Establishing Water Clarity Targets for Sarasota County Estuarine Waters

Technical Memorandum

DRAFT

Prepared for:

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INTRODUCTION:

The quality and clarity of estuarine waters has important scientific implications for estuarine ecosystems and is an observable phenomenon that is of great interest to the general public. In Sarasota County, water clarity has declined from increasing nutrient pollution, discharge of sediments, and changes in runoff volume from watersheds. Additionally, the community has voiced concern about water clarity in several estuarine waterbodies of Sarasota County.

Water clarity is generally measured either by a secchi disk reading in which one follows the descent of the disk to a depth in the water column where it is just barely visible; or by an electronic meter that measures light attenuation through the water via two sensors spaced a constant distance apart (e.g., 0.5m) under the waters surface. While water clarity is measurable, from a management perspective water clarity can only be managed through manipulation of water quality parameters. Water quality parameters that affect light attenuation include; color, turbidity, and suspended matter as well as phytoplankton concentrations (usually measured as chlorophyll a concentrations) that are thought to be limited by nutrient inputs such as nitrogen and phosphorus species.

Many of the estuarine waters in Sarasota County have chlorophyll-a concentrations that are near the thresholds described in the Florida Impaired Waters Rule, or “IWR” (Chapter 62-303, Florida Administrative Code); and therefore, may have required pollutant load reductions assigned to them through the state’s Total Maximum Daily Load (TMDL) Program (PBS&J 2006). In particular, Roberts Bay (WBID 1968D) and Blackburn Bay (WBID 1968F) are currently listed as impaired for historical increases in chlorophyll-a. Upper Lemon Bay (WBID 1983A) is also listed as impaired for chlorophyll-a (exceedance of the 11 µg/L threshold). Therefore, chlorophyll-a concentration is a measure of great concern with respect to managing estuarine water quality and water clarity in Sarasota County.

Sarasota County is partnering with the Environmental Protection Agency (EPA), The Florida Department of Environmental Protection (FDEP) and other agencies to develop Basin Management Action Plans (BMAP) to manage activities and implement projects to restore and protect valuable estuarine resources. As part of that goal, Sarasota County Water Resources has set out to establish water clarity targets for Sarasota County estuarine waters that are;

- objective
- scientifically defensible,
- geographically specific,
- related to a valued natural resource, and
- linked to a human activity that can be managed.

Goals and Objectives:

The goal of this project was to develop water clarity targets which are scientifically defensible and also easily understood by the non-scientific community such that Sarasota County can bolster community activism in protecting their valued natural resources. Once the water clarity targets are identified, estuarine response models, including deterministic and empirically based water quality models, can support management decisions on how to most effectively protect water clarity in these estuarine waters of concern. The objectives listed below represent a series of steps we used to establish water clarity targets in Sarasota County estuarine waters based on the best available scientific information and related to requirements for a valued natural resource whenever possible.

Several objectives were identified in order to define the appropriate mechanisms for developing water clarity targets. The defined objectives were to:

1) Identify water quality parameters that influence water clarity in Sarasota County waters.

2) Identify a segmentation scheme to divide Sarasota County waters into areas (segments) where the empirical distributions of water quality parameters tend to be similar to establish geographically specific water clarity targets.

3) Identify a valued natural resource component and criterion for protection of the resource

4) Identify a resource based water clarity target that protects the valued resource.

5) Identify status and trends for each water quality parameter of interest for each segment that may influence management decisions about how best to protect the resource

6) Translate the scientific information derived from these analyses to the non-scientific community to encourage activism in protecting the valued resource.

Approach:

The following outlines the approach used to accomplish the specific objectives listed above.

- Step1 *Identify water quality parameters which influence or are related to water clarity in Sarasota County waters*.

A master dataset of all measured water quality parameters was compiled primarily using the Sarasota County Water Atlas (http://www.wateratlas.usf.edu/) and augmented by data from the Florida Department of Environmental Protections legacy STORET database. The specific water quality parameters identified for analysis included:

- Chlorophyll a (ug/l)
- Color (pcu)
- Total Nitrogen (mg/l)
- Total Phosphorus (mg/l)
- Salinity (ppt)
- Secchi disk depth (m)
- Dissolved Oxygen (mg/l)
- Total Suspended Solids (mg/l)
- Turbidity (NTU)
- Light Attenuation (K)

Once these parameters were subset from the master database, the data were imported into ArcGIS (ESRI, 2005) and plotted based on listed geographic coordinates. The majority of these data represent a fixed location sampling scheme conducted under the direction of the Sarasota County Ambient Water Quality Monitoring Network. The GIS software was used to assign the water quality data to the existing segmentation schemes including the County sampling scheme and the FDEP water body identifiers (WBID).

- Step 2 *Identify a segmentation scheme to divide Sarasota County waters into areas (segments) where the empirical distributions of water quality parameters tend to be similar to establish geographically specific water quality targets.*

Previously established segmentation schemes include the Sarasota County Ambient Water Quality Monitoring Network segmentation scheme (Figure 1) and the FDEP Waterbody Identifiers (WBIDs; Figure 2). To identify a segmentation scheme for establishing water clarity targets, water quality data were examined for similarities in their distributions across county waters. A cumulative distribution function (CDF) of the empirical data for each water quality parameter of interest was generated for each estuarine segment and compared against one other. Segmentation schemes were then compared by comparing the distribution for each water quality parameter of interest across existing segmentations.

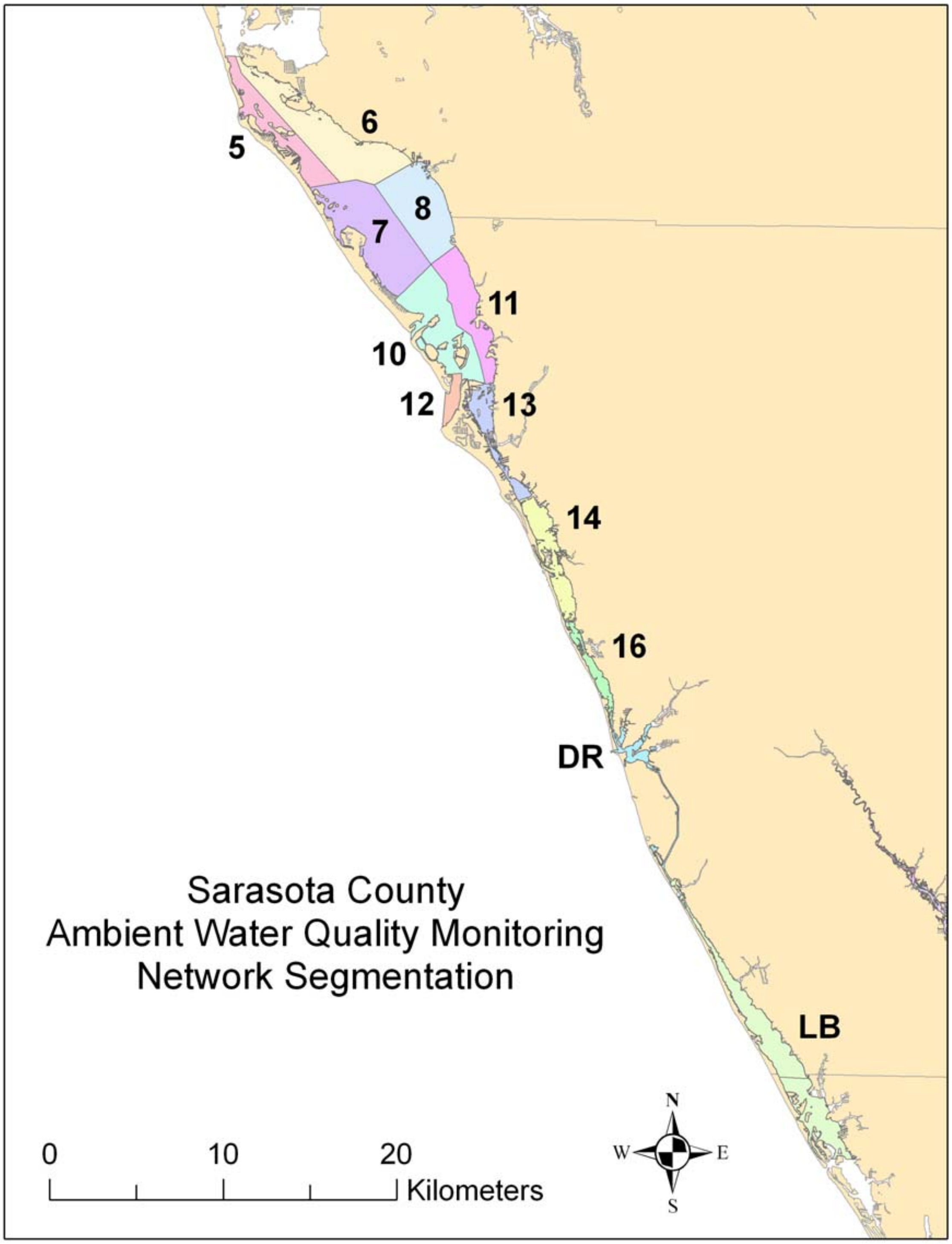

Figure 1. Sarasota County Ambient Water Quality Monitoring Network segmentation scheme.

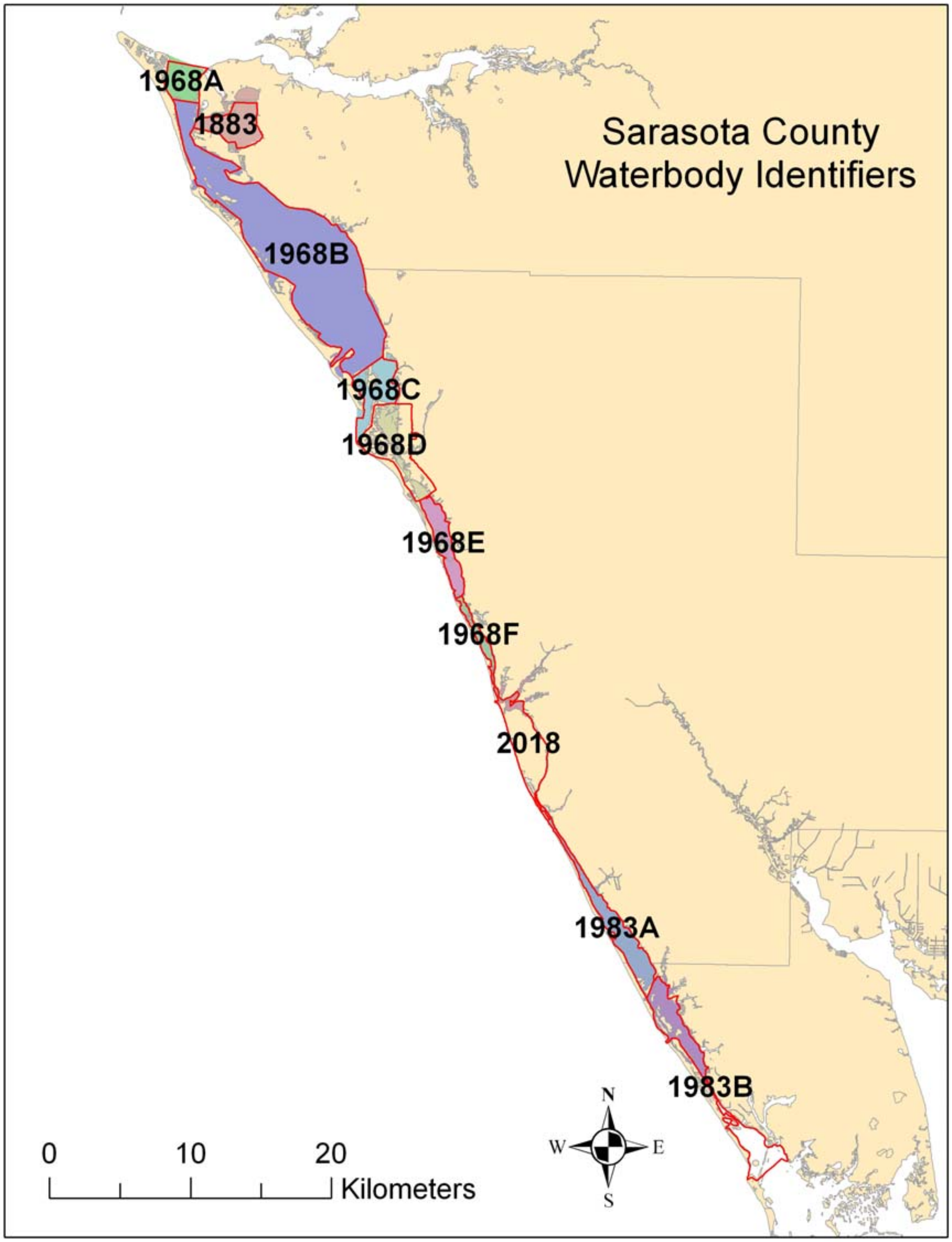

Figure 2. Sarasota County Waterbody Identifiers (WBIDs) designated by the FDEP.

- Step 3. *Identify a valued natural resource component and criterion for protection of the resource.*

Seagrass was identified as the primary valued natural resource for protection in Sarasota County estuarine waters. The light requirements of seagrass have been used as a criterion for establishing water clarity and water quality targets in several other Florida estuarine systems including Tampa Bay (Janicki Environmental, 1996), Charlotte Harbor (Corbett and Hale 2006) and the Indian River Lagoon (Gallegos and Kenworthy 1996). Two types of seagrass are dominant in these waters; *Halodule wrightii* and *Thalassia testudinum.* It is suggested that *Halodule* is the pioneer species for establishing seagrass colonization and that *Thalassia* is the apex species becoming dominant in older more stable seagrass beds. The depth to which these species distribute varies as a function of many environmental parameters including sediment type and wave energy but is thought to be primarily regulated by the amount of light available for photosynthesis. Photosynthetically Active Radiation (PAR) is often used to estimate the amount of light just below the surface of the water that is available at a given depth. The attenuation of PAR is estimated by the coefficient Kd described in the equation for downward irradiance (Kirk 1994).

$$Iz = Io^{-K_d*(Z)}$$

Where:

Io = Incident light just below the surface

Iz = incident Light at depth z

K_d = Light Attenuation Coefficient

Z = Depth in meters

For the purposes of these analyses light penetration at a given depth is expressed as a percentage of the sub-surface irradiance (i.e., the amount of light available just below the waters surface) though in practice the scattering of light due to surface turbulence and other factors affect the penetration of light into the water. The transparency of water was measured as an in-situ parameter using two distinct methods; a secchi disk and a downwelling irradiance sensor. The downwelling irradiance sensor estimates the diffuse light attenuation coefficient (Kd) and is measured as a routine part of the Sarasota County Water Quality Monitoring program. The diffuse light attenuation coefficient (Kd) is calculated:

$$K_d = \frac{-Ln(E_d(z_2)/E_d(z_1))}{z_2 - z_1}$$

Where :

Z_1 and Z_2= depths of the top and bottom light sensors

E_d = measured downward irradiance

Higher values of K_d indicate higher attenuation of PAR and a smaller percentage of the light just below the surface available at a given depth.

- *Step 4. Identify a resource based water clarity target that protects the valued resource*.

Identifying a water clarity target for seagrass involved estimating the light requirement for seagrass in Sarasota County waters. To accomplish this we needed to examine the historic extent of seagrass in Sarasota County to determine where and how deep the seagrasses grow. We examined the empirical data collected on seagrass using the Southwest Florida Water Management Districts (SWFWMD) aerial seagrass surveys. The Southwest Florida Water Management District has performed aerial seagrass mapping surveys since 1982. The surveys have become a critical component of SWFWMD's Surface Water Improvement and Management (SWIM) program. The source data for these surveys are USGS 7.5' topographic quadrangles and the end products are GIS polygon shapefiles of seagrasses along the coastal estuarine waters of southwest Florida. The final estuary characterization includes multiple habitat codes. We combined two types of codes, patchy and continuous seagrass, to determine the presence or absence of seagrass. The minimum mapping unit for determining seagrass coverage was 0.5 acres. This determines the smallest area which was identified as patchy or continuous seagrass with certainty. Several years of seagrass data did not cover the entire area of interest and were subsequently not used in the analysis. Seagrass data for 1982, 1990, and 1992 were completed only for parts of Sarasota Bay or Lemon Bay. In addition, the methodology used for the first year of analysis (i.e.,1982) was deemed too unreliable compared to the methodology used for later years. The following years were surveyed for the entire area of concern and used in our analysis: 1988, 1994, 1996, 1999, 2001, and 2004. Seagrass data from 1990 and 1992 were used in the areas where data were available.

To correlate seagrass data from the aerial surveys with depth, we obtained bathymetry data from the National Geophysical Data Center (NGDC). These datasets were compiled from multiple sources: US National Ocean Service Hydrographic Database, US Geological Survey, Monterey Bay Aquarium Research Institute, US Army Corps of Engineers LIDAR, USGS 3 arc-second DEM's and Shuttle Radar Topography Data, and various other academic institutions (Divins, 2006). The final data were corrected, compiled and merged, and distributed as the NGDC 3 Arc-Second Coastal relief Model.

A 3 arc-second grid in this geographical area roughly corresponded to a 83m x 90m rectangular grid. These data were referenced to the mean low water (MLW) local vertical datum. In addition, they had a vertical accuracy of 0.3 m in waters 0 – 20 m deep and an accuracy of 1.0 m in waters deeper than 20 m. The horizontal accuracy was 1.5 mm of the sounding location.

To assign depth to seagrass coverages it was necessary to develop a grid network such that the bathymetry and seagrass coverages could be joined. We chose a 45m x 45m grid to join these data. The grid cell size was determined by calculating the smallest possible square that was greater than the seagrass survey minimum mapping unit. The grid network was joined with the bathymetry coverage, the seagrass coverages for each survey year and the official County estuarine shoreline coverage from the Sarasota Bay Estuary Program (SBEP). The SBEP shoreline extends from Sarasota Bay to Roberts Bay. The official FDEP county shoreline was used for the area extending south of Roberts Bay to the southern border of Lemon Bay. The FDEP and SBEP shorelines were extremely similar over the area over their common extents giving us confidence that the DEP shoreline can be used for the area south of Roberts Bay.

Using ESRI ArcGIS 9.0, grid cells were removed when the center point of the cell was outside the shoreline shapefile (on land). In addition, we used our best judgment to remove cells in selected man-made “finger canals”. These grid cells amounted to less than 1% of the total area analyzed. This approach is consistent with the selection of non-restorable areas when setting seagrass targets in Tampa Bay (Janicki Environmental 1996). Once this was completed we had identified a population of interest for analytical purposes.

Analysis of the seagrass depth distribution for each segment was conducted by calculating the cumulative distribution of depths across cells where greater than 50% of the cell area contained seagrass in any seagrass survey year. The 90th percentile of the depth distribution was identified as the target depth for protection of seagrass in Sarasota County. That is, if sufficient light for seagrass success was allowed to penetrate to the depth above which 90 percent of the seagrass had ever been recorded, this would serve as an appropriate water clarity target. Once the 90th percentile was identified the equation for downward irradiance was rearranged to solve for a Kd value that allowed 25% of sub-surface irradiance to penetrate to the target depth. The 25 percent sub-surface irradiance value represents a conservative estimate of the light requirements based on several studies of Florida estuaries including Tampa Bay (20.5%, Janicki Environmental 1996), Charlotte Harbor (25%, Corbett and Hale 2006) and others (cited in Corbett and Hale, 2006).

- Step 5. *Identify the status and trends for each water quality parameter of interest.*

The Kendall Tau test for trend is a test commonly employed for evaluating status and trends in water quality parameters for estuarine waters (Reckhow et al., 1993). The test uses non-parametric statistical procedures to evaluate the direction and magnitude of time series water quality trends while accounting for the effects of seasonality and autocorrelation on the estimate of the error structure associated with the significance testing procedure. The Kendall Tau trend test was performed for each parameter of interest in each of the proposed segments Sarasota County estuarine waters to assess the significance and direction of trend. This analysis was principally employed to aid in management decisions about prioritizing water quality constituents for remedial actions if necessary. The period of record chosen for trend analysis was from 1995 through 2005 which represents a time period when data were consistently collected for most water bodies of interest. Dona And Roberts Bay lacked the long term time series of data collection necessary for trend analysis.

- *Step 6. Translate the scientific information derived from these analyses to the non-scientific community to encourage activism in protecting the valued resource.*

A major aim of this project was to translate findings regarding water clarity targets into actions that could be taken by the non-scientific community to become participants in monitoring water clarity in Sarasota County. As such, once the target criteria were established, the target *Kd* values were translated into a corresponding secchi disk depth which is easily used by non scientific personnel. Giesen (1990) reported the relationship between light attenuation and secchi disk depth in the Dutch Wadden Sea could be described using the relationship:

$$\text{Secchi disk (meters)} = 1.7/Kd$$

We estimated the relationship between secchi disk depth and a given *Kd* measure using the empirical data collected within Sarasota County. By using data where secchi disk and *Kd* values were recorded concurrently, we developed a regression equation to estimate the mean secchi disk depth for a given observed *Kd* value. Since the light attenuation coefficient and secchi disk depth are inversely related, the regression equation took the form of:

$$Y = B_1 * 1/Kd$$

Where:

Y= secchi disk depth in meters
B_1 = coefficient used to translate *Kd* to secchi depth

Secchi disk readings where the secchi lay on the bottom were excluded from this analysis as well as Kd values greater than 5 and less than 0.17 (less than 5 percent of the data distribution). By relating *Kd* and secchi depth, secchi disk data collected by volunteers could be related to water clarity targets.

Results:

Exploratory data analysis suggested that both the Sarasota County Ambient Water Quality Monitoring Networks segmentation scheme and the FDEP WBID designations represented relatively homogeneous groupings for most water quality parameters of interest. However, segmentation on the Sarasota County WBID scale offered several advantages with respect to setting water quality targets.

- Sarasota County WBIDs are based on hydrologic units and therefore reflect variation in hydrologic inputs which contribute to variations in water clarity within the receiving waterbodies.

- Regulatory evaluation of water quality is performed by WBID and therefore target criteria established for water quality and water clarity would be relevant to regulatory assessments conducted by the state regulatory agencies.

- Using a segmentation scheme on the WBID scale reduces the number of segments requiring targets which simplifies the process of evaluating water quality and water clarity in Sarasota County waters while maintaining continuity in sampling design and logistical considerations.

However, the water clarity target segments we developed are not identical to the FDEP designations. In particular, several WBID boundaries group nearshore estuarine waters in Sarasota Bay as being part of adjacent land based WBIDs whereas our segment definitions groups those areas into the Sarasota Bay Estuarine WBIDs (See Figure 3). The segmentation scheme identified for water clarity is shown in Figure 4.

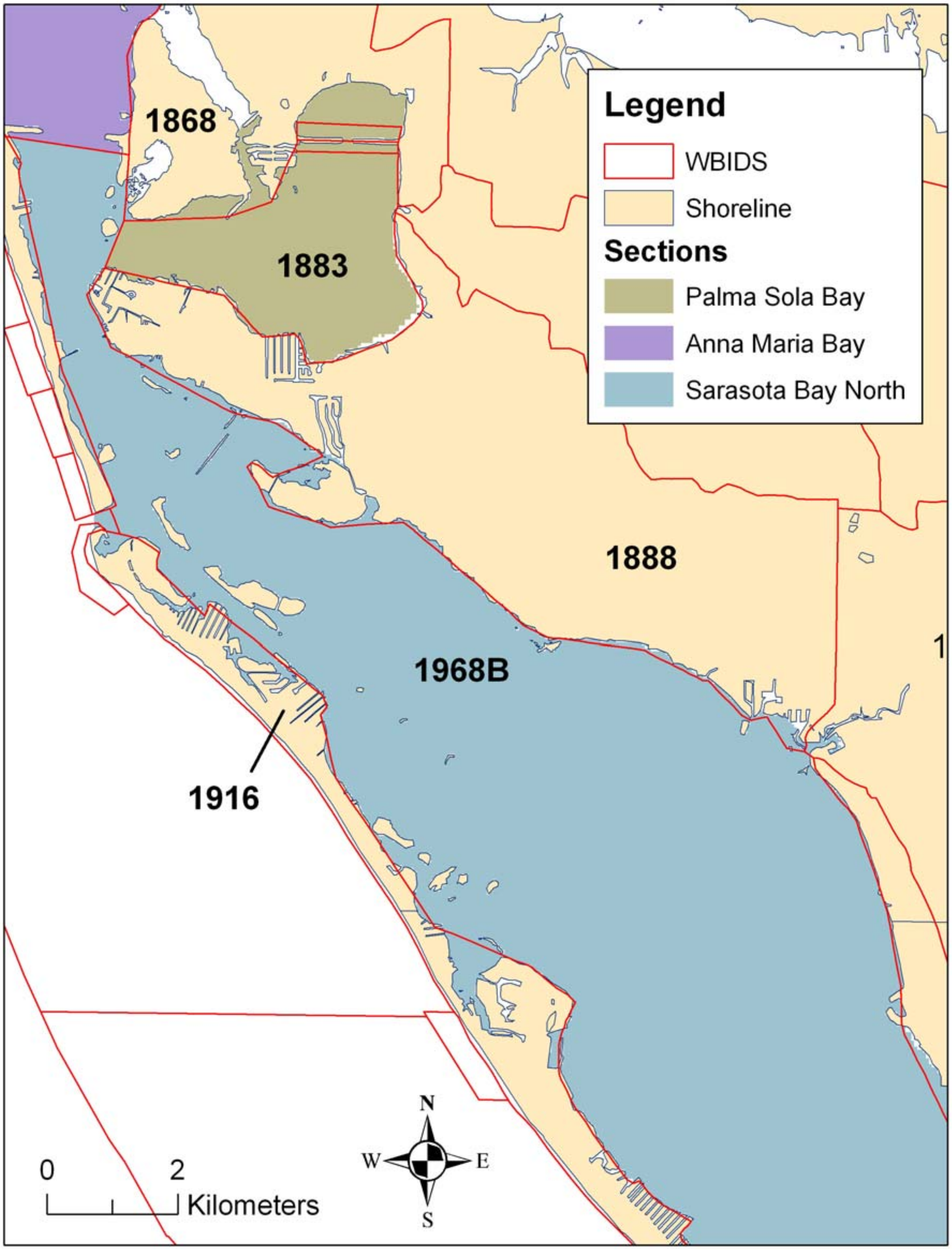

Figure 3. Differences between the FDEP WBID boundaries associated with Sarasota Bay North and the derived water clarity segments used for target setting (blue background).

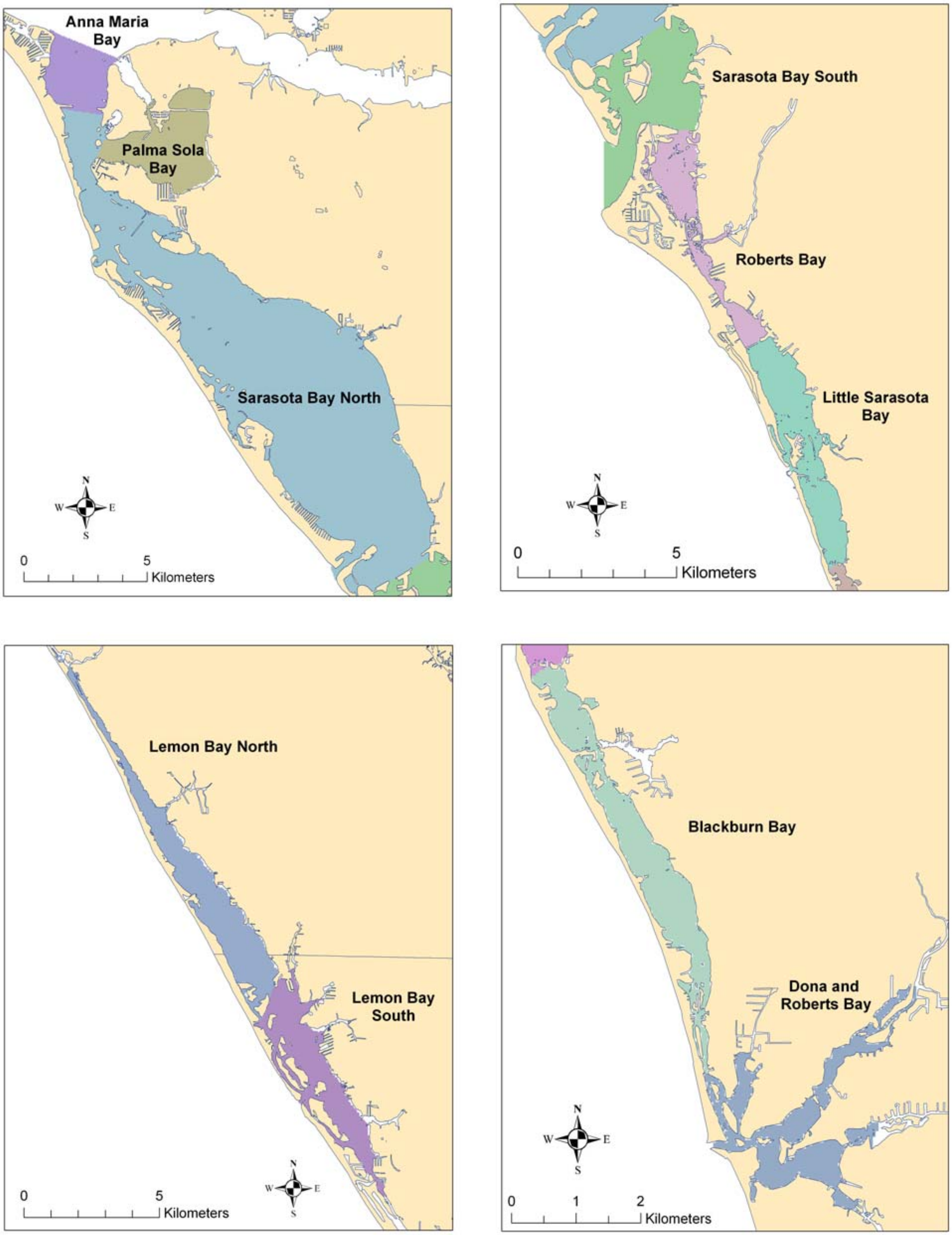

Figure 4. Proposed water clarity target segmentation scheme showing segments clockwise form north to south. Lemon Bay South is shown but not included in the analysis.

In comparing the empirical water quality data, the cumulative distributions and results of the Kendall Tau trend tests suggested similarities exist with respect to several important water quality constituents. For example, the cumulative distribution of Total Nitrogen was similar in both segments of Sarasota Bay which appeared to be somewhat distinct from the remaining segments (Figure 5). We chose to characterize the distributions as being higher than average, average and below average to describe the patterns. Therefore for total nitrogen, the two Sarasota Bay segments were characterized as below average while Little Sarasota Bay and Lemon Bay were characterized as above average (Table 1). The segments tended to group themselves according to their proximity to one another as well as the influence of fresh water sources such as Philippe Creek in Roberts Bay and Cow Pen Slough in Dona and Roberts Bay. Cumulative distribution plots for all water quality parameters of interest are located in Appendix 1. The Kendall Tau trend test revealed similar patterns seen in the CDF plots (Table 2) though not all segments met the requirements of 5 continuous years and 60 samples necessary to be included in the testing procedure (i.e. Dona and Roberts Bay). The detailed results of the Kendall Tau analysis are provided in Appendix 2.

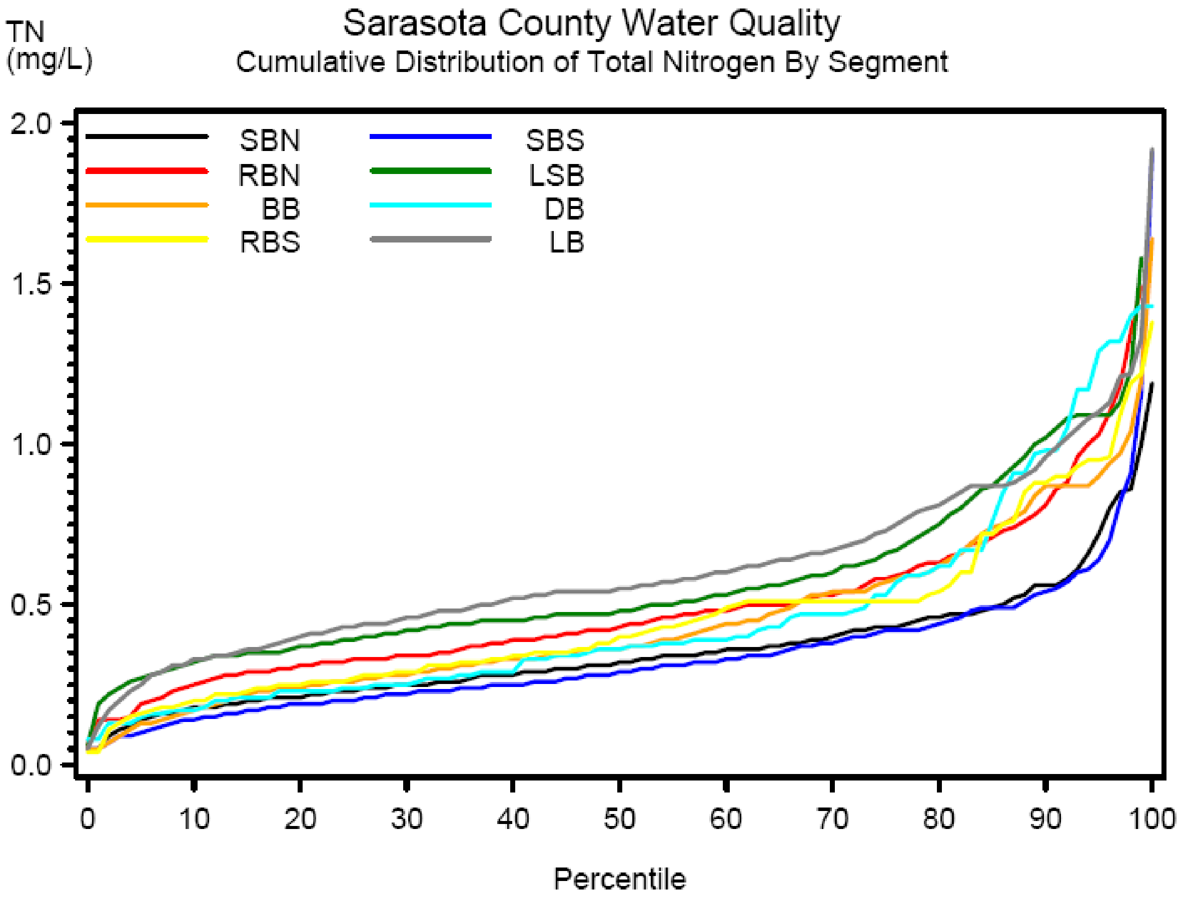

Figure 5. Cumulative distribution of Total Nitrogen by Sarasota County segment.

Table 1. Results of distribution comparisons for water quality parameters by segment. Table is arranged from North (top) to South (bottom).

Segment	Chla (ug/l)	TN (mg/l)	Color (pcu)	Salinity (ppt)	Secchi (ft)	Light (Kd)
Sarasota Bay	---	---	---	++	++	---
Sarasota Bay South	---	---	---	++	++	---
Roberts Bay	O	O	O	O	O	O
Little Sarasota Bay	O	++	O	---	---	O
Blackburn Bay	O	O	O	O	O	O
Dona Bay	---	O	++	---	---	++
Roberts Bay South	---	O	++	O	O	++
Lemon Bay	++	++	++	---	---	O

++ = Higher than average O = Average distribution --- = Lower than average

Table 2. Trend results for Kendall Tau trend test based on data from 1995 through 2005.

Segment	Salinity ppt	Chla_C ug/L	Color pcu	DO mg/L	K 1/meter	TP mg/L	TSS mg/L	TN mg/L
Sarasota Bay	++	++	O	O	O	++	++	O
Sarasota Bay South	++	++	O	++	O	++	O	O
Roberts Bay	O	++	O	O	O	++	O	----
Little Sarasota Bay	O	O	O	O	O	++	----	O
Blackburn Bay	O	O	O	O	O	++	O	----
Lemon Bay	O	O	O	O	O	++	----	----

++ = Increasing O = No trend --- = Decreasing

Trends in seagrass abundance were evident for some of the segment areas with apparent increases in Seagrass from 1994 through 2001 in Little Sarasota Bay, Blackburn Bay and Lemon Bay (Figure 6). This is interesting given the apparent increasing trends in Total Phosphorus and decreasing trends in Total Nitrogen in these areas over the sampling period. The ubiquitous trend in TP over the time period is suspicious and should be investigated further to rule out any methodological changes that may have resulted in this result. Note that 1990 and 1992 were partial seagrass survey years and therefore the lines in Figure 6 are interpolated between 1988 and 1994.

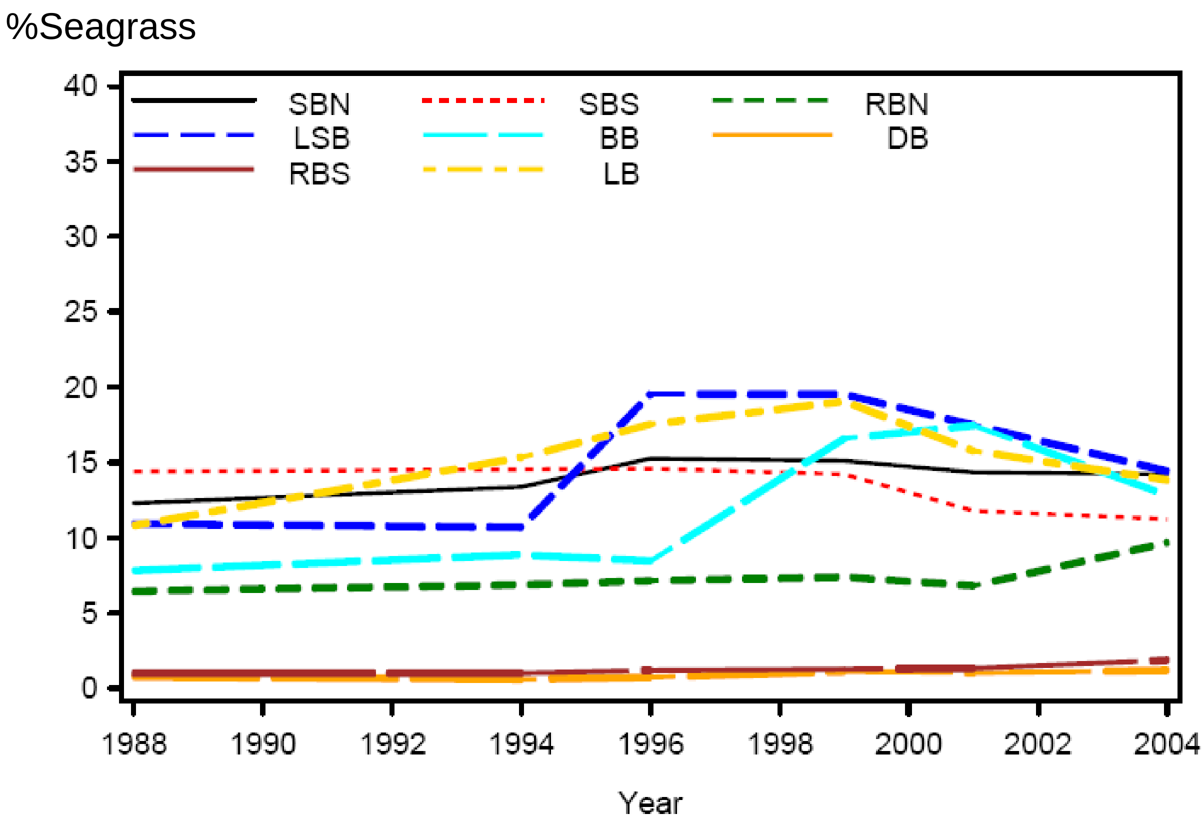

Figure 6. Seagrass abundance expressed as a percentage of the total segment area from 1988 through 2004. Note: lines are interpolated for years without full coverage

To estimate the extent of seagrass coverage within each segment we used the grid overlay to assign cell values to the 45m X 45m cells dependent on whether or not seagrass was present. If greater than 50% of the grid cell contained seagrass in any year the cell was considered a seagrass cell (See example Figure 7 where green cells contained seagrass and light blue cells did not). All grid cells identified as seagrass grid cells were then plotted for each segment (Figure 8). We then assigned bathymetry to each cell (Figure 9) and calculated the depth distribution of those cells that ever were recorded as containing seagrass.

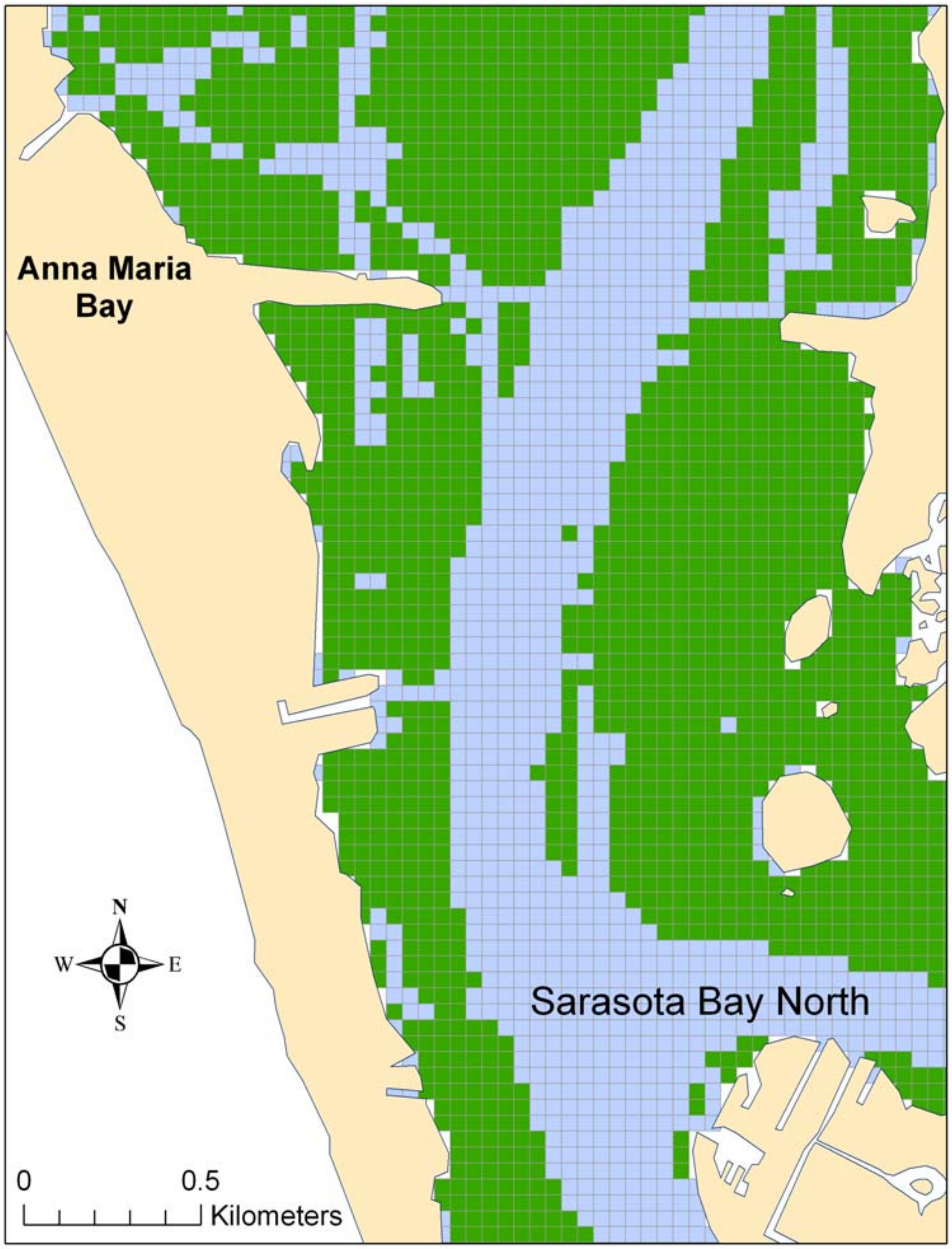

Figure 7. Example of grid overlay and assignment of seagrass cells in Sarasota Bay North.

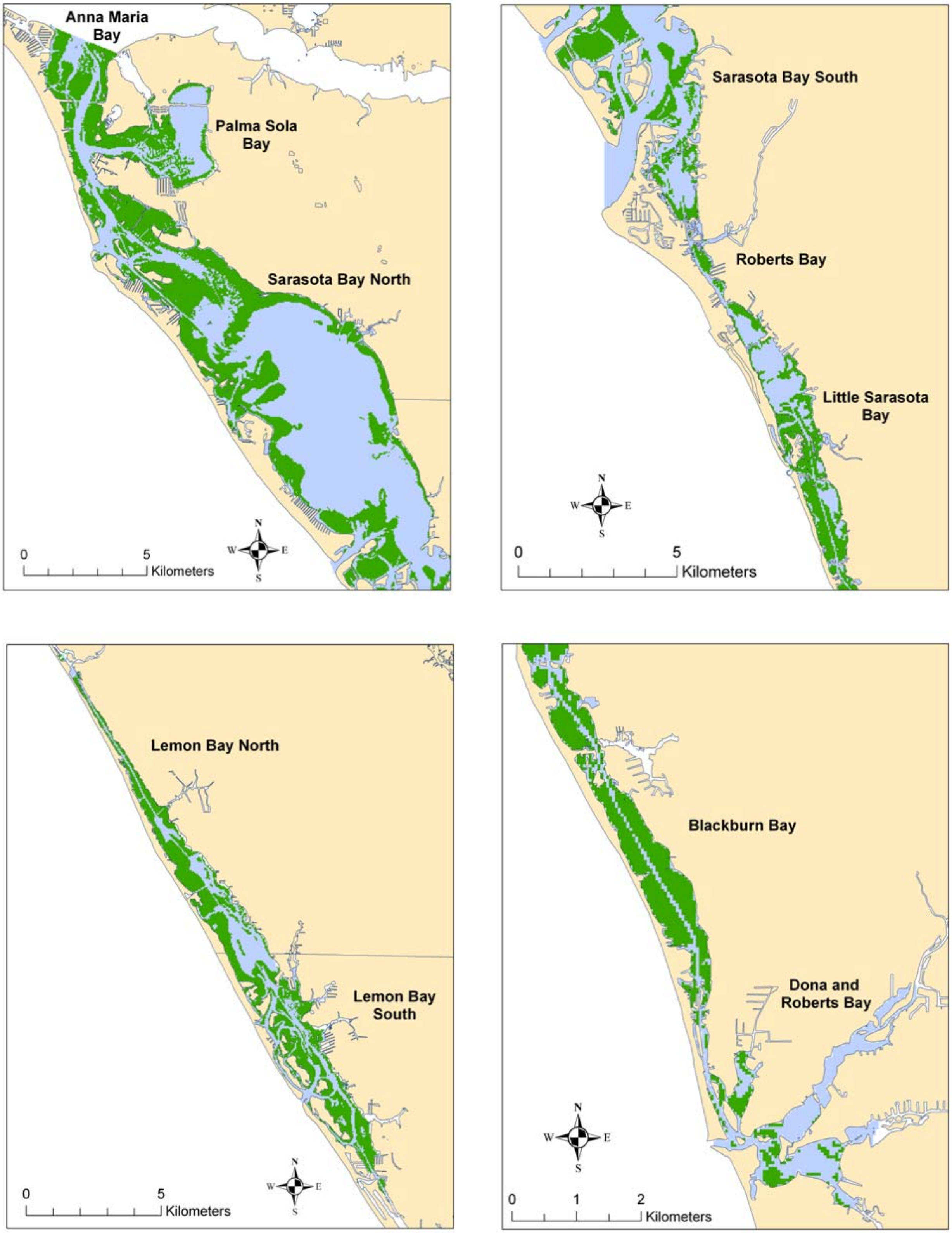

Figure 8. Historical extent of seagrass coverage based on SWFWMD SWIM survey years 1998-2004.

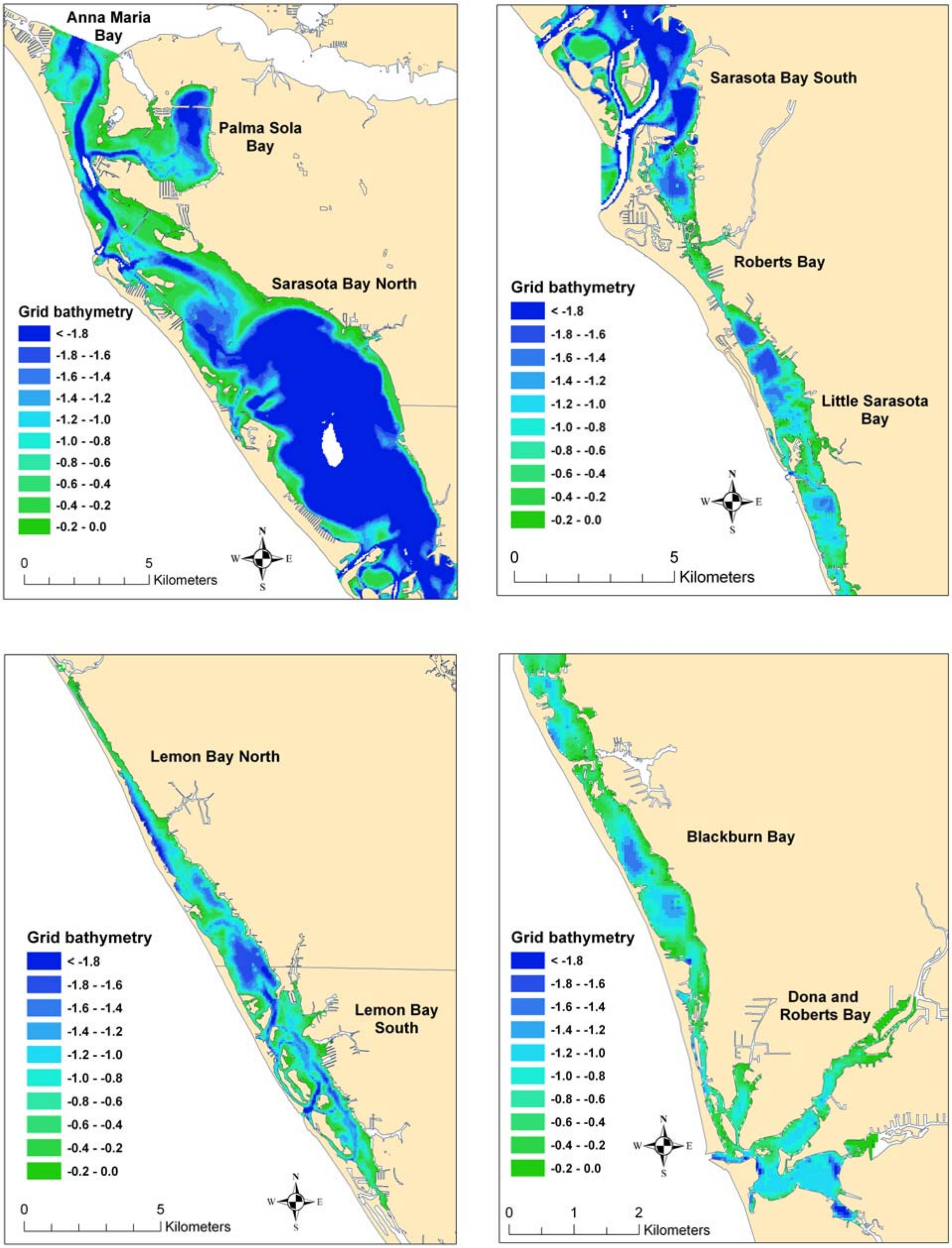

Figure 9. Bathymetry (depth at mean low water) for Sarasota Bay segments.

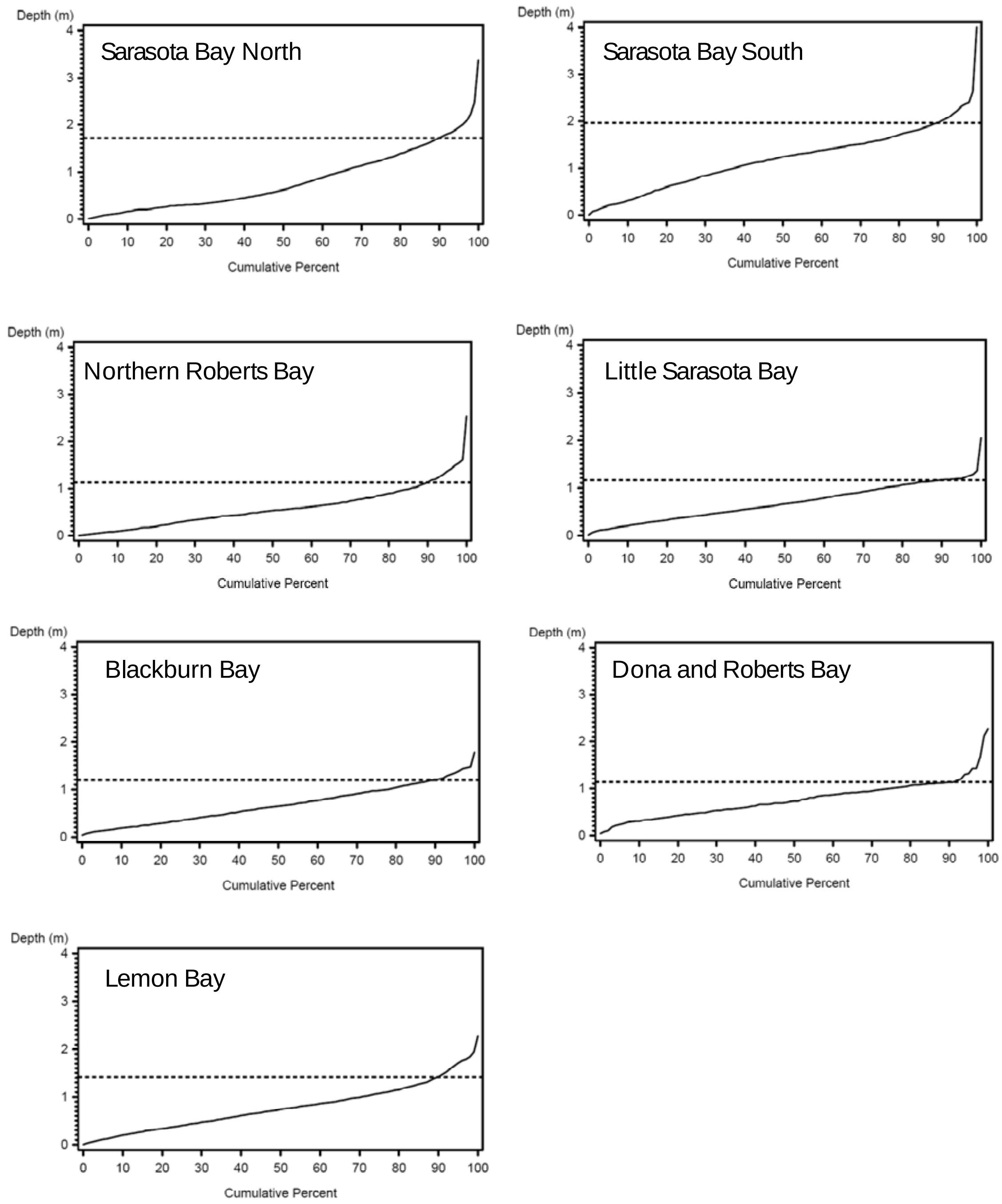

Figure10. Seagrass depth targets (dotted horizontal line) for each water clarity segment in Sarasota County.

The seagrass depth distributions varied substantially by segment (Figure 10) indicating both differences in the bottom contours by segment as well as differences in light availability. For example, in Sarasota Bay North approximately 40% of seagrass was found in depths greater than 1 meter (at mean low water) while in the southern portion of Sarasota Bay, 60% of the seagrass was found in depths greater than 1 meter. This is thought to be primarily due to bathymetry as northern Sarasota Bay which has a more delineated shelf with lower proportion of available habitat between 1 and 2 meters (at mean low water) while the southern portion of the bay has a higher proportion of available habitat between 1 and 2 meters.

Using the equation for downward irradiance rearranged to solve for Kd, the target depths were converted to target Kd values and subsequently, secchi disk depths using the resuls from the empirically derived coeffients from regression analysis (Table 3). The target values in reference to the empirical data are shown for Kd in Figure 11 and Secchi in Figure 12.

Table 3. Target seagrass depths (based on 90th percentile of distribution) and corresponding target Kd values.

Segment	Target Depth (m)	Target Kd	Correction Factor	Target Secchi (m)
Sarasota Bay North	1.73	0.81	1.16	1.43
Sarasota Bay South	1.96	0.71	1.18	1.66
Roberts Bay North	1.12	1.24	1.10	0.88
Little Sarasota Bay	1.16	1.20	0.93	0.77
Blackburn Bay	1.19	1.16	0.99	0.85
Dona / Roberts Bay	1.13	1.23	1.04	0.93
Lemon Bay North	1.42	0.98	0.91	0.85

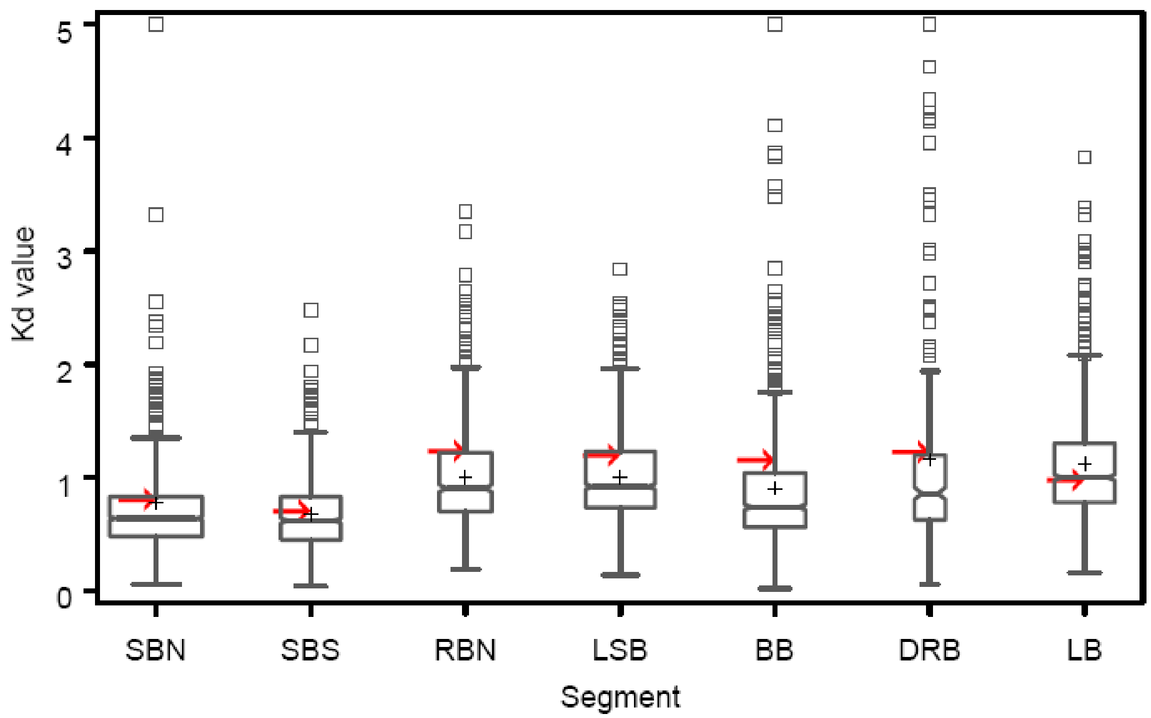

Figure 11. Distribution of the light attenuation coefficient *Kd* by Sarasota County water clarity segment.

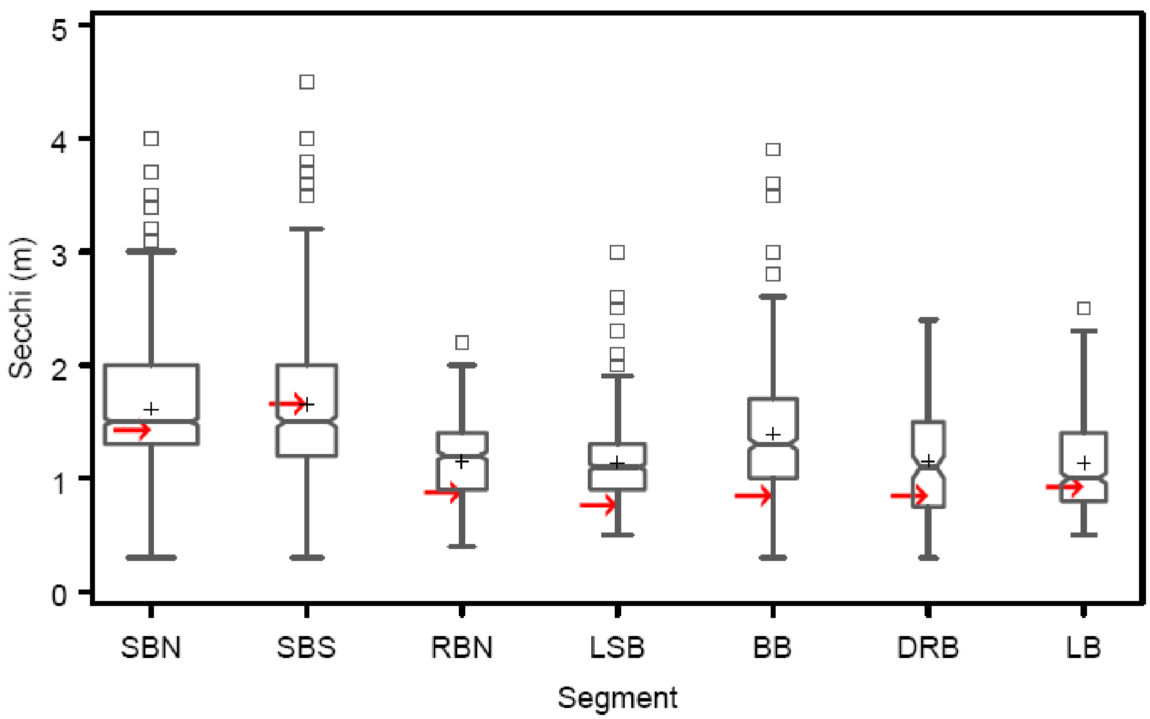

Figure 12. Distribution of secchi disk depths measured in each Sarasota County water clarity segment.

Discussion:

Sarasota County Water Resources is working in partnership with several other state and local agencies to develop watershed based aquatic resource goals for their waterbodies under the construct of the FDEPs Basin Management Action Plan. As part of this larger goal, Sarasota County has identified the development of water clarity targets as a desirable component within the larger process. Criteria associated with establishing water clarity targets were that they be resource based, scientifically defensible and translatable to the non scientific community to bolster community activism in protecting Sarasota County waters. The water clarity targets proposed within this report are based on empirical data collected within Sarasota County waters and relate water clarity to light requirements for seagrass, a valued natural resource. The targets appear to be achievable based on comparisons to the empirical data collected on light attenuation and secchi disk depth and are easily translated to encourage community participation. These targets therefore represent an objective, empirically derived, and measurable estimate of the water clarity necessary to maintain the light requirements of seagrass. However, it is important to recognize the assumptions associated with this target setting approach.

A major assumption associated with these targets is the light requirements of seagrass. There is still much debate about the quantity and quality of light necessary to maintain seagrass communities as well as what physical and environmental properties may affect the utilization of available light. The 25% of sub-surface irradiance value was chosen as a conservatively high estimate of the light requirement of seagrass based on published literature values for southwest Florida estuaries. While this estimate is more than twice some estimates for seagrass light requirements in Florida, it does not account for the potential light limiting effects of epiphytic growth which has been observed in Sarasota County waters. The bathymetry data used for this analysis were collected nearly 50 years ago and updated only for major passes and navigable channel yet remain the best currently available data for assigning depths to the waterbodies of interest. The SWFWMD SWIM seagrass surveys rely on good visibility and water clarity conditions to accurately reflect the true extent of seagrass coverage. The accuracy and precision of the Kd and secchi disk measurement tools also contribute to uncertainty in the exactness of the target to provide the requirements necessary to maintain healthy seagrass communities. It is also known that several factors other than water clarity including wave energy, sedimentation, and disease influence the health of seagrass.

As more information becomes available on the localized light requirements of seagrass in Sarasota County, these targets can be re-evaluated to assess their effectiveness but presently represent a quantifiable, objective and scientifically defensible target that can be used by water resource managers to evaluate the effectiveness of their restoration efforts.

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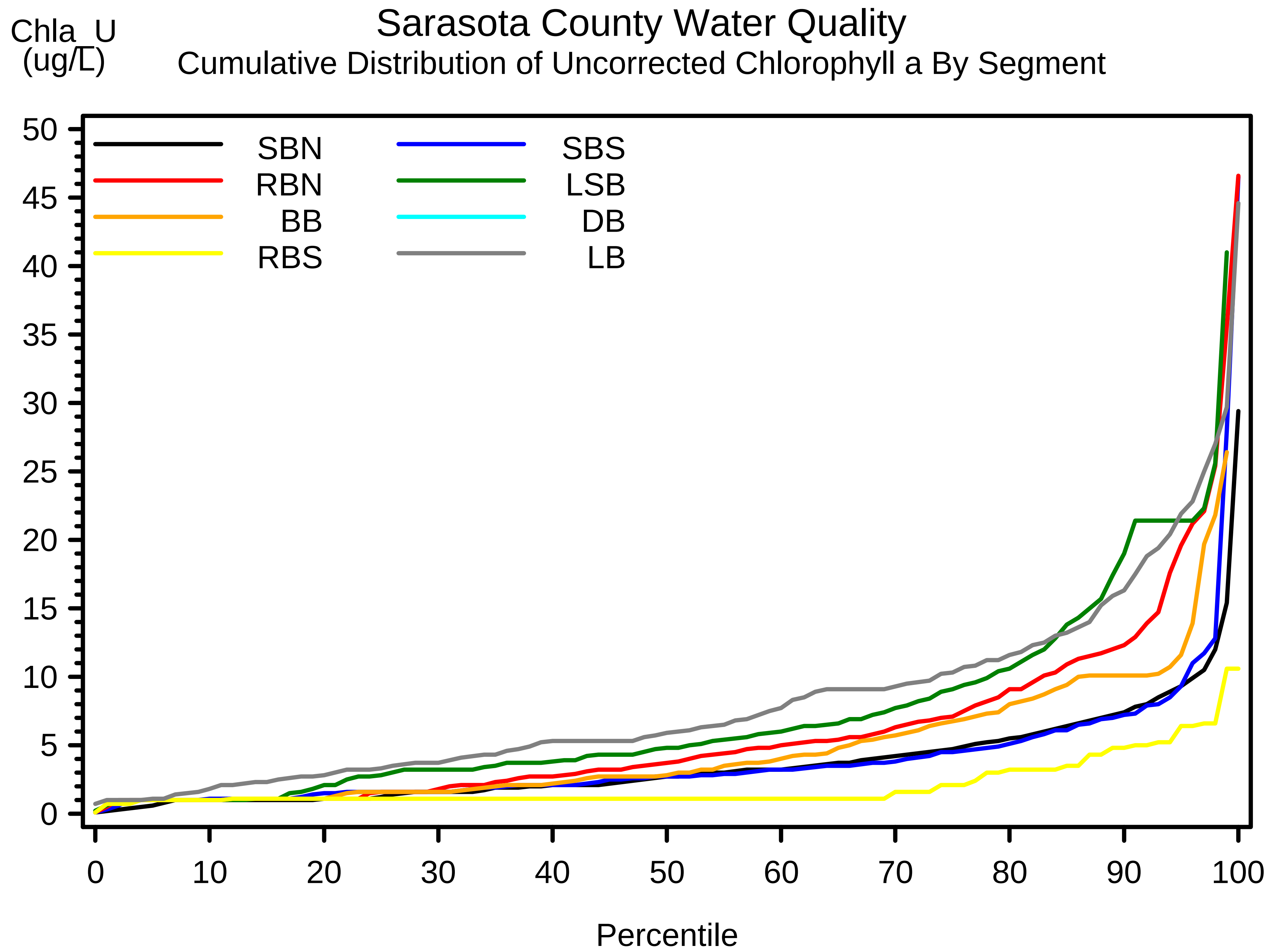
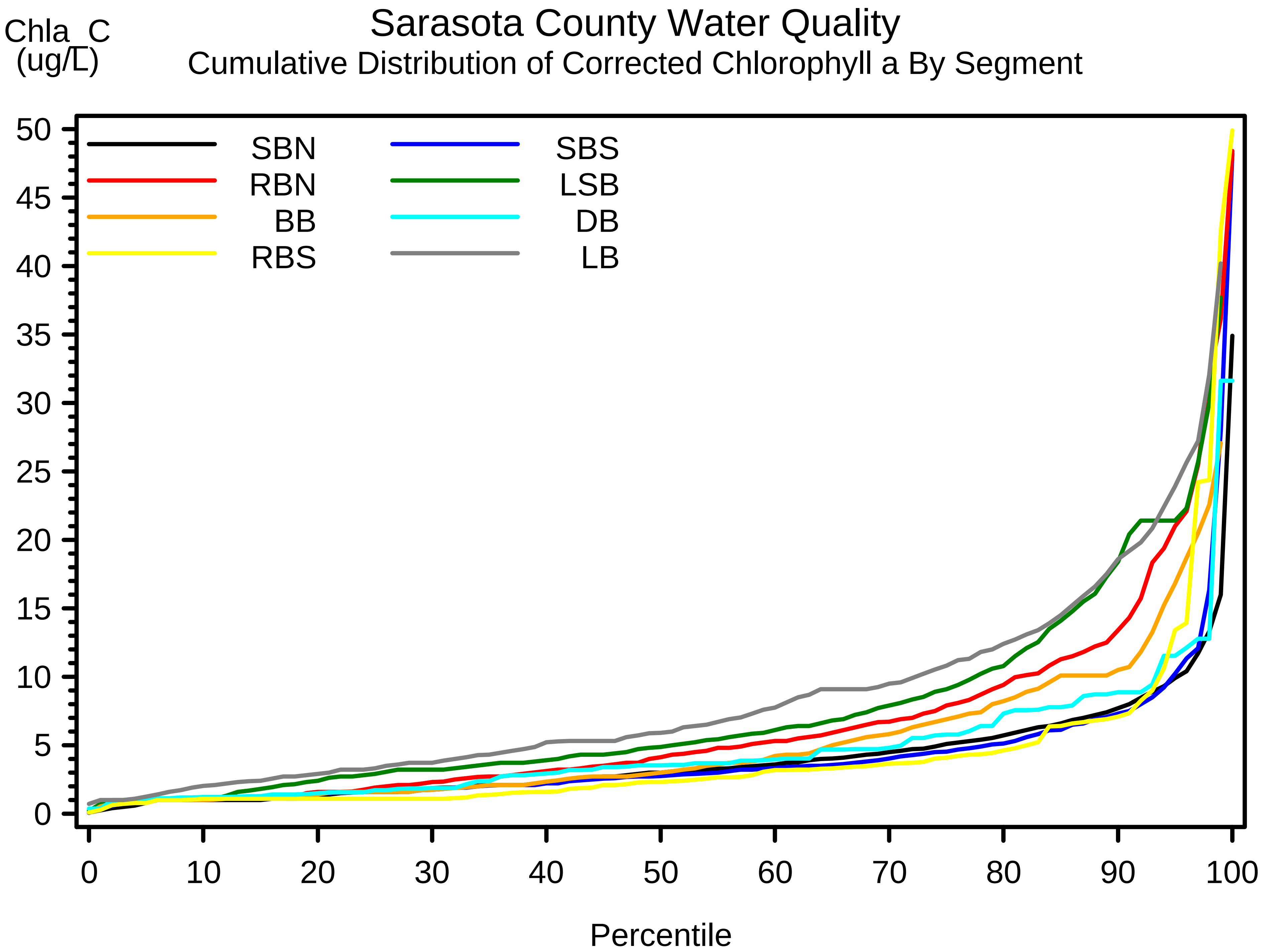
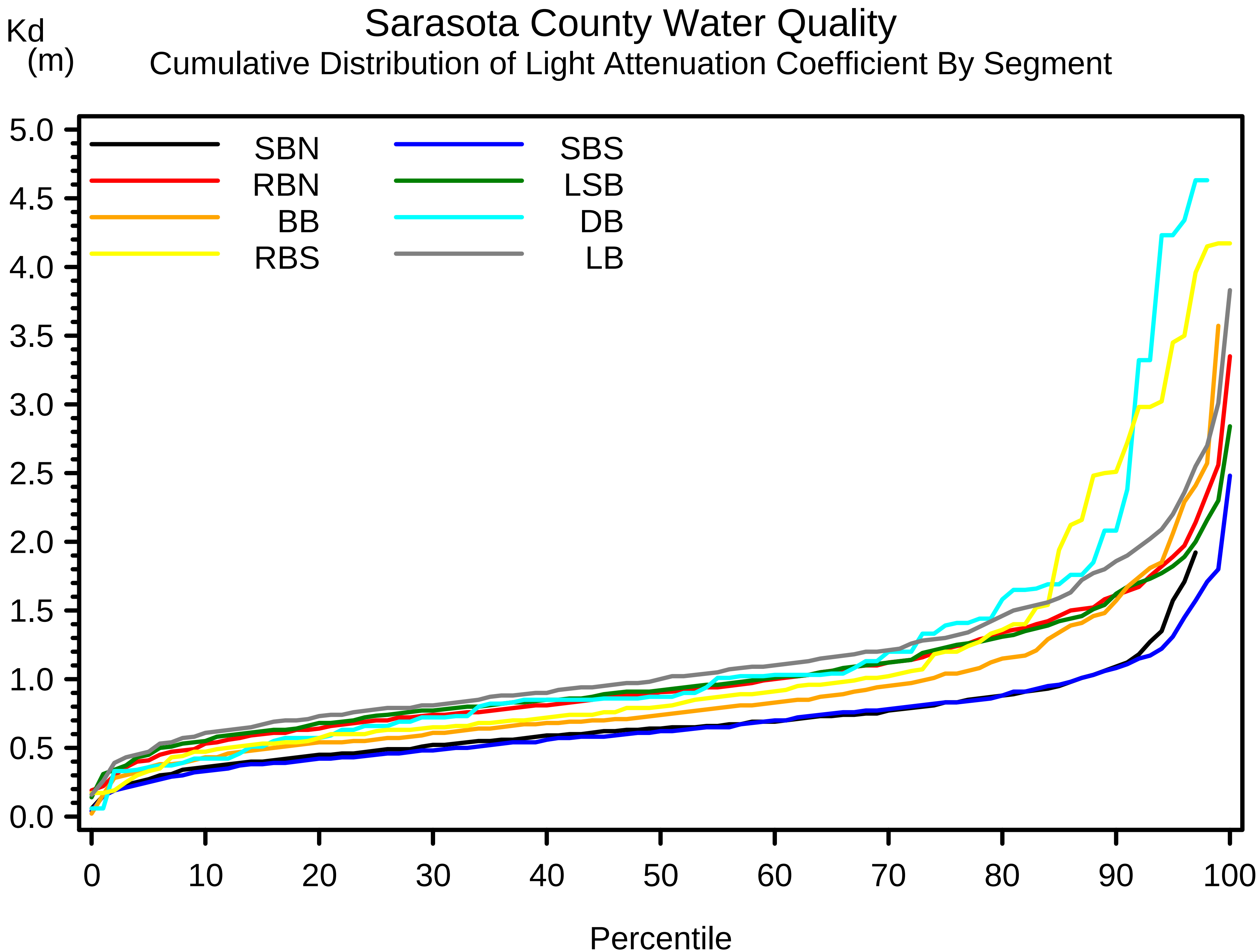
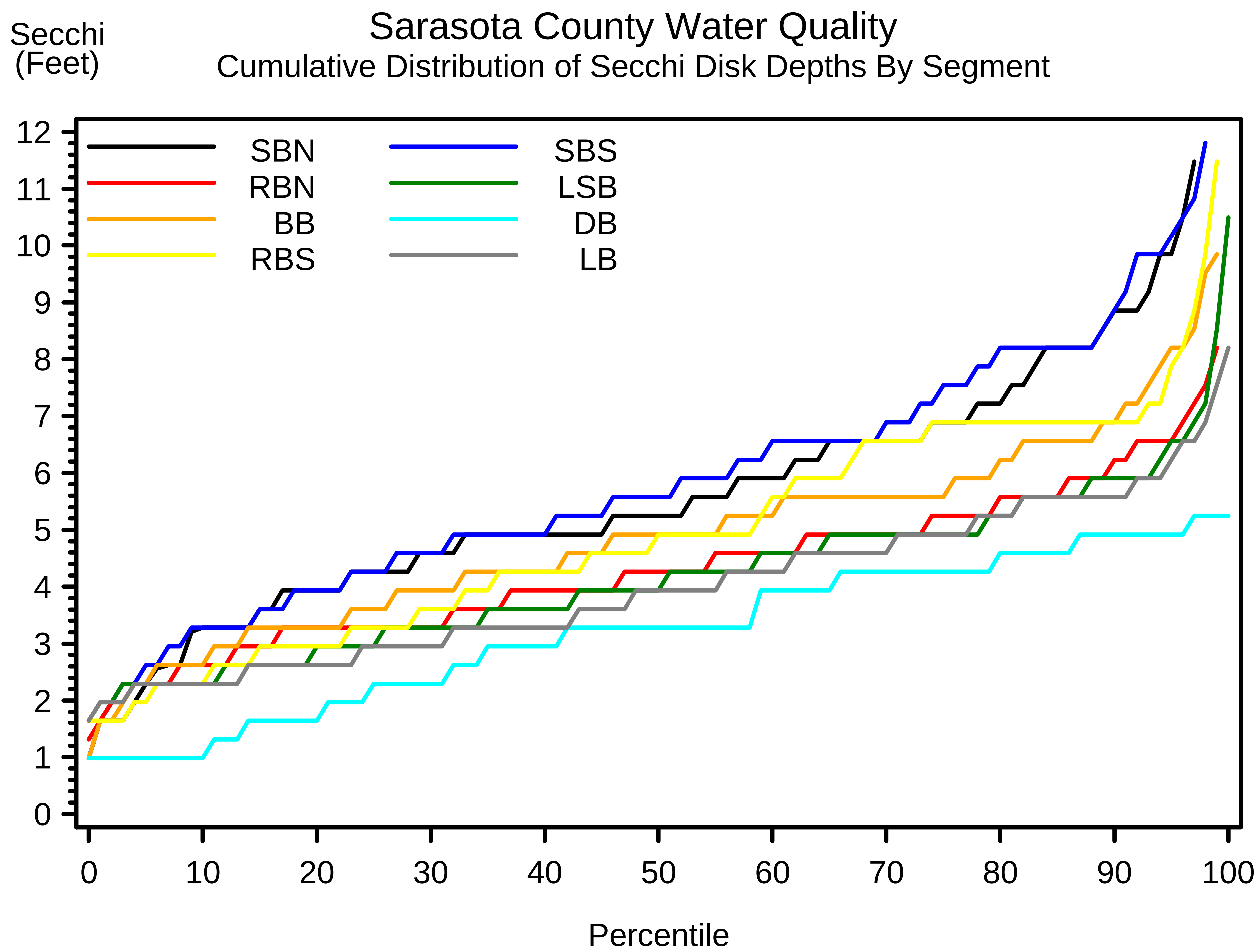
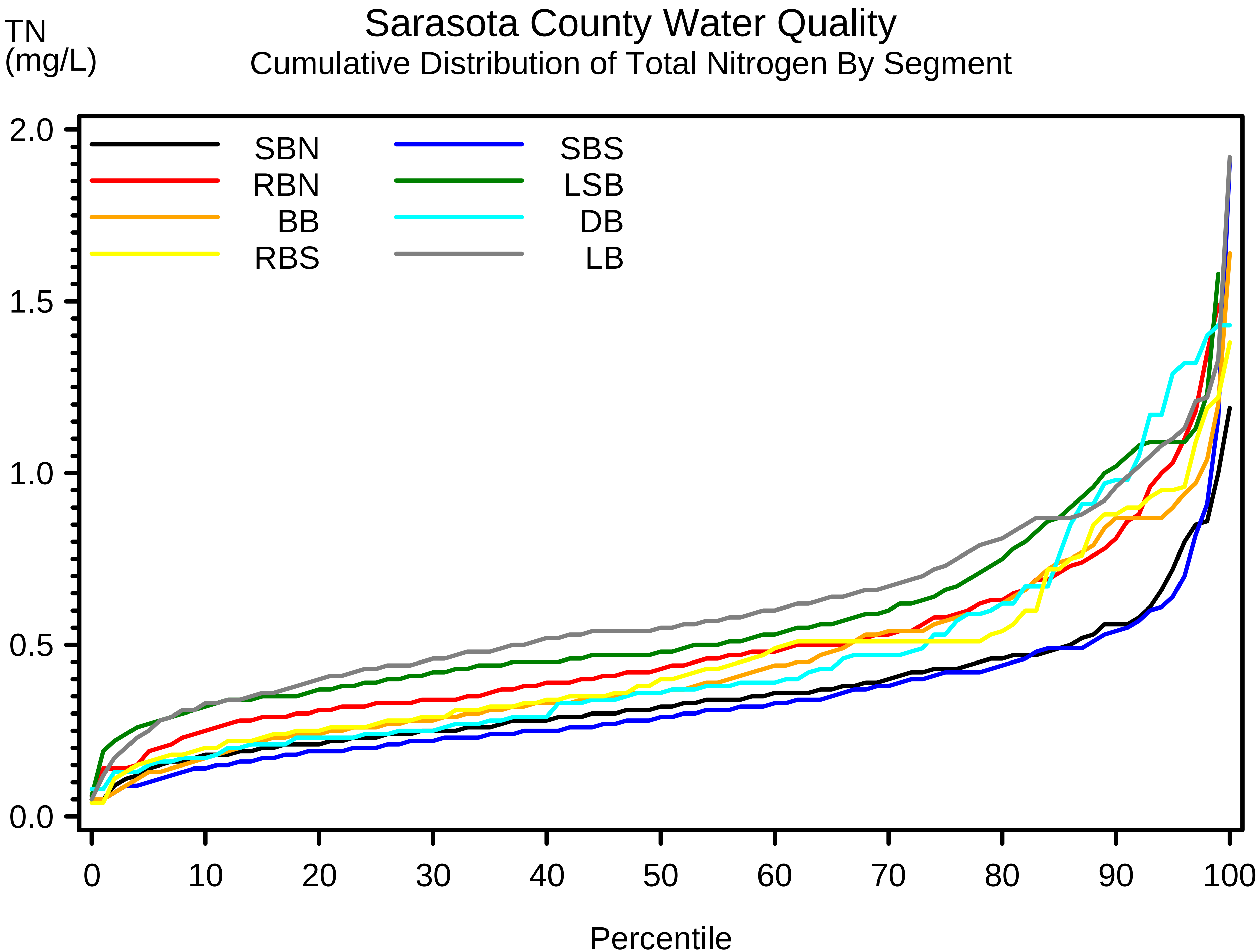
Appendix 1


Chla_U
(ug/L)
Sarasota County Water Quality
Cumulative Distribution of Uncorrected Chlorophyll a By Segment
SBN
RBN
BB
RBS
SBS
LSB
DB
LB
0
5
10
15
20
25
30
35
40
45
50
0
10
20
30
40
50
60
70
80
90
100
Percentile

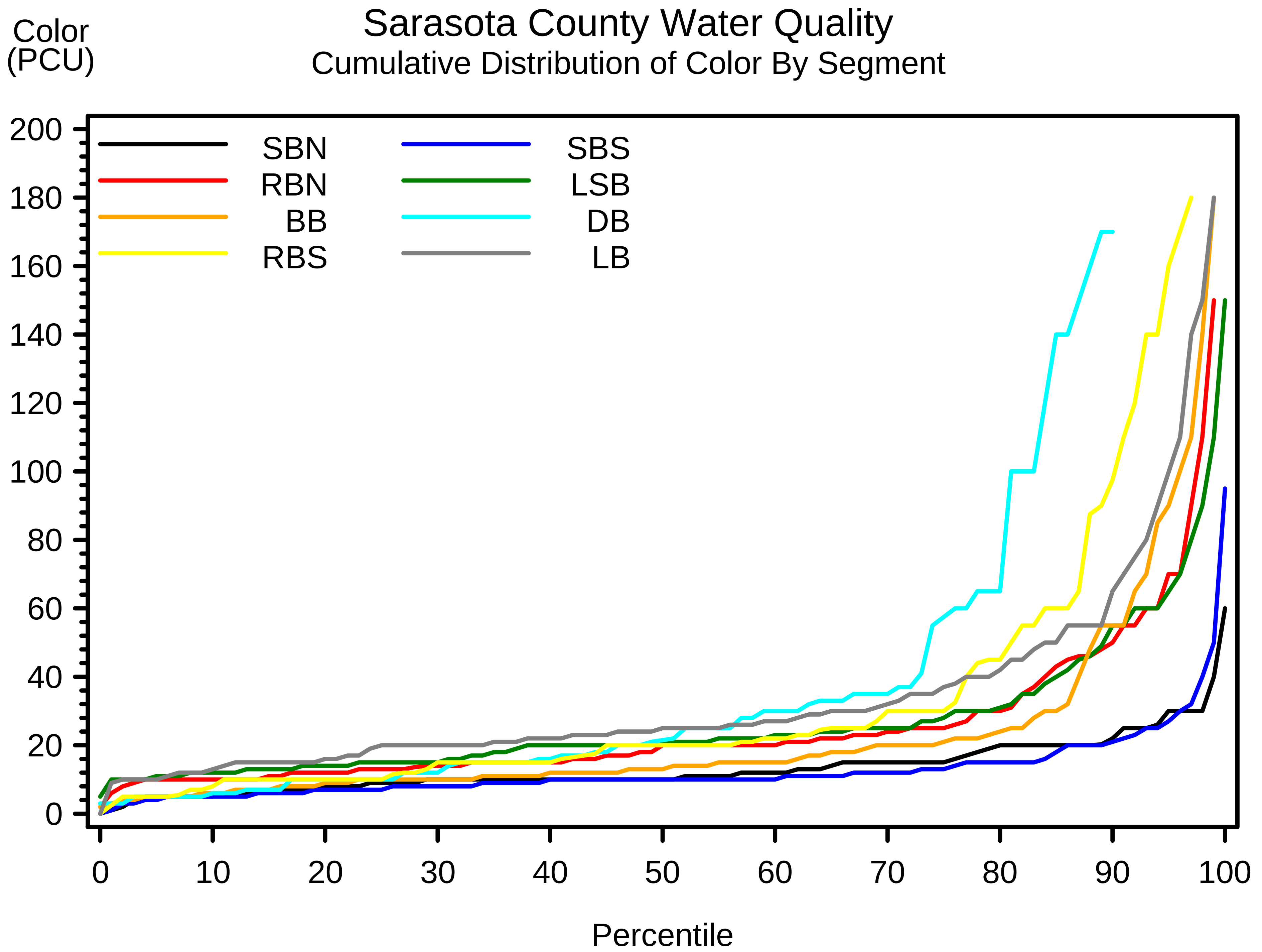

Chla_C
(ug/L)
Sarasota County Water Quality
Cumulative Distribution of Corrected Chlorophyll a By Segment
SBN
RBN
BB
RBS
SBS
LSB
DB
LB
0
5
10
15
20
25
30
35
40
45
50
0
10
20
30
40
50
60
70
80
90
100
Percentile


Sarasota County Water Quality
Cumulative Distribution of Light Attenuation Coefficient By Segment
Kd
(m)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
SBN
RBN
BB
RBS
SBS
LSB
DB
LB
0
10
20
30
40
50
60
70
80
90
100
Percentile

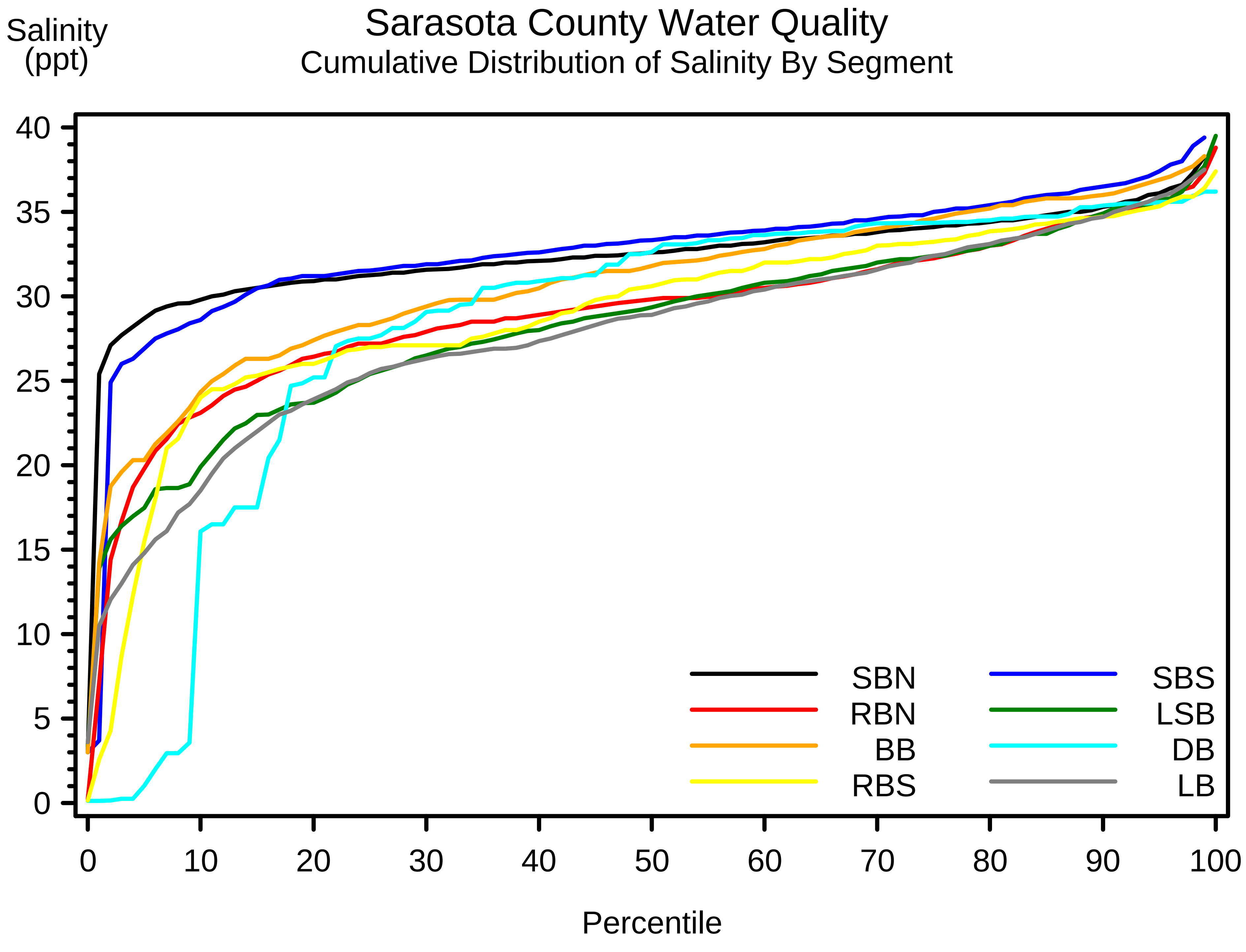

Sarasota County Water Quality
Cumulative Distribution of Secchi Disk Depths By Segment
Secchi (Feet)
SBN
RBN
BB
RBS
SBS
LSB
DB
LB
0
1
2
3
4
5
6
7
8
9
10
11
12
0
10
20
30
40
50
60
70
80
90
100
Percentile

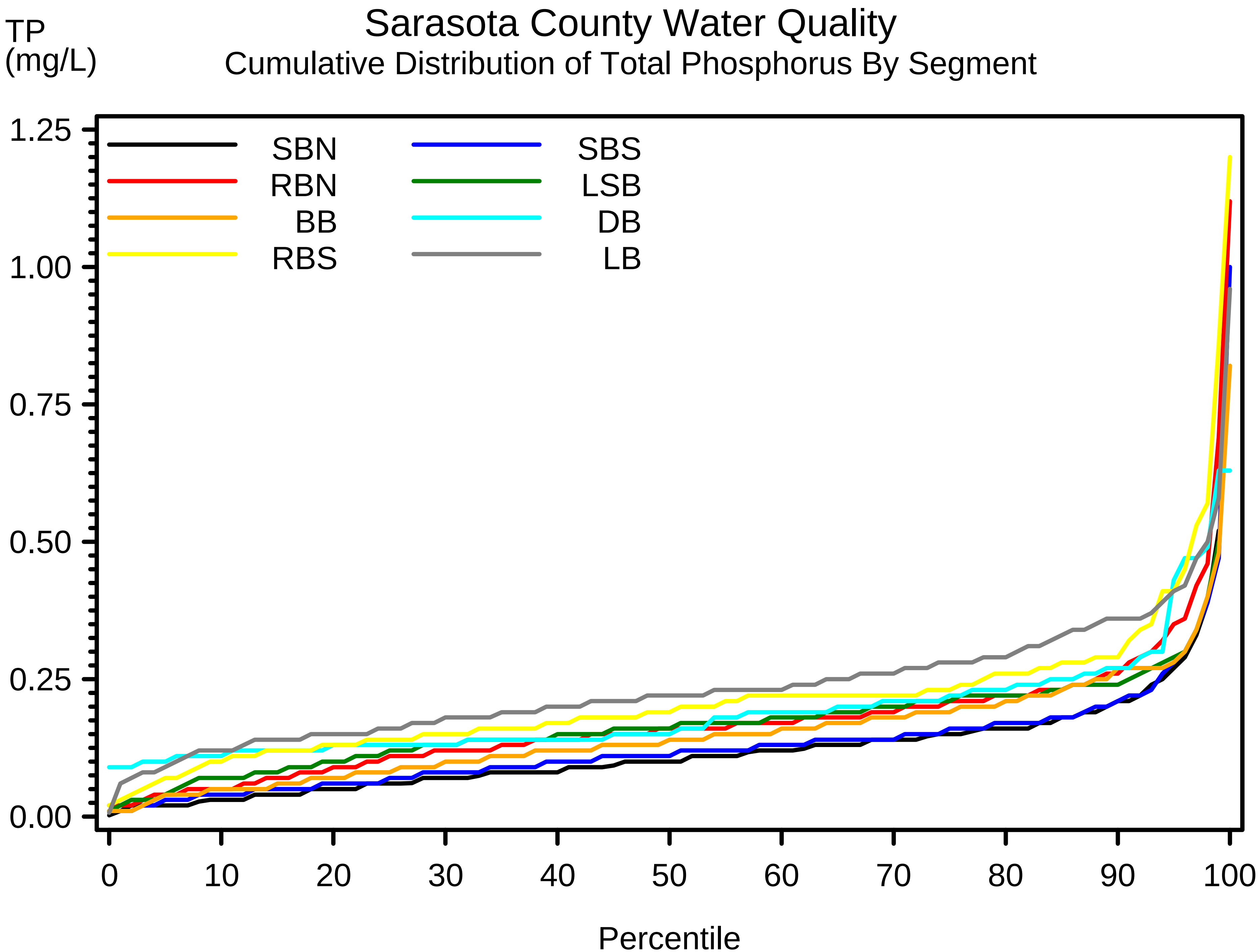


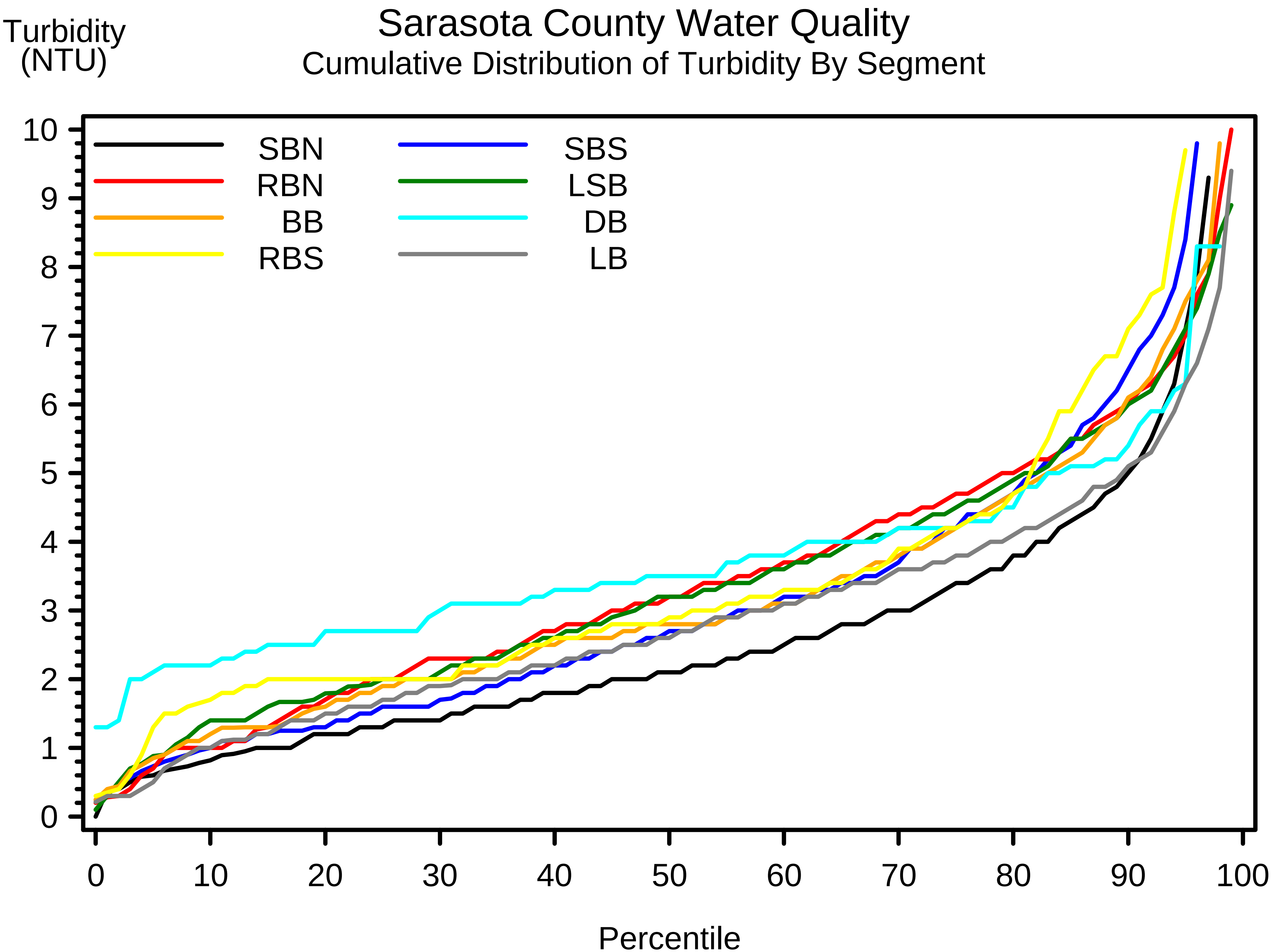
TN
(mg/L)
Sarasota County Water Quality
Cumulative Distribution of Total Nitrogen By Segment
SBN
RBN
BB
RBS
SBS
LSB
DB
LB
2.0
1.5
1.0
0.5
0.0
0
10
20
30
40
50
60
70
80
90
100
Percentile



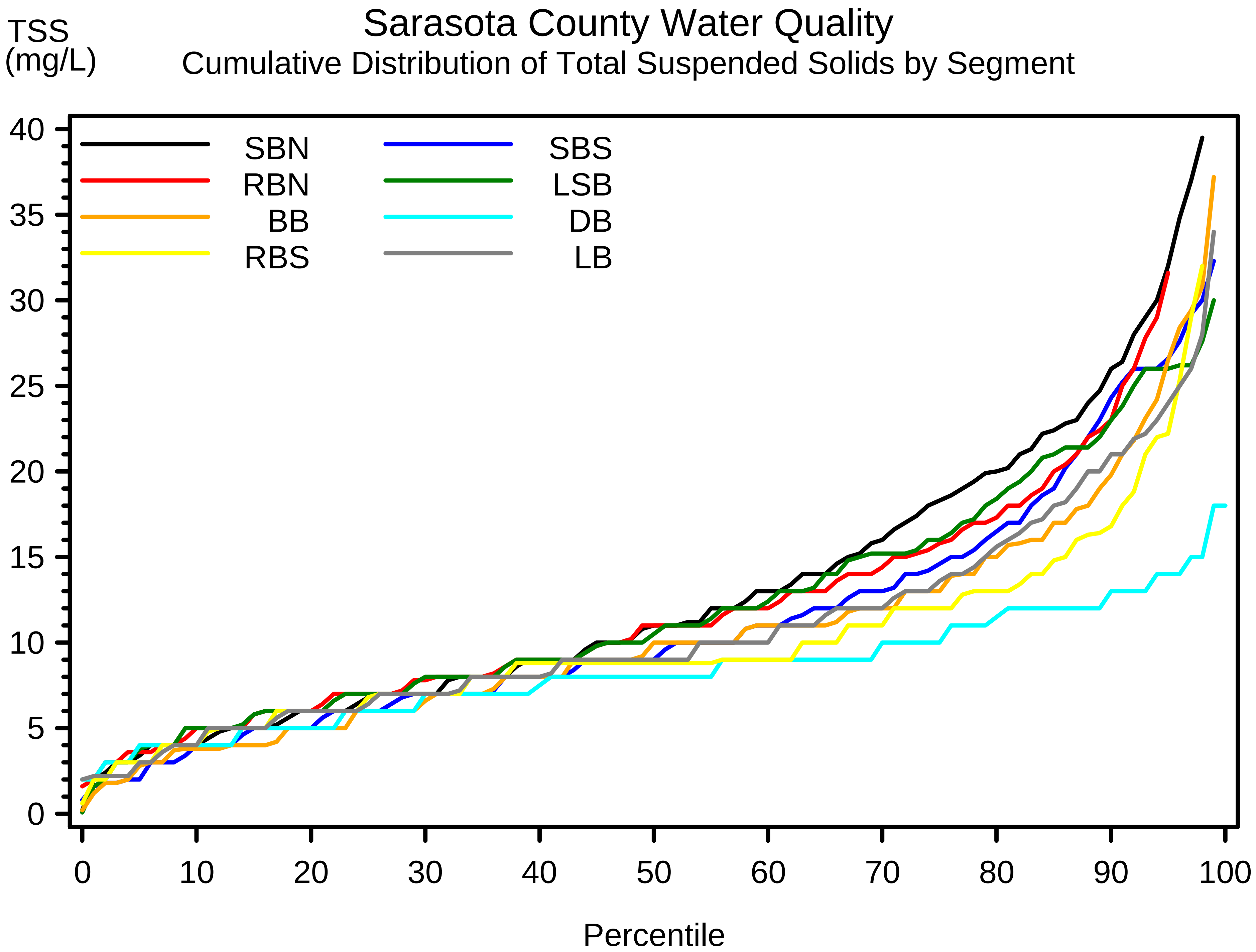
Color
(PCU)
Sarasota County Water Quality
Cumulative Distribution of Color By Segment
SBN
RBN
BB
RBS
SBS
LSB
DB
LB
200
180
160
140
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
90
100
Percentile


Salinity
(ppt)
Sarasota County Water Quality
Cumulative Distribution of Salinity By Segment
40
35
30
25
20
15
10
5
0
0
10
20
30
40
50
60
70
80
90
100
Percentile
SBN
RBN
BB
RBS
SBS
LSB
DB
LB


Sarasota County Water Quality
Cumulative Distribution of Total Phosphorus By Segment
TP
(mg/L)
SBN
RBN
BB
RBS
SBS
LSB
DB
LB
1.25
1.00
0.75
0.50
0.25
0.00
0
10
20
30
40
50
60
70
80
90
100
Percentile



Sarasota County Water Quality
Cumulative Distribution of Turbidity By Segment
Turbidity (NTU)
10
9
8
7
6
5
4
3
2
1
0
SBN
RBN
BB
RBS
SBS
LSB
DB
LB
0
10
20
30
40
50
60
70
80
90
100
Percentile



TSS
(mg/L)
Sarasota County Water Quality
Cumulative Distribution of Total Suspended Solids by Segment
SBN
RBN
BB
RBS
SBS
LSB
DB
LB
0
5
10
15
20
25
30
35
40
0
10
20
30
40
50
60
70
80
90
100
Percentile

Appendix 2