NITROGEN LOADINGS TO TAMPA BAY: MODEL BASED ESTIMATES OF 1998 AND 2010 LOADS TO MAJOR BASINS, AND TN LOAD REDUCTION/PRECLUSION APPORTIONMENT

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EXECUTIVE SUMMARY

The Florida Department of Environmental Protection (FDEP) has adopted a watershed management approach to managing water resources in Florida. This approach is based on naturally occurring hydrologic features such as river basins, as opposed to political or regulatory boundaries, thus promoting the management of entire natural systems. In addition, this approach strives to increase cooperation among programs and provide consistent environmental management, while maintaining the flexibility to address local and regional issues and implement Total Maximum Daily Loads (TMDLs).

One of the primary goals established in the Tampa Bay National Estuary Program Comprehensive Conservation and Management Plan is to restore seagrass extent in the bay to levels similar to those observed in the 1950s. The Nitrogen Management Strategy seeks to prevent future impacts due to excessive nitrogen loadings to Tampa Bay. The TBEP adopted the "hold the line" strategy, which seeks to maintain loadings at or below the 1992-1994 levels. Local government partners agreed to preclude increases in future nitrogen loadings to the bay to aid in this effort.

In order to better address the FDEPs watershed management approach to water resource management, the Tampa Bay Estuary Program is currently examining loading estimates at the major basin level. The objectives of this report are as follows:

- ***provide model based estimates of nitrogen loading for the existing period (1998) and the future period (2010), and***
- ***describe the nitrogen load apportionment process adopted by the TBEP for the 2000-2004 period***

This report provides brief descriptions of the methods used to derive the model based total nitrogen loadings from major basins for 1998 and 2010. The model based loading estimates are then used to apportion nitrogen load reductions/preclusions among jurisdictions in each major basin.

FOREWORD

This report was prepared by Janicki Environmental, Inc., under the direction of Mr. Dick Eckenrod and Ms. Holly Greening of the Tampa Bay Estuary Program. This work was performed under Contract No. T-00-01 for the Tampa Bay Estuary Program.

ACKNOWLEDGEMENTS

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1.0 INTRODUCTION

The Florida Department of Environmental Protection (FDEP) has adopted a watershed management approach to managing water resources in Florida (FDEP webpage). This approach is based on naturally occurring hydrologic features such as river basins, as opposed to political or regulatory boundaries, thus promoting the management of entire natural systems. In addition, this approach strives to increase cooperation among programs and provide consistent environmental management, while maintaining the flexibility to address local and regional issues and implement Total Maximum Daily Loads (TMDLs).

The watershed management approach is being carried out as a part of the regular water resource assessment cycle. These assessments consist of five phases:

- Initial assessment of watershed health
- Strategic monitoring
- Data analysis and TMDL development
- Watershed plan development
- Watershed plan implementation

Each cycle lasts five years and will lead to the development of a detailed watershed management plan that focuses on protecting healthy water bodies and reducing pollution in impaired surface waters, normally by developing TMDLs (FDEP webpage).

In an effort to quantify the loadings of key water quality parameters into Tampa Bay, the Tampa Bay Estuary Program (TBEP) has developed loading estimates for the 1985-1991, 1992-1994, and 1995-1998 periods (Zarbock *et al.*, 1994; Zarbock *et al.*, 1996a; Pribble *et al.*, 2001). These estimates were developed for total nitrogen, total phosphorus, and total suspended solids loadings to the seven bay segments (Old Tampa Bay, Hillsborough Bay, Middle Tampa Bay, Lower Tampa Bay, Terra Ceia Bay, Boca Ciega Bay, and Manatee River). In addition, biological oxygen demand loads were calculated for the 1995-1998 period.

The estimated 1992-1994 mean annual total nitrogen loadings were identified as sufficient to meet the TBEP's seagrass restoration goals. An empirical model relating total nitrogen loadings to seagrass restoration goals (Janicki and Wade, 1996), and observed increases in seagrass coverage through 1992, suggested that light availability necessary for obtaining seagrass restoration goals could be met by establishing a "hold the line" strategy for nitrogen loadings. This strategy would hold nitrogen loadings to each segment of the bay to the average levels of 1992-1994. The TBEP adopted this strategy in 1996, and local government partners agreed to preclude increases in future nitrogen loadings to the bay to aid in this effort. Janicki *et al.* (2001) updated estimated model-based pollutant loadings for each bay segment (Figure 1) for existing conditions (1998) and future conditions (2010).

In order to better address the FDEP watershed management approach to water resource management, the TBEP is currently examining loading estimates at the major basin level (Figure 1-2). The objectives of this report are as follows:

- ***provide model based estimates of nitrogen loading for the existing period (1998) and the future period (2010), and***
- ***describe the nitrogen load apportionment process adopted by the TBEP for the 2000-2004 period.***

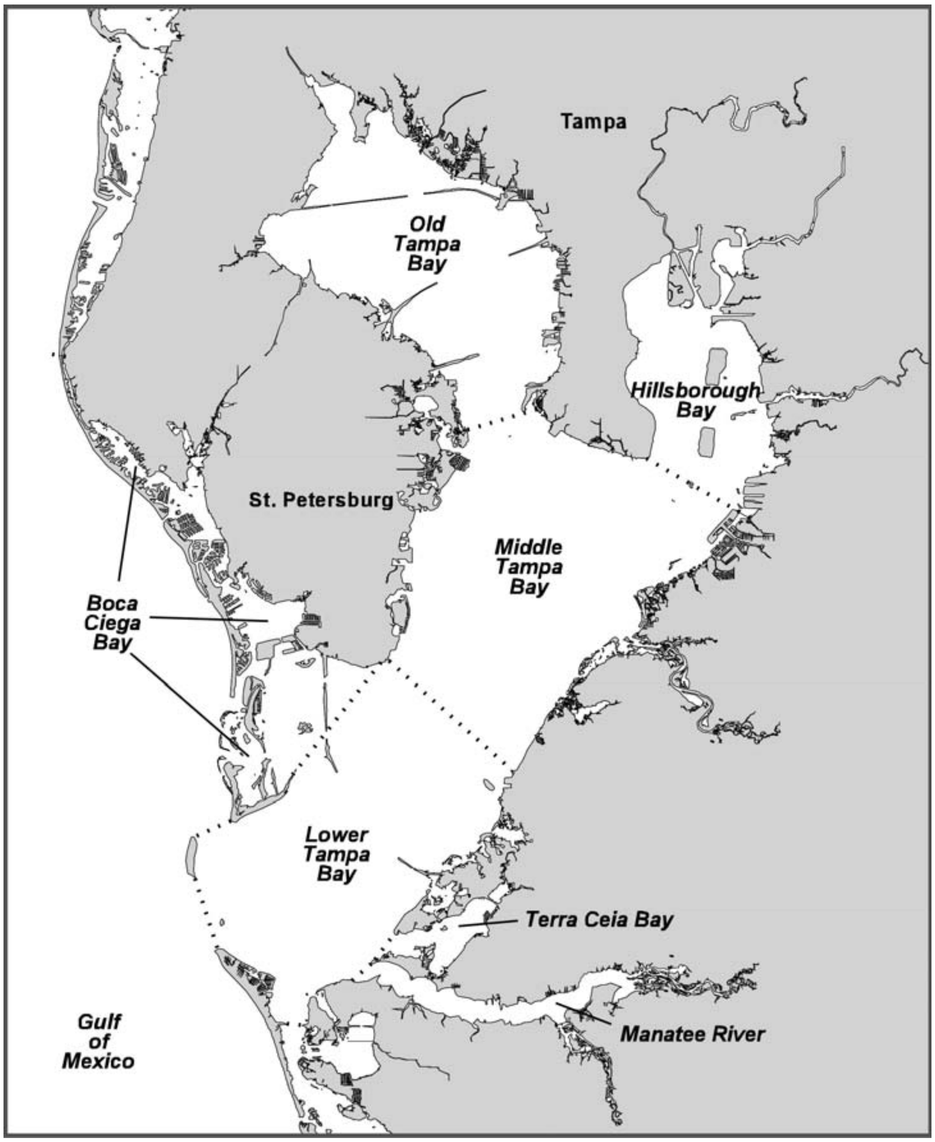

Figure 1-1. Bay segments of Tampa Bay.

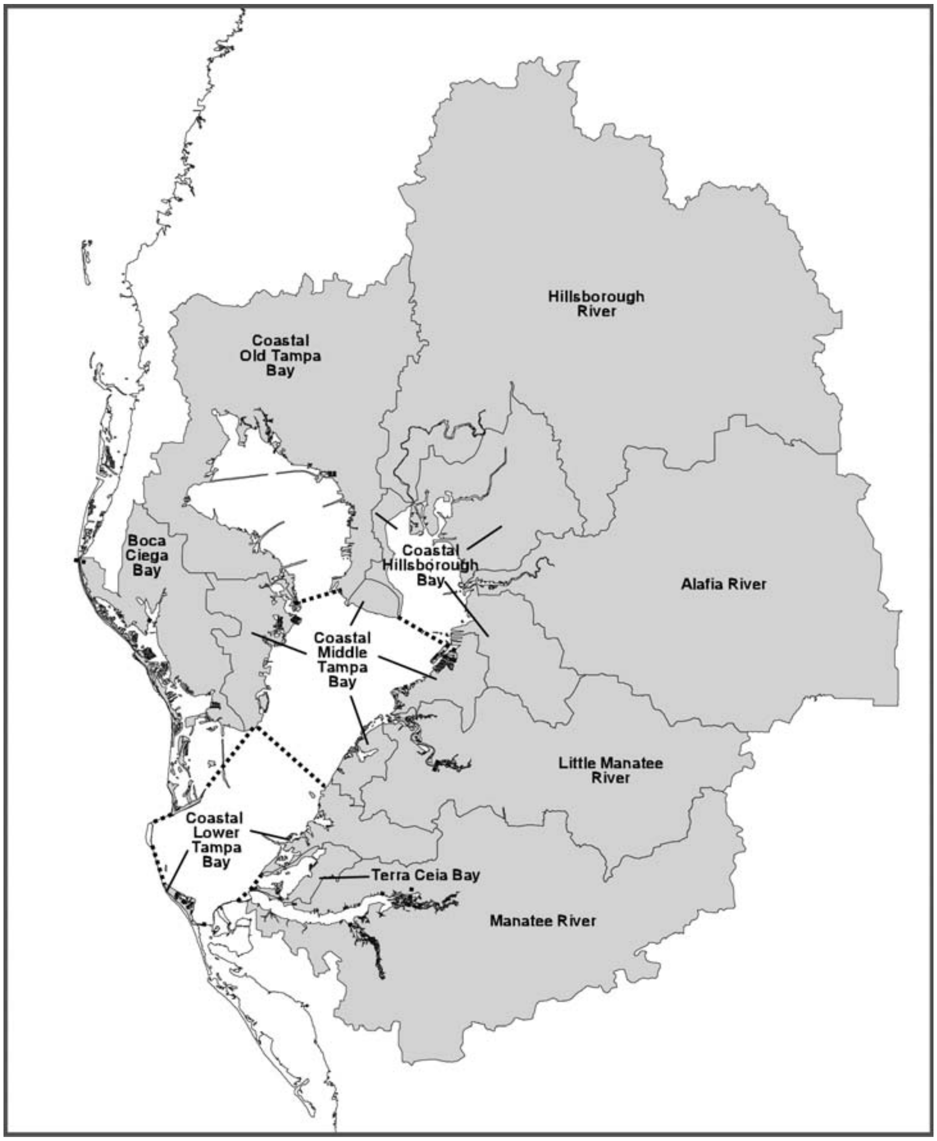

Figure 1-2. Major drainage basins of the Tampa Bay watershed.

2.0 MODEL BASED ESTIMATES OF 1998 AND 2010 LOADS

The annual average model based estimated nitrogen loadings are derived from monthly loading estimates at the major basin level, using methods as described in Janicki *et al.* (2001) for the existing period (1998) and for the future period (2010). These model based estimates are used in reviewing the previous TN load reduction/preclusion targets set by the TBEP. A brief description of the methods used for estimation of the annual loads from each source is given below, followed by the estimated annual loads by major basin.

2.1 Methods for Annual Model Based TN Load Estimates

Model based total nitrogen loads were previously estimated to each of the seven bay segments of Tampa Bay for 1998 and 2010 (Janicki *et al.*, 2001). Seven loading sources contribute TN loads to the bay, as follows:

- Atmospheric deposition,
- Domestic point sources,
- Industrial point sources,
- Springs,
- Groundwater,
- Material losses, and
- Nonpoint sources.

The methods used for deriving the model based estimates of TN loadings from each of these sources to Tampa Bay are described briefly below. For additional description of methods, see Janicki *et al*. (2001).

Atmospheric Deposition

Atmospheric deposition is defined as the pollutant load delivered to the surface of the bay from the fallout of airborne pollutants, including both rainfall (wet) and airborne (dry) pollutants. Only nutrients delivered to the open water estuary were accounted for as atmospheric input.

Precipitation volume [(rainfall depth) x (open water area of the bay)] and pollutant concentration data were used to estimate pollutant loadings delivered directly to the estuary via atmospheric deposition for the existing (1998) period. Wet deposition loadings were calculated on a monthly basis for each bay segment by multiplying the precipitation volume (expressed as volume per unit time) by the pollutant concentration (expressed as mg/L). The monthly mean precipitation-weighted TN concentration in rainfall was derived from the Tampa Bay Atmospheric Deposition Study (TBADS) data for the period August 1996 through December 1998, and multiplied by the monthly mean 1992-1994 hydrologic load due to rainfall to derive the wet TN loading estimate for the existing 1998 condition.

Pollutants are also delivered to the bay via dry deposition. Monitoring at the TBADS site also provided data concerning atmospheric concentrations of nitrogen. Utilizing these data, meteorological data, and a deposition model, dry fluxes of nitrogen to the surface of the bay were estimated (Pribble *et al.*, 2001). Seasonal-specific ratios of dry:wet deposition were then estimated. These ratios were used to estimate monthly atmospheric deposition from both wet and dry deposition.

For the 2010 atmospheric deposition, the simplest method of relating changes in atmospheric nitrogen concentration to potential changes in emissions was used. A reduction in atmospheric nitrogen concentrations was considered to be linearly related to a reduction in atmospheric emissions. For these purposes, it was assumed that atmospheric emissions remained unchanged in 2010 from the emissions for 1997 from sources other than stationary point sources. The reduction in emissions resulting from the scheduled modifications to the TECO facilities, and the projected no net change in on-road mobile sources emissions, correspond to a reduction in atmospheric emissions of 46% by 2010. For this estimate, the 46% reduction in atmospheric emissions by 2010 corresponds to a 46% reduction in atmospheric nitrogen concentrations from the 1995-1998 period to 2010.

Domestic and Industrial Point Sources

Existing domestic and industrial point sources were identified in Pribble *et al*. (2001), and included direct surface discharges and land application discharges within the watershed with a permitted average daily flow (ADF) of 0.1 million gallons per day (MGD) or greater. Through interviews with local government utility planners and facility operators, projected flows and planned future facilities were identified for this analysis.

Existing condition (1998) point source loading estimates were developed by Janicki *et al*. (2001) as monthly loads for 1998. All facilities were assumed to discharge independently except the St. Petersburg facilities. Effluent from St. Petersburg's four facilities enters a common distribution system, and commingles prior to discharge as land application reuse.

Direct surface water discharges were calculated by multiplying the flow expressed as volume per unit time (i.e. MGD) by the reported TN concentration (mg/L). With appropriate conversion factors, this calculation yields a mass per unit time, such as tons per year. All of the effluent released via surface discharge was assumed to reach the Tampa Bay system.

Land application of treated effluent is discharged most commonly by either spray irrigation or in percolation ponds. The applied effluent either evaporates, is taken up by vegetation, becomes surface runoff (generally a very small component of the total volume), or infiltrates to the water table. Therefore, pollutant loadings that reach the bay generally do so via groundwater. Land application loadings were estimated using recorded effluent quality data from specific facilities, with attenuation rates (Zarbock *et al*., 1996a) applied to flows and nitrogen loads once the effluent enters the environment.

The methods used to estimate projected future loads were the same as those used to estimate point source loads for the current period, using revised flows or concentrations based on interviews and visits with representatives of each of the governmental entities responsible for the specific sources (Janicki *et al*. 2001).

Springs and Groundwater

Springs are a significant source of nitrogen loading to the bay. Estimates of spring loads were developed using existing measured data, and were developed independently of groundwater loads. Groundwater provides another source of nutrient loading to the bay. The surficial (water table), intermediate, and Floridan aquifers all contribute loadings to the bay.

The methods used to calculate existing (1998) pollutant loadings from springs and groundwater follow those used in previous loading estimates (Zarbock *et al.*, 1996a; Pribble *et al.*, 2001; Janicki *et al.* 2001). For both sources, average monthly TN concentrations for 1998 were multiplied by monthly flows to yield monthly TN loadings.

Future condition spring loadings were estimated using 1998 data from the USGS and SWFWMD, as described for existing (1998) conditions. No defensible means of quantifying trends in spring flows or spring nutrient concentrations is available. Therefore, the 1998 data were used to estimate future conditions spring loadings. Similarly, groundwater loading estimates for 1998 were assumed to be representative of future conditions.

Material Losses

Fertilizer losses from loading docks at port facilities constitute a source of nutrient loading classified as material losses. In particular, bulk phosphate fertilizer is subject to product losses during its transfer from land carrier to storage facility, and onto vessels for shipping. Product is lost both through spilled product washing into the bay with stormwater runoff, and via fugitive dust. Material losses occur at facilities at the Port of Tampa, in the Coastal Hillsborough Bay basin, and at Port Manatee, in the Coastal Lower Tampa Bay basin.

The estimates for the 1998 period represent the best estimates by facility personnel of actual losses. These estimates reflect both actual reductions in nutrient losses from improved handling practices implemented by most facilities, and improved loss estimation techniques for both ship loading losses and air borne losses.

Material losses for future conditions were estimated by changing existing condition loadings by 1% per year from 1998 through 2010. This information was obtained from Mr. Craig Kovach, CF Industries, and Mr. Bruce DeGrove, Florida Phosphate Council, as representative of industry growth through 2010.

Nonpoint Sources

Nonpoint sources include stormwater runoff and baseflow as streamflow. All nonpoint source loading estimates for existing conditions were model-based, and used no measured water quality or flow data. This approach was used so that an equitable comparison of existing condition to future condition loads (all model-based) could be made (Janicki *et al.*, 2001). An empirical hydrologic model previously developed (Zarbock *et al.*, 1996a) provided estimates of nonpoint source surface water inflows.

Existing condition nonpoint source loads were estimated using 1995 land use, soils, land use-specific runoff coefficients and water quality concentrations, and 1992-1994 rainfall data. Future condition nonpoint source loads for the entire watershed were estimated using the same empirical hydrologic model that was used to estimate flows and loads for the existing conditions. Monthly nonpoint source loads for 2010 were estimated using the same NWS rainfall data, those for 1992-1994, as used for existing conditions, and 2010 estimated land use (Janicki *et al.*, 2001). Therefore, for the future conditions loadings, only the land use was different from the existing conditions. The resultant twelve monthly loads were summed to yield a representative annual load for 2010 (Janicki *et al.*, 2001).

2.2 1998 and 2010 Model Loads to Bay Segments

Existing (1998) and future (2010) TN loadings to Tampa Bay were estimated for bay segments by source (Janicki *et al.*, 2001). These model-based loading estimates were developed to assist the TBEP in setting living resource targets and in working with local governments to reexamine apportionment of pollutant load reductions set previously.

Existing (1998) Bay Segment Loadings by Source

For the existing period (1998), a model based estimated annual load of approximately 3,666 tons of TN reached the bay (Janicki *et al.*, 2001). Existing condition TN loading estimates are presented by source and bay segment in Table 2-1. From the updated estimate of existing conditions, nonpoint sources had the highest contribution with 1,427 tons/year (39% of the total external load). Atmospheric deposition had the second highest contribution with 1,142 tons/year (31%). Domestic and industrial point sources contributed approximately 436 (12%) and 382 tons/year (10%), respectively. Material losses of fertilizer products totaled 32 tons/year (1%). Groundwater and spring loadings totaled 247 tons/year (7%), with the great majority of that (approximately 245 tons/year) originating from springs.

Of the seven major bay segments, Hillsborough Bay (HB) received the highest TN loadings from the watershed, approximately 1,369 tons/year (37% of the total bay-wide loading). The sources with the highest contributions to Hillsborough Bay included nonpoint source (487 tons/year, or 36%), domestic point sources (281 tons/year, or 21%), and groundwater and springs (246 tons/year, or 18%). Industrial point sources (202 tons/year, or 15%), material losses (32 tons/year, or 2%), and atmospheric deposition (121 tons/year, or 9%) made up the balance of the TN load to Hillsborough Bay.

Table 2-1. Total Nitrogen Loading Estimates (tons/year) by Source and Bay Segment, 1998.

Source	Bay Segment							
	OTB	**HB**	**MTB**	**LTB**	**BCB**	**TCB**	**MR**	**TOTAL**
Atmospheric Deposition	258	121	322	277	99	19	47	**1142**
Domestic Point Source	87	281	23	1	14	4	27	**436**
Industrial Point Source	4	202	60	103	0	0	12	**382**
Material Losses	0	32	0	<1	0	0	0	**32**
Nonpoint Source	167	487	290	19	79	6	379	**1427**
Groundwater+Springs	<1	246	<1	<1	<1	<1	<1	**247**
TOTAL	**516**	**1369**	**695**	**400**	**193**	**28**	**464**	**3666**

Middle Tampa Bay (MTB) received the next highest TN loading for existing conditions (approximately 695 tons/year). The largest contributors included atmospheric deposition (322 tons/year, or 47%), nonpoint source (290 tons/year, or 42%), and industrial point sources (60 tons/year, or 9%). No other source contributed more that 3% to this bay segment. Atmospheric deposition loading was the largest external TN source for this segment because of the large open water area of that segment with respect to the contributing watershed-based inputs.

Old Tampa Bay (OTB) received the next highest TN loading for existing conditions (516 tons/year). The highest source-specific load was atmospheric deposition (258 tons/year, or 50%). Atmospheric deposition loading was a significant external source for Old Tampa Bay because of the relatively large open water area of that segment with respect to the size of the watershed. The second highest contributor was nonpoint source (167 tons/year, or 32%). Domestic point sources (87 tons/year, or 17%) were the only other significant TN source to Old Tampa Bay.

The Manatee River (MR) segment received approximately 464 tons TN/year for the current period. Nonpoint source loads were most significant (379 tons/year, or 82% of the total). Industrial and domestic point source contributed 12 tons/year (3%) and 27 tons/year (6%), respectively. Atmospheric deposition contributed 47 tons/year (10%). These loadings reflect the Manatee River's large tributary basin with respect to other inputs.

Lower Tampa Bay (LTB) received 400 tons/year for the current period, with 277 tons/year (69%) of that total from atmospheric deposition. Again, the large surface area of water with respect to watershed area, and the lack of other significant sources, makes atmospheric deposition by far the most important external source for this bay segment.

Boca Ciega Bay received a total TN load of 193 tons/year, with 99 tons/year (51%) originating from atmospheric deposition and 79 tons/year (41%) from nonpoint sources. Domestic point sources contributed approximately 14 tons/year (7%).

Terra Ceia Bay had the smallest TN loading of the bay segments, with only 28 tons/year. Of that amount, approximately 19 tons/year (68%) originated as atmospheric deposition, 6 tons/year (21%) was from nonpoint sources, and 4 tons/year (14%) resulted from domestic point sources.

Future (2010) Bay Segment Loadings by Source

For the 2010 period, an estimated average annual load of 2,950 tons/year of TN is projected to reach the bay, as presented in Table 2-2. From the future estimate, nonpoint sources were projected to have the highest contribution with approximately 1,432 tons/year (49%), and atmospheric deposition was projected to have the second highest contribution with 578 tons/year (20% of the total external load). Domestic and industrial point sources were estimated to contribute approximately 453 (15%) and 204 tons/year (7%), respectively. Material losses of fertilizer products were estimated to total 36 tons/year (1%). Groundwater and springs loadings were estimated to total 247 tons/year (8%), with much of that (about 246 tons/year) originating from springs.

Table 2-2. Total Nitrogen Loading Estimates (tons/year) by source and Bay Segment, 2010.

Source	**Bay Segment**							
	OTB	**HB**	**MTB**	**LTB**	**BCB**	**TCB**	**MR**	**TOTAL**
Atmospheric Deposition	117	60	159	153	48	11	29	**578**
Domestic Point Source	84	283	32	2	14	7	31	**453**
Industrial Point Source	4	130	58	0	0	0	11	**204**
Material Losses	0	36	0	<1	0	0	0	**36**
Nonpoint Source	183	502	265	21	88	8	366	**1432**
Groundwater+Springs	<1	246	<1	<1	<1	<1	<1	**247**
TOTAL	**388**	**1257**	**515**	**176**	**150**	**26**	**438**	**2950**

Of the bay segments, Hillsborough Bay was expected to receive the highest future TN loading, estimated at 1,257 tons/year. The sources with the highest expected future contributions to Hillsborough Bay included nonpoint source (502 tons/year, or 40% of the total), domestic point sources (283 tons/year, or 23% of the total), and industrial point sources (130 tons/year, 10% of the total). Springs and groundwater were projected to contribute 246 tons/year (20%), atmospheric deposition 60 tons/year (5%), and material losses 36 tons/year (3%).

Middle Tampa Bay was projected to have the second highest future condition TN loading (515 tons/year). Nonpoint sources were estimated to be the most significant TN loading source (265 tons/year, or 51% of the total). Atmospheric deposition was estimated to be another significant source, contributing 159 tons/year, or 31% of the total. Industrial and domestic point sources combined for 89 tons/year, or 17% of the total load.

The Manatee River segment was projected to receive the next highest loading for future conditions, approximately 438 tons/year. Nonpoint source loads were expected to be most significant (366 tons/year, or 84% of the segment total). Industrial and domestic point sources were expected to contribute 11 tons/year (3%) and 31 tons/year (7%), respectively, and atmospheric deposition approximately 29 tons/year (7% of the total to that segment).

Old Tampa Bay was expected to receive the next highest TN loading for future conditions (388 tons/year). The highest source-specific load was projected to be from nonpoint sources (183 tons/year, or 47%). Atmospheric deposition loads were estimated to be 117 tons year (30% of the total). Atmospheric deposition will continue to be a significant external TN source for Old Tampa Bay because of the relatively large open water area of that segment, and because of the small contributions of other sources (small tributary drainage area and few point sources). Domestic point sources (84 tons/year, or 22%) and industrial point sources (4 tons/year, or 1%) were the only other significant TN sources to Old Tampa Bay.

Lower Tampa Bay was expected to receive an average of approximately 176 tons/year for ca. 2010, with 153 tons/year (87%) of that total from atmospheric deposition. Again, the large surface area of water and the lack of other significant sources made atmospheric deposition by far the most important external source for this bay segment. Of the remainder, 21 tons/year (10%) is expected to be from nonpoint sources, with 2 tons/year (1%) from domestic point sources. Less than 1 ton/year is expected from the material losses at Port Manatee.

Boca Ciega Bay was projected to receive a total TN load of 150 tons/year, with 88 tons/year (59%) from nonpoint sources and 48 tons/year (32%) originating from atmospheric deposition. Domestic point sources were expected to contribute about 14 tons/year (9%). Terra Ceia Bay had the smallest projected future TN loading of the bay segments, with almost 26 tons/year. Of that amount, approximately 11 tons/year (42%) was expected to originate as atmospheric deposition and 7 tons/year (27%) from nonpoint sources.

2.3 1998 and 2010 Model Loads from Major Basins

Total nitrogen loads were estimated from the major basins to Tampa Bay from five nitrogen sources, as follows:

- Domestic point sources,
- Industrial point sources,
- Springs,
- Material losses, and
- Nonpoint sources.

Two additional sources, atmospheric deposition and groundwater, contribute nitrogen loads to the major basins as well as directly to Tampa Bay. However, the contributions of these sources to the major basins loadings are already accounted for in the nonpoint source loadings, and are thus not included in this description of the model based TN loadings from the major basins for 1998 and 2010.

The model based estimates for 1998 are shown in Table 2-3 by source for each major basin. In this table, the major basins and receiving bay segments are denoted as follows:

- OTB: Coastal Old Tampa Bay major basin (Old Tampa Bay),
- HB – AR: Alafia River major basin (Hillsborough Bay),
- HB – Coast: Coastal Hillsborough Bay major basin (Hillsborough Bay),
- HB – HR: Hillsborough River major basin (Hillsborough Bay),
- MTB – Coast: Coastal Middle Tampa Bay major basin (Middle Tampa Bay),
- MTB – LMR: Little Manatee River major basin (Middle Tampa Bay),
- LTB: Coastal Lower Tampa Bay major basin (Lower Tampa Bay),
- BCB: Boca Ciega Bay major basin (Boca Ciega Bay),
- TCB: Terra Ceia Bay major basin (Terra Ceia Bay), and
- MR: Manatee River major basin (Manatee River).

Nonpoint source loads make up approximately 57% of the TN load from the major basins, with domestic and industrial point sources contributing 17% and 15% of the total, respectively.

Table 2-3. Model based TN loads for 1998 by major basin and source (tons/year).

	OTB	HB			MTB		LTB	BCB	TCB	MR	Total
		AR	Coast	HR	Coast	LMR					
NPS	167	284	102	101	48	242	19	79	6	379	1427
DPS	87	32	219	30	21	2	1	14	4	27	436
IPS	4	59	65	78	9	51	103	0	0	12	382
ML	0	0	32	0	0	0	<1	0	0	0	32
SPR	0	133	0	112	0	0	0	0	0	0	245
Total	258	507	418	321	78	296	123	93	10	418	2522

The model based estimates for 2010 are shown in Table 2-4 by source for each major basin. The total TN load from the major basins, 2370 tons/year, is slightly less than the model based estimate for 1998, 2522 tons/year. In 2010, nonpoint sources contribute approximately 60% of the TN load from the major basins, while domestic and industrial point sources contribute 21% and 10% of the total, respectively.

Table 2-4. Model based TN loads for 2010 by major basin and source (tons/year).

	OTB	HB			MTB		LTB	BCB	TCB	MR	Total
		AR	Coast	HR	Coast	LMR					
NPS	183	259	105	138	49	216	21	88	8	366	1432
DPS	84	44	213	25	19	13	2	14	7	31	453
IPS	4	53	60	18	2	56	<1	0	0	11	204
ML	0	0	36	0	0	0	<1	0	0	0	36
SPR	0	133	0	112	0	0	0	0	0	0	245
Total	271	488	413	294	70	285	23	102	15	408	2370

3.0 APPORTIONMENT OF TN LOAD REDUCTION/PRECLUSION FOR 2000-2004

One of the primary goals established in the Tampa Bay National Estuary Program Comprehensive Conservation and Management Plan (CCMP) (TBNEP, 1996) is to restore seagrass extent in the bay to levels similar to those observed in the 1950s. To attain the seagrass restoration goal, the TBNEP developed the Nitrogen Management Strategy. The Strategy seeks to prevent future impacts due to excessive nitrogen loadings to Tampa Bay.

Empirical relationships between external total nitrogen (TN) loads and chlorophyll *a* concentrations, between chlorophyll *a* concentrations and light attenuation, and between light availability and restorable seagrass area were developed and presented in Janicki and Wade (1996). Using these relationships, predictions of the responses in chlorophyll *a* concentrations, light attenuation, and the extent of seagrass restoration to changes in external TN loading were derived.

The estimated 1992-1994 mean annual TN loads represent those loads identified by the TBEP expected to result in light availability sufficient to meet the seagrass restoration goals. The empirical model relating total nitrogen loads to seagrass restoration goals (Janicki and Wade, 1996) suggested that light availability necessary for obtaining seagrass restoration goals could be met by establishing a "hold the line" strategy for nitrogen loads. This strategy would hold nitrogen loads to each segment of the bay to the average levels of 1992-1994, denoted the "baseline" period. The Tampa Bay Nitrogen Management Consortium adopted this strategy in 1996.

To implement this strategy, local government partners agreed to preclude increases in future nitrogen loadings to the bay. The ca. 2010 total nitrogen loading estimates presented in Zarbock *et al*. (1996b) were developed to quantify expected TN loading increases. The TN load reduction/preclusion totaled approximately 84 tons for the five-year period 1995-1999, based on the difference between the estimated 2010 TN loads and the baseline period loads. Local government and agency partners accepted responsibility for a portion of this TN load reduction/preclusion, with the remainder assigned to the Tampa Bay Nitrogen Management Consortium (the Consortium).

The Consortium is a task force of representatives from the TBEP's Management Board, the electric utility industry, the fertilizer industry, and agriculture. The Consortium was established in 1996 to develop a plan of specific actions to address the remaining portion of the TN load reduction/preclusion goal, totaling approximately 56 tons TN for the five-year period. TN loading sources for which the Consortium assumed responsibility included atmospheric deposition, industrial point sources, fertilizer shipping and handling, and intensive agriculture.

The future (2010) load estimates were updated in 2001, as were the existing period (1998) load estimates (Janicki *et al*., 2001). Comparison of these load estimates to those of the baseline period was completed, followed by re-examination of the apportionment of the TN load reduction/preclusion goals for the next five-year period, 2000-2004.

In 2001, the TBEP Policy Board, acting on the recommendation of the Consortium, approved a baywide 85 ton/year nitrogen reduction/preclusion target for the 2000-2004 period. The new goal is virtually equivalent to the 84 ton/year target adopted in 1996 for the 1995-1999 time period. Although very little change is expected between the current load (1998) and the future load (2010) (Janicki *et al*., 2001), the Consortium and Policy Board believed it was important to maintain a positive load reduction target as a safety net against backsliding on progress in managing nitrogen loading and seagrass recovery in Tampa Bay.

This section of the report describes the methodology used to evaluate the TN load apportionment for the 2000-2004 period, and the results of this evaluation.

3.1 Apportionment Methods

The apportionment process assigns TN load reductions/preclusions to local government jurisdictions and to the Consortium within each major basin. The government jurisdictions include the following;

- Pinellas County,
- Clearwater,
- St. Petersburg,
- Hillsborough County,
- Tampa,
- Manatee County,
- Polk County,
- Pasco County, and
- Sarasota County,

Jurisdictional load reductions/preclusions include those TN loads associated with the following loading sources;

- Domestic point sources,
- Groundwater, and
- Nonpoint source loads less those from agriculture and mining landuses.

Consortium load reductions/preclusions include those TN loads associated with the remaining loading sources;

- Industrial point sources,
- Atmospheric deposition,
- Material losses from fertilizer handling and shipping operations,

- Springs, and
- Nonpoint source loads from agriculture and mining landuses.

For the purposes of the apportionment process, atmospheric deposition TN loads were held the same over all time periods. The atmospheric deposition loads were estimated using the 1992-1994 rainfall, nitrogen concentration in the rainfall derived from the 1998 data collected by the TBADS program, and the wet:dry deposition ratio derived from the TBADS data. Also for the apportionment process, springs and groundwater loads to a bay segment were divided among major basins discharging to that segment according to the relative areas of the major basins.

Data for the 1992-1994 baseline loads, 1998 current period modeled loads, and 2010 estimated future loads were used in the apportionment process. Estimated loadings by source and major basin for each of the periods are provided below in Table 3-1. The TN loading sources in Table 3-1 are denoted as follows:

- NPS – Nonpoint source,
- DPS – Domestic point source,
- IPS – Industrial point source,
- ML – Material losses from fertilizer handling and shipping operations,
- GW+SP – Groundwater and springs, and
- AD – Atmospheric deposition.

Only two bay segments receive drainage from multiple major basins. Hillsborough Bay is the receiving water body for the Alafia River Basin (Alafia), the Coastal Hillsborough Bay Basin (Coastal), and the Hillsborough River Basin (Hills). Middle Tampa Bay receives drainage from the Coastal Middle Tampa Bay Basin (Coastal) and the Little Manatee River Basin (LMR).

The first step in the apportionment process was to assign major basin-specific TN load reduction/preclusion goals. Table 3-2 summarizes the apportionment of the 85 tons/year target to each of ten major drainage basins. This approach shifts the emphasis from targets for specific segments of the bay that receive nitrogen loads (the 1995-1999 approach) to targets for major basins draining into the bay that deliver nitrogen loads. This new approach may better facilitate linking TMDL requirements for Group 2 waterbodies with nitrogen management targets for the bay proper.

The proposed approaches and options were developed through a series of meetings with Consortium Co-Chairs Jake Stowers and Craig Kovach, TBEP Technical Advisory Committee Co-Chair Rob Brown, Consortium member George Henderson with the Florida Marine Research Institute, and Tony Janicki of Janicki Environmental, Inc., consultant to TBEP.

The following assumptions were employed in development of the data presented in Table 3-2:

- For estimating nonpoint source (NPS) loads in each of the three time periods, 1992-1994 average rainfall data were used.

- For atmospheric deposition loads, 1992-1994 average rainfall data and 1998 TBADS data for wet concentration of N and the wet:dry ratio from the 1998 TBADS data were used for all time periods.

- Loads from direct atmospheric deposition to bay segments were apportioned to major drainage basins based on the ratio of area in each major drainage basin to total watershed area.

- Loads from springs and groundwater to bay segments were apportioned to major drainage basins based on the ratio of area in each major drainage basin to total watershed area.

The 85 ton/year five-year target is apportioned to major drainage basins in direct proportion to the baseline load, future load, and existing load as follows: the Proportional Baseline and Future Loads (Table 3-2, Part A) are together (i.e., as an average) weighted equally to the Proportional Existing Load (Table 3-2, Part B). The cumulative apportionment factor for each drainage basin is thus established by the average of the combined Baseline-Future Load apportionment factor and the Existing Load apportionment factor. It is reasonable that all three loading conditions – Baseline, Existing, and Future – be considered in the apportionment decision. At the same time it was recognized that the Existing Load represents the most recent and best estimate of nitrogen loading to the bay, and that the Future Load estimate is the least accurate.

The apportionment factor for each major drainage basin is computed as follows:

Cumulative Apportionment Factor =
([Proportion of Average Baseline and Future Loads] +
[Proportion of Baywide Existing Load])/2

For example, the factor for the Hillsborough River basin (under the Hillsborough Bay segment in Table 3-2) is computed as follows:

Cumulative Apportionment Factor = [0.09 + 0.11]/2 = 0.10

Multiplying the 85 ton/year baywide target by the Cumulative Apportionment Factor for the Hillsborough River basin yields an 8.5 ton/year target for that drainage basin.

The final step of the apportionment process is assignment of load reduction targets for each major drainage basin to local government entities and the Consortium based on the Proportion of Existing Load to each basin contributed by each entity. This approach uses the most accurate estimate of loading and is consistent with the method of apportioning the 1995-1999 load reduction/preclusion targets. In the process, the nonpoint source loads from all agricultural landuses was assigned to the Consortium. This approach was adopted by the TBEP in 2002. Table 3-3 provides the results of the apportionment process, with TN load reduction/preclusion goals for each government entity within each major basin. In this table, the reduction/preclusion goals for Polk, Pasco, and Sarasota counties were included in the Consortium goal, comprising less than 4% of the total Consortium goal.

Table 3-1. TN loads for baseline (1992-1994), existing (1998), and future (2010) periods used in apportionment process.

1992-1994 Baseline Loads (tons/year)

Source	Old Tampa Bay	Hillsborough Bay			Middle Tampa Bay		Lower Tampa Bay	Boca Ciega Bay	Terra Ceia Bay	Manatee River	Total
		Alafia	Coastal	Hills	Coastal	LMR					
NPS	144	324	103	106	47	207	20	74	5	360	**1390**
DPS	85	4	206	11	20	0	1	15	5	16	**363**
IPS	0	42	23	16	2	56	1	0	0	11	**151**
ML	0	0	233	0	0	0	24	0	0	0	**257**
GW+SP	<1	65	27	104	<1	<1	<1	<1	<1	<1	**199**
AD	267	45	19	72	166	195	349	110	25	67	**1314**
Total	**497**	479	611	308	236	458	**395**	**199**	**35**	**455**	**3674**
		1399			**694**						

1998 Existing Loads (tons/year)

Source	Old Tampa Bay	Hillsborough Bay			Middle Tampa Bay		Lower Tampa Bay	Boca Ciega Bay	Terra Ceia Bay	Manatee River	Total
		Alafia	Coastal	Hills	Coastal	LMR					
NPS	167	284	102	101	48	242	19	79	6	379	**1427**
DPS	87	32	219	30	21	2	1	14	4	27	**436**
IPS	4	59	65	78	9	51	103	0	0	12	**382**
ML	0	0	32	0	0	0	<1	0	0	0	**32**
GW+SP	<1	81	34	130	<1	<1	<1	<1	<1	<1	**246**
AD	267	45	19	72	166	195	349	110	25	67	**1314**
Total	**525**	500	471	411	244	491	**473**	**203**	**35**	**485**	**3836**
		1381			**735**						

2010 Future Loads (tons/year)

Source	Old Tampa Bay	Hillsborough Bay			Middle Tampa Bay		Lower Tampa Bay	Boca Ciega Bay	Terra Ceia Bay	Manatee River	Total
		Alafia	Coastal	Hills	Coastal	LMR					
NPS	183	259	105	138	49	216	21	88	8	366	**1432**
DPS	84	44	214	26	19	13	2	14	7	31	**454**
IPS	4	53	60	18	2	56	<1	0	0	11	**204**
ML	0	0	36	0	0	0	<1	0	0	0	**36**
GW+SP	<1	81	34	130	<1	<1	<1	<1	<1	<1	**246**
AD	267	45	19	72	166	195	349	110	25	67	**1314**
Total	**539**	481	466	384	236	480	**372**	**212**	**40**	**475**	**3685**
		1331			**716**						

Table 3-2. Major basin-specific TN load reduction/preclusion targets for 2000-2004.

	Hillsborough Bay			**Old Tampa Bay**	**Middle Tampa Bay**		**Lower Tampa Bay**	**Boca Ciega Bay**	**Terra Ceia Bay**	**Manatee River**	**Total**
	Alafia	Coastal	Hills		Coastal	LMR					
Baseline (Average 1992-1994)	479	611	308	497	236	458	395	199	35	455	**3674**
Current (1998)	500	471	411	525	244	491	473	203	35	485	**3836**
Future (2010)	481	466	384	539	236	480	372	212	40	475	**3685**
A)											
Average of Baseline and Future Loads	480	539	346	518	236	469	384	206	38	465	**3679**
Proportion of Average Baseline and Future Loads	0.13	0.15	0.09	0.14	0.06	0.13	0.10	0.06	0.01	0.13	**1.00**
Major Basin-specific Load Reduction	11.09	12.44	7.99	11.97	5.45	10.84	8.86	4.75	0.87	10.74	**85**
B)											
Current Load	500	471	411	525	244	491	473	203	35	485	**3836**
Proportion of Baywide Current Load	0.13	0.12	0.11	0.14	0.06	0.13	0.12	0.05	0.01	0.13	**1.00**
Major Basin-specific Load Reduction	11.08	10.44	9.11	11.63	5.41	10.88	10.48	4.50	0.78	10.75	**85**
Cumulative Apportionment Factor	0.13	0.13	0.10	0.14	0.06	0.13	0.11	0.05	0.01	0.13	**1.00**
Major Basin-specific Load Reduction Target for the period 2000-2004	**11.08**	**11.44**	**8.55**	**11.80**	**5.43**	**10.86**	**9.67**	**4.62**	**0.82**	**10.75**	**85**

Table 3-3. Nitrogen load apportionment to entities in major basins for 2000-2004.

Proportion of Existing Load

	Pin. Co.	Clearwater	St. Pete	Hills. Co.	Tampa	Man. Co.	Consortium	Total
Hillsborough Bay								
Alafia R.	0	0	0	0.09	0	0	0.91	1
Coastal HB	0	0	0	0.07	0.52	0	0.41	1
Hillsborough R.	0	0	0	0.09	0.13	0	0.78	1
Old Tampa Bay	0.13	0.08	0.03	0.16	0.05	0	0.55	1
Middle Tampa Bay								
Coastal MTB	0	0	0.22	0.04	0	0	0.74	1
Little Manatee River	0	0	0	0.08	0	0.02	0.9	1
Lower Tampa Bay	0	0	0	0	0	0.02	0.98	1
Terra Ceia Bay	0	0	0	0	0	0.24	0.76	1
Manatee River	0	0	0	0	0	0.24	0.76	1
Boca Ciega Bay	0.22	0	0.23	0	0	0	0.55	1

Major Drainage Basin-specific Load Reduction (tons/yr)

	Pin. Co.	Clearwater	St. Pete	Hills. Co.	Tampa	Man. Co.	Consortium	Total
Hillsborough Bay								
Alafia R.	0.00	0.00	0.00	1.00	0.00	0.00	10.08	**11.08**
Coastal HB	0.00	0.00	0.00	0.80	5.95	0.00	4.69	**11.44**
Hillsborough R.	0.00	0.00	0.00	0.77	1.11	0.00	6.67	**8.55**
Old Tampa Bay	1.53	0.94	0.35	1.89	0.59	0.00	6.49	**11.80**
Middle Tampa Bay								
Coastal MTB	0.00	0.00	1.19	0.22	0.00	0.00	4.02	**5.43**
Little Manatee River	0.00	0.00	0.00	0.87	0.00	0.22	9.77	**10.86**
Lower Tampa Bay	0.00	0.00	0.00	0.00	0.00	0.19	9.48	**9.67**
Terra Ceia Bay	0.00	0.00	0.00	0.00	0.00	0.20	0.62	**0.82**
Manatee River	0.00	0.00	0.00	0.00	0.00	2.58	8.17	**10.75**
Boca Ciega Bay	1.02	0.00	1.06	0.00	0.00	0.00	2.54	**4.62**
Total	**2.55**	**0.94**	**2.61**	**5.54**	**7.65**	**3.19**	**62.53**	**85.02**

Table 3-3. Nitrogen load apportionment to entities in major basins for 2000-2004 (tons/yr).

Bay Segment-specific Load Reduction Targets

	Pin. Co.	Clearwater	St. Pete	Hills. Co.	Tampa	Man. Co.	Consortium	Total
Hillsborough Bay	0.00	0.00	0.00	2.57	7.06	0.00	21.44	**31.07**
Old Tampa Bay	1.53	0.94	0.35	1.89	0.59	0.00	6.49	**11.80**
Middle Tampa Bay	0.00	0.00	1.19	1.09	0.00	0.22	13.79	**16.29**
Lower Tampa Bay	0.00	0.00	0.00	0.00	0.00	2.97	18.27	**21.24**
Boca Ciega Bay	1.02	0.00	1.06	0.00	0.00	0.00	2.54	**4.62**
Total	**2.55**	**0.94**	**2.61**	**5.54**	**7.65**	**3.19**	**62.53**	**85.02**

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