A DESIGN OF A SURFACE WATER QUALITY MONITORING PROGRAM FOR PINELLAS COUNTY, FLORIDA

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EXECUTIVE SUMMARY

This document provides a monitoring program design for an ambient surface water quality monitoring program for the coastal waters of Pinellas County Florida.

The Pinellas County Department of Environmental Management (DEM) has conducted coastal surface water quality monitoring under a monitoring program that was the predecessor to the program described in this document since 1991. The 1991-2002 monitoring program was designed to collect monthly surface water quality data at a series of fixed stations at locations of interest. The site locations were selected in order to represent ambient surface water quality conditions, and the data were summarized on an annual basis.

The revised monitoring program defined by this document is similar to the predecessor program, but employs a wider geographic extent and a statistical-based probabilistic design to address key monitoring questions.

Pinellas County DEM staff identified the following monitoring questions to be answered by this revised monitoring program: The questions are not prioritized.

1) Which water bodies are not meeting their designated uses?

2) What proportion or area of the County's surface waters are currently meeting their designated uses?

3) Is the proportion or area of the County's surface waters that are currently meeting their designated uses changing over time?

4) Which parameters are leading to a response in light attenuation?

5) Which are the worst and best water bodies in the County in terms of water quality?

This document is a living document and sections are revised as the program is fine tuned to meet the program objectives. A complete set of archived design documents is maintained by the Department in order to record changes to this design.

ACKNOWLEDGEMENTS

The monitoring program design and this report were prepared in consultation with Andrew Squires, Kelli Hammer Levy, and staff of the Pinellas County Department of Environmental Management, Environmental Resources Management Division.

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1.0 Background

The Pinellas County Department of Environmental Management (DEM) has conducted coastal ambient surface water quality monitoring from 1991 through 2002. This monitoring effort has provided important water quality data to support:

- Pinellas County Watershed planning initiatives in accordance with State Water Policy (Chapter 62-40 FAC),
- the Pinellas County Comprehensive Plan ,
- agreements with the Tampa Bay Estuary Program (TBEP) (e.g., the Tampa Bay Comprehensive Conservation and Management Plan (TBEP CCMP) (TBEP 1996), and
- the monitoring and reporting requirements of the Pinellas County National Pollutant Discharge Elimination System (NPDES) permit (United States Environmental Protection Agency (USEPA), 1997).

Existing Pinellas County Ambient Water Quality Monitoring Program

The DEM designed the existing 1991-2002 ambient water quality monitoring program to collect monthly water quality data at a series of fixed stations at locations of interest (Figure 1-1). The site locations were selected in order to represent ambient water quality conditions, and the data were summarized and reported periodically (Moores et al., 1992; Moores et al., 1994; and Myers et al., 2000).

The western geographic extent of the existing ambient sampling program covered many of the water bodies of the western Pinellas County shoreline inshore of the barrier islands. These western water bodies included the northern portion of Boca Ciega Bay (north of the Pinellas Bayway Bridge), The Narrows, and Clearwater Harbor. The existing program also collected data in the County's two major lakes, Lake Tarpon and Lake Seminole. Along the eastern coastline of Pinellas County, the existing program collected data from fixed location stations in Riviera Bay, Bayou Grande, Old Tampa Bay, Coffee Pot Bayou and Big Bayou. In addition, this program monitored water quality in rivers, streams, and creeks throughout the county.

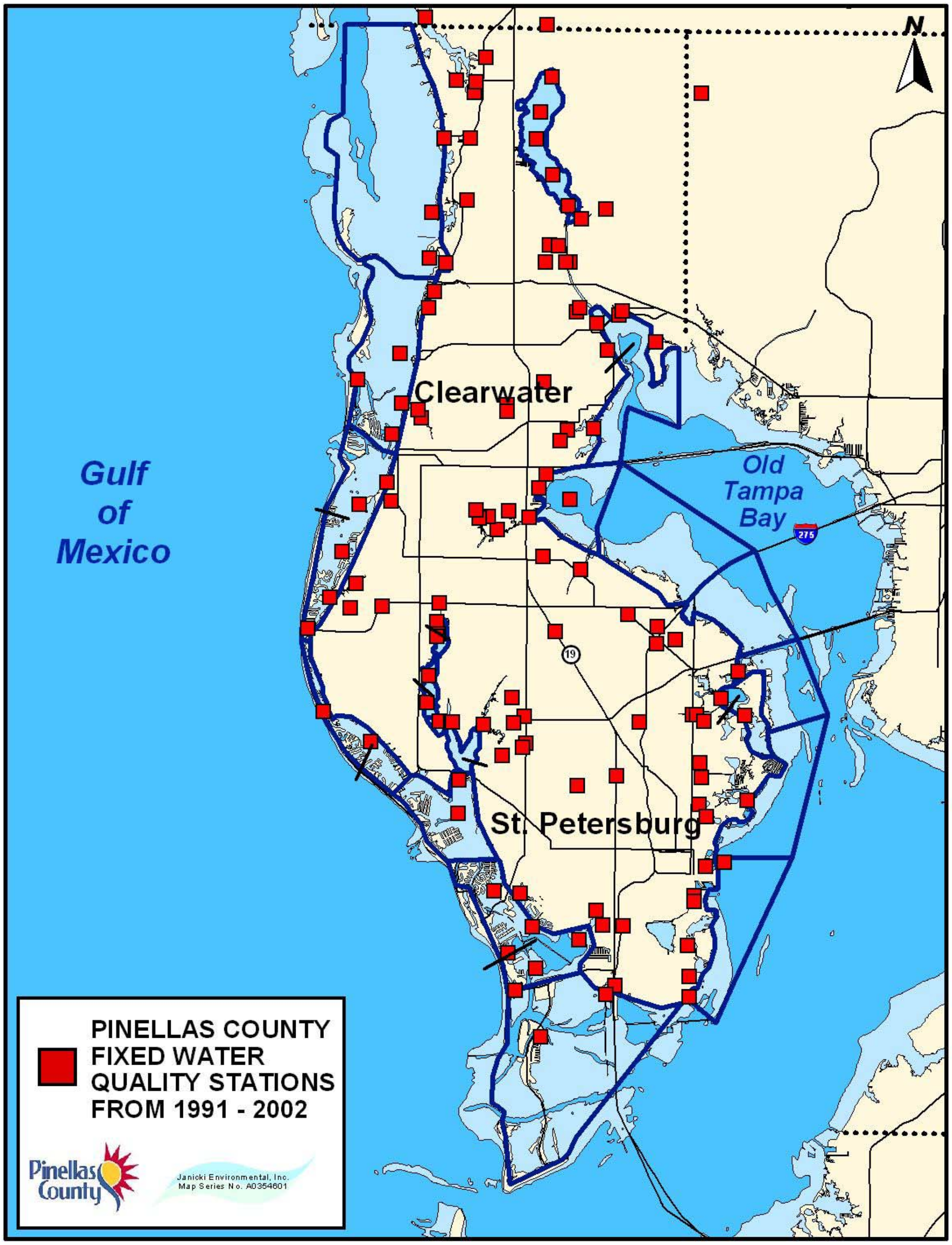

Figure 1-1 Fixed stations sampled by DEM from 1991 to 2002. The coastal stations in this figure represent the ambient coastal surface water quality monitoring stations. The bold blue lines represent the geographic reporting units for the revised ambient water quality monitoring program that is described in this document. The following sections discuss geographic data gaps visible in this figure.

Concomitant Surface Water Monitoring Programs

Pinellas County and other government agencies are conducting ambient surface water quality monitoring programs concomitant with the Pinellas County ambient surface water quality monitoring fixed stations.

Pinellas County DEM has collected water quality data at randomly selected surface water stations in the northern and southern portions of Boca Ciega Bay since 1995 (northern and southern delineated by the Pinellas Bayway Bridge). Pinellas County DEM staff selected these random station locations to coincide spatially with the random station locations of the TBEP Benthic Monitoring Program.

The Environmental Protection Commission of Hillsborough County continues to operate a bay-wide network of fixed surface water quality stations in Tampa Bay. These stations have been sampled monthly from the mid 1970s to date. These stations cover Tampa Bay waters greater than 2-meters in depth east of Pinellas County.

Limitations of the Existing Monitoring Program

The existing Pinellas County fixed station water quality monitoring program resulted in several relatively large geographic data gaps (Figure 1-1). These geographic data gaps included:

- St. Joseph Sound,
- Anclote Anchorage,
- the southern portion of Boca Ciega Bay,
- the shallow coastal waters of the eastern shoreline that were not covered by the Hillsborough County monitoring program,
- Mobbly Bay,
- Safety Harbor, and
- the Feather Sound region.

The existing fixed station program does not allow statistical estimation or trend analysis for the water bodies as regions, but limits inferences to the locations of the fixed stations. The locations of the fixed stations were selected using professional judgment. In some cases, the site locations were selected to monitor the effects on water quality of discharges from known or suspected pollution sources. In other cases, samples were collected at easy access points such as bridges, docks, and piers.

The existing monitoring program collected data using a non-probabilistic sampling schedule, and the degree to which the sampled days are representative of the annual daytime surface water quality conditions is unknown.

Evolving Needs for Pinellas County Surface Water Quality Monitoring (adapted from Pinellas County 2002).

The DEM expects the ambient monitoring program to be under increased scrutiny by the Florida Department of Environmental Protection's (FDEP's) NPDES Stormwater administrator to provide credible long-term water quality assessments of the County receiving water bodies as one of the measures of success of the Pinellas County Stormwater Management Program. Design Improvements of the existing monitoring program are needed, including a geographic expansion, and probabilistic design to allow inferences to be made regarding the status and trends of the receiving water bodies as well as statistically defensible results of long-term seasonal and annual water quality trends. In addition, the ambient monitoring program needs to support TBEP CCMP (TBEP 1996), FDEP's statewide watershed management approach, and the Southwest Florida Water Management District's (SWFWMD's) Comprehensive Watershed Management Plan for the Tampa Bay/ Anclote River watershed (SWFWMD, 2002).

During the past ten years, leading estuarine researchers and environmental managers have recognized that results obtained from fixed station sampling designs are often improperly used to make statements about water quality trends of defined water bodies. A probabilistic monitoring approach developed by USEPA's Environmental Monitoring and Assessment Program (EMAP) has gained considerable scientific support nationwide. A probabilistic approach incorporates a selection of sampling sites within a geographical area based on known or equal proportions of the population of interest for which each site represents, thus minimizing or eliminating any bias in choosing sampling sites. One commonly used example of a probabilistic approach incorporates random sample locations where each site represents an equal but unknown proportion of the population of interest. The Tampa Bay Estuary Program has strongly recommended and implemented a probabilistic design to assess water and sediment quality trends in Tampa Bay. This has allowed environmental managers to determine, with a known level of confidence, if and when water quality restoration targets have been achieved.

Based on the limitations of the existing ambient water quality monitoring program and the evolving needs of the County, the DEM proceeded to refine the existing monitoring program. This refined monitoring program is detailed in this document.

Important Questions to be Answered by the Monitoring Program

Pinellas County DEM staff and the DEM consultant identified the following monitoring questions in order to provide further direction for the development of this refined monitoring program design: The questions are not prioritized.

1) Which water bodies are not meeting their designated uses?

2) What proportion or area of the County's surface waters are currently meeting their designated uses?

3) Is the proportion or area of the County's surface waters that are currently meeting their designated uses changing over time?

4) Which parameters are effecting light attenuation?

5) Which are the worst and best water bodies in the County in terms of water quality?

Living Nature of this Document

The DEM expects that elements of the monitoring program may be re-examined in future years to continue to address these important questions, and sections of this document will be updated accordingly.

> Version control dates are printed in the upper right header portion of each page in this document. Sections are updated as needed in order to maintain the most current working version of the document. The Department maintains archive files of all monitoring design documents in order to document changes in the design.

2.0 Program Goals and Objectives

The DEM and its consultant developed the goals and objectives for the ambient surface water quality monitoring program as products from a series of meetings with Pinellas County DEM staff.

Program Goals

The goals for the water quality sampling program were stated as follows:

- Support the efforts to maintain or improve water quality in the open-water receiving water bodies of the County.
- Determine the status and trends of water quality in the County receiving waters.

The Department recognized that these goals are broad management directions and may not be fully attained by this monitoring program alone. The Department will move towards these goals by meeting the specific program objectives stated on the following page.

Specific Program Objectives

The following list presents the specific program objectives for the ambient surface water quality monitoring program. The listed objectives are not ordered by priority at this time.

Objective 1: Fulfill the County's NPDES permit obligations.

Objective 2: Provide status and trends information to the citizens of the County, the Board of County Commissioners, the Pinellas County DEM staff, and cooperating agencies (e.g., Tampa Bay Estuary Program, Florida Department of Environmental Protection, and SWFWMD).

Objective 3: Develop a mechanism of information delivery to provide data to any member of the public who requests it.

Objective 4: Fulfill State water policy (per Chapter 62-40 F.A.C.) and County Comprehensive Plan requirements.

Objective 5: Provide an early warning program to detect potentially serious water quality problems before they occur. In particular, provide a method of identifying water bodies that are approaching a condition of not meeting their designated uses.

Objective 6: Measure the impacts of management efforts (e.g., the effectiveness of stormwater management plans).

Objective 7: Provide information needed to prioritize management actions.

Objective 8: Fill important surface water quality data gaps and maximize the sampling effort with respect to sampling priority open water habitat types (e.g., sample shallow coastal waters).

Objective 9: Provide the information needed to develop quantitative water quality targets for living resources.

Objective 10: Provide a means of estimating the annual aerial extent of given measurements of each water quality parameter for the County, East County Shallow, West County Shallow, West County Shallow and Deep, and each geographic stratum.

Objective 11: Estimate the magnitude and direction of the change in the aerial extent measures (listed in Objective 10) at least every five years.

3.0 Design Guidelines and Constraints

The DEM identified the design guidelines and constraints for the ambient water quality monitoring program at the start of the design process, and its consultant further developed them as products from a series of meetings with the DEM staff.

Relationships with other Monitoring Activities

The surface water quality monitoring activities described by this document will not supersede other monitoring activities by the DEM. In particular, it is expected that the DEM surface water quality sampling in creeks, streams, and small lakes will continue to collect information for those elements of the County's natural resources.

The surface water quality monitoring activities described by this document will not replace other monitoring activities conducted by other local and regional governments entities. In particular, the surface water quality monitoring program was designed in anticipation that the Environmental Protection Commission of Hillsborough County will continue to monitor its network of fixed Tampa Bay stations. The revised monitoring program defined by this document will provide a valuable augmentation to the Hillsborough County program by allowing comparison of the fixed stations > 2-meters to statistical estimates of the adjacent areas < 2-meters.

Specific Design Guidelines

The DEM identified a set of geographic reporting units to be applied to this monitoring design (Figure 3-1). These reporting units were formalized as a GIS map layer as a product of this design work. A total of 18 geographic reporting units were defined as follows:

- Eight West Coast Geographic Reporting Units,
- Seven East Coast Geographic Reporting Units,
- A Lake Tarpon Reporting Unit,
- A Lake Seminole Reporting Unit, and
- A Riviera Bay Reporting Unit.

The DEM requested that the parameters to be measured by this program be focused to the set of parameters that will directly address the important questions to be answered by this monitoring program (Section 1.0).

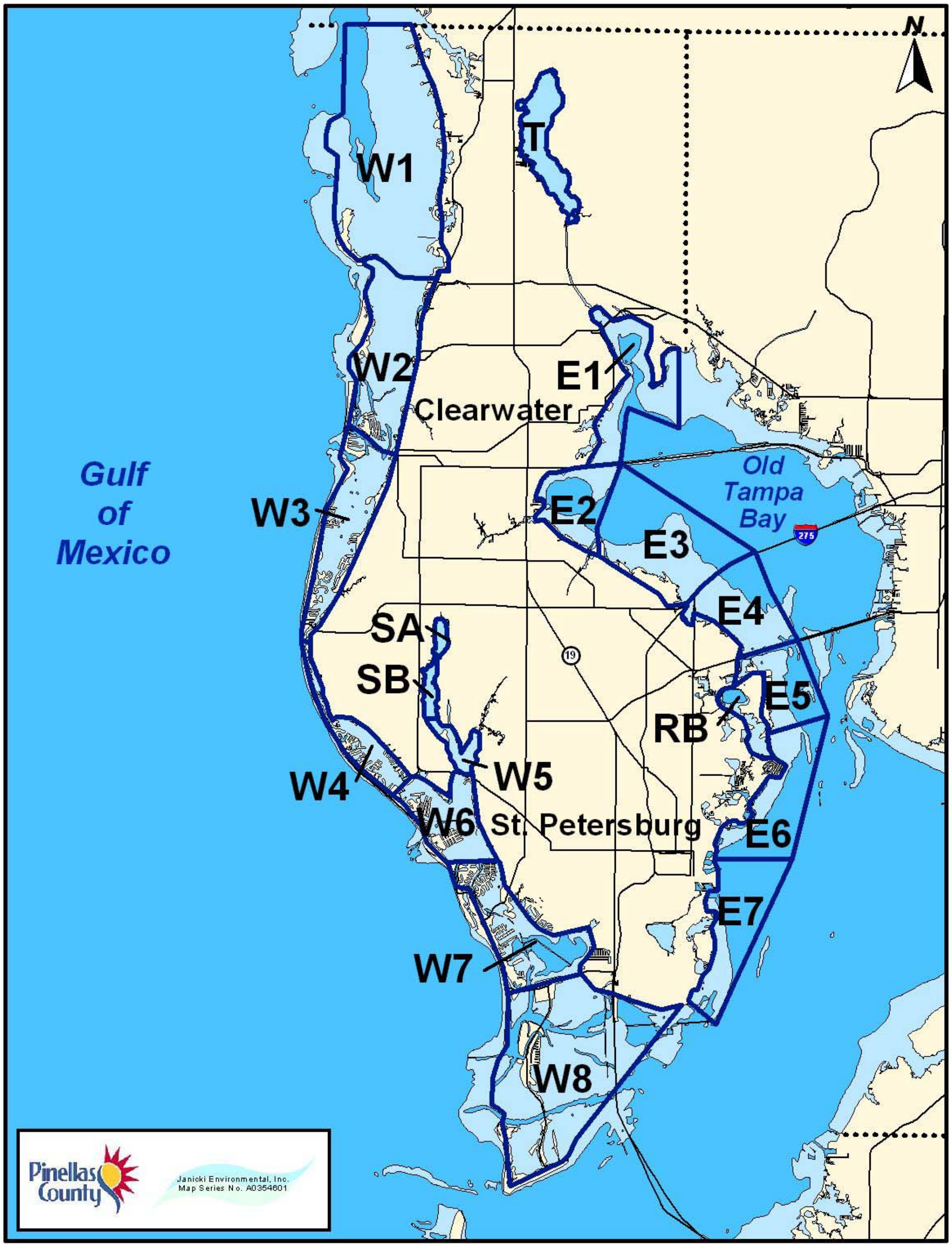

Figure 3-1 Geographic reporting units for the monitoring program.

Specific Design Constraints

The DEM identified several specific design constraints based on budgetary, logistical, and staff safety considerations.

- The sampling effort was constrained to 36 stations to be sampled per each of the 18 geographic reporting units per year.
- Water quality samples were restricted to near surface waters (with the exception of Hydrolab ® profiles).
- Sampling was restricted to Monday through Thursday during normal daylight working hours.
- Sampling was precluded on a specific set of DEM holidays, and these holidays will be defined by the DEM in future years.
- Sampling should be conducted by two field crews on the same day with each of the two field crews visiting a separate set of geographic reporting units.
- Geographic reporting units will be visited in the following groups due to anticipated travel time constraints. Each row of the tables represents a group to be visited on a sampling day by one of the two field crews.

  <u>West Reporting Units</u>
  W1
  W2 and W3
  W4 and W6
  W5
  W7 and W8
  Lake Seminole

  <u>East Reporting Units</u>
  E1 and E2
  E3 and E4
  E5 and Riviera Bay
  E6 and E7
  Lake Tarpon

4.0 Program Design Approach

The DEM consultant developed the overall approach to the monitoring program in order to:

- collect the information needed to answer the questions posed in Section 1.0,
- move towards completion of the goals identified in Section 2.0,
- meet the specific objectives identified in Section 2.0, and
- adhere to the DEM guidelines and constraints presented in Section 3.0.

The approach of the monitoring program is a probabilistic design that employs a parallel EPA EMAP-based element and a stratified-random sampling design element. The EMAP-based design element is used by overlaying grids of geographic strata on each of the geographic reporting units. A random sample location is selected within each grid cell. Thus, estimates and confidence limits of the total surface area of various water quality conditions within each geographic reporting unit can be estimated. The stratified-random design element is used by collecting two random samples in each grid cell in each year, and hence, stratified random sampling statistical methods can also be applied to estimate population means and confidence limits. The use of these parallel elements benefits the overall sampling design because the sampling probabilities of each sample collected can be calculated.

The following sections discuss how each of the County's monitoring program objectives will be met. The listed objectives are not ordered by priority at this time.

Objective 1: Fulfill the County's NPDES permit obligations.

The Pinellas County NPDES Permit is provided in Appendix G. Relevant excerpts with respect to ambient surface water monitoring are presented in italics.

The coastal ambient surface water quality monitoring program will meet the requirements of Section V.B.1 as follows:

V.B.1 Monitoring Program

b.) The monitoring program developed shall assist in determining the impact of storm water discharges on receiving waters located in the geographical area covered by this permit.

c.) The monitoring program developed shall assist in determining the effectiveness of the storm water management programs being *implemented under this permit and shall assist in identifying and prioritizing portions of the MS4 requiring additional controls.*

d.) *The monitoring program developed shall be designed to help identify local sources and impacts of specific pollutants considered a problem in the geographic area covered by this permit. Once the source and the impacts are identified, these pollutants may be more effectively reduced or eliminated.*

The coastal ambient surface water quality monitoring program will assist the Florida Department of Environmental Protection in meeting their monitoring goals as defined in Section VIII.X with two exceptions. The DEM ambient program will not meet objectives VIII.X.3 or VIII.X.4. It is anticipated that these two objectives are being addressed under the DEM fixed-station creeks, streams, and small lakes monitoring program.

PART VIII. DEFINITIONS

VIII.X. *"Surface Water Ambient Monitoring Program" refers to a comprehensive program implemented by the Florida Department of Environmental Protection, Bureau of Surface Water Management, which is designed to accomplish the following goals:*

1. *Identify and document the existing condition of the surface waters of the State,*

2. *Document potential problem areas,*

3. *Establish stream ecoregion reference sites for comparison purposes,*

4. *Collect biological data at ecoregion reference sites to establish preliminary biological integrity measurements techniques, and*

5. *Establish a Statewide ambient monitoring network which will eliminate duplication, share data, increase efficiency, and improve assessment and management capabilities.*

Objective 2: Provide status and trends information to the citizens of the County, the Board of County Commissioners, the Pinellas County DEM staff, and cooperating agencies (e.g., Tampa Bay Estuary Program, Florida Department of Environmental Protection).

This monitoring design will provide ambient status information for the Pinellas County coastal surface waters annually. After five years of data collection, the monitoring program will provide trend information on a cumulative and five-year recent trend basis. For example, the first trend information will be available for the 2003 to 2007 period. After six years of sampling, cumulative trend information will be available for the 2003 to 2008 period, and recent trend information will be available for the 2004 to 2008 period.

Objective 3: Develop a mechanism of information delivery to provide data to any member of the public who requests it.

The monitoring design will provide information delivery capabilities by supporting annual published reports, and a technical website.

Objective 4: Fulfill state water policy and Comprehensive Plan requirements as stated in Objectives 1.4, 1.5, and 1.7 of the Surface Water Management Element.

The monitoring design will address these requirements.

Objective 5: Provide a method of identifying potential water quality problems before they occur. In particular, provide a method of identifying water bodies that are approaching a condition of not meeting their designated uses.

The monitoring design will meet this requirement by providing the data needed to determine the FDEP Impaired Waters Rule status on an annual and five-year basis. By providing data from an entire water body region, the program will avoid the geographic data gaps derived from fixed station approaches, and will provide data for statistical trend analysis. The DEM will be able to make inferences regarding whether the surface area of a potential water quality problem is increasing and/or whether magnitude location measures (means, medians) of a potential water quality problem are increasing. Importantly, the DEM will be able to make inferences for a reporting unit as a whole before a potential water quality problem leads to impairment.

Objective 6: Measure the impacts of management efforts (e.g., the effectiveness of stormwater management plans).

The monitoring design will meet this objective by providing the statistical basis and data needed to test for statistically significant differences before and after stormwater management plans are implemented. The monitoring plan will provide the statistical basis for power analysis to determine the sensitivity of these tests to changes in the water quality conditions resulting from stormwater management plan actions.

Objective 7: Provide information needed to prioritize management actions.

The monitoring design will meet this objective by providing comparable information in 18 strata covering the full geographic extent of the County's nearshore waters. Management actions will be directed to contributory drainage basins of any one or more strata showing degraded water quality conditions.

Objective 8: Fill important data gaps and maximize the sampling effort with respect to sampling all habitat types (e.g., sample shallow coastal waters).

The monitoring design will meet this objective by filling important data gaps with respect to previously un-sampled shallow coastal waters. Remaining data gaps will be the deeper waters of Tampa Bay (currently sampled by Hillsborough County with a non-probabilistic fixed-station design with respect to dates sampled and sample locations), and the nearshore Gulf of Mexico waters west of the County's barrier islands.

Objective 9: Provide the information needed to develop quantitative water quality targets for living resources.

The monitoring design will provide the information needed to develop quantitative water quality targets for living resources. In particular, the program will provide total nitrogen, chlorophyll a, color (lakes only), water clarity, and dissolved oxygen information.

Objective 10: Provide a means of estimating the annual aerial extent of each water quality parameter for the County, East County Shallow, West County Shallow, West County Shallow and Deep, and each geographic stratum.

The EMAP-based component of the monitoring program and specified level of sampling effort will meet this objective.

Objective 11: Estimate the magnitude and direction of the change in the aerial extent measures (listed in Objective 10) every five years.

The EMAP-based component of the monitoring program and specified level of sampling effort will meet this objective.

5.0 Program Design

This section presents important operational definitions for the monitoring design and the detailed implementation components.

5.1 Design Elements Overview

The DEM consultant defined the design elements based on meeting the program objectives, and adhering to the program guidelines and constraints (Sections 2.0 and 3.0).

5.1.1 Sampling Units and Population of Interest

The temporal and spatial sampling units and population of interest are defined in this subsection. In addition, sample exclusionary criteria and the target populations are defined. Temporal and spatial reporting units are defined later in this document in Section 6.0.

Temporal Sampling Unit and Population of Interest

The temporal sampling unit for the water quality monitoring program will be a daytime period of approximately four hours in duration. There are two temporal sampling units in each day, and these two sampling units will represent morning and afternoon.

The temporal population of interest was defined as a one-year set of all possible temporal sampling units.

Within each temporal sampling unit, the year will not be broken down into finer time periods for practical and logistical reasons. This allows samples to be collected by planning a safe and efficient starting location and boat route between stations. This will introduce relatively small temporal sampling biases within each four-hour period. However, It should be noted that by sampling days (mornings and afternoons) in a probabilistic unbiased manner, the major temporal biases typically expected due to varying weather conditions are minimized, and importantly, they are also documented.

Temporal sampling exclusionary criteria were pre-defined as follows:

- Temporal sampling units are excluded for Fridays, Saturdays, Sundays, and

- Pinellas County DEM Holidays determined and documented each sampling year.

One notable consideration of this sampling design is that weekend and holiday periods of expected higher recreational boating traffic, and potentially different point and non-point source pollutant loadings will not be sampled.

In addition to the pre-defined exclusionary criteria, the DEM expects to encounter the need for additional logistical temporal exclusionary criteria during implementation of the sampling program. It is expected that, at times, the randomly selected dates will conflict with other scheduled activities, or they will coincide with weather conditions that will preclude safe sampling trips. Temporal sampling units that cannot be sampled due to logistical exclusionary criteria will be documented in the monitoring program records, so that over time a more precise description of the targeted temporal population may be determined. These units that cannot be sampled will include both days that cannot be sampled and four-hour sampling periods within days that cannot be sampled.

For example, by comparing a list of the days that could not be sampled over a year due to inclement weather conditions to weather data records for the year, the DEM will be able to estimate the proportion of the year that can be sampled (i.e., the targeted temporal population of interest) and the wind speed, wave conditions, and rainfall conditions for both the targeted and non-targeted populations of interest.

This will provide valuable information for management decisions regarding how representative the estimated water quality measurements are of the year as a whole. The DEM will also be able to characterize the non-sampleable periods (e.g., when do they occur, how long do they last, how frequent are they, do they coincide with seagrass growing seasons, could they possibly explain seagrass losses by limiting light for a sufficient period of time etc.). The DEM could employ special studies to determine the existence of any potentially ecologically significant data gaps (e.g., continuous recorders or ISCO® style samplers could be placed to record dissolved oxygen or to take water samples in advance of a storm system).

Spatial Sampling Unit and Populations of Interest

The spatial sampling unit was defined as a geographic location within each of the geographic reporting units previously described in Section 3.0 of this document. Each sampling unit was defined as a circle approximately 30-meters across to allow for a reasonable GPS error and boat drift while on station.

In general, the spatial populations of interest were defined as the set of all geographic locations within each geographic reporting unit. Specific details are:

- The populations of interest for the east coastal reporting units in Tampa Bay extend from the Pinellas County shoreline to the 2- meter mean lower low water isobath in Tampa Bay.

- The populations of interest for the west coastal reporting units extend from the Pinellas peninsula mainland shoreline to the eastern shore of the barrier islands (i.e., they do not include the waters on the Gulf side of the barrier islands).

- The populations of interest for each of the eastern and western coastal reporting units were defined such that each reporting unit was not located within more than one Tampa Bay Estuary Program bay segment reporting unit.

The DEM will develop spatial exclusionary criteria in the field during the first year of sampling (January 2003 – December 2003), and will continue to define these criteria as sampling progresses. Whenever a location cannot be sampled, the field crew will record the location and the reason for not sampling. The DEM will compile an expanded list of exclusionary criteria from the field notes. The DEM will map the spatial exclusionary criteria in a GIS layer where possible after the first year of sampling, and the maps will be applied to further refine the definitions of the spatial populations of interest. Expected spatial exclusionary criteria include:

- location too shallow to be visited by boat at a depth of x-meters,

- unsafe vessel traffic in the vicinity of the location (e.g., located in an active channel fairway, located in the vicinity of a dredge operation, located in the vicinity of a designated diver down area), and

- location could not be sampled due to a physical barrier to navigation (e.g., jetty, permanent obstruction, batter-boards).

5.1.2 Temporal List Frame

The DEM will construct a temporal list frame for a specific year by compiling a list of all of the temporal sampling units available for that year (i.e., all of the non-holiday, mornings and afternoons for all Mondays, Tuesdays, Wednesdays, and Thursdays of the year to be sampled).

A SAS program for building the temporal list frames is provided in Appendix E.

5.1.3 Temporal Sample Selection

The DEM will select random samples using a stratified random sampling approach with a non-random set of back-up sampling days added for logistical purposes.

The sampling strata will be defined for each calendar year by dividing the number of days in the year into nine evenly spaced temporal strata. Primary and secondary sampling dates will then be selected at random from each stratum.

The Lake Seminole population of interest will be stratified geographically into a northern and southern stratum for sampling purposes, and the temporal sample selection (e.g., north in the morning and south in the afternoon, etc.) for these two strata will be randomized.

A few non-random components were defined in the temporal sample selection method to satisfy the design constraints previously identified.

1) A number of days (15-days) were reserved at the end of each of the nine sampling strata to provide last chance sampling dates. These non-random dates will be sampled in the event that weather or scheduling conflicts exhaust the set of randomized sampling dates.

2) Following the monitoring program guidelines defined in Section 3.0, two sampling crews (an east crew and a west crew) will typically visit random geographic populations of interest on the same random sampling date. This scheduling method will save field preparation and lab processing time.

3) Following the monitoring program guidelines defined in Section 3.0, certain pairs of strata will be sampled on the same randomly determined day. The order of visitation (i.e., morning vs. afternoon) of each pair will also be randomized within the random sampling day. The pairs of strata were defined to save travel time:

Each line in the list of reporting units shown below represents reporting units, or a unit to be visited on a given sampling day by one field crew.

<u>West Reporting Units</u>
W1
W2 and W3
W4 and W6
W5
W7 and W8
Lake Seminole

<u>East Reporting Units</u>
E1 and E2
E3 and E4
E5 and Riviera Bay
E6 and E7
Lake Tarpon

A SAS program for selecting the stratified random temporal samples is provided in Appendix E.

5.1.4 Spatial List Frame

The DEM will construct a spatial list frame each year for the population of interest by generating random sampling locations from uniform random deviates for northing and easting coordinates, and overlaying these sets of random coordinates on the spatial populations of interest polygons using a Geographic Information System (GIS) software package.

5.1.5 Spatial Sample Selection

The DEM consultant defined a set of geographic sampling strata based on the USEPA EMAP hexagonal grid approach for each of the geographic populations of interest. Figures 5-1 through 5-18 present the geographic boundaries of the populations of interest or primary sampling strata ("sampling strata") and the secondary sampling strata ("sampling grid"). Specific notes for these strata are provided below:

Stratification of Lake Seminole Population of Interest

The Lake Seminole population of interest was stratified geographically into a northern and southern lobe consistent with the geographic narrowing of the lake. This stratification was imposed to ensure that an equal number of samples were collected in each north and south lobe of the lake. The entire lake, including both north and south lobes, comprises one Lake Seminole reporting unit.

Eastern Coastal Populations of Interest

The populations of interest for the eastern coast of Pinellas County were defined as water less than 2-meter. Thus the spatial sample selection strata were clipped in the GIS system by the 2-meter isobath.

Western Coastal Populations of Interest

The populations of interest for the western coast of Pinellas County were defined as inshore of the barrier islands. Thus the spatial sample selection strata were clipped in the GIS system by the barrier island shorelines.

SAS programs for selecting the stratified random sample locations are provided in Appendix F.

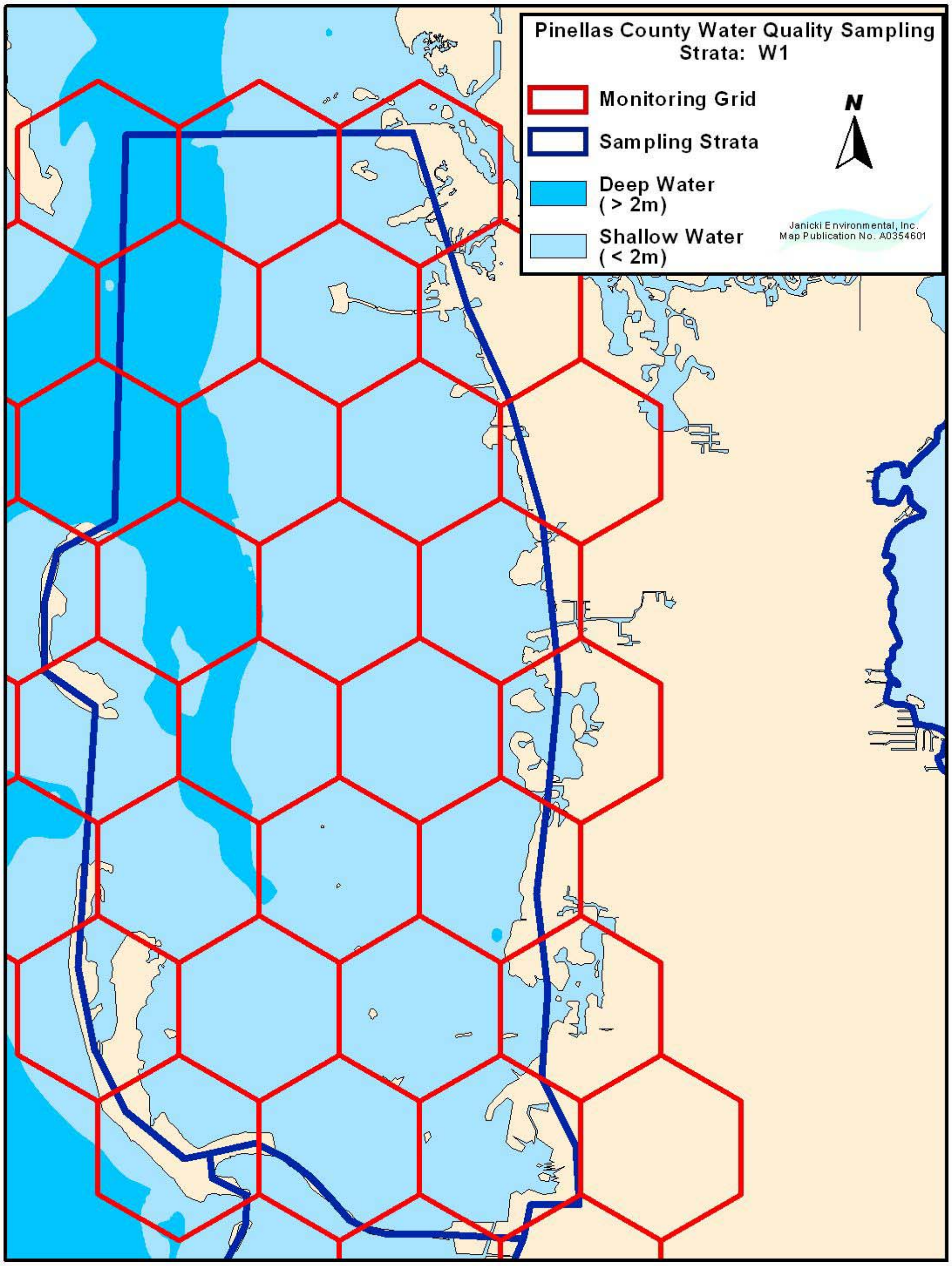

Figure 5-1 Sampling strata for geographic reporting unit W1.

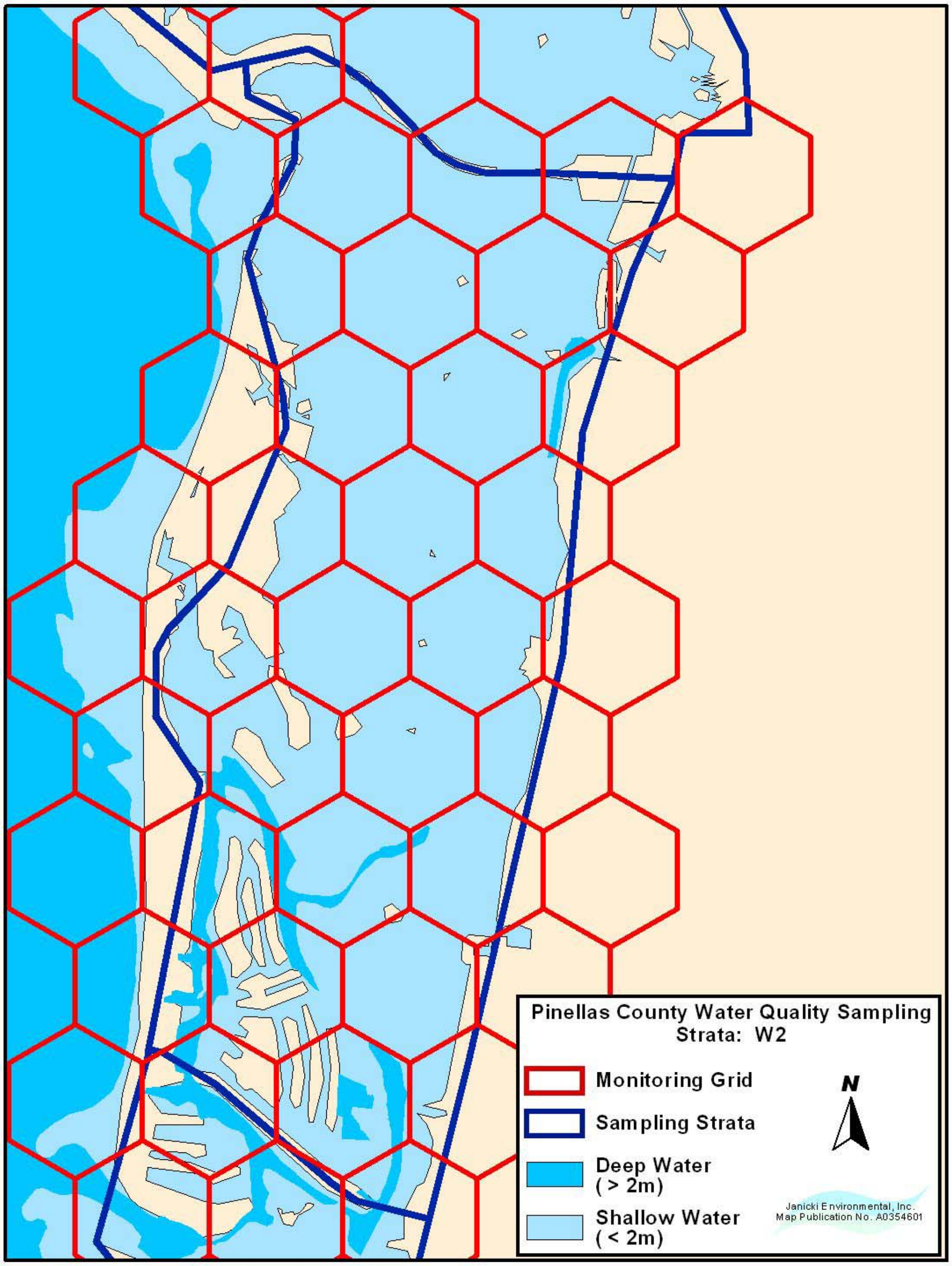

Figure 5-2 Sampling strata for geographic reporting unit W2.

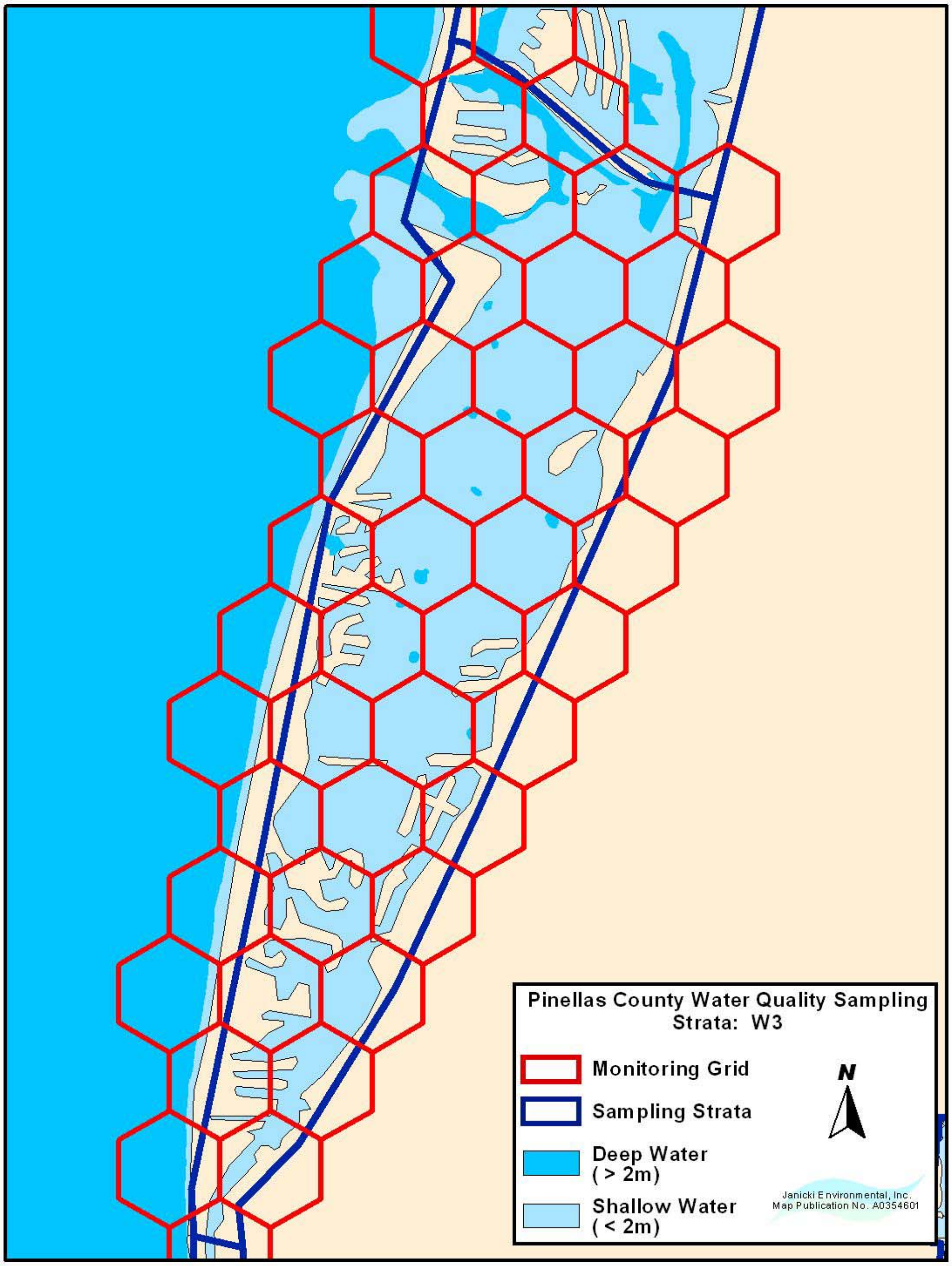

Figure 5-3 Sampling strata for geographic reporting unit W3.

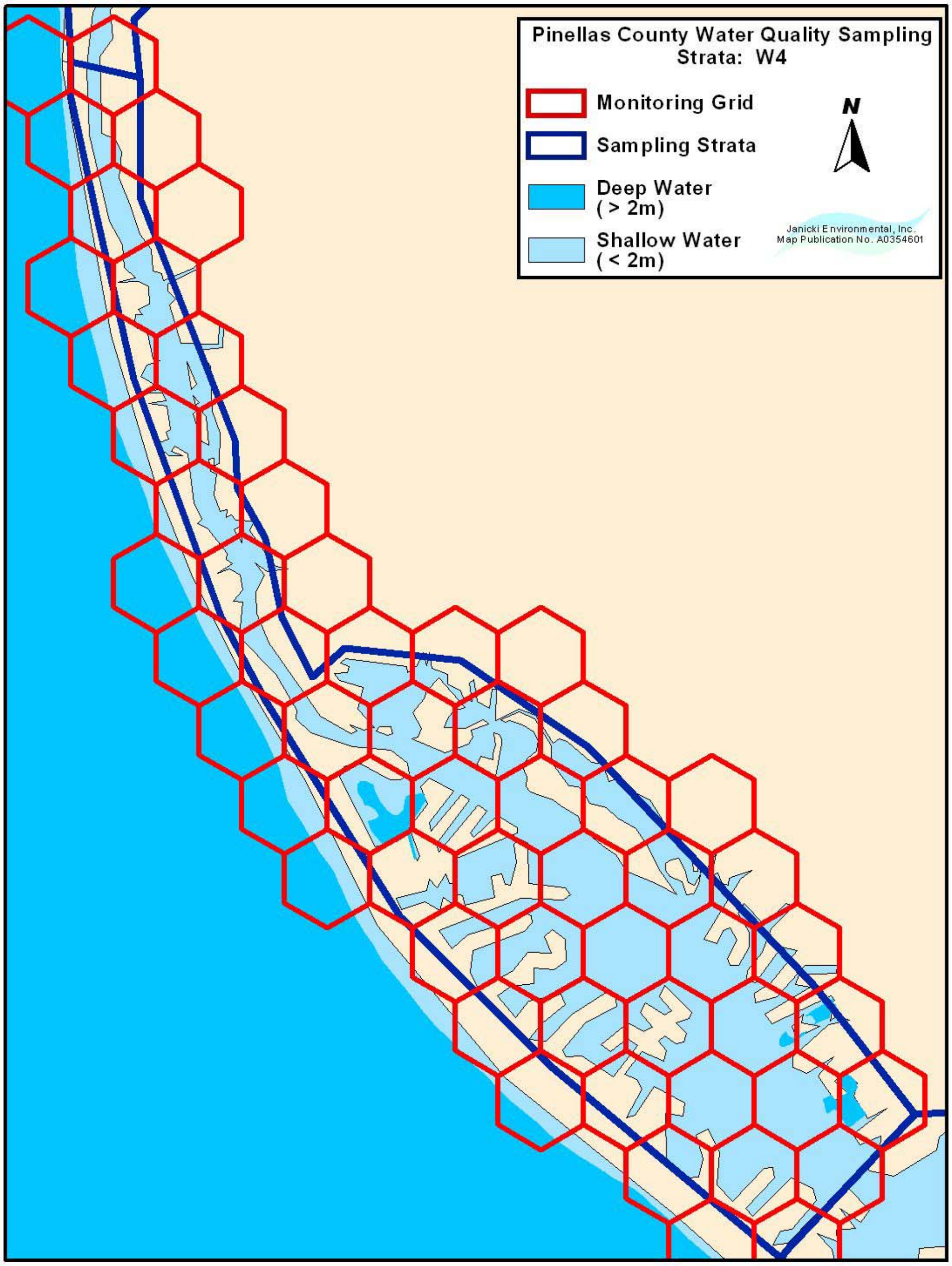

Figure 5-4 Sampling strata for geographic reporting unit W4.

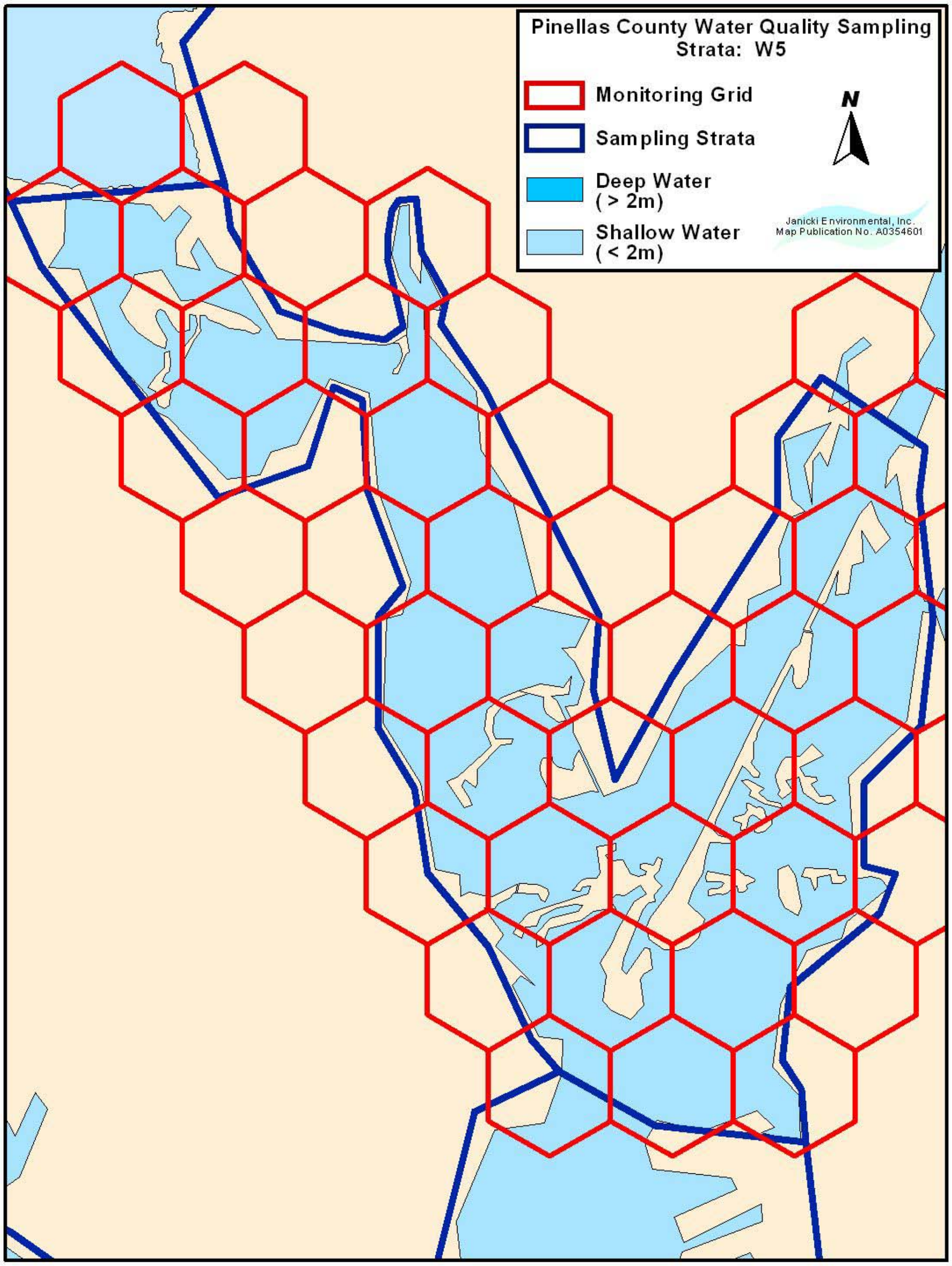

Figure 5-5 Sampling strata for geographic reporting unit W5.

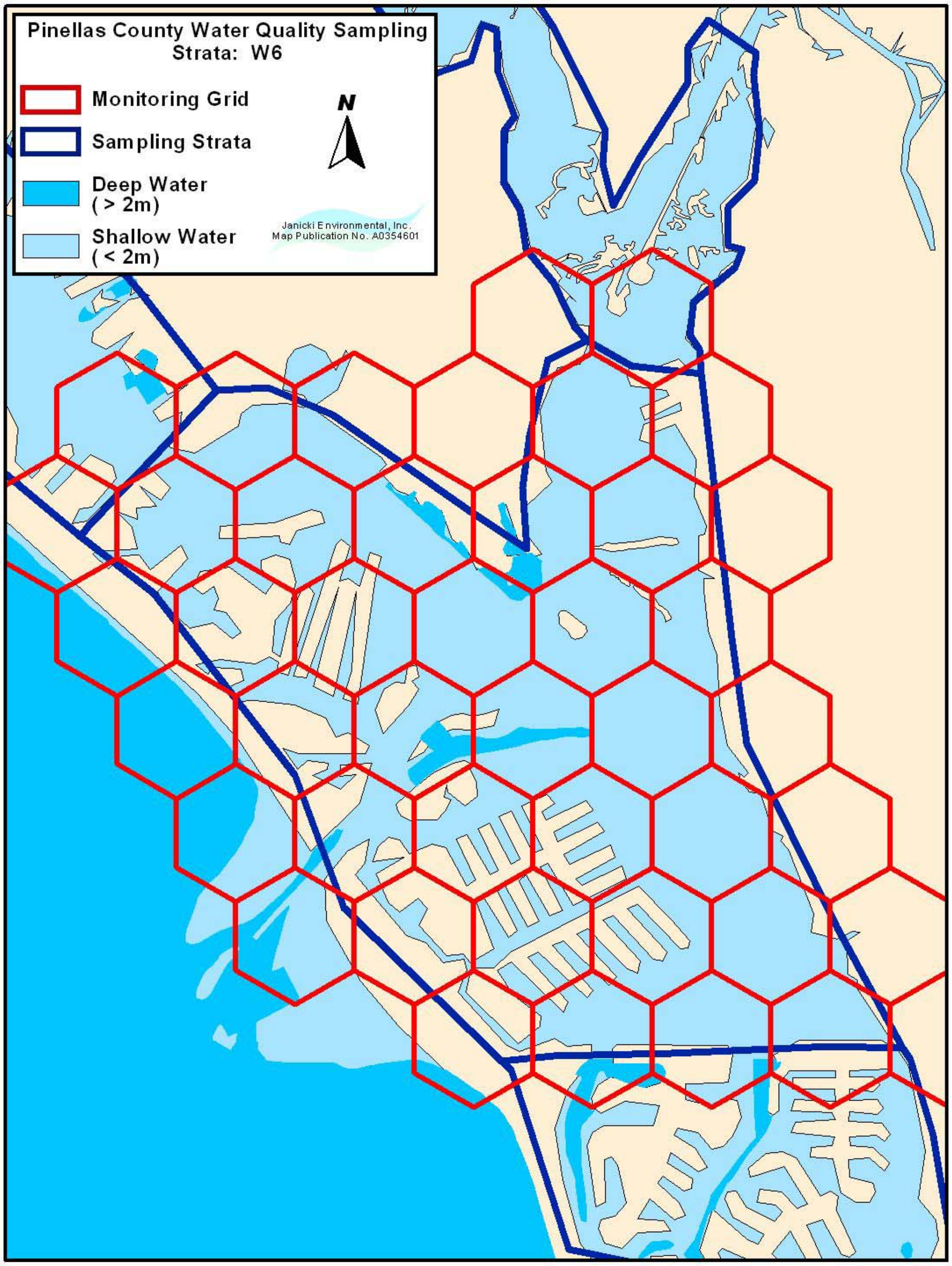

Figure 5-6 Sampling strata for geographic reporting unit W6.

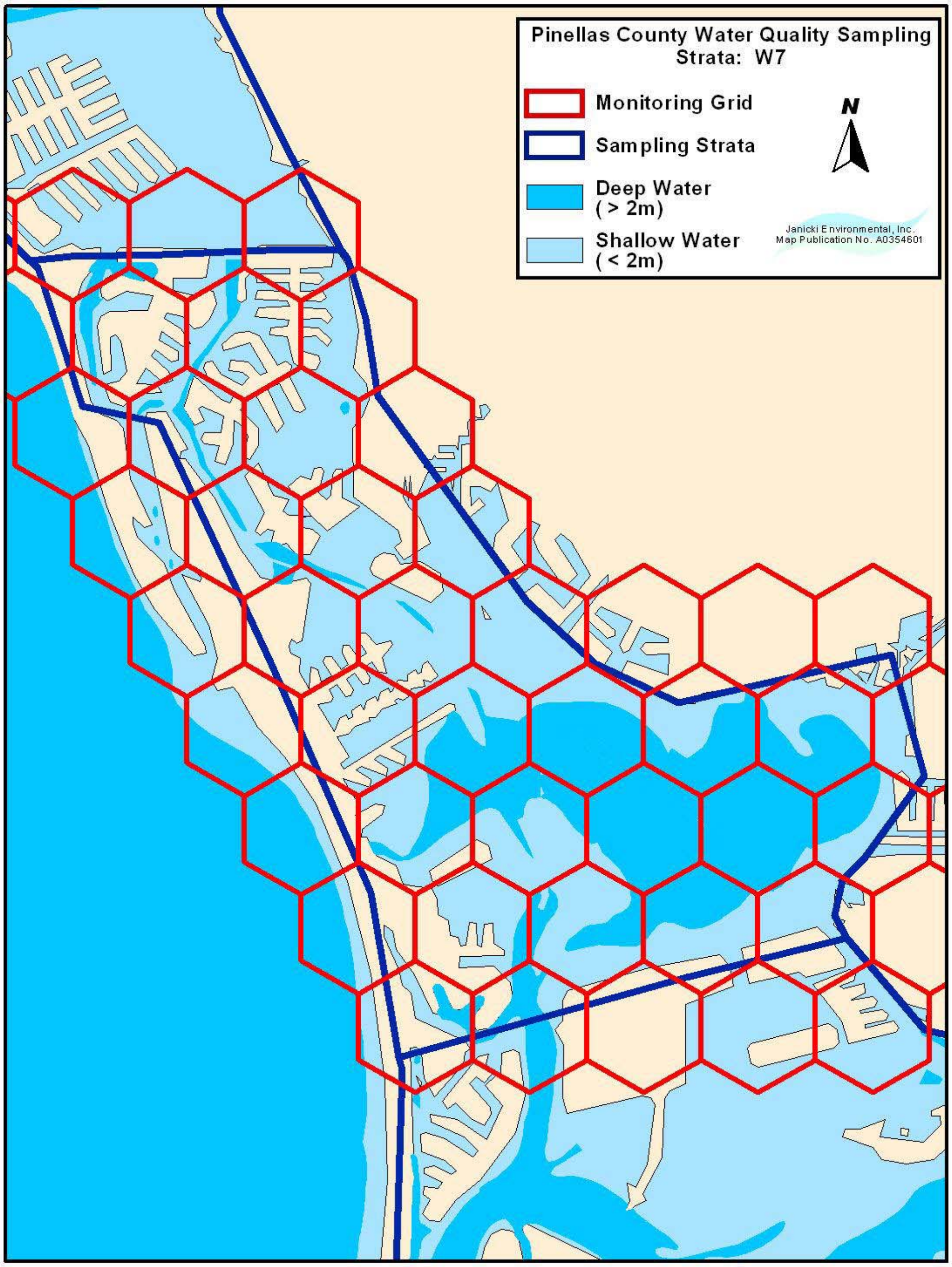

Figure 5-7 Sampling strata for geographic reporting unit W7.

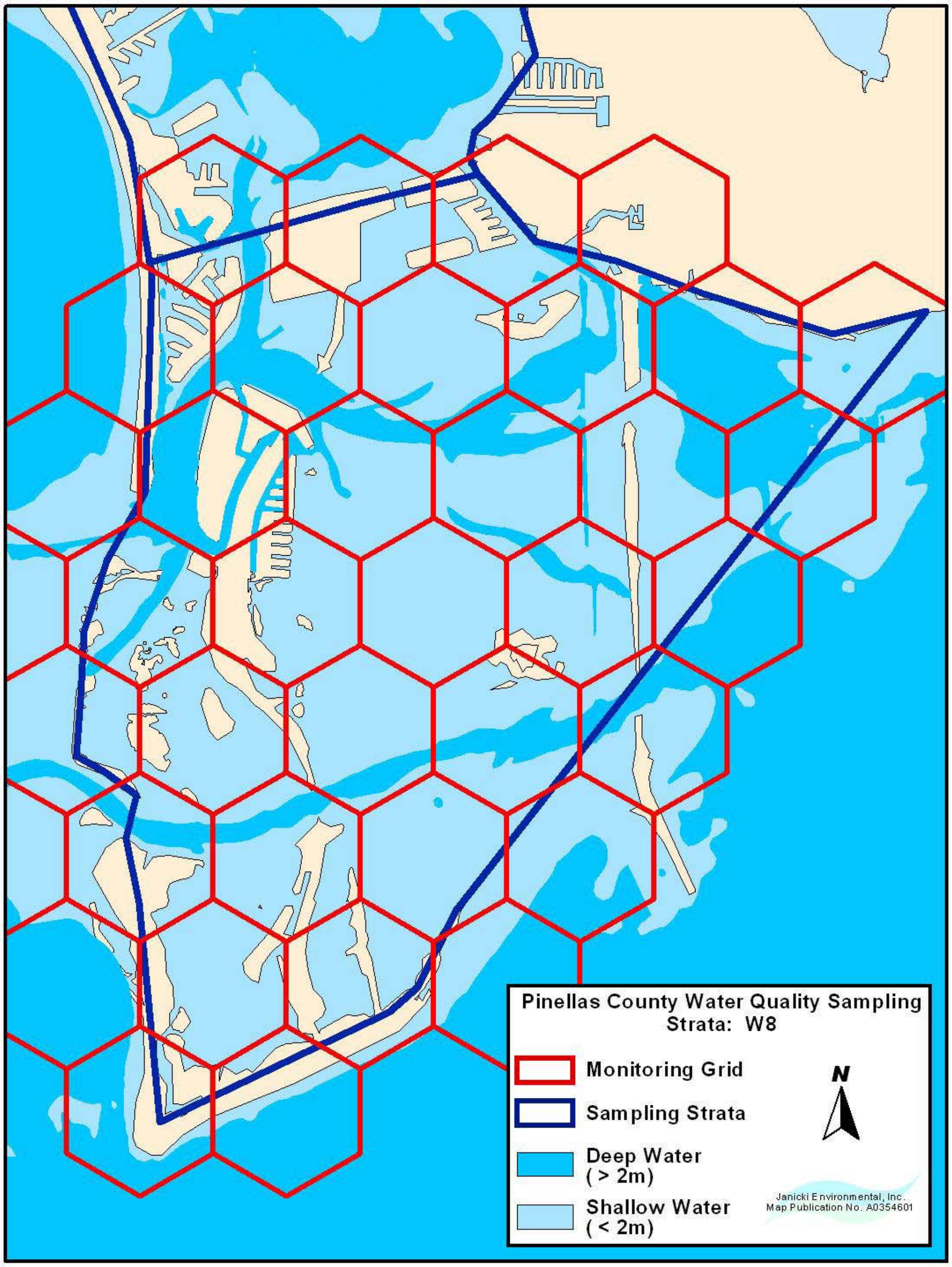

Figure 5-8 Sampling strata for geographic reporting unit W8.

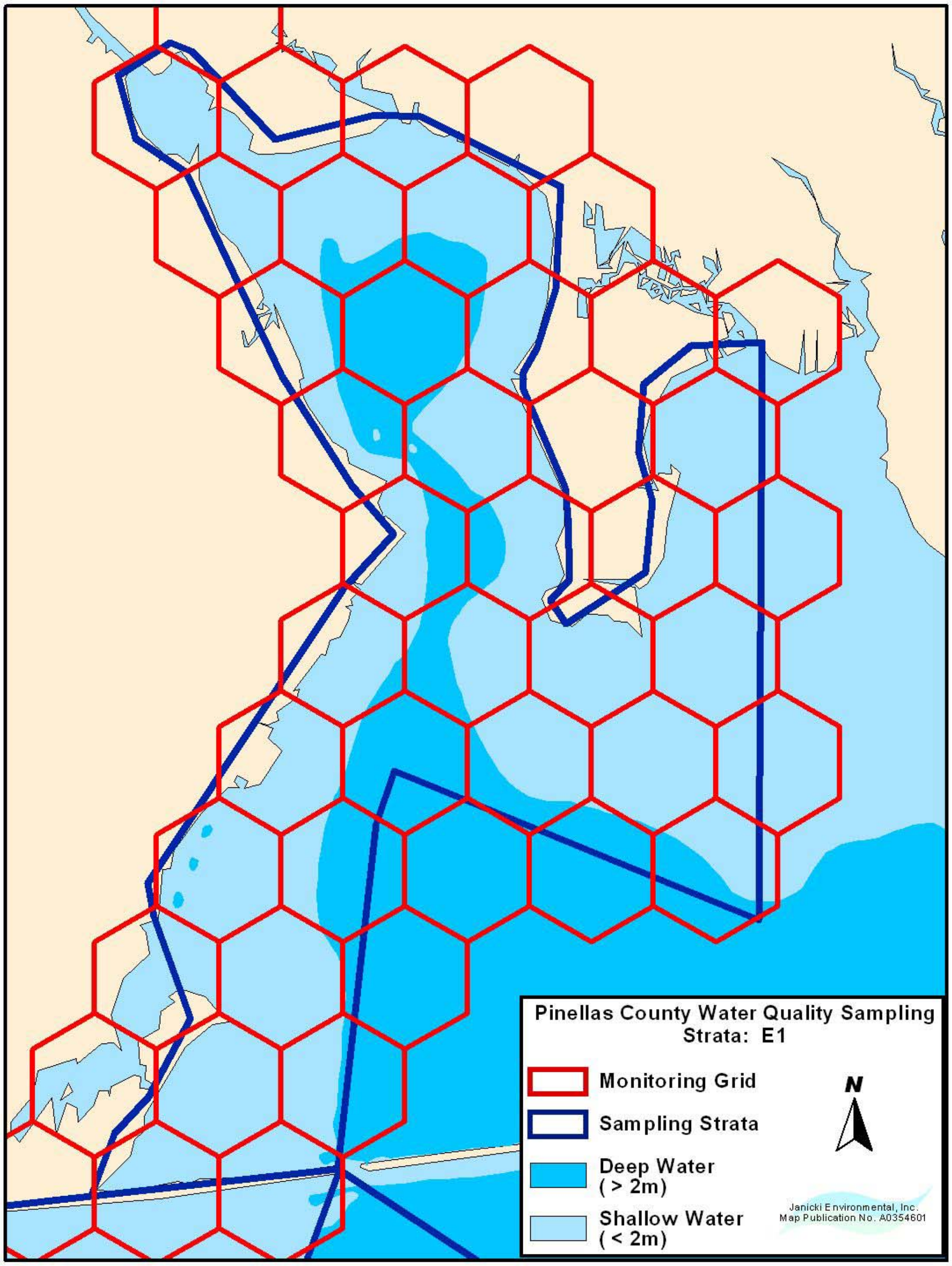

Figure 5-9 Sampling strata for geographic reporting unit E1.

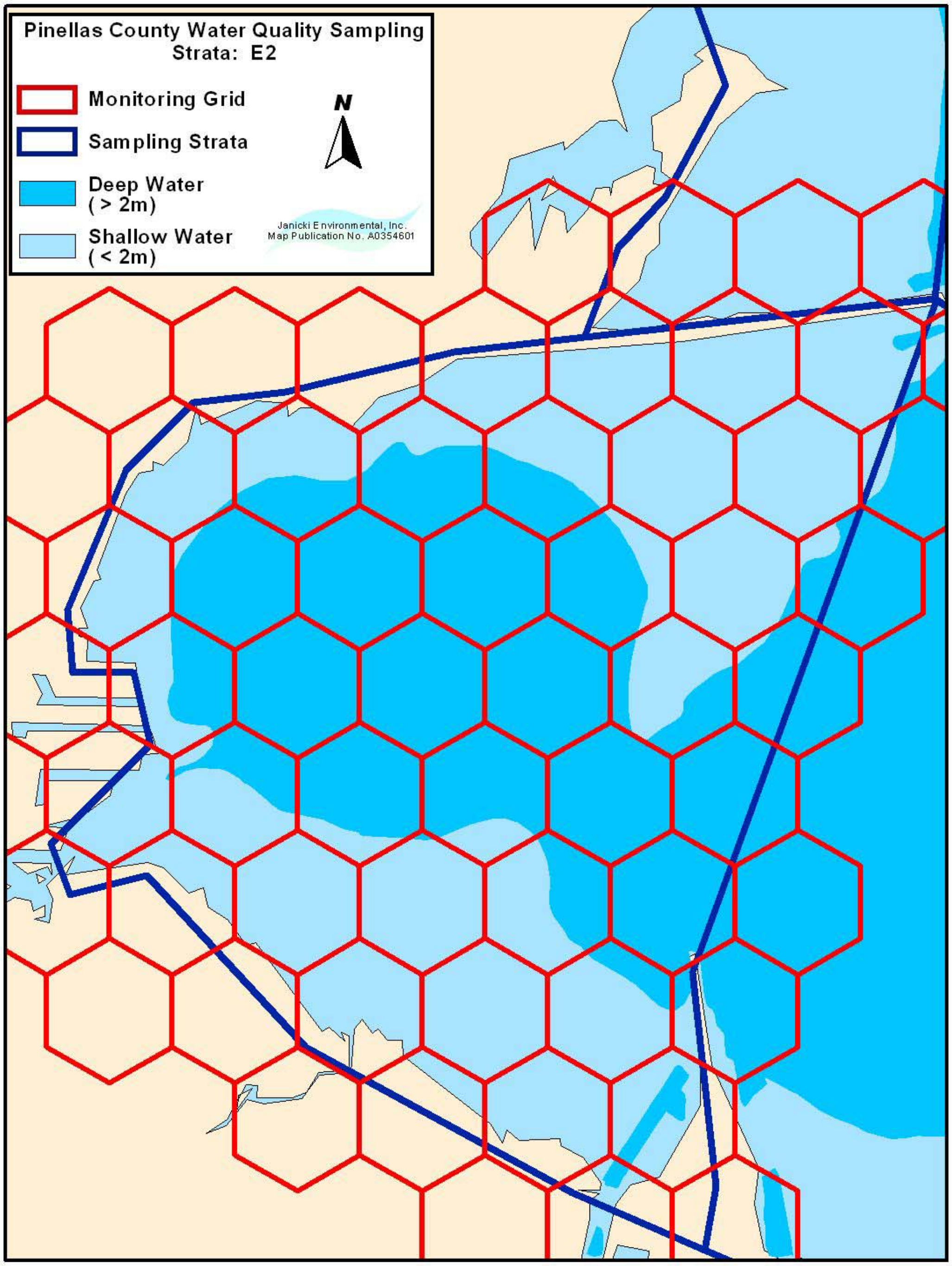

Figure 5-10 Sampling strata for geographic reporting unit E2.

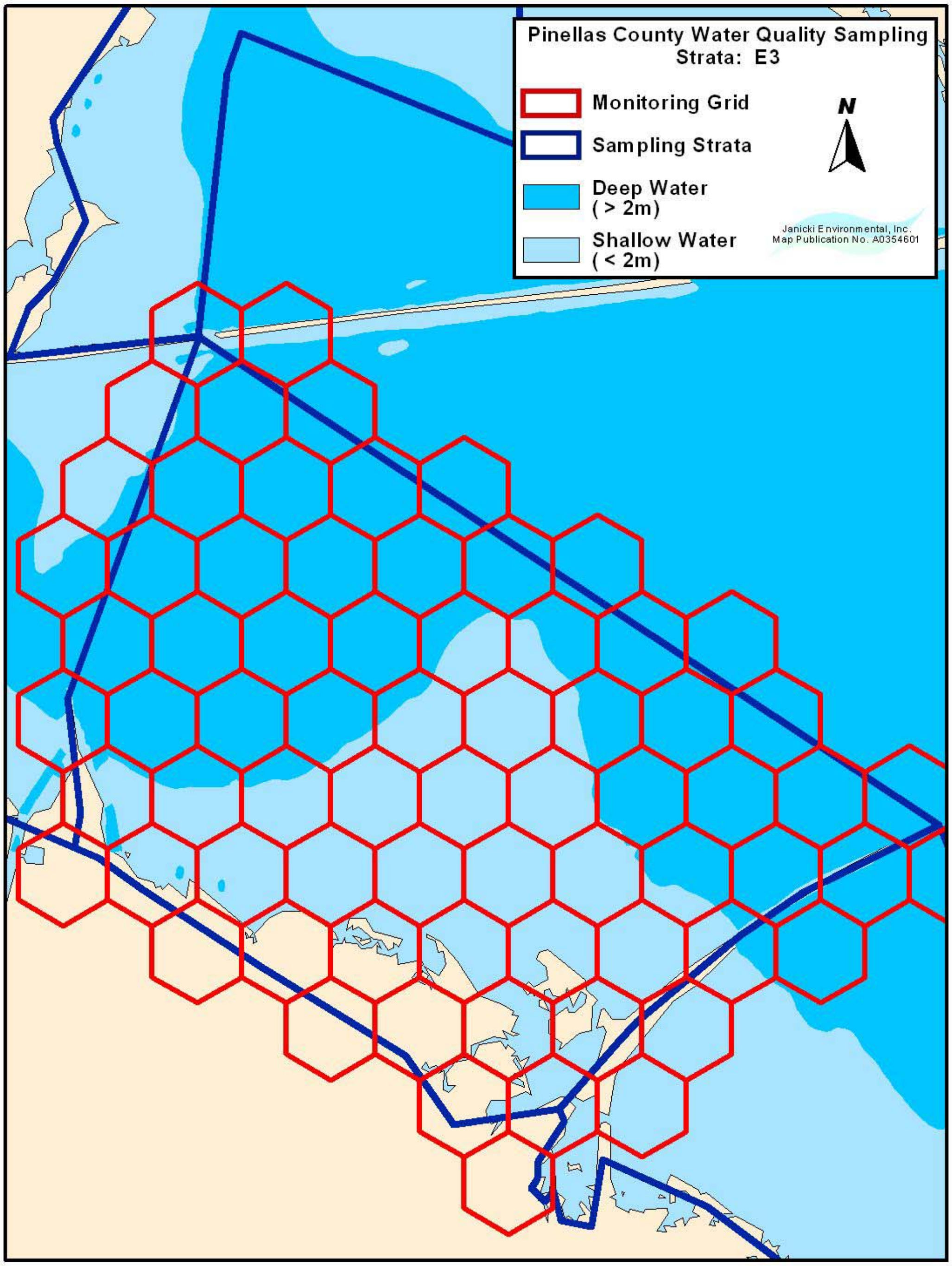

Figure 5-11 Sampling strata for geographic reporting unit E3.

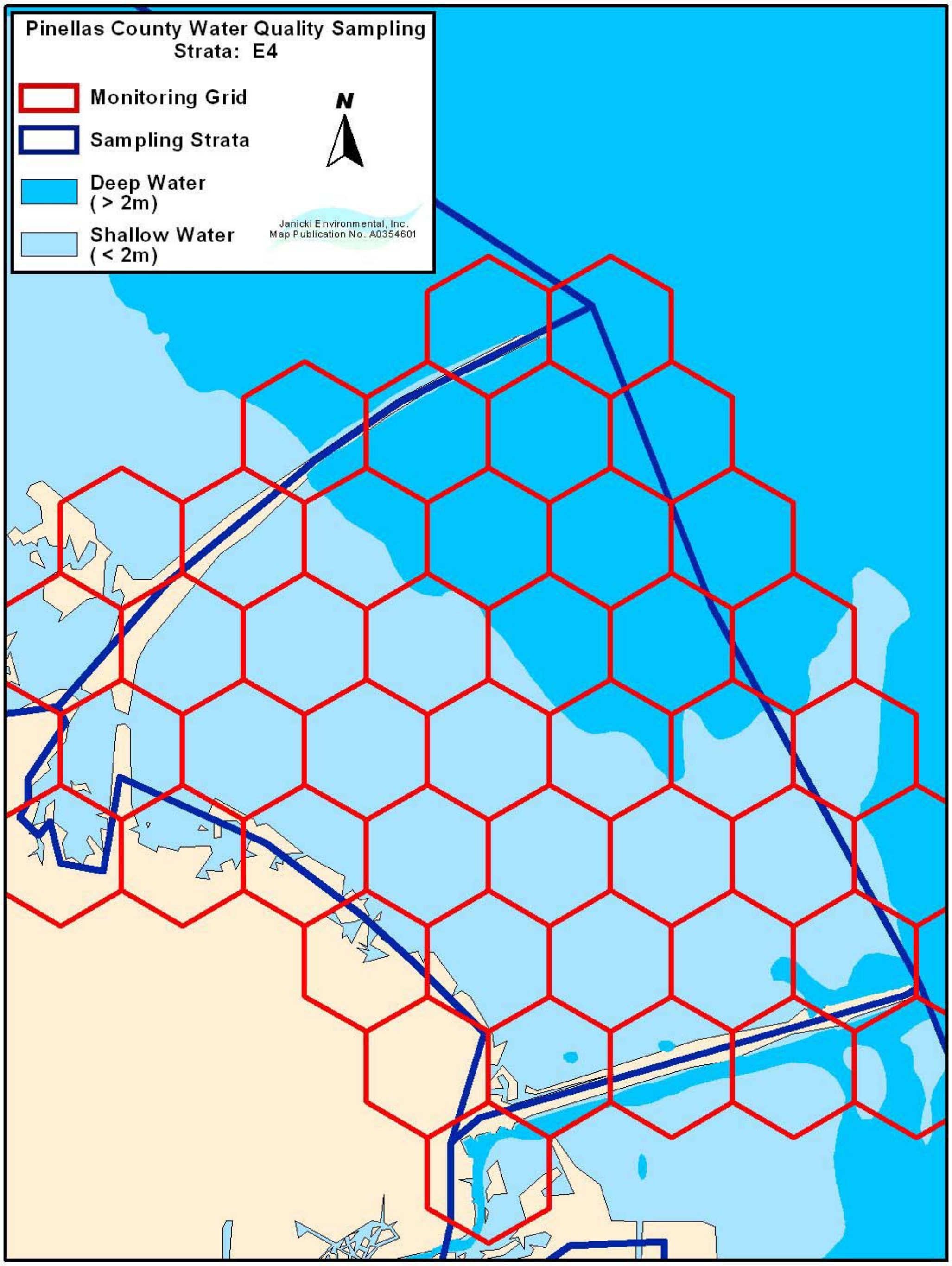

Figure 5-12 Sampling strata for geographic reporting unit E4.

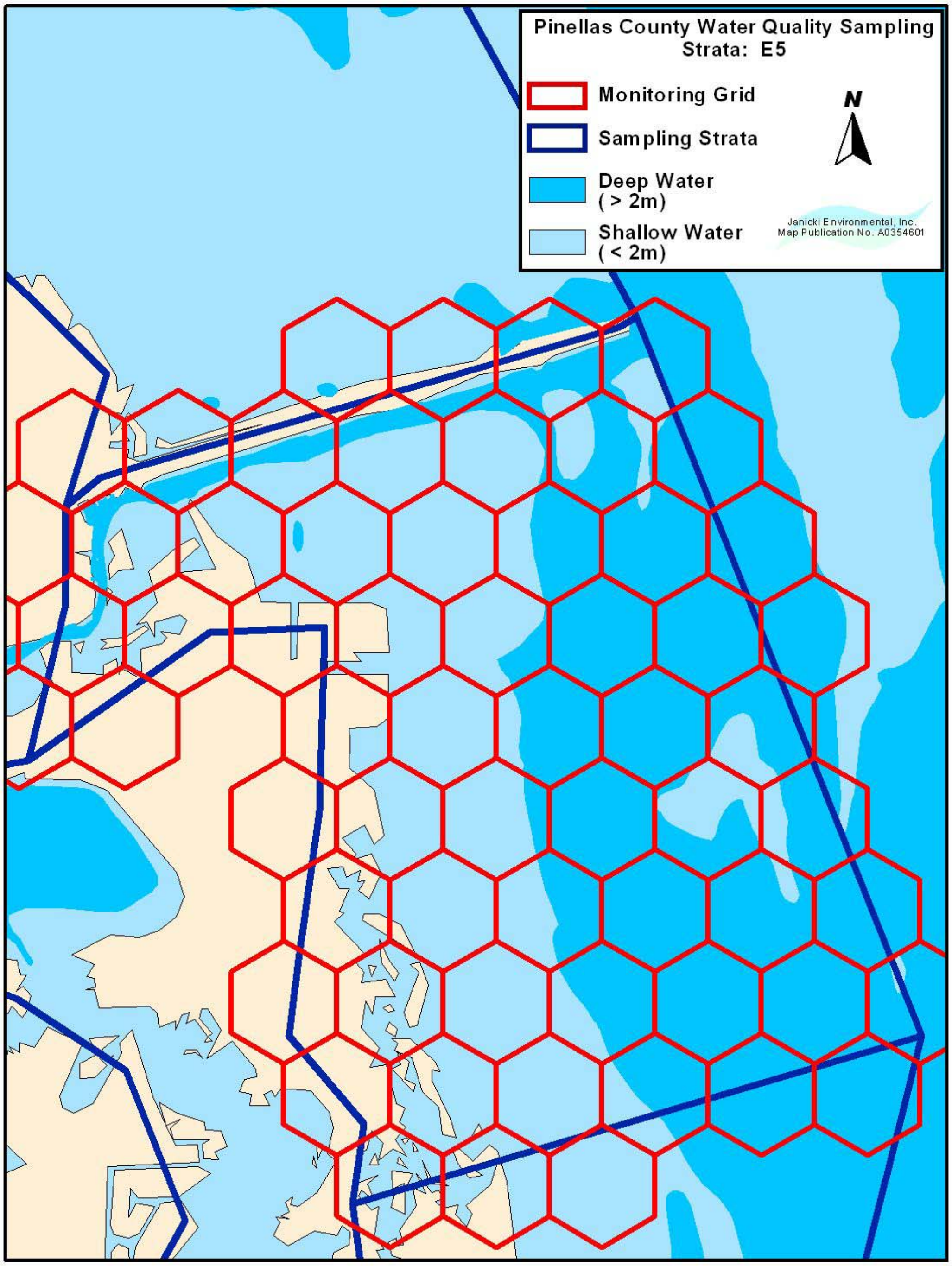

Figure 5-13 Sampling strata for geographic reporting unit E5.

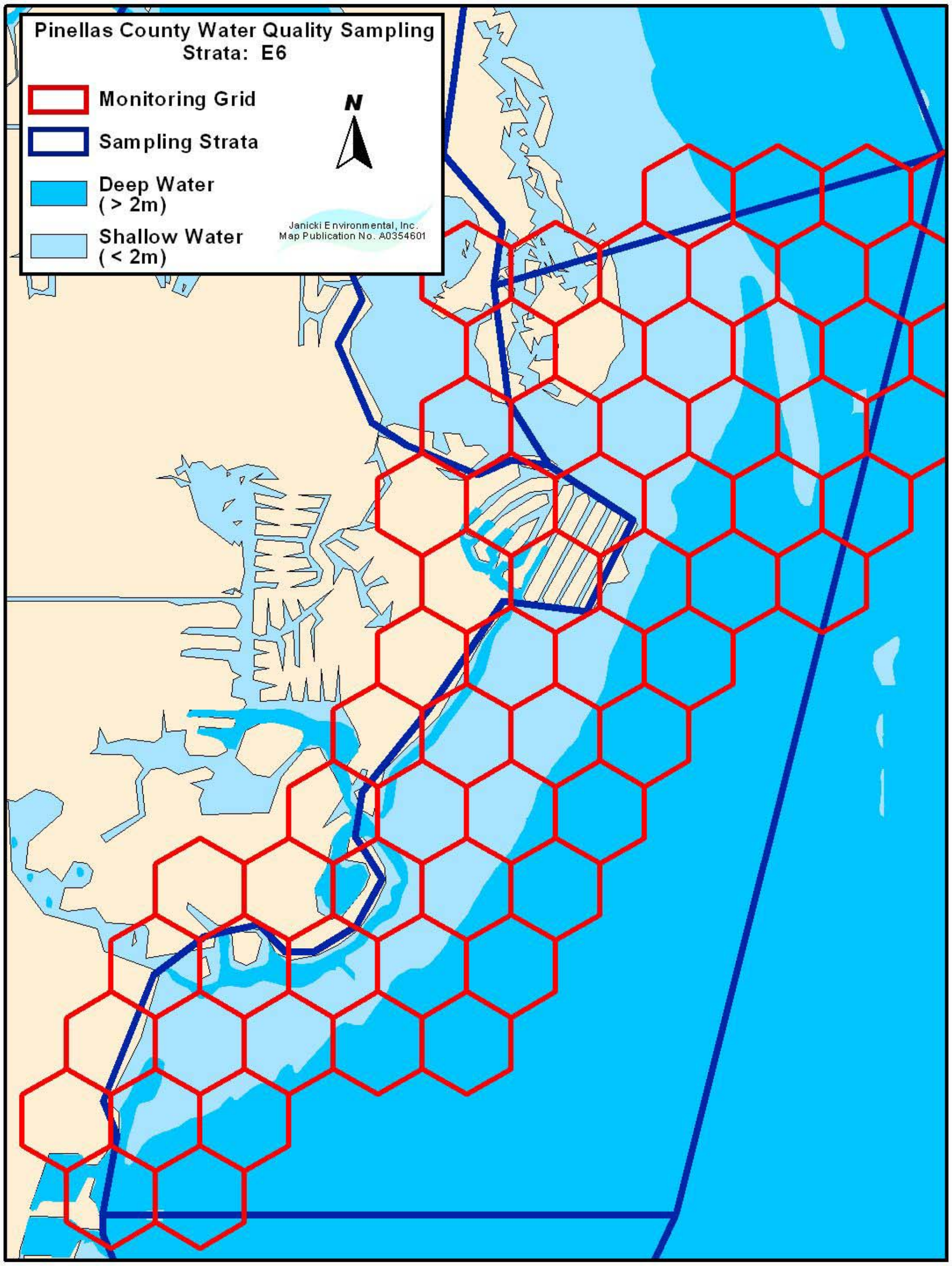

Figure 5-14 Sampling strata for geographic reporting unit E6.

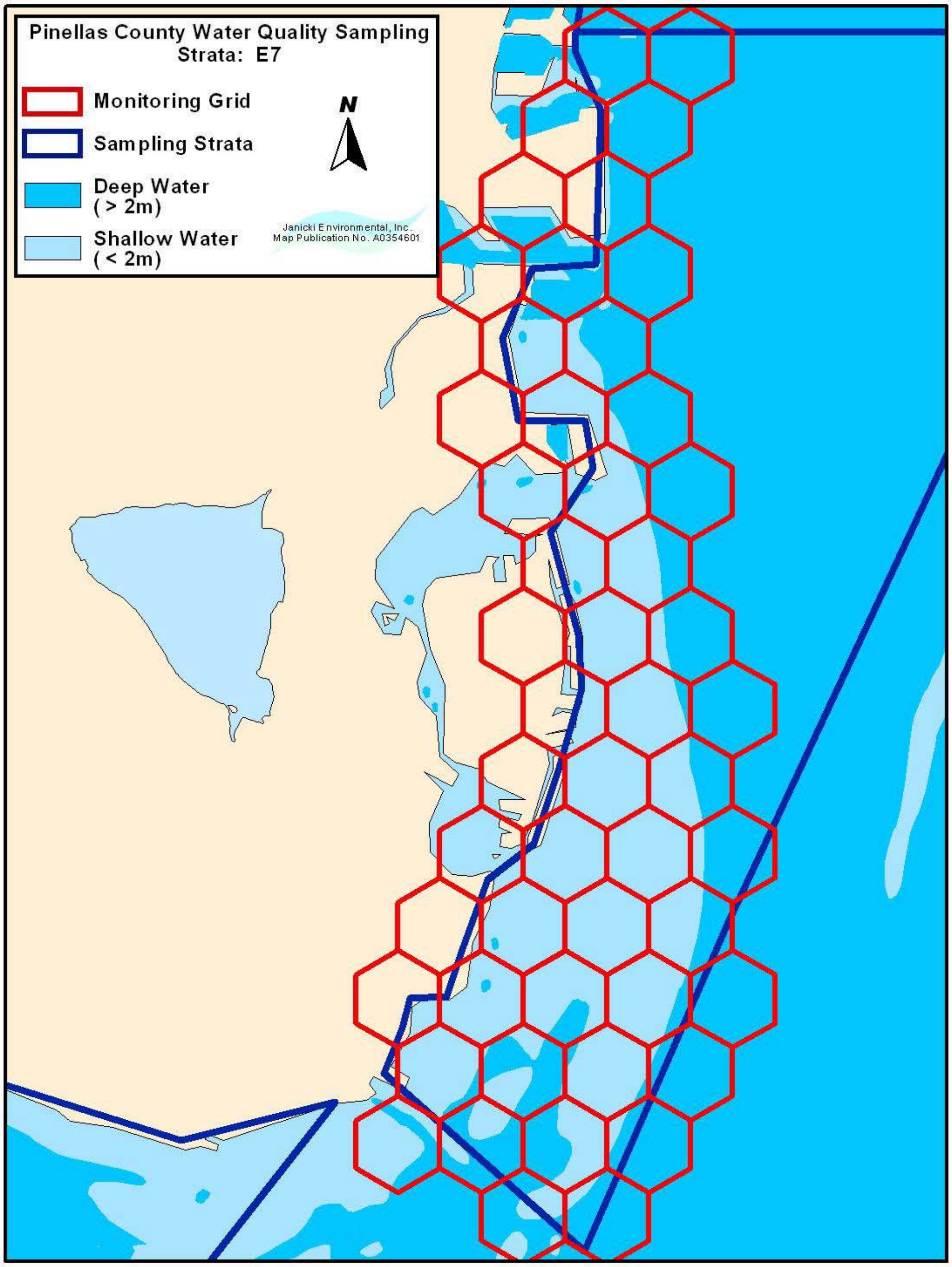

Figure 5-15 Sampling strata for geographic reporting unit E7.

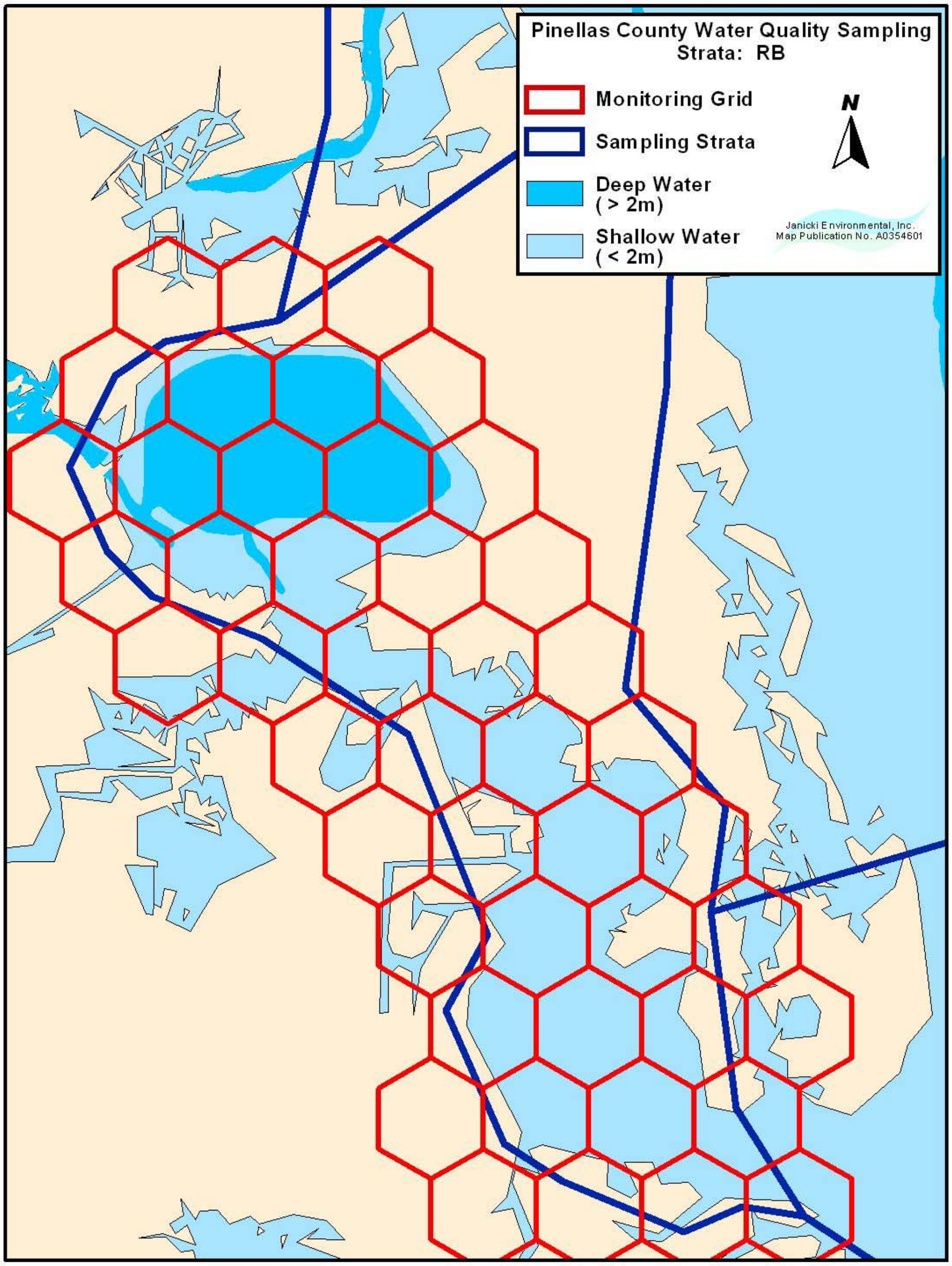

Figure 5-16 Sampling strata for geographic reporting unit RB, Riviera Bay.

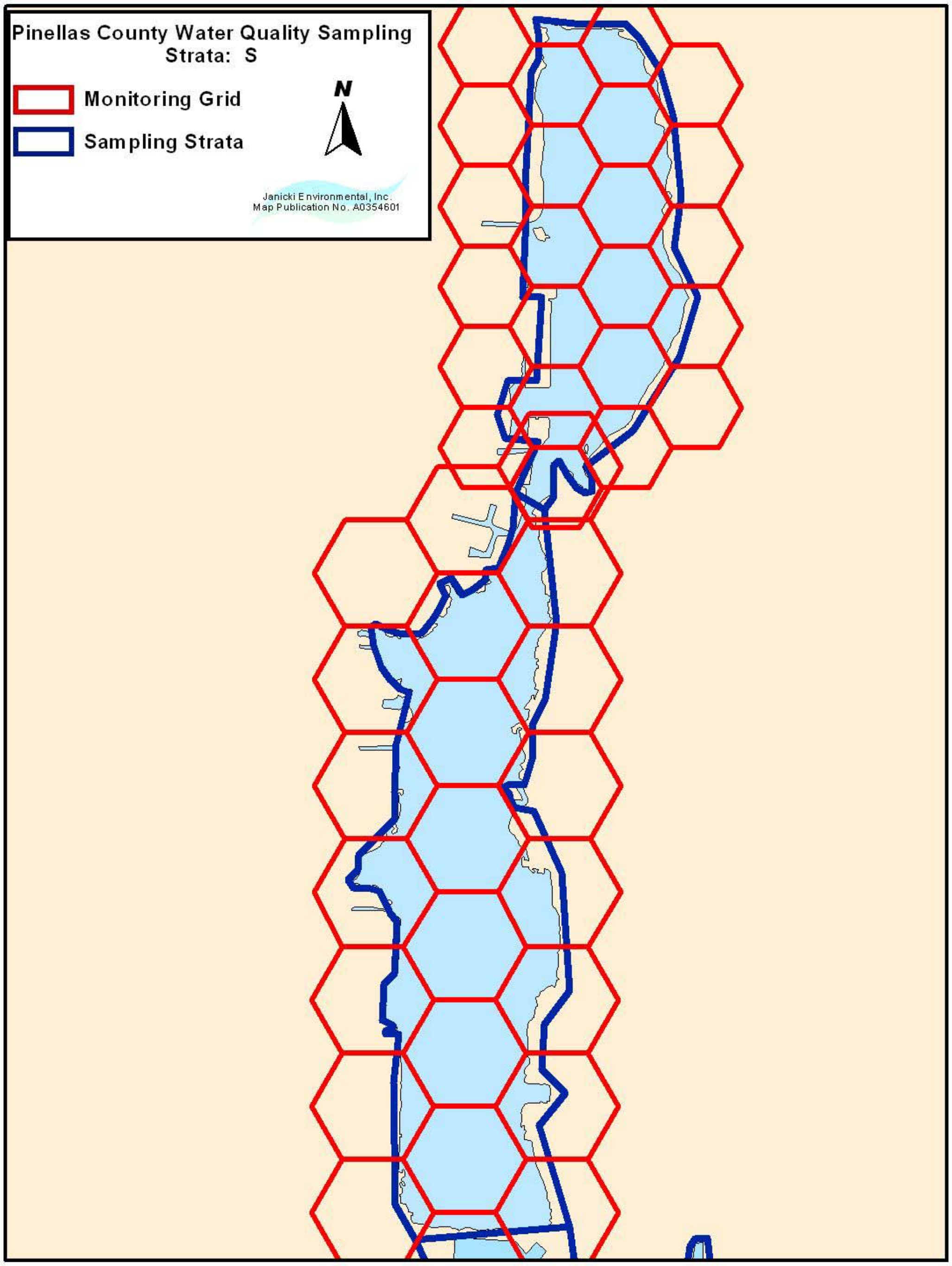

Figure 5-17 Sampling strata for geographic reporting unit S, Lake Seminole.

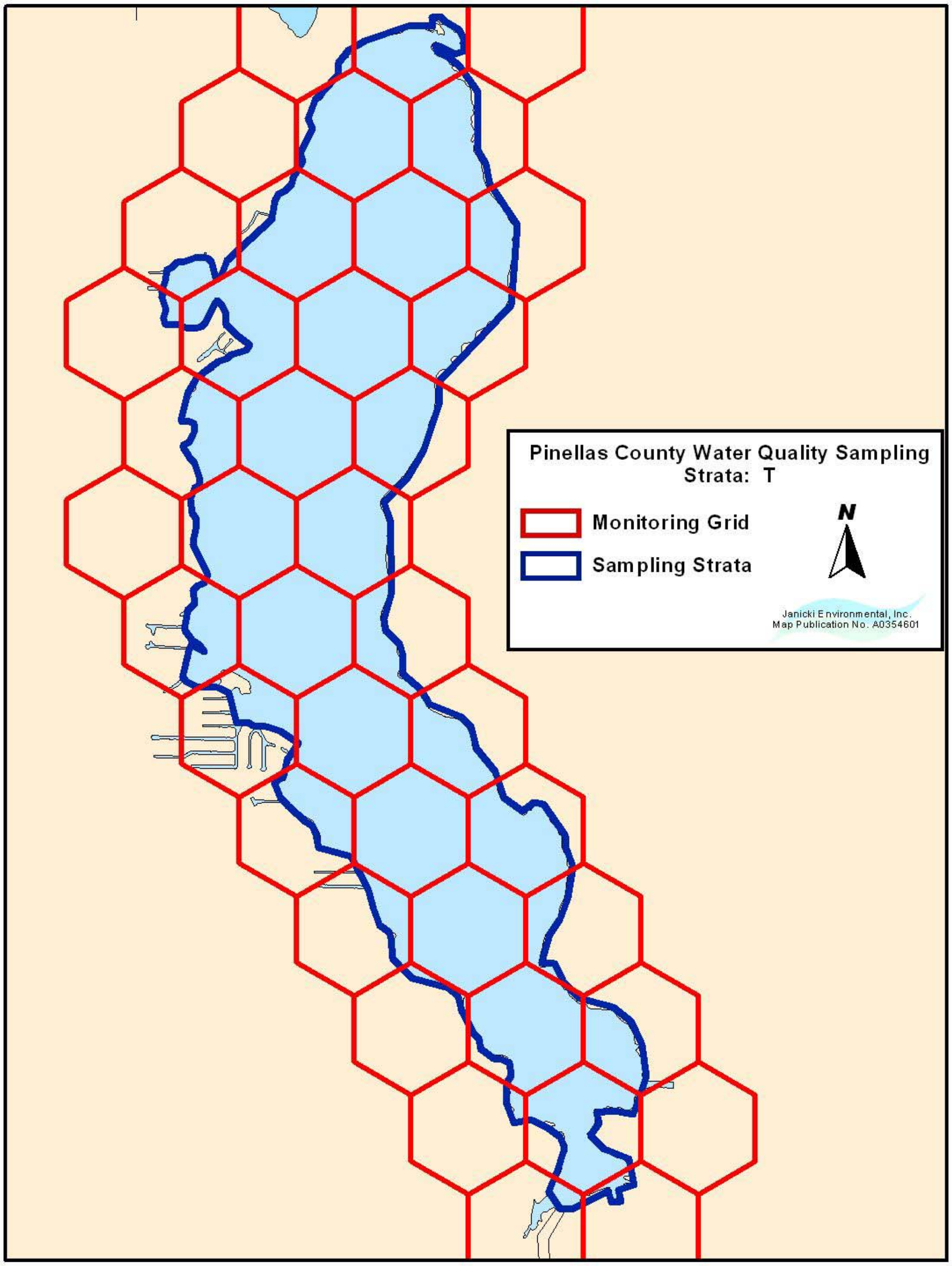

Figure 5-18 Sampling strata for geographic reporting unit T, Lake Tarpon.

5.1.6 Sampling Effort

The DEM defined the sampling effort for the 2003 calendar year as sampling of four stations for each of nine temporal reporting units per each geographic reporting unit. Thus, (4x9=36) 36 samples are intended to be collected annually in each geographic reporting unit.

Annual stratum-specific area estimates, from 36 measurements, should yield a confidence interval of +/- 15%. A recent sample size analysis was completed for Pinellas County and the other partners of the Tampa Bay Estuary Program in order to determine the expected confidence intervals for estimates derived using the EMAP-based sampling approach (TBEP 2002). The following in-text figure presents the empirically determined relationship between sample size and confidence limits for the estimates.

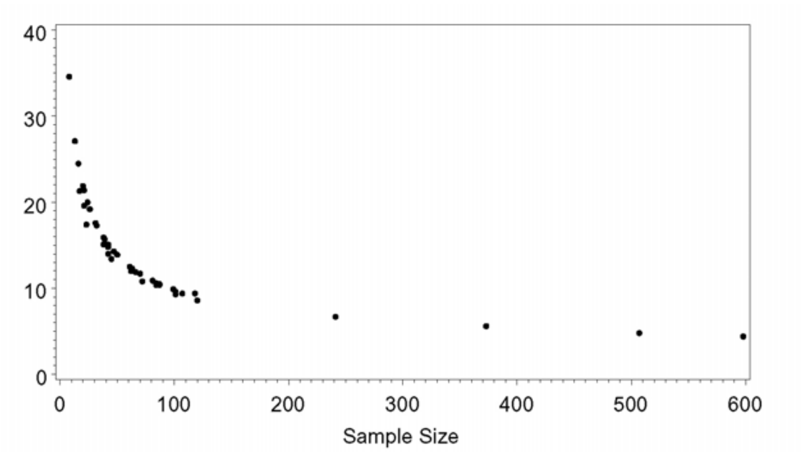

Figure 5-19. Confidence Intervals for 50% of Total Stratum Area Estimate (+/- percent of total stratum area).

Each point on Figure 5-19 represents the 95% confidence interval for a given sample size for an estimate of 50% of the total area of a stratum for a particular water quality condition. For example, 100 samples would yield an estimate of 40% to 60% of the stratum area at a specific dissolved oxygen level with 95% confidence.

Figure 5-19 also illustrates that as additional samples are added over the 36 samples per year, the return on investment with respect to precision diminishes at a relatively rapid rate.

5.1.7 Parameters

Table 5-1 presents the draft list of water quality and explanatory indicators for the ambient surface water quality monitoring program.

Table 5-1 Draft Indicators List

Water Quality Indicators	Explanatory Indicators
Water Temperature Conductivity Dissolved Oxygen Concentration Chlorophyll-*a* Concentration Ammonia Nitrite-Nitrate Total Kjeldahl Nitrogen Total Phosphorous Orthophosphate Secchi Disk Depth Photosynthetically Active Radiation (PAR) PAR Attenuation Turbidity Total Suspended Solids Color (for lakes only) PH	Water Depth Tide Stage (perhaps at a nearby location) Streamflow (of nearby hydrologic inputs) Time of Sample Collection Date of Sample Collection Insolation Cloud Cover Bottom Type Classification Wind Direction and Speed Wave Height

Table 5-2 presents indicators that are also being considered for inclusion in the monitoring program design.

Table 5-2 Additional Indicators Under Consideration

Water Quality Indicators
Transmissivity Screening level wet season pollutants in water and/or sediments Rapid Grain Size Assessment

5.1.8 Data Management

[This Section to be Provided by Pinellas County]

5.2 Field Methods

The following field procedures must be followed to meet the program objectives, and to provide a safe working environment for the field crews.

5.2.1 Sample Trip Selection Procedures

The DEM will re-randomize the sampling dates for each calendar year by running the SAS program provided in Appendix E with a new random seed and a year-specific set of DEM holidays.

The randomly selected sampling times for each of the nine sampling events for 2003 are provided by calendar year in Appendix A. The following steps should be used to select a sample date for each of the nine sampling events in a year.

Step 1) The preferred random sample dates for each of the geographic populations of interest for 2003 are provided in the primary sample date table in Appendix A. For pairs of geographic reporting units, the order of each pair listed was randomized, and indicates which one of the paired locations should be visited first (morning) and which one should be visited last (afternoon).

Step 2) If weather or scheduling conflicts prevent sampling a primary sampling date, then an alternate date should be selected from the top row of the secondary sample dates table. The reason for missing the primary sampling date should be documented in the monitoring program records as discussed previously so that the targeted temporal population for the year can be compiled at the end of the year.

Step 3) Step 2 should be repeated as necessary to sample all trips for each of the nine sampling periods. The rows in the secondary sampling date table were randomized, and they should be used in order top to bottom.

Step 4) If weather and schedule conflicts prevent sampling until the random sampling dates are exhausted for a given sampling period, then a back-up sampling date should be selected from the 15-day reserved period at the end of each sampling period.

5.2.2 Sample Location Selection Procedures

At the start of each calendar year, The DEM will re-randomize the random sampling locations for the year by running the SAS program provided in Appendix E with a new random seed.

Field maps showing the primary random sample locations and recent aerial photographs of sand drifts and other relatively dynamic navigational hazards should be prepared at the start of each year for use by field sampling crews. These maps are to be used for planning purposes, and will not be used as a substitute for normal safe vessel operation, current navigational charts, and reference to the most recent Guide to Mariners. The field maps for 2003 are assembled in Appendix C.

The following steps should be used to select sampling locations for each of the nine sampling events per geographic stratum per year.

Step 1) The primary sampling table provided in Appendix B indicates the preferred sampling locations by stratum and sampling period. These sites should be visited in the preferred order if possible. It would be a minor violation of the random design if the sites were visited in another order within the same half-day period (i.e., morning/afternoon).

Step 2) If a primary sampling destination cannot be reached in the field, then the following actions should be taken:

a) Record the reason(s) why the sampling location could not be reached in the monitoring program records.

b) Select a backup location from the secondary sampling location list for the appropriate segment and season.

Notes: For statistical design reasons there are only a few secondary locations (please see 3)). There is a secondary table for the wet season and one for the dry season.

Step 3) If a secondary location can not be reached, then the following actions should be taken:

a) Record the reason why the secondary location could not be reached.

b) Select the next backup location from the appropriate secondary sampling table.

Step 4) If all of the secondary dates are exhausted for a particular season and segment, then there is a large table of random tertiary sampling locations that can be used to obtain the desired number of samples. The sample locations were listed in random order, and the selections should be made from top to bottom within a segment until the desired number of samples is obtained.

5.2.3 Trip Preparation

[This Section to be Provided by Pinellas County DEM]

5.2.4 Field Data Collection Procedures

[This Section to be Provided by Pinellas County DEM]

5.2.5 Field Quality Assurance Procedures

[This Section to be Provided by Pinellas County DEM]

5.3 Laboratory Methods

The following laboratory methods must be followed in order to meet the program objectives.

5.3.1 Laboratory Analysis Procedures

[This Section to be Provided by Pinellas County DEM]

5.3.2 Laboratory Quality Assurance Procedures

[This Section to be Provided by Pinellas County DEM]

6.0 Data Reporting Methods

The following reporting methods should be followed to meet the program objectives.

6.1 Periodic Data Reporting

Reporting Cycle for each Calendar Year

1st Quarter:

- Preparation and publication of the annual report for the previous sampling year.

  For the first four annual reports of the monitoring program, this annual report will present water quality status information. For the fifth year and all years after the fifth year, this annual report will present status and trends information.

- Update of results of the monitoring program on the technical website on an annual basis.

2nd Quarter:

- No scheduled reporting activities

- Implementation of the annual monitoring program review using information from the previous year's monitoring results (Section 6.2).

3rd Quarter:

- No scheduled reporting activities

- Publication of the annual monitoring program review results using information from the previous year's monitoring results (Section 6.2).

4th Quarter:

- Preparation of random samples and monitoring plan for the next sampling year (Includes any adjustments based on results of annual monitoring program review).

Annual Reporting

The annual report will include the results from the previous calendar year of sampling. At a minimum, after five years of sampling, the annual report will include trend analysis results.

- A summary section with descriptive answers to the important questions identified for the ambient monitoring program.

- Spatial reporting units consist of the individual geographic populations of interest, east vs. west grouped reporting units, TBEP Bay Segments where applicable.

- Temporal reporting units consist of each calendar year. Using every two years of sampling results, the wet season and dry season statistics will be reported.

- The results for all measured parameters will be reported in each annual report.

- The EMAP-based statistical analyses will be conducted to produce cumulative frequency distributions of the area of each spatial reporting unit for each water quality parameter. Results will be presented in tabular and graphical format. A set of SAS programs and example output is provided in Appendix H of this design document.

- The stratified-random analyses will be conducted to compute the annual mean and standard error for each spatial reporting unit and parameter measured.

- The FDEP Impaired Water Rule criteria will be applied to classify each coastal Water Body (WBID) using data from this monitoring program and any other applicable monitoring activities (e.g., Hillsborough County, Tampa Bay Benthic Monitoring Program).

- Statistical comparisons will be made between the following: East vs. West reporting units, shallow east vs. deep east Hillsborough County fixed-station results.

- Potential water quality problem areas will be identified, prioritized, and discussed in each annual report.

- The targeted spatial and temporal populations of interest will be compiled through review of the exclusionary criteria applied during the previous year.

The data will also be summarized on a technical website for the ambient monitoring program on an annual basis. The website will include:

- A summary of the monitoring program, and the important questions that it addresses,
- A high level summary of the most recently reported results for the ambient monitoring program,
- Program contact information,
- A description of the annual reporting cycle and an updated status of the items in the reporting cycle,
- A library of PDF documents of past annual reports.
- A library of PDF documents of past annual monitoring program review reports.

6.2 Annual Monitoring Program Review

In each year, the DEM will review the cumulative and recent annual monitoring results from the previous years in order to determine if any adjustments to the sampling program are required for future years. This review will be completed in a systematic manner by comparing the results from the monitoring program to each of the specific objectives of the monitoring program. An executive summary of this review document will include a list of program objectives met, a list of program objectives not met, and any changes that are imposed on the sampling program design.

Definitions of Populations of Interest

The DEM will review the data to determine if any of the definitions of the populations of interest require refinement. Any changes to these definitions should be organized so as to minimize impacts on use of the previous years of data. Examples of potential definition refinements include:

- Splitting existing geographic populations of interest to focus on specific areas of emerging water quality problems (splitting existing populations of interest without modifying geographic boundaries will still allow trend analysis using past years of data);
- Adding geographic populations of interest not currently sampled (e.g., deeper areas of Tampa Bay); and
- More specifically defining the populations of interest based on review of the exclusionary criteria from previous years.

Definitions of Sampling Effort

The DEM will review the data to determine if any of the sampling effort quantities need to be adjusted. Examples of potential adjustments include:

- Reducing or increasing the sample size for specific reporting units (based on power analysis of the data collected in previous years); and
- Re-allocating sampling effort to particular sampling strata (e.g., moving effort from the dry season to the wet season based on power analysis of data collected to date).

An initial review of the sampling effort based on post-stratified historical data is presented in Appendix I of this design document.

Program Methodology Review

The DEM staff will meet to review the program methodology to determine if methods need to be revised in order to meet the project objectives or to improve logistical or safety conditions. The results of the meeting will be included in the annual monitoring program review.

7.0 Literature Cited

Moores, D., E. Quinn, P. Leasure, N. Page, M. Andersen, S. Coats, S. Myers, D. Hicks, and C. Cox. 1992. Ambient surface water quality monitoring report, data year October 1990-December 1991, Pinellas County, Florida. Pinellas County Department of Environmental Management, Clearwater, Florida.

Moores, D., E. Quinn, P. Leasure, N. Page, M. Andersen, S. Coats, S. Myers, D. Hicks, and Lisa Baltus. 1994. Ambient surface water quality monitoring report, data year October 1992-December 1992, Pinellas County, Florida. Pinellas County Department of Environmental Management, Clearwater, Florida.

Myers, S., N. Page, and A. Squires. 2000. Ambient surface water quality monitoring report 1991-1997 Pinellas County, Florida. Pinellas County Department of Environmental Management, Clearwater, Florida.

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Tampa Bay Estuary Program (TBEP). 2002. Tampa Bay Benthic Monitoring Program Redesign Assessment. Prepared for the Tampa Bay Estuary Program, St. Petersburg, Florida. Prepared by Janicki Environmental, Inc., St. Petersburg, Florida.

United States Environmental Protection Agency, Region IV. 1997. Permit Number FLS000005 - Major MS4. Authorization to discharge under the National Pollutant Discharge Elimination System.

Appendix A

Random Sampling Date Tables

Appendix B

Random Sampling Location Tables

Appendix C

Field Sampling Maps

Appendix D

Program Design Meeting Minutes

From October 18, 2002 Meeting

Goals

The draft goals for the water quality sampling program are stated as follows. The program will move towards these goals by meeting the specific program objectives stated later in this document:

- Maintain or improve water quality in the open-water receiving water bodies of the County.

- Determine the status and trends of water quality in the County receiving waters.

Objectives

The following table presents the draft list of objectives for the water quality monitoring program. The listed objectives are not ordered by priority at this time.

Objective 1: Fulfill the County's NPDES obligations.

Objective 2: Provide status and trends information to the citizens of the County, the Board of County Commissioners, the Pinellas County DEM staff, and cooperating agencies (e.g., Tampa Bay Estuary Program, Florida Department of Environmental Protection).

Objective 3: Develop a mechanism of information delivery to provide data to any member of the public who requests it.

Objective 4: Fulfill state water policy and Comprehensive Plan requirements.

Objective 5: Provide a method of identifying potential water quality problems before they occur. In particular, provide a method of identifying water bodies that are approaching a condition of not meeting their designated uses).

Objective 6: Measure the impacts of management efforts (e.g., the effectiveness of stormwater management plans).

Objective 7: Provide information needed to prioritize management actions.

Objective 8: Fill important data gaps and maximize the sampling effort with respect to sampling all habitat types (e.g., sample shallow coastal waters).

Objective 9: Provide the information needed to develop quantitative water quality targets for living resources.

Objective 10: Provide a means of estimating the annual aerial extent of each water quality parameter for the County, East County Shallow, West County Shallow, West County (Shallow and Deep), and each geographic stratum.

Objective 11: Estimate the magnitude and direction of the change in the aerial extent measures (listed in Objective 10) every five years.

Important Questions to be Answered by the Monitoring Program

The following monitoring questions were identified in order to provide further direction for the development of the monitoring program design: The questions are not prioritized.

1) Which water bodies are not meeting their designated uses?

2) What proportion or area of the County's surface waters are currently meeting their designated uses?

3) Is the proportion or area of the County's surface waters that are currently meeting their designated uses changing over time?

4) Which parameters are effecting light attenuation?

5) Which are the worst and best water bodies in the County in terms of water quality?

Spatial Extent and Reporting Units

The following draft spatial extent and reporting units were identified for the water quality monitoring program.

Spatial Extent

- Coastal waters and major lakes within County Boundaries
- From shore to the 2 meter or 3 meter (mllw) isobath in Tampa Bay (isobath to be chosen during program design)
- From Pinellas peninsula shore to barrier island shores in western County
- Adopting Tampa Bay Estuary Program boundaries where they occur within the study area

Spatial Reporting Units

- Proportion of total area meeting designated use criteria
- East vs. West
- West side divided into deep vs. shallow
- Smaller geographic strata based on locations of dominant physical landscape features likely to effect water quality geographic distributions (e.g., causeways, peninsulas).

In addition, future areas of special concern (e.g., surface waters near point sources) may be added as needed to meet the monitoring program objectives. Consideration will be given to including the Riviera Bay/Bayou Grande estuary in the coastal study area.

Temporal Reporting Units

The following draft temporal extent and reporting units were identified for the water quality monitoring program.

Temporal Extent

- Year round sampling

Temporal Reporting Units

- Reporting on an annual basis.
- Seasonal reporting for lakes and coastal waters for specific parameters based on review of the historical data.

Indicators

The following table presents the draft list of indicators for the water quality monitoring program.

Water Quality Indicators	Explanatory Indicators
Water Temperature	Water Depth
Conductivity	Tide Stage (perhaps at a nearby location)
Dissolved Oxygen Concentration	Streamflow (of nearby hydrologic inputs)
Chlorophyll-*a* Concentration	Time of Sample Collection
Ammonia	Date of Sample Collection
Nitrite-Nitrate	Insolation
Total Kjeldahl Nitrogen	Cloud Cover
Total Phosphorous	Bottom Type Classification
Orthophosphate	Wind Direction and Speed
Secchi Disk Depth	Wave Height
PAR Attenuation	
Turbidity	
Total Suspended Solids	
Color (for lakes only)	
pH	

In addition to these draft indicators, the following indicators are being considered for tentative inclusion in the sampling plan: Transmissivity, Screening level wet season pollutants in water and/or sediments, Rapid Grain Size Assessment.

Methodology

The following draft criteria were defined for the methodology to be applied in the monitoring program.

1) The methodology must be Florida Department of Environmental Protection approved methodology and must include a quality assurance plan.

2) The methodology must meet the objectives of the water quality monitoring program (e.g., must meet the NPDES requirements).

3) The methodology must apply repeatable measurement techniques.

4) The methodology must be consistent with or have a quantifiable difference from the methods used by other members of the Southwest Florida Regional Ambient Monitoring Program (SWF RAMP).

Appendix E

SAS Program to Select Random Sampling Trips

The program used to generate the random temporal sample selection for each sampling year is included in this binder.

Step-8.sas produces an Adobe PDF® version of the tables.

Step-8d.sas produces an Excel® spreadsheet version of the tables.

```
*****************************************************;
*                                                   *;
*                  JANICKI ENVIRONMENTAL, INC.      *;
*                                                   *;
*                                                   *;
*                                                   *;
* Project        : Pinellas County WQ Design        *;
*                                                   *;
* Program name   : Step-8.sas                       *;
*                                                   *;
* Date           : Dec 24 2002                      *;
*                                                   *;
* Description    : Create 2003 sampling schedule    *;
*                                                   *;
* Input datasets : step_7.sas7bdat                  *;
*                                                   *;
* Output datasets:                                  *;
*                                                   *;
* Programmer(s)  : David Wade                       *;
*                                                   *;
*                                                   *;
*****************************************************;
*                                                   *;
* History:                                          *;
*                                                   *;
*                                                   *;
*                                                   *;
*****************************************************;

options nodate nonumber sasautos=("c:.") noovp mprint mtrace ls=80  ps=59
formchar="³ÄÚÂ¿ÃÅ´ÀÁÙ";

libname c "c:"; run;
libname c6 v612 "c:"; run;
libname c8 v8 "c:"; run;


*** create the list frame of sampling dates ***;

    data dates;

      retain start d d_period period_n;

      start="01JAN2003"d;
      d=start;

      d_period=d;
      period_n=0;
      do d=d_period to (start + (365/9)*1 - 1);
         period=1;
         period_n=period_n+1;
         output;
      end;

      d_period=d;
      period_n=0;
      do d=d_period to (start + (365/9)*2 - 1);
         period=2;
         period_n=period_n+1;
         output;
      end;


      d_period=d;
      period_n=0;
      do d=d_period to (start + (365/9)*3 - 1);
         period=3;
         period_n=period_n+1;
         output;
      end;

      d_period=d;
      period_n=0;
      do d=d_period to (start + (365/9)*4 - 1);
         period=4;
         period_n=period_n+1;
         output;
      end;

      d_period=d;
      period_n=0;
      do d=d_period to (start + (365/9)*5 - 1);
         period=5;
         period_n=period_n+1;
         output;
      end;
```

```
      d_period=d;
      period_n=0;
      do d=d_period to (start + (365/9)*6 - 1);
         period=6;
         period_n=period_n+1;
         output;
      end;

      d_period=d;
      period_n=0;
      do d=d_period to (start + (365/9)*7 - 1);
         period=7;
         period_n=period_n+1;
         output;
      end;

      d_period=d;
      period_n=0;
      do d=d_period to (start + (365/9)*8 - 1);
         period=8;
         period_n=period_n+1;
         output;
      end;

      d_period=d;
      period_n=0;
      do d=d_period to (start + (365/9)*9 - 1);
         period=9;
         period_n=period_n+1;
         output;
      end;

      format d date9.;
      keep period period_n d;
    run;


    *** exclude days planned for no sampling events ***;

    data dates;
      set dates;

      *** List of 2003 Exclusion Dates from A Squires 12/23/2002 Email ***;

          if d="01JAN2003"d then delete;
          if d="20JAN2003"d then delete;
          if d="26MAY2003"d then delete;
          if d="04JUL2003"d then delete;
          if d="01SEP2003"d then delete;
          if d="11NOV2003"d then delete;
          if d="27NOV2003"d then delete;
          if d="28NOV2003"d then delete;
          if d="25DEC2003"d then delete;
          if d="26DEC2003"d then delete;

          if weekday(d) in(1,6,7) then delete;  * Fri Sat Sun excluded *;

          if period_n <=25;  *** reserve last 15 days of each period for last chance
          make-up dates;

      keep d period;
    run;


  *** randomize the dates ***;

      data dates;
        set dates;
        r=ranuni(83);
      run;

      proc sort data=dates; by period r; run;

      data dates;
        set dates;
        retain period_n;

        by period r;
        if first.period then period_n=1; else period_n=period_n+1;
      run;

      data primary secondary;
        set dates;

        if period_n<=6 then output primary;
                       else output secondary;

        drop r;
     run;
```

```
*** create a list of sampling destinations ***;

    data west_trips;
      length trip $ 20;

      do period=1 to 9;

         trip="W1"; output;

         if ranuni(11)>0.5 then do; trip="W2 and W3"; output; end;
                           else do; trip="W3 and W2"; output; end;

         if ranuni(11)>0.5 then do; trip="W4 and W6"; output; end;
                           else do; trip="W6 and W4"; output; end;

         trip="W5"; output;

         if ranuni(11)>0.5 then do; trip="W7 and W8"; output; end;
                           else do; trip="W8 and W7"; output; end;

         if ranuni(11)>0.5 then do; trip="SA and SB"; output; end;
                           else do; trip="SB and SA"; output; end;

      end;
    run;


    data east_trips;
      length trip $ 20;

      do period=1 to 9;

         if ranuni(11)>0.5 then do; trip="E1 and E2"; output; end;
                           else do; trip="E2 and E1"; output; end;

         if ranuni(11)>0.5 then do; trip="E3 and E4"; output; end;
                           else do; trip="E4 and E3"; output; end;

         if ranuni(11)>0.5 then do; trip="E5 and RB"; output; end;
                           else do; trip="RB and E5"; output; end;

         if ranuni(11)>0.5 then do; trip="E6 and E7"; output; end;
                           else do; trip="E7 and E6"; output; end;

         trip="T"; output;

         trip=""; output;

      end;
    run;


    *** shuffle-merge east and west trips as pairs ***;

        data west_trips; set west_trips; length west_trip $ 20; r=ranuni(7);
west_trip=trip; drop trip; run;
        data east_trips; set east_trips; length east_trip $ 20; r=ranuni(1);
east_trip=trip; drop trip; run;

        proc sort data=west_trips; by period r; run;
        proc sort data=east_trips; by period r; run;

        data west_trips; set west_trips; n=_N_; run;
        data east_trips; set east_trips; n=_N_; run;

        data trips;
          merge west_trips east_trips;
          by n;
          keep period west_trip east_trip;

          label period = "Sampling~Period"
                west_trip = "Western Crew~Destination"
                east_trip = "Eastern Crew~Destination";
        run;


        data trips;
          set trips;
          by period;

          retain period_n;

          if first.period then period_n=1; else period_n=period_n+1;
        run;
```

```
*** put together the randomized dates and randomized destinations ***;

    proc sort data=primary; by period period_n; run;
    proc sort data=trips  ; by period period_n; run;
    data primary;
      merge primary trips;
      by period period_n;
      label d="Sampling~Date";
    run;

    data primary; set primary;;
      format d worddate20.; run;

    proc sort data=primary; by period d; run;

    data primary;
      set primary;
      by period;
      output;
      if last.period then do; west_trip=" "; d=.; east_trip=" "; output; end;
    run;


    data secondary;
      set secondary;
      label period="Sampling~Period"
            d     ="Date";
      format d worddate20.;
    run;



* GOPTIONS  PDF  *****************************************************;

 goptions reset=all  device=winprtc
          rotate=portrait
          ftext="Times"       ftitle="Times"
          htitle=0.25 in      htext=0.20 in;
          run;


 options  orientation =  portrait
            papersize =  letter
           leftmargin = "0.7 in"
          rightmargin = "0.7 in"
            topmargin = "0.7 in"
         bottommargin = "0.7 in" ;
 run;


ods pdf file="c:primary 2003 schedule.pdf";
    title1 "Pinellas County Water Quality Monitoring Schedule 2003"; run;
    title2 "Primary Sampling Dates - Randomized Dates and Destinations"; run;
    footnote1 "Prepared Dec 24, 2002"; run;

    proc report data=primary headline headskip split="~";
      columns period d west_trip east_trip;
      define period    / group;
      define d         / display;
      define west_trip / display;
      define east_trip / display;
      break after period / skip;
   run;
ods pdf close;




ods pdf file="c:secondary 2003 schedule.pdf";
    title1 "Pinellas County Water Quality Monitoring Schedule 2003"; run;
    title2 "Secondary Sampling Dates - Randomized Dates"; run;
    footnote1 "Prepared Dec 24, 2002"; run;

    proc report data=secondary headline headskip split="~";
      columns period d;
      define period    / group;
      define d         / display;
      break after period / skip;
   run;
ods pdf close; run;
```

```
*******************************************************;
*                                                     *;
*                  JANICKI ENVIRONMENTAL, INC.        *;
*                                                     *;
*                                                     *;
*                                                     *;
* Project        : Pinellas County WQ Design          *;
*                                                     *;
* Program name   : Step-8d.sas                        *;
*                                                     *;
* Date           : Jan 03 2003                        *;
*                                                     *;
* Description    : Create 2003 sampling schedule      *;
*                  the same as was done for step-8.sas *;
*                  but output excel files and not pdf  *;
*                                                     *;
* Input datasets : step_7.sas7bdat                    *;
*                                                     *;
* Output datasets:                                    *;
*                                                     *;
* Programmer(s)  : David Wade                         *;
*                                                     *;
*                                                     *;
*******************************************************;
*                                                     *;
* History:                                            *;
*                                                     *;
*                                                     *;
*                                                     *;
*******************************************************;

options nodate nonumber sasautos=("c:.") noovp mprint mtrace ls=80  ps=59
formchar="³ÄÚÂ¿ÃÅ´ÀÁÙ";

libname c "c:"; run;
libname c6 v612 "c:"; run;
libname c8 v8 "c:"; run;


*** create the list frame of sampling dates ***;

    data dates;

      retain start d d_period period_n;

      start="01JAN2003"d;
      d=start;

      d_period=d;
      period_n=0;
      do d=d_period to (start + (365/9)*1 - 1);
         period=1;
         period_n=period_n+1;
         output;
      end;

      d_period=d;
      period_n=0;
      do d=d_period to (start + (365/9)*2 - 1);
         period=2;
         period_n=period_n+1;
         output;
      end;


      d_period=d;
      period_n=0;
      do d=d_period to (start + (365/9)*3 - 1);
         period=3;
         period_n=period_n+1;
         output;
      end;

      d_period=d;
      period_n=0;
      do d=d_period to (start + (365/9)*4 - 1);
         period=4;
         period_n=period_n+1;
         output;
      end;

      d_period=d;
      period_n=0;
```

```
      do d=d_period to (start + (365/9)*5 - 1);
         period=5;
         period_n=period_n+1;
         output;
      end;

      d_period=d;
      period_n=0;
      do d=d_period to (start + (365/9)*6 - 1);
         period=6;
         period_n=period_n+1;
         output;
      end;

      d_period=d;
      period_n=0;
      do d=d_period to (start + (365/9)*7 - 1);
         period=7;
         period_n=period_n+1;
         output;
      end;

      d_period=d;
      period_n=0;
      do d=d_period to (start + (365/9)*8 - 1);
         period=8;
         period_n=period_n+1;
         output;
      end;

      d_period=d;
      period_n=0;
      do d=d_period to (start + (365/9)*9 - 1);
         period=9;
         period_n=period_n+1;
         output;
      end;

      format d date9.;

      keep period period_n d;
    run;


    *** exclude days planned for no sampling events ***;

    data dates;
      set dates;

      *** List of 2003 Exclusion Dates fro A Squires 12/23/2002 Email ***;

          if d="01JAN2003"d then delete;
          if d="20JAN2003"d then delete;
          if d="26MAY2003"d then delete;
          if d="04JUL2003"d then delete;
          if d="01SEP2003"d then delete;
          if d="11NOV2003"d then delete;
          if d="27NOV2003"d then delete;
          if d="28NOV2003"d then delete;
          if d="25DEC2003"d then delete;
          if d="26DEC2003"d then delete;

          if weekday(d) in(1,6,7) then delete;  * Fri Sat Sun excluded *;

          if period_n <=25;  *** reserve last 15 days of each period for last chance
make-up dates;

      keep d period;
    run;


  *** randomize the dates ***;

      data dates;
        set dates;
        r=ranuni(83);
      run;
      proc sort data=dates; by period r; run;
      data dates;
        set dates;
        retain period_n;
        by period r;
        if first.period then period_n=1; else period_n=period_n+1;
      run;
```

```
      data primary secondary;
        set dates;

        if period_n<=6 then output primary;
                       else output secondary;

        drop r;
     run;




*** create a list of sampling destinations ***;

    data west_trips;
      length trip $ 20;

      do period=1 to 9;

         trip="W1"; output;

         if ranuni(11)>0.5 then do; trip="W2 and W3"; output; end;
                           else do; trip="W3 and W2"; output; end;

         if ranuni(11)>0.5 then do; trip="W4 and W6"; output; end;
                           else do; trip="W6 and W4"; output; end;

         trip="W5"; output;

         if ranuni(11)>0.5 then do; trip="W7 and W8"; output; end;
                           else do; trip="W8 and W7"; output; end;

         if ranuni(11)>0.5 then do; trip="SA and SB"; output; end;
                           else do; trip="SB and SA"; output; end;

      end;
    run;


    data east_trips;
      length trip $ 20;

      do period=1 to 9;

         if ranuni(11)>0.5 then do; trip="E1 and E2"; output; end;
                           else do; trip="E2 and E1"; output; end;

         if ranuni(11)>0.5 then do; trip="E3 and E4"; output; end;
                           else do; trip="E4 and E3"; output; end;

         if ranuni(11)>0.5 then do; trip="E5 and RB"; output; end;
                           else do; trip="RB and E5"; output; end;

         if ranuni(11)>0.5 then do; trip="E6 and E7"; output; end;
                           else do; trip="E7 and E6"; output; end;

         trip="T"; output;

         trip=""; output;

      end;
    run;


    *** shuffle-merge east and west trips as pairs ***;

        data west_trips; set west_trips; length west_trip $ 20; r=ranuni(7);
west_trip=trip; drop trip; run;
        data east_trips; set east_trips; length east_trip $ 20; r=ranuni(1);
east_trip=trip; drop trip; run;

        proc sort data=west_trips; by period r; run;
        proc sort data=east_trips; by period r; run;

        data west_trips; set west_trips; n=_N_; run;
        data east_trips; set east_trips; n=_N_; run;

        data trips;
          merge west_trips east_trips;
```

```
          by n;
          keep period west_trip east_trip;

          label period = "Sampling~Period"
                west_trip = "Western Crew~Destination"
                east_trip = "Eastern Crew~Destination";
        run;


        data trips;
          set trips;
          by period;

          retain period_n;

          if first.period then period_n=1; else period_n=period_n+1;
        run;


*** put together the randomized dates and randomized destinations ***;

    proc sort data=primary; by period period_n; run;
    proc sort data=trips  ; by period period_n; run;
    data primary;
      merge primary trips;
      by period period_n;
      label d="Sampling~Date";
    run;

    data primary; set primary;;
      format d worddate20.; run;

    proc sort data=primary; by period d; run;

    data primary;
      set primary;
      by period;
      output;
      if last.period then do; west_trip=" "; d=.; east_trip=" "; output; end;
    run;


    data secondary;
      set secondary;
      label period="Sampling~Period"
            d     ="Date";
      format d worddate20.;
    run;


* GOPTIONS  PDF  *****************************************************;

 goptions reset=all  device=winprtc
          rotate=portrait
          ftext="Times"       ftitle="Times"
          htitle=0.25 in      htext=0.20 in;
          run;


 options  orientation =  portrait
            papersize =  letter
           leftmargin = "0.7 in"
          rightmargin = "0.7 in"
            topmargin = "0.7 in"
         bottommargin = "0.7 in" ;
 run;



data x;
  file "c:primary 2003 schedule.txt";
  set primary;

  if _N_=1 then do;
    put "Pinellas County Water Quality Monitoring Schedule 2003";
    put "Primary Sampling Dates - Randomized Dates and Destinations";
    put " ";
    put "Prepared Jan 31 2003 (Same content as tables prepared Dec 24 2002)";
    put " ";

    put '"Sampling","Sampling","Western Crew","Eastern Crew"';
```

```
    put '"Period","Date","Destination","Destination"';
  end;

  put '"' period '","' d '","' west_trip '","' east_trip '"';
run;



data x;
  file "c:secondary 2003 schedule.txt";
  set secondary;

  if _N_=1 then do;
    put "Pinellas County Water Quality Monitoring Schedule 2003";
    put "Secondary Sampling Dates - Randomized Dates";
    put " ";
    put "Prepared Jan 31 2003 (Same content as tables prepared Dec 24 2002)";
    put " ";

    put '"Sampling","Sampling"';
    put '"Period","Date"';
  end;

  put '"' period '","' d '"';

run;
```

Appendix F

SAS Programs to Select Random Sampling Locations

The programs used to generate the random spatial sample selection for each sampling year is included in this binder.

Step-10.sas produces a set of neeeded SAS datasets.

Step-10b.sas produces Adobe PDF® version of the tables.

Step-10c.sas produces Excel® spreadsheet versions of the tables.

The Step-10.sas program must be run first. The run order of Step-10b.sas and Step-10c.sas does not matter with respect to program operation.

```
*****************************************************;
*                                                   *;
*                  JANICKI ENVIRONMENTAL, INC.      *;
*                                                   *;
*                                                   *;
*                                                   *;
* Project        : Pinellas County WQ Design        *;
*                                                   *;
* Program name   : Step-10.sas                      *;
*                                                   *;
* Date           : Dec 31 2002                      *;
*                                                   *;
* Description    : Pick Sampling Points for 2003    *;
*                                                   *;
* Input datasets : step_7.sas7bdat                  *;
*                                                   *;
* Output datasets:                                  *;
*                                                   *;
* Programmer(s)  : David Wade                       *;
*                                                   *;
*                                                   *;
*****************************************************;
*                                                   *;
* History:                                          *;
*                                                   *;
*                                                   *;
* Jan 02 2003  dlw  revised order number on SA and SB  *;
*                                                   *;
*                                                   *;
*****************************************************;

options nodate nonumber sasautos=("c:.") noovp mprint mtrace ls=80  ps=59
formchar="³ÄÚÂ¿ÃÅ´ÀÁÙ";

libname c "c:"; run;
libname c6 v612 "c:"; run;
libname c8 v8 "c:"; run;


data points;
  set c.step_7;
run;


*** first identify the wet grid, dry grid, and stratified random sets ***;

    proc sort data=points;  by segment hex_no rand_no; run;
    data points;
      set points;
      retain hex_n 0;

      by segment hex_no rand_no;
      if first.hex_no then hex_n=1; else hex_n=hex_n+1;
    run;

    data wet_grid dry_grid strat_rand;
      set points;

      if  hex_n=1 then output wet_grid;
      if  hex_n=2 then output dry_grid;
      if  hex_n>2 then output strat_rand;
    run;


*** determine the primary and secondary wet_grid samples ***;

    data wet_grid wet_grid_nosample;
      set wet_grid;
      sample=1;
      if trim(left(stratum)) ne trim(left(segment)) then do;
         output wet_grid_nosample; * outside the geographic reporting unit;
         sample=0;
      end;
      if     segment in("E1","E2","E3","E4","E5","E6","E7")
         and depth in("Deep","null","Land") then do;
         output wet_grid_nosample; * outside the shallow pop of interest;
         sample=0;
      end;
      if not(segment in("E1","E2","E3","E4","E5","E6","E7"))
         and depth in("null","Land") then do;
         output wet_grid_nosample; * outside the shallow/deep pop of interest;
         sample=0;
```

```
      end;
      if sample=1 then output wet_grid;
    run;

    data dry_grid dry_grid_nosample;
      set dry_grid;
      sample=1;
      if stratum ne segment then do;
         output dry_grid_nosample; * outside the geographic reporting unit;
         sample=0;
      end;
      if     segment in("E1","E2","E3","E4","E5","E6","E7")
         and depth in("Deep","null","Land") then do;
         output dry_grid_nosample; * outside the shallow pop of interest;
         sample=0;
      end;
      if not(segment in("E1","E2","E3","E4","E5","E6","E7"))
         and depth in("null","Land") then do;
         output dry_grid_nosample; * outside the shallow/deep pop of interest;
         sample=0;
      end;
      if sample=1 then output dry_grid;
    run;



*** randomly put extra primary samples for wet and dry grids into secondary sets ***;

    data wet_grid;
      set wet_grid;
      secondary_rand_no = ranuni(91);
    run;
    proc sort data=wet_grid; by segment secondary_rand_no; run;
    data wet_grid;
      set wet_grid;
      by segment secondary_rand_no;

      retain segment_n 0;
      if first.segment then segment_n=1; else segment_n=segment_n+1;
    run;
    data primary_wet secondary_wet;
      set wet_grid;
      secondary=1;
      if not(segment in("SA","SB")) and segment_n<=16 then do; output primary_wet;
secondary=0; end;
      if     segment in("SA","SB")  and segment_n<= 8 then do; output primary_wet;
secondary=0; end;
      if secondary=1 then output secondary_wet;
    run;

    data dry_grid;
      set dry_grid;
      secondary_rand_no = ranuni(33);
    run;
    proc sort data=dry_grid; by segment secondary_rand_no; run;
    data dry_grid;
      set dry_grid;
      by segment secondary_rand_no;

      retain segment_n 0;
      if first.segment then segment_n=1; else segment_n=segment_n+1;
    run;
    data primary_dry secondary_dry;
      set dry_grid;
      secondary=1;
      if not(segment in("SA","SB")) and segment_n<=20 then do; output primary_dry;
secondary=0; end;
      if     segment in("SA","SB")  and segment_n<=10 then do; output primary_dry;
secondary=0; end;
      if secondary=1 then output secondary_dry;
    run;



*** subset the stratified random samples for the populations of interest ***;

    data tertiary;
      set strat_rand;

      if trim(left(segment)) ne trim(left(stratum)) then delete; * avoid overlapping grid
areas;
```

```
      if     stratum in("E1","E2","E3","E4","E5","E6","E7")  and depth
in("Deep","null","Land") then delete;

      if not(stratum in("E1","E2","E3","E4","E5","E6","E7")) and depth in("null","Land")
then delete;

    run;



   *** identify the extents of the primary short falls ***;

       proc sort data=primary_wet; by segment; run;
       proc means data=primary_wet noprint;
         var hex_no;
         by segment;
         output out=primary_wet_short n=n;
       run;
       data primary_wet_short;
         set primary_wet_short;
         if not(segment in("SA","SB")) then short = 16-n;
         if     segment in("SA","SB")  then short =  8-n;
         if short>0;
         keep segment short;
       run;

       proc sort data=primary_dry; by segment; run;
       proc means data=primary_dry noprint;
         var hex_no;
         by segment;
         output out=primary_dry_short n=n;
       run;
       data primary_dry_short;
         set primary_dry_short;
         if not(segment in("SA","SB")) then short = 20-n;
         if     segment in("SA","SB")  then short = 10-n;
         if short>0;
         keep segment short;
       run;



*** randomly pull out of the tertiary data set any samples needed to make up primary
short falls ***;

    data tertiary;
      set tertiary;
      tertiary_rand_no = ranuni(12);
    run;

    proc sort data=tertiary; by segment tertiary_rand_no; run;
    data tertiary;
      set tertiary;
      retain tertiary_n 0;

      by segment tertiary_rand_no;
      if first.segment then tertiary_n=1; else tertiary_n=tertiary_n+1;
    run;
    data primary_wet_short;
      merge primary_wet_short tertiary;
      by segment;
    run;

    data tertiary primary_wet_short;
      set primary_wet_short;

      if short ne . and tertiary_n<=short then output primary_wet_short;
                                          else output tertiary;
    run;
    data tertiary; set tertiary; drop short tertiary_n; run;


    proc sort data=tertiary; by segment tertiary_rand_no; run;
    data tertiary;
      set tertiary;
      retain tertiary_n 0;

      by segment tertiary_rand_no;
      if first.segment then tertiary_n=1; else tertiary_n=tertiary_n+1;
    run;
    data primary_dry_short;
      merge primary_dry_short tertiary;
      by segment;
```

```
    run;

    data tertiary primary_dry_short;
      set primary_dry_short;

      if short ne . and tertiary_n<=short then output primary_dry_short;
                                          else output tertiary;
    run;
    data tertiary; set tertiary; drop short tertiary_n; run;


*** create the final primary data sets (secondary and tertiary already ready to go at
this point) ***;

    data primary_wet;
      set primary_wet primary_wet_short;
    run;

    data primary_dry;
      set primary_dry primary_dry_short;
    run;



*** randomly assign the sampling periods to the primary and secondary data sets ***;

    data primary_wet;
      set primary_wet;
      date_rand_no = ranuni(41);
    run;
    proc sort data=primary_wet; by segment date_rand_no; run;
    data primary_wet primary_wet_seminole;
      set primary_wet;
      if segment in("SA","SB") then output primary_wet_seminole;
                               else output primary_wet;
    run;
    data primary_wet;
      set primary_wet;
      by segment date_rand_no;
      retain sample_order 0;
      if first.segment then sample_order=1; else sample_order=sample_order+1;
    run;
    data primary_wet;
      set primary_wet;
      if sample_order>=1  and sample_order<=4  then period=4;
      if sample_order>=5  and sample_order<=8  then period=5;
      if sample_order>=9  and sample_order<=12 then period=6;
      if sample_order>=13 and sample_order<=16 then period=7;
    run;
    data primary_wet;
      set primary_wet;
      sample_order=sample_order - ((period-4)*4);
    run;
    data primary_wet_seminole;
      set primary_wet_seminole;
      by segment date_rand_no;
      retain sample_order 0;
      if first.segment then sample_order=1; else sample_order=sample_order+1;
    run;
    data primary_wet_seminole;
      set primary_wet_seminole;
      if sample_order>=1  and sample_order<=2  then period=4;
      if sample_order>=3  and sample_order<=4  then period=5;
      if sample_order>=5  and sample_order<=6  then period=6;
      if sample_order>=7  and sample_order<=8  then period=7;
    run;
    data primary_wet_seminole;
      set primary_wet_seminole;
      sample_order=sample_order - ((period-4)*2);
    run;


    data primary_dry;
      set primary_dry;
      date_rand_no = ranuni(09);
    run;
    proc sort data=primary_dry; by segment date_rand_no; run;
    data primary_dry primary_dry_seminole;
      set primary_dry;
      if segment in("SA","SB") then output primary_dry_seminole;
                               else output primary_dry;
    run;
    data primary_dry;
```

```
  set primary_dry;
  by segment date_rand_no;
  retain sample_order 0;
  if first.segment then sample_order=1; else sample_order=sample_order+1;
run;
data primary_dry;
  set primary_dry;
  if sample_order>=1  and sample_order<=4  then period=1;
  if sample_order>=5  and sample_order<=8  then period=2;
  if sample_order>=9  and sample_order<=12 then period=3;
  if sample_order>=13 and sample_order<=16 then period=8;
  if sample_order>=17 and sample_order<=20 then period=9;
run;
data primary_dry;
  set primary_dry;
  if period=1 then sample_order=sample_order - 0;
  if period=2 then sample_order=sample_order - 4;
  if period=3 then sample_order=sample_order - 8;
  if period=8 then sample_order=sample_order -12;
  if period=9 then sample_order=sample_order -16;
run;
data primary_dry_seminole;
  set primary_dry_seminole;
  by segment date_rand_no;
  retain sample_order 0;
  if first.segment then sample_order=1; else sample_order=sample_order+1;
run;
data primary_dry_seminole;
  set primary_dry_seminole;
  if sample_order>=1  and sample_order<=2  then period=1;
  if sample_order>=3  and sample_order<=4  then period=2;
  if sample_order>=5  and sample_order<=6  then period=3;
  if sample_order>=7  and sample_order<=8  then period=8;
  if sample_order>=9  and sample_order<=10 then period=9;
run;
data primary_dry_seminole;
  set primary_dry_seminole;
  if period=1 then sample_order=sample_order - 0;
  if period=2 then sample_order=sample_order - 2;
  if period=3 then sample_order=sample_order - 4;
  if period=8 then sample_order=sample_order - 6;
  if period=9 then sample_order=sample_order - 8;
run;



data primary;
 set primary_wet
     primary_wet_seminole
     primary_dry
     primary_dry_seminole;
run;


proc sort data=secondary_wet; by segment secondary_rand_no; run;
data secondary_wet;
  set secondary_wet;
  by segment secondary_rand_no;
  retain sample_order 0;
  if first.segment then sample_order=1; else sample_order=sample_order+1;
run;

proc sort data=secondary_dry; by segment secondary_rand_no; run;
data secondary_dry;
  set secondary_dry;
  by segment secondary_rand_no;
  retain sample_order 0;
  if first.segment then sample_order=1; else sample_order=sample_order+1;
run;

proc sort data=tertiary; by segment tertiary_rand_no; run;
data tertiary;
  set tertiary;
  by segment tertiary_rand_no;
  retain sample_order 0;
  if first.segment then sample_order=1; else sample_order=sample_order+1;
run;
```

```
*** output the final selection datasets ***;

    data c.wet_grid_nosample; set wet_grid_nosample; run;
    data c.dry_grid_nosample; set dry_grid_nosample; run;
    data c.primary;           set primary;           run;
    data c.secondary_wet;     set secondary_wet;     run;
    data c.secondary_dry;     set secondary_dry;     run;
    data c.tertiary;          set tertiary;          run;
```

```
*****************************************************;
*                                                   *;
*                  JANICKI ENVIRONMENTAL, INC.      *;
*                                                   *;
*                                                   *;
*                                                   *;
* Project        : Pinellas County WQ Design        *;
*                                                   *;
* Program name   : Step-10b.sas                     *;
*                                                   *;
* Date           : Dec 31 2002                      *;
*                                                   *;
* Description    : Create sampling point tables     *;
*                                                   *;
* Input datasets : various                          *;
*                                                   *;
* Output datasets:                                  *;
*                                                   *;
* Programmer(s)  : David Wade                       *;
*                                                   *;
*                                                   *;
*****************************************************;
*                                                   *;
* History:                                          *;
*                                                   *;
*                                                   *;
* Jan 03 2003 dlw  reran with no change to this code *;
*                  change to input dataset          *;
*                                                   *;
*****************************************************;

options nodate nonumber sasautos=("c:.") noovp mprint mtrace ls=80  ps=59
formchar="³ÄÚÂ¿ÃÅ´ÀÁÙ";

libname c "c:"; run;
libname c6 v612 "c:"; run;
libname c8 v8 "c:"; run;



* GOPTIONS  PDF  *****************************************************;

 goptions reset=all  device=winprtc
          rotate=portrait
          ftext="Times"        ftitle="Times"
          htitle=0.25 in       htext=0.20 in;
          run;


 options  orientation =  portrait
            papersize =  letter
           leftmargin = "0.7 in"
          rightmargin = "0.7 in"
            topmargin = "0.7 in"
         bottommargin = "0.7 in" ;
 run;



 data primary;       set c.primary;       year="03"; run;
 data secondary_dry; set c.secondary_dry; year="03"; run;
 data secondary_wet; set c.secondary_wet; year="03"; run;
 data tertiary;      set c.tertiary     ; year="03"; run;

 proc sort data=primary;       by segment year period sample_order; run;
 proc sort data=secondary_dry; by segment year sample_order; run;
 proc sort data=secondary_wet; by segment year sample_order; run;
 proc sort data=tertiary;      by segment year sample_order; run;


ods pdf file="c:primary 2003 points.pdf";
    title1 "Pinellas County Water Quality Monitoring Schedule 2003"; run;
    title2 "Primary Sampling Points"; run;
    footnote1 "Prepared Jan 03, 2003"; run;
    footnote2 "Coordinates Presented in WGS 1984 Datum"; run;

    proc report data=primary headline headskip split="~";
      columns segment year period sample_order lat_dm lon_dm;
      define segment      / order   "Geographic~Reporting~Unit";
      define year         / order   "Year"                     ;
      define period       / order   "Sampling~Period~(1-9)"    ;
```

```
      define sample_order / order   "Preferred~Sampling~Order" ;
      define lat_dm       / display "Latitude~(Deg Min)"       ;
      define lon_dm       / display "Longitude~(Deg Min)"      ;
   run;
ods pdf close;



ods pdf file="c:secondary dry 2003 points.pdf";
    title1 "Pinellas County Water Quality Monitoring Schedule 2003"; run;
    title2 "Secondary Sampling Points (Jan 1-May 1 and Oct 11-Dec 31)"; run;
    footnote1 "Prepared Jan 03, 2003"; run;
    footnote2 "Coordinates Presented in WGS 1984 Datum"; run;

    proc report data=secondary_dry headline headskip split="~";
      columns segment year sample_order lat_dm lon_dm;
      define segment      / order   "Geographic~Reporting~Unit";
      define year         / order   "Year"                     ;
      define sample_order / order   "Preferred~Sampling~Order" ;
      define lat_dm       / display "Latitude~(Deg Min)"       ;
      define lon_dm       / display "Longitude~(Deg Min)"      ;
   run;
ods pdf close;



ods pdf file="c:secondary wet 2003 points.pdf";
    title1 "Pinellas County Water Quality Monitoring Schedule 2003"; run;
    title2 "Secondary Sampling Points (May 2 - Oct 10)"; run;
    footnote1 "Prepared Jan 03, 2003"; run;
    footnote2 "Coordinates Presented in WGS 1984 Datum"; run;

    proc report data=secondary_wet headline headskip split="~";
      columns segment year sample_order lat_dm lon_dm;
      define segment      / order   "Geographic~Reporting~Unit";
      define year         / order   "Year"                     ;
      define sample_order / order   "Preferred~Sampling~Order" ;
      define lat_dm       / display "Latitude~(Deg Min)"       ;
      define lon_dm       / display "Longitude~(Deg Min)"      ;
   run;
ods pdf close;


ods pdf file="c:tertiary wet 2003 points.pdf";
    title1 "Pinellas County Water Quality Monitoring Schedule 2003"; run;
    title2 "Tertiary Sampling Points For Entire Year of 2003"; run;
    footnote1 "Prepared Jan 03, 2003"; run;
    footnote2 "Coordinates Presented in WGS 1984 Datum"; run;

    proc report data=tertiary headline headskip split="~";
      columns segment year sample_order lat_dm lon_dm;
      define segment      / order   "Geographic~Reporting~Unit";
      define year         / order   "Year"                     ;
      define sample_order / order   "Preferred~Sampling~Order" ;
      define lat_dm       / display "Latitude~(Deg Min)"       ;
      define lon_dm       / display "Longitude~(Deg Min)"      ;
   run;
ods pdf close;


endsas;
```

```
*****************************************************;
*                                                   *;
*                   JANICKI ENVIRONMENTAL, INC.     *;
*                                                   *;
*                                                   *;
*                                                   *;
* Project        : Pinellas County WQ Design        *;
*                                                   *;
* Program name   : Step-10c.sas                     *;
*                                                   *;
* Date           : Jan  3 2002                      *;
*                                                   *;
* Description    : Create sampling point tables     *;
*                  In Excel format                  *;
*                  (same as step-10b.sas otherwise) *;
*                                                   *;
* Input datasets : various                          *;
*                                                   *;
* Output datasets:                                  *;
*                                                   *;
* Programmer(s)  : David Wade                       *;
*                                                   *;
*                                                   *;
*****************************************************;
*                                                   *;
* History:                                          *;
*                                                   *;
*                                                   *;
*                                                   *;
*****************************************************;

options nodate nonumber sasautos=("c:.") noovp mprint mtrace ls=80  ps=59
formchar="³ÄÚÂ¿ÃÅ´ÀÁÙ";

libname c "c:"; run;
libname c6 v612 "c:"; run;
libname c8 v8 "c:"; run;



* GOPTIONS  PDF  ****************************************************;

 goptions reset=all  device=winprtc
          rotate=portrait
          ftext="Times"        ftitle="Times"
          htitle=0.25 in       htext=0.20 in;
          run;


 options  orientation =  portrait
            papersize =  letter
           leftmargin = "0.7 in"
          rightmargin = "0.7 in"
            topmargin = "0.7 in"
         bottommargin = "0.7 in" ;
 run;



 data primary;       set c.primary;       year="03"; run;
 data secondary_dry; set c.secondary_dry; year="03"; run;
 data secondary_wet; set c.secondary_wet; year="03"; run;
 data tertiary;      set c.tertiary     ; year="03"; run;

 proc sort data=primary;       by segment year period sample_order; run;
 proc sort data=secondary_dry; by segment year sample_order; run;
 proc sort data=secondary_wet; by segment year sample_order; run;
 proc sort data=tertiary;      by segment year sample_order; run;



 data x;
   set primary;
    file "c:primary 2003 points.txt";

    lat_deg =int(lat);
    lat_min =(lat-int(lat))*60;

    lon=lon*-1;
    lon_deg =int(lon);
```

```
   lon_min =(lon-int(lon))*60;

   if _N_=1 then do;
     put '"Pinellas County Water Quality Monitoring Schedule 2003"';
     put '"Primary Sampling Points"';
     put '" "';
     put '"Prepared Jan 03, 2003"';
     put '"Coordinates Presented in WGS 1984 Datum"';
     put '" "';
     put '"Geographic Reporting Unit",'
         '"Year",'
         '"Sampling Period (1-9)",'
         '"Preferred Sampling Order",'
         '"Latitude (Deg)",'
         '"Latitude (Min)",'
         '"Longitude (Deg)", '
         '"Longitude (Min)"'     ;
   end;

   put '"' segment   '",'
       year          ','
       period        ','
       sample_order  ','
       lat_deg       ','
       lat_min       ','
       lon_deg       ','
       lon_min           ;
  run;



data x;
  set secondary_dry;
  file "c:secondary dry 2003 points.txt";

   lat_deg =int(lat);
   lat_min =(lat-int(lat))*60;

   lon=lon*-1;
   lon_deg =int(lon);
   lon_min =(lon-int(lon))*60;

   if _N_=1 then do;
     put '"Pinellas County Water Quality Monitoring Schedule 2003"';
     put "Secondary Sampling Points (Jan 1-May 1 and Oct 11-Dec 31)";
     put '" "';
     put '"Prepared Jan 03, 2003"';
     put '"Coordinates Presented in WGS 1984 Datum"';
     put '" "';
     put '"Geographic Reporting Unit",'
         '"Year",'
         '"Preferred Sampling Order",'
         '"Latitude (Deg)",'
         '"Latitude (Min)",'
         '"Longitude (Deg)",'
         '"Longitude (Min)"'     ;
   end;

   put '"' segment   '",'
       year          ','
       sample_order  ','
       lat_deg       ','
       lat_min       ','
       lon_deg       ','
       lon_min           ;
  run;


data x;
  set secondary_wet;
  file "c:secondary wet 2003 points.txt";

   lat_deg =int(lat);
   lat_min =(lat-int(lat))*60;

   lon=lon*-1;
   lon_deg =int(lon);
   lon_min =(lon-int(lon))*60;

   if _N_=1 then do;
     put '"Pinellas County Water Quality Monitoring Schedule 2003"';
```

```
      put  "Secondary Sampling Points (May 2 - Oct 10)";
      put '" "';
      put '"Prepared Jan 03, 2003"';
      put '"Coordinates Presented in WGS 1984 Datum"';
      put '" "';
      put '"Geographic Reporting Unit",'
          '"Year",'
          '"Preferred Sampling Order",'
          '"Latitude (Deg)",'
          '"Latitude (Min)",'
          '"Longitude (Deg)",'
          '"Longitude (Min)"'     ;
    end;

    put '"' segment   '",'
        year          ','
        sample_order  ','
        lat_deg       ','
        lat_min       ','
        lon_deg       ','
        lon_min          ;
   run;


 data x;
   set tertiary;
   file "c:tertiary wet 2003 points.txt";

    lat_deg =int(lat);
    lat_min =(lat-int(lat))*60;

    lon=lon*-1;
    lon_deg =int(lon);
    lon_min =(lon-int(lon))*60;

    if _N_=1 then do;
      put '"Pinellas County Water Quality Monitoring Schedule 2003"';
      put "Tertiary Sampling Points For Entire Year of 2003";
      put '" "';
      put '"Prepared Jan 03, 2003"';
      put '"Coordinates Presented in WGS 1984 Datum"';
      put '" "';
      put '"Geographic Reporting Unit",'
          '"Year",'
          '"Preferred Sampling Order",'
          '"Latitude (Deg)",'
          '"Latitude (Min)",'
          '"Longitude (Deg)",'
          '"Longitude (Min)"'     ;
    end;

    put '"' segment   '",'
        year          ','
        sample_order  ','
        lat_deg       ','
        lat_min       ','
        lon_deg       ','
        lon_min          ;
   run;
```

Appendix G

Pinellas County NPDES Permit

Appendix H

SAS Programs to Estimate Cumulative Distributions

Key to Appendix H SAS Sample Programs

Sample-cdf-data.sas	A complete SAS program that creates a realistic example chlorophyll-a dataset for a fictitious year of sampling.
Cdfdata.sas	A SAS macro to estimate cumulative area distributions.
Plot-cdf.sas	A SAS program that calls cdfdata.sas, and plots the results.

The SAS programs and example tables and figures are included in the following pages.

```
*****************************************************;
*                                                   *;
*                 JANICKI ENVIRONMENTAL, INC.       *;
*                                                   *;
*                                                   *;
*                                                   *;
* Project        : Pinellas County Water Quality Design*;
*                                                   *;
* Program name   : sample-cdf-data.sas              *;
*                                                   *;
* Date           : April 3 2003                     *;
*                                                   *;
* Description    : Make an example dataset          *;
*                  of simulated chlorophyll a data  *;
*                  for one year of sampling.        *;
*                                                   *;
* Input datasets : none                             *;
*                                                   *;
* Output datasets: sample.sas7bdat                  *;
*                                                   *;
* Programmer(s)  : David Wade                       *;
*                                                   *;
*                                                   *;
*****************************************************;
*                                                   *;
* History:                                          *;
*                                                   *;
*                                                   *;
*                                                   *;
*****************************************************;

options sasautos=("c:.") noovp mprint mtrace ls=132 ps=59 formchar="³ÄÚÂ¿ÃÅ´ÀÁÙ";

libname c "c:"; run;


*** Create the overall population of fictious chlorophyll data ***;

data population;
      length stratum $ 2;

      year=2003;

      do hex = 1 to 18;   *** grids were sized to expect approximately 18 hits per
stratum
                              taking into account proportion of cells that are land
                              and proportion of stations that cannot be reached in the
field ***;

        do samples=1 to 50;

                 stratum = "T";
             stratum_size = 1035;
                 hex_size = 54;
            chlorophyll_a = (log(normal(131))*-1)*5+20;
            output;

                 stratum = "W1";
             stratum_size = 6766;
                 hex_size = 335;
            chlorophyll_a = (log(normal(721))*-1)*3+8;
            output;

        end;

      end;


    label       stratum = "Sampling Stratum"
          chlorophyll_a = "Chlorophyll-a (ug/L)"
               hex_size = "Hex Area (ha)"
                   year = "Year"
           stratum_size = "Stratum Area (ha)";

run;

title1 "Chlorophyll a Data Population"; run;
proc sort data=population; by stratum; run;
proc univariate plot normal data=population;
  var chlorophyll_a;
  by stratum;
run;


*** create a sample for 1 year to demonstrate cdf estimation programs ***;

    data w1;
      set population;
      if stratum="W1" and chlorophyll_a ne .;
    run;
    data w1; set w1; if _N_<=36; hex=_N_; run;
```

```
data t;
  set population;
  if stratum="T"  and chlorophyll_a ne .;
run;
data t ; set t ; if _N_<=36; hex=_N_; run;

data c.sample; set w1 t;  drop samples; run;

title1 "Sample Chlorophyll a Data"; run;
proc print data=c.sample noobs label; run;
```

```
*****************************************************.
*                                                   *;
*                 JANICKI ENVIRONMENTAL, INC.       *;
*                                                   *;
*                                                   *;
*                                                   *;
* Project        : Pinellas County Water Quality Design*;
*                                                   *;
* Program name   : cdfdata.sas                      *;
*                                                   *;
* Date           : April 3 2003                     *;
*                                                   *;
* Description    : Sample Calculation of CDF data   *;
*                                                   *;
* Input datasets : sample.sas7bdat                  *;
*                                                   *;
* Output datasets: cdf_data.sas7bdat                *;
*                                                   *;
* Programmer(s)  : David Wade                       *;
*                                                   *;
*                                                   *;
*****************************************************;
*                                                   *;
* History:                                          *;
*                                                   *;
*                                                   *;
*                                                   *;
*****************************************************;

options sasautos=("c:.") noovp mprint mtrace ls=132 ps=59 formchar="³ÄÚÂ¿ÃÅ´ÀÁÙ";

libname c "c:"; run;

********************************************************************.
*                                                                  *;
*           Citation of Original Developer                         *;
*                                                                  *;
* Abstract: EMAP Estimator macros provided by Gulf Breeze          *;
*           Laboratory (Engle 2001)                                *;
*                                                                  *;
*                                                                  *;
*           Modified into a standalone macro with year as a parameter *;
*                                                                  *;
*     sendout = name of permanent data set containing data         *;
*     vname   = name of variable to be analyzed within sendout     *;
*     year    = 4 digit year                                       *;
*     sname   = name of station sendout                            *;
*     outlib  = name of the output library                         *;
*                                                                  *;
********************************************************************;

option spool;

%macro cdfdata(sendout,vname,year,dname);

         %let  sname=c.stations;
         %let  outlib=work.;

  *****************************************************************.
  * THE_DATA CONTAINS THE STATION ID, VARIABLE UNDER CONSIDERATION *;
  * AND THE AREA ASSOCIATED WITH THAT STATION.  THERE MAY OR MAY   *;
  * NOT BE MULTIPLE OBS AT ANY PARTICULAR STATION.                 *;
  *****************************************************************;

  data the_data;
     set c.&sendout;

     class=stratum;
  run;

  data the_data;
    set the_data;

     if year=&year;
  run;

  proc sort data=the_data;
     by &vname; run;

  data x_axis(keep=x);           *** X_AXIS CONTAINS ONE COPY OF EACH   ***;
     set the_data;               *** VALUE OF THE VARIABLE NAME FOR THE ***;
     by &vname;                  *** ENTIRE DATA SET                    ***;
     if &vname ne .;
     x = &vname;
     if last.&vname then output;
  run;
*--------------------------------------------------------------*;
```

```
%macro class(class);

data data1_&class(keep = hex class &vname hex_size)
       num_&class(keep=n_&class n2_&class);
  set the_data end=lastobs;

    if class = "&class" then output data1_&class;
    if class = "&class" then n_&class+1;
    if class = "&class" and &vname ne . then n2_&class+1;
    if lastobs then output num_&class;
run;


data data_&class;                  *** CONTAINS-STATION CLASS &VNAME HEX_SIZE ***;
  if _n_ = 1 then set num_&class;   *** NUMBER OF OBS IN EACH SIZE CLASS ***;
  set data1_&class;
  if &vname ne .;
run;


%mend class;

*------------------------------------------------------------*;



*CALL CLASS MACROS*;

%class(W1);
%class(T);


*-----------------------------------------------------------*;

%macro constant(w1_area,t_area);


** CALCULATE THE Horvitz-Thompson ESTIMATE IS THE SAME FOR EVERY    **;
** SIZE CLASS.  THEREFORE, A MACRO HAS BEEN CREATED TO PASS THRU    **;
** 2 DISTINCT SETS OF VARIABLE NAMES SO THAT UNIQUE DATA SETS WILL  **;
** BE CREATED EACH TIME THE MACRO IS RUN.                           **;


    %macro large(n,n2,data,end,mse,phat,upper,lower);

    data normal;
       set x_axis;
         n1=0;
         pointer=0;
         do until(pointer = &n2);
            pointer+1;
            set &data point=pointer;
            n1+1;                          *** COUNT NUMBER STATIONS IN SAMPLE ***;
            if &vname le X then Yi = 1;    *** INDICATOR VARIABLE CREATED AS IN ***;
               else Yi = 0;                *** SMALL ESTUARY SECTION            ***;
            Pi = hex_size / (&n * hex_size);  *** INCLUSION PROBABILITY         ***;
            output normal;
         end;



    proc means noprint max sum data=normal;
       by x;                        *** creates summary for every value of X ***;
       var n1 hex_size;
       output out=next1 sum = n2tot tothex_size  max = nii maxhex_size;

    data next2;
       keep x yi pi nii tothex_size;
       merge normal next1;
       by x;

    data copy2;   *** CREATES A SECOND COPY OF THE DATA ***;
      set next2;
   nj = nii;
   Yj = Yi;
   Pj = Pi;
   Aj = tothex_size;
   keep x nj Yj Pj Aj;



*  NEXT STEP COMPLETES DOUBLE SUMMATION.  THE FIRST SUMMATION IF OVER *
*  X WITH VARIABLES DENOTED WITH i.  THE SECOND SUMMATION, j, MUST    *
*  START AT ONE HIGHER INCREMENT THAN i.  Pij DENOTES THE PROBABILITY *
*  THAT SITES i AND j ARE SELECTED FOR SAMPLING.                      *;


data &end;
   set next2;
   by x;
   retain &mse 0 phat 0 obs 0 firstobs;
```

```
   obs+1;
   if first.x then do;
     &mse=0;
     phat=0;
     firstobs=obs;
   end;

   k=obs;
   phat = phat + (Yi/nii);       *** GIVEN EQUAL HEX_SIZES WITHIN A CLASS ***;
   hold = 0;
   do j = (k + 1) to (firstobs + nii - 1);   *** j LOOP MUST START AT ONE ***;
      set copy2 point = j;                   *** INCREMENT HIGHER THAN i  ***;
      if _error_ then abort;                 *** i.e., k+1       ***;
      Pij   = (2*(nii-1)*Pi*Pj)/(2*nii - Pi - Pj);
      part1 = (Pi*Pj - Pij)/Pij ;
      part2 = (Yi*Pi - Yj*Pj)**2 ;
      hold  = hold + part1 * part2;
   end;
   &mse = &mse + hold;

   if last.x then do;
      &phat = phat;


*** NEXT COMPUTE 95% CONFIDENCE INTERVALS ***;

      &upper=&phat+(1.96*sqrt(&mse));
      &lower=&phat-(1.96*sqrt(&mse));
      output;
   end;
   keep x &phat &mse &upper &lower;

%mend large;
*------------------------------------------------------------*;

*** RUN THIS ROUTINE FOR EACH SIZE CLASS ***;

  %large(n_w1,n2_w1,data_w1,w1_end,w1_mse,w1_phat,w1_upper,w1_lower);
  %large(n_t,n2_t,data_t,t_end,t_mse,t_phat,t_upper,t_lower);
*--------------------------------------------------------------------------*;


data combined;
   merge w1_end t_end;
   by x;
run;


data pc1;
   set combined;

             ** PHAT FOR ALL SIZE CLASSES COMBINED **;

   w_area1 = &w1_area + &t_area;


   w1_wt1 = &w1_area/w_area1;
   t_wt1  = &t_area /w_area1;

   phat1 = (w1_wt1 * w1_phat) + (t_wt1 * t_phat);

   mse1  = (w1_wt1**2 * w1_mse) + (t_wt1**2 * t_mse);

   upper1 = phat1 + 1.96 * sqrt(mse1);
   lower1 = phat1 - 1.96 * sqrt(mse1);

   phat1  = 100 * phat1;
   upper1 = 100 * upper1;
   lower1 = 100 * lower1;


   *** INDIVIDUAL CLASS ESTIMATES ***;

   w1_phat  = 100 * w1_phat;
   w1_upper = 100 * w1_upper;
   w1_lower = 100 * w1_lower;
    t_phat  = 100 * t_phat;
    t_upper = 100 * t_upper;
    t_lower = 100 * t_lower;

   label phat1     = 'Cumulative Percent'
         upper1    = 'Upper 95% CI'
         lower1    = 'Lower 95% CI'
         w1_phat  = 'Cumulative Percent'
         w1_upper = 'Upper 95% CI'
         w1_lower = 'Lower 95% CI'
         t_phat  = 'Cumulative Percent'
         t_upper = 'Upper 95% CI'
         t_lower = 'Lower 95% CI'
        ;

run;
```

```
*----- OUTPUT DATASETS ------*;

** ALL PINELLAS COUNTY **;

data &outlib.pc&dname;
   set pc1;
   keep x phat1 upper1 lower1;
   rename phat1=phat upper1=upper lower1=lower;

** W1 **;

proc sort data=pc1 out=w1;
   by w1_phat;

data &outlib.w1&dname(keep=x w1_phat w1_upper w1_lower);
   set w1;
   if (w1_phat gt 0) and (first.w1_phat);
   by w1_phat;


** T **;

proc sort data=pc1 out=t;
   by t_phat;

data &outlib.t&dname(keep=x t_phat t_upper t_lower);
   set t;
   if (t_phat gt 0) and (first.t_phat);
   by t_phat;


%mend constant;



%constant(6216,1035);   *** SAMPLEABLE AREA IN HECTARES OF EACH STRATUM ***;


** END MAIN MACRO **;

%mend cdfdata;
```

```
/*****************************************************
**
**                   JANICKI ENVIRONMENTAL
**
**  Project        :   002002-04
**
**  Program name   :  plot-cdf.sas
**
**  Date           :   April 3 2003
**
**  Description    :   Classifying Area by Pinellas Co Strata
**
**  Input datasets :
**
**  Output datasets:
**
**  Programmer(s)  : dw - modified mw
**
*
*
*****************************************************************/

    options sasautos=("c:.") noovp nonumber mprint mtrace ls=80
            ps=68 formchar="³ÄÚÂ¿ÃÅ´ÀÁÙ";

    libname c 'c:'; run;

   *---------------------------------------------------*;
   *  PDF GOPTIONS                                      *;
   *---------------------------------------------------*;
    goptions reset=all            device=winprtc
             ftext="Times"        ftitle="Times" CTEXT=Black
             htitle=17pt          htext=17pt
             rotate=landscape
             ;
             run;

    options  orientation =  landscape
             nodate nonumber nonotes nostimer
               papersize =  letter
              leftmargin = "0.7 in"
             rightmargin = "0.7 in"
               topmargin = "0.5 in"
            bottommargin = "0.5 in" ;
    run;




*       CALL MACRO TO GET DATASET IN RIGHT FORMAT              *;
*                                                              *;
*   dataset = name of permanent data set containing data       *;
*   vname   = name of variable to be analyzed within dataset   *;
*   year    = 4 digit year                                     *;


*-----------------------------------------------*;
*            MACRO FOR PLOTTING                 *;
*                                               *;
* %plotmac(dset,seg,titlyr,type,type,high,by)   *;
*;
*-----------------------------------------------*;

%macro plotmac(dset,seg,titlyr,type,high,by);

  *-------------------------------------------------*;
  *            CREATE MACRO VARIABLES               *;
  *-------------------------------------------------*;

       %if "&seg" = "W1" %then %let segarea= 6216;
       %if "&seg" = "T"  %then %let segarea= 1035;

       %if "&seg" = "W1" %then %let titlseg="West-1 Stratum";
       %if "&seg" = "T"  %then %let titlseg="Lake Tarpon Stratum";


  *-------------------------------------------------*;
  *                FIX DATASET                     -*;
  *-------------------------------------------------*;

    data plot;
      set &dset;
```

```
        by &seg._phat;
        if (&seg._phat gt 0) and (first.&seg._phat);
    run;

  *------------------------------------------------*;
  *       ADD A ZERO SO ONLY PLOTS UNDER CURVE      *;
  *------------------------------------------------*;

  data zero;
    x=0;
    &seg._phat=0;
    &seg._upper=0;
    &seg._lower=0;
  run;

  data plot2;
    set zero plot;
  run;

  data plot2;
    set plot2;

    phat_acre =((&seg._phat/100) *&segarea.)/1000;
    upper_acre=((&seg._upper/100)*&segarea.)/1000;
    lower_acre=((&seg._lower/100)*&segarea.)/1000;

     phat_acre=round(phat_acre,.01);
    upper_acre=round(upper_acre,.01);
    lower_acre=round(lower_acre,.01);

  run;

  *------------------------------------------------*;
  *               CREATE TABLE                      *;
  *------------------------------------------------*;

  data fortab;
     set plot2;

   label          x = "&type"
         &seg._phat = "Cummlative % of &type"
        &seg._upper = "Upper 95% Confidence Limit of Cumulative % of &type"
        &seg._lower = "Lower 95% Confidence Limit of Cumulative % of &type"
          phat_acre = "Area of &type (1000 ha)"
         upper_acre = "Upper 95% Confidence Limit of Area (1000 ha)"
         lower_acre = "Lower 95% Confidence Limit of Area (1000 ha)"
      ;

  run;

  ods printer pdf file="&dset._table.pdf";
  options nodate;

  Title1 j=c "Estimates of Areal Extent of &type in &titlyr";
  Title2 &titlseg;

  proc print data=fortab noobs label;
  run;

  ods printer close;


*----------------------------------------------*;
*               BEGIN PLOTTING                 *;
*----------------------------------------------*;


  *-------- GOPTIONS - PDF  ------------------------*;

  goptions  device=pdfc        fcache=30
             ctext=black       gsfmode=replace
            ftitle=hwpdf009     ftext=hwpdf009
            htitle=0.20 in      htext=0.15 in
           horigin=0 in       vorigin=0 in
              hpos=0              vpos=0
             hsize=8.5          vsize=9
            noprompt             nodisplay;
  run;
  *------------------------------------------------*;


  *------ OPTIONS  ------------------------*;

  Title1 j=c " " ;
```

```
Title2 j=c "Estimates of Areal Extent of Chlorophyll-a &type in &titlyr";
Title3 j=c " " ;
Title4 j=c &titlseg;

Symbol1 v=none  i=join  ci=blue   W=8 ;
Symbol2 v=none  i=join  ci=BIG    W=8 ;

pattern1 color=LIGR  value=solid;
pattern2 color=none  value=solid;
pattern3 color=none  value=solid;


AXIS1 major=(W=1   H=.6 )
      minor=none
      order=(0 to 100 by 5)
      label=(j=l "Cumulative %       " j=l " " j=l "of Area      ")
    ;

AXIS2 major=( W=1   H=.6 )
      minor=( W=0.4 H=0.3)
      label=(j=c "&type")
    ;

*----------------------------------------*;



*---------------------------------------*;
*               PLOT 1                  *;
*---------------------------------------*;

    proc gplot data=plot2 gout=plotcat;

      plot &seg._phat *x=1
           &seg._upper*x=2
           &seg._lower*x=2
           &seg._phat *x=1
                        /skipmiss overlay area=1 vaxis=axis1 haxis=axis2

           ;

       label x = "00"x;

       data dummy;  x=1;  *  <---- THIS TRICKS SAS INTO MAKING THE PLOT
                                   WITHOUT DOUBLING ALL OF THE FEATURES;

    run;


*---------------------------------------*;
*               PLOT 2                  *;
*---------------------------------------*;

 Title2 "  ";
 Title4 "  ";


 AXIS3 major=(W=1   H=.6 )
       minor=(W=0.4 H=0.3)
       order=(0 to &high by &by)
       label=(j=l "Area                 " j=l " " j=l "(1000 ha)            ");

 AXIS4 major=( W=1   H=.6 )
       minor=( W=0.4 H=0.3)
       label=(j=c "&type")
     ;  run;

 data dummy; x=1; run;

*----------------------------------------*;

  proc gplot data=plot2 gout=plotcat ;

     plot phat_acre  *x=1
          upper_acre *x=2
          lower_acre *x=2
          phat_acre  *x=1  /overlay area=1 vaxis=axis3 haxis=axis4
          ;

      label x = "00"x;

      data dummy;  x=1;  *  <---- THIS TRICKS SAS INTO MAKING THE PLOT
                                  WITHOUT DOUBLING ALL OF THE FEATURES;

  run;


*---------------------------------------*;
```

```
  *          DUMMY PLOT FOR GRID         *;
  *-------------------------------------*;

     proc gplot data=plot2 gout=plotcat ;

       plot phat_acre  *x=1
            upper_acre *x=2
            lower_acre *x=2
            phat_acre  *x=1  /overlay autohref autovref frame lvref=20 lhref=20
                              vaxis=axis3 haxis=axis4
            ;

        label x = "00"x;

        data dummy;  x=1;  *  <---- THIS TRICKS SAS INTO MAKING THE PLOT
                                    WITHOUT DOUBLING ALL OF THE FEATURES;

     run;

%mend;


*----------------------------------------------------------*;
*                   OUTPUT PDFS MACRO                      *;
*----------------------------------------------------------*;

%macro outpdf(g);

  *---- PDF GOPTIONS --------*;

     goptions gsfname=g&g noprompt display vsize=0 hsize=0;  run;

     * FILENAMES *;

       filename g1  "chla-2003.pdf";

  *-------------------------------------*;

  proc greplay igout=plotcat tc=tempcat nofs;
               tdef topbot
                    1 /llx=0    lly=50
                       ulx=0    uly=100
                       lrx=100  lry=50
                       urx=100  ury=100

                    2 /llx=0    lly=0
                       ulx=0    uly=50
                       lrx=100  lry=0
                       urx=100  ury=50
                    ;

               device=pdfc ;
               template topbot; *W1*;
               treplay 1:1
                       2:2
                       2:3;

               template topbot; *T*;
               treplay 1:4
                       2:5
                       2:6;

               end;
    run;

   proc greplay igout=plotcat nofs;
                delete _All_;
                end;
   run;

%mend;

*---------------------------------------------*;
*            MAIN MACRO CALLS                 *;
*---------------------------------------------*;

*plotmac(dset,seg,titlyr,type,high);
*cdfdata(sendout,vname,year,dname)*;
*outpdf (g)*;


*---------------- 2003 Chlorophyll a --------------------*;

 %cdfdata(sample, chlorophyll_a, 2003, chla2003);   run;
```

```
 %plotmac(w1chla2003, W1 , 2003, Chlorophyll-a, 7, 1);
 %plotmac( tchla2003, T  , 2003, Chlorophyll-a, 1.1, .1);

 %outpdf(1);

proc datasets library=work kill;
run;
```

Appendix I

Sampling Effort Review Technical Memorandum

TECHNICAL MEMORANDUM:
2003 PRE-SAMPLING
WATER QUALITY SAMPLING EFFORT REVIEW
PINELLAS COUNTY, FLORIDA

May 8, 2003

Prepared for:

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Background

The Pinellas County Department of Environmental Management (DEM) has defined a new water quality monitoring program, and has begun sampling for the year 2003. This technical memorandum provides a review of the efficacy of the sampling effort of the new water quality program, based on analyses of historical data from a previous water quality monitoring program.

In future years, the DEM will review the cumulative and recent annual monitoring results from the previous years of sampling in order to determine if any adjustments to the sampling program are required for future years. Examples of potential adjustments include:

- Reducing or increasing the sample size for specific reporting units (based on power analysis of the data collected in previous years); and
- Re-allocating sampling effort to particular sampling strata (e.g., moving effort from the dry season to the wet season based on power analysis of data collected to date).

Since data from the first year of sampling (i.e., 2003) have not been collected at this time, the review conducted for this technical memorandum was based on historical water quality data.

Historical Pinellas County Water Quality Sampling Program

The Pinellas County Department of Environmental Management has conducted coastal ambient surface water quality monitoring from 1991 through 2002. This existing 1991-2002 ambient surface water quality monitoring program was designed to collect monthly surface water quality data at a series of fixed stations at locations of interest. The site locations were selected in order to represent ambient surface water quality conditions, and the data were summarized and reported on an annual basis.

The existing fixed-station program does not allow statistical estimation or trend analysis for the water bodies as regions, but limits inferences to the locations of the fixed stations. The locations of the fixed stations were chosen using professional judgment. In some cases, the site locations were chosen to monitor the effects on water quality of discharges from known or suspected pollution sources.

The existing monitoring program collected data using a non-probabilistic sampling schedule, and the degree to which the sampled days are representative of the annual daytime surface water quality conditions is unknown.

Objectives

The objectives of this sample size review were:

- to compare the statistical power of the current intra-annual sampling effort allocation among wet season and dry season to alternative sampling effort allocation strategies based on historical data; and

- to compare the statistical power of the current total annual sampling effort to alternative sampling effort strategies based on historical data.

Methods

The DEM consultant defined the fundamental approach of this review to simulate random samples of annual data for an extreme sampling stratum of the new sampling program design, and then apply Monte Carlo statistical tests to the random samples to estimate the power to detect changes in the water quality parameters.

SAS programs to generate the Monte Carlo sampling pools (step-2a.sas) and to analyze the statistical power results (step-2b.sas) are included in this appendix.

Simulated Water Quality Samples

The DEM consultant simulated water quality data for one year of sampling under the new water quality design in an example stratum. The example stratum applied was stratum W-2, and the location of this stratum is presented in Figure 3-1 in the main body of this document. Historical water quality data were available from six fixed stations that were previously located in this stratum. The Pinellas County station numbers for these stations were 9-1, 10-1, 54-1, 54-4, 54-3, and 54-2. DEM located two of these stations in in-shore estuarine waters (9-1 and 10-1), and the others were located offshore between the Pinellas Peninsula and the barrier islands.

The statistical populations that were sampled for this review were generated by constructing standard probability cumulative density functions using historical data pooled from 1991-2002 for the six stations. The probability cumulative density functions were constructed for chlorophyll-a, conductivity, dissolved oxygen, ammonia, NOx species, orthophosphate, pH, salinity, Secchi disk depth, temperature, total Kjeldhal nitrogen, total phosphorous, total suspended solids, and turbidity.

Statistical Power

The DEM consultant tested the probability of detecting a true 10-percent, 15-percent, and 20-percent change in the population location (i.e., measure of central tendency) for each parameter by using standard statistical tests at an alpha level of 0.05. Because many of the water quality parameters tested did not have normal distributions, non-parametric methods were used to test for the differences in the population locations. Two non-parametric methods were applied to test for differences in each pair of baseline population and shifted population, and these methods were the Kruskal-Wallis test, and the Savage test (SAS Institute, Cary, North Carolina, NPAR1WAY Procedure ®). The widely used Kruskal-Wallis test first ranks all of the data across both the baseline population and the shifted population, and then tests for a significant difference between the locations of the two populations by comparing the sums of the ranks within each population using a test statistic and test statistic distribution. Thus, the Kruskal-Wallis test is robust to non-normally distributed data. The statistical power of the Savage test was also examined because the test is also robust to non-normally distributed data and it is expected to have a greater statistical power for parameters with occasional extreme values (e.g., chlorophyll concentration). The Savage test compares the locations of the two populations using Savage scores based on the exponential distribution. Two-hundred statistical tests were completed for each type of statistical test for each true difference (i.e., 10%, 15%, 20%) and sampling effort allocation that was tested.

Due to the limited geographic coverage of the six historical fixed stations available for this analysis, a power test of the proportion of area statistics was not conducted. However, Figure 5-19 in the main body of this document presents the expected 95% confidence limits for varying sample sizes of the Horovitz-Thompson proportion of area estimators based on Benthic data from the Tampa Bay Estuary Program.

Definition of Wet Season and Dry Season

The DEM consultant defined wet season and dry season in terms of the nine evenly spaced temporal sampling periods employed in the new water quality sampling program. Each of these nine periods encompasses a primary time window of 25 days of potential sampling dates. Rainfall data from the National Climatic Data Center were averaged for each of these 25 days for the period of record, and totaled within each of the nine temporal sampling periods. The rainfall data were compiled from the Clearwater, St. Petersburg, Tampa, and Tarpon Springs rainfall stations. The wet season was defined as periods four through seven, this corresponded to a calendar period of May 2 through October 10. The remaining five time periods were defined as the dry season.

Comparisons

The statistical power comparisons were made to address the objectives of this task discussed above.

- <u>Compare three scenarios of wet season / dry season sampling allocation</u>

  current 2003 allocation: 4 samples per stratum per period in the wet season (16 total)
  4 samples per stratum per period in the dry season (20 total)

  increase in dry season: 3 samples per stratum per period in the wet season (12 total)
  5 samples per stratum per period in the dry season (20 total)

  increase in wet season: 5 samples per stratum per period in the dry season (20 total)
  3 samples per stratum per period in the wet season (15 total)

- <u>Compare three scenarios of varying total sampling effort</u>

  current 2003 allocation: 4 samples per stratum per period in the wet season (16 total)
  4 samples per stratum per period in the dry season (20 total)

  decrease total effort: 3 samples per stratum per period in the wet season (12 total)
  3 samples per stratum per period in the dry season (15 total)

  Increase total effort: 5 samples per stratum per period in the dry season (20 total)
  5 samples per stratum per period in the wet season (25 total)

Results

The results of the comparisons of the three scenarios of wet season and dry season sampling effort allocation are presented in Table series I-1. The power estimates provided in these tables represent the percentage of the time that a true difference between years could be detected given the sample size tested. The results indicated that the power to detect changes in the ten to twenty percent range was low for some parameters (e.g., chlorophyll-a) and high for other parameters (e.g., salinity). The shifting of sampling effort to either wet season or dry season resulted in similar power quantities.

The results of the comparisons of the three scenarios of varying total sampling effort are presented in Table series I-2. As previously stated, the power estimates provided in these tables represent the percentage of the time that a true difference between years could be detected given the sample size tested. The results indicated that the increases in total sampling effort greatly improved the statistical power for some parameters (e.g., dissolved oxygen), and to a lesser extent for other parameters (e.g., chlorophyll-a).

Discussion

The relatively low power observed for some parameters in this analysis may be the result of the few fixed stations that were available for analysis. For example, if one or more of these stations had a distinctively different water quality condition than the other stations, then the increased variation observed in the historical data may not have been representative of the variation in the W-2 stratum as a whole. The new probabilistic-based water quality program for 2003 is expected to correctly represent the variation of the stratum as a whole, and the strata were delineated to encompass relatively homogenous areas of the County with respect to expected water quality. Thus, the power from the 2003 sampling effort will likely be higher than that observed for this review.

Recommendations

The DEM consultant recommends that the DEM review the first year, 2003, monitoring results promptly after they are collected in order to determine if any adjustments to the sampling program are required for future years. Examples of potential adjustments include:

- Reducing or increasing the sample size for specific reporting units (based on power analysis of the data collected in previous years); and

- Re-allocating sampling effort to particular sampling strata (e.g., moving effort from the dry season to the wet season based on power analysis of data collected to date).

This review should include statistical power of both the proportion of area estimates and the stratified-random estimates of population locations (i.e., measures of central tendency).