Technical Memorandum

To: **Mac Hatcher, PM Collier County**

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Date: **February 24, 2010**

Re: **Watershed Model Update and Plan Development**
Contract 08-5122, PO 4500106318
Element 1, Task 2.3: Groundwater Quality
Element 1, Task 2.4: Groundwater Loading to Canal Network

1.0 Objective

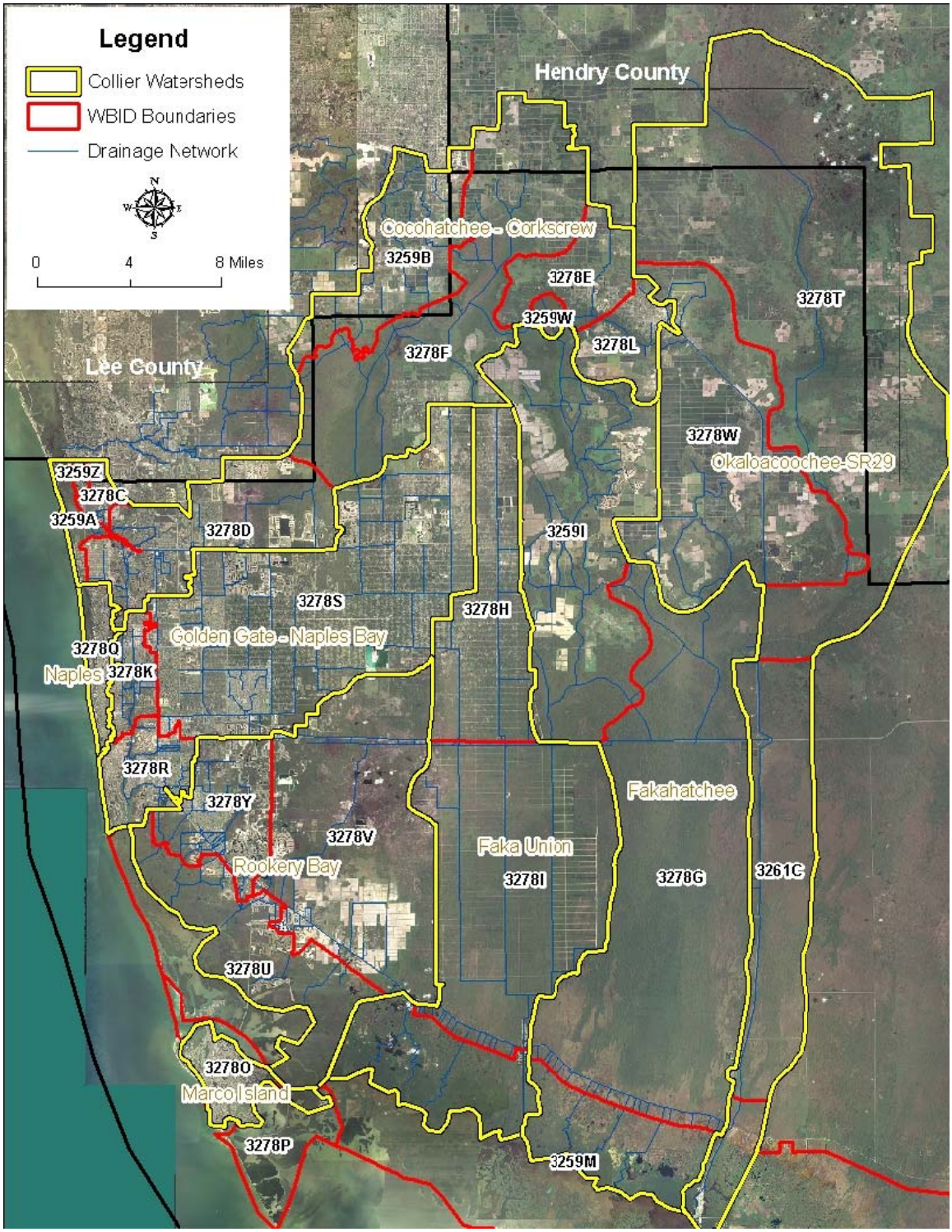
This Technical Memorandum addresses Element 1, Task 2.3: Groundwater Quality and Element 1, Task 2.4: Groundwater Pollutant Loading. The objective of this task is twofold, characterization of the groundwater quality conditions of the Cocohatchee-Corkscrew, Golden Gate - Naples Bay, Rookery Bay, Faka Union, Okaloacoochee - SR29, and Fakahatchee watersheds, (**Figure 1**), and estimation of pollutant loads discharged from the Surficial and Tamiami aquifers into the surface water system in these watersheds.

This effort focused on characterizing the groundwater quality in the context of the water body impairment analysis, as discussed in the Technical Memorandum for Element 1, Task 1.2: In-Stream Water Quality.

2.0 Introduction

The topics addressed in this document include the following: 1) data collection, 2) description of the applied analysis methodology, 3) groundwater concentrations of pollutants of concern, and 4) estimated groundwater pollutant loads. In addition, this document describes results of a preliminary analysis conducted to assess the potential impacts of septic tanks on the groundwater system.

Figure 1. Collier County Watersheds



3.0 Data Collection

Water quality in the County's drainage network is affected by groundwater quality. Data collection efforts, as well as the overall analysis, focused on the groundwater quality conditions in the Surficial and Lower Tamiami aquifer systems. The other aquifers are confined and have no known interaction with the surface water drainage system.

The groundwater quality data used for the analyses included data from Florida STORET, the South Florida Water Management District (SFWMD) DBYHDRO, the United States Geologic Survey (USGS), and Collier County. This resulted in an updated and comprehensive database of groundwater quality data. A total of 163 monitoring wells were identified within the model study area. Of those wells, 136 are located within the Surficial and Lower Tamiami aquifer systems.

In terms of water quality parameters, the analysis focused on Dissolved Oxygen (DO), Total Nitrogen (TN), Total Phosphorus (TP), Copper (Cu), and Iron (Fe). It should be noted, that the DO data collected in the southern Golden Gate Estates area of the Faka Union watershed, as reported in DBHYDRO, was revised to correct for an apparent data entry error. Review of the data collection sheets indicated that the data was initially collected in units of percent saturation; however, the data was reported in units of mg/L (Rhonda Watkins, personal communication). The reported DO concentrations were converted to units of mg/L using a methodology proposed by the University of Wisconsin (2006).

4.0 Groundwater Quality Analysis Methodology

The analysis included calculation of groundwater quality concentrations of the parameters of interest throughout the study area, and subsequent estimates of pollutant loads discharged from the local aquifers into the surface water network that eventually would reach the receiving estuaries. Following is a brief description of the methodology applied for determining both concentrations and pollutant loads.

4.1 Chemical Concentration Data Analysis and Kriging Interpolation

As indicated previously, data for 136 monitoring wells in the Surficial and Lower Tamiami aquifer systems were identified within the model study area. Because groundwater systems, as opposed to surface water, are regional in nature, the Kriging interpolation methodology was applied to create regional groundwater concentration maps for each constituent. For each well where data was available, median concentrations were calculated and groundwater concentration was predicted for each cell within the hydrologic/hydraulic model domain. This made the groundwater quality analysis consistent with the surface water modeling approach.

The results of the Kriging analysis for Dissolved Oxygen (DO), Total Nitrogen (TN), Total Phosphorus (TP), Copper, and Iron are shown in **Figures 2 through 6**. Each of the figures is colored such that orange, red, and brown represent areas where the predicted concentration of the constituent exceeds the corresponding surface water standard or screening levels described in the Technical Memorandum for Element 1, Task 1.2: In-Stream Water Quality. Each of these figures

also includes the locations of wells included in the analysis for each specific parameter. Following is a description of the results by constituent.

Figure 2. Estimated Dissolved Oxygen concentrations

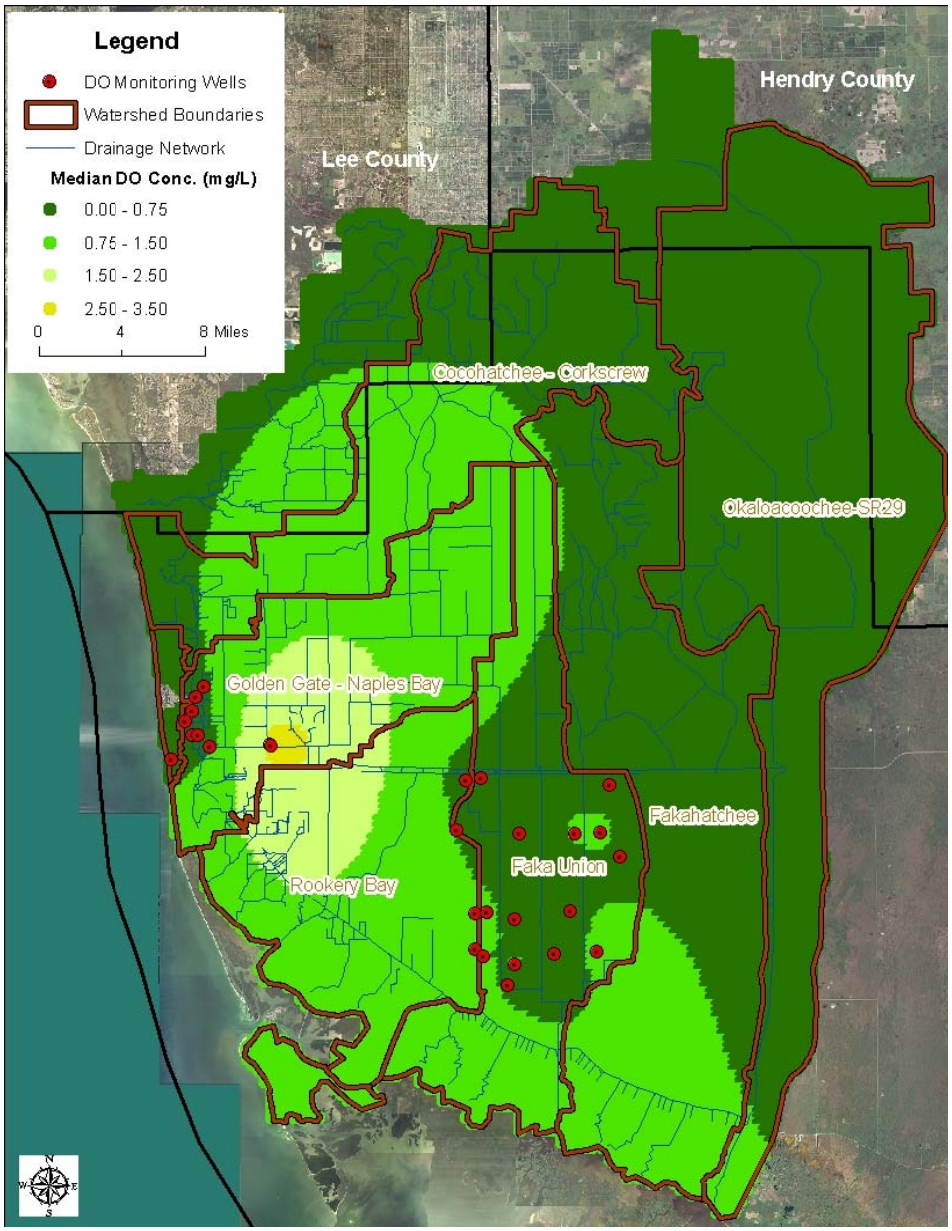


Figure 3. Estimated Total Nitrogen concentrations

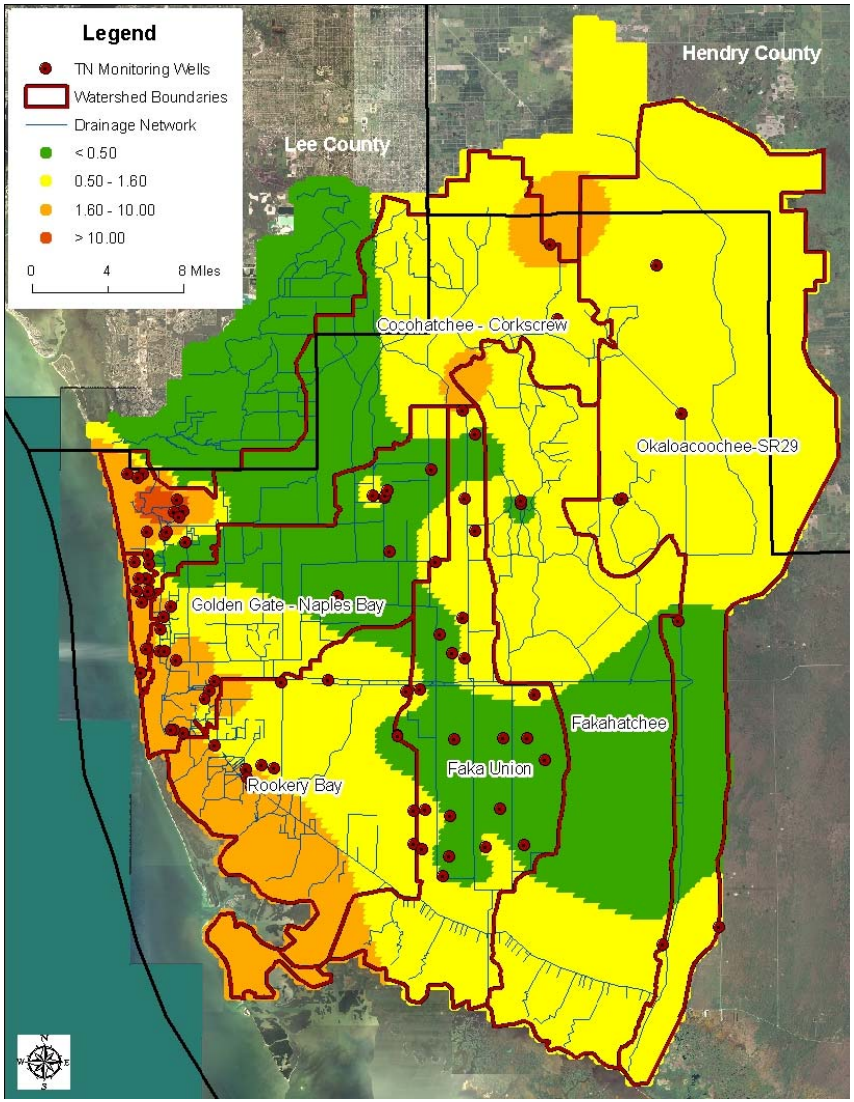


Figure 4. Estimated Total Phosphorus concentrations

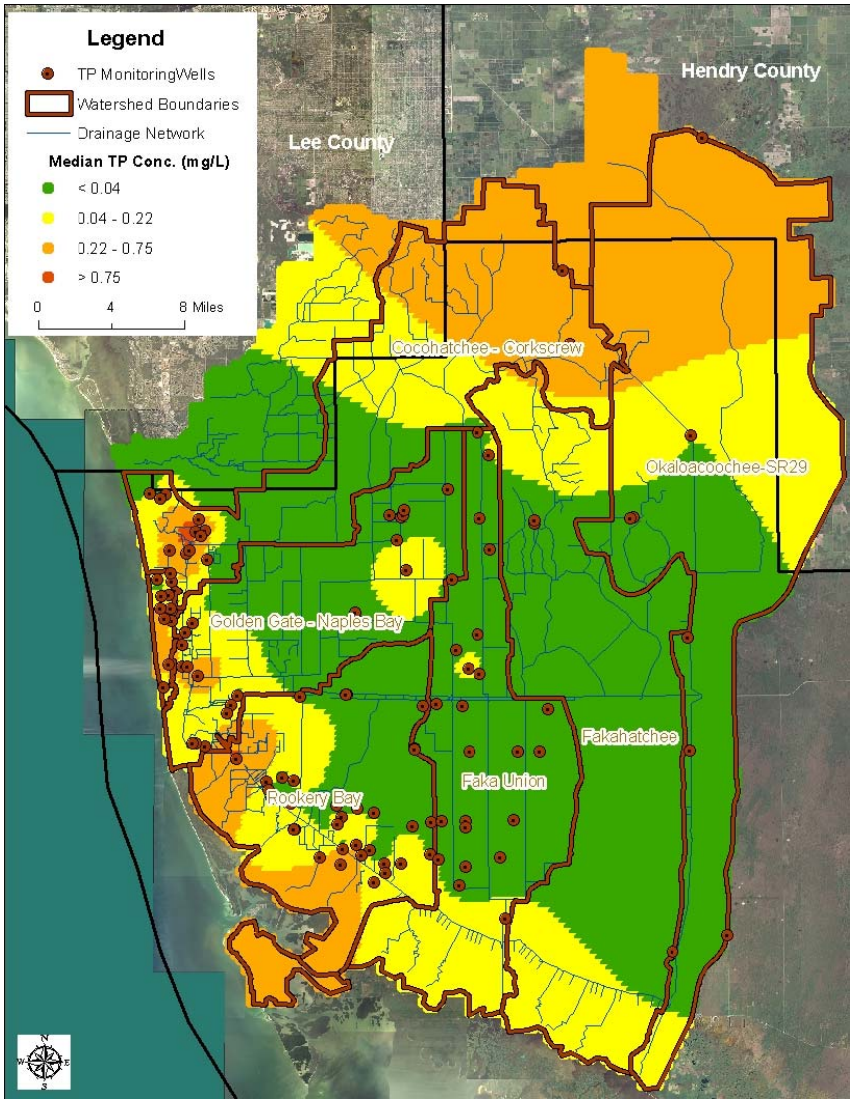


Figure 5. Estimated Copper concentrations

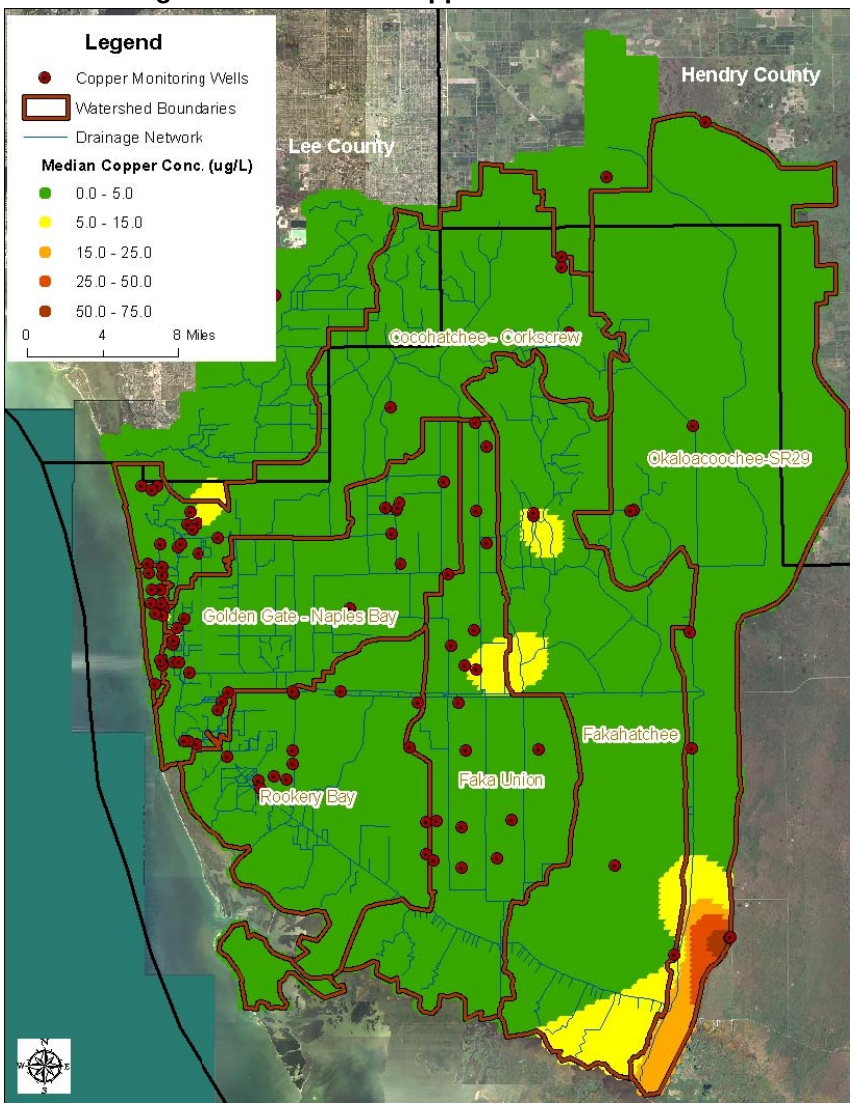
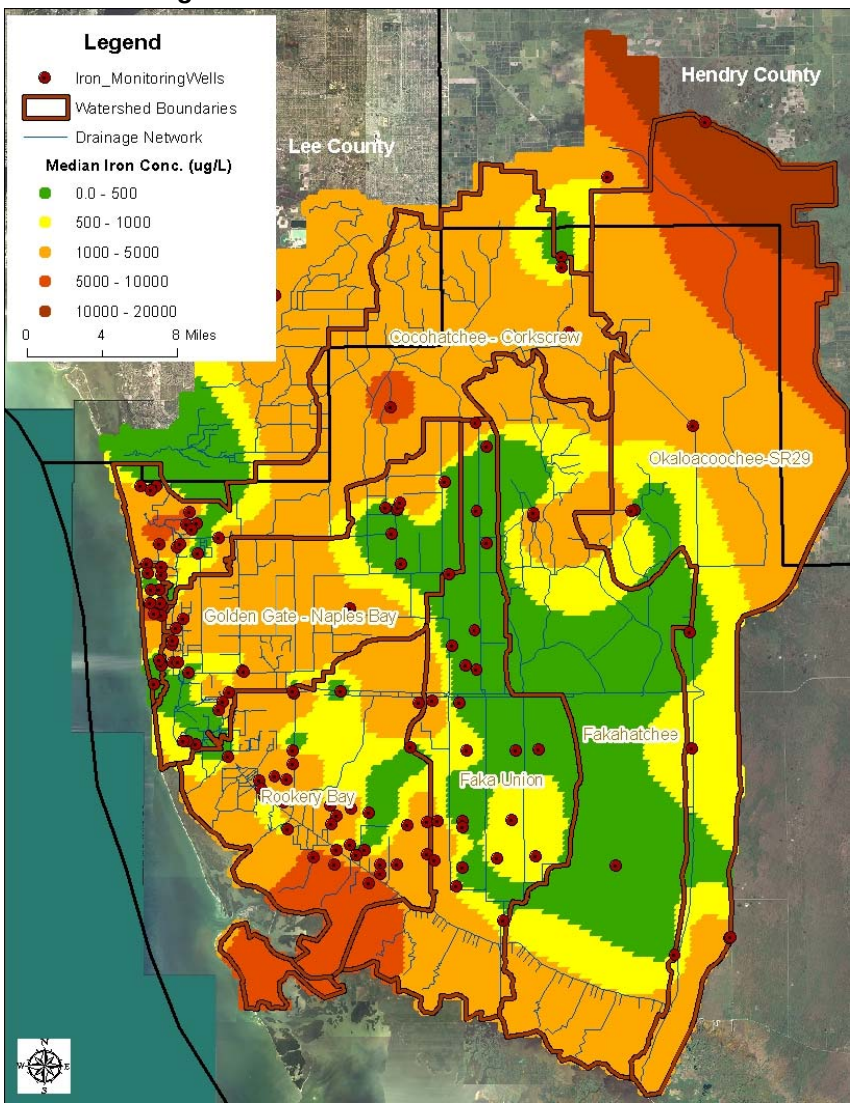


Figure 6. Estimated Iron concentrations



4.2 Dissolved Oxygen Concentration

Dissolved oxygen concentration is not a parameter commonly monitored in groundwater. Therefore, the available data is limited. The majority of the data comes from wells located in the Gordon River and the Picayune Strand areas. No data are available for the Cocohatchee-Corkscrew, Faka Union, and Okaloacoochee - SR29 watersheds, or the eastern portion of the Golden Gate watershed. Nevertheless, given that DO concentrations do not vary significantly across the study area, it is considered that the information available can be used to appropriately assess watershed conditions.

The location of the wells and the results of the Kriging interpolation analysis are shown in **Figure 2.** Results indicate that predicted concentrations throughout the study area are less than the in-stream water quality standard of 5.0 mg/L. The highest concentrations are associated with two wells located adjacent to I-75 and the Golden Gate Main Canal. In 1994, a single measurement of DO was made in each well and the reported concentrations were between 2.5 and 3.0 mg/L. These data appear to be outdated and the wells should be re-sampled to verify the accuracy of the reported values.

All other samples, measured in the Gordon River and Southern Golden Gate Estates area have reported concentrations between 0.5 mg/L and 1.5 mg/L. These data were collected between 2007 and 2009.

The low DO concentration in the groundwater, coupled with the significant amount of base flow in the main drainage canals, are likely contributing to the low measured DO concentrations in the canal network.

4.3 Total Nitrogen Concentration

Total nitrogen concentration data is available at 94 wells located throughout the study area. Well locations and Kriging interpolation results are shown in **Figure 3.**

A potential problem identified for this analysis was that a total of 47 wells exist along the coast from the Cocohatchee canal to Henderson Creek, but 38 of these wells are associated with the County's reuse monitoring program. It was considered possible that the reuse data may be biasing the results. To assess this condition, the measured TN concentrations at the reuse wells were compared to those at wells not associated with reuse. Results indicated that there is not a significant difference in measured concentrations for the majority of the wells, except for the area influenced by reuse monitoring wells CCN4 and CCN5, which are located near the coast north of the Cocohatchee Canal (**Figure 7**), and well CCS2 located near Rock Creek between Radio Road and Davis Blvd (**Figure 8**). These three wells are screened into the Surficial aquifer and concentrations amount to 21.52 mg/L, 31.96 mg/L, and 8.14 mg/L, respectively.

The fact that the areas of influence of wells CCN4, CCN5, and CCS2 are well defined by the Kriging interpolation and there is not a significant difference in concentrations between the other reuse wells and the non-reuse wells, it was considered that the analysis is providing adequate results. It is noted that the three wells showing high concentrations are located at golf courses

irrigated by reuse water and it is unclear if groundwater concentrations are directly related to golf course land management practices or are influenced by other factors, including activities in the surrounding land uses.

Figure 7. Total Nitrogen (TN) Monitoring Wells in the Western Cocohatchee Watershed

Figure 8. Total Nitrogen Monitoring Wells in the Western Golden Gate-Naples Bay Watershed

Overall the analysis showed that areas with predicted TN groundwater concentrations that exceed the in-stream water quality screening levels are located primarily in the western portion of the County. FDEP's screening criteria for streams uses the 75th percentile of values in STORET. It amounts to 1.6 mg/L TN. FDEP has also developed a TMDL TN target of 0.74 mg/L for Hendry Creek in Lee County that is being used in this analysis as an alternative screening criterion.

In addition to the area influenced by wells CCN4, CCN5, results of the analysis show that groundwater concentrations in the Cocohatchee- Corkscrew watershed exceed the TN criteria in the area represented by WBIDs 3259A, 3259Z, 3278C, and the most western portion of WBID 3278D. These areas are located along the coast. Although none of these WBIDs have been found TMDL impaired for nutrients, they may be considered at risk due to the potential groundwater discharges. As shown in **Figure 3,** the rest of the watershed shows predicted groundwater TN concentrations less than the in stream screening level of 1.6 mg/L, except for a single well located near Immokalee, which has a mean reported concentration of 1.7 mg/L.

In the Golden Gate –Naples Bay watershed, WBID 3278R (coastal segment of Naples Bay) and WBID 3278K (Gordon River Extension) show groundwater TN concentrations that exceed the screening criteria. Similar to the Cocohatchee- Corkscrew watershed, those WBIDs have not been found impaired for nutrients, but they may be considered at risk due to the potential groundwater discharges.

In Rookery Bay, Kriging interpolation analysis indicates that groundwater concentrations of TN along the coastal portion of the watershed (WBID 3278U) exceed the in-stream water quality screening level of 1.6 mg/L. This would appear to support the identified TMDL impairment for nutrients. However, it should be noted that monitoring wells with TN data in this area are all located in the Lely area. In the eastern portion of the watershed predicted concentrations result from the extrapolation of concentrations observed in two wells. The location of these wells, CCS16 and CCS17 are shown in **Figure 9**. Additional sampling is necessary in this area to verify the extrapolated results.

Groundwater TN concentration data in the Faka Union, Fakahatchee, and Okaloacoochee-SR29 watersheds includes data from the wells in Picayune Strand. TN concentrations at these locations were calculated by adding the reported Total Kjeldahl Nitrogen and Nitrate – Nitrite results. Nine of the other 14 sampling stations are located in the northern part of the Faka Union at single family residences. The average predicted concentration of TN is less than the in stream water quality screening level in the majority of the watershed area. The highest reported mean concentration in these watersheds was 2.96 mg/L in a sample taken from the well located in the headwaters of the Faka Union watershed. It is unclear what might be contributing to the elevated TN concentration in this well.

The Okaloacoochee-SR29 watershed was designated as a watershed of concern for TN in the Technical Memorandum prepared for Element 1, Task 1.2 – In Stream Water Quality. However, the lack of data makes it is difficult to accurately assess the potential contributions of TN from

groundwater. Additional groundwater monitoring should be completed to evaluate the contribution of TN to the surface water drainage network

Figure 9. Total Nitrogen Monitoring Wells in Rookery Bay Watershed

Table 1 shows the predicted TN median concentration in the groundwater by WBID. These were calculated by averaging the total load by grid cell. A total of six (6) WBIDs have predicted concentrations that equal or exceed the in stream screening level of 1.6 mg/L and all except five exceed the Hendry Creek TMDL screening value of 0.74 mg/L.

Table 1. Groundwater Concentrations Predicted by Kriging Interpolation Analysis for Critical Parameters per WBID

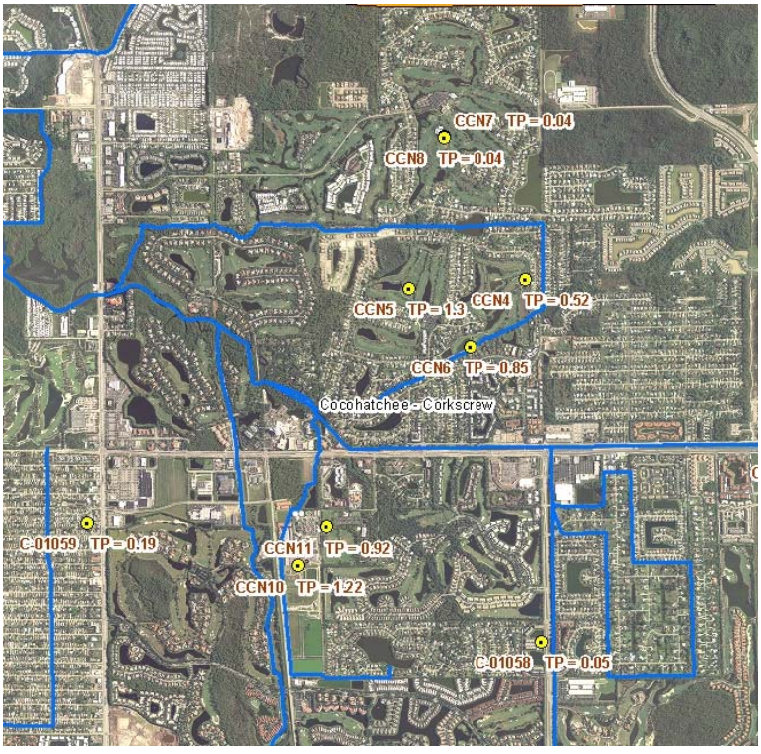
WBID	Watershed	Name	Dissolved Oxygen	Total Nitrogen	Total Phosphorus	Copper	Iron
			mg/L			ug/L	
3259A	Cocohatchee - Corkscrew	COCOHATCHEE RIVER	0.56	6.22	0.10	0.99	2425
3259B		DRAINAGE TO CORKSCREW	0.72	0.59	0.22	1.90	3050
3259W		LAKE TRAFFORD	0.70	1.43	0.31	0.91	2136
3259Z		LITTLE HICKORY BAY	0.59	2.78	0.01	0.52	251
3278C		COCOHATCHEE GOLF COURSE DISCHARGE	0.63	5.05	0.11	0.74	1133
3278D		COCOHATCHEE (INLAND SEGMENT)	0.95	2.30	0.12	2.38	1514
3278E		COW SLOUGH	0.67	1.45	0.42	1.15	1667
3278F		CORKSCREW MARSH	0.76	0.96	0.23	1.40	2951
3278L		IMMOKALEE BASIN	0.66	1.14	0.29	0.95	1807
3278K	Golden Gate - Naples Bay	GORDON RIVER EXTENSION	0.61	1.60	0.15	1.84	1445
3278R		NAPLES BAY (COASTAL SEGMENT)	1.18	3.08	0.14	1.03	740
3278S		NORTH GOLDEN GATE	1.35	0.50	0.03	1.26	1552
3278U	Rookery Bay	ROOKERY BAY (COASTAL SEGMENT)	1.24	2.44	0.25	0.91	4180
3278V		ROOKERY BAY (INLAND EAST SEGMENT)	1.21	0.91	0.04	1.38	1527
3278Y		ROOKERY BAY (INLAND WEST SEGMENT)	1.82	1.49	0.24	0.62	1476
3259I	Fakahatchee	CAMP KEAIS	0.66	0.81	0.06	2.93	901
3278G		FAKAHATCHEE STRAND	0.68	0.48	0.02	2.56	474
3278H	Faka Union	FAKA UNION (NORTH SEGMENT)	0.73	0.61	0.02	1.96	348
3278I		FAKA UNION (SOUTH SEGMENT)	0.67	0.42	0.02	0.86	721
3261C	Okaloacoochee - SR29	BARRON RIVER CANAL	0.66	0.45	0.02	8.87	700
3278T		OKALOACOOCHEE SLOUGH	0.60	1.11	0.26	2.01	6222
3278W		SILVER STRAND	0.61	0.87	0.10	2.14	1332

4.4 Total Phosphorus

TP concentration data is available at 117 wells located throughout the study area. Results of the Kriging interpolation analysis are shown in **Figure 4**. Similar to the TN analysis, the interpolated values were compared to the FDEP's screening criteria for streams (0.22 mg/L) and Hendry Creek TMDL (0.04 mg/L). However, as with TN, a potential identified problem is that 80 percent of the wells located along the coast from the Cocohatchee canal to Henderson Creek are associated with the County's reuse monitoring program. Since the reuse data may bias the results, the measured TP concentrations at the reuse wells were compared to those at wells not associated with reuse. Results indicated that there is not a significant difference in measured concentrations for the majority of the wells. Unfortunately, as opposed to the TN analysis, the reuse wells showing higher TP concentrations do not define specific problem areas, but are present at various locations along the coast.

One of the wells showing high TP concentrations is CCN5, which is located north of the Cocohatchee Canal (**Figure 10**). This well also shows high TN concentrations. A total of six samples were collected at this well from October 2006 through April 2009. The measured values range from a low of 0.171 mg/L in August 2007 to a maximum of 2.5 mg/L in April 2008. The measured values prior to September 2007 are all less than 0.22 mg/L, but are all higher than 2.20 mg/L after March 2008. This suggests that the increased concentrations may be associated with a change in land management practices, potentially including application of reuse water.

Figure 10. Total Phosphorus Median Concentrations in the Western Cocohatchee-Corkscrew Watershed



Other examples of wells with TP concentrations exceeding the screening criteria are CCN10, MW-9, and CCS20. Well CCN10 is located adjacent to a wastewater treatment facility, well MW-9 is located on a golf course adjacent to the Golden Gate Main Canal south of Golden Gate Parkway and west of Airport Pulling Road, and well CCS20 is located in the Lely Golf Estates near the Tamiami Trail.

As indicated above, the area of influence of some of the reuse wells showing high TP concentrations is not very well defined. However, there is not a clear criterion to select only a certain number of wells for the analysis without biasing the results. Therefore, it was decided that the best approach is to include all wells in the Kriging interpolation and recognize that the results probably err on the side of higher-than-actual concentrations.

Overall, results indicate that the areas where the predicted concentrations exceed the in stream water quality screening levels are located along the coast, as well on the northeastern portion of the study area. It is noted that the predicted concentration in northeast Collier County are based on sample results from only three wells. One of these wells is located in the City of Immokalee, one is located in an agricultural area near Immokalee, and the third is located near Keri Rd close to the study area boundary. There is insufficient data to determine if land use activities contribute to the measured concentrations. However, no stream water quality impairments for TP have been identified in that area.

In the Cocohatchee-Corkscrew and Golden Gate – Naples Bay watersheds the high TP concentrations along the coast seem to be the result of interpolation of the high concentrations at some of the reuse wells. In the Rookery Bay watershed the highest reported median TP concentrations are 0.71 mg/L and 0.76 mg/L in wells CCS20 and 021-67, respectively. These values far exceed the screening criteria. Well CCS20 is located in the Lely Golf Estates near the Tamiami Trail. TP concentrations exceed 1.0 mg/L in three (3) of the seven (7) collected samples. The data from well 021-67, which is located south of the Tamiami Trail in the agricultural lands east of Collier Blvd, was collected in 1997-1998. At this location, TP concentrations exceed 0.65 mg/L in three (3) of four (4) samples.

Finally, in the Faka Union, Fakahatchee and Okaloacoochee-SR 29 watersheds the highest reported mean concentration of 0.44 mg/L for TP was measured in well HE-852 located in Hendry County at the northern boundary of the Okaloacoochee-SR 29 watershed. The data from well HE-852 was collected in 1989 and 1990. All other monitoring wells in these watersheds have a median concentration of 0.07 mg/L or less.

A summary of the results indicates that the relatively high groundwater TP concentrations are not currently determining surface water quality conditions in terms of nutrients because only one WBID (3278U – Rookery Bay Coastal Segment) has been identified as impaired for nutrients. However, the relatively high groundwater TP concentrations in the groundwater at some of the reuse wells may indicate a risk of groundwater pollution loads. As shown in **Table 1**, the median TP concentration in five (5) of the WBIDs exceeds the stream screening criteria of 0.22 mg/L, whereas the Hendry Creek criteria of 0.04 mg/L is exceeded in 12 out of the 15 WBIDs in the Cocohatchee-Corkscrew, Golden Gate – Naples Bay, and Rookery Bay watersheds. Most of the WBIDs in the undeveloped areas of the County meet the 0.04 mg/L screening criteria.

4.5 Copper

The predicted results for copper (**Figure 5**) indicate that only one area is of concern for copper in groundwater. Well C-00495, which monitors the Lower Tamiami aquifer system, is located near the SR29 canal and has a median copper concentration in excess of 90 µg/L and a maximum concentration of 213 µg/L. As a comparison, the in-stream standard for copper in WBID 3261C is calculated to be 22.69 µg/L based on the average hardness value from the groundwater samples. Collier County is investigating potential sources of metals in the area around this well (Rhonda Watkins, personal communication). There is no known activity in the area that would contribute to elevated copper concentrations. It is noted that no exceedance of water quality standards for copper has been reported in the SR29 canal.

4.6 Iron

The results of the Kriging interpolation analysis for iron concentrations in groundwater are shown in **Figure 6**. Results indicate that the groundwater concentration of iron in most of the study area exceed the in-stream water quality standard of 1,000 ug/L. As shown in **Table 1**, the calculated median concentration exceeds the in stream water quality standard in 68 percent (15 of 22) of the WBIDs. These results suggest that identified surface water iron impairments may be attributed to groundwater inflows.

In the Cocohatchee-Corkscrew watershed, all but one of the WBIDs exceed the screening criteria. Well C-492, located adjacent to the Corkscrew Swamp in the central portion of the watershed reported the highest mean concentration of iron. The reported median concentration is 8,100 µg/L.

In the Golden Gate – Naples Bay watershed, reported mean concentrations of iron in the Surficial and Lower Tamiami aquifers range from 50 µg/L, in the north Golden Gate Estates to 5,060 µg/L near the Gordon River. Concentrations in two of the three WBIDs exceed the State water quality standard.

In the Rookery Bay watershed, the Kriging analysis indicated that groundwater iron concentrations exceed 5,000 µg/L in some parts of the watershed and median predicted concentrations exceed 1,400 µg/L. These concentrations are higher than those in the Cocohatchee – Corkscrew and Golden Gate – Naples Bay. However, there are limited groundwater contributions to overland flow in the Rookery Bay watershed, which may explain why there are no identified impairments for iron in the stream network.

5.0 Groundwater Pollutant Loading to the Surface Water Network

Pollutant loads associated with groundwater discharges from the Surficial and Lower Tamiami aquifers to the surface water system were calculated based on a) water flows obtained for each cell from the H&H model simulation domain, and b) pollutant concentrations determined from the Kriging analysis described herein. Pollutant loads were calculated for TN, TP and copper. The analysis was limited to the parameters of concern that are also part of the NPDES list of pollutants included in the calculation of surface water loads. The pollutant load was assumed to

be zero (0) in WBIDs were surface runoff in the drainage network is lost to the surface aquifers. Pollutant loads by cell were also aggregated to determine the load by WBID. Iron is not one of the NPDES parameters and no comparisons are possible with surface water laodings because event mean concentration data is not available.

Table 2 shows the total estimated annual groundwater pollutant load by WBID and watershed. For comparison purposes, the table also shows the calculated surface water pollutant loads, as described in the corresponding technical memorandum. The largest total predicted TN groundwater load in lbs / year is found in WBID 3278S (Northern Golden Gate). Naples Bay is listed as impaired for DO with the likely cause identified as nutrients. It is likely that baseflow in the canal network, which results from groundwater discharging into the surface water system, contributes to the low DO concentrations in the estuary; however nutrients entering the groundwater system and discharging to the canal network may also contribute to the impairment.

Results also show that in terms of nutrients, 74 and 88 percent of the total TN and TP load in the study area comes from surface water sources, respectively. However, Rookery Bay is the only watershed where the predicted groundwater load of TN is basically the same as the predicted surface water load and groundwater represents about 40 percent of the TP load. In other watersheds, the TN load from groundwater is less than 30 percent. As Rookery Bay is the only estuary found impaired for nutrients, results suggest that the control of nutrients entering the groundwater would be important to address the impairment condition.

Copper pollution seems to be originating primarily in the surface water system, which account for 76 percent of the total load.

It should be noted that as total pollution loads are determined by the extent of the watershed and the anticipated baseflow entering the surface water system, total loads do not provide a good representation of actual WBID conditions. A better indicator is the load per unit area. **Table 3** shows the pollutant load by WBID per unit area (acres). It also shows the mean unit area pollutant load by watershed. Rookery Bay shows by far the largest nutrient load / acre / year. Approximately 60 percent of the TN load per acre appears to be of groundwater origin.

Table 2. Predicted Pollution Loads from the Groundwater and Surface Water Systems

WBID	Watershed	Name	Groundwater Pollutant Load			Surface Water Pollutant Load		
			TN	TP	Cu	TN	TP	Cu
			lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr
3259A	Cocohatchee - Corkscrew	COCOHATCHEE RIVER	6,489	109	1	4,614	661	38
3259B		DRAINAGE TO CORKSCREW	3,152	1,202	10	83,815	16,768	110
3259W		LAKE TRAFFORD	0	0	0	0	0	0
3259Z		LITTLE HICKORY BAY	0	0	0	1,605	268	11
3278C		COCOHATCHEE GOLF COURSE DISCHARGE	2,623	58	0	4,807	614	39
3278D		COCOHATCHEE (INLAND SEGMENT)	82,284	4,291	85	77,840	13,398	253
3278E		COW SLOUGH	716	208	1	31,052	6,049	61
3278F		CORKSCREW MARSH	8,572	2,040	13	99,729	19,880	141
3278L		IMMOKALEE BASIN	2,551	656	2	31,806	6,148	82
Subtotal			**106,387**	**8,564**	**112**	**335,267**	**63,786**	**734**
3278K	Golden Gate - Naples Bay	GORDON RIVER EXTENSION	2,574	243	3	21,885	3,482	132
3278R		NAPLES BAY (COASTAL SEGMENT)	13,397	609	4	52,523	8,001	526
3278S		NORTH GOLDEN GATE	135,931	7,396	339	166,652	28,165	838
Subtotal			**151,901**	**8,247**	**346**	**241,060**	**39,648**	**1,497**
3278U	Rookery Bay	ROOKERY BAY (COASTAL SEGMENT)	46,964	4,760	17	23,551	4,315	77
3278V		ROOKERY BAY (INLAND EAST SEGMENT)	40,289	1,662	61	94,760	18,550	160
3278Y		ROOKERY BAY (INLAND WEST SEGMENT)	60,045	9,798	25	28,130	4,151	145
Subtotal			**147,298**	**16,220**	**104**	**146,442**	**27,015**	**382**
3259I	Fakahatchee	CAMP KEAIS	0	0	0	231,302	46,134	300
3278G		FAKAHATCHEE STRAND	0	0	0	5,532	1,113	7
3278H	Faka Union	FAKA UNION (NORTH SEGMENT)	48,412	1,705	155	36,092	6,312	2
3278I		FAKA UNION (SOUTH SEGMENT)	88,616	4,120	179	129	25	4
3261C	Okaloacoochee-SR29	BARRON RIVER CANAL	6,234	264	122	311	34	2
3278T		OKALOACOOCHEE SLOUGH	1,587	380	3	291,256	58,543	9
3278W		SILVER STRAND	33,443	3,690	82	379,120	76,110	541
Subtotal			**178,292**	**10,160**	**541**	**943,743**	**188,271**	**866**
Total	**All Watersheds**		**583,878**	**43,191**	**1,103**	**1,666,512**	**318,720**	**3,479**

Table 3. Predicted Pollution Loads by Unit Area from the Groundwater and Surface Water Systems

WBID	Watershed	Name	Groundwater Pollutant Load			Surface Water Pollutant Load		
			TN	TP	Cu	TN	TP	Cu
			lbs/ac/yr	lbs/ac/yr	lbs/ac/yr	lbs/ac/yr	lbs/ac/yr	lbs/ac/yr
3259A	Cocohatchee - Corkscrew	COCOHATCHEE RIVER	2.166	0.036	0.000	1.540	0.221	0.013
3259B		DRAINAGE TO CORKSCREW	0.147	0.056	0.000	3.910	0.782	0.005
3259W		LAKE TRAFFORD	0.000	0.000	0.000	0.000	0.000	0.000
3259Z		LITTLE HICKORY BAY	0.000	0.000	0.000	2.390	0.400	0.016
3278C		COCOHATCHEE GOLF COURSE DISCHARGE	1.238	0.028	0.000	2.270	0.290	0.018
3278D		COCOHATCHEE (INLAND SEGMENT)	3.192	0.166	0.003	3.020	0.520	0.010
3278E		COW SLOUGH	0.061	0.018	0.000	2.660	0.518	0.005
3278F		CORKSCREW MARSH	0.162	0.038	0.000	1.880	0.375	0.003
3278L		IMMOKALEE BASIN	0.287	0.074	0.000	3.580	0.692	0.009
Average			**0.806**	**0.046**	**0.001**	**2.361**	**0.422**	**0.009**
3278K	Golden Gate - Naples Bay	GORDON RIVER EXTENSION	0.484	0.046	0.001	4.114	0.655	0.025
3278R		NAPLES BAY (COASTAL SEGMENT)	1.457	0.066	0.000	5.713	0.870	0.057
3278S		NORTH GOLDEN GATE	1.853	0.101	0.005	2.272	0.384	0.011
Average			**1.265**	**0.071**	**0.002**	**4.033**	**0.636**	**0.031**
3278U	Rookery Bay	ROOKERY BAY (COASTAL SEGMENT)	1.699	0.172	0.001	0.852	0.156	0.003
3278V		ROOKERY BAY (INLAND EAST SEGMENT)	0.743	0.031	0.001	1.747	0.342	0.003
3278Y		ROOKERY BAY (INLAND WEST SEGMENT)	3.954	0.645	0.002	1.852	0.273	0.010
Average			**2.132**	**0.283**	**0.001**	**1.484**	**0.257**	**0.005**
3259I	Fakahatchee	CAMP KEAIS	0.000	0.000	0.000	4.154	0.829	0.005
3278G		FAKAHATCHEE STRAND	0.000	0.000	0.000	0.058	0.012	0.000
3278H	Faka Union	FAKA UNION (NORTH SEGMENT)	1.755	0.062	0.006	1.309	0.229	0.000
3278I		FAKA UNION (SOUTH SEGMENT)	1.505	0.070	0.003	0.002	0.000	0.000
3261C	Okaloacoochee-SR29	BARRON RIVER CANAL	0.195	0.008	0.004	0.010	0.001	0.000
3278T		OKALOACOOCHEE SLOUGH	0.013	0.003	0.000	2.372	0.477	0.000
3278W		SILVER STRAND	0.618	0.068	0.002	7.004	1.406	0.010
Average			**0.584**	**0.030**	**0.002**	**2.130**	**0.422**	**0.002**
Average	**All Watersheds**		**0.979**	**0.077**	**0.001**	**2.396**	**0.429**	**0.009**

6.0 Assessment of Pollution Loads from Septic Tanks

Septic tanks are common in parts of Collier County that are not served by sewer. They are also potential sources of nutrients discharges into the receiving water bodies by way of percolation into the water table aquifer. The objective of this analysis was to evaluate the potential effect of septic tanks on the groundwater concentrations of TN and TP. This was done by first estimating the number of septic tanks in each cell within the model domain and subsequently conducting a correlation analysis between septic tank density and constituent concentration in the groundwater.

The actual density of septic systems is unknown in most parts of the county. The Florida Department of Health (FDoH) is in the process of developing a comprehensive inventory of septic tanks in Florida; however, that inventory is not complete. In the interim, the FDoH has developed a GIS based shapefile that predicts the probability of a septic tank existing in any area within the State. This map was modified as part of this project to estimate the existing density of septic tanks within each grid cell that makes up the existing conditions H&H model (ECM). The process consisted of the following steps.

- The FDoH data was modified to represent only the probability of existing septic systems in Collier and Lee counties. If a polygon was located within an area currently served by sanitary sewer, the probability of a septic tank was set to zero (0). It is possible that some septic systems exist in sewered areas, but this decision eliminates the potential influence of outside sources when comparing septic system density and groundwater concentrations.

- The probability value was then converted to predicted number of septic tanks per parcel and summed within the area of a grid cell. **Figure 11** shows the predicted location and density of septic tanks per grid cell in Collier County.

Figures 12 and 13 are scatter diagrams of predicted septic tank density versus predicted concentrations of TN and TP. Concentrations were as determined from the Kriging interpolation analysis described previously. For illustration purposes, the line of best fit to the data was also included, along with the corresponding coefficient of determination.

Results of this analysis indicate that there is little correlation between TN and TP and septic tank density. Therefore, it can be concluded that septic tanks appear not to be a major countywide problem. Of course localized problems may exist.

Figure 11. Estimated Septic Tank Density in Collier County

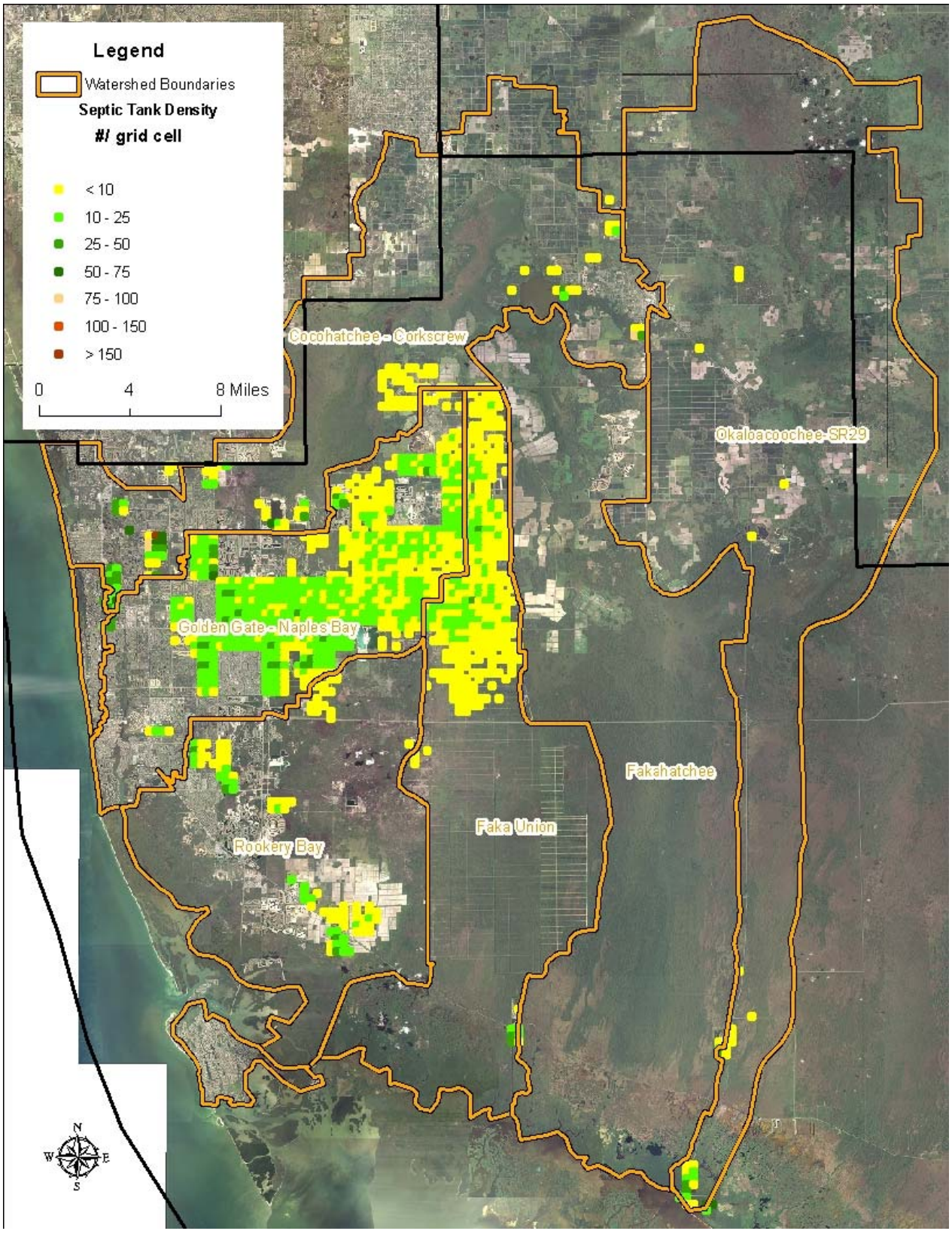


Figure 12. Scatter Diagram of Septic Tank Density vs. TN Concentration

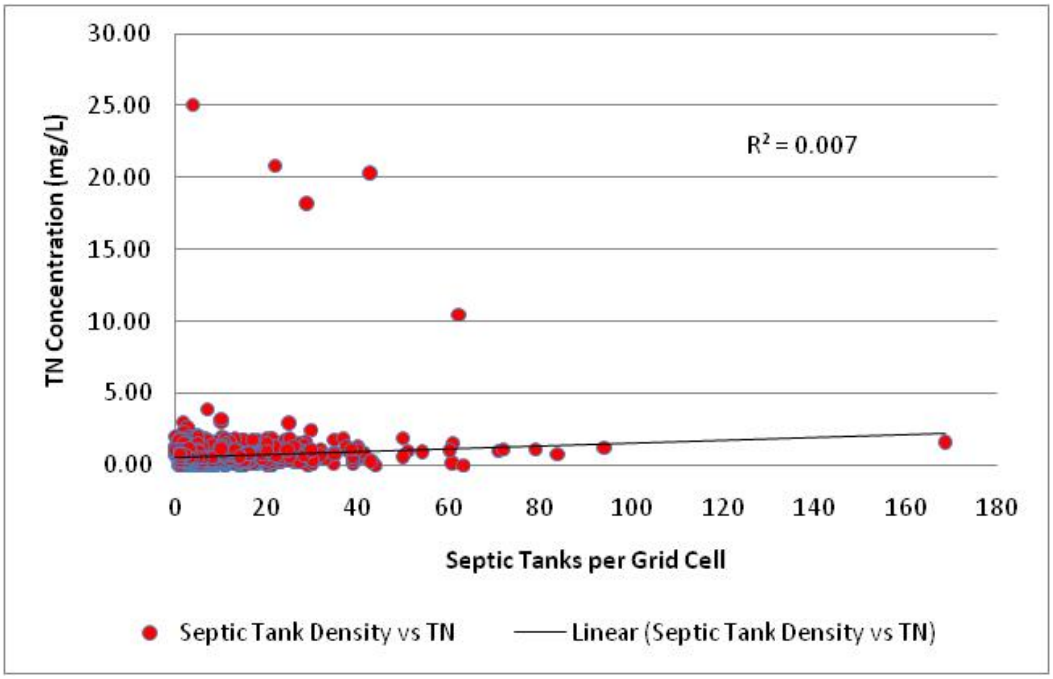
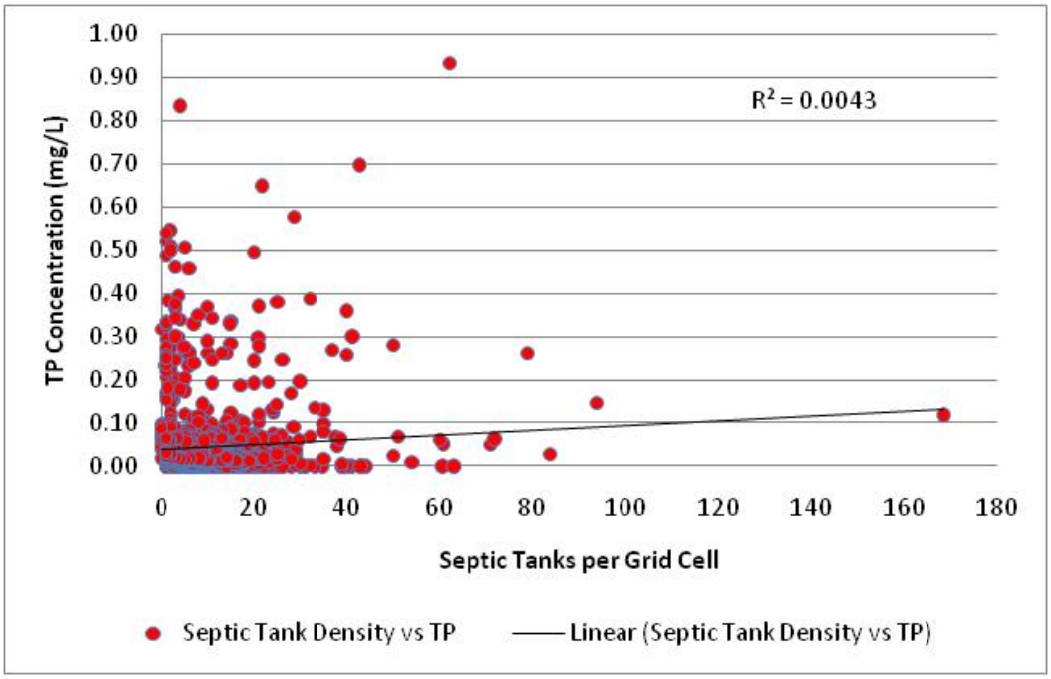


Figure 13. Scatter Diagram of Septic Tank Density vs. TP Concentration



7.0 Conclusions

The following conclusions can be drawn from the analysis:

- Dissolved oxygen concentration data is not commonly reported. Data for the Surficial and Tamiami aquifers was available only in the Gordon River and Picayune Strand. The collected data and the Kriging interpolation analysis indicate that dissolved oxygen concentrations in groundwater are less than 1.5 mg/L throughout most of Collier County. Groundwater inflows likely contribute to identified DO impairments in the canal network.
- A potential problem identified for this analysis was that many of the wells whose data was used to predict TN and TP loads are associated with the County's reuse monitoring program. It was considered possible that the reuse data may be biasing the results. To assess this condition, measured concentrations at the reuse wells were compared to those at wells not associated with reuse. Results indicated that there is not a significant difference in measured concentrations for the majority of the wells
- Results indicate that TN concentrations in groundwater exceed the corresponding screening criteria for surface water in a significant portion of the study area. TP concentrations exceed the criteria along the coast and in the northern portion of the area. The limited data available suggests that land practices in the immediate vicinity of the wells may contribute to the elevated groundwater concentrations. Additional sampling data that provides a better overview of existing conditions is necessary.
- Copper concentrations in groundwater are generally very low across Collier County suggesting that copper impairments in the canal network can be attributed to surface runoff. One well, located at the edge of the Big Cypress Preserve, shows elevated copper concentrations. Additional on-site assessments should be completed to identify the source of copper at this location.
- Iron concentrations in groundwater are elevated relative to the Class 3 surface water standard in many WBIDs within the study area. The areas of elevated iron concentrations in groundwater correspond with the locations of identified impairment in the canal network. It is likely that groundwater inflows are significant sources of iron to the surface water system.
- Pollution load calculations indicate that groundwater is a potential contributor to the nutrient impairment in the Rookery Bay watershed. Additional site specific studies should be conducted to verify groundwater contributions to the canal network.
- There is little correlation between TN and TP and septic tank density. Therefore, it can be concluded that septic tanks appear not to be a major countywide problem. Of course localized problems may exist.

8.0 References

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