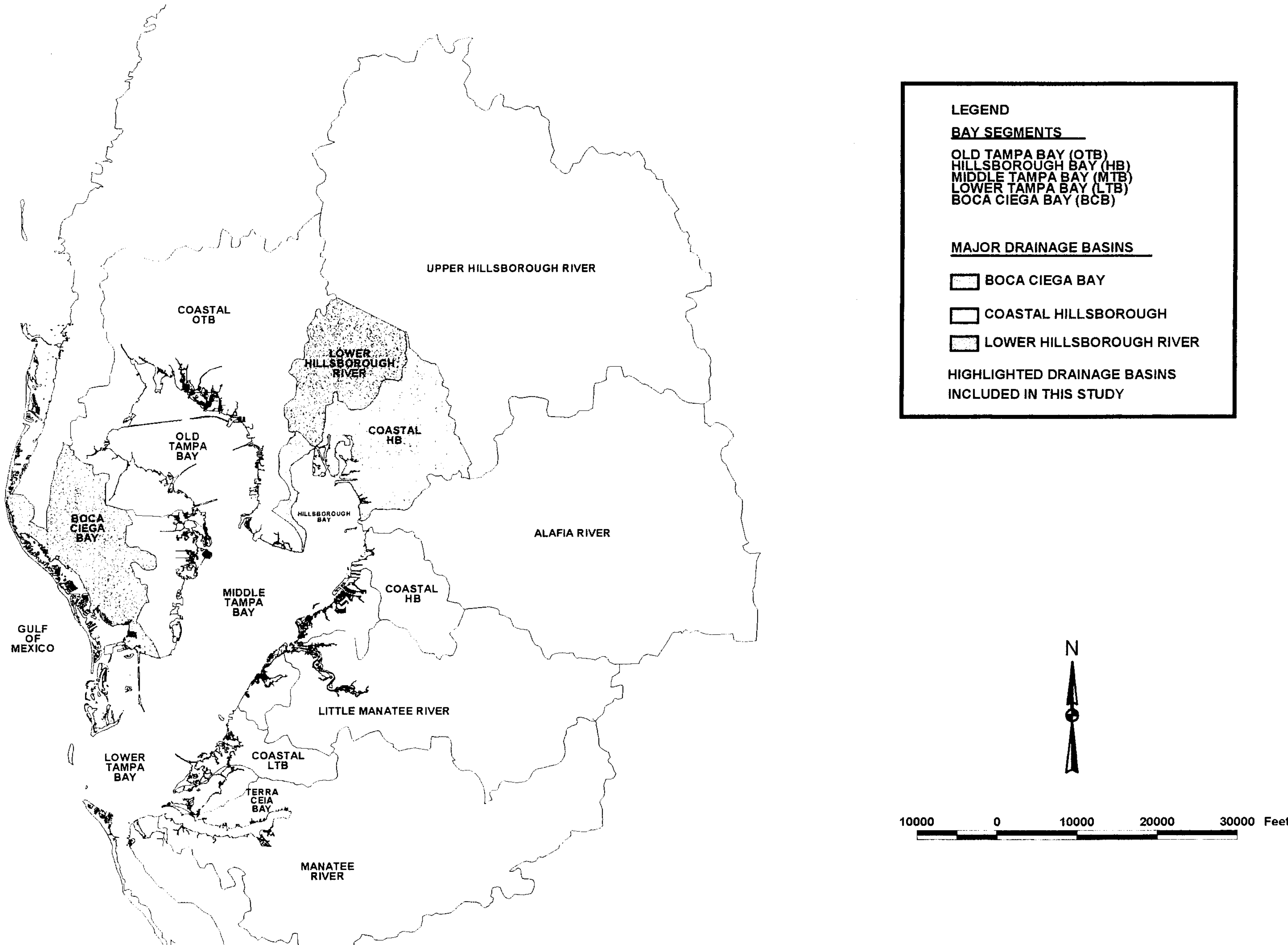

Figure 1.1- Location of Tampa Bay Segments and Major Drainage Basins

This report is divided into the following sections:

- Section 1 provides an introduction and description of the report.
- Section 2 provides a discussion of sediment contaminants identified as ecological and human health risk drivers in upper Hillsborough and Boca Ciega Bays.
- Section 3 includes a discussion of general sources of COCs including chlorinated pesticides, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and metals.
- Section 4 provides the methodology used to evaluate specific sources of COCs and estimate loadings for point and nonpoint sources within priority basins.
- Section 5 presents the findings of this evaluation including specific sources and loadings of contaminants, and the prioritization of sub-basins.
- Section 6 provides an overall summary and general recommendations for prioritizing management actions to address COC releases in Hillsborough and Boca Ciega sub-basins.
- Section 7 provides a listing of references cited in the report.

2.0 SEDIMENT CONTAMINANTS IN PRIORITY AREAS OF TAMPA BAY

Potential ecological and human health risks related to sediment contaminants in Hillsborough and Boca Ciega Bays were evaluated during Task 1 of the Toxic Contamination Sources Assessment project (McConnell et al. 1996). Risks due to sediment contaminant exposure were evaluated by comparing potential exposures to toxicity values for representative ecological indicator species and human receptors. These comparisons allowed an estimation of the likelihood of adverse effects occurring as a result of exposure of the receptors to specific chemicals.

2.1 Overview of the Identification of Contaminants of Concern

As part of the risk characterization for sediment contaminants, the following criteria were used to identify specific chemicals as contaminants of concern (COCs): 1) estimated exposures represented a significant potential for adverse effects based on the magnitude of exceedance of the risk threshold, 2) the number of receptors affected, 3) the frequency of contaminant detection, and 4) the uncertainty associated with components of the risk estimate.

Indicator species selected for the risk assessment to evaluate direct and/or food web exposures included: polychaetes, representing benthic deposit feeders; oyster (*Crassostrea virginica*) representing benthic filter feeders; blue crab (*Callinectes sapidus*), representing benthic omnivores; spot (*Leiostomus xanthurus*) representing mid-level benthic carnivores; spotted seatrout (*Cynoscion nebulosis*), representing top-level aquatic piscivores; and osprey (*Pandion haliaetus*), representing terrestrial piscivores.

Human ingestion of fish containing elevated levels of sediment contaminants with a demonstrated potential for bioaccumulation was also of concern. A hypothetical recreator ingesting contaminated fish was used to evaluate these potential health risks. Other potential exposure pathways for humans (i.e., oral or dermal) were considered to represent a minor contribution to overall risk due to the limited potential for direct exposure to sediment contaminants. For this reason, these pathways were not evaluated.

2.2 Contaminants of Concern for Hillsborough and Boca Ciega Bays

A summary of sediment contaminants identified as COCs in Hillsborough and Boca Ciega Bays is provided in Table 2-1.

Table 2-1.
Summary of Sediment Contaminants of Concern in Upper Hillsborough and Boca Ciega Bays

Chemical	Upper Hillsborough Bay		Boca Ciega Bay	
	Ecological[1]	Human Health[2]	Ecological	Human Health
Pesticides				
Chlordane, alpha		X		
DDD, total	X			
DDTs, total	X			
Endrin	X			
Heptachlor	X	X		
Heptachlor epoxide	X			
Lindane	X			
PCBs				
PCBs, total	X	X	X	
HPAHs				
Benzo(a)anthracene	X		X	
Benzo(a)pyrene		X		X
Benzo(b)fluoranthene		X		X
Chrysene	X			
Fluoranthene	X		X	
Pyrene	X			
Total HPAHs	X		X	
Metals				
Chromium	X			
Copper	X			
Mercury	X			
Nickel	X			

Note:
1. Ecological indicates a contaminant with a significant potential for adverse ecological effects (HQ > 10, species affected at different trophic levels or by direct and food web exposure).
2. Human health indicates a contaminant with a potential for human health effects (RME excess CR $>10^{-4}$, CT excess CR $>10^{-6}$, or HQ>1).

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DATA-SUM.XLS:COCs 6/14/97

2.2.1 Upper Hillsborough Bay

Sediment contaminants identified as COCs for Hillsborough Bay based on a significant potential for adverse ecological or human health effects are listed below.

- Ecological COCs for upper Hillsborough Bay: four chlorinated pesticides (DDT/DDD, endrin, heptachlor/heptachlor epoxide, and lindane), total polychlorinated biphenyls (PCBs), high molecular weight polyaromatic hydrocarbons (HPAHs) (benzo(a)anthracene, chrysene, fluoranthene, pyrene, and total HPAHs), and four metals (chromium, copper, mercury, and nickel).
- Human health COCs for upper Hillsborough Bay: two chlorinated pesticides (chlordane and heptachlor), total PCBs; and two HPAHs (benzo(a)pyrene and benzo(b)fluoranthene).

2.2.2 Boca Ciega Bay

Sediment contaminants identified as COCs for Boca Ciega Bay based on a significant potential for adverse ecological or human health effects are listed below.

- Ecological COCs for Boca Ciega Bay: HPAHs (benzo(a)anthracene, fluoranthene, and total HPAHs), and total PCBs.
- Human health COCs for Boca Ciega Bay: two HPAHs (benzo(a)pyrene and benzo(b)fluoranthene).

2.3 Uncertainty Associated with the Identification of COCs

Because new environmental data were not collected for this project, the evaluation of sediment contamination involved the compilation and analysis of existing data collected from a variety of sources (Long et al. 1994; FDEP 1994; Grabe et al. 1996; Brooks and Doyle 1992). These studies had been performed to evaluate sediments on a large scale (i.e., bay-wide) and so limited numbers of samples were collected in the priority areas of the bay for this project. In addition, although lab analyses included USEPA priority pollutants for most of the samples, analyses for certain parameters were incomplete, increasing the uncertainty associated with the evaluation of these contaminants.

For example, organotins are of potential concern in certain areas of the bay due to ship repair/hull painting activities, and the bioaccumulative potential and toxicity of these contaminants. Organotins were detected at low levels in samples from upper Hillsborough Bay (three of seven samples), but were not detected in lower Hillsborough Bay (three samples) or McKay Bay (four samples), Boca Ciega Bay (one sample), or Bayboro Harbor (one sample). Organotins were not included in sample analyses for two other areas of Tampa Bay that were included in the risk assessment (adjacent to Bayboro Harbor and western Old Tampa Bay). Although these contaminants were not identified as COCs, due to the low frequency of detection and low detected concentrations, the limited data available increase the uncertainty associated with evaluation of these contaminants.

3.0 DATA SOURCES FOR EVALUATION OF CONTAMINANT LOADING

3.1 Overview

Preliminary data and literature reviewed during Task 1 of this project suggested that point sources, stormwater runoff, and atmospheric deposition were significant potential sources for various COCs. The main objective of Task 2 of the Toxic Contamination Sources Assessment project was to identify and evaluate specific sources of COCs within sub-basins of coastal Hillsborough, lower Hillsborough River, and Boca Ciega major drainage basins.

Evaluation of specific source loading of contaminants requires consideration of the nature of the release and chemical properties affecting transport of the pollutant in the environment. For example, atmospheric deposition is a significant source of mercury loading to the bay, while chromium and copper tend to enter the bay in stormwater runoff. Primary anthropogenic sources of PAHs include releases to the atmosphere during combustion of fossil fuels, waste incinerators, or open burning, as well as stormwater runoff from asphalt and other transportation-related land uses.

Atmospheric deposition in the form of wet- and dryfall is a primary source of many pollutants in most urban areas. Once deposited, up to 90 percent of the atmospheric pollutants deposited on impervious surfaces are delivered to receiving waters without attenuation (Schueler 1987). This is why the net effect of urbanization is to increase pollutant loading by at least an order of magnitude over pre-development levels (Schueler 1987). An important source of current loadings of PCBs and chlorinated pesticides to the bay is considered to be atmospheric deposition (Frithsen et al. 1995). Possible releases of PCBs to the environment include direct discharge from production facilities into municipal sewage systems, leaching from disposal sites, and refuse incineration. Because PCBs and some pesticides degrade slowly and accumulate in soils, activities within drainage basins that disturb soil, such as agricultural or construction activities, can mobilize these contaminants, which may then enter the bay attached to suspended solids in stormwater runoff or tributary flow from historically contaminated areas.

3.2 Urban Stormwater Runoff

Nonpoint source pollution from stormwater runoff is influenced heavily by land use and population density. Pollutants may be contained in runoff from a variety of urban land use types including transportation, light/heavy industrial, and residential. Runoff rates are usually much higher in urban areas due to impervious surface surfaces such as pavement and roofs (USEPA 1983). Potential sources of COCs in urban runoff include incomplete combustion of fossil fuels, metal corrosion, pesticides use, manufacturing, and atmospheric deposition (USEPA 1994). Runoff from transportation and industrial areas may contribute the highest loadings of contaminants attributable to urban land uses. Evaluation of urban runoff requires consideration of multiple parameters, including land use activity, percent imperviousness, rainfall, automobile traffic density, and atmospheric deposition rates.

For many of the contaminants of concern in Tampa Bay sediments, few direct measurements have been made of concentrations in urban runoff to the Bay. A previous TBNEP study (Zarbock et al. 1994) used data collected by the USEPA National Urban Runoff Program (NURP) (USEPA 1983) to estimate urban runoff within major basins of the Tampa Bay watershed. To evaluate specific sources of COCs as part of this project, data more specific to the areas of interest were required. Sources of data for this study included stormwater characterization studies performed by Hillsborough and Pinellas Counties in support of municipal NPDES permit applications. Some additional information was available in local governments' NPDES Part 1 application dry weather discharge inventories, or subsequent monitoring studies, that attempt to identify illicit discharges of contaminants to stormwater systems. Because these data were collected for a very limited set parameters and could not be incorporated into loading estimates, however, they were not used for this project.

3.2.1 Runoff from Transportation Land Uses

Major sources of PAHs and metals include transportation-related land uses: spillage or leakage of oil, gas, antifreeze, lubricating fluids, cleaning agents, and other automotive related compounds. A study sponsored by the Maryland Department of the Environment (Schueler and Shepp 1993) indicated that numerous "hotspots" exist within the urban landscape that generate significant PAH and metal loadings, particularly where vehicles are fueled, serviced, and parked for extended periods. The oil grit separators (OGS) installed for many of these facilities were designed to control hydrocarbons, floatables, and coarse sediments and are ineffective for long-term removal of PAHs. Gas station OGS sites had significantly greater concentrations of hydrocarbons, total organic carbon (TOC), zinc, copper, lead, and cadmium than other OGS sites. Pollutant scans of stormwater runoff from primarily residential land uses may not detect the presence of PAHs that are present in the automotive-influenced sites. The study by Schueler and Shepp (1993) indicated that washoff or leakage of fuels and fluids from vehicles may be a key sources of sediment contamination.

Although stormwater runoff from bridges in many cases has a direct pathway to surface waters, few direct measurements of concentrations of pollutants flushed from bridge surfaces have been made. Numerous studies indicate that runoff from roadways is a significant source of contaminants of concern; these data can also be used to evaluate runoff from bridges. Several of the contaminants identified as COCs are common highway runoff constituents (from U.S. Department of Transportation [USDOT] 1984, as listed by Snyder 1993):

- Chromium: metal plating, moving engine parts, brake lining wear
- Copper: metal plating, bearing and bushing wear, moving engine parts, brake lining wear (automotive and aircraft), fungicides and insecticides (roadside maintenance operations), water treatment (reservoir algaecide)
- Petroleum hydrocarbons: spills or leaks of motor lubricants, antifreeze, hydraulic fluids, asphalt surface leachate

- PCBs: spraying of highway right-of-ways, atmospheric deposition, PCB catalyst in tires.

According to USDOT (1984), the majority of pollutant loading from roadways is attributable to metal (lead, zinc, and copper), although loadings of organics are considered significant. Loadings of these contaminants are site-specific and variable, and reflect factors such as traffic characteristics, highway or bridge design, maintenance activities, accidental spills, and surrounding land uses.

A study recently completed by USGS (Stoker 1996) was performed to evaluate the quantity and quality of runoff from a new bridge over a portion of Old Tampa Bay in Pinellas County, Florida. Stormwater runoff from only one source, roadway runoff, could be evaluated for this study due to the unique stormwater collection and detention system included with this bridge design. Contaminant runoff and detention system effectiveness were evaluated for multiple storms over a several-year period, and concentrations of contaminants in runoff were evaluated before and after the bridge was opened to traffic. Constituents included in this study that were identified as sediment COCs for this TBNEP study included chromium, copper, mercury, and nickel. These contaminants were all detected in stormwater runoff and were attributed to bridge materials and vehicles. Concentrations of copper and nickel were similar before and after the bridge was opened to traffic; concentrations of chromium and mercury increased after the bridge was opened to traffic (Stoker 1996). The detention pond treatment system incorporated as part of this bridge design effectively reduced concentrations of these contaminants before discharge to the bay (Stoker 1996).

3.2.2 Runoff from Industrial Facilities

The volume and quantity of stormwater discharges associated with industrial activities depends on several factors including the particular industrial activities occurring at the facility, the amount and frequency of precipitation, and surface permeability characteristics. Sources of pollutants differ with the type of operations and facility-specific characteristics that may include air emissions, material storage, or stormwater discharge with low levels of pollutants. Table 3-1 provides a summary matrix for sediment COCs and general industries associated with releases of these contaminants.

Classes of industrial activity that have been identified as major potential sources of pollutants found in industrial stormwater discharge include: loading or unloading of dry bulk materials or liquids, outdoor storage of raw materials or products, outdoor process activities, dust or particulate generating activities, inadequate management practices, and waste disposal practices. (The descriptions of industrial activities potentially introducing contaminants into industrial stormwater are excerpted from [Weiss 1993]).

Loading and unloading operations are typically performed along facility access roads and railways and loading/unloading docks and terminals. These operations include

Table 3-1.
Sediment-Contaminant Source Matrix

Contaminant	Aluminum	Ammunitions	Anti-Fouling Paints	Automobiles	Batteries	Chemical Manufacturing	Commercial Farming	Corrosion Metallurgy	Dairy	Detergents/Surfactants	Dye	Electrical	Explosives	Plot Glass	Fruits and Vegetables	Leather/Tanning	Meat Products	Metal Finishing/Refining	Metallurgical Processors	Nitric Acid Manufacturing	Oxide Manufacturing	Perfume	Pesticides/Fertilizers	Petroleum Refining	Phosphate Mining	Phosphorus	Photographic	Pigments/Ink	Plastics	Printing Plates	Pulp and Paper Mills	Rubber	Steam Power	Steel Iron	Sulfuric Acid	Textiles	Utilities	Valuable Mineral Mining	Wastewater Treatment Plants	Non-Point Sources	Boat Manufacturing/Repair	Boat Refueling
GENERAL INDUSTRIES																																										
Metals																																										
Chromium	●			●		●		●								●		●			●						●						●						●	●	●	
Copper		●	●	●				●				●	●					●			●													●					●	●	●	
Mercury			●			●						●																●			●						●		●	●	●	
Nickel	●							●				●						●	●												●		●						●	●		
Pesticides																																										
Aldrin							●																●																			
Chlordane																																							●			
DDE																																								●		
DDT							●																																	●		
Endrin																							●																			
Heptachlor																							●																			
PCBs																																										
PCBs				●								●																						●					●		●	
PAHs																																										
Benzo(a)anthracene																																		●							●	●
Benzo(a)pyrene				●														●															●	●		●				●	●	●
Fluoranthene																																								●	●	●
Pyrene																																		●					●	●	●	●
Oil and Grease				●		●												●	●												●			●					●	●	●	●

Source:
Compiled by USEPA Region 5 from studies by Eckenfelder (1980), Merck (1989), WDNR/USGS (1992), USEPA (1987), and NOAA (1991).

pumping of liquids or gases from trucks or rail cars to a storage facility, or vice versa; pneumatic transfer of dry chemicals to or from the loading/unloading vehicle; transfer by mechanical conveyor systems; and transfer of bags, boxes, drum or other containers from vehicles by forklifts or other materials handling equipment. Material spills or losses may discharge directly into storm drainage systems or may accumulate in soils or on surfaces, to be washed away during a storm or facility washdown.

Outdoor storage includes the storage of fuels, raw materials, byproducts, intermediates, final products, and process residuals and wastes. Methods of material storage include use of storage containers (drums or tanks), platforms or pads, bins, silos, boxes, and piles. Materials, containers, and material storage areas exposed to rainfall or runoff may contribute contaminants to stormwater when materials wash off or materials dissolve into solution. Other outdoor activities include certain types of manufacturing and commercial operations and land-disturbance operations. Although many manufacturing operations are performed indoors, some activities (equipment and vehicle maintenance and cleaning, raw material processing) typically occur outdoors. Processing operations may result in liquid spillage and losses of material solids to the drainage system or surrounding surfaces, or creation of dusts or mists that can be deposited locally. Some outdoor industrial activities cause substantial physical disturbance of land surfaces that result in soil erosion by stormwater.

Dust or particulate generating processes include industrial activities with stack emissions of process dusts that settle on plant surfaces. Localized atmospheric deposition is typically only of particular concern with heavy manufacturing industries. Improper connection, spills, and improper dumping or disposal of containers or process or rinse waters can also introduce contaminants to industrial stormwater. Waste management practices including temporary storage of waste materials and operations at landfills, waste piles, and land application sites, or outdoor waste treatment practices including pumping, additions of treatment chemicals, mixing, aeration, clarification, and dewatering, can also introduce contaminants into stormwater discharges.

Many industrial facilities are required to have individual stormwater permits; these facilities were evaluated as point sources (see Section 3.3). Additional facilities that may be potential contributors of contaminants include facilities discharging stormwater under a general permit with no monitoring required, or facilities discharging below the applicable permit required threshold. Examples of these include many of the facilities located at the Port of Tampa.

3.3 Point Sources

Methods for evaluating specific point sources and development of loading estimates include identifying point sources within drainage basins, providing qualitative characterization and quantitative estimates of contaminant contributions where possible, and estimating concentrations and loading by extrapolation from similar discharges where data are lacking.

Previous studies for TBNEP (Frithsen et al. 1995) used data contained in the National Oceanic and Atmospheric Administration's (NOAA's) National Coastal Pollutant Discharge Inventory (NCPDI) database. These data were obtained from the U.S. Environmental Protection Agency's (USEPA's) Permit Compliance System (PCS) database, which includes discharge information from selected facilities having permits issued as part of the National Pollution Discharge Elimination System (NPDES) (Pacheco et al. 1993). Data included in the NCPDI database were from 1991, and use typical loading estimates for industry types when facility data are not available. For these reasons, the NCPDI database may not represent current conditions at facilities within the Hillsborough and Boca Ciega major basins; more recent data reported by facilities within priority sub-basins were used for this project. The USEPA PCS database was searched for more current reports for point source discharges. These data were supplemented by additional point source information including discharge characterization data collected to support permit applications and permit-required monitoring data.

Many industrial facilities are required to have individual stormwater permits; these facilities were evaluated as point sources. Bulk petroleum facilities at the Port of Tampa receive refined petroleum products via marine vessels, offload product into bulk storage tanks, and dispense them into tank trucks for distribution. Wastewater generated by these activities includes product tank bottom water, contaminated runoff from truck loading areas, boiler blowdown, and other non-process water. Tank bottom water is stored for disposal offsite. The other wastewater streams are routed to oil-water separators for removal of the floating oil. The effluent from the treatment system is then routed for discharge through outfalls to various channels connecting to Hillsborough Bay.

Monitoring data for municipal facilities discharging to Hillsborough Bay and Boca Ciega Bay were also evaluated to identify sources of contaminants. Chemical parameters typically monitored and reported by these facilities include a limited set of analytes and elevated analytical limits. An evaluation of monitoring data from these facilities indicates that improvements in wastewater treatment have been very effective in reducing discharges of priority pollutants, but due to the limited permit-required monitoring, data are not available for many COCs. In addition, these data may not be completely representative of facility discharges due to the "snapshot" of discharge data reviewed, and concentrations reported below detection limits (BDL) may or may not equal zero. The data reviewed suggest that treatment facilities are primary contributors of metal loadings, but not other COCs, to Hillsborough Bay.

3.4 Atmospheric Deposition

Atmospheric deposition of materials has been increasingly recognized as a significant pathway for addition of contaminants to aquatic systems. In Tampa Bay, deposition is estimated to contribute more than 10 percent of the total load of heavy metals and the majority of PCBs (Frithsen et al. 1995). Sources of information for specific industrial facilities and hazardous waste sites that discharge to the atmosphere include the USEPA Toxics Release Inventory (TRI) and CERCLIS databases. Atmospheric releases by industrial facilities within the watershed have been identified for cadmium, chromium, lead, and zinc. These data cannot be used to estimate inputs to the estuary because whether contaminants are deposited within the Tampa Bay watershed or transported downwind is not known, but the data are useful for qualitatively evaluating known or potential sources of contaminants. The TRI database contained release data for larger facilities, but did not include release data from smaller facilities from which cumulative contributions may be significant.

Local and state governments maintain air quality monitoring stations for critical air pollutants, but few atmospheric deposition (rainfall or dryfall) monitoring stations exist in the watershed. Data used for this study were obtained from a study completed by Dixon et al. (1996) for TBNEP. This project was developed to evaluate atmospheric deposition within the Tampa Bay watershed, and measured contaminant bulk deposition rates for seven stations located around the Tampa Bay area. The results of this study indicated significant differences in loading rates between stations. For the sources assessment study, these data were used to estimate atmospheric loadings by apportioning loads within specific areas of the priority basins. These data could not be used to estimate actual atmospheric loadings of contaminants in Hillsborough or Boca Ciega Bays, but do provide useful information regarding relative loadings and loading within Hillsborough and Pinellas Counties.

The potential exists for atmospheric release of COCs from specific facilities within the priority sub-basins. The contribution from these sources is unknown, although most facilities with permitted stack emissions located in the priority sub-basins are unlikely sources of COCs. Identification of atmospheric sources of COCs is problematic to the long-distance transport of atmospheric contaminants. Based on cursory review of data from the USEPA AIRS database, no facilities were identified with permitted air releases of COCs. Most of the releases from these facilities included volatile organic compounds (VOCs), oxides of sulfur and nitrogen (SOx/NOx), and particulates. Some atmospheric releases of COCs were reported in the TRI database, but it was not possible to incorporate these historical loads into current loading estimates.

3.5 Other Potential Sources of COCs

Toxic contaminants can also leach from soils into the water table or confined aquifers and enter an estuary through groundwater discharge zones. Sources of contaminants in groundwater include leachate from landfills, hazardous waste sites, leaking underground storage tanks, or agricultural areas. Elevated contaminant concentrations are typically localized and may take decades to reach the estuary due to the slow rate of groundwater flow. Previous studies of contaminant loading to Tampa Bay due to groundwater infiltration (Frithsen et al. 1995) used Ambient Groundwater Quality Monitoring Program (AGWQMP) (SWFWMD 1990) contaminant concentration data, and groundwater flow estimates from Zarbock et al. (1994), to develop estimates of contaminant loading due to groundwater infiltration. AGWQMP data include measurements taken for each aquifer; concentrations were assumed to be typical for each aquifer and concentrations reported as below detection were assumed to be zero. Loading estimates were made only for metals due to the limited number of concentrations reported as above detection limits. In addition, measured concentrations reported for organics were considered suspect (SWFWMD 1990).

Due to these data limitations, no attempt was made to include groundwater infiltration estimates for specific basins or bay segments.

Hazardous waste sites identified for the Tampa Bay watershed include three National Priority List (NPL) and 29 non-NPL sites in the Hillsborough River basin, five NPL and 31 non-NPL sites in the Coastal Hillsborough basin, and four non-NPL sites in the Boca Ciega basin. Additional potential sources of contaminants include above- or below-ground storage tanks and gas stations or other fuel storage facilities. Sites with known hazardous waste contamination were identified using the USEPA CERCLIS database. Loadings from these sources were not evaluated due to the lack of data regarding the amount and type of contaminants being transported from these sites to the estuary and tributaries.

Groundwater discharge to channels or creeks near contaminated sites may greatly increase loadings from contaminated sites, but this loading can be included in surface runoff estimates. Estimates of contaminant inputs from groundwater infiltration could be improved by examining data characterizing contaminant concentrations in groundwater and better quantification of flow from surficial aquifers in the estuary. With the exception of metals, however, few recent data were available for the COCs. In addition, identifying specific sources of contaminant loading through groundwater requires a significant modeling effort, which was beyond the scope of this project.

Estimates of pollutant loading from tributaries can be made using water quality data collected as part of various studies for the Hillsborough River, such as the West Coast Regional Water Supply (WCRWSA) Hillsborough River/Tampa Bypass Canal Hydrobiologic Monitoring Program, or data collected by U.S. Geological Survey (USGS) from tributaries within the priority basins. With the exception of limited data for metals, however, few recent data were available for the contaminants identified as COCs.

One potential specific source of mercury, that is unique to major waterways includes batteries for aids to navigation (ATON). ATON are located throughout Tampa Bay at both aquatic and terrestrial sites. The following discussion of historical disposal practices, and the current recovery plan, is based on a study by the USCG (1995) performed to investigate potential releases of contaminants from ATON sites.

Batteries associated with ATON have historically contained small amounts of mercury. Additional metals in these batteries may include lead and zinc. Historical maintenance activities at ATON sites have included disposal of spent batteries at some of the sites. Because the use of the mercury-containing batteries was discontinued in the mid-1980s, the current potential sources of mercury include contaminated sediments, and releases from leaking batteries discarded near ATON sites. The investigation and recovery plan implemented by the USCG included removing easily recovered batteries (minimal sediment disruption), preventing future battery losses at these sites, and monitoring soil and sediments affected by disposal practices (USCG 1995).

The USCG investigation and recovery plan also included several studies performed for the Volpe Center (Borener 1995) to evaluate potential mercury contamination at ATON sites across the U.S., including sites within Tampa Bay. The results of this investigation overall were: low to non-detectable levels of total mercury in sediments at ATON sites, little evidence of bioavailable mercury as indicated by the fraction of methylated vs. total mercury present, and no evidence of total or methyl mercury tissue concentrations above background for aquatic organisms.

The results of investigations at ATON sites in Tampa Bay showed large numbers of discarded and broken batteries at several sites and mercury concentrations above background and ecological benchmarks (ER-L) in sediments adjacent to these sites, but low tissue concentrations in aquatic organisms. Metals concentrations in sediments adjacent to ATON sites suggested some potential risk to marine organisms in small localized areas close to high concentrations of batteries. No elevated levels of mercury were measured more than ten meters from any of the sites evaluated.

The extremely low percentage of methyl mercury relative to total mercury, and the low mercury concentrations detected in aquatic organisms suggests little potential for bioaccumulation and ecological risk due to food web exposure. All mercury concentrations were below benchmark values for adverse human health effects. Although the extent of elevated sediment mercury concentrations was very limited (less than one meter at most sites), elevated concentrations in areas with a high density of casings and/or broken casings could increase potential risks for aquatic organisms in localized areas (especially attached to or inside casings). According to the USCG recovery plan, batteries were removed from all ATON areas except where sediment disturbance would significantly impact an existing benthic community or increase potential risks by suspending contaminated particles.

Other potential sources of contaminants include marinas, boats and docks, hazardous waste handlers and storage sites, or contaminant spills and releases. Chemicals used to chemically treat wood for docks and associated structures include: ammoniacal copper arsenate, chromated copper arsenate, creosote-coal tar, acid copper chromate, chromated zinc chloride, fluorochrome arsenate phenol, pentachlorophenol, and creosote-petroleum solutions (Webb and Gjovink 1988). Most of these individual sources are minor contributors to total loading of copper and PAHs. No data have been located for release of contaminants from these specific sources.

Additional sources of copper loading include the use of copper sulfate as an aquatic herbicide/algaecide in the Hillsborough Reservoir. Based on previous studies by Martin and Hohman (1995), sediment samples in this area of the Hillsborough River contain elevated levels of copper, but aqueous copper was not found in water samples collected. An additional study by Martin et al. (1990) suggested that the chelated form of copper applied for algae control does not migrate significantly beyond the area of application. Because the findings of these studies (Martin and Hohman 1995; Martin et al. 1990) suggest little potential for migration of copper from this source to the lower Hillsborough River, potential loadings from this source were not evaluated as part of this TBNEP study.

Other sources of information regarding contaminant releases include USEPA databases that contain release records for specific facilities that handle and/or have reported releases of contaminants. Additional hazardous waste release incident reports are available from state or local government agencies. The USEPA TRI database was searched for to identify major releases to air, water, or land by specific facilities. An attempt was made to use the

USEPA RCRA Biennial Reporting System (BRS) database to identify facilities handling COCs for processing, storage, or treatment. Due to the nature of actual or potential releases from these facilities, and the limited characterization data available, accidental release information could not be incorporated into contaminant loading estimates. A review of FDEP, the USCG Marine Safety Office primary spills record database, or other state or local hazardous waste release incident reports was outside the scope of this study.

Most of the point source loading data was obtained from regulatory agency databases and facility files that contain monitoring data reported to a particular agency. Because testing requirements are based on anticipated discharges, this information should be representative of facility discharges, although significant releases to go undetected due to lack of monitoring. A number of the facilities identified in the Port of Tampa area have not been required to obtain environmental permits. While discharges from most of these facilities are not likely to be significant, discharges from particular facilities (e.g., scrap metal facilities) may be a concern.

3.6 Summary of Available Loading Data for COCs

A summary of the available COC source/loading data used to evaluate sources and develop loading estimates is provided in Table 3-2. Available data and loading estimates for each source type are discussed in Section 4.0.

Table 3-2.
Summary of Source/Loading Data for Contaminants of Concern Hillsborough and Boca Ciega Sub-Basins

Chemical	Upper Hills. Bay		Source Data(3)					Boca Ciega Bay		Source Data				
	ECO(1)	HH(2)	PS	STW	AD	TRI	BRS	ECO	HH	PCS	STW	AD	TRI	BRS
Pesticides														
DDD, total	x													
DDTs, total	x						●							
Endrin	x	x		●										
Heptachlor/epoxide	x	x				●						●		
Lindane	x				○	●						○		
Chlordane		x												
PCBs														
PCBs, total	x	x						x						
PCB 153					●							●		
High Molecular Wt PAHs:														
Benzo(a)anthracene	x	x						x				●		
Benzo(a)pyrene		x							x			●		
Benzo(b)fluoranthene		x			●				x			●		
Chrysene	x													
Fluoranthene	x				●			x				●		
Pyrene	x				●							●		
Total HPAHs	x							x						
Total PAHs			○	○		●	●			○	○			
Metals														
Chromium	x		●	●		●	●			●			●	●
Copper	x		●	●	●	●								
Mercury	x		●	●			●							●
Nickel	x		●	●						●				

Note:
1. ECO indicates a contaminant with a significant potential for adverse ecological effects.
2. HH indicates a contaminant with a significant potential for human health effects.
   Upper Hillsborough includes McKay Bay.
3. PS - point source discharge data from USEPA Permit Compliance System (USEPA 1996).
   STW - stormwater data from Hills. and Pinellas County NPDES permit applications and USEPA Region IV.
   AD - TBNEP Bulk Deposition Study (Dixon et al., 1996).
   TRI - Toxic Release Inventory System (USEPA 1996); BRS - RCRA Biennial Reporting System 1993 (USEPA 1995).

● - Available data. Data for nickel from facility monitoring reports, not PCS database.
○ Surrogate data available - alpha/delta-BHC for lindane; oil and grease for total PAHs.

4.0 METHODOLOGY USED TO EVALUATE SPECIFIC SOURCES

An outline of the general steps used to identify sources of contaminants and estimate loadings from sources in the priority basins is provided in this section. Loadings for individual COCs within a class were evaluated as available data allowed and specific sources identified where possible. Source identification/loading estimates could not be performed for individual COCs in all cases (e.g., loadings were calculated for individual metals and some pesticides, but not all PAHs or PCBs). COCs that could not be addressed individually were evaluated by contaminant class (i.e., total pesticides, total PCBs, and total HPAHs).

4.1 Outline of Steps for Evaluation of Sources

Methods for determining sources of COCs were examined during Task 1 of this TBNEP project. Based on the results of Task 1, urban runoff, atmospheric deposition, and point sources were identified as the major potential contributors of COCs. These source categories were the focus of remaining activities regarding identification of sources for potential control measures. The steps used to evaluate sources are listed below and described in detail in the following sections. These general steps included:

- Identification of sub-basins within priority basins by overlay of basin/sub-basin/coastline delineations (Section 4.2).
- Evaluation of stormwater runoff by: 1) overlay of land use/soils/sub-basin delineations; determine areas for each land use using Florida Land Use, Cover, and Forms Classification System (FLUCCS) categories (FDOT 1985); 2) assignment of runoff coefficients using soils and land use characteristics; 3) estimation of pollutant runoff using event mean concentrations, land use/runoff coefficients, and average rainfall (Section 4.3).
- Identification of point sources contributing to COC loading (PCS database, permit application/monitoring files); evaluation of available data to estimate COC loadings from these sources (Section 4.4).
- Estimation of atmospheric loading estimates for basins using bulk deposition rates for Hillsborough and Pinellas Counties (from Dixon et al. 1996); apportionment of atmospheric deposition rates based on basin area (Section 4.5).
- Identification of other facilities releasing/handling COCs within sub-basins (TRI/BRS databases); identification of sites where historical contamination may be a source of COCs (CERCLIS database) (Section 4.6).
- Integration of loads from stormwater runoff, point sources, and atmospheric deposition to estimate total load and the portion attributable to each source category; ranking of point/nonpoint sources within sub-basin based on total loading of all COCs and/or loading per unit area (Sections 5.1 through 5.4).

Using the steps listed above, contaminant source data were evaluated to determine specific sources and loadings. Sub-basins can then be prioritized to allow targeted management actions based on reduction of ecological and human health risks, the effectiveness and cost of management alternatives, or the need for additional investigation.

4.2 Identification of Sub-Basins

Sub-basins within priority drainage basins were identified by determining the configuration of the drainage system from stormwater atlas sheets and topographic maps. Each basin has a contributing stream or channel that ends in the target portion of the estuary. For each contributing channel, there are many associated overland flow paths or secondary channels that transport the contaminants to the channel. The extent of all flow paths ending in the outfall point were used to define the basin boundaries.

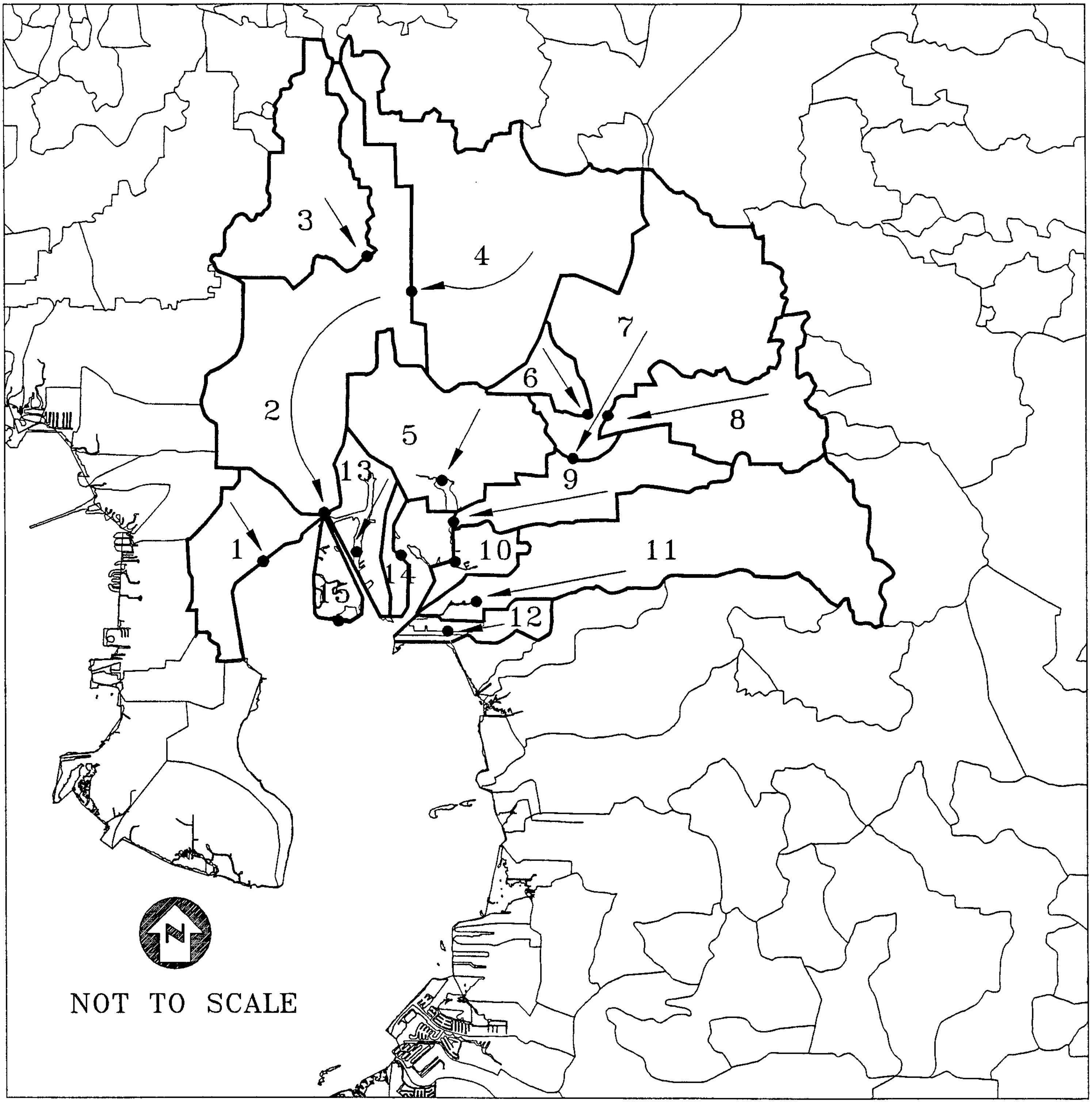
The upper Hillsborough Bay basin and sub-basins (shown in Figure 4-1) were delineated based on major conveyances contributing to upper Hillsborough Bay such as the Tampa Bypass Canal, Hillsborough River, and storm sewer systems in the McKay Bay watershed. The Boca Ciega Bay basin and sub-basins (shown in Figure 4-2) were delineated based on major rivers or streams that empty into the bay and their associated contributing area of runoff.

Sub-basins were defined by separating major basins based on major conveyances such as rivers, canals, or storm sewers that terminate in the estuary of concern. The loading point for each sub-basin was the intersection of the basin boundary and the major stream or river discharging to the bay. For this study, the Lower Hillsborough River and Coastal Hillsborough major basins were combined because they both empty into upper Hillsborough Bay. Sub-basin delineations obtained from the Southwest Florida Water Management District (SWFWMD) were aggregated in some cases due to basins having identical loading points and the relative size among different sub-basins. Aggregation of sub-basins was warranted given the level of detail for available loading data.

4.3 Urban Runoff

To determine the proportion of each land use type and Soil Conservation Service (SCS) soil hydrologic category, the TBNEP coastline delineation for Tampa Bay and sub-basin delineations described above were overlaid on FLUCCS land use maps obtained from SWFWMD. Based on available event mean concentrations from stormwater characterization studies, the land use categories were aggregated into the following groups: low density residential, high density residential, light industrial, agriculture, commercial-office, commercial-retail, recreational, and highway/utility

A runoff coefficient for each land use-soil type pair was assigned based on typical impervious area. Each FLUCCS code and hydrologic soil type (A,B/D,C,D) was assigned an associated runoff coefficient. A weighted average stormwater runoff coefficient per sub-basin was estimated using land use (FLUCCS code) and soils area combinations.



BASINS

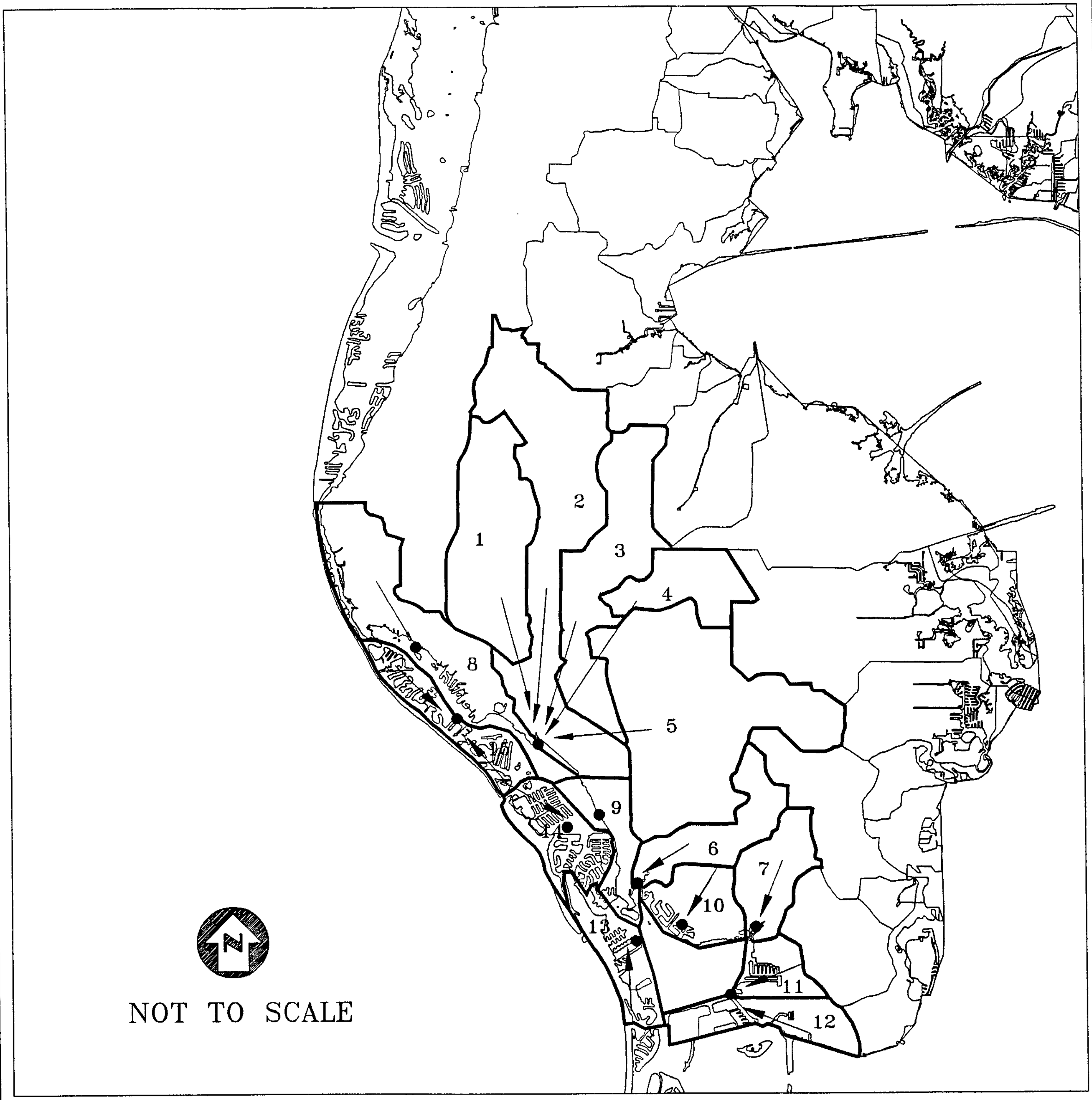
1)DIRECT RUNOFF TO BAY
2)LOWER HILLS. RIVER 1
3)CURIOSITY CREEK
4)LOWER HILLS. RIVER 2
5)MCKAY BAY 1
6)BELLOWS LAKE OUTFALL
7)TAMPA BYPASS CANAL
8)MANGO DRAIN
9)PALM RIVER
10)DITCH
11)DELANEY CREEK
12)BLACK POINT
13)YBOR CHANNEL
14)MCKAY BAY 2
15)DAVIS ISLANDS

LOADING POINT ●←

FIGURE 4-1

UPPER HILLSBOROUGH BAY
WATERSHED BASINS AND LOADING POINTS
TAMPA BAY NATIONAL ESTUARY PROGRAM

PARSONS ENGINEERING SCIENCE, INC.



Basins

LOADING POINT ● ←

1)Lake Seminole
2)Long Bayou
3)Cross Canal
4)Pinellas Park
5)St. Joe Creek
6)Bear Creek
7)Clam Bayou Drain
8–14)Direct Runoff to Bay

FIGURE 4-2

BOCA CIEGA BAY
WATERSHED BASINS AND LOADING POINTS
TAMPA BAY NATIONAL ESTUARY PROGRAM

PARSONS ENGINEERING SCIENCE, INC.

To estimate the potential contaminant runoff for each land use/soil type present in particular sub-basins, event mean concentration (EMC) data collected by municipal governments as part of the NPDES permit application process were reviewed. NPDES stormwater characterization data were available from the City of Tampa (1993), Hillsborough County (1993), and Pinellas County (1993). These data were evaluated, and EMC values considered most representative of land use conditions within each drainage basin were selected. The stormwater runoff event mean concentrations used for this study are provided in Table 4-1. Areas for land use categories within the Hillsborough and Boca Ciega Bay sub-basins are shown on Figures 4-3 and 4-4, respectively. Total areas corresponding to these land uses are provided in Table 4-2.

Although EMC values reported by the City of Tampa were slightly higher for some contaminants and land uses (e.g., lead), most values were similar. Because the Hillsborough County data included additional land use categories, contained additional detections of contaminants, and incorporated the entire drainage basin, these data were used to evaluate the upper Hillsborough Bay sub-basins. Because the stormwater characterization data reported by Pinellas County did not include all land use types present within the Boca Ciega sub-basins, EMC values reported by Hillsborough County were used as surrogate data for land use categories without EMC values.

Stormwater pollutant loadings were estimated using the simple method given by the USEPA Guidance Manual - Guidance for the Preparation of Discharge Monitoring Reports (USEPA 1992). The formula is given as:

$$L_i = (0.227)(P)(CF)(Rv_i)(C_i)(A_i)(CF)$$

where

L_i = annual pollutant load per sub-basin (lb/yr)

P = annual precipitation for area(in/yr)

Rv_i = weighted average runoff coefficient based on impervious area

C_i = event mean concentration (mg/L)

A_i = catchment area contributing to outfall (acres)

CF = correction factor for storms that produce no runoff (assumed 10 percent of storms produce no runoff)

The total load was determined by summing all of the sub-basin loads. Total annual loads were calculated based on the simple method for detected pollutants and summarized in Tables 4-3 and 4-4. Total annual loads for COCs detected in stormwater runoff are provided in this table.

Table 4-1.
Event Mean Concentrations for Constituents Detected in Hillsborough and Pinellas Co. Stormwater(1)

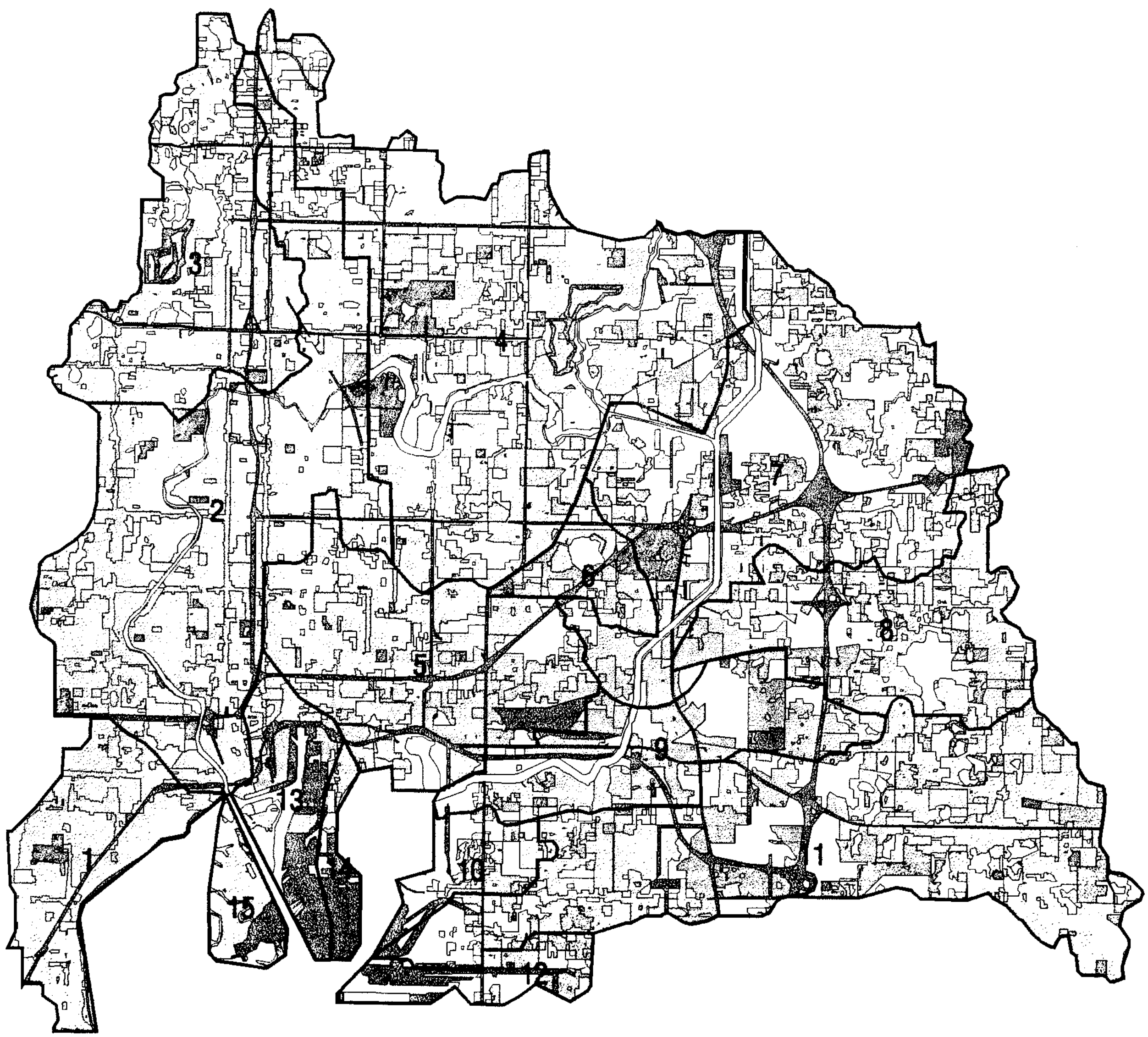
Hillsborough County NPDES Appl. - 1993.
Event Mean Concentrations (mg/l)

LANDUSE	As	Ba	Cd	Cr	Cu	Pb	Hg	Zn	O&G	Phenols	Di-n-butyl-phthalate	Endo-sulfan	Endo-sulfan II	Endrin	BOD	COD	NO2/NO3	TP	TDP	TDS	TKN	TSS
SINGLE FAMILY RES.				0.059	0.013	0.008		0.022	1.370	0.095						26.70	0.28	0.40	0.28	143.00	1.08	19.00
MULTI-FAMILY RES.					0.047	0.006		0.058	2.220	0.150	0.063				2.60	36.70	0.68	1.34	0.55	68.00	1.37	29.00
LIGHT INDUSTRIAL					0.024	0.006		0.096	5.245	0.110		0.0005			2.87	31.70	0.19	0.33	0.19	567.00	2.09	18.20
AGRICULTURE	0.007		0.013		0.041			0.017		0.053	0.024	0.001	0.0005	0.0005	18.30	45.00	0.80	2.35	1.22	463.00	2.17	12.70
COMMERCIAL-OFFICE	0.006				0.014			0.036	1.380	0.130					2.62	15.20	0.17	0.31	0.18	38.30	2.21	36.50
COMMERCIAL-RETAIL		1.050		0.033	0.021	0.005	0.001	0.015		0.130					2.72	36.70	0.60	0.25	0.13	99.70	1.08	9.33
RECREATIONAL			0.007		0.041	0.006		0.004							3.80	36.67	0.51	0.05		185.00	2.09	11.10
HIGHWAY/UTILITY			0.040		0.103	0.960		0.410							24.00	14.70	1.14	0.12		185.00	2.99	261.00

Pinellas County NPDES Appl. - 1993.
Event Mean Concentrations (mg/l)

LANDUSE	As	Ba	Cd	Cr	Cu	Pb	Hg	Zn	O&G	Phenols	Di-n-butyl-phthalate	Endo-sulfan	Endo-sulfan II	Endrin	BOD	COD	NO2/NO3	TP	TDP	TDS	TKN	TSS
SINGLE FAMILY RES.			0.003		0.033	0.021	0.001	0.097	7.800						10.30	70.30	0.57	0.59	0.52	66.70	1.47	49.70
MULTI-FAMILY RES.			0.000		0.000	0.008		0.140							5.70	32.30	0.45	0.15	0.13	45.00	1.60	8.30
LIGHT INDUSTRIAL	0.014		0.000		0.033	0.032		0.407							16.00	54.70	0.82	0.49	0.44	183.00	1.10	84.30
AGRICULTURE(2)	0.007		***0.013***		***0.041***	***0.000***		***0.017***		0.053	0.024	0.001	0.0005		***18.30***	***45.00***	***0.80***	***2.35***	***1.22***	***463.00***	***2.17***	***12.70***
COMMERCIAL-OFFICE			0.000		0.000	0.004		0.097							14.50	30.00	0.68	0.11	0.12	73.00	0.72	6.20
COMMERCIAL-RETAIL			0.000		0.000	0.008		0.070		0.050					11.40	33.00	0.50	0.18	0.14	111.00	0.78	14.50
RECREATIONAL(2)			***0.007***		***0.041***	***0.006***		***0.004***							***3.80***	***36.67***	***0.51***	***0.05***	***0.00***	***185.00***	***2.09***	***11.10***
HIGHWAY/UTILITY(2)			***0.040***		***0.103***	***0.960***		***0.410***							***24.00***	***14.70***	***1.14***	***0.12***	***0.00***	***185.00***	***2.99***	***261.00***

Note:
1. Includes all contaminants detected in stormwater runoff; loadngs were only evlauted for chemicals identified as COCs.
2. Land uses not included in characterization sampling for Pinellas Co.; values for Hillsborough Co. used as surrogates.



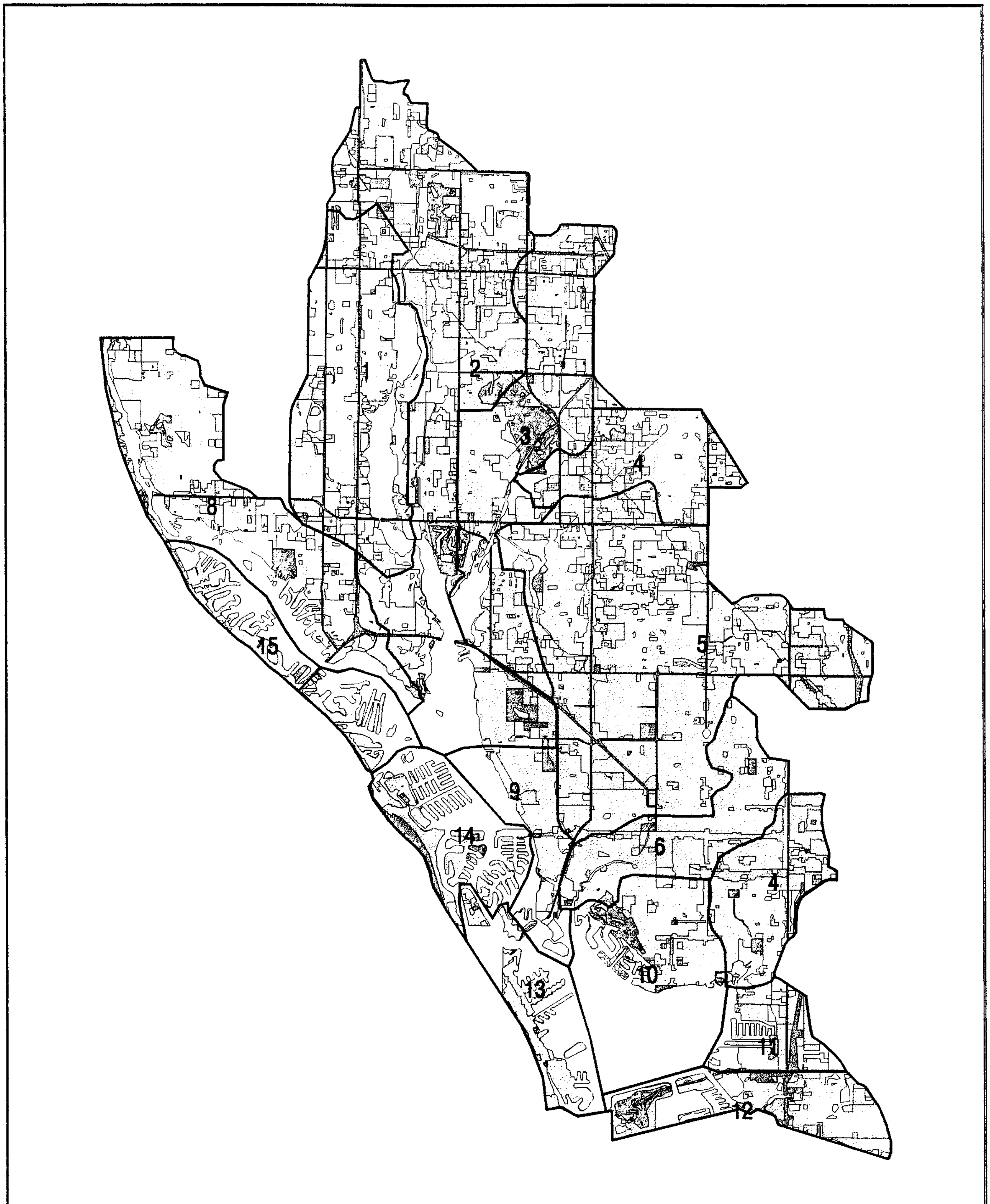
Legend

Residential	Recreational
Commercial	Highway/Utility
Light Industrial	Not Classified
Agriculture	

Figure 4.3

Upper Hillsborough Bay

Landuse by Sub-Basin



Legend

- Residential
- Commercial
- Light Industrial
- Agriculture
- Recreational
- Highway/Utility
- Not Classified

Figure 4.4

Boca Ciega Bay

Landuse by Sub-Basin

Table 4-2.
Area (acres) for Land Use Categories - Upper Hillsborough and Boca Ciega Bay Sub-Basins

Upper Hillsborough Bay

SUB-BASIN NO.	SINGLE FAMILY RES.	MULTI-FAMILY RES.	LIGHT INDUSTRIAL	AGRICULTURE	COMMERCIAL OFFICE	COMMERCIAL RETAIL	RECREATIONAL	HIGHWAY/ UTILITY	TOTAL
1	24.5	2307.1	0.0	0.0	83.0	665.1	100.5	196.1	3376.3
2	186.6	7133.9	152.2	2.7	693.9	2447.4	477.8	485.6	11580.0
3	409.6	3455.9	0.0	20.6	195.0	870.9	205.2	215.4	5372.5
4	3033.0	3349.1	624.5	522.4	955.9	1879.1	688.5	588.1	11640.5
5	161.1	2162.9	592.7	14.5	239.5	1753.5	78.9	604.8	5608.0
6	53.7	301.1	42.9	122.8	59.3	247.9	95.4	68.5	991.6
7	2413.8	280.8	377.7	1972.6	91.8	785.5	244.6	793.7	6960.6
8	1417.5	844.2	166.7	743.8	82.0	582.0	35.6	135.0	4006.7
9	498.7	236.6	750.1	323.9	48.9	411.0	37.4	370.2	2676.9
10	207.0	19.0	128.5	29.0	0.0	101.6	0.0	156.2	641.3
11	2952.7	1463.3	57.8	1931.2	233.9	1453.2	62.8	682.9	8837.8
12	70.7	8.1	97.4	192.8	0.0	84.9	0.0	342.3	796.2
13	11.0	184.7	259.0	0.0	77.0	232.5	0.0	823.5	1587.6
14	0.0	115.5	0.0	0.0	0.0	22.9	1.4	395.9	535.8
15	0.0	569.3	0.0	0.0	19.7	11.6	29.6	165.7	795.8
Total	**11439.8**	**22431.4**	**3249.4**	**5876.3**	**2779.9**	**11549.2**	**2057.6**	**6024.0**	**65407.6**

Boca Ciega Bay

SUB-BASIN NO.	SINGLE FAMILY RES.	MULTI-FAMILY RES.	LIGHT INDUSTRIAL	AGRICULTURE	COMMERCIAL OFFICE	COMMERCIAL RETAIL	RECREATIONAL	HIGHWAY/ UTILITY	TOTAL
1	203.8	2760.3	25.9	85.9	109.5	435.8	99.4	214.1	3934.6
2	733.0	3298.0	939.4	69.2	206.1	623.7	555.7	345.5	6770.6
3	381.0	1886.0	528.9	0.0	79.9	605.1	398.1	228.8	4107.7
4	212.8	1181.6	53.1	59.3	54.5	231.6	52.5	72.7	1918.2
5	458.1	6314.3	388.4	40.6	552.5	1230.9	85.7	467.1	9537.7
6	16.3	1891.1	29.2	0.0	105.2	343.4	44.8	33.1	2463.0
7	30.1	1226.7	150.1	1.7	117.8	303.7	37.7	72.2	1939.9
8	768.0	2241.9	0.0	35.8	188.4	219.5	168.1	115.9	3737.5
9	73.7	760.1	22.1	0.0	90.9	87.5	45.4	11.8	1091.4
10	68.0	1157.0	0.0	0.0	75.9	133.3	186.5	0.0	1620.6
11	192.9	284.1	0.0	0.0	23.5	188.7	13.8	125.9	828.9
12	186.6	779.6	0.0	0.0	208.8	41.7	173.7	102.3	1492.7
13	40.0	473.3	0.0	0.0	1.8	219.3	30.1	6.1	770.7
14	0.0	734.7	0.0	0.0	0.0	184.4	151.6	2.6	1073.3
15	0.0	674.9	0.0	0.0	0.0	143.5	19.4	6.2	844.0
Total	**3364.3**	**25663.5**	**2137.1**	**292.5**	**1814.8**	**4991.8**	**2062.4**	**1804.3**	**42130.8**

Table 4-3.
Summary of Annual Loads (lbs/yr) for COCs Detected in Stormwater Runoff - Upper Hillsborough Bay Sub-Basins

Chemical	Loading	Sub-Basin Number and Area (acres) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total Load (tons)
		3376.3	11580.0	5372.5	11640.5	5608.0	991.6	6960.6	4006.7	2676.9	641.3	8580.2	1053.9	1587.6	535.8	795.8	
Metals																	
Chromium	total	143.1	535.6	249.1	921.6	378.8	54.5	614.9	367.1	180.8	63.0	792.7	30.2	55.3	4.3	2.6	2.2
	per acre	0.042	0.046	0.046	0.079	0.068	0.055	0.088	0.092	0.068	0.098	0.092	0.029	0.035	0.008	0.003	
Copper	total	852.0	2654.0	1268.8	1857.1	1308.4	192.4	1084.8	551.9	541.5	148.6	1331.0	271.0	732.2	240.8	309.8	6.6
	per acre	0.252	0.229	0.236	0.160	0.233	0.194	0.156	0.138	0.202	0.232	0.155	0.257	0.461	0.449	0.389	
Mercury	total	4.2	15.1	5.0	11.2	10.5	1.3	4.5	3.3	2.4	0.6	7.9	0.5	1.6	0.1	0.1	0.03
	per acre	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.001	0.0002	0.0001	
Nickel	total	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Sum of metals	total	999	3205	1523	2790	1698	248	1704	922	725	212	2132	302	789	245	313	8.9
	per acre	0.30	0.28	0.28	0.24	0.30	0.25	0.24	0.23	0.27	0.33	0.25	0.29	0.50	0.46	0.39	
Pesticides																	
Endosulfan I*	total	nd	5.59E-01	6.78E-02	3.12E+00	2.29E+00	4.69E-01	5.87E+00	2.34E+00	3.34E+00	4.91E-01	4.59E+00	7.97E-01	1.12E+00	nd	nd	1.25E-02
	per acre	nd	4.82E-05	1.26E-05	2.68E-04	4.08E-04	4.73E-04	8.43E-04	5.84E-04	1.25E-03	7.65E-04	5.34E-04	7.56E-04	--	--	--	
Endosulfan II*	total	nd	3.58E-03	3.39E-02	4.96E-01	1.93E-02	1.75E-01	2.33E+00	8.86E-01	4.19E-01	3.54E-02	2.20E+00	2.39E-01	nd	nd	nd	3.42E-03
	per acre	nd	3.09E-07	6.31E-06	4.26E-05	3.44E-06	1.76E-04	3.35E-04	2.21E-04	1.57E-04	5.52E-05	2.56E-04	2.27E-04	--	--	--	
Endrin*	total	nd	3.58E-03	3.39E-02	4.96E-01	1.93E-02	1.75E-01	2.33E+00	8.86E-01	4.19E-01	3.54E-02	2.20E+00	2.39E-01	nd	nd	nd	3.42E-03
	per acre	nd	3.09E-07	6.31E-06	4.26E-05	3.44E-06	1.76E-04	3.35E-04	2.21E-04	1.57E-04	5.52E-05	2.56E-04	2.27E-04	--	--	--	
PCBs																	
PCBs, total	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
PAHs/Semivolatiles																	
Oil And Grease*	total	30398	101751	49242	83212	50999	5935	27040	22890	31140	5477	34161	3649	14652	1529	8587	233.7
	per acre	9.0	8.8	9.2	7.1	9.1	6.0	3.9	5.7	11.6	8.5	4.0	3.5	9.2	2.9	10.8	
Total HPAHs	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na

Note:
* - not a COC, but serves as surrogate.
na - not analyzed in stormwater characterization studies.
nd - not detected.
Loads calculated using the simple method (Schueler 1987) with NPDES Stormwater Discharge Characterization for Hillsborough County (1993).
Runoff coefficients and annual rainfall (54 in/yr) from Hillsborough County (1993).

Table 4-4.
Summary of Annual Loads (lbs/yr) for COCs Detected in Stormwater Runoff - Boca Ciega Sub-Basins

Chemical	Loading	Sub-Basin Number and Area (acres)															Total Load (tons)
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
		3934.6	6770.6	4107.7	1918.2	9537.7	2463.0	1939.9	3737.5	1091.4	1620.6	828.9	1492.7	770.7	1073.3	844.0	
PCBs																	
PCBs, total	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
PAHs/Semivolatiles																	
Oil And Grease*	total	6446	21694	10615	5747	13353	571	1001	21032	2398	1762	4367	4456	1240	nd	nd	47.3
	per acre	1.6	3.2	2.6	3.0	1.4	0.2	0.5	5.6	2.2	1.1	5.3	3.0	1.6	nd	nd	
Total HPAHs	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na

Note:

* - not a COC, but serves as surrogate.

na - not analyzed in stormwater characterization studies.

nd - not detected.

Loads calculated using the simple method (Schueler 1987) with NPDES Stormwater Discharge Characterization for Hillsborough County (1993).

Runoff coefficients and annual rainfall (54 in/yr) from Hillsborough County (1993).

4.4 Point Sources

Prioritization of sub-basins and management actions for reduction of COC loading to Tampa Bay requires identification of point source discharges containing COCs, estimates of point source contributions to total loadings, or elimination of point source discharges as significant contributors of COCs where appropriate.

4.4.1 Data Sources

Available discharge data were obtained from relevant local, state, and federal agencies and reviewed to identify sources of COCs and estimate loadings. Types of discharge data evaluated included characterization data performed to determine permitting requirements, data collected in support of permit applications, and permit compliance monitoring data. Loading information for specific types of point source dischargers according to standard industrial classification (SIC) codes or other classification system was available for some types of facilities located within sub-basins. Because discharge monitoring requirements or typical loads have not been established for many of the facilities located within these basins (especially the bulk transfer facilities), however, this approach was not used for this study.

Available databases containing surface water discharge information were searched, and interviews with agency staff were held to complete or clarify facility information as required. Site visits or contacts for specific facilities were outside the scope of this investigation. Many of the agency staff contacted, however, had extensive knowledge of current and historical site activities at most of the facilities located within priority sub-basins. Specific sources of discharge data used for this information included the following:

- USEPA Permit Compliance System (PCS) database
- USEPA Region IV PCS and STORET databases, and permit files
- USEPA Envirofacts database. This is relational database that integrates data extracted from five major USEPA program systems: AIRS/AFS (air emission estimates for pollutants regulated under the Clean Air Act); CERCLIS (Superfund hazardous waste facility locations and status); PCS (facilities with permitted surface water releases); RCRIS (facilities permitted to process/transfer/treat hazardous waste); and TRIS (USEPA database for toxic chemicals released to air, land, or water)
- FDEP Groundwater Management System (GMS) database, discharge monitoring reports (DMRs), and permit files
- Hillsborough County Environmental Protection Commission (EPC) permit files, and port facility inventories
- Discharge characterization and monitoring data for domestic wastewater discharges in Hillsborough and Pinellas Counties

The major source for surface water discharge data was the USEPA PCS database. This database contains point source discharge data reported to USEPA by facilities permitted under the NPDES program. The completeness of this dataset was uncertain because most facilities do not monitor for constituents identified as COCs. Because the quality of these data were suspect due to blanks and incorrect information identified, additional data were obtained from USEPA Region IV.

Based on the conversations with Region IV staff, the PCS data were the only electronic data available from USEPA. These data contained only permit required parameters and are collected for compliance purposes, which limits the value of these data for other purposes. Although water quality data for the COCs were not contained in the STORET database for the period 1990-present, some data collected in the 1980s contain detected concentrations for some of the COCs. Additional sources of point discharge data evaluated included the FDEP GMS database; this database consists of a centralized repository for monitoring data collected by each FDEP district office. The GMS database was searched for all facilities identified within the priority sub-basins. The results of this search indicated that this database contains information for conventional wastewater parameters (similar to the USEPA PCS database) with very little additional information for potential COC discharges by facilities.

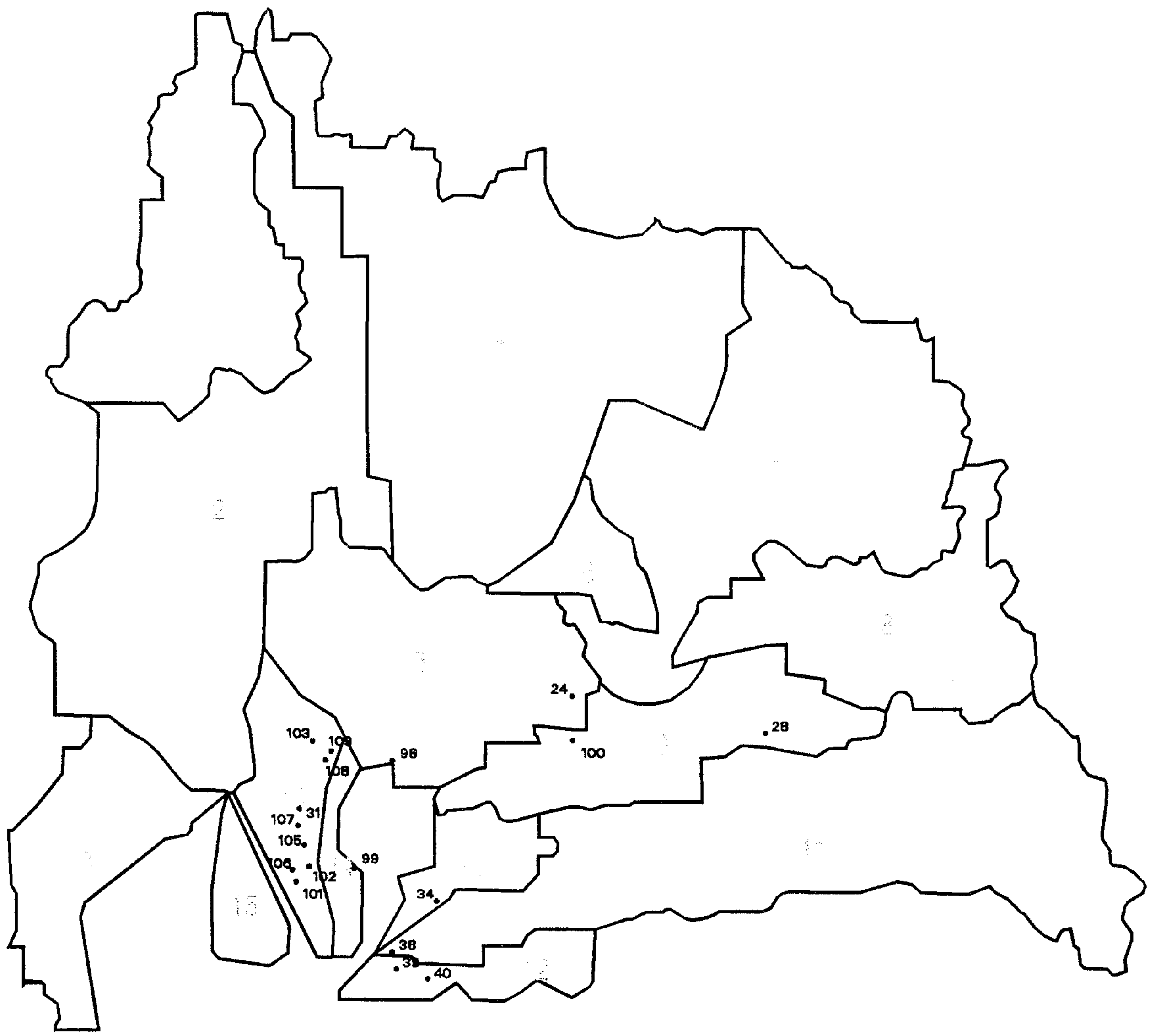
FDEP Southwest District surface water permitting staff were contacted for information on facilities with (existing/in process) wastewater discharge permits. All data submitted to the district office to meet required permit conditions were being forwarded to Tallahassee; many of these data had not yet been entered into the database system. Because permit monitoring requirements reflect industrial processes and anticipated discharges, significant discharges should be included in permit monitoring dataset. Additional characterization data collected in support of the permit applications were also reviewed. Some of the facilities identified were in the permitting process, or under a consent order, and data collected were not being input into USEPA or FDEP databases. These facilities were evaluated through review of permit files and conversations with FDEP permitting staff.

Hillsborough County EPC staff involved with surface water protection were also contacted. Point sources discharges for several metals identified as COCs were located by EPC. EPC staff confirmed that permit monitoring parameters were tailored to the particular facility process, and that monitoring reports should contain data for significant discharges. EPC has concluded that most of the sediment COCs result from historical releases, not current discharges, and that potential current discharges are not continuous, but involve stormwater runoff.

The locations of permitted surface water dischargers of COCs in Hillsborough sub-basins are provided in Figure 4-5. The locations of permitted surface water dischargers of COCs in Boca Ciega sub-basins are provided in Figure 4-6.

4.4.2 Loading Estimates

The PCS data from USEPA Region IV were examined to determine which data could be used for loading estimates. These data were compared to the GMS dataset, and information obtained from facility files received from FDEP, to fill in gaps where possible. The combined dataset was then used to estimate loadings for certain parameters (metals, oil and



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• Facility Locations

N

4-14

Figure 4.5

Upper Hillsborough Bay

Permitted Surface Water Dischargers of COC's

Sub-Basin 5

24 Gulf Coast Lead Company Inc.
98 McKay Bay Refuse - To-Energy

Sub-Basin 9

28 Hillsborough Co Resource Recovery Facility
100 Trademark Nitrogen Corp.

Sub-Basin 10

34 CSX Transportation Inc.

Sub-Basin 11

38 TECO - Gannon

Sub-Basin 12

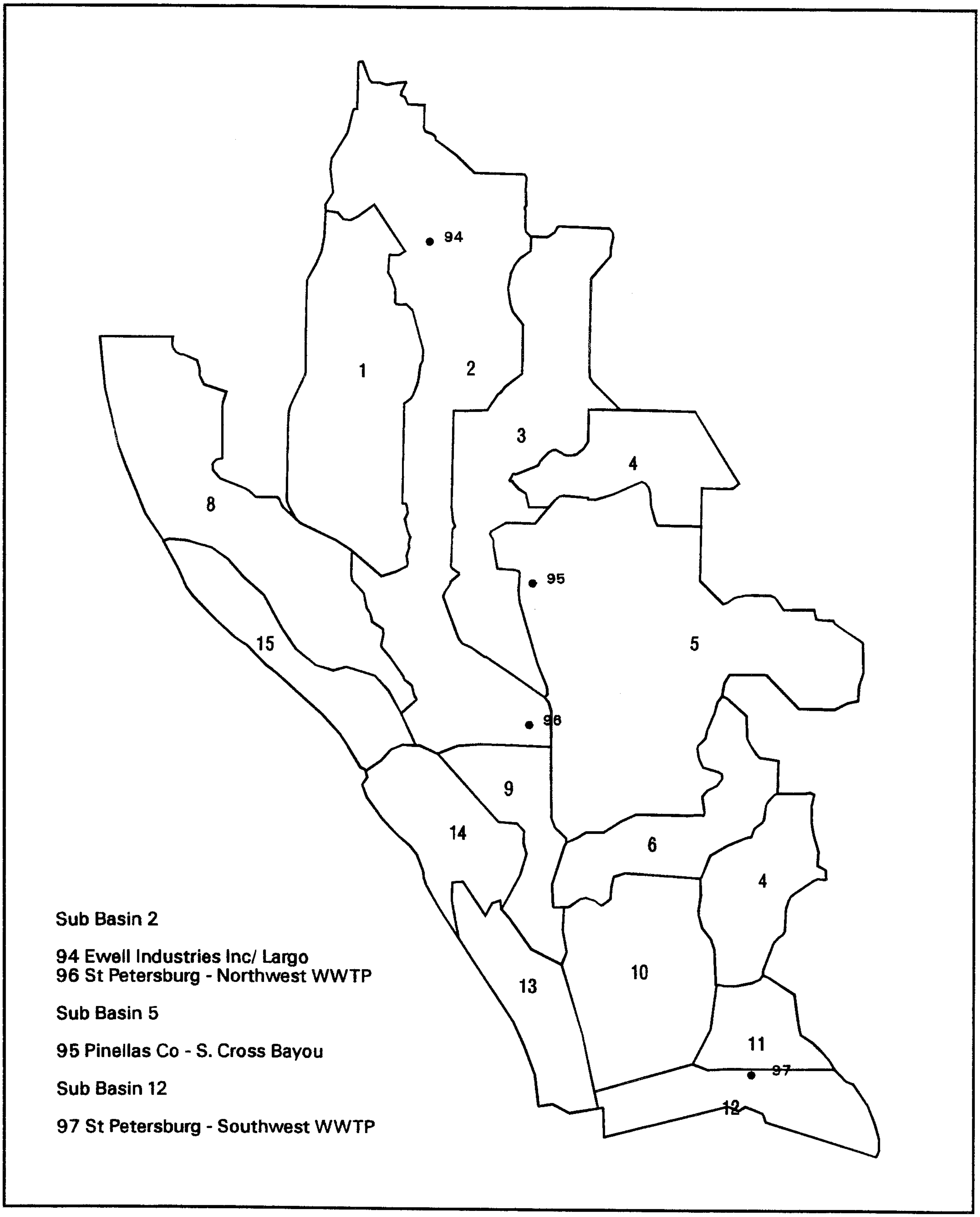
39 IMC-Agrico Co. Port Sutton
40 Pakhoed Dry Bulk Terminals

Sub-Basin 13

31 TECO-Hookers Pt. Sta
101 GATX Tampa Terminal
102 Tampa-Hookers Point WWTP
103 Amerada Hess Corp.
105 Amoco Oil
106 Murphy Oil Corp.
107 Citgo Petroleum
108 Marathon Oil
109 Star Enterprises

Sub-Basin 14

99 CF Industries Loading Terminal



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• Facility Locations

Figure 4.6

Boca Ciega Bay

Permitted Surface Water Dischargers of COC's grease) for most of the facilities identified within sub-basins. These loading estimates included all permitted facilities and discharges of constituents identified as COCs. The loading estimates do not provide an exact quantity for each COC load, but allow a determination of the relative contribution of point sources to total loads.

The locations of permitted surface water dischargers in Hillsborough sub-basins are provided in Figure 4-5. The locations of permitted surface water dischargers in Boca Ciega sub-basins are provided in Figure 4-6. A summary of annual loads for permitted surface water discharges in Hillsborough and Boca Ciega sub-basins is provided in Table 4-5. Annual loads were estimated using average maximum concentrations and flows where available values. Statistics other than average daily maximum values used to calculate loads are identified in Table 4-5. Many of the bulk petroleum facilities discharge wastewater during hydrostatic tank test. These data were obtained from FDEP files and used to estimate an annual load based on a once-a-year test frequency (FDEP 1997).

4.5 Atmospheric Deposition

COC loading rates for atmospheric deposition were estimated using bulk deposition data collected by Dixon et al. (1996) for TBNEP. Two stations used for this study were located in Hillsborough and Pinellas Counties; these stations are shown on Figure 4-7. The station used to measure bulk deposition in Hillsborough County was Station 4 at the Tampa SWFWMD office. Recorded deposition rates for this station were applied throughout the upper Hillsborough Bay basin. The station used to measure bulk deposition in Pinellas County was Station 1 at the Pinellas County Sheriff's Administration Building. Recorded deposition rates for this station were applied throughout the Boca Ciega Bay basin.

Annual atmospheric deposition rates are provided in Table 4-6. Deposition rates for these stations were measured at these stations based on three-month sample times; these were extended to yearly rates to allow estimation of annual loads.

The atmospheric loadings (Li) were calculated as follows:

Li = (units conversion)*(runoff percentage)*(sub-basin area)*(deposition rate)

The runoff percentage was assumed to be 10 percent of the amount deposited within the sub-basin (Frithsen et al. 1995).

A summary of atmospheric COC loading rates by sub-basin is provided in Tables 4-7 and 4-8 for Hillsborough and Boca-Ciega Basins, respectively. Because atmospheric deposition loads were based on data collected at a single station for each basin, differences in calculated loading rates reflect the size of these sub-basins, and loads in all basins were equal on a per-acre basis. Because atmospheric loading rates were significantly lower than stormwater loads, the relative contribution from this source type was less where particular COCs were also detected in stormwater. This atmospheric loading information was useful, however, for identification of sources of a particular COC, especially in sub-basins where the contaminant was not detected in stormwater or point source discharges.

Table 4-5.
Summary of Annual COC Loads (lbs/yr) for Permitted Wastewater/Stormwater Dischargers in Priority Basins

Facility/Location	Permitted Surface Water Discharge	1° Material	COC(s) Reported in Discharge (Yes/No?)	COCs	Annual Load (lbs/yr)	Comments
Upper Hillsborough Bay						
Sub-Basin 5						
Gulf Coast Recycling Co.	Stormwater	Metals recovery/recycling	Yes	Yes	--	Permitted stormwater discharge - insufficient data to determine COC load.
McKay Bay Refuse-to-Energy Facility	Stormwater	Municipal waste/incinerator ash	No	--	--	No discharge of process water; no monitoring of potential stormwater discharge.
Sub-Basin 9						
Hillsborough Dept Of Solid Waste	Stormwater	Municipal waste	Yes	O&G	3611	
Trademark Nitrogen Corp.	Stormwater	Bulk Fertilizer	Yes	Cr	2	
Sub-Basin 10						
CSX Transportation Inc. (Rockport)*	Stormwater	Bulk Fertilizer	No	--	--	Treatment required by consent order.
Sub-Basin 11						
Tampa Elec-Gannon Steam	Process	Cooling/blowdown water	Yes	Cr	3707	
			Yes	Cu	458	
			Yes	Ni	531	
Sub-Basin 12						
IMC-Agrico Co - Port Sutton*	Stormwater	Bulk Fertilizer	No	--	--	Treatment required by consent order.
Pakhoed Dry Bulk Terminals*	Stormwater	Bulk Fertilizer	No	--	--	Treatment required by consent order.
Sub-Basin 13						
Tampa Elec-Hookers Point Steam	Process	Cooling/blowdown water	No	--	--	
Tampa-Hooker's Point WWTP	Process	Domestic wastewater	Yes	Hg	--	Not detected in current discharge.
			Yes	Ni	1129	
Citgo Petroleum Tampa Terminal	Stormwater	Bulk Petroleum	Yes	O&G	80	
Star Enterprise	Stormwater	Bulk Petroleum	Yes	O&G	139	

Table 4-5 (cont.).
Summary of Annual COC Loads (lbs/yr) for Permitted Wastewater/Stormwater Dischargers in Priority Basins

Facility/Location	Permitted Discharge Type	1° Material	COC(s) Reported in Discharge (Yes/No?)	COCs	Annual Load (lbs/yr)	Comment
Sub-Basin 13 (cont.)						
Amoco Oil-Tampa	Stormwater	Bulk Petroleum	Yes	Cu	1.4	
			Yes	O&G	1944	
Murphy Oil Corp	Stormwater	Bulk Petroleum	Yes	O&G	2960	
Amerada Hess Corp.-Tampa Terminal	Stormwater	Bulk Petroleum	Yes	O&G	0.8	
Marathon Oil-Tampa Terminal	Stormwater	Bulk Petroleum	Yes	O&G	1116	
GATX Tampa Terminal**	Stormwater	Bulk Petroleum	Yes	O&G	0.1	Treatment required by consent order. Data for hydrostat test only.
Sub-Basin 14						
CF Industries Loading Terminal*	Stormwater	Bulk Fertilizer	No	--	--	
Boca Ciega Bay						
Sub-Basin 2						
Ewell Industries Inc/ Largo*	Process/Stormwater	Concrete manufacture	Yes	O&G	766	
St Petersburg - Northwest WWTP	No discharge	Domestic wastewater	No	--	--	Discharge to underground injection wells.
Sub-Basin 5						
Pinellas Co - S. Cross Bayou	No discharge	Domestic wastewater	No	--	--	Discharge to underground injection wells.
Sub-Basin 12						
St Petersburg - Southwest WWTP	No discharge	Domestic wastewater	No	--	--	Discharge to underground injection wells.

Note:
All discharge data from USEPA Region IV PCS database except:
* Discharge information from FDEP permit files.
** Discharge information from FDEP GMS database.

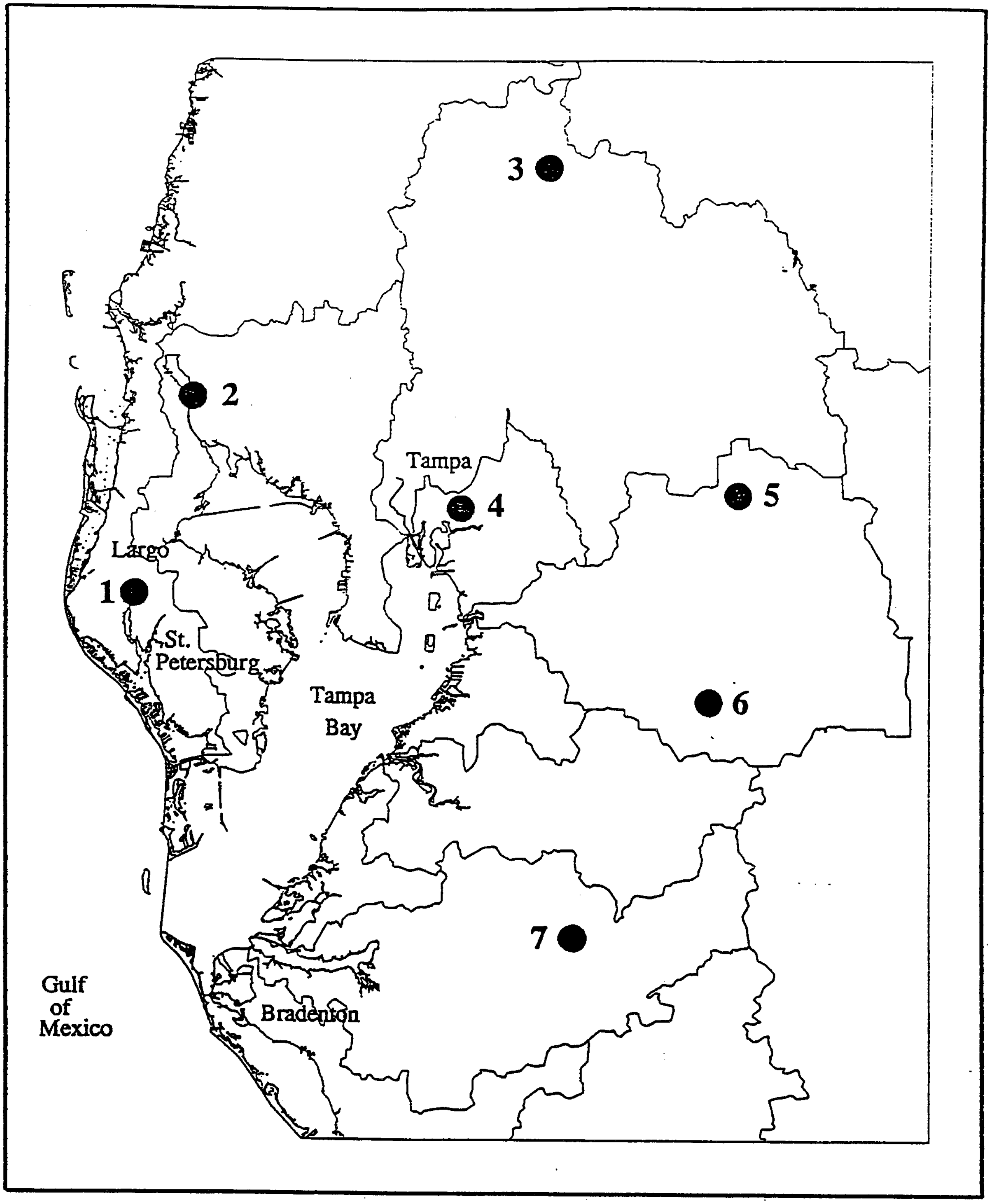


Figure 4-7 Atmospheric Bulk Deposition Stations Within the Tampa Bay Watershed (from Dixon et al. 1996).

Table 4-6.
Atmospheric Deposition Rates for COCs Detected - Hillsborough and Pinellas County Stations(1)

Chemical	Hillsborough Co. g/ha/yr	Hillsborough Co. kg/ac/yr	Pinellas Co. g/ha/yr	Pinellas Co. kg/ac/yr
Metals				
copper	9.2	2.27E-02	not COC	--

Chemical	Hillsborough Co. ng/m²/0.25 yr	Hillsborough Co. kg/ac/yr	Pinellas Co. ng/m²/0.25 yr	Pinellas Co. kg/ac/yr
Pesticides				
d bhc*	83	1.85E-07	not COC	--
endosulfan 1*	259	5.78E-07	not COC	--
endosulfan 2*	304	6.78E-07	not COC	--
PAHs				
benzo(a)anthracene	nd	--	2	4.46E-09
benzo(a)pyrene	nd	--	2	4.46E-09
benzo(b)fluoranthene	5	1.12E-08	24	5.35E-08
benzo(g,h,i)perylene	nd	--	5	1.12E-08
benzo(h)fluoranthene	nd	--	22	4.91E-08
fluoranthene	6	1.34E-08	30	6.69E-08
indeno(1,2,3)pyrene	nd	--	9	2.01E-08
phenanthrene	nd	--	1	2.23E-09
pyrene	2	4.46E-09	22	4.91E-08
PCBs				
PCB congener #153	81	1.81E-07	63	1.41E-07

Note:
Bulk deposition data were obtained from Dixon et al. 1996.
Stations 1 and 4 were for Boca Ciega Bay and Upper Hillsborough Bay Basins, respectively.
nd - not detected
* - indicates not specific COC, but part of COC class (i.e., chlorinated pesticides).

Table 4-7.
Estimated Atmospheric Loading Rates for COCs (lbs/yr)
Upper Hillsborough Bay Sub-Basins

	Sub-Basin No.															
Chemical	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**Total**
total area (acres)	3376	11580	5372	11640	5608	992	6961	4007	2677	641	8580	1054	1588	536	796	
Metals																
copper	7.7E+00	2.6E+01	1.2E+01	2.6E+01	1.3E+01	2.2E+00	1.6E+01	9.1E+00	6.1E+00	1.5E+00	1.9E+01	2.4E+00	3.6E+00	1.2E+00	1.8E+00	1.5E+02
Pesticides																
d bhc*	1.1E-04	3.9E-04	1.8E-04	3.9E-04	1.9E-04	3.3E-05	2.3E-04	1.3E-04	9.0E-05	2.2E-05	2.9E-04	3.5E-05	5.3E-05	1.8E-05	2.7E-05	2.2E-03
endosulfan 1*	3.5E-04	1.2E-03	5.6E-04	1.2E-03	5.9E-04	1.0E-04	7.3E-04	4.2E-04	2.8E-04	6.7E-05	9.0E-04	1.1E-04	1.7E-04	5.6E-05	8.3E-05	0.0E+00
endosulfan 2*	4.2E-04	1.4E-03	6.6E-04	1.4E-03	6.9E-04	1.2E-04	8.6E-04	4.9E-04	3.3E-04	7.9E-05	1.1E-03	1.3E-04	2.0E-04	6.6E-05	9.8E-05	0.0E+00
PCBs																
PCB congener #153	1.1E-04	3.8E-04	1.8E-04	3.8E-04	1.8E-04	3.3E-05	2.3E-04	1.3E-04	8.8E-05	2.1E-05	2.8E-04	3.5E-05	5.2E-05	1.8E-05	2.6E-05	2.1E-03
PAHs																
benzo(b)fluoranthene	6.8E-03	2.3E-02	1.1E-02	2.4E-02	1.1E-02	2.0E-03	1.4E-02	8.1E-03	5.4E-03	1.3E-03	1.7E-02	2.1E-03	3.2E-03	1.1E-03	1.6E-03	1.3E-01
fluoranthene	8.2E-03	2.8E-02	1.3E-02	2.8E-02	1.4E-02	2.4E-03	1.7E-02	9.7E-03	6.5E-03	1.6E-03	2.1E-02	2.6E-03	3.9E-03	1.3E-03	1.9E-03	1.6E-01
pyrene	2.7E-03	9.4E-03	4.3E-03	9.4E-03	4.5E-03	8.0E-04	5.6E-03	3.2E-03	2.2E-03	5.2E-04	6.9E-03	8.5E-04	1.3E-03	4.3E-04	6.4E-04	5.3E-02

Note:

Bulk deposition data were obtained from Dixon et al. 1996.

Stations 1 and 4 were used corresponding to Boca Ciega Bay and Upper Hillsborough Bay, respectively.

To estimate loadings, reported mean values were used for trace metals, and reported 3 month totals were used for organics.

The estimated percentage for runoff to the estuary was 10%.

* - indicates not specific COC, but part of COC class (i.e., chlorinated pesticides).

Table 4-8.
Estimated Atmospheric Loading Rates for COCs (lbs/yr)
Boca Ciega Bay Sub-Basins

Chemical	**Sub-Basin No.**															**Total**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	
total area (acres)	3935	6771	4108	1918	9538	2463	1940	3737	1091	1621	829	1493	771	1073	844	
PCBs																
PCB congener #153	1.0E-04	1.7E-04	1.0E-04	4.9E-05	2.4E-04	6.3E-05	4.9E-05	9.5E-05	2.8E-05	4.1E-05	2.1E-05	3.8E-05	2.0E-05	2.7E-05	2.2E-05	1.1E-03
PAHs																
benzo(a)anthracene	3.2E-03	5.5E-03	3.3E-03	1.6E-03	7.7E-03	2.0E-03	1.6E-03	3.0E-03	8.8E-04	1.3E-03	6.7E-04	1.2E-03	6.2E-04	8.7E-04	6.8E-04	3.4E-02
benzo(a)pyrene	3.2E-03	5.5E-03	3.3E-03	1.6E-03	7.7E-03	2.0E-03	1.6E-03	3.0E-03	8.8E-04	1.3E-03	6.7E-04	1.2E-03	6.2E-04	8.7E-04	6.8E-04	3.4E-02
benzo(b)fluoranthene	3.8E-02	6.6E-02	4.0E-02	1.9E-02	9.3E-02	2.4E-02	1.9E-02	3.6E-02	1.1E-02	1.6E-02	8.0E-03	1.4E-02	7.5E-03	1.0E-02	8.2E-03	4.1E-01
benzo(g,h,i)perylene	8.0E-03	1.4E-02	8.3E-03	3.9E-03	1.9E-02	5.0E-03	3.9E-03	7.6E-03	2.2E-03	3.3E-03	1.7E-03	3.0E-03	1.6E-03	2.2E-03	1.7E-03	8.5E-02
benzo(h)fluoranthene	3.5E-02	6.0E-02	3.7E-02	1.7E-02	8.5E-02	2.2E-02	1.7E-02	3.3E-02	9.7E-03	1.4E-02	7.4E-03	1.3E-02	6.9E-03	9.6E-03	7.5E-03	3.8E-01
fluoranthene	4.8E-02	8.2E-02	5.0E-02	2.3E-02	1.2E-01	3.0E-02	2.4E-02	4.5E-02	1.3E-02	2.0E-02	1.0E-02	1.8E-02	9.4E-03	1.3E-02	1.0E-02	5.1E-01
indeno(1,2,3)pyrene*	1.4E-02	2.5E-02	1.5E-02	7.0E-03	3.5E-02	9.0E-03	7.1E-03	1.4E-02	4.0E-03	5.9E-03	3.0E-03	5.4E-03	2.8E-03	3.9E-03	3.1E-03	1.5E-01
phenanthrene*	1.6E-03	2.7E-03	1.7E-03	7.8E-04	3.9E-03	1.0E-03	7.8E-04	1.5E-03	4.4E-04	6.6E-04	3.4E-04	6.0E-04	3.1E-04	4.3E-04	3.4E-04	1.7E-02
pyrene*	3.5E-02	6.0E-02	3.7E-02	1.7E-02	8.5E-02	2.2E-02	1.7E-02	3.3E-02	9.7E-03	1.4E-02	7.4E-03	1.3E-02	6.9E-03	9.6E-03	7.5E-03	3.8E-01

Note:

Bulk Deposition of the listed chemicals was obtained from the Assessment of Bulk Atmospheric Deposition to the Tampa Bay Watershed

Stations 1 and 4 were used corresponding to Boca Ciega Bay and Upper Hillsborough Bay, respectively.

To estimate loadings, reported mean values were used for trace metals, and reported 3 month totals were used for organics.

The estimated percentage to runoff into the estuary was 10%.

* - indicates member of class of sediment COCs, but chemical is not specifically a COC.

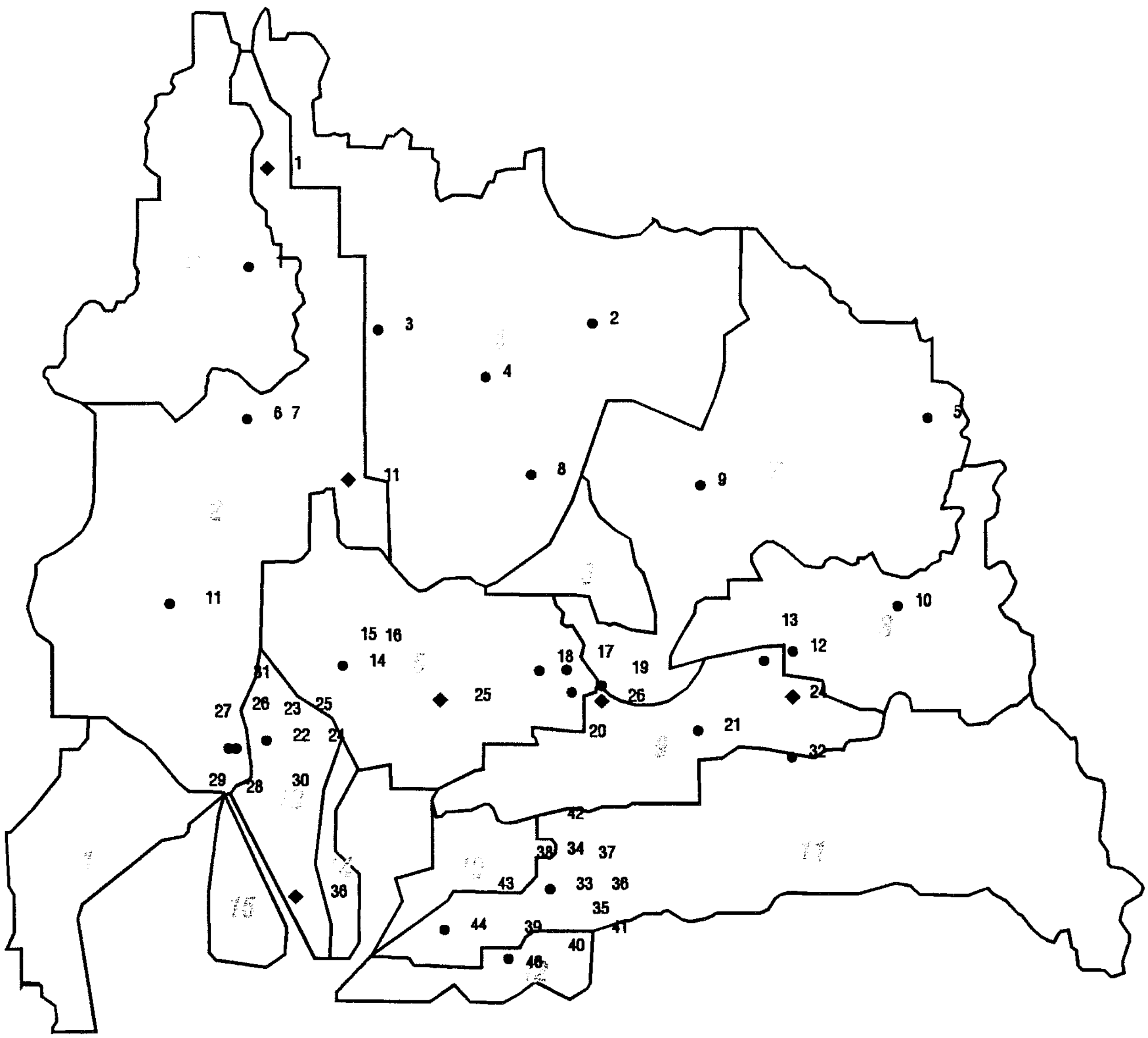
4.6 Facilities Handling/Releasing COCs

Three additional types of sources were evaluated to determine potential contributions of COCs within sub-basins of the priority watersheds. These included releases as reported in the USEPA TRI database, sites with known hazardous waste contamination as identified in the USEPA CERCLIS database, and facilities handling COCs for processing, storage, or treatment as identified in the USEPA RCRA Biennial Reporting System (BRS) database. These facilities were not included with other point sources in Section 4.4 due to the nature of releases associated with these facilities, and the limited amount of data available for characterization.

Facilities releasing COCs within sub-basins were identified using the USEPA TRI database. The TRI database contains information for contaminant releases to land, surface water, or the atmosphere. Source names and type were tabulated for each COC and facility; locations of facilities releasing were mapped. Loadings from these facilities could not be quantified; this information was useful, however, for identifying potential sources based on location, and the number of facilities within a sub-basin handling COCs.

Additional facilities where historical contamination may be a source of COCs were identified using the USEPA CERCLIS database. Potential loadings from these sources were not evaluated due to the lack of data regarding the amount and type of contaminants being transported from these sites to the areas of Tampa Bay or tributaries to the bay. Facilities with sub-basins handling COCs (process/storage/treatment) were also identified using the USEPA BRS database. Due to the incomplete nature of the BRS database, not all facilities handling COCs may have been identified. Because location coordinates were not readily available for most of these facilities, and the BRS database includes information regarding handling but not releases of COCs, these facilities were not mapped.

The locations of TRI and CERCLIS facilities within the upper Hillsborough Bay basin are provided on Figure 4.8. The TRI facilities shown on this figure include only those with releases of COCs reported between 1987-1993. The locations of CERCLIS facilities within the Boca Ciega Bay basin are provided on Figure 4.9. No releases of COCs by facilities located in the Boca Ciega basin were reported in the TRI database from 1987-1993. Table 4-9 provides a summary of TRI and BRS facilities for Hillsborough sub-basins; for the Boca Ciega Bay basin, no facilities releasing or handling COCs were identified in the TRI or BRS databases. Table 4-10 provides a listing of CERCLIS facilities located in Hillsborough and Boca Ciega sub-basins.



◆ TRI Facility Locations
● CERCLIS Facility Locations

Figure 4.8

Upper Hillsborough Bay

TRI/CERCLIS Facilities

TRI

Sub Basin 2

1 ROBBINS MFG. CO.

11 GENERAL CABLE CO. TAMPA PLANT

Sub Basin 5

25 GARDNER ASPHALT CORP.

Sub Basin 9

24 UNIVERSAL AUTO RADIATOR MFG. CO.
26 FLORIDA STEEL CORP. TAMPA MILL DIV.

Sub Basin 13

36 PETROLEUM PACKERS INC.

CERCLIS

Sub Basin 2

6 Rowlett Park Landfill #39
7 Rogers Park Golf Course Landfill #41
11 Sinclair & Valentine Co
27 Tampa Unknown Spill
28 Hillsborough River Abandoned Drum
29 Westcoast Warehouse Co Inc
30 Peoples Gas System
31 Eureka Springs Landfill

Sub Basin 3

1 Northgate Sinkhole Landfill

Sub Basin 4

2 Normandy Park Apartments
3 Tri-City Oil Conservationist Corp
4 River Hills Dr. & 50th St. Battery Dump
8 Tampa Elec Co Francis J Gannon Sta

Sub Basin 5

14 Swift Adhesives & Coatings
15 Union Carbide Corp Solvents Terminal
16 Tampa Municipal Incinerator
17 Sixty-Second Street Dump
18 Kassouf-Kimerling Battery Disposal
20 Gulf Coast Lead Co

Sub Basin 7

5 Cast Crete Corporation
9 Chemical Waste Management
19 Alaric Incorporated

Sub Basin 8

10 Williams Rd. & U.S. Highway 92
12 Cast Metals

Sub Basin 9

13 Sunshine Skyway Bridge Paint Dump
21 WRB Enterprises Inc

Sub Basin 11

32 Chloride Automotive Batteries
33 Bay Drum
34 A-AAA Printing Ink Co
35 MRI Corp
36 Florida Steel Corp Tampa Mill Division
37 Reeves Southeastern Galvanizing Corp
38 Peak Oil Co/Bay Drum Co
39 Orient Park
40 Royal Crome Bumper
41 Stauffer Chem/Tampa
42 Hordis Brothers
43 FMC Corp
44 Raleigh Street Dump Site

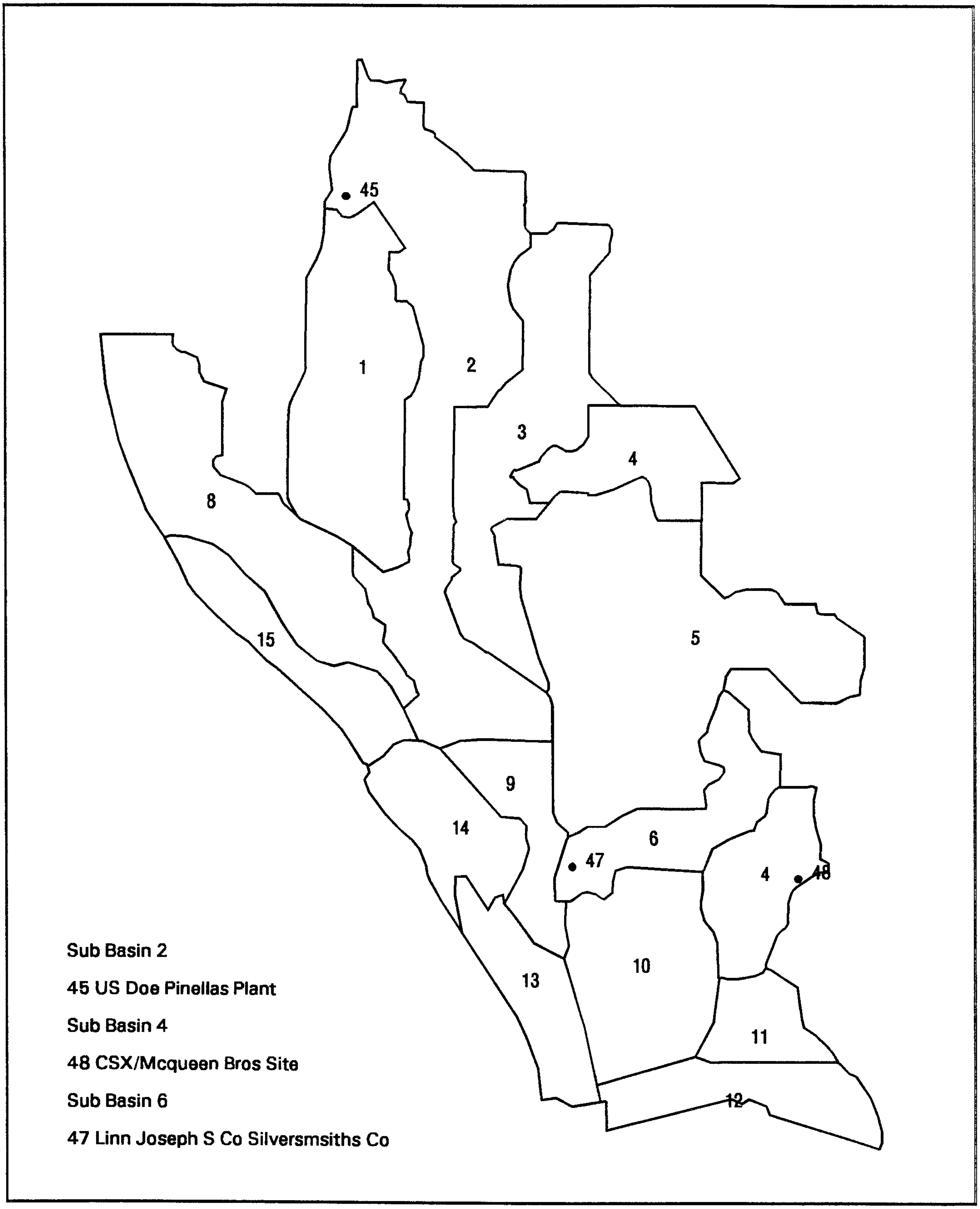
Sub Basin 12

46 Nitram Inc

Sub Basin 13

22 American Petrofina Marketing Inc
23 Essex Group Inc
24 Helena Chemical Company
25 Hillsborough County Northwest Landfill
26 Roto - Rooter

Key for Facilities Shown on 4.8



Legend

- Facility Locations

Figure 4.9

Boca Ciega Bay

CERCLIS Facilities

Table 4-9.
Summary of Facilities Releasing/Handling COCs - Upper Hillsborough Bay Sub-Basins
Data source: USEPA TRI and BRS databases[1]

Facility	Metals			Pesticides				PAHs	Comments
	Cu	Cr	Hg	Chlordane	DDT	Heptachlor	Lindane		
Sub-Basin 2									
General Cable Co. Tampa Plant	R								
Robbins Mfg. Co.	R	R,H							Storage only
Sub-Basin 4									
Anheuser Busch Inc.			H						Facility closed.
Southern Mill Creek Prods. Co. Inc.						R	R		Facility closed in 1994.
Sub-Basin 5									
Davies Can Co.									Facility closed in 1994.
Gardner Asphalt Corp.								R	
Gulf Coast Recycling Inc.									
Sub-Basin 9									
Florida Steel Corp. Tampa Mill Div.	R	R							
Universal Auto Radiator Mfg. Co.	R								
Sub-Basin 11									
Stauffer Chemical Superfund Site					H				
Sub-Basin 13									
Amerada Hess Tampa									
Citgo Corporation									
Devoe & Raynolds Co.		H							
Gatx Terminals Corp.									
Louis Dreyfus Energy									
Marathon Oil Co.									
Petroleum Packers Inc.	R								
Star Enterprise									

Table 4-9 (cont.)
Summary of Facilities Releasing/Handling COCs - Upper Hillsborough Bay Sub-Basins
Data source: USEPA TRI and BRS databases[1]

Sub-Basin 14

CF Industries, Inc.		H							
Bausch & Lomb Pharmaceutical			H						
Chromalloy Castings		H							
CSX Transportation Inc		H							
Electro Lab/Electro Lab 2		H							
General Electric Apparatus Svc. Ctr.		H							
MacDill Air Force Base		H	H						
Ringhaver Equip. Co.		H							
Tampa Electric Co. Big Bend		H	H						
Tampa Electric Co. Central Op.			H	H					

Note:

1. USEPA Toxic Release Inventory (TRI) database 1987-1993 and USEPA RCRA Biennial Reposrting System database 1993.

R - reported release; H - handler (process/transfer/storage).

Table 4-10.
Summary of CERCLIS Facilities - Upper Hillsborough and Boca Ciega Sub-Basins

FACILITY	USEPA_ID
Upper Hillsborough Bay	
Sub-Basin 2	
Rowlett Park Landfill #39	FLD982119737
Rogers Park Golf Course Landfill #41	FLD982119786
Sinclair & Valentine Co	FLD980559439
Tampa Unknown Spill	FLD984170225
Hillsborough River Abandoned Drum	FLD984170233
Westcoast Warehouse Co Inc	FLD021715198
Peoples Gas System	FLD982119653
Eureka Springs Landfill	FLD981468663
Sub-Basin 3	
Northgate Sinkhole Landfill	FLD982119836
Sub-Basin 4	
Normandy Park Apartments	FLD984229773
Tri-City Oil Conservationist Corp	FLD070864541
River Hills Dr. & 50th St. Battery Dump	FLD984258574
Tampa Elec Co Francis J Gannon Sta	FLD000654582
Sub-Basin 5	
Swift Adhesives & Coatings	FLD064687577
Union Carbide Corp Solvents Terminal	FLD000616409
Tampa Municipal Incinerator	FLD000865451
Sixty-Second Street Dump	FLD980728877
Kassouf-Kimerling Battery Disposal	FLD980727820
Gulf Coast Lead Co	FLD004092839
Sub-Basin 7	
Cast Crete Corporation	FLD004427662
Chemical Waste Management	FLD051572808
Alaric Incorporated	FLD012978862
Sub-Basin 8	
Williams Rd. & U.S. Highway 92	FLD982119919
Cast Metals	FLD064690837
Sub-Basin 9	
Sunshine Skyway Bridge Paint Dump	FLD981757263
WRB Enterprises Inc	FLD073205460
Sub-Basin 11	
Chloride Automotive Batteries	FLD000632646
Bay Drum	FLD088783865
A-AAA Printing Ink Co	FLD061433934
MRI Corp	FLD088787585
Florida Steel Corp Tampa Mill Division	FLD000814434
Reeves Southeastern Galvanizing Corp	FLD000824896
Peak Oil Co/Bay Drum Co	FLD004091807
Orient Park	FLD982119844
Royal Crome Bumper	FLD042475723
Stauffer Chem/Tampa	FLD004092532
Hordis Brothers	FLD057512741
FMC Corp	FLD004094181
Raleigh Street Dump Site	FLD984227249
Sub-Basin 12	
Nitram Inc	FLD004107710

Table 4-10.
Summary of CERCLIS Facilities -
Upper Hillsborough and Boca Ciega Sub-Basins

FACILITY	USEPA ID
Sub-Basin 13	
American Petrofina Marketing Inc	FLD069660561
Essex Group Inc	FLD046088258
Helena Chemical Company	FLD053502696
Hillsborough County Northwest Landfill	FLD980556633
Roto - Rooter	FLD981015621
Boca Ciega Bay	
Sub-Basin 2	
US Doe Pinellas Plant	FL6890090008
Sub-Basin 4	
CSX/Mcqueen Bros Site	FLD984171033
Sub-Basin 6	
Linn Joseph S Co Silversmsiths Co	FLD064673528

Many types of industrial areas occur within the Port of Tampa area including petroleum storage and distribution, phosphate rock and fertilizer products storage and distribution, inorganic and organic chemical distribution, scrap metal processing and distribution, and other activities associated with bulk commodities (EPC 1993). Many of the industrial facilities in this area generate industrial wastewater and contaminated stormwater. Facilities discharging under FDEP and USEPA permits for surface water discharges were discussed in Section 4.4.2. Additional facilities potentially discharging contaminants to the bay have been identified by EPC. These facilities, with a brief description of potential discharges and identified constituents, are provided on Table 4-11.

Many of the facilities listed on Table 4-11 are bulk transfer facilities. No specific USEPA/FDEP NPDES testing requirements have been established for these bulk facilities. Because testing requirements are based on manufacturing processes and anticipated potential discharges, test requirements by industrial classification (SIC code) are not applicable for these facilities. According to FDEP, bulk facilities are evaluated on a site-specific basis.

Table 4-11.
Additional Port of Tampa Facilities Identified in Upper Hillsborough Bay Sub-Basins

Facility Name	Location	Discharge	Constituents
Sub-Basin 10			
Eastern Associated Terminals Inc.	E. Side E. Bay	Stormwater	Nutrients
Sub-Basin 12			
Commercial Metals Inc.	N. Side Pt. Sutton Rd.	Stormwater	Scrap Metal
Sub-Basin 13			
Americold	E. Side Cut "D" Channel	NA	--
Bay Transportation Corp.	E. Side Cut "D" Channel	NA	--
Central Oil	E. Side Sparkman Channel		
Cruise Terminal No. 2	N. Side Garrison Channel		
Cruise Terminal No. 6	W. Side Ybor channel		
Detsco Terminals Inc.	W. Side Ybor channel		
E.A. Mariani Asphalt Co.	E. Side Ybor Channel		
Florida Aquarium	W. Side Ybor channel		
Freeport Sulfur Terminals	E. Side Sparkman Channel		
Garrison Seaport Center	W. Side Ybor channel	NA	--
Gulf Marine Repair Corp.	E. Side Ybor Channel		
Independence Excavating	E. Side Ybor Channel		
International Ship Repair	W. Side Ybor channel		
Internationl Ship Repair and Marine Services	E. Side Ybor Channel	NA	--
Louis Dreyfus Energy	E. Side Sparkman Channel		
Marathon Petroleum Co. (asphalt)	E. Side Ybor Channel	NA	--
Martin Marietta Aggregates (DRAVCO)	E. Side Cut "D" Channel	NA	--
Petroleum Packers Inc.	E. Side Cut "D" Channel	Groundwater	Motor oil
Sahlman Foods	E. Side Ybor Channel	NA	--
SATCO	E. Side Cut "D" Channel	Stormwater/rinsewater	Sulfuric acid
Tampa Bay International Terminals (TBIT)	E. Side Sparkman Channel	NA	--
Tampa Bay Stevedores	E. Side Cut "D" Channel		
Tampa Electric Co.	E. Side Sparkman Channel		
Tampa Export Co.	E. Side Cut "D" Channel		
Tampa Shipbuilding Co.	E. Side Sparkman Channel	NA	Blasting grit
Terminal 1	N. Side Garrison Channel		
Texaco Inc.	E. Side Ybor Channel		
The David J. Joseph Company	E. Side Cut "D" Channel	Stormwater	Scrap metal
TPA Livestock Loading Facility	E. Side Cut "D" Channel		
U.S. Naval Reserve	W. Side Ybor channel	NA	--
Sub-Basin 14			
A.R. Savage & Son Inc./ Tampa Terminals Inc.	W. Side McKay Bay		
Harborside Refrigerated Services Inc.	Facing E. Bay	NA	--
Holland Cruise Terminal	Facing E. Bay		
Interim Use Ship Layout - Repair	Facing E. Bay		
Maritrans Operating Partners	Facing E. Bay	NA	--
Tampa Bay International Terminals (TBIT)	Facing E. Bay		
Tampa Juice Services Inc.	Facing E. Bay		
Winter Metals (Louisville Scrap)	S. of Hookers Point WWTP	Stormwater	Scrap Metal
Northstar		Stormwater	Scrap Metal
Tampa Scrap		Stormwater	Scrap Metal

Note:
Source - Port of Tampa facilites map (Tampa Port Authority 1995), Port of Tampa Facilites Survey (HCEPC 1993-95).
NA - no discharge or permit required.

5.0 INTEGRATION OF COC LOADINGS AND RANKING OF SUB-BASINS

The overall objective for Task 2 of the Toxic Contamination Sources Assessment project was to identify sources of COCs in the priority drainage basins, to estimate loadings by these sources where possible, and to prioritize sub-basins for development of management actions. The results of this study will be used for a separate TBNEP project to develop a sediment contamination management action plan to reduce risks associated with COCs. Potential management strategies to be considered include: reduction of loadings by sources where feasible, and treatment of runoff/inflow within basins prior to entering Tampa Bay.

Point sources and nonpoint sources including stormwater runoff and atmospheric deposition were evaluated (see Section 4.0) to determine the fraction of total COC loads attributed to each source type. Because of the inexact nature of these loading calculations, the purpose of the loading model used was not to calculate an exact amount of COC released from the watershed, but to estimate the relative importance of sources contributing to loading of COCs.

5.1 Sources of COC Loading to Upper Hillsborough Bay

Sediment contaminants identified as COCs for Hillsborough Bay based on a significant potential for adverse ecological or human health effects included: four metals (chromium, copper, mercury, and nickel), HPAHs (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, fluoranthene, pyrene, and total HPAHs), five chlorinated pesticides (chlordane, DDT/DDD, endrin, heptachlor/heptachlor epoxide, and lindane), and total PCBs.

Annual COC loads for point discharges, stormwater runoff, and atmospheric deposition within Hillsborough sub-basins are provided in Table 5-1. The percentage of annual COC loads by point discharge, stormwater runoff, and atmospheric deposition are provided in Table 5-2. COC loadings and sources in specific basins are discussed below. Sub-basin names from Figure 4-1 are provided with the corresponding sub-basin number in parentheses.

5.1.1 Metals

Primary sources of metal loading in upper Hillsborough Bay sub-basins include point discharges and stormwater runoff. Based on total loadings for the metals identified as COCs (chromium, copper, mercury, and nickel), the five sub-basins with highest total metal loads were Delaney Creek (11), Lower Hillsborough River No. 1 (2), Lower Hillsborough River No. 2 (4), Ybor Channel (13), and Tampa Bypass Canal (7). Sources of metals loading in the Delaney Creek and Ybor Channel sub-basins included point and nonpoint discharges; metals loading from the other sub-basins was primarily from stormwater runoff.

Table 5-1.
Summary of Annual COC Loads (lbs/yr) for Point Discharges, Stormwater Runoff, and Atmospheric Deposition - Upper Hillsborough Bay

Chemical	Loading	Sub-Basin Number															Total
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Load (tons)
Metals																	
Chromium	point	--	--	--	--	--	--	--	--	1.7	--	3707.0	--	--	--	--	1.9
	stormwater	143.1	535.6	249.1	921.6	378.8	54.5	614.9	367.1	180.8	63.0	792.7	30.2	55.3	4.3	2.6	2.2
	atmospheric	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Total	143.1	535.6	249.1	921.6	378.8	54.5	614.9	367.1	182.5	63.0	4499.7	30.2	55.3	4.3	2.6	4.1
Copper	point	--	--	--	--	--	--	--	--	--	--	458.0	--	1.4	--	--	0.2
	stormwater	852.0	2654.0	1268.8	1857.1	1308.4	192.4	1084.8	551.9	541.5	148.6	1331.0	271.0	732.2	240.8	309.8	6.7
	atmospheric	7.7	26.3	12.2	26.4	12.7	2.2	15.8	9.1	6.1	1.5	19.0	2.4	3.6	1.2	1.8	0.1
	Total	859.7	2680.3	1281.0	1883.5	1321.1	194.6	1100.6	561.0	547.6	150.0	1808.0	273.4	737.2	242.0	311.6	7.0
Mercury	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Not analyzed in Atmospheric	stormwater	4.2	15.1	5.0	11.2	10.5	1.3	4.5	3.3	2.4	0.6	7.9	0.5	1.6	0.1	0.1	0.03
Deposition Study.	atmospheric	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Total	4.2	15.1	5.0	11.2	10.5	1.3	4.5	3.3	2.4	0.6	7.9	0.5	1.6	0.1	0.1	0.03
Nickel	point	--	--	--	--	--	--	--	--	--	--	531.0	--	1129.0	--	--	0.8
	stormwater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	atmospheric	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Total	--	--	--	--	--	--	--	--	--	--	531.0	--	1129.0	--	--	0.8
Sum of 4 metals	point	--	--	--	--	--	--	--	--	1.7	--	4696.0	--	1130.4	--	--	2.9
	stormwater	999.3	3204.7	1522.9	2789.9	1697.7	248.2	1704.2	922.3	724.7	212.2	2131.6	301.7	789.2	245.2	312.5	8.9
	atmospheric	7.7	26.3	12.2	26.4	12.7	2.2	15.8	9.1	6.1	1.5	19.0	2.4	3.6	1.2	1.8	0.1
	Total	1006.9	3231.0	1535.1	2816.3	1710.4	250.5	1720.0	931.4	732.5	213.7	6846.6	304.1	1923.2	246.4	314.3	11.9
PAHs																	
Benzo(b)fluoranthene	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	atmospheric	6.83E-03	2.34E-02	1.09E-02	2.36E-02	1.13E-02	2.01E-03	1.41E-02	8.11E-03	5.42E-03	1.30E-03	1.70E-02	2.10E-03	3.21E-03	1.08E-03	1.61E-03	6.60E-05
Fluoranthene	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	atmospheric	8.20E-03	2.81E-02	1.30E-02	2.83E-02	1.36E-02	2.41E-03	1.69E-02	9.73E-03	6.50E-03	1.56E-03	2.10E-02	2.60E-03	3.85E-03	1.30E-03	1.93E-03	7.95E-05
Pyrene	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	atmospheric	2.73E-03	9.37E-03	4.35E-03	9.42E-03	4.54E-03	8.02E-04	5.63E-03	3.24E-03	2.17E-03	5.19E-04	6.90E-03	8.50E-04	1.28E-03	4.34E-04	6.44E-04	2.64E-05
Sum of PAHs	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	atmospheric	0.02	0.06	0.03	0.06	0.03	0.01	0.04	0.02	0.01	0.003	0.04	0.006	0.01	0.003	0.004	0.0002
	Total	0.018	0.061	0.028	0.061	0.030	0.005	0.037	0.021	0.014	0.003	0.045	0.006	0.008	0.003	0.004	0.344

Parsons Engineering Science, Inc.
LOADSUM3.XLS:hills# 7/14/97

Table 5-1 (cont.)
Summary of Annual COC Loads (lbs/yr) for Point Discharges, Stormwater Runoff, and Atmospheric Deposition - Upper Hillsborough Bay

Chemical	Loading	Sub-Basin Number															Total Load (tons)
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Pesticides																	
delta-BHC	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	atmospheric	1.13E-04	3.89E-04	1.80E-04	3.91E-04	1.88E-04	3.33E-05	2.34E-04	1.35E-04	8.99E-05	2.15E-05	2.90E-04	3.50E-05	5.33E-05	1.80E-05	2.67E-05	1.10E-06
Endosulfan I	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	5.59E-01	6.78E-02	3.12E+00	2.29E+00	4.69E-01	5.87E+00	2.34E+00	3.34E+00	4.91E-01	4.59E+00	7.97E-01	1.12E+00	--	--	1.25E-02
	atmospheric	3.54E-04	1.21E-03	5.63E-04	1.22E-03	5.88E-04	1.04E-04	7.29E-04	4.20E-04	2.81E-04	6.72E-05	9.53E-04	5.64E-05	1.66E-04	5.62E-05	8.34E-05	3.43E-06
Endosulfan II	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	3.58E-03	3.39E-02	4.96E-01	1.93E-02	1.75E-01	2.33E+00	8.86E-01	4.19E-01	3.54E-02	2.20E+00	2.39E-01	--	--	--	3.42E-03
	atmospheric	4.15E-04	1.42E-03	6.61E-04	1.43E-03	6.90E-04	1.22E-04	8.56E-04	4.93E-04	3.29E-04	7.89E-05	1.12E-03	6.63E-05	1.95E-04	6.59E-05	9.79E-05	4.02E-06
Endrin	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	3.58E-03	3.39E-02	4.96E-01	1.93E-02	1.75E-01	2.33E+00	8.86E-01	4.19E-01	3.54E-02	2.20E+00	2.39E-01	--	--	--	3.42E-03
	atmospheric	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sum of 4 Pesticides	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	0.6	0.1	4.1	2.3	0.8	10.5	4.1	4.2	0.6	9.0	1.3	1.1	--	--	0.02
	atmospheric	0.001	0.003	0.001	0.003	0.001	0.0003	0.002	0.001	0.001	0.0002	0.002	0.0002	0.0004	0.0001	0.0002	0.00001
	Total	0.001	0.6	0.1	4.115	2.3	0.8	10.5	4.113	4.2	0.6	9.0	1.3	1.1	0.0001	0.0002	38.7
PCBs																	
(congener #153)	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	atmospheric	1.11E-04	3.80E-04	1.76E-04	3.82E-04	1.84E-04	3.25E-05	2.28E-04	1.31E-04	8.77E-05	2.10E-05	2.80E-04	3.50E-05	5.20E-05	1.76E-05	2.61E-05	1.07E-06
	Total	1.11E-04	3.80E-04	1.76E-04	3.82E-04	1.84E-04	3.25E-05	2.28E-04	1.31E-04	8.77E-05	2.10E-05	2.80E-04	3.50E-05	5.20E-05	1.76E-05	2.61E-05	1.07E-06
SUM OF COCs 1[1]	point	--	--	--	--	--	--	--	--	2	--	4696	--	1130	--	--	2.9
	stormwater	999	3205	1523	2794	1700	249	1715	926	729	213	2141	303	790	245	313	8.9
	atmospheric	7.7	26.3	12.2	26.5	12.8	2.3	15.8	9.1	6.1	1.5	19.0	2.4	3.6	1.2	1.8	7.41E-02
	Total	1007	3232	1535	2821	1713	251	1731	936	737	214	6856	305	1924	246	314	12
Oil And Grease[2]	point	--	--	--	--	--	--	--	--	3611.0	--	--	--	6239.9	--	--	4.9
	stormwater	30398	101751	49242	83212	50999	5935	27040	22890	31140	5477	34161	3649	14652	1529	8587	235.3
	atmospheric	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Total	30398	101751	49242	83212	50999	5935	27040	22890	34751	5477	34161	3649	20892	1529	8587	240
SUM OF COCs 2[3]	point	--	--	--	--	--	--	--	--	3612.7	--	4696.0	--	7370.3	--	--	7.8
	stormwater	31397	104956	50765	86006	52699	6184	28755	23816	31869	5689	36301	3952	15442	1774	8900	244
	atmospheric	7.7	26.3	12.2	26.5	12.8	2.3	15.8	9.1	6.1	1.5	19.0	2.4	3.6	1.2	1.8	7.41E-02
	Total	31405	104983	50777	86033	52712	6187	28771	23825	35487	5691	41016	3954	22816	1775	8902	252

Note:
1. Total COC load excluding oil and grease (O&G).
2. Oil and Grease (O&G) was not a COC, but represents a surrogate for PAHs.
3. Total COC load including O&G.

"--" - not detected in point discharges, stormwater, or atmospheric deposition studies.

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Table 5-2.

Percentage of Annual COC Loads (lbs/yr) for Point Discharges, Stormwater Runoff, and Atmospheric Deposition - Upper Hillsborough Bay

Chemical	Loading	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total Load (tons)
Metals																	
Chromium	point	--	--	--	--	--	--	--	--	1%	--	82%	--	--	--	--	1.9
	stormwater	100%	100%	100%	100%	100%	100%	100%	100%	99%	100%	18%	100%	100%	100%	100%	2.2
	atmospheric	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Total	143	536	249	922	379	55	615	367	183	63	4500	30	55	4	3	4.1
Copper	point	--	--	--	--	--	--	--	--	--	--	25%	--	0.2%	--	--	0.2
	stormwater	99%	99%	99%	99%	99%	99%	99%	98%	99%	99%	74%	99%	99%	99%	99%	6.7
	atmospheric	1%	1%	1%	1%	1%	1%	1%	2%	1%	1%	1%	1%	0.5%	1%	1%	0.1
	Total	860	2680	1281	1884	1321	195	1101	561	548	150	1808	273	737	242	312	7.0
Mercury Not analyzed in Atmospheric Deposition Study.	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	0.03
	atmospheric	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Total	4	15	5	11	10	1	4	3	2	1	8	0.5	2	0.1	0.1	0.03
Nickel	point	--	--	--	--	--	--	--	--	--	--	100%	--	100%	--	--	0.8
	stormwater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	atmospheric	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Total	--	--	--	--	--	--	--	--	--	--	531	--	1129	--	--	0.8
Sum of 4 metals	point	--	--	--	--	--	--	--	--	<1%	--	69%	--	59%	--	--	2.9
	stormwater	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	31%	99%	41%	100%	99%	8.9
	atmospheric	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	<1%	1%	<1%	<1%	1%	0.1
	Total	1007	3231	1535	2816	1710	250	1720	931	732	214	6847	304	1923	246	314	11.9
PAHs																	
Benzo(b)fluoranthene	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	atmospheric	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	6.60E-05
Fluoranthene	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	atmospheric	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	7.95E-05
Pyrene	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	atmospheric	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	2.64E-05
Sum of PAHs	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	atmospheric	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	0.0002
	Total	0.018	0.061	0.028	0.061	0.030	0.005	0.037	0.021	0.014	0.003	0.045	0.006	0.008	0.003	0.004	0.344

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Table 5-2 (cont.).
Percentage of Annual COC Loads (lbs/yr) for Point Discharges, Stormwater Runoff, and Atmospheric Deposition - Upper Hillsborough Bay

Chemical	Loading	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total Load (tons)
Pesticides																	
delta-BHC	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	atmospheric	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	1.10E-06
Endosulfan I	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	100%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	--	--	1.25E-02
	atmospheric	100%	<1%	1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	100%	100%	3.43E-06
Endosulfan II	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	72%	98%	100%	97%	100%	100%	100%	100%	100%	100%	100%	--	--	--	3.42E-03
	atmospheric	100%	28%	2%	<1%	3%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	100%	100%	100%	4.02E-06
Endrin	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	--	--	--	3.42E-03
	atmospheric	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sum of 4 Pesticides	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	99%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	--	--	0.02
	atmospheric	100%	1%	1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	100%	100%	8.55E-06
	Total	0.001	0.569	0.137	4.115	2.329	0.818	10.542	4.113	4.181	0.561	8.985	1.275	1.120	0.0001	0.0002	38.7
PCBs																	
	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(congener #153)	atmospheric	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	1.07E-06
	Total	1.11E-04	3.80E-04	1.76E-04	3.82E-04	1.84E-04	3.25E-05	2.28E-04	1.31E-04	8.77E-05	2.10E-05	2.80E-04	3.50E-05	5.20E-05	1.76E-05	2.61E-05	1.07E-06
SUM OF COCs 1[1]	point	--	--	--	--	--	--	--	--	<1%	--	68%	--	59%	--	--	2.9
	stormwater	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	31%	99%	41%	100%	99%	8.9
	atmospheric	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	<1%	1%	<1%	<1%	1%	0.07
	Total	1007	3232	1535	2821	1713	251	1731	936	737	214	6856	305	1924	246	314	12
Oil And Grease[2]	point	--	--	--	--	--	--	--	--	10%	--	--	--	30%	--	--	4.9
	stormwater	100%	100%	100%	100%	100%	100%	100%	100%	90%	100%	100%	100%	70%	100%	100%	235.3
	atmospheric	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Total	30398	101751	49242	83212	50999	5935	27040	22890	34751	5477	34161	3649	20892	1529	8587	240
SUM OF COCs 2[3]	point	--	--	--	--	--	--	--	--	10%	--	11%	--	32%	--	--	7.8
	stormwater	100%	100%	100%	100%	100%	100%	100%	100%	90%	100%	89%	100%	68%	100%	100%	244
	atmospheric	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	7.41E-02
	Total	31405	104983	50777	86033	52712	6187	28771	23825	35487	5691	41016	3954	22816	1775	8902	252

Note:
1. Total COC load excluding oil and grease (O&G).
2. Oil and Grease (O&G) was not a COC, but represents a surrogate for PAHs.
3. Total COC load including O&G.

"--" - not detected in point discharges, stormwater, or atmospheric deposition studies.

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Chromium

Major sources of chromium loading within specific sub-basins in the upper Hillsborough Bay basin include one major point source in the Delaney Creek (11) sub-basin, a minor discharger in the Palm River (9) sub-basin, and stormwater runoff in all sub-basins. The five sub-basins with highest total chromium loads in decreasing order were Delaney Creek (11), Lower Hillsborough River No. 2 (4), Tampa Bypass Canal (7), Lower Hillsborough River No. 1 (2), and McKay Bay No. 1 (5).

Point discharges accounted for 82 percent of the total chromium load in the Delaney Creek sub-basin, and less than 1 percent of the total chromium load in the Palm River sub-basin. Identified point sources of chromium included one facility discharging process water, Tampa Electric Co. Gannon Steam (Delaney Creek sub-basin), and one bulk fertilizer facility with permitted stormwater outfalls, Trademark Nitrogen (Palm River sub-basin). No point sources of chromium were identified in the remaining sub-basins.

Because chromium was not detected in atmospheric bulk deposition samples collected at the Hillsborough County station, stormwater runoff accounted for 100 percent of the chromium load in the remaining basins. Land uses associated with stormwater runoff containing chromium included low density family residential and commercial-retail. Although chromium was not detected in the stormwater characterization data used for transportation and industrial land use categories, these land uses have been associated with significant chromium loading in other studies.

Based on the TRI database from 1987-1993, one facility in the Lower Hillsborough River No. 1 (2) sub-basin, Robbins Manufacturing Co., and one facility in the Palm River sub-basin (9), Florida Steel Corp.-Tampa Mill Division, reported releases of chromium. No other facilities within Hillsborough sub-basins reported chromium releases.

Copper

Major sources of copper loading within specific sub-basins in the upper Hillsborough Bay basin included major point sources in the Delaney Creek (11), a minor discharger in the Ybor Channel (13) sub-basin, and stormwater runoff in all sub-basins. The five sub-basins with highest total copper loads in decreasing order were Lower Hillsborough River No. 1 (2), Lower Hillsborough River No. 2 (4), Delaney Creek (11), McKay Bay No. 1 (5), and Curiosity Creek (3).

Point discharges accounted for 25 percent of the total copper load in the Delaney Creek sub-basin, and less than one percent of the total copper load in the Ybor Channel sub-basin. No point sources of copper were identified in the remaining sub-basins. Point sources of copper included one facility discharging process water, Tampa Electric Co. Gannon Steam (Delaney Creek sub-basin), and one bulk petroleum facility with permitted stormwater outfalls, Amoco Oil-Tampa (Ybor Channel sub-basin).

Additional potential sources of copper loading included the copper sulfate used as an aquatic herbicide/algaecide in the Hillsborough Reservoir (sub-basin 4). Loadings from this source were not evaluated as part of this study. However, previous studies by Martin and Hohman (1995), found elevated levels of copper in sediment samples in this area of the

Hillsborough River, but did not find aqueous copper in water samples collected. In addition, a study by Martin et al. (1990) found that the chelated form of copper applied for algae control does not migrate significantly beyond the area of application. These studies suggest a limited contribution from this source to copper loading in upper Hillsborough Bay.

Stormwater runoff accounted for 74 percent and 99 percent of the total copper load in the Delaney Creek and Ybor Channel sub-basins, respectively, and accounted for approximately 99 percent of the total copper load in the remaining sub-basins. Copper was detected in bulk deposition samples collected at the Hillsborough County station, and accounted for approximately 1 percent of the copper load in all sub-basins. All land uses included in the Hillsborough County stormwater characterization study contained copper in runoff. The event mean concentration (EMC) for highway/utility land uses was more than double that of any other land use category sampled.

Based on the TRI database from 1987-1993, two facilities in the Lower Hillsborough River No. 1 (2) sub-basin, General Cable Co.-Tampa Plant and Robbins Manufacturing Co., two facilities in the Palm River (9) sub-basin, Florida Steel Corp.-Tampa Mill Div. and Universal Auto Radiator Manufacturing Co., and one facility in the Ybor Channel sub-basin (13), Petroleum Packers Inc., reported releases of copper. No other facilities within Hillsborough sub-basins reported copper releases.

Mercury

Major sources of mercury loading within specific sub-basins in the upper Hillsborough Bay basin include stormwater runoff in all sub-basins. The five sub-basins with highest total mercury loads in decreasing order were Lower Hillsborough River No. 1 (2), Lower Hillsborough River No. 2 (4), McKay Bay No. 1 (5), Delaney Creek (11), and Tampa Bypass Canal (7).

No current point discharges of mercury were identified in any of the sub-basins. Mercury was detected in one effluent sample at the Howard F. Curren (Hookers Point) wastewater treatment plant (WWTP) in 1994. This detection was reported for a sample collected while the facility was in the process of modifying sampling protocol; mercury has not been detected in other effluent samples collected from 1989 to present. None of the facilities with permitted stormwater outfalls detected mercury in discharge water.

Atmospheric deposition is considered to be a significant source of mercury inputs to Tampa Bay (Frithsen et al. 1995). Because mercury was not measured in the bulk deposition samples collected by Dixon et al. (1996), however, the contribution from atmospheric deposition was not incorporated into loading estimates for this study.

Because no point sources were identified, and atmospheric deposition was not incorporated into loading estimates, stormwater runoff accounted for 100 percent of the mercury load in all sub-basins. One land use included in the Hillsborough County stormwater characterization studies, commercial retail, contained detectable concentrations of mercury in runoff.

An additional potential source of mercury in parts of the bay, includes discarded batteries from aids to navigation (ATON) sites and associated sediment contamination (see Section 3.5). Based on the report issued by the USCG (1995), batteries have been removed where feasible (minimal sediment disruption), and remaining mercury concentrations in sediments pose only minor risks for aquatic organisms in localized areas (attached to or inside battery casings). According to the USGS report, there is little potential for adverse impacts to other aquatic organisms due to food web exposure, or adverse human health effects.

Based on the TRI database from 1987-1993, no facilities within upper Hillsborough Bay sub-basins reported releases of mercury.

Nickel

Major sources of nickel loading within specific sub-basins in the upper Hillsborough Bay basin include two point sources within the Ybor Channel (13) sub-basin, and one point source within the Delaney Creek (11) sub-basin. Point discharges accounted for 100 percent of the total nickel load from these sub-basins. Point sources of nickel in the Ybor Channel sub-basin included one discharger of treated domestic wastewater, the Howard F. Curren WWTP (Hookers Point). Point sources of nickel in the Delaney Creek sub-basin included one facility discharging nickel in process water, Tampa Electric Co.-Gannon Steam. The total nickel load in the Ybor Channel sub-basin was approximately double the load in the Delaney Creek sub-basin.

Nickel was not detected in stormwater runoff or bulk deposition samples collected at the Hillsborough County station. No land uses were identified associated with stormwater runoff containing nickel.

Based on the TRI database from 1987-1993, no facilities within upper Hillsborough Bay sub-basins reported nickel releases.

5.1.2 PAHs

PAHs identified as COCs were detected in the atmospheric bulk deposition study (Dixon et al. 1996); these data were used for total and percentage loading estimates provided in Tables 5-1 and 5-2, respectively. Due to the lack of monitoring data for specific PAHs in point source discharges or stormwater runoff, oil and grease (O&G) was used as a surrogate for PAH loading. O&G is a measure of organic hydrocarbons that may include plant (vegetable) matter; due to the nature of the facilities and land uses where O&G was detected at significant concentrations, however, this parameter was considered a representative measure of PAH loading. Because of the magnitude of the O&G loads relative to other COCs, this parameter was evaluated separately to minimize the potential for masking the significance of other COC loadings. Total and percentage loading estimates for O&G are also provided in Tables 5-1 and 5-2, respectively.

The five sub-basins in the upper Hillsborough Bay major basin with highest PAH loads due to atmospheric deposition were the Lower Hillsborough River No. 1 (2), Lower Hillsborough River No. 2 (4), Delaney Creek (11), Tampa Bypass Canal (7), and McKay Bay No. 1 (5), and Palm River (9). The five sub-basins with highest O&G loads due to point and nonpoint discharges were the Lower Hillsborough River No. 1 (2), Lower Hillsborough River No. 2 (4), McKay Bay No. 1 (5), Curiosity Creek (3), and Palm River (9). Major sources of O&G loading within specific sub-basins include point sources within the Palm River (9) and Ybor Channel (13) sub-basins, and stormwater runoff in all sub-basins.

Point discharges accounted for 30 percent of the O&G load in the Ybor Channel sub-basin, and 10 percent of the O&G load in the Palm River sub-basin. No point sources of PAHs were identified in the remaining sub-basins. Point sources of PAHs included facilities with permitted stormwater outfalls; no facilities discharging process water were identified as sources of PAHs. Permitted facilities discharging PAHs in stormwater included seven bulk petroleum facilities (Ybor Channel sub-basin), and the Hillsborough County Department of Solid Waste facility (Palm River sub-basin).

Because loadings of PAHs detected in bulk deposition samples collected at the Hillsborough County station were low relative to stormwater O&G loadings, stormwater runoff accounted for approximately 100 percent of the PAH load in all basins except Ybor Channel and Palm River. During the Hillsborough County stormwater characterization studies, O&G was detected in low and high density residential, commercial office, and light industrial land uses. The EMC for light industrial land use was more than 2-times the next lowest land use category. Although O&G is typically associated with transportation land uses, this parameter was not detected in the characterization sampling for the highway/utility land use category.

Based on the TRI database from 1987-1993, one facility in the McKay Bay No. 1 (5) sub-basin, Gardener Asphalt Corp., reported a PAH release. No other facilities reported PAH releases.

5.1.3 Pesticides

Only one pesticide identified as a COC, endrin, was detected in stormwater runoff. This pesticide was not detected in point source discharges or atmospheric bulk deposition samples at the Hillsborough County station. One additional pesticide that was detected in atmospheric bulk deposition samples, delta-BHC, may serve as a surrogate for lindane (gamma-BHC). Due to the lack of pesticide source loading data, two additional chlorinated pesticides (endosulfan and endosulfan II) present in stormwater runoff and atmospheric bulk deposition samples were included in total pesticide loadings within the sub-basins. These two pesticides were detected in upper Hillsborough Bay sediment, but were present at concentrations below risk thresholds. The five sub-basins with highest total chlorinated pesticide loads in decreasing order were Tampa Bypass Canal (7), Delaney Creek (11), Palm River (9), Lower Hillsborough River No. 2 (4), and Mango Drain (8).

No point source discharges of chlorinated pesticides were identified. Three chlorinated pesticides (endosulfan, endosulfan II, and endrin) were detected in stormwater characterization samples for the agricultural land use category. One chlorinated pesticide, endosulfan, was detected in the light industrial land use category. Because loadings of pesticides detected in bulk deposition samples collected at the Hillsborough County station were low relative to stormwater loadings, stormwater runoff accounted for 99-100 percent of the total pesticide loadings in all sub-basins except McKay Bay No. 2 (14), Davis Islands (15), and direct runoff to the bay (1) which did not contain land uses associated with chlorinated pesticides. In these three sub-basins, atmospheric deposition accounted for 100 percent of the chlorinated pesticide load.

Based on the TRI database from 1987-1993, one facility in sub-basin Lower Hillsborough River No. 2 (4), Southern Mill Creek Products Inc. reported releases of heptachlor and lindane. This facility was closed in 1994. No other facilities reported chlorinated pesticide releases.

5.1.4 PCBs

Only one PCB, congener 153, was detected in atmospheric bulk deposition samples at the Hillsborough County station. No other PCBs were detected in atmospheric deposition samples, and PCBs were not detected in point source discharges or stormwater.

In all sub-basins, atmospheric deposition accounted for 100 percent of the PCB load. The five sub-basins with highest total PCB load based on atmospheric bulk deposition were the Lower Hillsborough River No. 2 (4), Lower Hillsborough River No. 1 (2), Delaney Creek (11), Tampa Bypass Canal (7), and McKay Bay No. 1 (5). This reflects the size of these sub-basins; PCB loads in all basins were equal on a per-acre basis.

Based on the TRI database from 1987-1993, no facilities reported releases of PCBs.

5.2 Basin Prioritization for Upper Hillsborough Bay

Sub-basins within the upper Hillsborough Bay drainage basin were ranked based on total loading (point and nonpoint discharges) from sources within each basin. Sub-basins were ranked using the following parameters:

- Total loading of COCs without O&G
- Total loadings for classes of COCs (i.e., metals, PAHs, pesticides, and PCBs).
- Sum of ranks for total loadings for classes of COCs
- Total loading of O&G
- Total loading of COCs including O&G.

Although oil and grease (O&G) was considered was considered representative of PAH loading, the magnitude of O&G loads masked the impacts of smaller quantity, but potentially more toxic, pollutants released from sources within basins. In addition, the non-specific nature of this parameter (i.e., organic hydrocarbons that may include vegetable matter) makes comparison of O&G loads between land use categories problematic. O&G loads may not be comparable between different land use categories for stormwater runoff (e.g., industrial and residential). For these reasons, sub-basins were ranked separately for O&G loads, and total load of COCs including O&G.

Sub-basin ranking for upper Hillsborough Bay is summarized in Table 5-3. In this table, sub-basins are listed in descending order for total COC load 1 (excluding O&G) with the top five basins overall listed separately. As shown in this table, rankings based on total COCs and metals were similar and with the exception of pesticides, the top four basins for all individual COC loads were included within the top five overall. Rankings based on pesticide loading do not strictly follow the other parameters due to the increased proportion of agricultural land uses within some of the basins. Table 5-3 also includes rankings based on O&G loading and total COC load 2 (with O&G). These results are more difficult to interpret due to the non-specific nature of this monitoring parameter.

Based on the overall sub-basin ranks for total load of COCs, and individual classes of COCs, the ranking based on total COC load 1 (excluding O&G) appears to be most appropriate for prioritization of sub-basins for evaluation of potential management actions. The top five basins for total COC load 1 and associated COCs are provided on Figure 5-1. These basins, significant COCs, and associated sources include:

1) Delaney Creek (11): point sources of chromium, copper, nickel; nonpoint sources of metals and pesticides.

2) Lower Hillsborough River No. 1 (2): nonpoint sources of metals and PAHs (O&G).

3) Lower Hillsborough River No. 2 (4): nonpoint sources of metals, PAHs (O&G), and pesticides.

4) Ybor Channel (13): point sources of copper and nickel; nonpoint sources of metals.

5) Tampa Bypass Canal (7): nonpoint sources of metals and pesticides.

Table 5-3.
Sub-Basin Ranking Based on Loading of COCs
Upper Hillsborough Bay

SUB-BASIN NAME (Map No.)	SUB-BASIN RANK							
	Total COC Load 1[1]	Sum of Metals[2]	Sum of PAHs[3]	Sum of Pesticides[4]	PCBs[5]	Sum of Ranks for COCs by Class[6]	Oil And Grease[7]	Total COC Load 2[8]
Delaney Creek (11)	1	1	3	2	3	2	6	5
Lower Hills. River No. 1 (2)	2	2	2	10	2	4	1	1
Lower Hills. River No. 2 (4)	3	3	1	4	1	1	2	2
Ybor Channel (13)	4	4	10	8	10	9	10	10
Tampa Bypass Canal (7)	5	5	4	1	4	3	8	8
McKay Bay No. 1 (5)	6	6	5	6	5	5	3	3
Curiosity Creek (3)	7	7	6	12	6	7	4	4
Direct Runoff to Bay (1)	8	8	8	13	8	10	7	7
Mango Drain (8)	9	9	7	5	7	6	9	9
Palm River (9)	10	10	9	3	9	8	5	6
Davis Islands (15)	11	11	13	14	13	13	11	11
Black Point (12)	12	12	11	7	11	11	14	14
Bellows Lake Outfall (6)	13	13	12	9	12	12	12	12
McKay Bay No. 2 (14)	14	14	15	15	15	15	15	15
Ditch (10)	15	15	14	11	14	14	13	13

Note:

1. Rank for total load of COCs excluding oil and grease (O&G).
2. Sum of ranks for individual metal COCs (i.e., Cr, Cu, Hg, Ni).
3. Rank for total load of detected PAHs (bulk deposition only).
4. Rank for total load of chlorinated pesticides (detected in bulk deposition and stormwater only).
5. Rank for PCB load (one PCB cogener detected in bulk deposition only).
6. Rank for sum of individual COC class ranks (i.e., sum of ranks for metals, PAHs, pesticides, and PCBs).
7. Rank for total load of O&G, a potential surrogate for PAHs.
8. Rank for total load of COCs including O&G.

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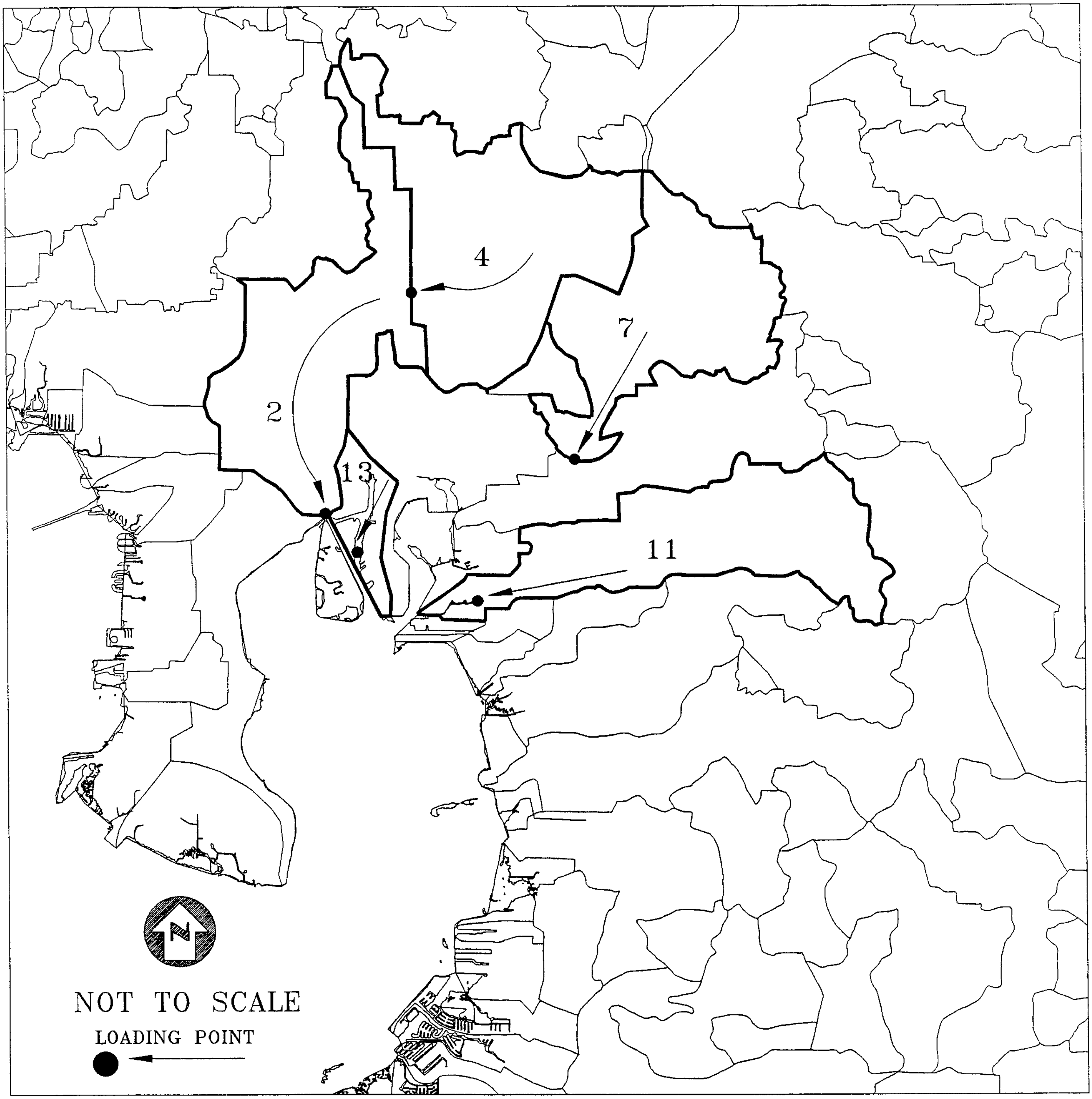

PRIORITY SUB-BASINS BASED ON TOTAL LOAD OF COCs

11)DELANEY CREEK: Point Source: Cr, Cu, Ni; Nonpoint: metals, pesticides

2)LOWER HILLS. RIVER 1: Nonpoint:metals, PAHs

4)LOWER HILLS. RIVER 2: Nonpoint: metals, PAHs, pesticides

13)YBOR CHANNEL: Point Source: Cu, Ni; Nonpoint: metals

7)TAMPA BYPASS CANAL: Nonpoint: metals, pesticides

Note:
Cr-Chromium, Cu-Copper, Ni-Nickel

FIGURE 5-1

PRIORITY SUB-BASINS FOR CONTAMINANTS OF CONCERN-UPPER HILLSBOROUGH BAY
TAMPA BAY NATIONAL ESTUARY PROGRAM

PARSONS ENGINEERING SCIENCE, INC.

5.3 Boca Ciega Bay

Sediment contaminants identified as COCs for Boca Ciega Bay based on a significant potential for adverse ecological or human health effects included: HPAHs (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, fluoranthene, and total HPAHs), and total PCBs.

Annual COC loads for point discharges, stormwater runoff, and atmospheric deposition within Boca Ciega sub-basins are provided in Table 5-4. The percentage of annual COC loads by point discharge, stormwater runoff, and atmospheric deposition are provided in Table 5-5. Loadings for each COC and source type are discussed below. Sub-basin names from Figure 4-2 are provided with the corresponding sub-basin number in parentheses.

5.3.1 PAHs

PAHs identified as COCs were detected in the atmospheric bulk deposition study (Dixon et al. 1996); these data were used for total and percentage loading estimates provided in Tables 5-4 and 5-5, respectively. Due to the lack of monitoring data for specific PAHs in point source discharges or stormwater runoff, oil and grease (O&G) was used as a surrogate for PAH loading. O&G is a measure of organic hydrocarbons that may include plant (vegetable) matter; due to the nature of the facilities and land uses where O&G was detected at significant concentrations, however, this parameter was considered a representative measure of PAH loading. Because of the magnitude of the O&G loads relative to other COCs, this parameter was evaluated separately to minimize the potential for masking the significance of other COC loadings. Total and percentage loading estimates for O&G are also provided in Tables 5-4 and 5-5, respectively.

The five sub-basins in the Boca Ciega Bay major basin with highest PAH loads due to atmospheric deposition were St. Joes Creek (5), Long Bayou (2), Cross Canal (3), Lake Seminole (1), and direct runoff to the bay (8). The five sub-basins with highest O&G loads due to point and nonpoint discharges were Long Bayou (2), Direct Runoff to Bay (8), St. Joe's Creek (5), Cross Canal (3), and Lake Seminole (1).

Major sources of PAH loading within specific sub-basins in the Boca Ciega Bay basin include one point source within the Long Bayou sub-basin (2), and stormwater runoff in all sub-basins. Point discharges accounted for 3 percent of the total PAH load in the Long Bayou sub-basin; stormwater discharge accounted for approximately 97 percent of the total PAH load. Point sources of PAHs in this sub-basin included one facility, Ewell Industries, Inc., with a permitted discharge for process water/stormwater. No point sources of PAHs were identified in the remaining sub-basins.

Because loadings of PAHs detected in bulk deposition samples collected at the Pinellas County station were low relative to stormwater loadings, stormwater runoff accounted for 100 percent of the PAH load in the remaining basins. O&G was detected for only one land use, low density residential, in the Pinellas County stormwater characterization studies. O&G is typically associated with transportation land uses; this land use category was not

Table 5-4.
Summary of Annual COC Loads (lbs/yr) for Point Discharges, Stormwater Runoff, and Atmospheric Deposition - Boca Ciega Bay

Chemical	Loading	Sub-Basin Number															Total Load (tons)
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
PAHs																	
Benzo(a)anthracene	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	atmospheric	3.18E-03	5.48E-03	3.32E-03	1.55E-03	7.72E-03	1.99E-03	1.57E-03	3.02E-03	8.83E-04	1.31E-03	6.71E-04	1.21E-03	6.24E-04	8.69E-04	6.83E-04	1.70E-05
Benzo(a)pyrene	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	atmospheric	3.18E-03	5.48E-03	3.32E-03	1.55E-03	7.72E-03	1.99E-03	1.57E-03	3.02E-03	8.83E-04	1.31E-03	6.71E-04	1.21E-03	6.24E-04	8.69E-04	6.83E-04	1.70E-05
Benzo(b)fluoranthene	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	atmospheric	3.82E-02	6.58E-02	3.99E-02	1.86E-02	9.26E-02	2.39E-02	1.88E-02	3.63E-02	1.06E-02	1.57E-02	8.05E-03	1.45E-02	7.48E-03	1.04E-02	8.20E-03	2.05E-04
Fluoranthene	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	atmospheric	4.78E-02	8.22E-02	4.99E-02	2.33E-02	1.16E-01	2.99E-02	2.35E-02	4.54E-02	1.32E-02	1.97E-02	1.01E-02	1.81E-02	9.36E-03	1.30E-02	1.02E-02	2.56E-04
Sum of PAHs	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	atmospheric	0.09	0.16	0.10	0.05	0.22	0.06	0.05	0.09	0.03	0.04	0.02	0.04	0.02	0.03	0.02	0.0005
	Total	0.09	0.16	0.10	0.05	0.22	0.06	0.05	0.09	0.03	0.04	0.02	0.04	0.02	0.03	0.02	0.001
PCBs																	
	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(congener #153)	atmospheric	1.00E-04	1.73E-04	1.05E-04	4.89E-05	2.43E-04	6.28E-05	4.95E-05	9.53E-05	2.78E-05	4.13E-05	2.11E-05	3.81E-05	1.96E-05	2.74E-05	2.15E-05	5.37E-07
SUM OF COCs 1(1)	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	atmospheric	0.1	0.2	0.1	0.05	0.2	0.1	0.05	0.1	0.03	0.04	0.02	0.04	0.02	0.03	0.02	4.95E-04
	Total	0.092	0.16	0.10	0.05	0.22	0.06	0.05	0.088	0.03	0.04	0.02	0.04	0.02	0.03	0.02	9.72E-07
Oil And Grease(2)	point	--	766.0	--	--	--	--	--	--	--	--	--	--	--	--	--	0.4
	stormwater	6446.1	21693.7	10615.3	5746.5	13353.2	571.4	1001.1	21032.1	2398.2	1762.5	4366.5	4455.6	1239.9	--	--	47
	atmospheric	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Total	6446	22460	10615	5747	13353	571	1001	21032	2398	1762	4367	4456	1240	--	--	48
SUM OF COCs 2(3)	point	--	766.0	--	--	--	--	--	--	--	--	--	--	--	--	--	0.4
	stormwater	6446	21694	10615	5747	13353	571	1001	21032	2398	1762	4367	4456	1240	--	--	47
	atmospheric	0.09	0.16	0.10	0.05	0.22	0.06	0.05	0.09	0.03	0.04	0.02	0.04	0.02	0.03	0.02	4.95E-04
	Total	6446	22460	10615	5747	13353	571	1001	21032	2398	1763	4367	4456	1240	0.03	0.02	47.72

Note:
1. Total COC load excluding oil and grease (O&G).
2. Oil and Grease (O&G) was not a COC, but represents a surrogate for PAHs.
3. Total COC load including O&G.

"--" - not detected in point discharges, stormwater, or atmospheric deposition studies.

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Table 5-5.
Percentage of Annual COC Loads (lbs/yr) for Point Discharges, Stormwater Runoff, and Atmospheric Deposition - Boca Ciega Bay

Chemical	Loading	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total Load (tons)
PAHs																	
Benzo(a)anthracene	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	atmospheric	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	1.70E-05
Benzo(a)pyrene	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	atmospheric	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	1.70E-05
Benzo(b)fluoranthene	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	atmospheric	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	2.05E-04
Fluoranthene	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	atmospheric	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	2.56E-04
Sum of PAHs	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	atmospheric	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	0.0005
	Total	0.09	0.16	0.10	0.05	0.22	0.06	0.05	0.09	0.03	0.04	0.02	0.04	0.02	0.03	0.02	0.001
PCBs																	
	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(congener #153)	atmospheric	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	5.37E-07
SUM OF COCs 1 (1)	point	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	stormwater	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	atmospheric	100%	100%	100.0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	4.95E-04
	Total	0.09	0.16	0.10	0.05	0.22	0.06	0.05	0.09	0.03	0.04	0.02	0.04	0.02	0.03	0.02	4.95E-04
Oil And Grease (2)	point	--	3%	--	--	--	--	--	--	--	--	--	--	--	--	--	0.4
	stormwater	100%	97%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	--	--	47
	atmospheric	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Total	6446	22460	10615	5747	13353	571	1001	21032	2398	1762	4367	4456	1240	--	--	48
SUM OF COCs 2 (3)	point	--	3%	--	--	--	--	--	--	--	--	--	--	--	--	--	0.4
	stormwater	100%	97%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	--	--	47
	atmospheric	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	100%	100%	4.95E-04
	Total	6446	22460	10615	5747	13353	571	1001	21032	2398	1763	4367	4456	1240	0.03	0.02	48

Note:

1. Total COC load excluding oil and grease (O&G).
2. Oil and Grease (O&G) was not a COC, but represents a surrogate for PAHs.
3. Total COC load including O&G.

"--" - not detected in point discharges, stormwater, or atmospheric deposition studies.

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included in the Pinellas County stormwater characterization studies, and O&G was not detected for this land use in the Hillsborough County characterization studies.

Based on the TRI database from 1987-1993, no facilities reported PAH releases.

5.3.2 PCBs

Only one PCB, congener 153, was detected in atmospheric bulk deposition samples at the Pinellas County station. No other PCBs were detected in atmospheric deposition samples, and PCBs were not detected in point source discharges or stormwater characterization studies.

In all sub-basins, atmospheric deposition accounted for 100 percent of the PCB load. The five sub-basins with highest total PCB load based on atmospheric bulk deposition in decreasing order were St. Joe's Creek (5), Long Bayou (2), Cross Canal (3), Lake Seminole (1), and Direct Runoff to Bay (8). This reflects the size of these sub-basins; PCB loads in all basins were equal on a per-acre basis.

Based on the TRI database from 1987-1993, no facilities reported releases of PCBs.

5.4 Basin Prioritization for Boca Ciega Bay

Although oil and grease (O&G) was considered was considered representative of total PAH loading, the non-specific nature of this parameter (i.e., organic hydrocarbons that may include vegetable matter) makes comparison of O&G loads between land use categories problematic. O&G loads may not be comparable between different land use categories for stormwater runoff (e.g., industrial and residential). Additional data for COCs (PAHs and PCBs) for Boca Ciega sub-basins was based on atmospheric bulk deposition collected at one central station, however, and calculated sub-basin loads for parameters reflect only the relative areas of each sub-basin. For these reasons, total COC loads including O&G data were used to rank individual sub-basins within the Boca Ciega basin.

Sub-basins within the Boca Ciega Bay drainage basin were ranked based on total loading (point and nonpoint discharges) from sources within each basin. Sub-basins were ranked using the following parameters:

- Total loading of COCs including O&G
- Total loading of O&G
- Total loading of COCs without O&G
- Total loadings of classes of COCs (i.e., PAHs and PCBs).
- Sum of ranks for total loadings for classes of COCs.

Sub-basin ranking for Boca Ciega Bay is summarized in Table 5-6. In this table, sub-basins are listed in descending order for total COC load 2 (including O&G) with the top five basins overall listed separately. As shown in this table, rankings for total COC load 2 and O&G were the same. Table 5-6 also includes rankings based on total COC load 1 (without O&G), loads of PAHs and PCBs (Atmospheric bulk deposition only), and a sum of ranks for PAHs and PCBs.

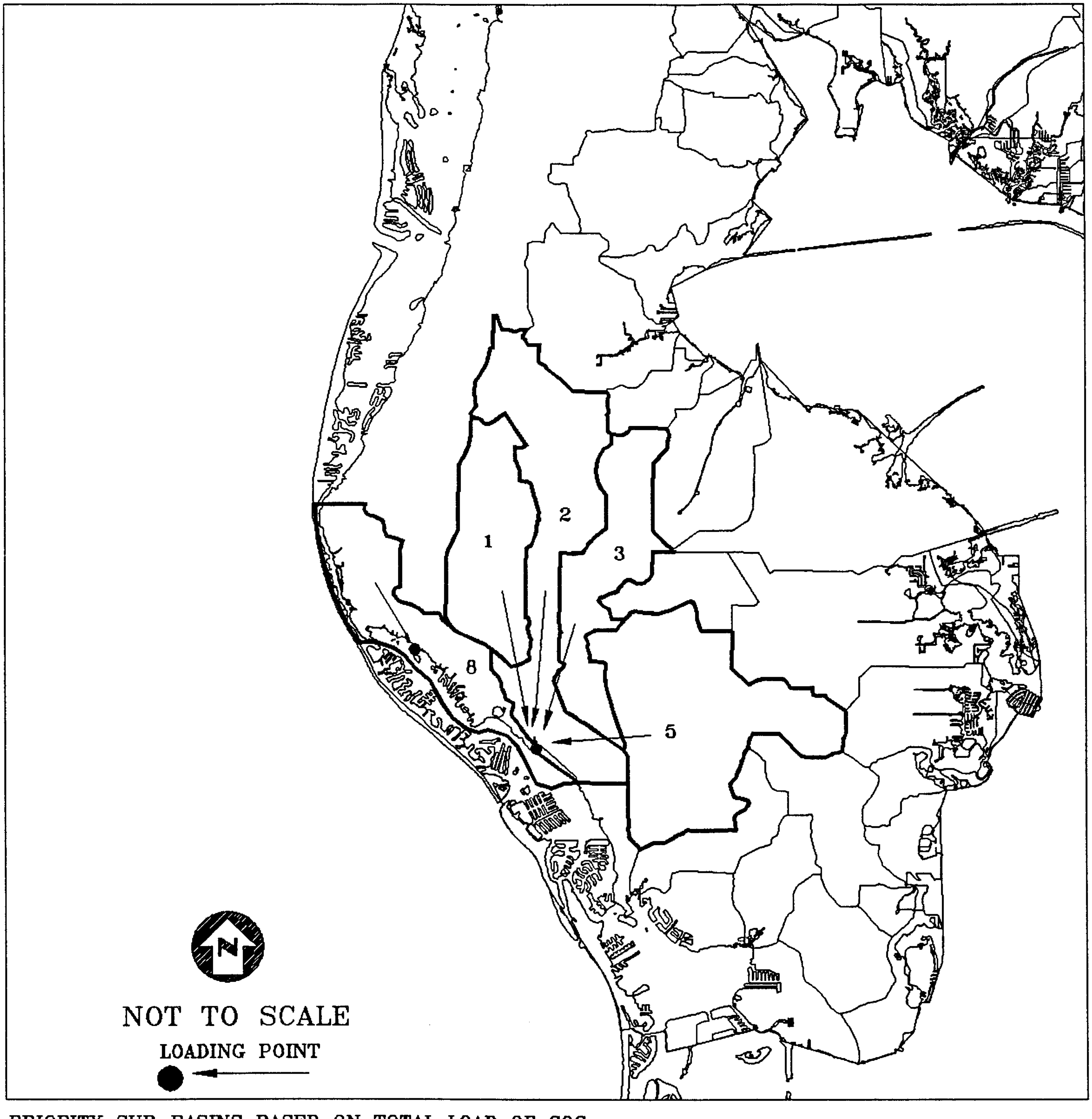
Based on the overall sub-basin ranks for total load of COCs, as well as individual classes of COCs, the ranking based on total COC load 2 (including O&G) appears to be most appropriate for prioritization of these sub-basins for evaluation of potential management actions. The top five basins for total COC load 2 and associated COCs are provided on Figure 5-2. These basins and associated COCs include:

1) Long Bayou (2): nonpoint sources of PAHs.
2) Direct Runoff to Bay (8): nonpoint sources of PAHs.
3) St. Joe's Creek (5): nonpoint sources of PAHs.
4) Cross Canal (3): nonpoint sources of PAHs.
5) Lake Seminole (1): nonpoint sources of PAHs.

Table 5-6.
Sub-Basin Ranking Based on Loading of COCs
Boca Ciega Bay

SUB-BASIN NAME (Map No.)	SUB-BASIN RANK					
	Total COC Load 2[6]	Oil And Grease[5]	Total COC Load 1[1]	Sum of PAHs[3]	PCBs[3]	Sum of Ranks for COCs by Class[4]
Long Bayou (2)	1	1	2	2	2	2
Direct Runoff to Bay (8)	2	2	5	5	5	5
St. Joes Creek (5)	3	3	1	1	1	1
Cross Canal (3)	4	4	3	3	3	3
Lake Seminole (1)	5	5	4	4	4	4
Pinellas Park (4)	6	6	8	8	8	8
Direct Runoff to Bay (12)	7	7	10	10	10	10
Direct Runoff to Bay (11)	8	8	14	14	14	14
Direct Runoff to Bay (9)	9	9	11	11	11	11
Direct Runoff to Bay (10)	10	10	9	9	9	9
Direct Runoff to Bay (13)	11	11	15	15	15	15
Clam Bayou Drain (7)	12	12	7	7	7	7
Bear Creek (6)	13	13	6	6	6	6
Direct Runoff to Bay (14)	14	14	12	12	12	12
Direct Runoff to Bay (15)	15	15	13	13	13	13

Note:
1. Rank for total load of COCs excluding oil and grease (O&G).
2. Rank for total load of detected PAHs (bulk deposition only).
3. Rank for PCB load (one PCB cogener detected in bulk deposition only).
4. Rank for sum of individual COC class ranks (i.e., sum of ranks for metals, PAHs, pesticides, and PCBs).
5. Based on total load of O&G, a potential surrogate for PAHs.
6. Rank for total load of COCs including O&G.



PRIORITY SUB-BASINS BASED ON TOTAL LOAD OF COCs

2)LONG BAYOU: PAHs
8)DIRECT RUNOFF TO BAY: PAHs
5)ST. JOE CREEK: PAHs
3)CROSS CANAL: PAHs
1)LAKE SEMINOLE: PAHs

FIGURE 5-2

PRIORITY SUB-BASINS FOR CONTAMINANTS OF CONCERN-BOCA CIEGA BAY
TAMPA BAY NATIONAL ESTUARY PROGRAM

PARSONS ENGINEERING SCIENCE, INC.

6.0 SUMMARY AND RECOMMENDATIONS

The objectives for this part of the Toxic Contamination Sources Assessment project were to identify potential sources of specific sediment contaminants, estimate loadings from these sources, and prioritize drainage basins based on pollutant loading. A summary of the results of this study and recommendations for future activities are provided in this section. The results from this study will be used by TBNEP to prioritize management actions based on reduction of ecological and/or human health risks, the effectiveness and cost of management alternatives, or the need for additional investigation.

6.1 Project Overview

The overall goals of the Toxic Contamination Sources Assessment project were to incorporate risk-based approaches into the evaluation of pollutants and sources, and to prioritize management actions based on potential ecological and/or human health risks. To meet these goals, this project was divided into two parts: the assessment of risks associated with sediment contaminants, and the identification and evaluation of sources of pollutants contributing significantly to overall risk. TBNEP will use the results of both parts of this study to develop a sediment contamination management action plan to reduce risks associated with contaminants of concern (COCs). General types of management actions to be considered include: treatment of runoff/inflow from basins prior to discharge to Tampa Bay, and reduction of loadings by sources where feasible.

The first part of this project involved an evaluation of potential ecological and human health risks associated with exposure to sediment contaminants in particular areas of Tampa Bay. The methodology and results for this evaluation were presented in a previous TBNEP report, Toxic Contamination Sources Assessment: Risk Assessment for Chemicals of Potential Concern and Methods for Identification of Specific Sources (McConnell et al. 1996). The results of the risk assessment were used to identify specific COCs (pesticides, PCBs, PAHs, and/or certain metals) for areas of Tampa Bay.

The main objective for the second part of the Toxic Contamination Sources Assessment project was to identify and evaluate sources of COCs in drainage basins discharging to priority areas of Tampa Bay, including the coastal Hillsborough, lower Hillsborough River, and Boca Ciega Major Drainage Basins. The distribution of sediment contaminants in Tampa Bay suggests both point and nonpoint source contributions, and urban runoff, atmospheric deposition, and point sources have been previously identified as contributors of specific types of contaminants. For the second part of this project, potential loadings of COCs were evaluated, and specific sources were identified where possible. Because new environmental data were not collected for this project, the evaluation of contamination, and sources of pollutants, involved the compilation and analysis of existing data collected from a variety of local, state, and federal government agencies, as well as individual facilities.

6.2 Summary of Evaluation Methodology and Data Sources

The general methodology used for evaluation of pollutant loadings was similar to that of other models used for integrated watershed assessments (e.g., the EPA Office of Water BASINS model), but allowed inclusion of more site-specific and supplemental data. This was required for a comprehensive assessment of toxic pollutant releases into specific areas of Tampa Bay. To compile and analyze point and nonpoint discharge data, a GIS was developed that included:

- The delineation of drainage basins using stormwater atlas sheets and topographic maps
- A pollutant loading model developed using land use/soil characteristics and stormwater characterization data
- Point sources identified using state/federal water quality monitoring databases and state/local agency permit application/monitoring files
- Atmospheric loading estimates based on previously measured deposition rates
- Historical releases of contaminants identified using databases and permit files.

Pollutants in stormwater runoff to the bay were evaluated using land use, soils, and drainage basin characteristics. Runoff coefficients based on soils and land use were combined with storm event mean concentrations (EMCs) to estimate annual loads of COCs in stormwater runoff. EMC values for specific pollutants were obtained from stormwater characterization studies performed by Hillsborough and Pinellas Counties in support of NPDES permit applications.

The primary source of surface water discharge data used for this project was the USEPA PCS database. This database contains point source discharge data reported to USEPA by major dischargers permitted under the NPDES program. These data do not necessarily provide an accurate evaluation of loadings for certain pollutants because many minor dischargers may have large cumulative inputs, most facilities reported only permit-required parameters, and most facilities did not monitor for many of the pollutants identified as COCs. For this project, a database compiled by USEPA Region IV was used to correct errors and omissions in the PCS database. A search of the STORET database identified contaminant data reported in the 1980s, but water quality data were not available from 1990-present because monitoring, or analyses for parameters of interest, had been discontinued.

COC loading rates for atmospheric deposition were estimated using bulk deposition data collected by Dixon et al. (1996) for TBNEP. Recorded deposition rates for stations located in Hillsborough and Pinellas Counties were used for each applicable drainage basin. Annual loading estimates for each basin were calculated from these measured deposition rates. Data limitations did not allow determination of actual atmospheric loadings, but the loading estimates were useful for evaluation of particular COCs that were not detected in stormwater or point source discharges.

Additional information regarding potential sources of pollutants was obtained from the USEPA Toxic Release Inventory (TRI), CERCLIS, and RCRA Biennial Reporting System (BRS) databases. The TRI database was used to identify historical releases of toxic pollutants, the CERCLIS database was used to identify sites with known hazardous waste contamination, and the BRS database was used to identify facilities handling COCs for processing, storage, or treatment. Loadings from these facilities could not be quantified due to a lack of data regarding the amount and type of contaminants being transported from these sites, but this information was very useful for identifying potential sources of contaminants found in Tampa Bay sediments.

Supplemental discharge data used for this project were obtained from state discharge monitoring databases, reports, and permit files; county permit files and facility inventories; and unreported monitoring data collected by specific dischargers. These data included discharge characterization data collected to determine permitting requirements, support permit applications, and/or monitor permit compliance. Use of these data was critical for identification/evaluation of pollutant releases. In addition, many of facilities contributing significantly to pollutant loading did not have established discharge monitoring requirements or typical load estimates (e.g., based on SIC codes); this was especially important for evaluation of bulk transfer-type facilities. Although visiting individual sites was outside the scope of this project, many of the agency staff contacted had extensive knowledge of current and historical site activities at most of the facilities. This information was used to fill in data gaps for facilities as well as identify additional facilities not included in existing databases.

The data described above were used to develop loading estimates for stormwater runoff, point sources, and atmospheric deposition. These estimates were combined to determine total contaminant loading from sources within basins. Sub-basins were then ranked for development of management actions based on total loading of contaminants identified as COCs, and classes of COCs (i.e., metals, PAHs, pesticides, or PCBs).

6.3 Prioritization of Sub-Basins Based on Contaminant Loading

Sub-basins within the upper Hillsborough Bay and Boca Ciega bay drainage basins were ranked based on total load of COCs. Using this information, sub-basins can be prioritized for targeting management actions based on point or nonpoint sources identified. In addition, management actions can be tied to reduction of total COC load, or reduction in loads for specific COCs. The prioritization of upper Hillsborough and Boca Ciega Bay sub-basins is summarized below. Basin names and map numbers refer those presented in Figure 4-2 and 4-2. Priority basins are shown on Figures 5.1 and 5.2.

6.3.1 Upper Hillsborough Bay

Sediment contaminants identified as COCs for upper Hillsborough Bay based on a significant potential for adverse ecological or human health effects included: four metals (chromium, copper, mercury, and nickel), HPAHs (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, fluoranthene, pyrene, and total HPAHs), five chlorinated pesticides (chlordane, DDT/DDD, endrin, heptachlor/heptachlor epoxide, and lindane), and total PCBs.

The priority sub-basins based on total COC load (excluding O&G), significant COCs, and associated sources included:

1) Delaney Creek (11): point sources of chromium, copper, nickel; nonpoint sources of metals and pesticides.
2) Lower Hillsborough River No. 1 (2): nonpoint sources of metals and PAHs (O&G).
3) Lower Hillsborough River No. 2 (4): nonpoint sources of metals, PAHs (O&G), and pesticides.
4) Ybor Channel (13): point sources of copper and nickel; nonpoint sources of metals.
5) Tampa Bypass Canal (7): nonpoint sources of metals and pesticides.

Sources of metals included point discharges in the Delaney Creek (11) and Ybor Channel (13) sub-basins. Stormwater runoff contained most of the loading for the other COCs with a minor contribution from atmospheric deposition.

Primary sources of metal loading in upper Hillsborough Bay sub-basins include point discharges and stormwater runoff. Based on total loadings for the metals identified as COCs (chromium, copper, mercury, and nickel), the five sub-basins with highest total metal loads were Delaney Creek (11), Lower Hillsborough River No. 1 (2), Lower Hillsborough River No. 2 (4), Ybor Channel (13), and Tampa Bypass Canal (7). Sources of metals loading in the Delaney Creek and Ybor Channel sub-basins included point and nonpoint discharges; metals loading from the other sub-basins was primarily from stormwater runoff. Point sources were identified for chromium, copper, and nickel; no point source discharges of mercury were identified. Land uses associated with stormwater runoff containing metals identified as COCs included low density residential and commercial-retail for chromium and copper; and high density residential, light industrial, agricultural, commercial-office, and highway/utility for copper.

Major sources of PAH loading within specific sub-basins in the upper Hillsborough Bay major basin include permitted stormwater outfalls from industrial facilities within the Palm River (9) and Ybor Channel (13) sub-basins, and stormwater runoff in all sub-basins. The five sub-basins with highest total PAH (O&G) loads were the Lower Hillsborough River No. 1 (2), Lower Hillsborough River No. 2 (4), McKay Bay No. 1 (5), Curiosity Creek (3), and Palm River (9). Land uses associated with stormwater runoff containing PAHs included low and high density residential, light industrial, and commercial-office. The EMC for light industrial land use was more than 2-times the next lowest land use category. Although O&G is typically associated with transportation land uses, this parameter was not detected in the characterization sampling for the highway/utility land use category.

Stormwater runoff accounted for 99-100 percent of the total pesticide loadings in all sub-basins except McKay Bay No. 2 (14), Davis Islands (15), and direct runoff to the bay (1) which did not contain land uses associated with chlorinated pesticides. In these three sub-basins, atmospheric deposition accounted for 100 percent of the chlorinated pesticide load. The five sub-basins with highest total chlorinated pesticide loads in decreasing order were Tampa Bypass Canal (7), Delaney Creek (11), Palm River (9), Lower Hillsborough River No. 2 (4), and Mango Drain (8). One pesticide identified as a COC, endrin, and two additional chlorinated pesticides (endosulfan and endosulfan II) were detected in stormwater runoff. These chlorinated pesticides were not detected in point source discharges or atmospheric bulk deposition samples at the Hillsborough County station. Land uses associated with stormwater runoff containing chlorinated pesticides included agricultural and light industrial.

Only one PCB, congener 153, was detected in atmospheric bulk deposition samples at the Hillsborough County station. No other PCBs were detected in atmospheric deposition samples, and PCBs were not detected in point source discharges or stormwater. The five sub-basins with highest total PCB load based on atmospheric bulk deposition were the Lower Hillsborough River No. 2 (4), Lower Hillsborough River No. 1 (2), Delaney Creek (11), Tampa Bypass Canal (7), and McKay Bay No. 1 (5). This reflects the size of these sub-basins; PCB loads in all basins were equal on a per-acre basis.

6.3.2 Boca Ciega Bay

Sediment contaminants identified as COCs for Boca Ciega Bay based on a significant potential for adverse ecological or human health effects included: HPAHs (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, fluoranthene, and total HPAHs), and total PCBs.

The priority sub-basins based on total COC load (including O&G), and associated COCs include:

1) Long Bayou (2): nonpoint sources of PAHs.
2) Direct Runoff to Bay (8): nonpoint sources of PAHs.
3) St. Joe's Creek (5): nonpoint sources of PAHs.
4) Cross Canal (3): nonpoint sources of PAHs.
5) Lake Seminole (1): nonpoint sources of PAHs.

Major sources of PAH loading within specific sub-basins in the Boca Ciega Bay basin include one point source within the Long Bayou sub-basin (2), and stormwater runoff in all sub-basins. The five sub-basins with highest total PAH loads in decreasing order were Long Bayou (2), Direct Runoff to Bay (8), St. Joe's Creek (5), Cross Canal (3), and Lake Seminole (1). Point discharges accounted for 3 percent of the total PAH load in the Long Bayou sub-basin (2); stormwater discharge accounted for approximately 97 percent of the total PAH load. No point sources of PAHs were identified in the remaining sub-basins; stormwater runoff accounted for approximately 100 percent of the PAH load in these basins. O&G was detected for only one land use, low density residential, in the Pinellas County stormwater characterization studies. O&G is typically associated with transportation land uses; this land use category was not included in the Pinellas County stormwater characterization studies.

Only one PCB, congener 153, was detected in atmospheric bulk deposition samples at the Pinellas County station. No other PCBs were detected in atmospheric deposition samples, and PCBs were not detected in point source discharges or stormwater characterization studies. In all sub-basins, atmospheric deposition accounted for 100 percent of the PCB load. The five sub-basins with highest total PCB load based on atmospheric bulk deposition in decreasing order were St. Joe's Creek (5), Long Bayou (2), Cross canal (3), Lake Seminole (1), and Direct Runoff to Bay (8). This reflects the size of these sub-basins; PCB loads in all basins were equal on a per-acre basis.

6.4 Data Gaps/Uncertainty

Most of the point source loading data were obtained from regulatory agency databases and facility files that contain monitoring data reported to a particular agency. Because testing requirements are based on anticipated discharges, this information should be representative of facility discharges, although the potential exists, however, for significant releases to go undetected due to a lack of required monitoring. A number of the facilities identified in the Port of Tampa area have not been not required to obtain environmental permits. While discharges from most these facilities are not likely to be significant, discharges from particular facilities (e.g., scrap metal facilities) may be significant.

Some additional potential sources of COCs have been identified in the McKay Bay No. 1 (5) basin. These potential sources include illicit storm sewer discharges from industrial facilities, and runoff from scrap metal or other recycling facilities. Discharges from these sources, as well as stormwater loadings of contaminants from the McKay Bay watershed, are being evaluated as part of a SWFWMD project. This project, performed in conjunction with the City of Tampa and USEPA, will identify opportunities to retrofit existing stormwater treatment facilities or create new facilities to control discharges of stormwater pollutants.

The potential exists for atmospheric release of COCs from facilities within the priority sub-basins. The contribution from these sources is unknown, although most facilities with permitted stack emissions located in the priority sub-basins are unlikely sources of COCs. Evaluation of atmospheric sources of COCs is problematic to the long-distance transport of atmospheric contaminants Based on data reviewed from the USEPA AIRS database, facilities with permitted air releases of COCs were not identified. Most of the releases from these facilities include volatile organic compounds (VOCs), oxides of sulfur and nitrogen (SOx/NOx), and particulates. Atmospheric releases of COCs were reported in the TRI database, but historical loads could not be incorporated into current loading estimates.

Toxic contaminants can also leach from the land surface into the water table or confined aquifers and enter an estuary through groundwater discharge zones. Sources of contaminants in groundwater include leachate from landfills, hazardous waste sites, or agricultural areas. Hazardous waste sites identified for the Tampa Bay watershed include three NPL and 29 non-NPL sites in the Hillsborough River basin, five NPL and 31 non-NPL sites in the Coastal Hillsborough basin, and four non-NPL sites in the Boca Ciega basin. Elevated contaminant concentrations are typically localized and may take decades to reach the estuary due to the slow rate of groundwater flow. Due to data limitations discussed in Section 3.5, no attempt was made to include groundwater infiltration to make estimates for specific basins or bay segments.

Because this investigation focused on sediment COCs, sources and loadings of other potential contaminants of concern in stormwater or atmospheric deposition (i.e., organophosphate pesticides currently used in the watershed or other water quality contaminants) were not evaluated. While the most significant contaminants have likely been identified, this approach may overlook other contaminants that contribute to ecological or human health risks.

6.5 General Recommendations for Management Actions

TBNEP intends to use the results of this study to develop a sediment contamination management action plan to reduce risks associated with contaminants of concern (COCs). General types of management actions to be considered include: treatment of runoff/inflow from basins prior to discharge to Tampa Bay and reduction of loadings by point sources where feasible.

6.5.1 Stormwater

Stormwater was identified as the dominant current source for most of the sediment COCs evaluated for this assessment. Stormwater treatment is an effective management action because it can capture the portion of atmospheric deposition that occurs within drainage basins, as well as reduce pollutant runoff from other types of sources. Stormwater control methods may be selected for specific sub-basins based on total impact reduction (i.e., COCs + nutrients + total suspended solids). Additional potential benefits of stormwater management actions include general water quality improvements, creation or restoration of wildlife habitats, and the opportunity for public education on the importance of reducing pollutants. Highly visible projects provide not only physical and/or chemical removal of stormwater pollutants, but also increase public awareness.

Best management practices (BMPs) to control stormwater runoff of contaminants may be structural (e.g., retention ponds, vegetated buffer strips, swales, and underdrains), or nonstructural (e.g., street sweeping, stricter zoning standards to limit development in sensitive areas, or public education). Historically, structural BMPs have consisted of small treatment facilities associated with individual development projects. This has resulted in increased long-term operation and maintenance costs, and limited possibilities for additional environmental benefits such as habitat improvement. For these reasons, interest in regional stormwater treatment facilities is increasing. Regional stormwater facilities can provide water quality treatment, flow attenuation, and compensatory volume for existing uses (retrofit), as well as planned or uncertain future development.

Examples of Structural BMP Projects

- Identify opportunities for stormwater treatment retrofit projects for existing development.

- Examine target sub-basins to identify specific projects where control measures would maximize reduction of loadings as well as habitat restoration. Develop prioritization schemes for these projects.
- Evaluate priority areas for the implementation of regional BMPs including potential areas for siting regional treatment facilities - may be based on solids removal.
- Treatment methods that involve large or multi-parcel sites are preferred, since they increase the likelihood of operational success and offer opportunities for habitat improvements.

Examples of Nonstructural BMP Projects

- Develop proposed guidelines requiring water quality monitoring at BMPs in priority areas, and recommend procedures to incorporate these requirements into the NPDES program.
- Develop/recommend implementation of proposed regulations to encourage or require stormwater retrofits for redevelopment projects.
- Education.

Following identification of specific types of BMPs, the TBNEP BMP "optimization" computer model can be used to evaluate the cost effectiveness of various methods for addressing stormwater pollution and determine the most cost-effective mix of management practices.

6.5.2 Point Sources

Although stormwater runoff was identified as the dominant source for most current loadings of COCs, point source discharges account for a significant portion of loads for several COCs (particularly chromium and nickel) in the upper Hillsborough Bay drainage basin.

Point source discharge accounted for 80% of the chromium loading from the Delaney Creek sub-basin, and 55% of the total chromium loadings from all sub-basins. Point source discharge accounted for 25% of the copper load from the Delaney Creek sub-basin, and 13% of the total chromium loadings from all sub-basins. Point source discharges from Delaney Creek and Ybor Channel sub-basins accounted for 100% of the nickel loading from all sources identified in the upper Hillsborough Bay drainage basin. Permitted stormwater outfalls contributed 10% and 30% of the O&G load in the Palm River and Ybor Channel sub-basins, respectively. Although the permitted discharge from these basins reflects only 2% of the total O&G loading from all sub-basins, the proximity of these outfalls to the bay suggests a greater potential for impacts to upper Hillsborough Bay.

Contaminant releases from facilities with wastewater or stormwater permits allowing discharge of specific COCs should be examined to identify opportunities for contaminant load reduction. The permitted discharges of wastewater or stormwater identified as sources of specific COCs should be examined in more detail. This evaluation would evaluate opportunities to decrease the loadings of specific COCs and associated risks.

6.5.3 Additional Investigation

For some of the COCs, that are no longer in common use, such as like chlorinated pesticides, the sediments themselves should be considered a primary source. Because direct or food web exposures to these sediment contaminants may present significant risks to fish and wildlife in portions of the bay, a sediment contamination action plan should address this additional source.

One possible remedial action for management of sediment contaminants includes removal of contaminated sediment (dredging, identification of appropriate disposal method, location of disposal site). Other possible remedial actions involve limiting receptor exposure to in-place contaminants. Some of the methods for this type of action include placement of clean fill over contaminated areas, or using other methods to "cap" the contaminants (bentonite seals, etc.). In addition to limiting exposure to sediment contamination, placement of clean material will impact a water body by altering water depths and changing benthic substrate. This technique has been used in other areas of sediment contamination with the additional benefit of benthic habitat restoration. On the downside, however, many of the contaminated areas consist of deeper "holes" that provide good fish habitat structure and fishing areas.

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APPENDIX A

Data Used to Evaluate Sources/Loading of Sediment Contaminants of Concern

Table A-1.
Estimated Annual Loads for Overland Flow by Sub-Basin - Upper Hillsborough Drainage Basin

Chemical	Sub-Basin Number															Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Load (tons)
Metals																
Arsenic	3.1	23.9	7.6	35.4	8.3	4.6	35.4	14.7	7.6	0.5	37.9	3.3	3.1	0.0	0.8	0.1
Barium	4399	15849	5250	11760	10990	1403	4698	3475	2515	660	8306	513	1701	136	83	36
Cadmium	48.9	127.8	59.0	157.9	160.1	23.6	274.6	59.8	106.8	39.1	233.1	92.2	226.7	79.9	49.2	0.9
Chromium	143.1	535.6	249.1	921.6	378.8	54.5	614.9	367.1	180.8	63.0	792.7	30.2	55.3	4.3	2.6	2.2
Copper	852	2654	1269	1857	1308	192	1085	552	541	149	1331	271	732	241	310	7
Lead	1253	3278	1485	3577	3965	455	5165	960	2351	930	4374	2072	5468	1921	1193	19
Mercury	4.2	15.1	5.0	11.2	10.5	1.3	4.5	3.3	2.4	0.6	7.9	0.5	1.6	0.1	0.1	0.0
Zinc	1348	4093	1910	3477	2934	355	2809	946	1621	502	2745	964	2642	860	725	14
PAHs/Semivolatiles																
Oil And Grease	30398	101751	49242	83212	50999	5935	27040	22890	31140	5477	34161	3649	14652	1529	8587	235
Phenols	2618	8726	4028	6329	3801	551	2127	1829	1298	260	3546	186	693	120	595	18
Di-n-butyl phthalate	839	2550	1297	1227	730	122	210	345	109	9	624	15	74	43	238	4
Pesticides																
Endosulfan	0.00	0.56	0.07	3.12	2.29	0.47	5.87	2.34	3.34	0.49	4.59	0.80	1.12	0.00	0.00	0.01
Endosulfan II	0.00	0.004	0.03	0.50	0.02	0.17	2.33	0.89	0.42	0.04	2.20	0.24	0.00	0.00	0.00	0.00
Endrin	0.00	0.004	0.03	0.50	0.02	0.17	2.33	0.89	0.42	0.04	2.20	0.24	0.00	0.00	0.00	0.00
Misc.																
BOD	76687	236169	106093	208981	170887	27696	237611	80063	97588	28518	233068	63571	151010	50068	39908	904
COD	675439	2221844	1033185	1697174	1045117	160294	817589	549496	417983	89323	1127773	98642	262736	59449	164405	5210
NO2/NO3	13120	41504	19423	29178	19975	3052	16479	9235	7265	1956	21733	3344	8734	2823	4066	101
TP	19210	60163	30039	37720	20759	3881	18916	13756	7134	1153	27963	1869	3542	1193	5271	126
TDP	8023	25439	12712	17500	9027	1754	9908	6758	3561	588	13791	858	1366	397	2124	57
TDS	1602887	5804855	2511146	7544058	5187456	697648	6234439	2912147	4163346	840067	5749815	1052900	2535131	429509	509095	23887
TKN	27874	94064	42863	82016	51931	7783	48203	24670	26155	6308	55758	9599	25971	7057	9352	260
TSS	760392	2299526	1078688	2006029	1610101	209177	1734489	547574	828030	287438	1735044	588941	1587017	542300	434021	8124

Note:
Loads calculated using the simple method (Schueler 1987) with NPDES Stormwater Discharge Characterization for Hillsborough County (1993).
Annual Rainfall (in/yr) 51.4

Table A-2.
Estimated Annual Loads for Overland Flow by Sub-Basin - Boca Ciega Drainage Basin

Chemical	Sub-Basin Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total Load (tons)
Metals																
Arsenic	3.7	84.5	45.2	5.8	41.8	2.9	16.3	0.6	2.5	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Cadmium	68.4	113.2	69.2	23.9	134.4	11.1	25.3	44.4	5.1	3.3	35.3	28.5	2.9	3.9	0.2	0.3
Copper	208.6	593.9	340.0	94.6	495.0	39.7	110.5	190.9	29.9	22.7	105.5	92.6	13.4	20.4	0.8	1.2
Lead	1688.6	2736.8	1704.3	561.0	3536.7	386.5	713.9	975.2	140.1	83.0	838.9	665.5	83.3	70.5	0.0	7.1
Mercury	1.0	3.3	1.6	0.9	2.1	0.1	0.2	3.2	0.4	0.3	0.7	0.7	0.2	0.0	0.0	0.0
Zinc	3603.6	7272.7	4077.6	1557.6	8804.8	2357.7	2253.3	2791.6	983.5	1298.6	749.1	1123.3	567.2	783.8	0.3	19.1
PAHs/Semivolatiles																
Oil And Grease	6446.1	21693.7	10615.3	5746.5	13353.2	571.4	1001.1	21032.1	2398.2	1762.5	4366.5	4455.6	1239.9	0.0	0.0	47.3
Phenols	153.8	207.0	173.4	79.3	441.5	131.5	119.0	75.5	29.4	51.7	54.0	11.5	77.1	63.7	1.0	0.8
Di-n-butyl phthalate	4.3	4.1	0.0	3.4	3.2	0.0	0.1	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0
Pesticides																
Endosulfan	0.18	0.17	0.00	0.14	0.13	0.00	0.01	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00
Endosulfan II	0.09	0.09	0.00	0.07	0.07	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Misc.																
BOD	199635	399056	221393	89904	509763	129052	126545	163555	54787	70478	50878	68726	38081	44570	341	1083
COD	808006	1519257	843637	377565	1932569	572094	481513	755771	247428	345494	152835	256086	164135	216744	839	4337
NO2/NO3	12722	23547	13068	5598	30744	8489	7618	10566	3600	4908	2759	4234	2325	3084	15	67
TP	4507	9619	5128	2382	10671	2772	2618	4433	1260	1630	922	1324	833	984	44	25
TDP	3625	8072	4302	1911	8922	2391	2224	3739	1106	1420	707	1118	699	825	23	21
TDS	1683503	3651870	2077037	790998	4250448	1067274	1093229	1312177	443975	609081	410350	521602	343480	447919	8634	9356
TKN	38592	59776	33906	16286	84145	25621	20330	31877	10559	15444	7318	11950	6611	9818	40	186
TSS	663528	1539566	901941	277593	1620659	244997	380405	498008	109838	101927	278434	246535	68101	69108	237	3500

Note:
Loads calculated using the simple method (Schueler 1987) with NPDES Stormwater Discharge Characterization for Hillsborough County (1993) and Pinellas County (1993).
Annual Rainfall (in/yr) 51.4

Table A-3.
Summary of PCS data for Permitted Surface Water Discharges of COCs
Upper Hillsborough and Boca Ciega Bay Sub-Basins[(1)]

NPID	Basin	Facility	Outfall	Parameter	MQMX _AVG (MGD)	LQXS	MCMX _AVG (mg/l)	LCXS	Annual Load (lbs/yr)	Comments
FL0000647	9	TRADEMARK	0011	Flow	1.22E-01	DAILY MX			--	
		NITROGEN CORP	0011	Cr			6.00E-03	DAILY MX	1.7	
		013193 - 123195								
FL0039241	9	HILLSBOROUGH	0011	Flow	4.35E-02	DAILY MX			--	
		DEPT OF SOLID WST	001Q	O&G			6.39E+00	DAILY MX	847	
		013193 - 123195	0021	Flow	4.13E-02	DAILY MX			--	
			002Q	O&G			2.20E+01	DAILY MX	2764	
FL0000809	11	TAMPA ELEC-	0031	Flow	1.15E-02	DAILY MX			--	
		GANNON STEAM	0031	Cu			6.53E-01	DAILY MX	20	
		013189 - 123195	0032	Flow	1.31E-02	DAILY MX			--	
			0032	Cu			3.07E-01	DAILY MX	10	
			0033	Flow	2.81E-02	DAILY MX			--	
			0033	Cu			6.13E-02	DAILY MX	3.4	
			0034	Flow	1.59E-02	DAILY MX			--	
			0034	Cu			5.07E-01	DAILY MX	19	
			0035	Flow	2.41E-02	DAILY MX			--	
			0035	Cu			9.50E-02	DAILY MX	6.0	
			0036	Flow	1.55E-02	DAILY MX			--	
			0036	Cu			6.51E-02	DAILY MX	2.7	
			0036	O&G			5.00E+00	DAILY MX	204	
			0041	Flow	8.69E+00	DAILY MX			--	
			0041	Cr			1.89E-01	DAILY MX	3651	
			0041	Cu			1.93E-02	DAILY MX	373	
			0041	Ni			2.75E-02	DAILY MX	531	
				Flow						Ave flow for 0031-36
			0051	Cr			1.64E-01	DAILY MX	7.1	
			0051	Cu			9.47E-02	DAILY MX	4.1	
			0052	Cr			2.27E-01	DAILY MX	10	
			0052	Cu			9.88E-02	DAILY MX	4.3	
			0053	Cr			3.73E-01	DAILY MX	16	
			0053	Cu			1.06E-01	DAILY MX	4.6	
			0054	Cr			2.71E-01	DAILY MX	12	
			0054	Cu			1.32E-01	DAILY MX	5.7	
			0055	Cr			2.63E-01	DAILY MX	11	
			0055	Cu			1.09E-01	DAILY MX	4.7	

Table A-3.
Summary of PCS data for Permitted Surface Water Discharges of COCs
Upper Hillsborough and Boca Ciega Bay Sub-Basins[(1)]

NPID	Basin	Facility	Outfall	Parameter	MQMX _AVG (MGD)	LQXS	MCMX _AVG (mg/l)	LCXS	Annual Load (lbs/yr)	Comments
FL0000531	13	CITGO PETROLEUM TAMPA TERMINAL 013193 - 123195	0011	Flow	7.33E-01	DAILY MX			--	
			0011	O&G			3.84E+00	DAILY MX	23	Hydrostat test
			0021	Flow	9.52E-01	DAILY MX			--	
			0021	O&G			7.15E+00	DAILY MX	57	Hydrostat test
FL0001384	13	STAR ENTERPRISE 013193 - 123195	0011	Flow	6.83E-02	DAILY MX			--	
			0011	O&G			6.67E-01	DAILY MX	139	
FL0001627	13	AMOCO OIL-TAMPA 013193 - 123196	0011	Flow	5.12E-01	DAILY MX			--	
			0011	O&G			7.25E+00	DAILY MX	1929	
			001Q	Cu			5.43E-03	DAILY MX	1.4	
			001Q	Naphthalene			9.17E-04	DAILY MX	0.24	
			0021	Flow	1.00E-03	DAILY MX			--	
			0021	O&G			5.00E+00	DAILY MX	15	
			002Q	Cu			8.82E-03	DAILY MX	0.03	
FL0020940	13	TAMPA-HOOKER'S POINT WWTP 013189 - 123195	0011	Flow	1.11E+02	DAILY MX			NA	
			0011	Flow	5.67E+01	MO AVG			--	
			0011	Hg			1.10E-03	DAILY MX	--	one detection in 1994
			0011	Ni			6.46E-03	DAILY MX	1114	annual ave flow
			0021	Flow	2.12E+00	DAILY MX			NA	
			0021	Flow	2.04E-01	MO AVG			--	
			0021	Hg			1.10E-03	DAILY MX	--	one detection in 1994
			0021	Ni			6.82E-03	DAILY MX	6.7	annual ave flow
			0031	Flow	4.37E+00	DAILY MX			NA	
			0031	Flow	4.05E-01	MO AVG			--	
			0031	Hg			1.10E-03	DAILY MX	--	one detection in 1994
			0031	Ni			6.70E-03	DAILY MX	8.1	annual ave flow

Table A-3.
Summary of PCS data for Permitted Surface Water Discharges of COCs
Upper Hillsborough and Boca Ciega Bay Sub-Basins(1)

NPID	Basin	Facility	Outfall	Parameter	MQMX _AVG (MGD)	LQXS	MCMX _AVG (mg/l)	LCXS	Annual Load (lbs/yr)	Comments
FL0032425	13	MURPHY OIL CORP	0011	Flow	1.77E+01	DAILY MX			--	
		013193 - 123195	0011	O&G			8.20E-01	DAILY MX	121	Hydrostat test
			0021	Flow	1.03E+01	DAILY MX			--	
			0021	O&G			5.50E+00	DAILY MX	471	Hydrostat test
			0031	Flow	3.55E+01	DAILY MX			--	
			0031	O&G			5.60E+00	DAILY MX	1658	Hydrostat test
			0041	Flow	1.70E+01	DAILY MX			--	
			0041	O&G			5.00E+00	DAILY MX	710	Hydrostat test
FL0037702	13	MARATHON OIL-	0011	Flow	1.79E-01	DAILY MX			--	
		TAMPA TERMINAL	0011	O&G			1.41E+00	DAILY MX	766	
		013193 - 123195	0021	Flow	1.01E-01	DAILY MX			--	
			0021	O&G			1.14E+00	DAILY MX	350	
			0031	Flow	1.26E-02	DAILY MX			--	
			0031	O&G			1.08E+00	DAILY MX	0.1	
FL0034622	13	AMERADA HESS CORP.-	A	Flow	5.80E-02	DAILY MX			--	
		TAMPA TERM		O&G			5.00E-01	DAILY MAX	0.2	
		110195-090196	B	Flow	1.34E-01	DAILY MX			--	
				O&G			5.00E-01	DAILY MAX	0.2	
			C	Flow	3.10E-02	DAILY MX			--	
				O&G			5.00E-01	DAILY MAX	0.2	
			D	Flow	1.40E-02	DAILY MX			--	
				O&G			5.00E-01	DAILY MAX	0.2	
	13	GATX Tampa Terminal		Flow	1.20E-02	DAILY MX			--	Hydrostat test - max flow
				O&G			1.20E+00	DAILY MAX	0.1	estimated as total discharge/365

BOCA CIEGA

FL000110170	2	EWELL INDUSTRIES	001	Flow	8.90E-02	MO MAX			--	
		110191 - 060195		O&G			4.76E+00	MO MX	766	

Note:

1. All facility data reported for detected COCs from USEPA Region IV database (1997) except Amerada Hess Corp., GATX, and Ewell Industries Inc.data from FDEP GMS database.

Daily maximum flow used only if daily average flow not reported.

Daily maximum concentrations used because average values (daily, monthly, or annual) were not reported for most facilities.

Annual load for discharge during hydrostat tests based on one test per year.

Table A-4.
PCS Data for Facilities in Priority Sub-Basins - Upper Hillsborough Bay
Source: USEPA Region IV

NPID	Basin	FNMS	VDSG	Parameter	MQAV_AVG (MGD)	LQAS	MQMX_AVG (MGD)	LQXS	MCAV AVG	LCAS	MCMX_AVG (mg/l)	LCXS	Annual Load (lbs/yr)	Comments
FL0000647	9	TRADEMARK	0011	Flow	9.20E-02	DAILY AV	1.22E-01	DAILY MX					--	
		NITROGEN CORP	0011	Cr							6.00E-03	DAILY MX	1.7	
		013193 - 123195	0011	TSS					1.26E+00	DAILY AV	3.29E+00	DAILY MX	921	
FL0039241	9	HILLSBOROUGH	0011	Flow	NR	MO AVG	4.35E-02	DAILY MX					--	
		DEPT OF SOLID WST	001Q	O&G						MO AVG	6.39E+00	DAILY MX	847	
		013193 - 123195	0021	Flow		MO AVG	4.13E-02	DAILY MX					--	
			002Q	O&G						MO AVG	2.20E+01	DAILY MX	2764	
FL0000809	11	TAMPA ELEC-	0031	Flow	1.02E-02	DAILY AV	1.15E-02	DAILY MX					--	
		GANNON STEAM	0031	Cu					3.37E-01	DAILY AV	6.53E-01	DAILY MX	20	
		013189 - 123195	0031	TSS					6.50E+00	DAILY AV	1.08E+01	DAILY MX	333	
			0032	Flow	1.07E-02	DAILY AV	1.31E-02	DAILY MX					--	
			0032	Cu					7.30E-02	DAILY AV	3.07E-01	DAILY MX	10	
			0033	Flow	1.80E-02	DAILY AV	2.81E-02	DAILY MX					--	
			0033	Cu					2.55E-02	DAILY AV	6.13E-02	DAILY MX	3.4	
			0033	TSS					5.50E+00	DAILY AV	7.00E+00	DAILY MX	385	
			0034	Flow	1.25E-02	DAILY AV	1.59E-02	DAILY MX					--	
			0034	Cu					3.08E-01	DAILY AV	5.07E-01	DAILY MX	19	
			0034	TSS					6.33E+00	DAILY AV	9.83E+00	DAILY MX	374	
			0035	Flow	2.06E-02	DAILY AV	2.41E-02	DAILY MX					--	
			0035	Cu					4.58E-02	DAILY AV	9.50E-02	DAILY MX	6.0	
			0035	TSS					6.00E+00	DAILY AV	8.00E+00	DAILY MX	503	
			0036	Flow	1.34E-02	DAILY AV	1.55E-02	DAILY MX					--	
			0036	Cu					3.25E-02	DAILY AV	6.51E-02	DAILY MX	2.7	
			0036	O&G					5.00E+00	DAILY AV	5.00E+00	DAILY MX	204	
			0036	TSS					4.00E+00	DAILY AV	5.00E+00	DAILY MX	204	
			0041	Flow	6.34E+00	30DA AVG	8.69E+00	DAILY MX					--	
			0041	As					7.36E-02	30DA AVG	7.73E-02	DAILY MX	1491	
			0041	Cd					8.21E-02	30DA AVG	7.60E-02	DAILY MX	1467	
			0041	Cr					1.82E-01	30DA AVG	1.89E-01	DAILY MX	3651	
			0041	Cu					1.88E-02	30DA AVG	1.93E-02	DAILY MX	373	
			0041	Pb						30DA AVG	2.62E-01	DAILY MX	5048	
			0041	Ni						30DA AVG	2.75E-02	DAILY MX	531	
			0041	TSS					2.14E+00	30DA AVG	7.01E+00	DAILY MX	135325	
				Flow	1.42E-02	DAILY AV								Ave flow for 0031-36
			0051	As							1.15E-01	DAILY MX	5.0	
			0051	Cd							2.52E-01	DAILY MX	11	
			0051	Cr							1.64E-01	DAILY MX	7.1	
			0051	Cu							9.47E-02	DAILY MX	4.1	
			0051	Pb							2.73E-01	DAILY MX	12	
			0052	As						30DA AVG	1.14E-01	DAILY MX	5.0	
			0052	Cd						30DA AVG	1.28E-01	DAILY MX	5.6	

Table A-4.
PCS Data for Facilities in Priority Sub-Basins - Upper Hillsborough Bay
Source: USEPA Region IV

NPID	Basin	FNMS	VDSG	Parameter	MQAV _AVG (MGD)	LQAS	MQMX _AVG (MGD)	LQXS	MCAV _AVG	LCAS	MCMX _AVG (mg/l)	LCXS	Annual Load (lbs/yr)	Comments
FL0000809	11	TAMPA ELEC-	0052	Cr						30DA AVG	2.27E-01	DAILY MX	10	
		GANNON STEAM	0052	Cu						30DA AVG	9.88E-02	DAILY MX	4.3	
		013189 - 123195	0052	Pb						30DA AVG	3.47E-01	DAILY MX	15	
			0053	As						30DA AVG	1.27E-01	DAILY MX	5.5	
			0053	Cd						30DA AVG	1.29E-01	DAILY MX	5.6	
			0053	Cr						30DA AVG	3.73E-01	DAILY MX	16	
			0053	Cu						30DA AVG	1.06E-01	DAILY MX	4.6	
			0053	Pb						30DA AVG	3.38E-01	DAILY MX	15	
			0054	As						30DA AVG	1.28E-01	DAILY MX	5.6	
			0054	Cd						30DA AVG	1.69E-01	DAILY MX	7.3	
			0054	Cr						30DA AVG	2.71E-01	DAILY MX	12	
			0054	Cu						30DA AVG	1.32E-01	DAILY MX	5.7	
			0054	Pb						30DA AVG	3.41E-01	DAILY MX	15	
			0055	As						30DA AVG	1.14E-01	DAILY MX	4.9	
			0055	Cd						30DA AVG	3.36E-01	DAILY MX	15	
			0055	Cr						30DA AVG	2.63E-01	DAILY MX	11	
			0055	Cu						30DA AVG	1.09E-01	DAILY MX	4.7	
			0055	Pb						30DA AVG	3.37E-01	DAILY MX	15	
			005A	Flow	9.83E+02	DAILY AV	1.18E+03	INST MAX					--	
			005A	TSS					8.06E+00	DAILY AV	2.98E+01	INST MAX	89335242	
			0061	Flow	NR	DAILY AV	3.00E+00	DAILY MX					--	
			0061	TSS							3.00E+00	INST MAX	27413	
FL0038652	12	FARMLAND HYDRO L.P.	0011	Flow	1.74E+00	MO AVG	1.99E+00	DAILY MX					NA	
		013193 - 123195												
FL0000264	12	IMC-AGRICO CO -	0011	Flow	3.67E+02	DAILY AV	4.67E+00	DAILY MX					--	
		PORT SUTTON	0011	TSS					2.36E+01	DAILY AV	3.38E+01	DAILY MX	37789598	
		013192 - 123195	0041	Flow	5.70E-02	DAILY AV	1.77E+00	DAILY MX					--	
			0041	TSS					3.30E+00	DAILY AV	3.30E+00	DAILY MX	573	
			0061	Flow	NR	DAILY AV	7.20E-03	DAILY MX					--	
			0061	TSS					1.20E+01	DAILY AV	1.20E+01	DAILY MX	263	
FL0001643	12	NITRAM CHEM TAMPA	0011	Flow	4.93E-01		3.99E-01	DAILY MX					NA	
		013189 - 123195												
FL0000531	13	CITGO PETROLEUM	0011	Flow	NR	MO AVG	7.33E-01	DAILY MX					--	
		TAMPA TERMINAL	0011	Pb						MO AVG	1.25E-03	DAILY MX	0.01	Hydrostat test
		013193 - 123195	0011	O&G						MO AVG	3.84E+00	DAILY MX	23	
			0021	Flow	NR	MO AVG	9.52E-01	DAILY MX					--	
			0021	Pb						MO AVG	7.60E-04	DAILY MX	0.01	Hydrostat test
			0021	O&G						MO AVG	7.15E+00	DAILY MX	57	
			0031	Flow	NR		1.10E+00	MAXIMUM					--	
			0031	Pb							8.50E-04	MAXIMUM	0.01	Hydrostat test

Table A-4.
PCS Data for Facilities in Priority Sub-Basins - Upper Hillsborough Bay
Source: USEPA Region IV

NPID	Basin	FNMS	VDSG	Parameter	MQAV _AVG (MGD)	LQAS	MQMX _AVG (MGD)	LQXS	MCAV _AVG	LCAS	MCMX _AVG (mg/l)	LCXS	Annual Load (lbs/yr)	Comments
FL0000825	13	TAMPA ELEC-	003A	Flow	1.57E+02	MO AVG	2.22E+02	DAILY MX					NA	
		HOOKERS POINT STEAM												
		013195 - 123195												
FL0001384	13	STAR ENTERPRISE	0011	Flow	NR	DAILY AV	6.83E-02	DAILY MX					--	
		013193 - 123195	0011	Pb						MO AVG	5.01E-03	DAILY MX	1.0	
			0011	O&G						MO AVG	6.67E-01	DAILY MX	139	
FL0001627	13	AMOCO OIL-TAMPA	0011	Flow	8.74E-02	DAILY AV	5.12E-01	DAILY MX					--	
		013193 - 123196	0011	O&G							7.25E+00	DAILY MX	1929	
			001Q	BTEX							2.99E-03	DAILY MX	0.8	
			001Q	Cu							5.43E-03	DAILY MX	1.4	
			001Q	Pb							4.94E-03	DAILY MX	1.3	
			001Q	Naphthalene							9.17E-04	DAILY MX	0.24	
			001Q	Zn							3.59E-02	DAILY MX	10	
			0021	Flow	1.00E-03	DAILY AV	1.00E-03	DAILY MX					--	
			0021	O&G							5.00E+00	DAILY MX	15	
			002Q	Cu							8.82E-03	DAILY MX	0.03	
			002Q	Pb							1.21E-02	DAILY MX	0.04	
			002Q	Zn							3.86E-02	DAILY MX	0.12	
FL0034622	13	AMERADA HESS CORP.-	0011	Flow			7.92E-02	DAILY MX					NA	
		TAMPA TERM	0021	Flow			7.92E-02	DAILY MX					NA	
		013193 - 033196	0031	Flow			7.92E-02	DAILY MX					NA	
			0041	Flow			7.92E-02	DAILY MX					NA	
			0051	Flow			7.92E-02	DAILY MX					NA	
			0061	Flow			7.92E-02	DAILY MX					NA	
			0071	Flow			2.88E-02	DAILY MX					NA	
			0081	Flow			7.92E-02	DAILY MX					NA	
FL0037702	13	MARATHON OIL-	0011	Flow			1.79E-01	DAILY MX					--	
		TAMPA TERMINAL	0011	O&G							1.41E+00	DAILY MX	766	
		013193 - 123195	0021	Flow			1.01E-01	DAILY MX					--	
			0021	O&G							1.14E+00	DAILY MX	350	
			0031	Flow			1.26E-02	DAILY MX					--	
			0031	O&G							1.08E+00	DAILY MX	0.1	Hydrostat test
FL0020940	13	TAMPA-HOOKER'S	0011	Flow	1.06E+02	WKLY AVG	1.11E+02	DAILY MX					NA	
		POINT WWTP	0011	Flow	5.66E+01	ANNL AVG	5.67E+01	MO AVG					--	
		013189 - 123195	0011	Pb							1.00E-03	DAILY MX	172	annual ave flow
			0011	Hg							1.10E-03	DAILY MX	--	one detection in 1994
			0011	Ni							6.46E-03	DAILY MX	1114	annual ave flow
			0011	Ag							5.50E-04	DAILY MX	95	annual ave flow
			0011	TSS	7.93E+02		9.96E+02		1.74E+00	MO AVG	2.21E+00	WKLY AVG	381847	annual ave flow
			0011	TSS					1.72E+00	ANNL AVG			--	
			0011	Zn							1.38E-02	DAILY MX	2374	

Table A-4.
PCS Data for Facilities in Priority Sub-Basins - Upper Hillsborough Bay
Source: USEPA Region IV

NPID	Basin	FNMS	VDSG	Parameter	MQAV _AVG (MGD)	LQAS	MQMX _AVG (MGD)	LQXS	MCAV AVG	LCAS	MCMX _AVG (mg/l)	LCXS	Annual Load (lbs/yr)	Comments
FL0020940	13	TAMPA-HOOKER'S POINT WWTP 013189 - 123195	0021	Flow	5.40E-01	WKLY AVG	2.12E+00	DAILY MX					NA	
			0021	Flow	3.21E-01	ANNL AVG	2.04E-01	MO AVG					--	
			0021	Pb							1.00E-03	DAILY MX	1.0	annual ave flow
			0021	Hg							1.10E-03	DAILY MX	--	one detection in 1994
			0021	Ni							6.82E-03	DAILY MX	6.7	annual ave flow
			0021	TSS							9.00E-04	DAILY MX	0.9	annual ave flow
			0021	TSS					1.86E+00	MO AVG	2.34E+00	WKLY AVG	2285	annual ave flow
			0021	Zn							1.57E-02	DAILY MX	15	
			0031	Flow	1.34E+00	WKLY AVG	4.37E+00	DAILY MX					NA	
			0031	Flow	3.95E-01	ANNL AVG	4.05E-01	MO AVG					--	
			0031	Pb							1.00E-03	DAILY MX	1.2	annual ave flow
			0031	Hg							1.10E-03	DAILY MX	--	one detection in 1994
			0031	Ni							6.70E-03	DAILY MX	8.1	annual ave flow
			0031	Ag							9.00E-04	DAILY MX	1.1	annual ave flow
			0031	TSS					1.86E+00	MO AVG	2.34E+00	WKLY AVG	2812	annual ave flow
			0031	Zn							1.57E-02	DAILY MX	19	annual ave flow
FL0032425	13	MURPHY OIL CORP 013193 - 123195	0011	Flow			1.77E+01	DAILY MX					--	
			0011	Pb							5.41E-03	DAILY MX	292	
			0011	O&G							8.20E-01	DAILY MX	44294	
			0011	Zn							8.96E-02	DAILY MX	4840	
			0021	Flow			1.03E+01	DAILY MX					--	
			0021	Pb							7.43E-03	DAILY MX	232	
			0021	O&G							5.50E+00	DAILY MX	171754	
			0021	Zn							6.22E-02	DAILY MX	1943	
			0031	Flow			3.55E+01	DAILY MX					--	
			0031	Pb							5.71E-03	DAILY MX	617	
			0031	O&G							5.60E+00	DAILY MX	605118	
			0031	Zn							3.53E-02	DAILY MX	3816	
			0041	Flow			1.70E+01	DAILY MX					--	
			0041	Pb							1.35E-02	DAILY MX	699	
			0041	O&G							5.00E+00	DAILY MX	259006	
			0041	Zn							6.02E-02	DAILY MX	3119	
			0051	Flow			2.30E+01	DAILY MX					--	
			0051	Pb							8.83E-03	DAILY MX	619	
			0051	Zn							3.58E-02	DAILY MX	2511	

Note:
Daily maximum flow used only if daily average flow not reported.
Daily maximum concentrations used because average values (daily, monthly, or annual) were not reported for most facilities.

Table A-5.
Bulk Deposition Rates for Atmospheric Pollutants Detected at Hillsborough and Pinellas County Stations[1]

Chemical	Hillsborough Co. g/ha/yr	Hillsborough Co. kg/ac/yr	Pinellas Co. g/ha/yr	Pinellas Co. kg/ac/yr
Metals				
aluminum	472.7	1.17E+00	539.2	1.33E+00
copper	9.2	2.27E-02	8.0	1.97E-02
lead	10.6	2.62E-02	7.0	1.73E-02
zinc	113.8	2.81E-01	101.9	2.52E-01

Chemical	Hillsborough Co. $ng/m^2/0.25$ yr	Hillsborough Co. kg/ac/yr	Pinellas Co. $ng/m^2/0.25$ yr	Pinellas Co. kg/ac/yr
Pesticides				
a bhc	nd	--	71	1.58E-07
d bhc	83	1.85E-07	213	4.75E-07
aldrin	nd	--	62	1.38E-07
chloripyriphos	nd	nd	360	8.03E-07
endosulfan 1	259	5.78E-07	nd	--
endosulfan 2	304	6.78E-07	nd	--
heptachlor epoxide	nd	--	107	2.39E-07
PAHs				
benzo(a)anthracene	nd	--	2	4.46E-09
benzo(a)pyrene	nd	--	2	4.46E-09
benzo(b)fluoranthene	5	1.12E-08	24	5.35E-08
benzo(g,h,i)perylene	nd	--	5	1.12E-08
benzo(h)fluoranthene	nd	--	22	4.91E-08
fluoranthene	6	1.34E-08	30	6.69E-08
indeno(1,2,3)pyrene	nd	--	9	2.01E-08
phenanthrene	nd	--	1	2.23E-09
pyrene	2	4.46E-09	22	4.91E-08
PCBs				
PCB congener #153	81	1.81E-07	63	1.41E-07

Note:

Bulk deposition data were obtained from Dixon et al. 1996.

Stations 1 and 4 were used corresponding to Boca Ciega Bay and Upper Hillsborough Bay, respectively.

To estimate loadings, reported mean values were used for trace metals, and reported 3 month totals were used for organics.

The estimated percentage for runoff to the estuary was 10%.

Table A-6.
Estimated Atmospheric Loading Rates (lb/yr)
Upper Hillsborough and Boca Ciega Bay Drainage Basins

Chemical	Upper Hillsborough Bay Sub-Basin No.															Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
total area (acres)	3376	11580	5372	11640	5608	992	6961	4007	2677	641	8580	1054	1588	536	796	
Metals																
aluminum	3.9E+02	1.4E+03	6.3E+02	1.4E+03	6.6E+02	1.2E+02	8.1E+02	4.7E+02	3.1E+02	7.5E+01	1.0E+03	1.2E+02	1.9E+02	6.3E+01	9.3E+01	7.6E+03
copper	7.7E+00	2.6E+01	1.2E+01	2.6E+01	1.3E+01	2.2E+00	1.6E+01	9.1E+00	6.1E+00	1.5E+00	1.9E+01	2.4E+00	3.6E+00	1.2E+00	1.8E+00	1.5E+02
lead	8.8E+00	3.0E+01	1.4E+01	3.0E+01	1.5E+01	2.6E+00	1.8E+01	1.0E+01	7.0E+00	1.7E+00	2.2E+01	2.8E+00	4.2E+00	1.4E+00	2.1E+00	1.7E+02
zinc	9.5E+01	3.3E+02	1.5E+02	3.3E+02	1.6E+02	2.8E+01	2.0E+02	1.1E+02	7.5E+01	1.8E+01	2.4E+02	3.0E+01	4.5E+01	1.5E+01	2.2E+01	1.8E+03
Pesticides																
d bhc	1.1E-04	3.9E-04	1.8E-04	3.9E-04	1.9E-04	3.3E-05	2.3E-04	1.3E-04	9.0E-05	2.2E-05	2.9E-04	3.5E-05	5.3E-05	1.8E-05	2.7E-05	0.0E+00
endosulfan 1	3.5E-04	1.2E-03	5.6E-04	1.2E-03	5.9E-04	1.0E-04	7.3E-04	4.2E-04	2.8E-04	6.7E-05	9.0E-04	1.1E-04	1.7E-04	5.6E-05	8.3E-05	0.0E+00
endosulfan 2	4.2E-04	1.4E-03	6.6E-04	1.4E-03	6.9E-04	1.2E-04	8.6E-04	4.9E-04	3.3E-04	7.9E-05	1.1E-03	1.3E-04	2.0E-04	6.6E-05	9.8E-05	0.0E+00
PCBs																
PCB congener #153	1.1E-04	3.8E-04	1.8E-04	3.8E-04	1.8E-04	3.3E-05	2.3E-04	1.3E-04	8.8E-05	2.1E-05	2.8E-04	3.5E-05	5.2E-05	1.8E-05	2.6E-05	0.0E+00
PAHs																
benzo(b)fluoranthene	6.8E-03	2.3E-02	1.1E-02	2.4E-02	1.1E-02	2.0E-03	1.4E-02	8.1E-03	5.4E-03	1.3E-03	1.7E-02	2.1E-03	3.2E-03	1.1E-03	1.6E-03	0.0E+00
fluoranthene	8.2E-03	2.8E-02	1.3E-02	2.8E-02	1.4E-02	2.4E-03	1.7E-02	9.7E-03	6.5E-03	1.6E-03	2.1E-02	2.6E-03	3.9E-03	1.3E-03	1.9E-03	0.0E+00
pyrene	2.7E-03	9.4E-03	4.3E-03	9.4E-03	4.5E-03	8.0E-04	5.6E-03	3.2E-03	2.2E-03	5.2E-04	6.9E-03	8.5E-04	1.3E-03	4.3E-04	6.4E-04	0.0E+00

Note:

Bulk Deposition of the listed chemicals was obtained from the Assessment of Bulk Atmospheric Deposition to the Tampa Bay Watershed

Stations 1 and 4 were used corresponding to Boca Ciega Bay and Upper Hillsborough Bay

Mean values for trace metals were used and total samping values over 3 months for the other chemicals were used to calc loadings

The estimated percentage to runoff into the estuary was 10%.

Table A-6.
Estimated Atmospheric Loading Rates (lb/yr)
Upper Hillsborough and Boca Ciega Bay Drainage Basins

Chemical	Boca Ciega Bay Sub-Basin No.															Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
total area (acres)	3935	6771	4108	1918	9538	2463	1940	3737	1091	1621	829	1493	771	1073	844	
Metals																
aluminum	4.6E+02	7.9E+02	4.8E+02	2.2E+02	1.1E+03	2.9E+02	2.3E+02	4.4E+02	1.3E+02	1.9E+02	9.7E+01	1.7E+02	9.0E+01	1.3E+02	9.9E+01	4.9E+03
copper	8.9E+00	1.5E+01	9.3E+00	4.4E+00	2.2E+01	5.6E+00	4.4E+00	8.5E+00	2.5E+00	3.7E+00	1.9E+00	3.4E+00	1.7E+00	2.4E+00	1.9E+00	9.6E+01
lead	1.0E+01	1.8E+01	1.1E+01	5.0E+00	2.5E+01	6.5E+00	5.1E+00	9.8E+00	2.9E+00	4.2E+00	2.2E+00	3.9E+00	2.0E+00	2.8E+00	2.2E+00	1.1E+02
zinc	1.1E+02	1.9E+02	1.2E+02	5.4E+01	2.7E+02	6.9E+01	5.5E+01	1.1E+02	3.1E+01	4.6E+01	2.3E+01	4.2E+01	2.2E+01	3.0E+01	2.4E+01	1.2E+03
Pesticides																
aldrin	9.9E-05	1.7E-04	1.0E-04	4.8E-05	2.4E-04	6.2E-05	4.9E-05	9.4E-05	2.7E-05	4.1E-05	2.1E-05	3.7E-05	1.9E-05	2.7E-05	2.1E-05	0.0E+00
a bhc	1.1E-04	1.9E-04	1.2E-04	5.5E-05	2.7E-04	7.1E-05	5.6E-05	1.1E-04	3.1E-05	4.7E-05	2.4E-05	4.3E-05	2.2E-05	3.1E-05	2.4E-05	0.0E+00
d bhc	3.4E-04	5.8E-04	3.5E-04	1.7E-04	8.2E-04	2.1E-04	1.7E-04	3.2E-04	9.4E-05	1.4E-04	7.1E-05	1.3E-04	6.6E-05	9.3E-05	7.3E-05	0.0E+00
chloripyriphos	5.7E-04	9.9E-04	6.0E-04	2.8E-04	1.4E-03	3.6E-04	2.8E-04	5.4E-04	1.6E-04	2.4E-04	1.2E-04	2.2E-04	1.1E-04	1.6E-04	1.2E-04	0.0E+00
heptachlor epoxide	1.7E-04	2.9E-04	1.8E-04	8.3E-05	4.1E-04	1.1E-04	8.4E-05	1.6E-04	4.7E-05	7.0E-05	3.6E-05	6.5E-05	3.3E-05	4.6E-05	3.7E-05	0.0E+00
PCBs																
PCB congener #153	1.0E-04	1.7E-04	1.0E-04	4.9E-05	2.4E-04	6.3E-05	4.9E-05	9.5E-05	2.8E-05	4.1E-05	2.1E-05	3.8E-05	2.0E-05	2.7E-05	2.2E-05	0.0E+00
PAHs																
benzo(a)anthracene	3.2E-03	5.5E-03	3.3E-03	1.6E-03	7.7E-03	2.0E-03	1.6E-03	3.0E-03	8.8E-04	1.3E-03	6.7E-04	1.2E-03	6.2E-04	8.7E-04	6.8E-04	0.0E+00
benzo(a)pyrene	3.2E-03	5.5E-03	3.3E-03	1.6E-03	7.7E-03	2.0E-03	1.6E-03	3.0E-03	8.8E-04	1.3E-03	6.7E-04	1.2E-03	6.2E-04	8.7E-04	6.8E-04	0.0E+00
benzo(b)fluoranthene	3.8E-02	6.6E-02	4.0E-02	1.9E-02	9.3E-02	2.4E-02	1.9E-02	3.6E-02	1.1E-02	1.6E-02	8.0E-03	1.4E-02	7.5E-03	1.0E-02	8.2E-03	0.0E+00
benzo(g,h,i)perylene	8.0E-03	1.4E-02	8.3E-03	3.9E-03	1.9E-02	5.0E-03	3.9E-03	7.6E-03	2.2E-03	3.3E-03	1.7E-03	3.0E-03	1.6E-03	2.2E-03	1.7E-03	0.0E+00
benzo(h)fluoranthene	3.5E-02	6.0E-02	3.7E-02	1.7E-02	8.5E-02	2.2E-02	1.7E-02	3.3E-02	9.7E-03	1.4E-02	7.4E-03	1.3E-02	6.9E-03	9.6E-03	7.5E-03	0.0E+00
fluoranthene	4.8E-02	8.2E-02	5.0E-02	2.3E-02	1.2E-01	3.0E-02	2.4E-02	4.5E-02	1.3E-02	2.0E-02	1.0E-02	1.8E-02	9.4E-03	1.3E-02	1.0E-02	0.0E+00
indeno(1,2,3)pyrene	1.4E-02	2.5E-02	1.5E-02	7.0E-03	3.5E-02	9.0E-03	7.1E-03	1.4E-02	4.0E-03	5.9E-03	3.0E-03	5.4E-03	2.8E-03	3.9E-03	3.1E-03	0.0E+00
phenanthrene	1.6E-03	2.7E-03	1.7E-03	7.8E-04	3.9E-03	1.0E-03	7.8E-04	1.5E-03	4.4E-04	6.6E-04	3.4E-04	6.0E-04	3.1E-04	4.3E-04	3.4E-04	0.0E+00
pyrene	3.5E-02	6.0E-02	3.7E-02	1.7E-02	8.5E-02	2.2E-02	1.7E-02	3.3E-02	9.7E-03	1.4E-02	7.4E-03	1.3E-02	6.9E-03	9.6E-03	7.5E-03	0.0E+00

Note:

Bulk Deposition of the listed chemicals was obtained from the Assessment of Bulk Atmospheric Deposition to the Tampa Bay Watershed

Stations 1 and 4 were used corresponding to Boca Ciega Bay and Upper Hillsborough Bay

Mean values for trace metals were used and total samping values over 3 months for the other chemicals were used to calc loadings

The estimated percentage to runoff into the estuary was 10%.

Table A-7.
Summary of TRI Releases 1987-1993 for Facilities within Sub-Basins - Boca Ciega Basin

Sub-Basin	Map-ID	Facility	Year	Chemical	Releases (lbs/yr)[1]			
					FUGIT-AIR	STACK-AIR	TOTAL-AIR	UNDGND
1	801	BAXTER HEALTHCARE CORP.	1987			0	0	0
1	801	BAXTER HEALTHCARE CORP.	1988	FREON 113, chromium* (transfe	76131	850	0	850
1	801	BAXTER HEALTHCARE CORP.	1989	FREON 113, chromium* (transfe	76131	2177	0	2177
1	801	BAXTER HEALTHCARE CORP.	1990			0	0	0
1	801	BAXTER HEALTHCARE CORP.	1991			0	0	0
1	801	BAXTER HEALTHCARE CORP.	1992			0	0	0
1	801	BAXTER HEALTHCARE CORP.	1993			0	0	0
1	811	DORA SUPPLY CO. INC.	1987			0	0	0
1	811	DORA SUPPLY CO. INC.	1988			0	0	0
1	811	DORA SUPPLY CO. INC.	1989			0	0	0
1	811	DORA SUPPLY CO. INC.	1990			0	0	0
1	811	DORA SUPPLY CO. INC.	1991			0	0	0
1	811	DORA SUPPLY CO. INC.	1992	GLYCOL ETHERS	N230	180	0	180
1	811	DORA SUPPLY CO. INC.	1993	GLYCOL ETHERS	N230	0	180	180
2	810	ADVA LITE INC.	1987			0	0	0
2	810	ADVA LITE INC.	1988			0	0	0
2	810	ADVA LITE INC.	1989			0	0	0
2	810	ADVA LITE INC.	1990			0	0	0
2	810	ADVA LITE INC.	1991	ACETONE	67641	9000	0	9000
2	810	ADVA LITE INC.	1992	ACETONE	67641	9050	0	9050
2	810	ADVA LITE INC.	1993	ACETONE	67641	9774	0	9774
2	797	ANVIL PAINT & COATINGS INC.	1987			0	0	0
2	797	ANVIL PAINT & COATINGS INC.	1988			0	0	0
2	797	ANVIL PAINT & COATINGS INC.	1989			0	0	0
2	797	ANVIL PAINT & COATINGS INC.	1990			0	0	0
2	797	ANVIL PAINT & COATINGS INC.	1991			0	0	0
2	797	ANVIL PAINT & COATINGS INC.	1992			0	0	0
2	797	ANVIL PAINT & COATINGS INC.	1993	BUTYL BENZYL PHTHALATE	85687	750	750	1500
2	795	BLUE DOLPHIN FIBERGLASS POOLS INC.	1987			0	0	0
2	795	BLUE DOLPHIN FIBERGLASS POOLS INC.	1988			0	0	0
2	795	BLUE DOLPHIN FIBERGLASS POOLS INC.	1989			0	0	0
2	795	BLUE DOLPHIN FIBERGLASS POOLS INC.	1990			0	0	0
2	795	BLUE DOLPHIN FIBERGLASS POOLS INC.	1991	ACETONE	67641	141466	0	141466
2	795	BLUE DOLPHIN FIBERGLASS POOLS INC.	1992	STYRENE	100425	41118	0	41118
2	795	BLUE DOLPHIN FIBERGLASS POOLS INC.	1993	ACETONE	67641	50694	0	50694
2	595	E-SYSTEMS INC. C. M. DIV.	1987			0	0	0
2	595	E-SYSTEMS INC. C. M. DIV.	1988	1,1,1-TRICHLOROETHANE	71556	26200	0	26200
2	595	E-SYSTEMS INC. C. M. DIV.	1989	1,1,1-TRICHLOROETHANE	71556	31900	0	31900
2	595	E-SYSTEMS INC. C. M. DIV.	1990	1,1,1-TRICHLOROETHANE	71556	30892	0	30892
2	595	E-SYSTEMS INC. C. M. DIV.	1991			0	0	0
2	595	E-SYSTEMS INC. C. M. DIV.	1992			0	0	0
2	595	E-SYSTEMS INC. C. M. DIV.	1993			0	0	0

Table A-7.
Summary of TRI Releases 1987-1993 for Facilities within Sub-Basins - Boca Ciega Basin

Sub-Basin	Map-ID	Facility	Year	Chemical	Releases (lbs/yr)[1]			
					FUGIT-AIR	STACK-AIR	TOTAL-AIR	UNDGND
2	612	E-SYSTEMS INC. C.M. DIV.	1987	1,1,1-TRICHLOROETHANE	71556	250	0	250
2	612	E-SYSTEMS INC. C.M. DIV.	1988	1,1,1-TRICHLOROETHANE	71556	27700	0	27700
2	612	E-SYSTEMS INC. C.M. DIV.	1989	1,1,1-TRICHLOROETHANE	71556	20900	0	20900
2	612	E-SYSTEMS INC. C.M. DIV.	1990	FREON 113	76131	29687	0	29687
2	612	E-SYSTEMS INC. C.M. DIV.	1991	FREON 113	76131	11000	0	11000
2	612	E-SYSTEMS INC. C.M. DIV.	1992			0	0	0
2	612	E-SYSTEMS INC. C.M. DIV.	1993			0	0	0
2	796	FIBRE TECH INC.	1987			0	0	0
2	796	FIBRE TECH INC.	1988			0	0	0
2	796	FIBRE TECH INC.	1989			0	0	0
2	796	FIBRE TECH INC.	1990			0	0	0
2	796	FIBRE TECH INC.	1991			0	0	0
2	796	FIBRE TECH INC.	1992			0	0	0
2	796	FIBRE TECH INC.	1993	STYRENE	100425	0	2360	2360
2	803	GRANUTEC INC.	1987	METHANOL	67561	0	22000	22000
2	803	GRANUTEC INC.	1988	METHANOL	67561	0	37647	37647
2	803	GRANUTEC INC.	1989	METHANOL	67561	0	46688	46688
2	803	GRANUTEC INC.	1990	METHANOL	67561	0	21583	21583
2	803	GRANUTEC INC.	1991			0	0	0
2	803	GRANUTEC INC.	1992			0	0	0
2	803	GRANUTEC INC.	1993			0	0	0
2	794	HENEFELT PRECISION PRODS. INC. INC.	1987			0	0	0
2	794	HENEFELT PRECISION PRODS. INC. INC.	1988	1,1,1-TRICHLOROETHANE	71556	8843	0	8843
2	794	HENEFELT PRECISION PRODS. INC. INC.	1989	1,1,1-TRICHLOROETHANE	71556	20344	0	20344
2	794	HENEFELT PRECISION PRODS. INC. INC.	1990	1,1,1-TRICHLOROETHANE	71556	22800	0	22800
2	794	HENEFELT PRECISION PRODS. INC. INC.	1991	1,1,1-TRICHLOROETHANE	71556	36592	0	36592
2	794	HENEFELT PRECISION PRODS. INC. INC.	1992	1,1,1-TRICHLOROETHANE	71556	37904	0	37904
2	794	HENEFELT PRECISION PRODS. INC. INC.	1993	1,1,1-TRICHLOROETHANE	71556	16253	0	16253
2	799	ISLAND PACKET YACHTS	1987			0	0	0
2	799	ISLAND PACKET YACHTS	1988	ACETONE	67641	37000	0	37000
2	799	ISLAND PACKET YACHTS	1989	ACETONE	67641	65000	0	65000
2	799	ISLAND PACKET YACHTS	1990	ACETONE	67641	56000	0	56000
2	799	ISLAND PACKET YACHTS	1991	ACETONE	67641	32000	0	32000
2	799	ISLAND PACKET YACHTS	1992	ACETONE	67641	33000	0	33000
2	799	ISLAND PACKET YACHTS	1993	ACETONE	67641	31000	0	31000
2	804	LINVATEC CORP.	1987			0	0	0
2	804	LINVATEC CORP.	1988	FREON 113	76131	750	0	750
2	804	LINVATEC CORP.	1989	FREON 113	76131	5500	0	5500
2	804	LINVATEC CORP.	1990	FREON 113	76131	14700	0	14700
2	804	LINVATEC CORP.	1991	FREON 113	76131	20500	0	20500
2	804	LINVATEC CORP.	1992	FREON 113	76131	23200	0	23200
2	804	LINVATEC CORP.	1993	FREON 113	76131	12100	0	12100

Table A-7.
Summary of TRI Releases 1987-1993 for Facilities within Sub-Basins - Boca Ciega Basin

Sub-Basin	Map-ID	Facility	Year	Chemical	Releases (lbs/yr)[1]			
					FUGIT-AIR	STACK-AIR	TOTAL-AIR	UNDGND
2	592	MOLEX-ETC INC.	1987	Copper*		0	0	0
2	592	MOLEX-ETC INC.	1988	Copper*		0	0	0
2	592	MOLEX-ETC INC.	1989	Copper*		0	0	0
2	592	MOLEX-ETC INC.	1990	Copper*		0	0	0
2	592	MOLEX-ETC INC.	1991	Copper*		0	0	0
2	592	MOLEX-ETC INC.	1992	Copper*		0	0	0
2	592	MOLEX-ETC INC.	1993	Copper*		0	0	0
2	800	SMITH & NEPHEW UNITED INC.	1987			0	0	0
2	800	SMITH & NEPHEW UNITED INC.	1988			0	0	0
2	800	SMITH & NEPHEW UNITED INC.	1989			0	0	0
2	800	SMITH & NEPHEW UNITED INC.	1990			0	0	0
2	800	SMITH & NEPHEW UNITED INC.	1991			0	0	0
2	800	SMITH & NEPHEW UNITED INC.	1992			0	0	0
2	800	SMITH & NEPHEW UNITED INC.	1993			0	0	0
2	807	SUN COATINGS	1987			0	0	0
2	807	SUN COATINGS	1988			0	0	0
2	807	SUN COATINGS	1989			0	0	0
2	807	SUN COATINGS	1990			0	0	0
2	807	SUN COATINGS	1991			0	0	0
2	807	SUN COATINGS	1992	VINYL ACETATE	108054	100	1502	1602
2	807	SUN COATINGS	1993	VINYL ACETATE	108054	5	1352	1357
2	593	TREDEGAR MOLDED PRODS.	1987	1,1,1-TRICHLOROETHANE	71556	5500	0	5500
2	593	TREDEGAR MOLDED PRODS.	1988	1,1,1-TRICHLOROETHANE	71556	10000	0	10000
2	593	TREDEGAR MOLDED PRODS.	1989	1,1,1-TRICHLOROETHANE	71556	7104	0	7104
2	593	TREDEGAR MOLDED PRODS.	1990	1,1,1-TRICHLOROETHANE	71556	7080	0	7080
2	593	TREDEGAR MOLDED PRODS.	1991			0	0	0
2	593	TREDEGAR MOLDED PRODS.	1992			0	0	0
2	593	TREDEGAR MOLDED PRODS.	1993			0	0	0
2	812	U.S. DOE PINELLAS PLANT MARTIN MARIETTA SPECIALI	1987	ACETONE	67641	1635	6541	8176
2	812	U.S. DOE PINELLAS PLANT MARTIN MARIETTA SPECIALI	1988	1,1,1-TRICHLOROETHANE	71556	2147	8587	10734
2	812	U.S. DOE PINELLAS PLANT MARTIN MARIETTA SPECIALI	1989	TRICHLOROETHYLENE	79016	2092	8368	10460
2	812	U.S. DOE PINELLAS PLANT MARTIN MARIETTA SPECIALI	1990	SULFURIC ACID	7664939	250	10000	10250
2	812	U.S. DOE PINELLAS PLANT MARTIN MARIETTA SPECIALI	1991	DICHLOROMETHANE	75092	5	10500	10505
2	812	U.S. DOE PINELLAS PLANT MARTIN MARIETTA SPECIALI	1992	1,1,1-TRICHLOROETHANE	71556	5	11000	11005
2	812	U.S. DOE PINELLAS PLANT MARTIN MARIETTA SPECIALI	1993	1,1,1-TRICHLOROETHANE	71556	0	8400	8400
2	806	UNIVERSAL CIRCUITS INC.	1987	SULFURIC ACID, Copper*	7664939	250	0	250
2	806	UNIVERSAL CIRCUITS INC.	1988	HYDROCHLORIC ACID, Coppe	7647010	250	0	250
2	806	UNIVERSAL CIRCUITS INC.	1989	SULFURIC ACID, Copper*	7664939	250	0	250
2	806	UNIVERSAL CIRCUITS INC.	1990	HYDROCHLORIC ACID, Coppe	7647010	250	0	250
2	806	UNIVERSAL CIRCUITS INC.	1991	HYDROCHLORIC ACID, Coppe	7647010	250	0	250
2	806	UNIVERSAL CIRCUITS INC.	1992	SULFURIC ACID	7664939	250	0	250
2	806	UNIVERSAL CIRCUITS INC.	1993			0	0	0

Table A-7.
Summary of TRI Releases 1987-1993 for Facilities within Sub-Basins - Boca Ciega Basin

Sub-Basin	Map-ID	Facility	Year	Chemical	Releases (lbs/yr)[1]			
					FUGIT-AIR	STACK-AIR	TOTAL-AIR	UNDGND
3	808	C & D HIT INC.	1987			0	0	0
3	808	C & D HIT INC.	1988			0	0	0
3	808	C & D HIT INC.	1989			0	0	0
3	808	C & D HIT INC.	1990	LEAD	7439921	5	5	10
3	808	C & D HIT INC.	1991	LEAD	7439921	0	5	5
3	808	C & D HIT INC.	1992	LEAD	7439921	0	5	5
3	808	C & D HIT INC.	1993			0	0	0
3	809	CATALINA YACHTS MORGAN DIV.	1987			0	0	0
3	809	CATALINA YACHTS MORGAN DIV.	1988			0	0	0
3	809	CATALINA YACHTS MORGAN DIV.	1989	ACETONE	67641	71798	0	71798
3	809	CATALINA YACHTS MORGAN DIV.	1990	STYRENE	100425	16709	0	16709
3	809	CATALINA YACHTS MORGAN DIV.	1991	STYRENE	100425	17000	0	17000
3	809	CATALINA YACHTS MORGAN DIV.	1992	STYRENE	100425	2000	0	2000
3	809	CATALINA YACHTS MORGAN DIV.	1993	TOLUENE	108883	8118	0	8118
3	590	ESSILOR OF AMERICA INC. MFG. DIV.	1987	METHANOL	67561	18000	0	18000
3	590	ESSILOR OF AMERICA INC. MFG. DIV.	1988	ACETONE	67641	46680	0	46680
3	590	ESSILOR OF AMERICA INC. MFG. DIV.	1989	ACETONE	67641	53150	0	53150
3	590	ESSILOR OF AMERICA INC. MFG. DIV.	1990	ACETONE	67641	58800	6500	65300
3	590	ESSILOR OF AMERICA INC. MFG. DIV.	1991	ACETONE	67641	53000	6000	59000
3	590	ESSILOR OF AMERICA INC. MFG. DIV.	1992	METHANOL	67561	1870	35670	37540
3	590	ESSILOR OF AMERICA INC. MFG. DIV.	1993	ACETONE	67641	28000	12000	40000
3	802	GENERAL COMPONENTS INC.	1987			0	0	0
3	802	GENERAL COMPONENTS INC.	1988			0	0	0
3	802	GENERAL COMPONENTS INC.	1989			0	0	0
3	802	GENERAL COMPONENTS INC.	1990			0	0	0
3	802	GENERAL COMPONENTS INC.	1991			0	0	0
3	802	GENERAL COMPONENTS INC.	1992			0	0	0
3	802	GENERAL COMPONENTS INC.	1993			0	0	0
3	805	NAUTICAL COATINGS INC.	1987			0	0	0
3	805	NAUTICAL COATINGS INC.	1988			0	0	0
3	805	NAUTICAL COATINGS INC.	1989	Copper*		0	0	0
3	805	NAUTICAL COATINGS INC.	1990			0	0	0
3	805	NAUTICAL COATINGS INC.	1991			0	0	0
3	805	NAUTICAL COATINGS INC.	1992			0	0	0
3	805	NAUTICAL COATINGS INC.	1993			0	0	0
3	819	TRANSITIONS OPTICAL INC.	1987			0	0	0
3	819	TRANSITIONS OPTICAL INC.	1988			0	0	0
3	819	TRANSITIONS OPTICAL INC.	1989			0	0	0
3	819	TRANSITIONS OPTICAL INC.	1990			0	0	0
3	819	TRANSITIONS OPTICAL INC.	1991	ISOPROPYL ALCOHOL	67630	250	3600	3850
3	819	TRANSITIONS OPTICAL INC.	1992	METHANOL	67561	0	4900	4900
3	819	TRANSITIONS OPTICAL INC.	1993	ISOPROPYL ALCOHOL	67630	0	6500	6500

Table A-7.
Summary of TRI Releases 1987-1993 for Facilities within Sub-Basins - Boca Ciega Basin

Sub-Basin	Map-ID	Facility	Year	Chemical	Releases (lbs/yr)[1]			
					FUGIT-AIR	STACK-AIR	TOTAL-AIR	UNDGND
3	591	WEST CO.	1987	ZINC COMPOUNDS	N982	0	250	250
3	591	WEST CO.	1988	BARIUM COMPOUNDS	N040	0	250	250
3	591	WEST CO.	1989	ZINC COMPOUNDS	N982	0	250	250
3	591	WEST CO.	1990	ZINC COMPOUNDS	N982	0	5	5
3	591	WEST CO.	1991	ZINC COMPOUNDS	N982	0	5	5
3	591	WEST CO.	1992	BARIUM COMPOUNDS	N040	0	5	5
3	591	WEST CO.	1993	BARIUM COMPOUNDS	N040	0	5	5
5	601	CELLU-CRAFT SOUTH	1987			0	0	0
5	601	CELLU-CRAFT SOUTH	1988			0	0	0
5	601	CELLU-CRAFT SOUTH	1989	TOLUENE	108883	542	10295	10837
5	601	CELLU-CRAFT SOUTH	1990	TOLUENE	108883	829	15659	16488
5	601	CELLU-CRAFT SOUTH	1991			0	0	0
5	601	CELLU-CRAFT SOUTH	1992			0	0	0
5	601	CELLU-CRAFT SOUTH	1993			0	0	0
5	604	ESSILOR OF AMERICA INC. REFLECTION FREE	1987			0	0	0
5	604	ESSILOR OF AMERICA INC. REFLECTION FREE	1988			0	0	0
5	604	ESSILOR OF AMERICA INC. REFLECTION FREE	1989			0	0	0
5	604	ESSILOR OF AMERICA INC. REFLECTION FREE	1990			0	0	0
5	604	ESSILOR OF AMERICA INC. REFLECTION FREE	1991	FREON 113	76131	9600	14400	24000
5	604	ESSILOR OF AMERICA INC. REFLECTION FREE	1992	FREON 113	76131	7500	11300	18800
5	604	ESSILOR OF AMERICA INC. REFLECTION FREE	1993			0	0	0
5	603	FLAV-O-RICH INC.	1987			0	0	0
5	603	FLAV-O-RICH INC.	1988			0	0	0
5	603	FLAV-O-RICH INC.	1989			0	0	0
5	603	FLAV-O-RICH INC.	1990			0	0	0
5	603	FLAV-O-RICH INC.	1991			0	0	0
5	603	FLAV-O-RICH INC.	1992			0	0	0
5	603	FLAV-O-RICH INC.	1993			0	0	0
5	814	FLORIDA PLATING INC.	1987			0	0	0
5	814	FLORIDA PLATING INC.	1988	METHYL ETHYL KETONE	78933	0	2900	2900
5	814	FLORIDA PLATING INC.	1989	1,1,1-TRICHLOROETHANE	71556	0	11000	11000
5	814	FLORIDA PLATING INC.	1990			0	0	0
5	814	FLORIDA PLATING INC.	1991			0	0	0
5	814	FLORIDA PLATING INC.	1992			0	0	0
5	814	FLORIDA PLATING INC.	1993			0	0	0
5	602	SUPERIOR PLATING INC.	1987			0	0	0
5	602	SUPERIOR PLATING INC.	1988	FREON 113	76131	0	11000	11000
5	602	SUPERIOR PLATING INC.	1989			0	0	0
5	602	SUPERIOR PLATING INC.	1990			0	0	0
5	602	SUPERIOR PLATING INC.	1991			0	0	0
5	602	SUPERIOR PLATING INC.	1992			0	0	0
5	602	SUPERIOR PLATING INC.	1993			0	0	0

Table A-7.
Summary of TRI Releases 1987-1993 for Facilities within Sub-Basins - Boca Ciega Basin

Sub-Basin	Map-ID	Facility	Year	Chemical	Releases (lbs/yr)[1] FUGIT-AIR	STACK-AIR	TOTAL-AIR	UNDGND
5	817	SUPERIOR PLATING INC.	1987			0	0	0
5	817	SUPERIOR PLATING INC.	1988			0	0	0
5	817	SUPERIOR PLATING INC.	1989			0	0	0
5	817	SUPERIOR PLATING INC.	1990			0	0	0
5	817	SUPERIOR PLATING INC.	1991			0	0	0
5	817	SUPERIOR PLATING INC.	1992			0	0	0
5	817	SUPERIOR PLATING INC.	1993			0	0	0
5	613	TAPE & LABEL ENG. INC.	1987			0	0	0
5	613	TAPE & LABEL ENG. INC.	1988	TETRACHLOROETHYLENE	127184	750	0	750
5	613	TAPE & LABEL ENG. INC.	1989	TETRACHLOROETHYLENE	127184	750	0	750
5	613	TAPE & LABEL ENG. INC.	1990			0	0	0
5	613	TAPE & LABEL ENG. INC.	1991			0	0	0
5	613	TAPE & LABEL ENG. INC.	1992			0	0	0
5	613	TAPE & LABEL ENG. INC.	1993			0	0	0
7	596	SPARKLETTS WATER SYS. AQUA VEND	1987	HYDROCHLORIC ACID	7647010	250	0	250
7	596	SPARKLETTS WATER SYS. AQUA VEND	1988	HYDROCHLORIC ACID	7647010	250	0	250
7	596	SPARKLETTS WATER SYS. AQUA VEND	1989	HYDROCHLORIC ACID	7647010	250	0	250
7	596	SPARKLETTS WATER SYS. AQUA VEND	1990	HYDROCHLORIC ACID	7647010	250	0	250
7	596	SPARKLETTS WATER SYS. AQUA VEND	1991			0	0	0
7	596	SPARKLETTS WATER SYS. AQUA VEND	1992			0	0	0
7	596	SPARKLETTS WATER SYS. AQUA VEND	1993			0	0	0
9	594	E-SYSTEMS INC. ECI DIV.	1987	1,1,1-TRICHLOROETHANE	71556	12893	0	12893
9	594	E-SYSTEMS INC. ECI DIV.	1988	1,1,1-TRICHLOROETHANE	71556	20629	0	20629
9	594	E-SYSTEMS INC. ECI DIV.	1989	1,1,1-TRICHLOROETHANE	71556	25449	0	25449
9	594	E-SYSTEMS INC. ECI DIV.	1990	1,1,1-TRICHLOROETHANE	71556	22491	0	22491
9	594	E-SYSTEMS INC. ECI DIV.	1991	1,1,1-TRICHLOROETHANE	71556	33000	0	33000
9	594	E-SYSTEMS INC. ECI DIV.	1992	1,1,1-TRICHLOROETHANE	71556	28000	0	28000
9	594	E-SYSTEMS INC. ECI DIV.	1993	1,1,1-TRICHLOROETHANE	71556	22000	0	22000

Note:
1. FUGIT-AIR: fugitive air release, STACK-AIR: permitted release, TOTAL-AIR: fugitive + stack release, UNDGRD: underground release.
Source: USEPA 1996.

Table 4.1. Summary results of bulk deposition for the Tampa Bay watershed. Trace metals are in units of g ha^{-1} yr^{-1}; nutrients are in units of kg ha^{-1} yr^{-1}. Data censored for bird debris and other obvious contamination.

Param-Sta	Median	Mean	n	StdDev	Max	75%	25%
Copper							
1	5.61	7.97	50	6.62	36.40	9.89	4.09
2	4.37	5.95	52	5.98	34.00	6.81	2.53
3	3.72	4.82	49	3.98	15.50	7.14	1.87
4	6.92	9.18	44	8.06	38.30	10.10	3.91
5	4.64	6.78	42	7.06	30.50	8.64	2.07
6	5.36	7.48	44	6.98	29.40	9.17	2.39
7	7.04	13.70	49	27.00	186.60	15.30	3.07
Pooled Data	5.43	8.07	337	12.10	186.60	9.21	2.67
Station Arith Avg.	5.38	7.98					
Lead							
1	4.78	7.00	50	5.64	21.20	11.20	2.90
2	3.84	5.82	52	6.76	36.20	6.35	2.00
3	2.85	5.14	49	6.56	35.10	6.67	1.18
4	8.07	10.60	44	10.50	46.20	13.20	3.75
5	3.45	5.17	42	4.74	22.10	6.81	1.98
6	3.52	5.87	44	6.49	28.20	6.97	1.38
7	2.62	6.22	49	13.20	87.90	6.44	1.06
Pooled Data	3.86	6.49	337	8.23	87.90	7.64	1.93
Station Arith Avg.	4.16	6.54					
Zinc							
1	70.53	101.90	50	122.73	858.80	113.66	57.84
2	42.58	56.67	52	45.74	228.70	71.52	27.08
3	24.37	34.26	49	27.54	137.70	49.21	14.21
4	49.59	113.80	44	137.70	671.60	191.34	30.39
5	37.77	67.65	42	94.24	494.90	61.80	25.06
6	52.65	91.40	43	116.33	676.80	127.52	20.62
7	33.89	91.94	49	318.40	2252.20	74.45	11.10
Pooled Data	46.16	79.26	336	152.01	2252.20	83.47	23.01
Station Arith Avg	44.48	79.66					
Aluminum							
1	159.89	539.16	50	1709.09	12097.50	456.84	36.19
2	203.89	421.70	52	797.81	5126.40	424.70	60.88
3	186.72	300.90	49	464.03	2948.90	345.09	69.55
4	222.19	472.74	44	1094.38	7210.80	362.86	129.06
5	296.93	540.62	42	912.18	5787.90	659.19	73.01
6	359.07	493.36	44	480.61	2150.40	628.59	205.45
7	200.69	403.14	49	591.65	3516.90	461.31	84.63
Pooled Data	236.83	444.39	337	946.62	12097.50	473.59	83.53
Station Arith Avg	232.78	453.09					

Table 4.1. (continued). Summary results of bulk deposition for the Tampa Bay watershed. Trace metals are in units of g ha^{-1} yr^{-1}; nutrients are in units of kg ha^{-1} yr^{-1}. Data censored for bird debris and other obvious contamination.

Param-Sta	Median	Mean	n	StdDev	Max	75%	25%
Nitrate-Nitrite Nitrogen							
1	2.48	3.28	51	3.30	19.86	4.33	1.31
2	1.70	2.74	52	3.31	22.30	3.82	0.87
3	1.59	2.50	48	2.48	12.87	2.92	0.97
4	1.77	3.77	44	5.36	26.94	3.98	1.22
5	1.54	2.83	42	3.59	17.66	2.85	0.69
6	1.93	3.02	43	3.19	14.44	3.84	0.98
7	1.75	3.44	48	4.95	30.21	4.58	0.81
Pooled Data	1.84	3.06	333	3.80	30.20	3.84	0.97
Station Arith Avg.		1.82	3.08				
Ammonium-Nitrogen							
1	0.83	1.49	51	1.89	9.56	1.98	0.23
2	0.71	1.28	52	1.84	9.43	1.36	0.23
3	1.13	1.78	48	1.86	9.84	2.53	0.60
4	1.56	2.58	44	2.55	9.70	3.91	0.69
5	1.93	3.30	42	4.05	16.97	2.71	0.60
6	1.98	2.55	43	2.10	9.38	3.45	0.88
7	0.90	2.19	48	3.92	24.00	2.44	0.30
Pooled Data	1.15	2.10	333	2.76	24.00	2.67	0.41
Station Arith Avg.		1.29	2.17				
Inorganic Nitrogen							
1	3.49	4.77	51	4.56	23.40	6.01	1.85
2	2.60	4.02	52	4.91	31.70	5.13	1.29
3	2.78	4.28	48	4.00	17.50	5.26	1.72
4	3.47	6.36	44	7.36	34.00	7.45	1.91
5	4.16	6.13	42	6.41	24.20	7.86	1.66
6	4.26	5.57	43	4.75	19.70	8.08	2.05
7	2.60	5.63	48	7.28	33.10	7.10	1.06
Pooled Data	3.27	5.16	333	5.69	34.00	6.17	1.66
Station Arith Avg.		3.34	5.25				
Total Kjeldahl Nitrogen							
1	2.39	7.33	51	15.85	71.36	5.37	0.79
2	1.84	3.28	52	3.82	19.45	4.48	0.81
3	2.23	3.86	48	6.57	44.97	4.39	1.17
4	3.43	5.17	44	6.51	41.01	6.41	2.07
5	3.06	10.02	42	22.15	118.12	6.44	1.66
6	3.13	4.31	43	5.20	31.86	5.56	0.92
7	2.10	4.38	48	7.99	49.66	4.97	0.49
Pooled Data	2.58	5.42	333	11.39	118.10	5.36	0.96
Station Arith Avg.		2.60	5.48				

Table 4.1. (continued). Summary results of bulk deposition for the Tampa Bay watershed. Trace metals are in units of g ha^{-1} yr^{-1}; nutrients are in units of kg ha^{-1} yr^{-1}. Data censored for bird debris and other obvious contamination.

Param-Sta	Median	Mean	n	StdDev	Max	75%	25%
Organic Nitrogen							
1	1.01	5.89	51	15.03	64.60	2.34	0.25
2	1.13	2.03	52	3.06	18.57	2.23	0.53
3	0.92	2.11	48	5.19	35.13	2.01	0.28
4	1.73	2.64	44	5.21	34.99	2.81	0.74
5	0.94	6.73	42	18.71	101.15	2.94	0.46
6	1.29	1.92	43	3.93	25.75	1.99	0.32
7	0.74	2.24	48	4.20	25.66	3.06	0.21
Pooled Data	1.15	3.37	333	9.71	101.20	2.44	0.37
Station Arith Avg.		1.11	3.36				
Total Nitrogen							
1	5.20	10.61	51	16.50	76.46	8.83	2.64
2	4.12	6.02	52	5.97	35.31	8.27	2.28
3	3.66	6.36	48	7.79	49.33	8.29	2.23
4	5.22	8.94	44	9.84	45.43	9.54	3.63
5	5.27	12.85	42	23.01	123.82	12.64	2.39
6	5.01	7.34	43	7.00	35.77	9.47	3.08
7	3.98	7.82	48	10.71	55.27	8.76	1.43
Pooled Data	4.60	8.47	333	12.68	123.80	8.72	2.48
Station Arith Avg.		4.63	8.56				
Total Phosphorous							
1	0.32	0.89	51	1.50	8.55	0.98	0.23
2	0.41	0.58	52	0.55	2.48	0.78	0.16
3	0.32	0.52	48	0.76	5.24	0.58	0.16
4	0.53	0.64	44	0.49	2.39	0.87	0.30
5	0.99	1.76	42	2.31	10.02	1.93	0.46
6	0.78	1.31	43	1.75	10.39	1.45	0.43
7	0.51	0.81	48	1.32	8.05	0.87	0.23
Pooled Data	0.51	0.91	333	1.40	10.40	1.01	0.23
Station Arith Avg.		0.55	0.93				

Table 4.3. Mean annualized loadings by quarter. Quarter 1 = Months 12, 1, 2; Quarter 2 = 3, 4, 5; Quarter 3 = 6, 7, 8; Quarter 4 = 9, 10, 11. Metals loadings in g ha^{-1} yr^{-1}. Nutrient loadings in kg ha^{-1} yr^{-1}.

Quarter	Copper	Lead	Zinc	Aluminum	Rainfall (cm)
1	4.33	4.17	55.1	267.5	16.7
2	8.17	7.50	70.8	459.9	15.8
3	10.44	7.93	121.3	890.0	57.2
4	9.48	6.38	69.8	167.5	23.7

Quarter	Total Kjeldahl Nitrogen	Nitrate-Nitrite-Nitrogen	Ammonium Nitrogen	Total Phosphorus	Total Nitrogen	Organic Nitrogen
1	4.94	1.78	1.42	0.67	6.72	3.62
2	5.39	2.23	2.32	0.80	7.62	3.10
3	6.18	5.86	2.64	1.15	12.04	3.55
4	5.19	2.45	2.07	1.02	7.63	3.16

Table 4.4. Comparison of deposition rates during six to eight weeks when no rainfall was received, and over the entire project. Metals units are in g ha^{-1} yr^{-1}, while nutrients are in kg ha^{-1} yr^{-1}.

	Annualized Deposition Rates		Dry as Percentage of Bulk
	Dry	Bulk	%
Copper	4.11	7.98	52
Lead	3.74	6.54	57
Zinc	20.40	79.70	26
Aluminum	178.10	453.10	39
Nitrate-nitrite-nitrogen	0.61	3.08	19
Ammonium-nitrogen	0.40	2.17	18
Inorganic Nitrogen	1.01	5.25	19
Total Kjeldahl nitrogen	1.77	5.48	32
Organic nitrogen	0.79	3.36	24
Total nitrogen	1.79	8.56	21
Total Phosphorus	0.44	0.93	47

Table D1. Pesticides (ng/m²/2 weeks)

Location:	STA-1	STA-1	STA-1	STA-1	STA-1	STA-1
Sample #:	0818/0826	0839/0847	0858/0870	0881/0889	1000/1007	1014/1021
Dates:	7/11+7/18	7/25+8/1	8/8+8/15	8/22+8/29	9/5+9/12	9/19+9/26
a bhc	<	<	<	71	<	<
a-chlordane	<	<	<	<	<	<
aldrin	<	<	<	62	<	<
b bhc	<	<	<	<	<	<
chlorpyriphos	<	<	360	<	<	<
d bhc	<	<	<	<	213	<
dieldrin	<	<	<	<	<	<
endosulfan I	<	<	<	<	<	<
endosulfan II	<	<	<	<	<	<
endosulfan sulfate	<	<	<	<	<	<
endrin	<	<	<	<	<	<
endrin aldehyde	<	<	<	<	<	<
heptachlor	<	<	<	<	<	<
heptachlor epox	<	<	107	<	<	<
lindane	<	<	<	<	<	<
methhoxychlor	<	<	<	<	<	<
pp ddd	<	<	<	<	<	<
pp dde	<	<	<	<	<	<
pp ddt	<	<	<	<	<	<
Total	**<**	**<**	**467**	**133**	**213**	**<**

Location:	STA-4	STA-4	STA-4	STA-4	STA-4	STA-4
Sample #:	0821/0829	0842/0850	0861/0873	0884/0892	1003/1010	1017/1024
Dates:	7/11+7/18	7/25+8/1	8/8+8/15	8/22+8/29	9/5+9/12	9/19+9/26
a bhc	<	<	<	<	<	<
a-chlordane	<	<	<	<	<	<
aldrin	<	<	<	<	<	<
b bhc	<	<	<	<	<	<
chlorpyriphos	<	<	<	<	<	<
d bhc	83	<	<	<	<	<
dieldrin	<	<	<	<	<	<
endosulfan I	<	<	<	<	<	259
endosulfan II	<	<	<	<	<	304
endosulfan sulfate	<	<	<	<	<	<
endrin	<	<	<	<	<	<
endrin aldehyde	<	<	<	<	<	<
heptachlor	<	<	<	<	<	<
heptachlor epox	<	<	<	<	<	<
lindane	<	<	<	<	<	<
methhoxychlor	<	<	<	<	<	<
pp ddd	<	<	<	<	<	<
pp dde	<	<	<	<	<	<
pp ddt	<	<	<	<	<	<
Total	**83**	**<**	**<**	**<**	**<**	**563**

Table D2. Hydrocarbons ($\mu g/m^2$/2weeks)

Location:	STA-1	STA-1	STA-1	STA-1	STA-1	STA-1
Sample #:	0818/0826	0839/0847	0858/0870	0881/0889	1000/1007	1014/1021
Dates:	7/11+7/18	7/25+8/1	8/8+8/15	8/22+8/29	9/5+9/12	9/19+9/26
Acenapthene	<	<	<	<	<	<
Acentphthalene	<	<	<	<	<	<
Anthracene	<	<	<	<	<	<
Benzo(a)anthracene	<	<	<	<	<	2
Benzo(a)pyrene	<	<	<	<	2	<
Benzo(b)Fluoranthene	<	<	10	<	10	4
Benzo(ghi)perylene	<	<	1	<	2	2
Benzo(k)Fluoranthene	4	4	4	10	<	<
Chrysene	<	<	<	<	<	4
Dibenzo(ah)anthr	<	<	1	<	<	<
Fluoranthene	6	2	6	6	6	4
Fluorene	<	<	<	<	<	<
Indeno(123)pyrene	<	<	4	2	2	1
Naphthalene	<	<	<	<	<	<
Phenanthrene	<	<	<	<	<	1
Pyrene	4	4	4	2	4	4
Total	**14**	**10**	**31**	**21**	**27**	**23**

Location:	STA-4	STA-4	STA-4	STA-4	STA-4	STA-4
Sample #:	0821/0829	0842/0850	0861/0873	0884/0892	1003/1010	1017/1024
Dates:	7/11+7/18	7/25+8/1	8/8+8/15	8/22+8/29	9/5+9/12	9/19+9/26
Acenapthene	<	<	<	<	<	<
Acentphthalene	<	<	<	<	<	<
Anthracene	<	<	<	<	<	<
Benzo(a)anthracene	<	<	<	<	<	<
Benzo(a)pyrene	<	<	<	<	<	<
Benzo(b)Fluoranthene	<	<	3	2	<	<
Benzo(ghi)perylene	<	<	<	<	<	<
Benzo(k)Fluoranthene	<	<	<	<	<	<
Chrysene	<	<	<	<	<	<
Dibenzo(ah)anthr	<	<	<	<	<	<
Fluoranthene	2	<	2	2	<	<
Fluorene	<	<	<	<	<	<
Indeno(123)pyrene	<	<	<	<	<	<
Naphthalene	<	<	<	<	<	<
Phenanthrene	<	<	<	<	<	<
Pyrene	<	<	2	<	<	<
Total	**2**	**<**	**7**	**4**	**<**	**<**

Table D3. PCBs (ng/m²/2 weeks)

Location:	STA-1	STA-1	STA-1	STA-1	STA-1	STA-1
Sample #:	0818/0826	0839/0847	0858/0870	0881/0889	1000/1007	1014/1021
Dates:	7/11+7/18	7/25+8/1	8/8+8/15	8/22+8/29	9/5+9/12	9/19+9/26
congner #8	<	<	<	<	<	<
18	<	<	<	<	<	<
28	<	<	<	<	<	<
52	<	<	<	<	<	<
44	<	<	<	<	<	<
66	<	<	<	<	<	<
101	<	<	<	<	<	<
77	<	<	<	<	<	<
118	<	<	<	<	<	<
153	<	<	63	<	<	<
105	<	<	<	<	<	<
138	<	<	<	<	<	<
126	<	<	<	<	<	<
187	<	<	<	<	<	<
128	<	<	<	<	<	<
180	<	<	<	<	<	<
170	<	<	<	<	<	<
195	<	<	<	<	<	<
206	<	<	<	<	<	<
209	<	<	<	<	<	<
Total	<	<	**63**	<	<	<

Location:	STA-4	STA-4	STA-4	STA-4	STA-4	STA-4
Sample #:	0821/0829	0842/0850	0861/0873	0884/0892	1003/1010	1017/1024
Dates:	7/11+7/18	7/25+8/1	8/8+8/15	8/22+8/29	9/5+9/12	9/19+9/26
congner #8	<	<	<	<	<	<
18	<	<	<	<	<	<
28	<	<	<	<	<	<
52	<	<	<	<	<	<
44	<	<	<	<	<	<
66	<	<	<	<	<	<
101	<	<	<	<	<	<
77	<	<	<	<	<	<
118	<	<	<	<	<	<
153	<	<	81	<	<	<
105	<	<	<	<	<	<
138	<	<	<	<	<	<
126	<	<	<	<	<	<
187	<	<	<	<	<	<
128	<	<	<	<	<	<
180	<	<	<	<	<	<
170	<	<	<	<	<	<
195	<	<	<	<	<	<
206	<	<	<	<	<	<
209	<	<	<	<	<	<
Total	<	<	**81**	<	<	<