Tampa Bay National Estuary Program
Technical Publication #19-96

ESTIMATES OF TOTAL NITROGEN, TOTAL PHOSPHORUS, AND TOTAL SUSPENDED SOLIDS TO TAMPA BAY, FLORIDA

TECHNICAL APPENDIX: 1992-1994 TOTAL NITROGEN LOADINGS TO TAMPA BAY, FLORIDA

FINAL REPORT

OCTOBER 1996

ESTIMATES OF TOTAL NITROGEN, TOTAL PHOSPHORUS, AND TOTAL SUSPENDED SOLIDS TO TAMPA BAY, FLORIDA

TECHNICAL APPENDIX:

1992-94 TOTAL NITROGEN LOADINGS TO TAMPA BAY, FLORIDA

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EXECUTIVE SUMMARY

The objective of the work described herein was to update estimates of total nitrogen (TN) loadings to Tampa Bay. Nutrient loadings for the period 1985-91 had been previously developed, and were presented in Zarbock et al. (1994). TN loading estimates were made for the period 1992-94 as data became available. The "best estimate" of external loadings was made by using measured data (streamflow, surface water and groundwater quality, and precipitation quantity and chemistry) to the fullest extent feasible. The best estimate loads were used with the Tampa Bay National Estuary Program (TBNEP) chlorophyll a-nutrient model to set TN loadings that will allow seagrasses to grow to target depths.

Five categories of potential major sources of TN loading to Tampa Bay were identified for the best estimate calculations. Identified sources included nonpoint sources (stormwater runoff and base flow), point sources (domestic and industrial), atmospheric deposition (wet deposition and dry deposition to the open water estuary), groundwater and springs, and material losses (inadvertent losses of phosphate rock and fertilizer products during handling and shipping). Loadings from these sources were estimated aided by the use of geographic information system (GIS) mapping and analytical techniques, and used the same data sources, methods, and assumptions as were used for the best estimate calculations for 1985-91 TN loadings. Measured data were used to the greatest extent feasible; in those cases where measured data were not available, modeling techniques or other methods were used.

Nonpoint source loads were calculated using measured streamflow and water quality data wherever possible. Atmospheric deposition loads were estimated using measured precipitation quantity and quality data, and locally-based ratios of dry deposition to wet deposition. Loads from point source were estimated using agency permit data. Groundwater loads were estimated using groundwater quality data and current potentiometric surface maps. TN loadings from springs were estimated using measured water quality and discharge measurements. Material losses were made using data supplied by the phosphate industry and other methods of estimating loss rates based on the volume of material shipped from each facility.

Results of the best estimate calculations show that total average annual TN loads delivered to Tampa Bay for the period 1992-94 were approximately 3,800 tons per year (tpy), approximately 4% iess than the estimated 1985-91 average annual TN load of 3,943 tpy. Of the major sources, atmospheric deposition contributed approximately 29% (1,103 tpy) of the total TN load to the bay for the 1992-94 period, nonpoint source loadings contributed approximately 45% (1,723 tpy), domestic and industrial point sources accounted for approximately 10% (361 tpy) and 4% (149 tpy), respectively. Material losses contributed 7% (257 tpy), and groundwater and springs accounted for almost 5% (206 tpy) of the total TN load.

Of the seven major bay segments, Hillsborough Bay received the largest TN load (1,451 tpy), almost twice that of the next largest segment load, to Middle Tampa Bay (799 tpy). Old Tampa

Bay, Lower Tampa Bay, and the Manatee River all had TN loads between 349 and 503 tpy, and Boca Ciega Bay and Terra Ceia Bay had the lowest total TN loads (177 tpy and 35 tpy, respectively).

The relative contributions of loadings to the bay segments from individual sources were similar to the results of the 1985-91 loadings. Bay segments with larger surface areas (Old Tampa Bay, Middle Tampa Bay, and Lower Tampa Bay) received proportionally more TN load from atmospheric deposition. In contrast, Hillsborough Bay received a far greater contribution from nonpoint source loads because of its large tributary area, as well as the largest loads from domestic and industrial point sources. Material losses occurred only in Hillsborough Bay (Port of Tampa) and Lower Tampa Eay (Port Manatee). Springs contributed only to TN loads to Hillsborough Bay. Groundwater discharges to all segments were small in relation to other sources.

In addition to TN loadings for current conditons, "best estimate" projected fbture condition (circa 2010) TN loadings were estimated for Tampa Bay. This was accomplished by determining the difference between the modeled current and fbture loadings, and increasing the best estimate loadings by the same amount, 7%. Using this method, projected 2010 TN loadings to Tampa Bay were estimated at approximately 4,066 tons/year.

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1. INTRODUCTION

Total nitrogen (TN) loads delivered to Tampa Bay influence the rate of growth of phytoplankton in the estuary (measured as changes in water column chlorophyll *a* concentrations), which in turn can limit the depth to which light penetrates the water column. Light penetration helps determine the maximum depth, and thus the areal extent, to which seagrasses may exist. Recolonization of portions of the bay with seagrasses is a major goal of the Tampa Bay National Estuary (TBNEP).

To aid resource managers in improving and protecting the quality of Tampa Bay, TBNEP is coordinating efforts to develop a systematic approach to controlling nutrient loadings to the bay, which will in turn promote seagrass growth. For this approach to be successful, the relationship between nutrient loadings and chlorophyll *a* must be quantified. If the level of reduction in nutrient loadings that is required to limit chlorophyll *a* to desirable levels is known, then local governments and other resource managers can develop programs to control stormwater runoff, wastewater plant discharges, or other sources of nutrient loading. The relationships between nutrient loading, chlorophyll *a* concentrations, and light penetration have been incorporated into the TBNEP Nitrogen Management Strategy. Major steps of the Nitrogen Management Strategy are:

- to develop reliable estimates of nutrient loadings to the bay,
- to determine the relationship between nutrient loadings and chlorophyll *a* concentrations in the bay,
- to agree upon target levels of seagrass growth (e.g., to recolonize seagrasses to target depths) and the chlorophyll *a* concentrations that will allow this to occur, and
- to implement controls on nutrient loadings that will allow target chlorophyll *a* concentrations to be maintained, through actions by local governments and other parties.

The following describes work that updates the first step in this program, which was to develop reliable estimates of nutrient loading to the bay. Additional updates of nutrient loadings will occur during the implementation of TBNEP's Nitrogen Management Strategy, which is a cornerstone of TBNEP's Comprehensive Conservation and Management Plan (TBNEP 1996).

It should be noted that a parallel modeling effort has developed model-based estimates of TN loading to the bay for the 1992-94 period (Zarbock et al. 1996). Unlike the best estimate methods described below, which utilized available measured data to the greatest extent feasible, the model-based TN loading estimates were developed to enable comparisons to be made between current loadings levels and projected future (circa 2010) loadings, so that the likely level of effort required to manage future loadings could be anticipated. The model-based approach used only modeled nonpoint source loads, and used the same rainfall (average for the period

1992-94) for both current and projected future conditions. Using these methods assured that projected changes in future nonpoint source loadings could be attributed to changes in land use alone, and not in rainfall variation.

1.1 Purpose and Objectives

The objective of the work described herein was to update estimates of TN loadings to Tampa Bay. Nutrient loadings for the period 1985-91 had been previously developed, and were presented in Zarbock et al. (1994). A "best estimate" of the magnitude of annual TN loadings for 1992-94 was made using measured data for streamflow, surface water and groundwater quality, point source discharges, rainfall, and rain chemistry to the greatest extent feasible. Nonpoint source loads from areas of the watershed that did not have streamflow and water quality data available (ungaged areas) were modeled using the same empirical model that was used to estimate 1985-91 ungaged nonpoint source loads.

The best estimate loads were used to develop the chlorophyll a-nutrient model used by TBNEP to set TN loadings that would allow adequate light penetration for seagrasses to grow to target depths (Janicki and Wade 1996). The chlorophyll a-nutrient model operates using the relationship that as the external TN load to the bay increases, chlorophyll a concentrations increase, signifying increased phytoplankton growth, followed by a reduction in light penetration and a reduced area of bay bottom suitable for seagrass coverage. Relationships between chlorophyll *a* concentrations and light penetration have been determined empirically by others, as discussed by Janicki and Wade (1996).

TN has been recognized by many resource managers as the water quality constituent of primary interest with respect to seagrass growth. The Southwest Florida Water Management District (SWFWMD) Surface Water Improvement and Management (SWIM) Plan for Tampa Bay has recognized the importance of nitrogen loadings to eutrophication processes within Tampa Bay (SWFWMD 1992a). Also, chlorophyll *a* levels have been shown to be closely related to total nitrogen loads to Hillsborough Bay (Johansson, 1991). Thus, the control of nitrogen loading to Tampa Bay is a primary focus of many resource managers in the Tampa Bay community, and underscores the importance of obtaining accurate estimates of TN loading rates.

1.2 Time Frame and Geographic Extent of Results

TN loading estimates for 1992-1994 were developed on an annual basis, for the entire Tampa Bay watershed. For this work, the Tampa Bay estuary was defined as the open water and littoral estuary and its tributaries up to the limit of usage by aquatic estuarine dependent species. In addition to watershed-wide loading estimates, pollutant loadings were summarized by bay segments, as were the 1985-91 loading estimates. The seven bay segments of Tampa Bay include Old Tampa Bay, Hillsborough Bay, Middle Tampa Bay, Lower Tampa Bay, Boca Ciega Bay, Terra Ceia Bay, and the Manatee River, and are illustrated in Figure 1-1. TN loads from all major basins of the Tampa Bay Watershed were estimated. Major basins include the Hillsborough, Alafia, Little Manatee, and Manatee rivers, the Tampa Bypass Canal, and coastal basins with smaller tributaries or direct runoff to the bay, as presented in Figure 1-2. Major basin loads were aggregated to estimate total TN loadings to each bay segment.

The methods used to calculate loadings from each pollutant source, the data sources used, and critical assumptions made to develop these estimates are described below in Section 2. Section 3 describes the results of the loading analysis, and Section 4 lists cited literature.

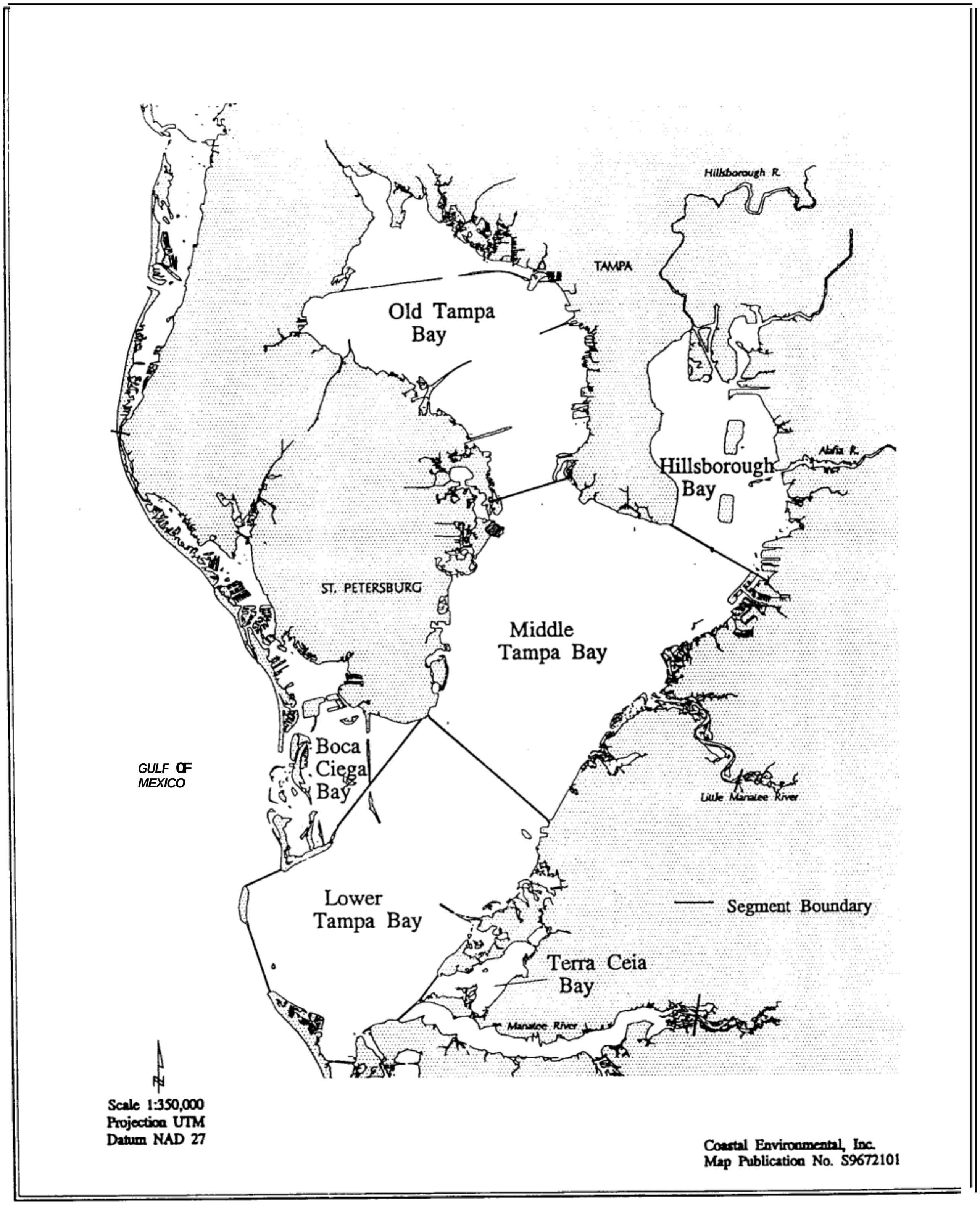

Figure 1-1. Tampa Bay segments.

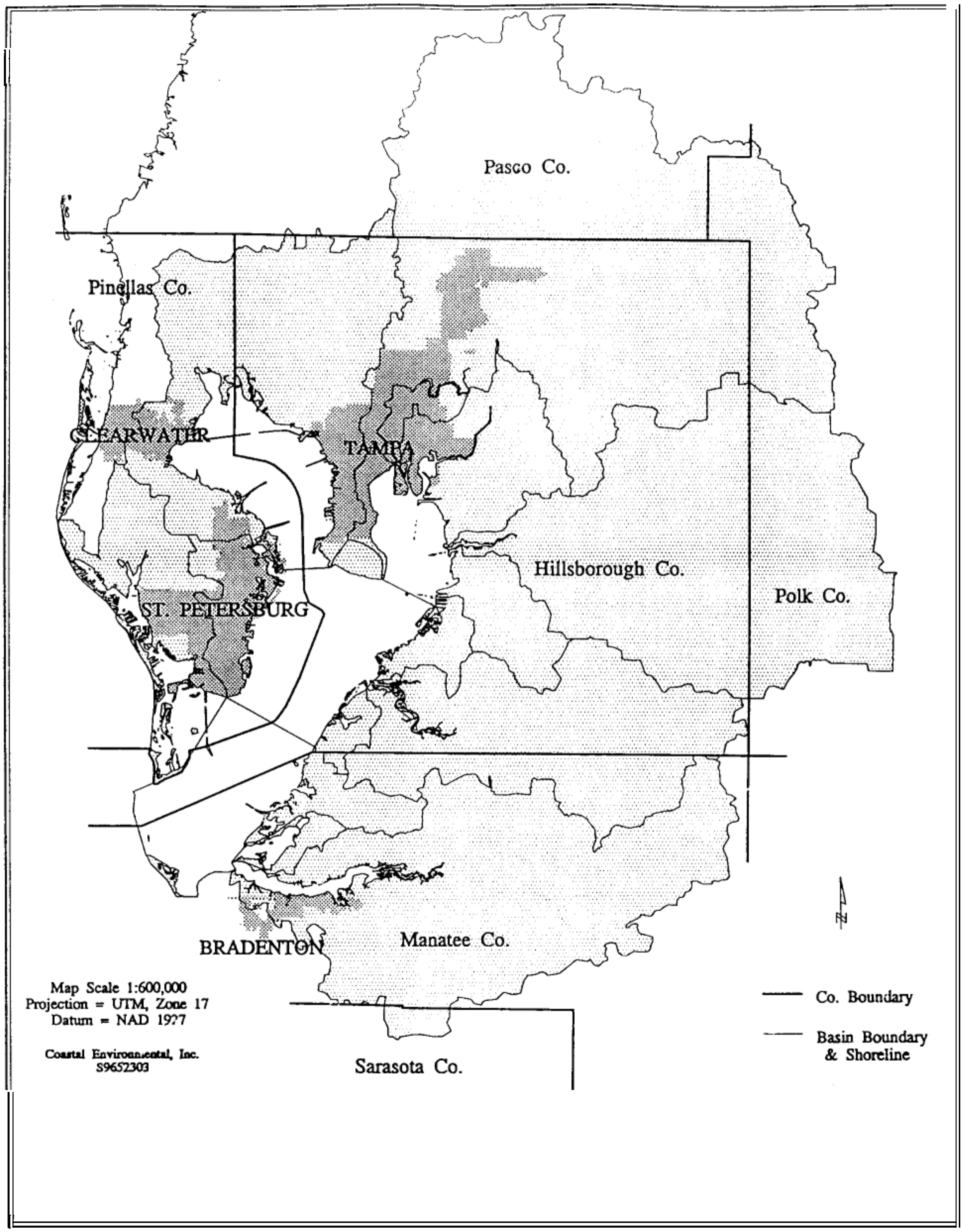

Figure 1-2. Tampa Bay Watershed major drainage basins.

2. METHODS

The following section summarizes the methods, data sources, and assumptions used in the calculation of 1992-94 "best estimate" TN loadings for Tampa Bay. Best estimate loadings incorporate measured precipitation quantity, precipitation quality, streamflow, surface water and groundwater quality, and point source effluent discharge data to the greatest extent feasible. Modeling techniques were used to estimate TN loads in areas of the watershed, or during time periods, with no measured data.

The loadings estimated for the period 1992-94 were developed for the purpose of updating the 1985-91 loadings reported in Zarbock et al. (1994). All major loading sources that were evaluated for 1985-91 were recalculated for the 1992-94 period during this update. Sources of nutrient loads that were evaluated included atmospheric deposition (wet deposition and dry deposition), domestic and industrial point sources (land application and surface water discharge), nonpoint sources (gaged and ungaged), groundwater and springs, and material losses (inadvertent releases of fertilizer products from shipping and handling facilities). Updated information was used for the 1992-94 loading estimates, but the methods used for the 1985-91 loading estimates were judged to be sound and were used as a basis for the calculations described herein. The methods used produced annual TN loading estimates for the entire bay, and for bay segments.

2.1 Atmospheric Deposition

Atmospheric deposition loadings were estimated as combined wet deposition (rainfall) and dry deposition (gaseous constituent interaction and dust fallout) to the open water bay segments. Atmospheric contributions to land-based loadings (via runoff from the watershed) were not estimated. Estimates of wet deposition loads were calculated by multiplying 1992-94 measured rainfall chemistry data obtained from the Verna Wellfield site of the National Atmospheric Deposition Program (NADP 1995) by monthly measured rainfall data obtained from the National Weather Service (NWS 1995). The Verna Wellfield site is near the southern boundary of the watershed in Sarasota County, and is the only local site. Data from 22 rainfall monitoring sites in or near the Tampa Bay Watershed were used to develop estimates of rainfall quantity.

Estimates of total atmospheric deposition were made using information obtained from the Florida Electric Power Coordinating Group (FCG 1987). During a FCG study several sites in Florida were monitored, including a site in Hillsborough County. Results suggest that dry to wet deposition ratios within Florida fall within a fairly narrow range (1.4-2.04), with the Hillsborough County ratio among the higher values (2.04). Because this long-term monitoring program provided data for local conditions, and was conducted with a relatively high degree of quality control and quality assurance, the dry to wet deposition ratio of 2.04 was used. Therefore, wet deposition loads were multiplied by 3.04 to obtain estimates of total atmospheric deposition.

2.2 Point Sources

Measured effluent flow and nitrogen concentrations were used to generate domestic and industrial point source loading estimates. Information on the quality and quantity of effluent from domestic and industrial point source facilities with a discharge of 100,000 gallons per day or greater was obtained from regulatory agencies, local governments, and individual facilities. Monthly data summarizing total effluent discharge, discharge method, and TN concentrations were obtained from monthly operating reports (MOR) (FDEP 1996). MORs were reviewed at the Florida Department of Environmental Protection (FDEP) Tampa District office, Environmental Protection Commission of Hillsborough County (EPCHC), and at various individual facilities.

Loadings from industrial facilities and domestic wastewater treatment plants were calculated by facility. Loadings from surface water discharge and land application (reuse) of effluent were also calculated independently. For each facility, TN loads were estimated by multiplying the reported monthly flow by the reported or estimated monthly effluent TN concentration. Loadings from reuse water (land application) were estimated by multiplying monthly flows by monthly effluent quality, and then attenuating the loads based on literature values, as described in Zarbock et al. (1994). Missing values were estimated based on available information.

Point source discharges contribute to stream flow and pollutant loading in gaged, as well as ungaged, portions of the watershed and are accounted for in the gaged flow and water quality data, without adding in the specific loads from each point source facility. Therefore, an amount equal to the point source loadings was subtracted from the total gaged nonpoint source loadings to avoid double counting the point sources.

2.3 Nonpoint Sources

Nonpoint source TN loads (stormwater runoff and base flow) were estimated for the period 1992-94 for gaged and ungaged portions of the watershed. Measured streamflow and water quality data were used to estimate nonpoint source loadings from gaged areas of the watershed. Streamflow data were obtained from US Geological Survey (USGS), SWFWMD, Manatee County, and the City of Bradenton. Water quality data were obtained from USGS, EPCHC, Pinellas County Department of Environmental Management (PCDEM), and Manatee County.

TN loads from gaged areas of the watershed were estimated by multiplying measured monthly flows at stream gage sites by TN concentrations measured at or very near the same site, yielding monthly TN loads (tons/month) at each gaged point. Although streamflow data were generally available for all months at the gaged sites, no TN concentrations existed for many months at most sites. The nitrogen concentration for any missing month at a stream gage was estimated by interpolating between the nearest preceding month and succeeding month. TN loads for the most downstream gage in each gaged river and stream were aggregated by bay segment on an annual basis. Data from the sites listed in Table 2-1 were used to estimate gaged area loadings.

Monitored Water Body	Streamflow Data (Agency/Site #)	Water Quality Data (Agency/Site #)
Lake Tarpon Outfall Canal	SWFWMD/FL012 (S-551)	PCDEW/3-9
Rocky Creek	USGS/02307000	EPCHC/103
Sweetwater Creek	USGS/02306647	EPCHC/104
Hillsborough River at Dam	USGS/02304500	EPCHC/105
Tampa Bypass Canal	SWFWMD/FLO13 (S-160)	EPCHC/147
Delaney Creek	USGS/02301750	EPCHC/138
Alafia River at Lithia	USGS/02301500	EPCHC/114
Bullfrog Creek	USGS/02300700	EPCHC/132
Little Manatee River at Wimauma	USGS/02300500	EPCHC/113
Manatee River at Lake Manatee Dam	Manatee County/Lake Manatee Dam	Manatee County/Lake Manatee Dam

The TBNEP empirical hydrology model was used with NWS rainfall data, ARC INFO geographic information system (GIS) coverages for land use, soils, and subbasin boundary, and land use-specific runoff coefficients and water quality concentrations, to estimate TN loads from ungaged areas of the watershed. Land use information was taken from the SWFWMD GIS coverage (SWFWMD 1992b), which was based on 1990 aerial photographs and classified according to the Florida Land Use and Cover Classification System (FDOT 1985). Land uses were aggregated into 21 categories for loading calculations. Soils data were taken from the SWFWMD GIS coverage which included soil series and hydrologic soils group information from the Natural Resources Conservation Service Soil Surveys. Subbasin delineations were also obtained from SWFWMD, and were based on USGS subbasin boundaries (Foose 1993). The same GIS coverages and methods that were used for the 1985-91 analysis were used to generate 1992-94 TN loading estimates.

Several steps were involved in the estimation of ungaged TN loads. First, the model was used to estimate total monthly streamflow from ungaged portions of each major basin. Then, the total major basin flows were apportioned to land use-specific flows using a simple weighting equation based on the extent of each land use in a subbasin, and land use and season-specific runoff coefficients. The resultant monthly land use-specific flows were then multiplied by land use-specific TN concentrations to yield a TN load for each land use in each subbasin. The land use-specific loads were then summed by major basin. Then, point source and springs loads were subtracted from the total gaged load to generate total annual TN nonpoint source loads to the bay and the bay segments. This step was necessary to avoid double counting point source and spring discharges upstream of stream gage sites. Finally, gaged loads and ungaged loads were summed for each bay segment to obtain total annual nonpoint source loads.

2.4 Material Losses

Material losses of fertilizer product from loading docks at port facilities constitute a specific source of industrial nutrient loading. Bulk fertilizer is subject to product losses ("shrinkage") during its transfer from land carrier to storage facility, and onto vessels for shipping. Product may be lost both through washing into the bay with stormwater runoff, or via fugitive dust. Losses occur at storage and shipping facilities at the Port of Tampa in upper Hillsborough Bay, and at Port Manatee on the east shore of Lower Tampa Bay. Locally-mined phosphate is a major constituent of fertilizers, and nitrogen is added to the fertilizer prior to shipping. If not well-contained, material losses may contribute to TN enrichment of the bay. Although material losses were reported to be a major source of nutrient enrichment to Tampa Bay in the past, significant improvements to operations at several facilities have occurred since 1991. Estimates of 1992-94 TN loadings suggest that fertilizer facilities are much less significant now as a source of nutrient loading to the bay.

Data that were used to estimate 1992-94 material losses were obtained from the Tampa Port Authority (1995), Port Manatee Port Authority (1995) and industry representatives. All operating facilities were requested to provide estimates of tons of product shipped or estimates of losses for the period 1992-94. Some facilities did not provide any information, and in these cases losses were estimated based on estimated loss rates provided by EPCHC and others. IMC-Agrico, Inc. submitted a detailed estimate of losses of phosphate rock and fertilizer products from their Tampa Bay facilities at Port Redwing and Big Bend (IMC-Agrico, 1994).

Using annual data for tons of phosphate rock and fertilizer products shipped from the Port of Tampa, Port Sutton, and Port Manatee, estimates of material losses were completed using the methods of Morrison and Eckenrod (1994). These estimates suggest an overall loss rate of approximately 0.02% of product shipped. Methods of estimating losses were different for several facilities and depended on the amount of data available, current handling procedures at a facility, and the type of product shipped. A spreadsheet was developed to calculate stormwater runoff, air losses, and other losses subject to data availability. If no data were available regarding site characteristics or loss estimates, the estimated 0.02% loss rate was applied to the total weight of product shipped. This was the same method used tc estimate material losses for the 1985-91 period.

2.5 Groundwater and Springs

Groundwater and springs constitute another source of nutrient loading to Tampa Bay. The surficial (water table), intermediate, and Floridan aquifers all contribute freshwater to Tampa Bay. Estimates of wet and dry season groundwater inflow to Tampa Bay were obtained from Hutchinson (1983) and Brooks et al. (1993). These studies provided estimates of inflows and TN loadings for 1978, 1985, and 1990. Estimates of groundwater inflows for 1992-94 were made using the methods of Hutchinson (1983), and were updated using USGS wet and dry season potentiometric surface maps for the Floridan aquifer (Metz 1995; Metz and Stelman 1995). Surficial aquifer data from 1982 were used by Brooks et al. (1993) to estimate inflows, and were thought to be the most representative data available. Therefore, these data were used for the loading calculations. Flow estimates were calculated using Darcy's equation (Walton, 1970), a well-recognized analytical method for estimating groundwater flow. Flows were estimated for bay segments by delineating groundwater divides in the watershed, and attributing flows to each bay segment.

TN and TP concentration data for groundwater were obtained from SWFWMD (Kelly 1988a, 1988b; Jones 1990; DeHaven 1991) and USGS (1993; 1994; 1995), and were used to supplement the water quality data used by Brooks et al. (1993). The estimated seasonal groundwater flow rates (expressed as volume per unit time such as million gallons per day) were then multiplied by the overall average pollutant concentration (mg/L) for each aquifer in a bay segment region. The resulting loading rates for each bay segment were expressed in mass/time, such as kg/month or tons/year, on a monthly basis for wet and dry seasons. Monthly loads for the four-month wet season and eight-month dry season were summed on an annual basis.

Only groundwater inflow that entered the bay directly from the shoreline or bay bottom was considered. Groundwater inflows to streams were accounted for in gaged streamflow and the empirical model. Septic tank loadings carried to the bay in groundwater were not explicitly accounted for in this analysis, but were implicitly incorporated in the gaged nonpoint source loadings and empirical model, as was the case for the 1985-91 estimates.

Loadings from Sulphur Springs, Crystal Springs, and Lithia Springs were calculated independently of the groundwater loading estimates. Spring discharge loadings were estimated based on measured discharge and water quality data obtained from USGS (1993; 1994; 1995), and SWFWMD (Jones 1995; Jones and Upchurch 1993). Only periodic data were available. The water quality component of the spring loadings was obtained by averaged measured data for each spring over 1992-94, or over the 1985-91 period if no more recent data existed. Discharge estimates for months with no measured data were made by interpolating between preceding and succeeding months with measured data. For each spring, the water quality concentration was multiplied by the estimated or measured discharge to obtain a monthly load. Monthly loads were summed on an annual basis and averaged to obtain an average annual load for 1992-94.

2.6 Future Total Nitrogen Loadings

"Best estimate" future TN loads were developed for Tampa Bay as a whole. It was desired to make the best estimate TN load for the future so as to equitably compare existing and future loadings in the TBNEP Comprehensive Conservation and Management Plan.

Projected fbture loads were estimated by using the model-based estimates of 1992-94 and future (circa 2010) TN loads as described by Zarbock et al.) (1996). The model-based fbture TN loadings were developed to compare current to projected conditions based on changes to land use, point sources, atmospheric deposition, and material losses. Future nonpoint source loadings were estimated by using a fbture land use scenario with the same rainfall that was used for the current (1992-94) loadings, so that changes in loadings would be due only to land use changes, and not rainfall variation. Local government utility planners were interviewed to obtain fbture wastewater demand projections to estimate fbture point source loadings. Industry representatives were interviewed to obtain estimates of future industrial point source discharges and material losses. Work by FDEP projecting future emissions in the Tampa Bay area was used to adjust atmospheric deposition for the year 2010.

Using the methods summarized above, future TN loads to Tampa Bay were projected to increase by approxiately 7% by the year 2010. Thus, the total 1992-94 best estimate TN load was multiplied by 1.07 to provide the best estimate of projected 2010 TN loadings.

3. RESULTS AND DISCUSSION

The results of the updated best estimate loading analysis are summarized below and in Table 3-1 and Figures 3-1 and 3-2. Average annual TN loads for 1992-94 were made for the entire bay, for bay segments, and are presented by source, including atmospheric deposition, nonpoint sources, industrial and domestic point sources, material losses, groundwater and springs. Nonpoint source loading estimates were obtained by using measured precipitation, precipitation quality, streamflow, and surface water quality data for the gaged areas, and by modeling the ungaged areas of the watershed using the methods described in Section 2. FDEP permit data were used to estimate TN loadings from point sources. Measured precipitation and precipitation quality data were used to estimate atmospheric deposition TN loadings, and information from ports and the phosphate industry was used to obtain estimates of material losses.

3.1 Bay-Wide Loadings

Total average annual TN loads delivered to Tampa Bay for the period 1992-94 were estimated to be approximately 3,839 tons per year (tpy), approximately 3% lower than the estimated 1985-91 average annual load of 3,943 tpy. Of the major sources, atmospheric deposition contributed approximately 29% (1,103 tpy) of the total TN load to the bay for the 1992-94 period, nonpoint source loadings contributed approximately 43% (1,652 tpy), domestic and industrial point sources accounted for approximately 9% (362 tpy) and 4% (149 tpy), respectively, material losses contributed 7% (257 tpy), and groundwater and springs accounted for approximately 8% (317 tpy) of the total TN load.

3.2 Bay Segment Loadings

Of the seven major bay segments, Hillsborough Bay received the largest average annual TN load (1,552 tpy), over twice that of the next largest bay segment load, (Middle Tampa Bay, with 750 tpy). Old Tampa Bay, Lower Tampa Bay, and the Manatee River all had TN loads between 349 and 482 tpy, and Boca Ciega Bay and Terra Ceia Bay had the lowest TN loads (168 tpy and 35 tpy, respectively).

The relative contributions of major sources to the bay segments were very similar to the 1985-91 loadings. The bay segments with larger open water surface areas (Old Tampa Bay, Middle Tampa Bay, and Lower Tampa Bay) received proportionally more TN load from atmospheric deposition. Hillsborough Bay received a far greater contribution from nonpoint source loads because of its large tributary area, as well as the largest loads from domestic and industrial point sources. The Manatee River also has a relatively large tributary area, and had the second largest nonpoint source TN loading (422 tpy). Material losses occurred only in Hillsborough Bay and Lower Tampa Bay, and groundwater loadings were relatively minor in all segments.

Table 3-1. Best estimate total nitrogen loadings to Tampa Bay for 1992-94 (tons/year).

Bay Segment	Load Sources						
	Nonpoint Source	Domestic Point Source	Industrial Point Source	Atmospheric Deposition	Groundwater and Springs	Material Losses	Total
Old Tampa Bay	174	85	0	227	<1	0	486
Hillsborough Bay	596	220	80	115	206	233	1,451
Middle Tampa Bay	415	20	58	306	<1	0	799
Lower Tampa Bay	36	1	<1	288	<1	24	349
Boca Ciega Bay	69	15	0	93	<1	0	177
Terra Ceia Bay	11	4	0	20	<1	0	35
Manatee River	422	16	11	54	<1	0	503
Total	1,723	361	149	1,103	206	257	3,800

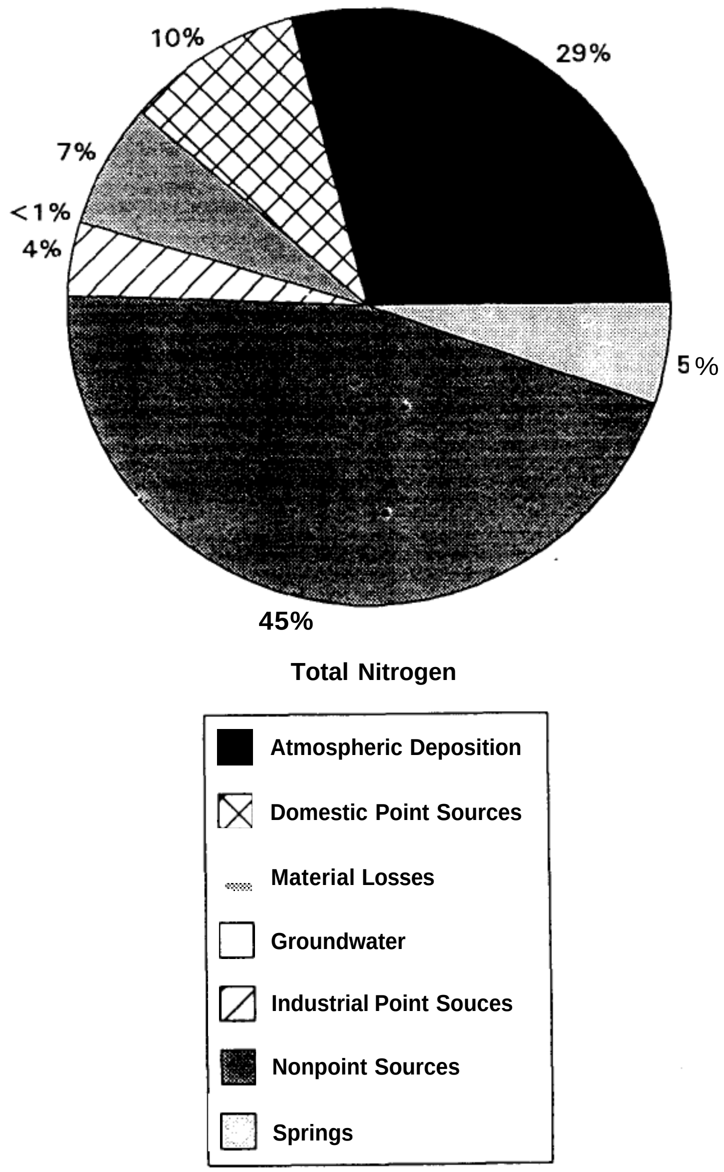

Figure 3-1. Major sources of nitrogen loading to Tampa Bay, 1992-94.

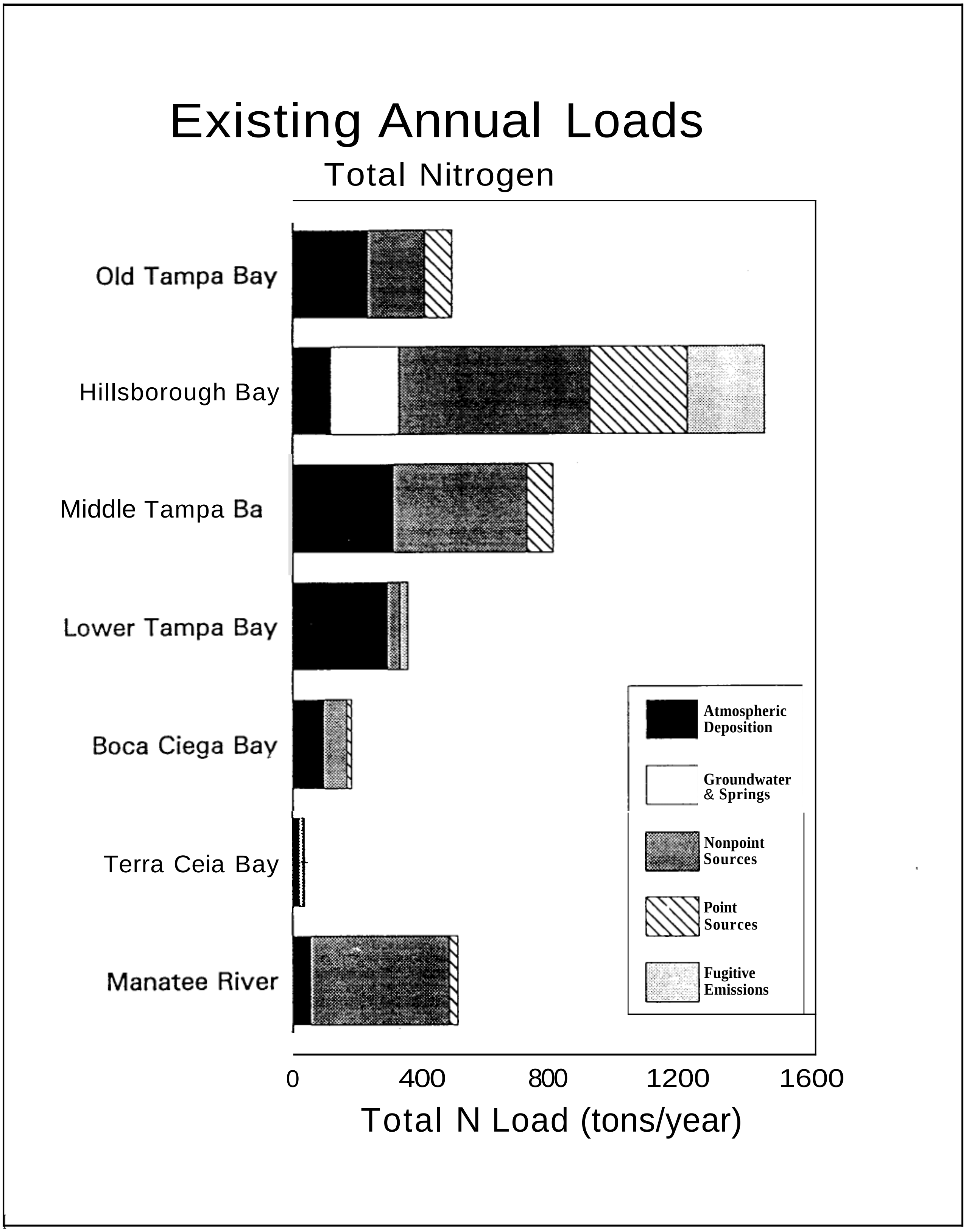

Figure 3-2. Best estimate total nitrogen loadings to Tampa Bay segments by source, 1992-94.

Estimated average annual TN loads to Old Tampa Bay for the period 1992-94 included 227 tpy from atmospheric deposition, 168 tpy from nonpoint sources, 87 tpy from domestic point sources, and less than one tpy from groundwater for a total of 482 tpy. TN loads to Hillsborough Bay were the largest of any bay segment, and included 115 tpy from atmospheric deposition, 581 tpy from nonpoint sources, 226 tpy from domestic point sources, 80 tpy from industrial point sources, 233 tpy from material losses, and 317 tpy from groundwater and springs for a total of 1,552 tpy.

Middle Tampa Bay had the second highest TN load of any bay segment during 1992-94, including 306 tpy from atmospheric deposition, 364 tpy from nonpoint sources, 22 tpy from domestic point sources, 58 tpy from industrial point sources, and less than one tpy from groundwater for a total of 750 tpy. Lower Tampa Bay TN loads totaled 349 tpy, and included 288 tpy from atmospheric deposition, 36 tpy from nonpoint sources, 1 tpy from domestic point sources, 24 tpy from material losses, and less than one tpy from groundwater.

TN loads to Boca Ciega Bay included 93 tpy from atmospheric deposition, 69 tpy from nonpoint sources, 6 tpy from domestic point sources, no load from industrial point sources or material losses, and less than 1 tpy from groundwater for a total of 168 tpy. Terra Ceia Bay TN loads were the smallest of any bay segment, totaling 35 tpy, including 20 tpy from atmospheric deposition, 11 tpy from nonpoint sources, 4 tpy from domestic point sources, and less than one tpy from groundwater. TN loads to the Manatee River included 54 tpy from atmospheric deposition, 422 tpy from nonpoint sources, 16 and 11 tpy from domestic and industrial point sources, respectively, and less than one tpy from groundwater for a total of 503 tpy.

4. LITERATURE CITED

Brooks, Gregg R., Thomas L. Dix, and Larry J. Doyle. 1993. Groundwater/Surface Water Interactions in Tampa Bay and Implications for Nutrient Fluxes. Prepared for Tampa Bay National Estuary Program. St. Petersburg, Florida. 44 p.

DeHaven, Eric C. 1991. Ground-Water Quality of the Southwest Florida Water Management District: Central Region - Section 2. Prepared by Ambient Ground-Water Monitoring Program. Brooksville, Florida.

Florida Department of Environmental Protection. 1996. Groundwater Monitoring Data Base. Monthly Operating Records for Domestic Wastewater Treatment Plants. Tampa, Florida.

Florida Department of Transportation Thematic Mapping Section. 1985. Florida Land Use, Cover and Forms Classification System. second ed. Tallahassee, Florida. 81 p.

Florida Electric Power Coordinating Group. 1987. Florida Acid Deposition Study - Five-Year Data Summary. Prepared by Environmental Science & Engineering, Inc. Tampa, Florida.

Foose, Donald. 1993. U.S. Geological Survey WRD. Personal communication. Tallahassee, Florida.

Hutchinson, C.B. 1983. Assessment of the Interconnection Between Tampa Bay and the Floridan Aquifer, Florida. U.S. Geological Survey Water Resources Investigations Report 82-54. Tallahassee, Florida. 61 p.

IMC-Agrico Company. 1994. Comments on Phase 1: Tampa Bay Water Quality Model. Prepared for Tampa Bay National Estuary Program. St. Petersburg, Florida.

Janicki, A.J. and D. Wade. 1996. Estimating Critical Nitrogen Loads for the Tampa Bay Estuary: An Empirical Approach to Setting Management Targets. Tampa Bay National Estuary Program Technical Publication #06-96. Prepared by Coastal Environmental, Inc. St. Petersburg, FL.

Johansson, J.O.R. 1991. Long-term Trends in Nitrogen Loading, Water Quality, and Biological Indicators in Hillsborough Bay, Florida. In: Treat, S.F. and P.A. Clark, (eds.) Proceedings, Tampa Bay Area Scientific Information Symposium 2. 1991 February 27-March 1. Tampa, Florida. p. 157-176.

Jones, G.W. 1990. Ground-Water Quality Sampling from Wells in the Southwest Florida Water

Management District: Central Region - Section 1. Prepared by Ambient Ground-Water Monitoring Program. Brooksville, Florida.

Jones, G.W and S.B. Upchurch. 1993. Origin of Nutrients in Ground Water Discharging fi-om Lithia and Buckhorn Springs. Ambient Groundwater Quality Monitoring Program. Southwest Florida Water Management District. Brooksville, Florida. 209 p.

Jones, G.W. 1996. Unpublished water quality data for Buckhorn Springs. Southwest Florida Water Management District. Brooksville, FL.

Kelly, G.M. 1988(a). Ground-water Resource Availability Inventory: Hillsborough County, Florida. Southwest Florida Water Management District. Brooksville, Florida. 184 p.

Kelly, G.M. 1988(b). Ground-water Resource Availability Inventory: Manatee County, Florida. Southwest Florida Water Management District. Brooksville, Florida. 203 p.

Metz. P.A. 1995. Potentiometric Surface of the Upper Floridan Aquifer, West-Central Florida, September 1994. U.S. Geological Survey WRD Open-File Report 95-277. Tampa, Florida.

Metz. P.A. and K.A. Stelman. 1995. Potentiometric Surface of the Upper Floridan Aquifer, West-Central Florida, May 1995. U.S. Geological Survey WRD Open-File Report 95-704. Tampa, Florida.

Morrison, G. and R. Eckenrod. 1994. Personal Communication. Estimated Fugitive Emissions to Tampa Bay, 1985 to 1991. Tampa, Florida.

National Atmospheric Deposition Program. 1995. Monitoring results from Verna Wellfield site, 1992-1994. Colorado State University. Natural Resources Ecology Laboratory. Ft. Collins, Colorado.

National Weather Service. 1995. Monthly precipitation data for 23 sites in west-central Florida. Asheville, North Carolina.

Port Manatee Port Authority. 1995. Estimates of phosphate and fertilizer products shipped from Port Manatee, 1992-94. Bradenton, FL.

Southwest Florida Water Management District. 1992(a). Surface Water Improvement and Management (SWIM) Plan for Tampa Bay. Brooksville, FL. 58 p.

Southwest Florida Water Management District - Mapping and GIS Section. 1992(b). Geographic Information System Data Distribution Procedures. Subbasin boundary, soils, and land use ARC INFO coverage. Brooksville, Florida.

Tampa Bay National Estuary Program. 1996. Comprehensive Conservation and Management Plan - DRAFT. St. Petersburg, FL.

Tampa Port Authority. 1995. Estimates of phosphate and fertilizer products shipped from Port of Tampa, 1992-94. Tampa, FL.

U.S. Geological Survey. 1993. Water Resources Data for Florida. Water Year 1992. Volume 3B: Southwest Florida Ground Water. USGS/WRDIHD-93/236. 257 p.

U.S. Geological Survey. 1994. Water Resources Data for Florida. Water Year 1993. Volume 3B: Southwest Florida Ground Water. USGS/WRD/HD-94/239. 225 p.

U.S. Geological Survey. 1995. Water Resources Data for Florida. Water Year 1994. Volume 3B: Southwest Florida Ground Water. USGSIWRDMD-95/240. 227 p.

Walton, W.C. 1970. Ground Water Resource Evaluation: McGraw-Hill series in Water Resources Environmental Engineering. McGraw-Hill Publishers, New York. 664 p.

Zarbock, Hans, Anthony Janicki, David Wade, Douglas Heimbuch, and Harold Wilson. 1994. Estimates of Total Nitrogen, Total Phosphorus, and Total Suspended Solids to Tampa Bay, Florida. Technical Publication #04-94. Prepared by Coastal Environmental, Inc. Prepared for Tampa Bay National Estuary Program. St. Petersburg, Florida.

Zarbock, H., A. Janicki, and D. Wade. 1996. Estimates of Model-Based Total Nitrogen Loading to Tampa Bay, Florida. Tampa Bay National Estuary Program Technical Publication #05-96. St. Petersburg, FL. Prepared by Coastal Environmental, Inc.

EXHIBITS

EXHIBIT 1

AGGREGATED FLORIDA LAND USE AND COVER CLASSIFICATION SYSTEM CATEGORIES

Coastal Land Use Code	FLUCCS Code
1 - Low Density Residential	1100
2 - Medium Density Residential	1200
3 - High Density Residential	1300
4 - Commercial	1400
5 - Industrial	1500
7 - Institutional, Transportation, Utilities	1700 8100 8200 8300

Coastal Land Use Code	FLUCCS Code
6 - Mining	1600
11 - Groves	2200 2210 2220 2230
12 - Feedlots	2300
13 - Nursery	2400
14 - Row and Field Crops	2100 2140 2150 2440

UPLAND FORESTED LAND USE CATEGORIES

Coastal Land Use Categories	FLUCCS Code
8 - Range Lands	1480 1800 1900 2420 2600 3100 3200 3300
9 - Barren Lands	7100 7200 7300 7400
10 - Pasture	2110 2120 2130
15 - Upland Forests	4100 4110 4120 4200 4300 4340 4400

WATER AND WETLANDS LAND USE CATEGORIES

Coastal Land Use Categories	FLUCCS Code
16 - Freshwater	2500 2540 2550 5100 5200 5210 5220 5230 5240 5300 5310 5320 5330 5340 5500 5600 6440 6450
17 - Saltwater	5400 9113 9116 9121
18 - Forested Freshwater Wetlands	6100 6110 6150 6200 6210 6240 6300
19 - Saltwater Wetlands	6120 6420
20 - Non-forested Freshwater Wetlands	6400,6410, 6411,6430 6530
21 - Tidal Flats	6500,6510 6520

EXHIBIT 2

LAND USE-SPECIFIC SEASONAL RUNOFF COEFFICIENTS

Seasonal Land Use-Specific Seasonal Runoff Coefficients

Coastal Land Use Classification and Land Use Type	Hydrologic Soil Group	Dry Season Runoff Coeff.	Wet Season Runoff Coeff
1) Single Family Residential	A	0.15	0.25
	B	0.18	0.28
	C	0.21	0.31
	D	0.24	0.34
2) Medium Density Residential	A	0.25	0.35
	B	0.30	0.40
	C	0.35	0.45
	D	0.40	0.50
3) Multifamily Residential	A	0.35	0.50
	B	0.42	0.57
	C	0.50	0.65
	D	0.58	0.75
4) Commercial	A	0.70	0.79
	B	0.74	0.83
	C	0.78	0.97
	D	0.82	0.91
5) Industrial	A	0.65	0.75
	B	0.70	0.80
	C	0.75	0.85
	D	0.80	0.90

Land Use-Specific Seasonal Runoff Coefficients (cont)

Land Use	Hydrologic Soil Group	Dry Season Runoff Coeff.	Wet Season Runoff Coeff.
6) Mining	A	0.20	0.20
	B	0.30	0.30
	C	0.40	0.40
	D	0.50	0.50
7) Institutional, Transportation Utils.	A	0.40	0.50
	B	0.45	0.55
	C	0.50	0.60
	D	0.55	0.65
8) Range Lands	A	0.10	0.18
	B	0.14	0.22
	C	0.18	0.26
	D	0.22	0.30
9) Barren Lands	A	0.45	0.55
	B	0.50	0.60
	C	0.55	0.65
	D	0.60	0.70
10) Agricultural - Pasture	A	0.10	0.18
	B	3.14	0.22
	C	0.18	0.26
	D	0.22	0.30

Land Use-Specific Seasonal Runoff Coefficients (cont)

Land Use	Hydrologic Soil Group	Dry Season Runoff Coeff.	Wet Season Runoff Coeff.
11) Agricultural - Groves	A	0.20	0.26
	B	0.23	0.29
	C	0.26	0.32
	D	0.29	0.33
12) Agricultural - Feedlots	A	0.35	0.45
	B	0.40	0.50
	C	0.45	0.55
	D	0.50	0.60
13) Agricultural - Nursery	A	0.20	0.30
	B	0.25	0.35
	C	0.30	0.40
	D	0.35	0.45
eld Crops	A	0.20	0.30
	B	0.25	0.35
	C	0.30	0.40
	D	0.35	0.45
15) Upland Forested	A	0.10	0.15
	B	0.13	0.18
	C	0.16	0.21
	D	0.19	0.24

Land Use-Specific Seasonal Runoff Coefficients (cont)

Land Use	Hydrologic Soil Group	Dry Season Runoff Coeff	Wet Season Runoff Coeff
	A	0.80	0.90
	B	0.80	0.90
	C	0.80	0.90
	D	0.80	0.90
17) Saltwater - Open Water	A	1.0	1.0
	B	1.0	1.0
	C	1.0	1.0
	D	1.0	1.0
18) Forested Freshwater Wetlands	A	0.50	.60
	B	0.55	0.65
	C	0.60	0.70
	D	0.65	0.75
19) Saltwater Wetlands	A	0.95	0.95
	B	0.95	0.95
	C	0.95	0.95
	D	0.95	0.95
20) Non-forested Freshwater Wetlands	A	0.45	0.55
	B	0.50	0.60
	C	0.55	0.65
	D	0.60	0.70
21) Tidal Flats	A	1.0	1.0
	B	1.0	1.0
	C	1.0	1.0
	D	1.0	1.0

EXHIBIT 3

LAND USE-SPECIFIC RUNOFF WATER QUALITY CONCENTRATIONS

Land Use-Specific Nonpoint Source Water Quality Concentrations

URBAN LAND USES					
Land Use Classification			Land Use-Specific Water Quality Concentrations		
Coastal Land Use Classification	Land Use Description	Reference	TN (mg/L)	TP (mg/L)	TSS (mg/L)
1 (LDR)	Low Density Single Family Residential (SFR)	(1)	2.31	0.40	33.0
		(1)	2.14	0.32	28.0
		(1)	0.605	0.073	7.2
		(1)	1.18	0.307	3.5
		(1)	3.0	0.45	-
		(1)	2.2	0.25	-
		(4)	1.87	0.39	-
		(8)	1.46	0.401	19.0
		(9)	1.56	0.27	20.8
		(10)	2.04	0.593	49.7
		(11)	2.88	0.72	56.8
		min	0.605	0.073	3.5
		mean	1.93	0.380	27.3
		max	2.88	0.598	56.8
2 (MDR)	Medium Density Res. (See notes)	mean	2.04	0.44	33.5
3 (HDR)	Multifamily Residential	(1)	1.61	0.33	53.0
		(1)	2.57	0.45	36.8
		(1)	4.68	0.72	95.6
		(1)	1.91	0.73	-
		(1)	1.02	0.033	67.6
		(1)	1.91	0.51	14.3
		(4)	1.65	0.33	-
		(8)	2.05	1.34	29.0
		(9)	2.04	0.282	10.7
		(10)	2.05	0.150	8.3
		(11)	2.00	0.56	41
		min	1.02	0.033	8.3
		mean	2.14	0.49	39.6
		max	4.68	1.34	95.6

URBAN LAND USES					
Land Use Classification			Land Use-Specific Water Quality Concentrations		
Coastal Land Use Classification	Land Use Description	Reference	TN (mg/L)	TP (mg/L)	TSS (mg/L)
4	Low Intensity Commercial	(1)	1.19	0.15	22.0
		(1)	1.10	0.10	45.0
	High Intensity Commercial	(1)	2.81	0.31	94.3
		(1)	3.53	0.82	-
		(1)	2.15	0.15	-
	Commercial (Office)	(8)	2.38	0.305	36.5
		(9)	1.08	0.495	50.6
		(10)	1.40	0.113	6.2
		(12)	1.05	0.145	13.8
	Commercial (Retail)	(8)	1.686	0.253	9.3
		(10)	1.28	0.177	14.5
		(11)	2.12	0.22	36.3
	Combined Commercial	min	1.05	0.10	6.2
		mean	1.82	0.27	32.9
		max	3.53	0.495	94.3
5	Industrial (light)	(1)	1.42	0.19	71.8
		(1)	1.42	0.31	102.0
		(4)	1.18	0.15	-
		(8)	2.28	0.332	18.2
		(9)	1.77	0.465	28.3
		(10)	1.92	0.490	84.3
		(11)	3.00	0.503	70.0
		min	1.18	0.15	18.2
		mean	1.85	0.349	62.4
		max	3.00	0.503	102
6	Mining	(4)	1.18	0.15	35 (e)
7	Institutional	(4)	1.18	0.15	35 (e)

AGRICULTURAL LAND USES					
Land Use Classification			Land Use-Specific Water Quality Concentrations		
Coastal Land Use Classification	Land Use Description	Reference	TN (mg/L)	TP (mg/L)	TSS (mg/L)
10	Pasture	(1)	2.37	0.697	-
		(1)	2.48	0.27	8.6
		(2)	2.0	0.3	-
		(3)	3.0	0.25	-
		(4)	1.02	0.16	-
		(5)	5.1	3.2	-
11	Citrus	(7)	2.31	0.10	-
11,13	Citrus, Nursery	(4)	0.92	0.41	-
12		(3)	29.3	5.1	-
		(3)	3.74	1.13	-
		(5)	26.0	5.1	-
14	Crop	(2)	2.5	0.25	-
		(3)	2.5	2.5	-
		(4)	3.75	1.13	-
		(8)	2.97	2.35	12.7
10,11	Citrus & Pasture	(1)	1.57	0.09	-
		(1)	1.33	0.09	4.6
		(1)	2.58	0.046	180
		(1)	2.68	0.562	-
		(1)	3.26	0.24	28.0
11,14	Citrus & Row Crops	(6)	1.78	0.3	5.6

(See following page for summarized agricultural water quality concentrations.)

SUMMARIZED AGRICULTURAL LAND USE DATA					
Land Use Classification			Land Use Specific Water Quality Concentrations		
Coastal Land Use Classification	Land Use Description	Reference	TN (mg/L)	TP (mg/L)	TSS (mg/L)
8	Rangeland	min mean max	0.90 1.24 1.47	0.02 0.01 0.21	4.8 11.0 17.3
10	Pasture	min mean max	1.0 2.66 5.1	0.16 0.81 3.2	8.6 8.6 8.6
11	Citrus	min mean max	0.92 1.62 2.31	0.10 0.27 0.41	5.0 5.3 5.6
12	Feed Lot	min mean max	3.74 19.7 29.3	1.13 3.8 5.1	50(e)
13	Nursery	mean	1.62(e)	0.27(e)	5.3(e)
14	Row Crop	mean	2.93	1.56	12.7

Land Use Classification			Land Use-Specific Water Quality Concentrations		
Coastal Land Use Classification	Land Use Description	Reference	TN (mg/L)	TP (mg/L)	TSS (mg/L)
8	Open Space/ Non-forested	(1)	1.38	0.07	17.3
		(1)	0.90	0.02	4.8
		(1)	1.47	0.07	-
		(4)	1.02	0.16	-
15	Upland Forest	(2)	0.1	0.007	-
		(3)	0.2	0.007	-
		(4)	1.02	0.16	-
16,17	Open Water	(1)	0.79	0.17	-
		(1)	0.73	0.04	0.00
		(1)	2.22	-	6.2
18,20	Freshwater Wetland	(1)	2.26	0.09	13.4
		(1)	1.02	0.16	-
		(1)	1.24	0.018	4.6
		(1)	1.88	0.33	12.7
		(4)	0.79	0.17	-
17	Saltwater		NA	NA	NA
19	Saltwater Wetlands		NA	NA	NA
21	Tidal Flats		NA	NA	NA

Notes:

- Concentrations for CLUCCS code 2 (MDR) are an average of CLUCCS codes 1 (LDR) and 3 (HDR).
- Concentrations for CLUCCS code 4 (Commercial) are an average of reported values for "low intensity" commercial, "high intensity" commercial, office, and retail.
- Estimated (e) values were based on data from similar land uses when no land use specific data were identified.
- Row crop data were oflen reported with other agricultural uses.
- Saltwater and saltwater wetlands were assigned zero loads.

References

(1) Harper, H.H. 1991. Estimation of Loading Rate Parameters for Tampa Bay Watershed. Southwest Florida Water Management District. Brooksville, Florida.

(2) Delwiche, L.L.D. and D.A. Haith. 1983. Loading Functions for Predicting Nutrient Losses from Complex Watersheds. Water Resources Bulletin vol. 19, no. 6. p. 95 1-959.

(3) Haith, D. A. and L.L. Shoemaker. 1987. Generalized Watershed Loading Function for Stream Flow Nutrients. Water Resources Bulletin. vol. 23, no. 3. p. 471-477.

(4) Camp, Dresser, & McKee. 1992. Point/Non-Point Source Loading Assessment for Sarasota Bay, Prepared for Sarasota Bay National Estuary Program, Sarasota, Florida.

(5) Andrews, W.J. 1992. Reconnaissance of Water Quality at Nine Dairy Farms in North Florida, 1990-1991. USGS WRI 92-4058. Tallahassee, Florida.

(6) Flannery, M.S. et al. 1991. Increased Nutrient Loading and Baseflow Supplementation in the Little Manatee Watershed. in: Treat, F.S. and P.A. Clark (eds.) Proceedings, Tampa Bay Area Scientific Information Symposium 2. 1991 February 27-March 1. Tampa, Florida. p. 369-396.

(7) Allhands, M. 1993. Water Quality Data for Gator Slough Groves. Agricultural Management Services. Punta Gorda, Florida.

(8) Hillsborough County Engineering Services. 1993. NPDES Part 2 Application. Tampa FL.

(9) City of Tampa Stormwater Management Division. 1994. NPDES Part 2 Application. Tampa FL.

(10) Pinellas County Department of Environmental Management. 1993. NPDES Part 2 Application. Clearwater, FL.

(11) City of St. Petersburg Engineering Department. 1993. NPDES Part 2 Application. St. Petersburg, FL.

(12) Carr, D.W. and B.T. Rushton. 1995. Integrating a Native Herbaceous Wetland into Stormwater Management. Southwest Florida Water Management District Stormwater Research Program. Brooksville, FL.

EXHIBIT 4

POINT SOURCE INVENTORY

Domestic Point Sources in the Tampa Bay Watershed (1992-94)		
Facility Name	Tributary to Bay Segment	Owner (1992-94)
Northwest	Old Tampa Bay, Middle Tampa Bay, and Boca Ciega Bay. (See note at end of table.)	City of St. Petersburg
Southwest		City of St. Petersburg
South		City of St. Petersburg
Albert Whitted		City of St. Petersburg
East	Old Tampa Bay	City of Clearwater
Northeast	Old Tampa Bay	City of Clearwater
Top of the World	Old Tampa Bay	Private
Largo	Old Tampa Bay	City of Largo
Oldsmar	Old Tampa Bay	City of Oldsmar
Eastlake Woodlands	Old Tampa Bay	Pinellas County
Northwest	Old Tampa Bay	Pinellas County
South Cross Bayou	Boca Ciega Bay	Pinellas County
Pine Ridge	Old Tampa Bay	Private
Tarpon Lake Village	Old Tampa Bay	Private
Tarpon Woods	Old Tampa Bay	Private
Howard F. Curren	Hillsborough Bay	City of Tampa
MacDill AFB	Middle Tampa Bay	US Air Force
Northwest Regional	Old Tampa Bay	Hillsborough County
River Oaks	Old Tampa Bay	Hillsborough County
Dale Mabry	Old Tampa Bay	Hillsborough County
Valrico Subregional	Hillsborough Bay	Hillsborough County
Faulkenburg	Hillsborough Bay	Hillsborough County
Progress Village	Hillsborough Bay	Hillsborough County

Domestic Point Sources in the Tampa Bay Watershed (1992-94)		
Facility Name	Tributary to Bay Segment	Owner (1992-94)
South County	Middle Tampa Bay	Hillsborough County
Bloomingdale Hills	Hillsborough Bay	Private
Boyette Springs	Hillsborough Bay	Private
Rice Creek	Hillsborough Bay	Private
Riverhills	Hillsborough Bay	Private
Seaboard Utilities	Hillsborough Bay	Private
Sterling Ranch	Hillsborough Bay	Private
Summerfield Subreg.	Hillsborough Bay	Private
Meadowlands	Hillsborough Bay	Private
Pebble Creek Village	Hillsborough Bay	Private
Plant City	Hillsborough Bay	City of Plant City
North Regional	Lower Tampa Bay	Manatee County
Southeast	Manatee River	Manatee County
Palmetto	Terra Ceia Bay	City of Palmetto
Bradenton	Manatee River	City of Bradenton
Lakeland	Hillsborough Bay	City of Lakeland
Mulberry	Hillsborough Bay	City of Mulberry

(*) Effluent is commingled in reuse distribution system and discharged in the coastal Old Tampa Bay, Middle Tampa Bay, and Boca Ciega Bay basins.

Industrial Point Sources in the Tampa Bay Watershed (1992-94)	
Facility Name	Tributary to Bav Segment
Mobile Big Four Mine	Hillsborough Bay
Mobile Nichols Prep Plant	Hillsborough Bay
Mobile Nichols Mine	Hillsborough Bay
TECO Gannon Station	Hillsborough Bay
TECO Big Bend Station	Hillsborough Bay
Farmland Hydro Green Bay Plant	Hillsborough Bay
Farmland Hydro Port Sutton	Hillsborough Bay
Crystals International	Hillsborough Bay
Florida Power and Light	Middle Tampa Bay
Tropicana	Manatee River
FDEP Fisheries Stock Enhancement	Middle Tampa Bay
Estech Silver City Mine	Hillsborough Bay
Florida Juice	Hillsborough Bay
Nitram	Hillsborough Bay
Trademark Nitrogen	Hillsborough Bay
Cargill	Hillsborough Bay
Shell Oil	Old Tampa Bsy
CF Industries Plant City	Hillsborough Bay
Mulberry Phosphates	Hillsborough Bay
IMC-Agrico - Haynesworth Maine	Hillsborough Bay
IMC Agrico - Port Sutton Terminal	Hillsborough Bay

Industrial Point Sources in the Tampa Bay Watershed (1992-94)	
Facility Name	Tributary to Bay Segment
IMC Agrico - Four Corners Mine	Middle Tampa Bay
IMC - Agrico Big Bend Terminal	Hillsborough Bay
Piney Point Phosphates	Lower Tampa Bay
CSX Winston Yard	Hillsborough Bay
City of Tampa Waterworks	Hillsborough Bay