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EVALUATION OF THE TOOLS AVAILABLE TO ASSESS THE POTENTIAL IMPACTS OF UNPLANNED POLLUTANT RELEASES TO TAMPA BAY

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1 INTRODUCTI0N

There is a relatively long history of unplanned releases of pollutants to Tampa Bay (Zarbock et al., 1994). Many of these releases were related to the phosphate mining activities in the Tampa Bay watershed. Recently, there have been several unplanned releases of domestic wastewater to Tampa Bay. The Nitrogen Management Consortium's strategy for controlling nitrogen inputs to the bay does not address the potential effects of these releases on attaining its nitrogen load goals.

There are several tools that may aid in the assessment of the potential impacts of these unplanned releases. Specifically, these tools include ambient monitoring and several models that relate nutrient loads to ambient water quality in the bay. Ambient water quality monitoring is currently being conducted by the Environmental Protection Commission of Hillsborough County, the City of Tampa, the Pinellas County Department of Environmental Management, and the Manatee County Environmental Management Department. These programs generally collect water quality data on a monthly basis from a wide array of fixed stations. The water quality response models include a mechanistic water quality model developed for the Southwest Florida Water Management District (SWFWMD) (Martin et al., 1996). This model was developed to examine Tampa Bay water quality using 1985-1994 pollutant loading data.

The objective of this study is to examine the utility of existing tools to assess the potential impacts of unplanned releases of nitrogen and other pollutants to Tampa Bay. Issues associated with microbiological contaminants were not considered here. Specifically, the tools evaluated are used to assess the potential impacts of an unplanned release of wastewater effluent from the City of St. Petersburg Albert Whitted Wastewater Treatment Plant that occurred over March 4 - April 15, 1999.

2 METHODS

Several methods were utilized to examine the possible effects of the unplanned release on water quality in Tampa Bay. These included examination of observed water quality data prior to, during, and following the release. Secondly, the mass of pollutants released was compared to the ambient mass of that pollutant in the bay waters adjacent to the release point. Thirdly, a mechanistic model was used to examine the potential effects of the unplanned release.

2.1 Ambient Water Quality Monitoring Data Analysis

Ambient water quality data were used in two ways to examine the possible influences of an unplanned nutrient loading event to the bay. The first comparison was an examination of changes in the spatial variation in water quality that could be attributed to the unplanned release. Water quality data from monitoring stations near the point of release, where influences are most likely to be observed, were compared to data from stations removed from the point of release. Comparisons were also made between expected water quality conditions, as represented by the historical record, and water quality conditions observed following the unplanned release. The second approach involved examination of the temporal variation in water quality conditions that may be attributed to the unplanned release.

Monthly ambient water quality monitoring data were obtained from the Pinellas County Department of Environmental Management (PCDEM). Data from nine monitoring sites north and south of the effluent discharge point were used for these analyses (Figure 1). The St. Pete Basin site combines data from the site southeast of the Pier with data from the site near Demen's Landing. Monthly ambient water quality monitoring data were also obtained from the Environmental Protection Commission of Hillsborough County (EPCHC) for the sites identified in Figure 1. Additional water quality data were obtained from the City of Tampa Bay Study Group (COTBSG), which monitors a site approximately three kilometers northeast of the Albert Whitted outfall.

Temporal variations in water quality were examined by comparing water quality data for March and April 1999 with data from the same months during preceding years, using the PCDEM dataset. Spatial differences in water quality during the release were examined using all three datasets. The PCDEM data were grouped into two areas, one containing stations near the Albert Whitted WWTP outfall location (nearfield) and the other containing stations more distant from the outfall (farfield). The Albert Whitted WWTP outfall is approximately 0.2 miles east of the Albert Whitted airport. The stations near the outfall were the PCDEM stations at Big Bayou, St. Pete Basin, North Coffee Pot, Coffee Pot, and Smack's Bayou. The PCDEM stations at Weedon Island, Riviera Bay, and Snug Harbor comprised the farfield sampling stations.

2.2 Mass Comparison

The masses of pollutants in waters near the point of the unplanned release were estimated for March and April 1999 using water quality data from the EPCHC. Figure 2 presents the area for which the estimates were derived; Segment 8 defines the receiving waters for the release. The mass of the pollutants added to the bay as a result of the unplanned release was also estimated, using data provided by the Florida Department of Environmental Protection (FDEP) and the City of St. Petersburg. FDEP provided effluent volume estimates. Water quality data for the effluent were obtained from the City of St. Petersburg with the assistance of Mr. Bill Johnson, Mr. Fred Crafa, Ms. Judy Gallizzi, and Mr. Frank Niles.

The mass of total nitrogen added to Tampa Bay as a result of the unplanned release is also compared to the average annual total nitrogen loads to Tampa Bay as a whole and to Middle Tampa Bay (which includes Segment 8). The 1992-1994 average annual total nitrogen loads are as reported in Zarbock et al. (1996).

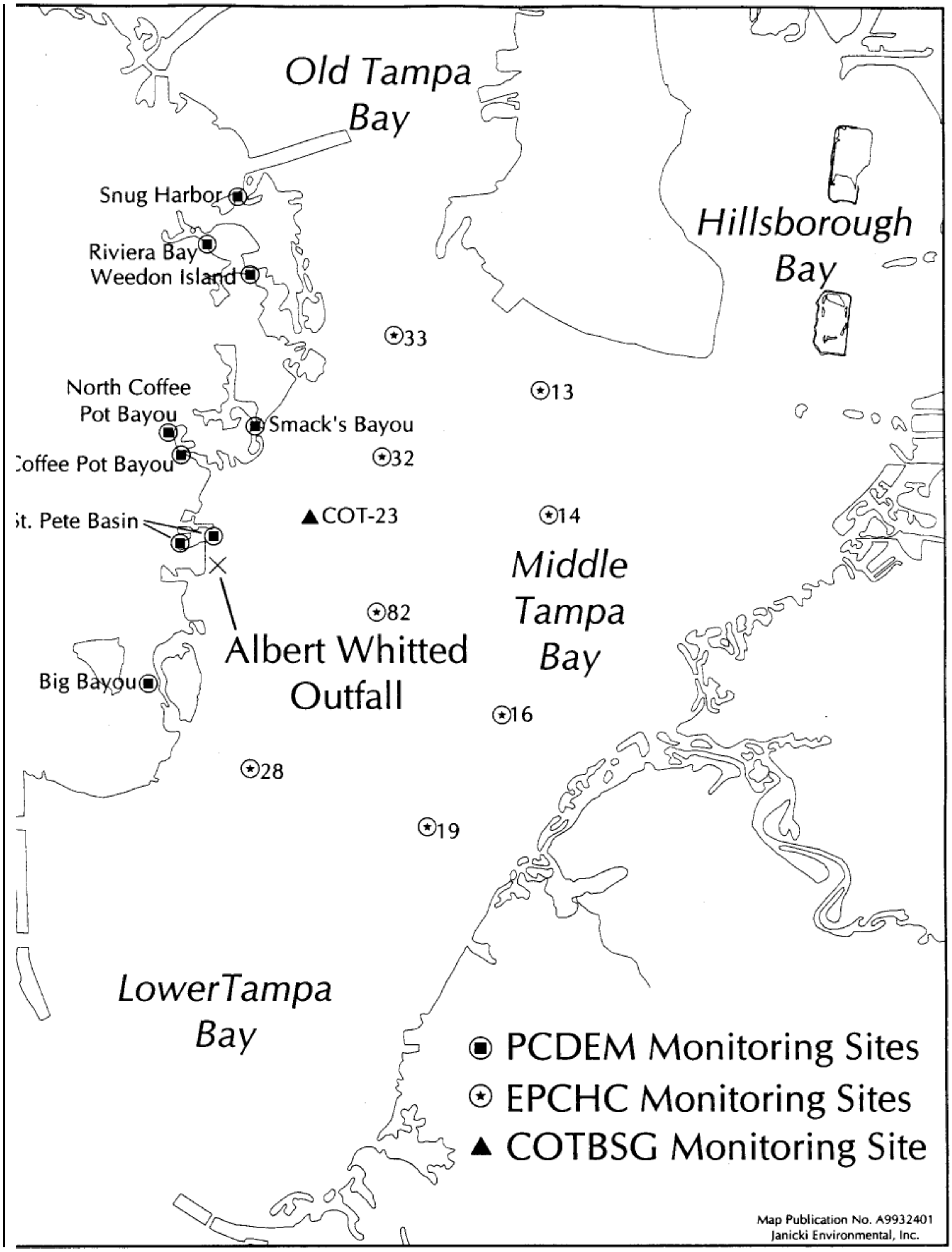

Figure 1. Water quality monitoring sites from which data used in the analyses were collected.

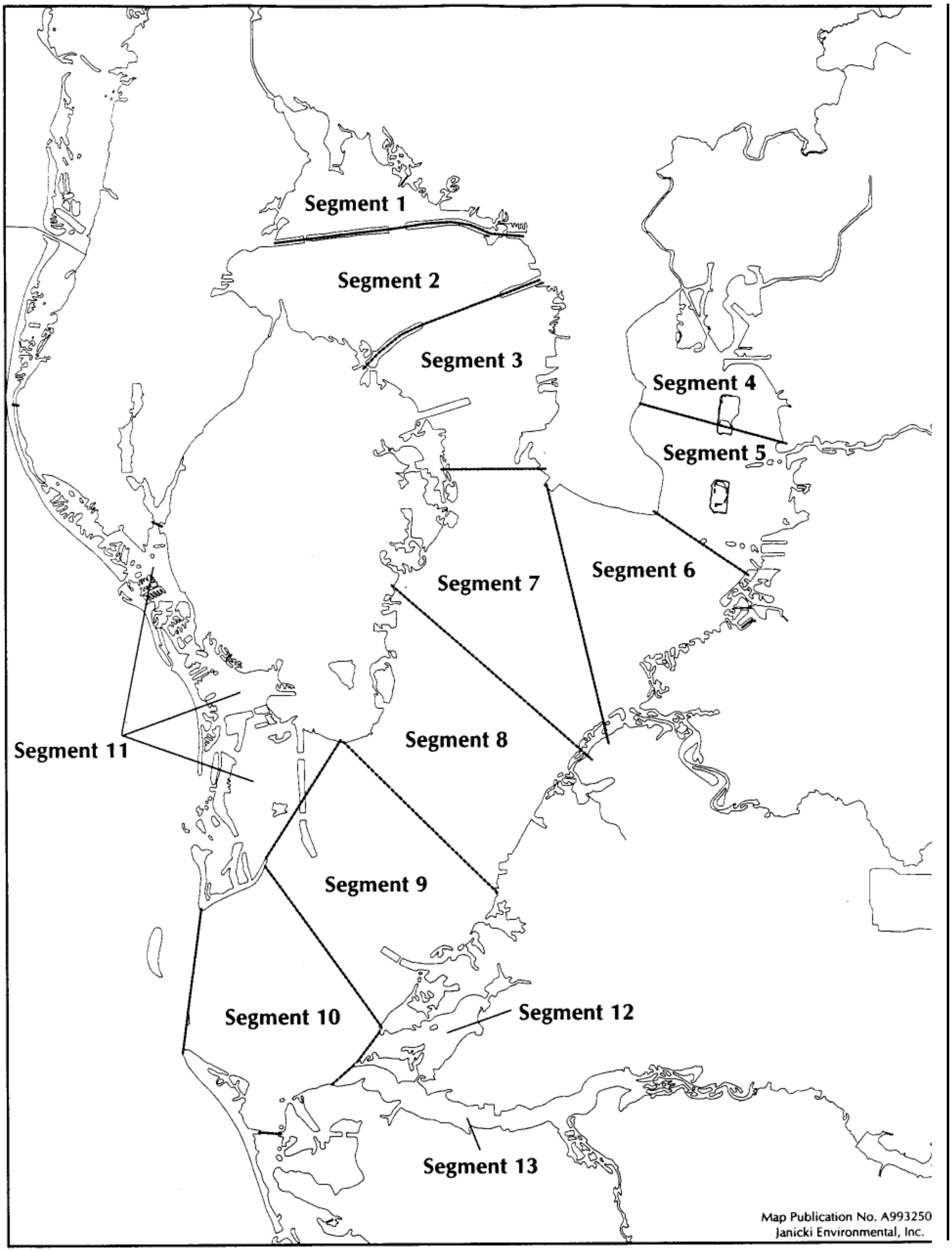

Figure 2. SWFWMD water quality model segmentation scheme (Martin et al., 1996).

2.3 SWFWMD Tampa Bay Model

A mechanistic water quality model of Tampa Bay developed for the Southwest Florida Water Management District (SWFWMD) (Martin et al., 1996) was used to examine the potential effects of the effluent release. This model serves as a tool to examine the impacts of nutrient loading on water quality in the bay, and was originally run using data from the period 1985-1994. Ideally, this model would be run using hydrologic and water quality constituent loadings for the 1999 time period to drive the model. However, these data are not available. Therefore, the following method was developed to utilize this tool.

The potential effects of an unplanned release depend upon the residence time in the bay. During periods of relatively rapid flushing (i.e., shorter residence time), less time is available for uptake of nutrients from the unplanned release and subsequent elaboration of algal biomass. Rapid flushing is more likely during wet periods. Conversely, dry periods may result in slower flushing (i.e., longer residence time), allowing more time for the algal community to respond to the enhanced nutrient availability. Since residence times will clearly vary with rainfall, the potential effects of the unplanned release in both wet and dry years were examined. The model outputs from both wet and dry years from the 1985-1994 time period defined baseline conditions. Model outputs incorporating the effluent release were compared to the baseline model output. The wet year chosen from the 1985-1994 time period was 1988, and the dry year was 1990. To allow for model spin-up and detection of any delayed effects of the release, the wet year scenario extended from 1987-1989 with the nutrient and CBOD loadings from the unplanned release added to the bay in March and April 1988. The dry year scenario extended from 1989-1991 and the nutrient and CBOD loadings from the unplanned release were added to the bay in March and April 1990.

3 RESULTS

3.1 Ambient Water Quality Monitoring Data Analysis

Spatial differences in water quality data from the March-April 1999 period were examined. Temporal differences between the March-April 1999 data and March-April data for the period of record were examined.

3.1.1 Spatial Differences

Mean chlorophyll, total nitrogen, ammonia nitrogen, and dissolved oxygen concentrations at the PCDEM nearfield sampling stations were all less than those observed at the PCDEM farfield stations (Table 1). Similarly, no offshore water quality changes were apparent at the EPCHC or COTBSG sampling stations during March-April 1999. Based on these analyses, there were no apparent effects of the unplanned release on the water quality at the sampling sites nearest the point of effluent release.

Table 1. March - April 1999 water quality data from nearfield and farfield PCDEM stations.

Water Quality Variable	Nearfield	Farfield
Chlorophyll	5.19 µg/L	5.50 µg/L
TN	0.38 mg/L	0.44 mg/L
NH_3-N	0.05 mg/L	0.07 mg/L
PO_4	0.09 mg/L	0.09 mg/L
DO	5.59 mg/L	5.86 mg/L
CBOD	1.40 mg/L	1.39 mg/L

3.1.2 Temporal Differences

A comparison of March and April chlorophyll concentrations between 1999 and 1991-1998 was made using data from the PCDEM sites (Table 2). The 1999 mean March-April chlorophyll concentration was greater than the median chlorophyll concentration from the 1991-1998 period at six monitoring sites: Big Bayou, St. Pete Basin, North Coffee Pot Bayou, Weedon Island, Riviera Bay, and Snug Harbor. Similarly, the mean surface dissolved oxygen concentration was also greater in 1999 at the Big Bayou, St. Pete Basin, North Coffee Pot Bayou, and Riviera Bay Basin sites; mean biochemical oxygen demand was greater in 1999 at the North Coffee Pot Bayou, Smack's Bayou, Weedon Island, and Snug Harbor sites. None of the observed water quality conditions were greater than the 95^{th} percentile concentrations observed from the 1991-1998 period.

In contrast, total nitrogen and ammonia nitrogen concentrations in 1999 were never greater than the 50^{th} percentile concentrations observed from 1991 through 1998 at any site examined.

Based on the results of these comparisons it can be inferred that no temporal differences in water quality were observed in regions of Tampa Bay most likely to be affected by the unplanned release.

Table 2. Comparison of March - April water qualitv data collected during 1991-1998 and 1999.

Water Quality Variable	Sampling Site	March-April 1991-1998 5th Percentile	March-April 1991-1998 50th Percentile	March-April 1991-1998 95th Percentile	March-April 1999 Mean
Chlorophyll (µg/L)	Big Bayou	0.50	5.70	8.70	6.30
	Coffee Pot Bayou	2.90	7.10	38.10	3.95
	N. Coffee Pot Bayou	0.35	2.00	14.40	6.85
	Riviera Bay	2.42	6.00	22.00	8.05
	Smack's Bayou	2.40	4.10	14.10	3.85
	Snug Harbor	1.28	2.65	7.70	3.85
	St. Pete Basin	1.20	3.10	11.20	5.00
	Weedon Island	0.64	4.10	15.10	,4.60
Dissolved Oxygen (mg/L)	Big Bayou	5.47	6.78	8.53	7.04
	Coffee Pot Bayou	3.80	7.03	9.56	4.94
	N. Coffee Pot Bayou	0.14	2.15	7.92	2.72
	Riviera Bay	5.11	6.50	8.67	6.66
	Smack's Bayou	5.18	6.98	13.69	6.45
	Snug Harbor	3.49	5.73	6.86	5.27
	St. Pete Basin	5.15	6.52	7.67	6.79
	Weedon Island	4.05	6.21	8.01	5.66
BOD (mg/L)	Big Bayou	1.0	1.4	3.0	1.0
	Coffee Pot Bayou	1.0	3.0	5.3	1.5
	N. Coffee Pot Bayou	1.0	1.4	9.3	2.0
	Riviera Bay	1.0	1.9	2.2	1.0
	Smack's Bayou	1.0	1.4	4.0	1.5
	Snug Harbor	1.0	1.1	1.6	1.5
	St. Pete Basin	1.0	1.4	2.6	1.0
	Weedon island	1.0	1.4	2.8	1.7
Total Nitrogen (mg/L)	Big Bayou	0.40	0.57	0.87	0.15
	Coffee Pot Bayou	0.48	0.62	1.00	0.41
	N. Coffee Pot Bayou	0.63	1.12	1.63	0.55
	Riviera Bay	0.57	0.77	0.88	0.45
	Smack's Bayou	0.40	0.51	0.66	0.35
	Snug Harbor	0.56	0.72	0.79	0.52
	St. Pete Basin	0.37	0.58	0.84	0.47
	Weedon Island	0.53	0.67	0.83	0.37
NH_3-N (mg/L)	Big Bayou	0.02	0.06	0.27	0.02
	Coffee Pot Bayou	0.02	0.08	0.31	0.08
	N. Coffee Pot Bayou	0.07	0.12	0.26	0.05
	Riviera Bay	0.03	0.15	0.33	0.05
	Smack's Bayou	0.02	0.06	0.23	0.04
	Snug Harbor	0.10	0.27	0.52	0.13
	St. Pete Basin	0.02	0.10	0.31	0.05
	Weedon Island	0.02	0.11	0.32	0.05

3.2 Mass Comparison

The pollutant masses from the unplanned release of wastewater were compared to the ambient pollutant masses observed during March and April 1999 within the immediate area of the release (Figure 2 - Segment 8). The masses added to the bay were estimated by multiplying the unplanned release volume and the concentrations of the pollutants. The total nitrogen concentration in the unplanned release averaged 27.9 mg/L and the total phosphorus concentration averaged 1.55 mg/L. The estimated volume of Segment 8 is 360 x 10^6 m^3; the estimated volume of the unplanned release was 296 x 10^3 m^3 during March 1999, and 158 x 10^3 m^3 during April 1999. The mass of the relevant pollutants in Segment 8 and the mass in the effluent released are shown in Table 3. Relative to the mass in Segment 8, the pollutant masses in the unplanned release were small. The masses of ammonia nitrogen, phosphorus, and CBOD in the unplanned release were less than 0.1 percent of the masses of these pollutants in Segment 8, respectively

Table 3. Comparison of pollutant masses in the effluent released and in Segment 8 of Tampa Bay, March and April, 1999.

Pollutant	Segment 8 (kg x 10^6)	Released Effluent (kg x 10^6)	$\left(\frac{\text{Released Effluent Mass}}{\text{Segment 8 Mass}}\right) * 100$
NH_3-N	12.0	0.0095	0.08
PO_4	19.1	0.0021	0.01
CBOD	288	0.0019	0.0007

An additional means of placing the Albert Whitted unplanned release in perspective is to compare the resultant loads with the bay-wide and segment total nitrogen loading. The total nitrogen load from the unplanned release was approximately 14 tons. For the 1992-1994 period, total nitrogen loads to the Middle Tampa Bay segment averaged 799 tons/year. For the same period, total nitrogen loads to all of Tampa Bay averaged 3,800 tons/year (Zarbock et al., 1996). Using the 1992-1994 average annual total nitrogen.loads for comparison, the Albert Whitted unplanned release was equivalent to 1.8% of the Middle Tampa Bay total nitrogen load and 0.4% of the bay-wide total nitrogen load.

3.3 SWFWMD Tampa Bay Model

Model simulation results suggest that the effect of the unplanned release on water quality in Tampa Bay would be small in both wet and dry year conditions. A comparison of model results with and without the unplanned release, for wet and dry years, is given in Table 4. The results indicate that no measurable differences in water quality are found as a result of the unplanned release.

Table 4. Comparison of model predictions of pollutant concentrations, for March and April.

Water Quality	Wet Year		Dry Year	
Variable	Without Release	With Release	Without Release	With Release
Chlorophyll	3.59 µg/L	3.61 µg/L	3.76 µg/L	3.77 µg/L
NH_3-N	0.08 mg/L	0.08 mg/L	0.08 mg/L	0.08 mg/L
NO_3-N	0.02 mg/L	0.02 mg/L	0.02 mg/L	0.02 mg/L
TN	0.36 mg/L	0.36 mg/L	0.36 mg/L	0.36 mg/L
PO_4-P	0.21 mg/L	0.21 mg/L	0.21 mg/L	0.21 mg/L
CBOD	1.56 mg/L	1.56 mg/L	0.54 mg/L	0.54 mg/L

4 CONCLUSIONS

Several approaches were used to determine if the unplanned effluent release from the Albert Whitted wastewater treatment plant resulted in measurable differences in water quality in the area of Tampa Bay most likely to be influenced by the release. Data from the PCDEM and EPCHC water quality monitoring sites were examined. A comparison of pollutant masses in the effluent and the segment of Tampa Bay most likely affected by the effluent was made. Finally, a mechanistic water quality model for Tampa Bay was used to assess the potential effects due to the unplanned release.

The results from each of the approaches taken to assess the influence of the unplanned release suggest that this release did not significantly affect water quality in the vicinity of the spill. Spatial and temporal differences in water quality were small or non-existent. The pollutant masses in the release were small relative to those observed in that portion of the bay most likely affected by the release, and in proportion to annual bay-wide and segment loads. The model simulation results agreed with the evidence offered by the empirical data. Irrespective of prevailing meteorological conditions, the model predictions indicated that a release of the magnitude of the Albert Whitted release would not significantly affect water quality in that portion of the bay most likely affected by the release.

The ability to detect changes in water quality due to an unplanned pollutant release is a function of two factors. The first is the pollutant mass released relative to the volume of the receiving water body. Clearly, larger releases are more likely to elicit a detectable change in water quality. Ancillary to this factor is the duration of the unplanned release. A prolonged release of pollutants may elicit a less severe response than a release of similar magnitude that occurs over a shorter period of time. The second factor is the sensitivity of the tools available to assess the potential changes due to the release. Specifically, the spatial and temporal scales of the tools must be sufficient to allow detection of water quality changes. The conclusion of no impact due to the unplanned release that has been examined should be accompanied by an assessment of the relative influence of these two factors.

A comparison of the impact of the Albert Whitted unplanned release to that associated with the acid spill of December 1997 in the Alafia River (Cardinale, 1998) has been made (Table 5). The Alafia River release was larger and occurred over a very short period of time, and its mass relative to the receiving water body was greater than that observed for the Albert Whitted release. Given the differences in release timing and mass, it is not surprising that the impact of the Alafia River release was more readily apparent by examining the water quality data routinely collected by EPCHC (Cardinale, 1998).

	Unplanned Release Event	
	Albert Whitted WWTP	Alafia River
Duration of Event (days)	43	1
TN Load (tons)	14	368
TN in Receiving Segment (tons)	222	95

The data and methods evaluated for assessment of possible effects of the Albert Whitted unplanned release suggest that this release did not significantly affect water quality in the vicinity of the spill. The Alafia River spill, conversely, released approximately 26 times as much nitrogen to the bay as did the unplanned release from the Albert Whitted WWTP. The effects of the loading resulting from the Alafia River spill were still evident in Tampa Bay in April 1998, with chlorophyll levels in May 1998 appearing to return to normal (Cardinale, 1998).

The sensitivity of the tools available to assess the potential changes due to the unplanned release must also be considered. The spatial and temporal scales of the monitoring programs from which data were available did not allow an examination of small-scale effects of the release. It is possible that short-term and localized impacts to water quality may have occurred in the area near the effluent release point, but the monitoring framework was not adequate to detect such impacts.

It is recommended that serious consideration be given to establishing a protocol for collecting empirical water quality data in a very timely fashion when knowledge of an unplanned release is received, and possibly following significant rainfall events. In response to the Alafia River spill, EPCHC's routine water quality data collection was augmented by more temporally intensive sampling upon learning of the release, thus improving the ability to assess the impact of that release. In some cases, knowledge of a release may come too late to allow augmenting the routine sampling. When adequate notice of a release exists, a sampling plan in response to the release should be activated. This sampling plan should include sampling of the array of stations routinely sampled to provide a sound basis for comparison of the more spatially and temporally intensive sampling.

With respect to the modeling tools, a more spatially and temporally intensive water quality model may increase the ability to assess the relative impacts of an unplanned release. Currently, the SWFWMD Tampa Bay Model is the most spatially and temporally intensive model available. Development of a more intensive model would require the construction, calibration, validation, and verification of that model. Effective model development also depends upon data availability for each of the model development elements. More complex models do not necessarily guarantee more effective impact assessment, as recent criticisms of models such as the Chesapeake Bay Model imply.

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