Brighton Reservation Monitoring

Optimization Leader: Mike Wessel, Janicki Environmental
Statistician: Mike Wessel, Janicki Environmental

Project Code: BRM

Type: Type II (with several Type 1 stations from Project X)

Mandate/Permit:
- 2000-Lake Okeechobee Protection Act (LOPA) Chapter 00-130;
- 1979-Lake Okeechobee Operating Permit (LOOP) (#50-0679349);
- 2004- Lake Okeechobee Protection Program (LOPP) Section 373.4595
- Agreement & Water Supply Plan for the Brighton Reservation, Implementing Section VI.B. of the Water Rights Compact & Subparagraph 3.3.3.2.A.3 of the Critical Manual (Agreement No. C4121);
- 1996- Agreement Providing for Water Quality, Water Supply and Flood Control Plans for the Big Cypress and Brighton Seminole Indian Reservations, Implementing Sections V.C and VI.D of the Water Rights Compact;
- FL Watershed Assessment Act (TMDLs/MFLs/PLRGs);
- TMDL - Total Phosphorous Rule 62-304.700

Project Start Date: 05/23/2002

Division Manager: Okeechobee Division: Susan Gray

Program Manager: Robert Boney

Points of Contact: Robert Boney, Steffany Gornak, Patrick Davis

Field Point of Contact: Patrick Davis

Spatial Description:
The Brighton Seminole reservation is located near the northwest shore of Lake Okeechobee in Glades County. The reservation lies between the C-40 and C-41 canals which drain agricultural and marsh areas between the reservation and Lake Istopoga. Historically, the Seminole tribes' Water Reservation came from Lake Istopoga. As the population grew on the reservation, the tribe felt they were not receiving sufficient amounts of water from Lake Istopoga. Under federal law, the state (i.e., the District) needed to make certain that the Water Reservation for the Seminole tribe was met. To address this concern, the District put in structures (G207 and G208) to pump water from Lake Okeechobee back to the reservation, particularly in times of drought.

Two stations to be sampled for Project BRM (C40VMB and C41VMB) are located at the southeast border where the water exits the reservation and are considered Type 2 mandated stations. The structures G207 and G208 are sampled under Project X but the data should be included in optimization efforts for Project BRM. Additionally, structures on the L-60 levee (L-59W, L60E, L60W, L61E) are part of Project X, but should be included when evaluating data for Project BRM. These stations considered Type 1 mandated under Project X. Stations S71 and S72 also should be considered when evaluating data for Project BRM. Again, these stations are monitored under project X as Type 1 stations because they are major inflows into Lake Okeechobee.

Project Purpose, Goals and Objectives:
The primary purpose of Project BRM is to address the mandates specified above, particularly the agreement the SFWMD has with the tribes to address water quality issues. The Brighton Seminole Reservation has its own internal water quality monitoring program. Project BRM was instituted because the Reservation began detecting spikes in the water coming off their land and it did not appear to be from any internal practices. Therefore, one goal of the project is to determine the source (s) of total phosphorous measured by the Tribe at monitoring stations

in the primary and secondary canals of the Brighton Seminole Indian Reservation. Another goal for this project involves investigating potential water quality changes within the reservation boundaries, in response to the integration of water supplies from Lake Okeechobee. Specific objectives include assessing the quality and quantity of water delivered to the reservation from Lake Okeechobee via pump stations G207 & G208, assessing the quality and quantity of water delivered to the reservation via the C-40 and C-41 canals, and assessing water sources entering and leaving the reservation.

Sampling Frequency and Parameters Sampled:
Samples are collected weekly from flow proportional autosamplers for total Kjeldahl nitrogen, nitrite+nitrate and total phosphorus. Autosamplers are located at sampling stations C40VMB, C41VMB, G207, G208, S71 and S72. Grab samples for the same parameters (total Kjeldahl nitrogen, nitrite+nitrate and total phosphorus) are sampled weekly when flowing from these same stations. Sampling also occurs at stations on the L-60 levee (L59W, L60E, L60W and L61E) on a bi-monthly basis when flowing. If the water is not flowing, sampling is conducted monthly.

Current and Future Data Uses:
The data from the BRM will be included in the annual Lake Okeechobee Watershed Assessment Report and the South Florida Environmental Report. Additionally, this information will be incorporated into a report for the Seminole Tribe under the Seminole Agreement.

In the future, data from several of the Project X stations that are sampled under Project BRM will also be used for TMDL development.

Identified Optimization Opportunities:
Discussions with District staff suggested that the data for this project may be limited due to the recent start date. However, some questions were generated that will provide useful for guiding the optimization.

- Are data sufficient both temporally and spatially to enable source identification?
- How well do data from Project X locations compare to the BRM stations?

Parameters Collected by Flow Proportional Autosamplers for Project BRM

Station	NOX	TKN	TPO4
C40VMB	w	w	w
C41VMB	w	w	w
G207	w	w	w
G208	w	w	w
S71	w	w	w
S72	w	w	w

w=weekly; gray shading indicates a Type 2 station. Note: S71 and S72 are Type I for Grabs under Project X

Parameters Collected by Grabs for Project BRM

Station	NOX	TKN	TPO4
C40VMB	w	w	w
C41VMB	w	w	w
G207	w	w	w
G208	w	w	w
L59W	bwf/m	bwf/m	bwf/m
L60E	bwf/m	bwf/m	bwf/m
L60W	bwf/m	bwf/m	bwf/m
L61E	bwf/m	bwf/m	bwf/m
S71	w	w	w
S72	w	w	w

wf = weekly when flowing; bwf/m = bi-weekly if flowing else monthly; gray shading indicates a Type 2 station; no shading indicates a Type 1 station. Note: Stations L59W, L60E, L60W, L61E, S71 and S72 are Type I mandate under Project X.

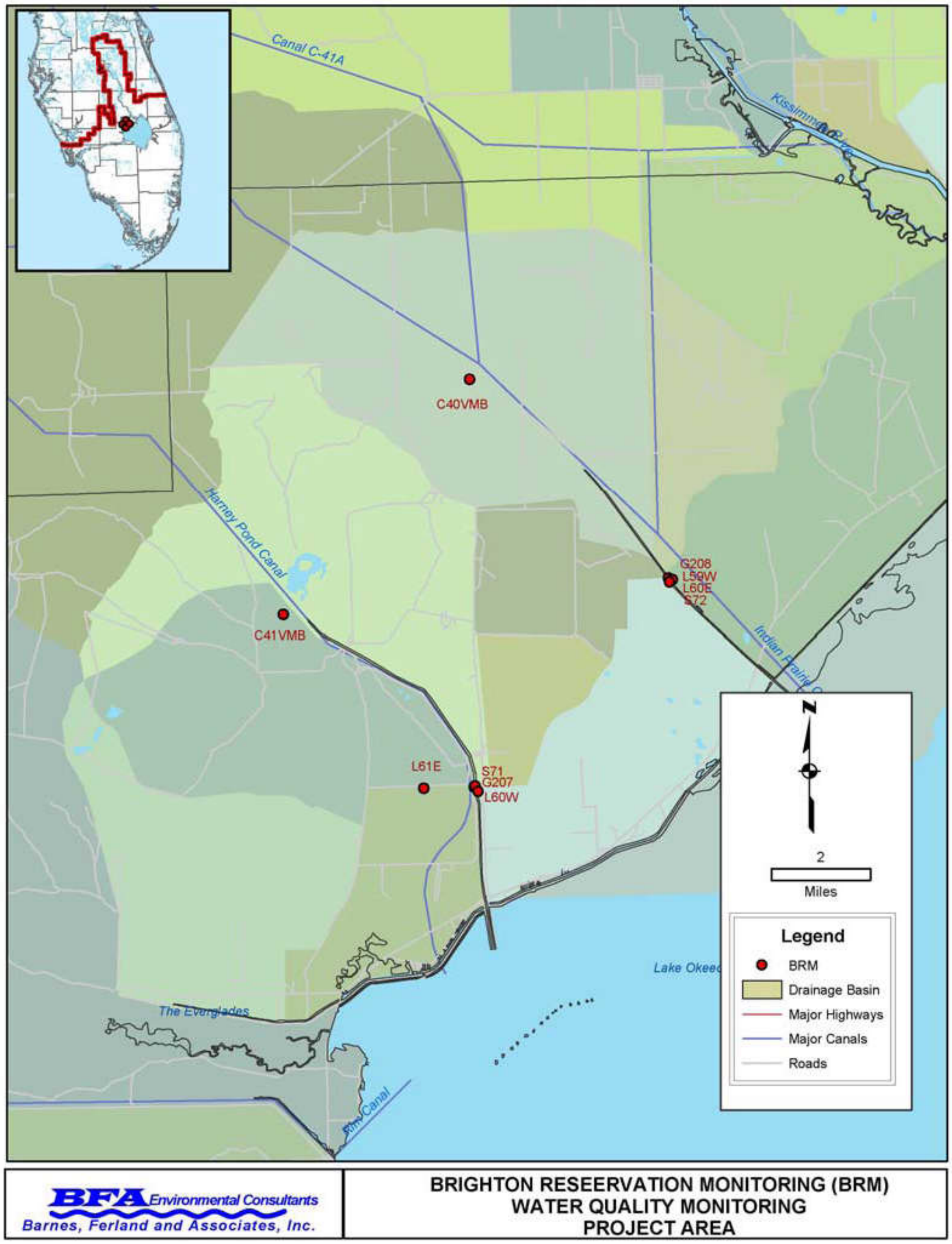


Figure 1. BRM Sampling Locations

Optimization analysis:
Optimization of the BRM water quality monitoring project was undertaken with respect to the specific tasks outlined above and detailed in the optimization plan modified and approved in September 2005. Briefly, the spatial and temporal adequacy of the BRM project was evaluated with respect to being able to detect changes between time periods, being able to detect trends in water quality parameters by station within the project, assessing information redundancies among stations and identifying stations located in proximity to potential point source discharges. The parameters identified for optimization for this project were:

Parameter	Units	DBHydro Code
NOx	mg/L	18
TKN	mg/L	21
TPO4	mg/L	25

- To estimate power and effect size detectable for the current monitoring program, Monte Carlo simulation using the nonparametric Sign Test was used to estimate the detectable change in median value for each parameter of interest across stations that would correspond to a significant shift in the distribution from current levels (i.e. long-term median condition) given the current sampling effort. Further, the test was constructed to establish whether or not a given magnitude of change would result in an detectable 20 % change in long term median.

- To estimate the power to detect a trend for a given water quality parameter, Monte Carlo simulations were performed using the Seasonal Kendall Tau Test for Trend. This procedure is being documented as a statistical evaluation tool for the SFWMD and the procedure will be outlined in detail in separate documentation. Briefly, the simulations result in an estimate of the slope (trend) that can be detected for a given monitoring routine using the current annual effort and under alternative sampling strategies. Again a 20% change in slope was used as a target change for detection.

The BRM project and the associated Project X monitor water quality in and around the Brighton Reservation including inflows to Lake Okeechobee. Several stations associated with this project are Type 1 stations sampled under project X as they are major inflows to Lake Okeechobee. The sampling stations directly associated with the BRM project include stations C40VMB and C41VMB which began sampling in 2002 with flow proportional auto-samplers and grab sampling. Also associated with the optimization of this project were stations from project X which have a longer period of record for sampling and are collected by grab samples.

The first component of the optimization was to examine the project-wide distribution for each parameter of interest, calculate the long term median value for each parameter of interest and generate a simulation dataset that could be used to test the effectiveness of the current monitoring sampling design to estimate changes in water quality parameters of interest to the District. Details of the sign test methods are conveyed in the master document. Briefly, the sign test simulation exercise is meant to demonstrate the ability of a sampling program to detect changes from a baseline value under a given sampling frequency. The long term median value was used to represent a baseline value and the test was constructed as a one-sample test to estimate the power to detect a change in the median value for each water quality variable of interest. Since there is only variability associated with one group of data for the comparison, the test is more powerful than a two- sample test where uncertainty is expressed in the distribution of each comparison group. Further, the sign test simulations do not account for serial auto-correlation which can be present in monitoring data. The presence of significant auto correlation, if not accounted for, can yield unrealistically optimistic assessments of the sample size necessary to detect changes. However, from a regulatory perspective, auto-correlation is often not considered when assessing whether or not a water body is meeting or exceeding a given water quality target (e.g., Impaired Waters Rule F.A.C. 62-303.320). Auto-correlation is not considered in the sign test simulations but is considered in the test for trend analysis presented later in this document.

Table 1 provides a summary of the simulation results for pooled grab sampling stations using the Sign Test to estimate the effect size (i.e., the annual percent change from median value) that is detectable under the current monitoring strategy and identify the number of years of data required to detect a specified magnitude of change from current conditions. The sample size was based on the number of samples collected in 2002 (n=144). The Sign Test simulations estimated the detectable change in median for 1-5 years worth of sampling so that the increased sampling frequency in 2003 and 2004 was accounted for in the simulations.

Table 1. Results of Monte Carlo simulation using the Sign Test to determine the effect size and number of samples to detect a 20% change in long term median value (Target) with 80% power for grab sampling stations.

Parameter	Nobs/Year	Long Term Median Value	Annual Percent Change Detected	Number of Samples to Detect Shift to Target
NOx	144	0.20	62.3	>720
TKN	144	1.50	12.3	90
TPO4	144	0.14	21.0	150

Results for grab samples suggest that the sampling frequency necessary to detect a 20% change from the median was adequate to detect annual changes in TKN concentrations, and adequate to detect bi annual changes of 20% in TPO4 concentrations but that the 20% change criterion for NOx was too restrictive suggesting even with extremely high sampling frequency would result in an inability to detect a 20% change in NOx. Indications are that only a change of approximately 0.15 mg/L would be detectable using an annual grab sampling frequency of 144 across stations.

Results for auto sampling stations suggested auto sampling yielded greater power to detect a 20% change in median for TPO4 and TKN and that a 20% change in NOx was detectable over a 4 year window (Table 2).

Table 2. Results of Monte Carlo simulation using the Sign Test to determine the effect size and number of samples to detect a 20% change in long term median value (Target) with 80% power for flow proportional auto-samplers.

Parameter	Nobs/Year	Long Term Median Value	Annual Percent Change Detected	Number of Samples to Detect Shift to Target
NOx	144	0.26	49.1	576
TKN	144	1.66	8.5	50
TPO4	144	0.17	18.2	140

The second component of the optimization was to assess power to detect trends in the water quality parameters of interest. For the BRM project, only the project X stations including L59W, L60E, L60W,S71 and S72 have a period of record long enough to warrant power analysis using the Seasonal Kendall Tau Test for Trend. For these stations, the time series of data was modeled to estimate the seasonal variability and autocorrelation in the data. A simulation dataset was generated from which samples could be pulled representing 5 year time series segments. For each replicate trial, the Seasonal Kendall Tau Test for Trend was used to estimate the annual percent change in slope that could be detected under the current sampling design and under alternative sampling frequencies.

Table 3. Results of Monte Carlo simulation using the Seasonal Kendall Tau Test for Trend on a 5 year time series of grab samples to determine the effect size for change in slope parameter.

Station	Parameter	Number of samples per year	Slope Estimate	Annual Percent Change Detectable	Can You Detect an Trend in 5 Years?
L59W	NOx	12	0	5.1	N +
L59W	TKN	12	0.0178	6.6	N
L59W	TPO4	12	0.0058	3.8	Y
L60E	NOx	12	0	5.7	N
L60E	TKN	12	0	7.2	N
L60E	TPO4	12	0	2.7	Y

L60W	NOx	12	-0.0260	13.1	N
L60W	TKN	12	0.0112	5.3	N +
L60W	TPO4	12	0	2.1	Y
S71	NOx	12	0	13.3	N
S71	TKN	12	0.013	6.7	N
S71	TPO4	12	0.006	3.1	Y
S72	NOx	12	0	5.6	N
S72	TKN	12	0.0114	6.6	N
S72	TPO4	12	0.0047	2.5	Y

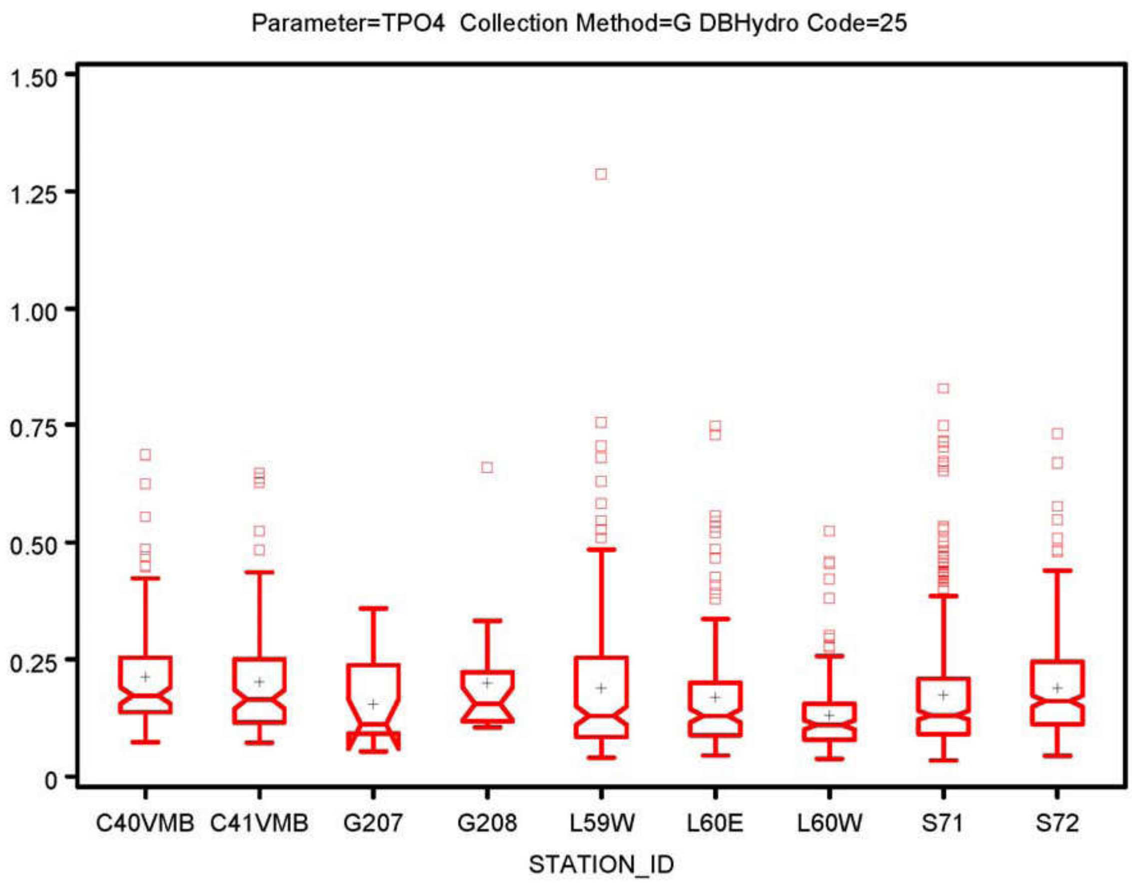
+ indicates that increasing sampling frequency to bi-weekly would result in ability to detect a 20% change over 5 years.

Results of trend tests for individual stations within the project indicate that the current sampling frequency is sufficient to detect trends in TPO4 that would result in a 20% increase in slope over 5 years. For TKN additional sampling to consistent bi-weekly sampling would yield sufficient power for detecting a 20% change in slope at stations L60W and L59W. Interestingly, TKN appeared to be increasing at all stations except L60W and the slope estimates for TPO4 were also significantly increasing at several of the stations evaluated.

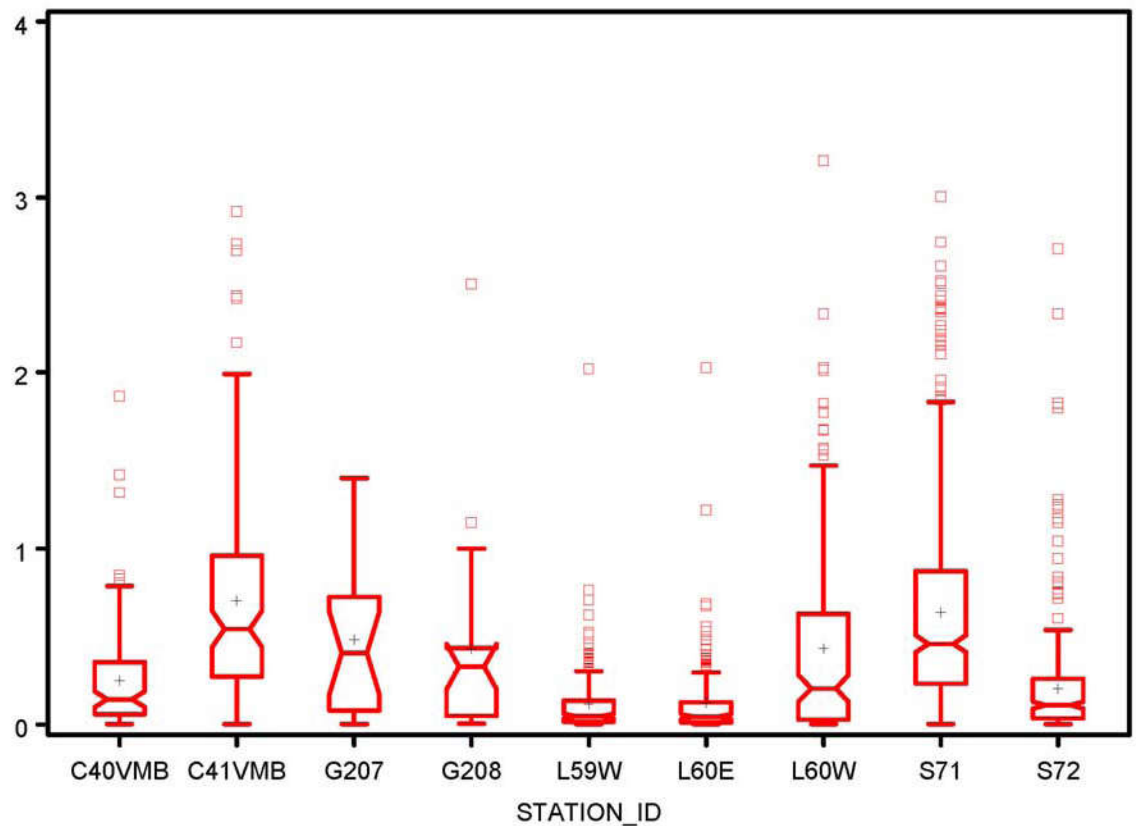
Distribution box plots for each parameter form 2002 -2004 by station (Appendix BRM-1) reveal that station C41VMB tended to record higher values for NOx than all other stations while for the other parameters of interest all the stations had similar distributions.

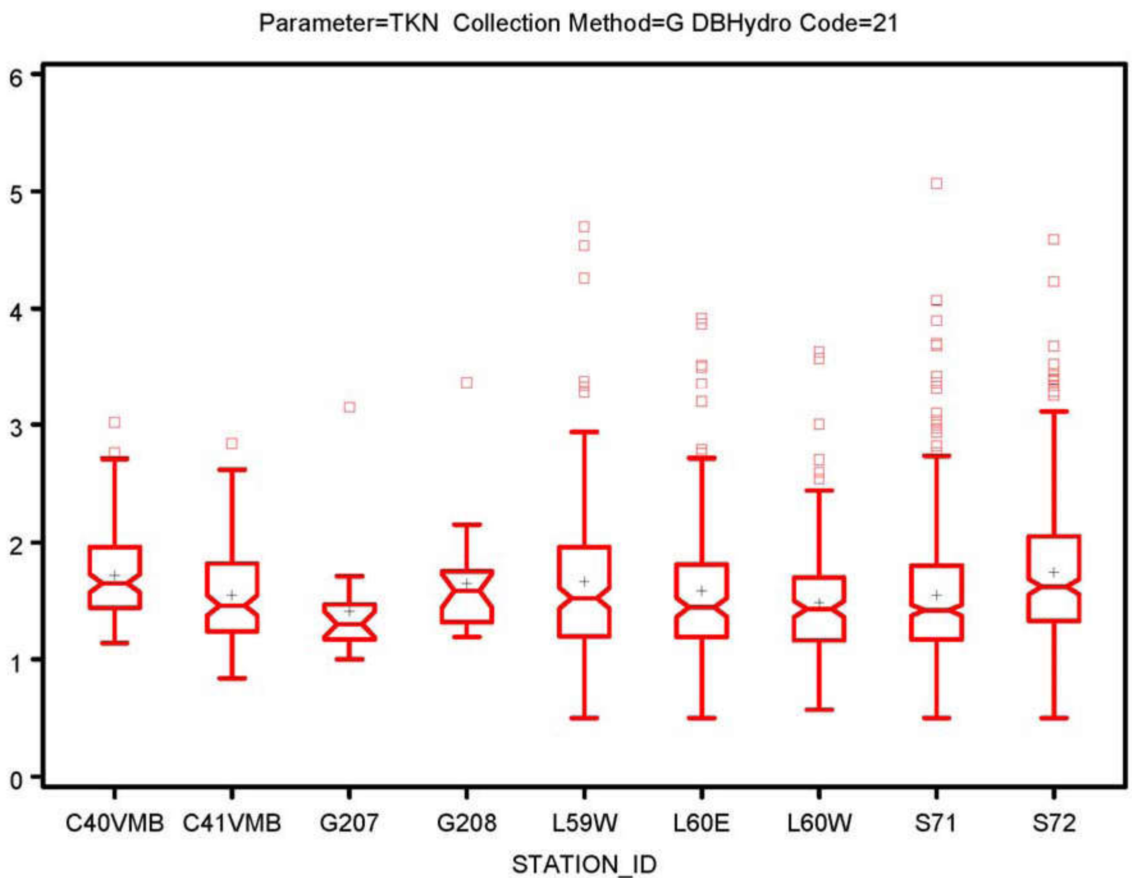
Recommendations:
The BRM project is an important part of the South Florida Water Quality Monitoring Network. The data are used to monitor water quality within the reservation and estimate nutrient concentrations into Lake Okeechobee. Since the BRM project has only been in operation for a short time, project X was included in this optimization study. In general it appears that this project is well suited to meet the goals and objectives established. Only with a longer time series of data can the power to detect trends for stations C40VMB and C41VMB be assessed. The target identified for assessing changes in the median value was a 20% change in magnitude. This change was reasonable for TPO$ and TKN but seemed to be to strict a criterion for NOx given the variability in the data. Consideration should be given to identifying specific criterion for each parameter of interest (e.g. state water quality standards) to evaluate whether any changes in magnitude or time series trend will result in an adverse condition within the BRM project. This will be in line will future mandates associated with TMDL development for the area. Otherwise sampling effort should continue at current levels until sufficient data are available to evaluate trends at the BRM stations and compare them with trends in the adjacent project X.

Appendix BRM-1
Box Plots


Parameter=TPO4 Collection Method=G DBHydro Code=25
1.50
1.25
1.00
0.75
0.50
0.25
0
C40VMB
C41VMB
G207
G208
L59W
L60E
L60W
S71
S72
STATION_ID

Parameter=NOx Collection Method=G DBHydro Code=18




Parameter=TKN Collection Method=G DBHydro Code=21
0
1
2
3
4
5
6
C40VMB
C41VMB
G207
G208
L59W
L60E
L60W
S71
S72
STATION_ID

Collier County Water Quality

Optimization Leader: Mike Wessel, Janicki Environmental
Statistician: Mike Wessel, Janicki Environmental

Project Code: CCWQ

Type: Type III

Mandate/Permit:

- Site Permit for Corkscrew Swamp for DEP
- Prairie Canal Permit from DEP
- WRDA 2000, PL 106-541, Title VI, Section 601 (Comprehensive Everglades Restoration Program)

Project Start Date: May 2000

Division manager: Big Cypress Basin Service Center: Clarence Tears
Coastal Ecosystem Division: Sean Sculley (Acting)

Program Manager: Clarence Tears

Points of Contact: Clarence Tears, Anantha Nath, Mike Duever, Tim Howard, Patrick Martin

Field Point of Contact: Patrick Martin

Spatial Description:
The CCWQ project collects samples from southwest Florida in Collier County. Forty-eight locations are sampled for project CCWQ. Forty-three of the stations are within the Big Cypress Basin's inland and estuarine waterbodies. Five stations are located within the Fakahatchee Strand and Corkscrew Swamp area. In addition to these stations, the county also samples monthly at 5 designated stormwater outfalls within the city of Immokalee. These stations are registered under Project IMKS.

Discussions with District staff familiar with Project CCWQ relayed that several of the stations (BC7, BC8, BC12 in the Prairie Canal and BC 13, BC14, BC15, COCAT41, COCEOF31 and CORK@846 in Corkscrew Swamp are Type 1 under the Prairie Canal site permit with DEP and Corkscrew Swamp Permit with DEP.

Several District staff mentioned that there may be some areas that need to be added to Project CCWQ. There are several natural areas (i.e., middle of Fakahatchee strand and the west prairies) that are not, and have not been, monitored, and therefore no baseline information is available.

Project Purpose, Goals and Objectives:
Although no active mandates specify this monitoring, this project supports the District's commitment to a unified sampling program to provide data to address southwest Florida water quality issues. No other water quality monitoring is currently conducted in this area. This southwest region of Florida has experienced rapid growth and development in terms of agriculture and urban-suburban growth over the past 10 years. A concern of this growth is the impact it will have on water quality. Therefore, the goals and objectives of this program are to collect baseline data and information that can be used to develop water management strategies for the Big Cypress basin watershed and adjacent coastal waters of Collier County

Sampling Frequency and Parameters Sampled:
The forty-eight stations sampled for Project CCWQ are sampled (via grab) quarterly for alkalinity, calcium, chloride, fluoride, magnesium, silica, sulfate, and metals (arsenic, cadmium, chromium, copper, iron lead and zinc). Monthly sampling is also conducted (via grab) for ammonia, dissolved inorganic nitrogen, total organic nitrogen, nitrate, nitrite, nitrate+nitrite, total nitrogen, total Kjeldahl nitrogen, total phosphorus, orthophosphrus, total dissolved solids, total suspended solids, turbidity, color, chlorophyll a, phaeophytin, fecal coliform, total coliform, total organic carbon and hardness.

In situ parameters are also measured at all sampling locations. These parameters include dissolved oxygen, pH, water temperature, salinity, and specific conductance.

Current and Future Data Uses:
Data from Project CCWQ are used in the development of water management strategies for the Big Cypress Basin watershed and adjacent coastal waters of Collier County and are critical to the Southwest Florida Feasibility Study. These data are used for District operations and the Districts Water Supply Plan for the Reservations. Data have been used in baseline discussions and will continue to be utilized in the monitoring requirements for Picayune Strand (Acceler8 Project). Data will also be used by the Belleglade RP. The Tamiami Trail project which is tied to the first phase of the Picayune Strand restoration project will also use data collected from Project CCWQ. In addition to use by CERP, several of the stations from CCWQ may be incorporated into the RECOVER Monitoring and Assessment Plan.

Several modeling activities are proposed for the southwest FL area and the data from CCWQ may feed into several of these models. For Collier County/Big Cypress Basin, proposed models include the MIKE SHE/MIKE 11 model be used for the watershed. The QUAL 2E model should be used for the non-tidally influenced streams, lakes and reservoirs water quality simulation whereas the WASP model is proposed for the tidally influenced streams/waterbodies.

Identified Optimization Opportunities:
Discussions with District staff identified some potential opportunities for optimization. Additionally, questions were generated that will provide useful for guiding the optimization.

- How comparable are stations within the Project area both spatially and temporally?
- Are any of the parameters measured highly correlated?

Parameters measured In Situ for Project CCWQ

Station	DO	PH	TEMP	SAL	SCOND
BARRIVN	m	m	m	m	m
BC1	m	m	m	m	m
BC10	m	m	m	m	m
BC11	m	m	m	m	m
BC12	m	m	m	m	m
BC13	m	m	m	m	m
BC14	m	m	m	m	m
BC15	m	m	m	m	m
BC16	m	m	m	m	m
BC17	m	m	m	m	m
BC18	m	m	m	m	m
BC19	m	m	m	m	m
BC2	m	m	m	m	m
BC20	m	m	m	m	m
BC21	m	m	m	m	m
BC22	m	m	m	m	m
BC23	m	m	m	m	m
BC24	m	m	m	m	m
BC25	m	m	m	m	m
BC3	m	m	m	m	m
BC4	m	m	m	m	m
BC5	m	m	m	m	m
BC6	m	m	m	m	m
BC7	m	m	m	m	m
BC8	m	m	m	m	m
BC9	m	m	m	m	m
CHKMATE	m	m	m	m	m
COCAT41	m	m	m	m	m
COCEOF31	m	m	m	m	m
COCPALM	m	m	m	m	m
CORK@846	m	m	m	m	m
CORKN	m	m	m	m	m
CORKS	m	m	m	m	m
CORKSCRD	m	m	m	m	m
CORKSW	m	m	m	m	m
ECOCORIV	m	m	m	m	m
FAKA	m	m	m	m	m
FAKA858	m	m	m	m	m
FAKAUPOI	m	m	m	m	m
GATOR	m	m	m	m	m
GGC@858	m	m	m	m	m
GGCAT31	m	m	m	m	m
HALDCRK	m	m	m	m	m
LELY	m	m	m	m	m
MONROE	m	m	m	m	m
OKALA858	m	m	m	m	m
TAMBR90	m	m	m	m	m
IMK6STS	m	m	m	m	m
IMKBRN	m	m	m	m	m
IMKFSHCK	m	m	m	m	m
IMKMAD	m	m	m	m	m
IMKSLGH	m	m	m	m	m

m = monthly; light gray shading indicates a Type 1 station; dark gray shading indicates a Type 2 station; no shading indicates a Type 3 station

Parameters measured from Grab samples for Project CCWQ

Station	ALKA	CA	CL	F	MG	SIO2	SO4	TOT AS	TOT CD	TOT CR	TOT CU	TOT FE	TOT PB	TOT ZN	NH4	DIN	TON	NO3	NO2	NOX	TN	TKN	TPO4	OPO4	TDS	TSS	TURBI	COLOR	CHLA	PHAEO	FCMF	TCMF	TORGC	HARD
BARRIVN	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
BC1	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
BC10	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
BC11	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
BC12	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
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BC16	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
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BC19	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
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BC23	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
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BC25	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
BC3	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
BC4	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
BC5	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
BC6	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
BC7	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
BC8	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
BC9	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
CHKMATE	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
COCAT41	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
COCEOF31	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
COCPALM	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
CORK@846	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
CORKN	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
CORKS	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
CORKSCRD	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
CORKSW	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
ECOCORIV	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
FAKA	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
FAKA858	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
FAKAUPOI	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
GATOR	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
GGC@858	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
GGCAT31	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
HALDCRK	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
LELY	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
MONROE	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
OKALA858	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
TAMBR90	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	qrt	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
IMK6STS						m	m	m		m	m		m	m	m					m		m	m			m		m						m
IMKBRN						m	m	m		m	m		m	m	m					m		m	m			m		m						m
IMKFSHCK						m	m	m		m	m		m	m	m					m		m	m			m		m						m
IMKMAD						m	m	m		m	m		m	m	m					m		m	m			m		m						m
IMKSLGH						m	m	m		m	m		m	m	m					m		m	m			m		m						m

m = monthly; qtr = quarterly; light gray shading indicates a Type 1 station; dark gray shading indicates a Type 2 station; no shading indicates a Type 3 station

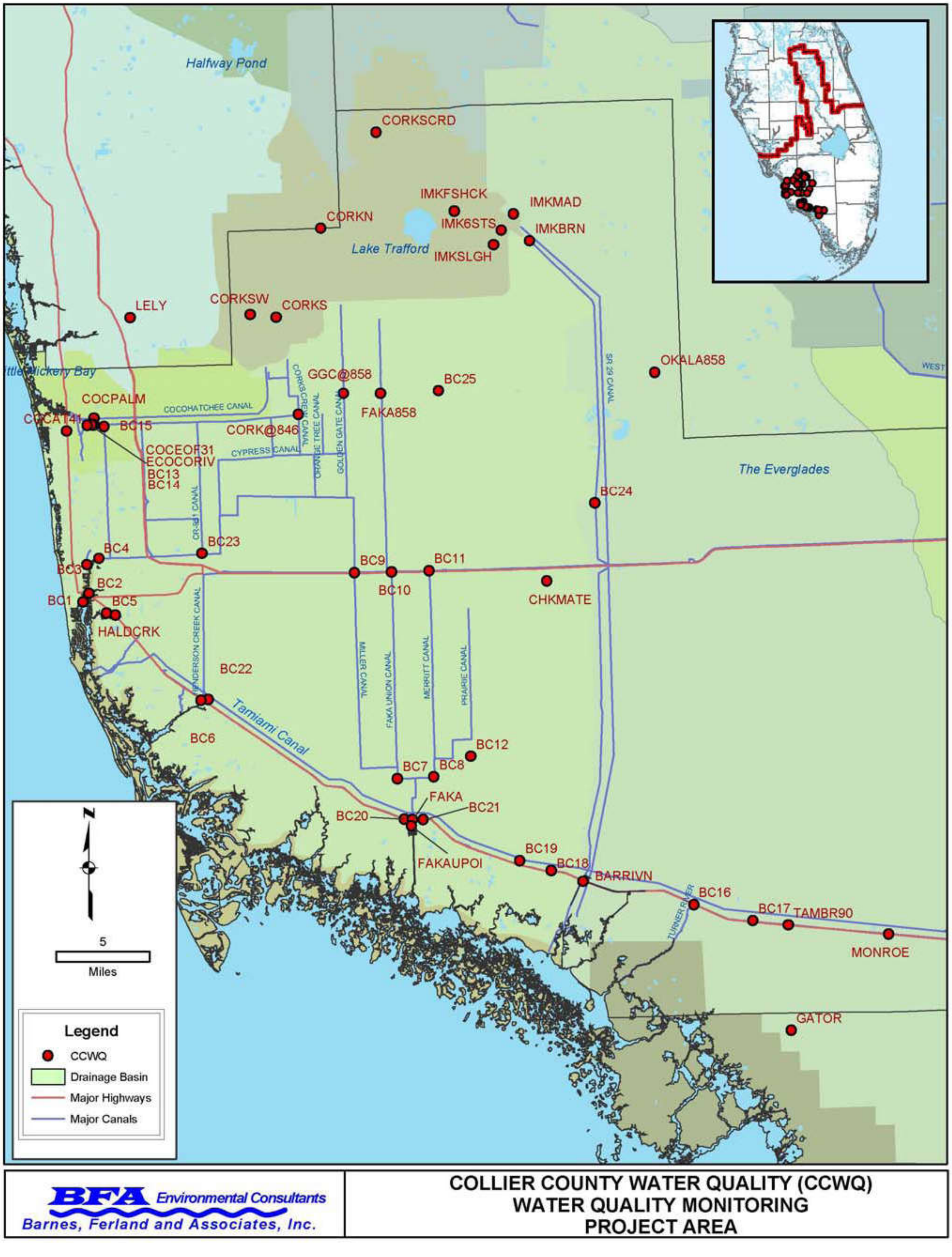


Figure 1. CCWQ Sampling Locations

Optimization analysis:

Optimization of the CCWQ water quality monitoring project was undertaken with respect to the specific tasks outlined above and detailed in the optimization plan modified and approved in September 2005. Briefly, the spatial and temporal adequacy of the CCWQ project was evaluated with respect to being able to detect changes between time periods and assessing information redundancies among stations. The parameters identified for optimization for this project were:

Parameter	Units	DBHydro Code
Dissolved Oxygen	mg/L	8
Chlorophyll a	mg/M3	61
TPO4	mg/L	25
TSS	mg/L	16
TN	mg N/L	80

Note: CHL2 was unavailable in DBHydro for analysis for the CCWQ project.
Note: More data were available for TN (code 80) in DBHyro than by calculating TN as the sum of NOx, NH4 and TKN.

- To estimate power and effect size detectable with the current monitoring program, Monte Carlo simulation using the nonparametric Sign Test was used to estimate the detectable change in median value for each parameter of interest across stations that would correspond to a significant shift in the distribution from current levels (i.e. long-term median condition) given the current sampling effort. Further, the test was constructed to establish whether or not a given magnitude of change would result in an observable exceedance of a water quality target defined as a 20 % change in long term median. The number of samples necessary to detect the defined change was also established through this simulation.

- To assess the monitoring program spatially, Principal Components Analysis (PCA) was used as a data reduction technique in an attempt to identify stations which co-vary significantly with respect to the parameters identified for optimization. The results of PCA were used to group stations into hypothetical strata from which differences in the distributions for each parameter of interest was assessed. PCA was also performed independently for each parameter of interest as a comparative tool.

- Spearmans rank correlation was used to compare stations that were spatially grouped in closest proximity against the results of PCA analysis.

The CCWQ project covers an expansive area of southwest Florida and samples structures on canals discharging from the lower everglades as well as relatively un-impacted natural areas. The monitoring program has been established to collect baseline information of water quality throughout the region and provide information necessary for water management strategies for the Big Cypress basin watershed and adjacent coastal waters of Collier County. Because the time series of data for CCWQ represents only three full years of sampling effort, power testing for trends in water quality was not performed.

The first component of the optimization was to examine the project-wide distribution for each parameter of interest, calculate the long term median value for each parameter of interest and generate a simulation dataset that could be used to test the effectiveness of the current monitoring sampling design to estimate changes in water quality parameters of interest to the district. Details of the sign test methods are conveyed in the project comprehensive report (Hunt *et. al*., 2006). Briefly, the sign test simulation exercise is meant to demonstrate the ability of a sampling program to detect changes from a baseline value under a given sampling frequency. The long term median value was used to represent a baseline value and the test was constructed as a one-sample test to estimate the power to detect a change in the median value for each water quality variable of interest. Since there is only variability associated with one group of data for the comparison, the test is more powerful than a two- sample test where uncertainty is expressed in the distribution of each comparison group. Further, the sign test simulations do not account for serial auto-correlation which can be present in monitoring data. The presence of significant auto correlation, if not accounted for, can yield unrealistically optimistic assessments of the sample size necessary to detect changes. However, from a regulatory perspective, auto-correlation is usually not considered when assessing whether or not a water body is meeting or exceeding a given water quality target (e.g., Impaired Waters Rule F.A.C. 62-303.320). Auto-correlation is not considered in the sign test simulations. Once a 5 year time series of data is available, it is recommended that the District perform trend analysis using software provided as part of this optimization process (Rust, 2005). The software package is designed to provide a tool for estimating the power of trend detection at individual monitoring stations and accounts for the potential effects of serial autocorrelation.

Table 1 provides a summary of the simulation results using the Sign Test to estimate the effect size (i.e., magnitude change in median value) that is detectable annually under the current monitoring strategy and identify the samples size (number of years of data) required to detect a specified magnitude of change from current conditions. The sample size for each parameter was estimated using the average number of grab samples taken in years 2001-2003.

Table 1. Results of Monte Carlo simulation using the Sign Test to determine the effect size and number of grab samples to detect a 20% change in long term median value (Target) with 80% power for stations.

Parameter	Average Number of Samples/Year	Long Term Median Value	Annual Percent Change Detected	Number of Samples to Detect Shift to Target
CHLA	358	3.20	14.0	300
DO	382	4.62	16.7	300
TN	276	0.69	9.9	160
TPO4	277	0.02	19.7	277
TSS	312	2.0	48.9	935

Results suggest that the sampling frequency necessary to detect a given change from the basin-wide median was parameter dependent. For the parameters CHLA and TN there was sufficient power to detect a 20% change in the long term median value annually. The sampling frequency was close to optimal for detecting a 20% change in median for TPO4. However, for TSS the sampling frequency necessary to detect a 20% change in the median was extremely large. This was apparently due to most (90%) of TSS values being recorded at a value of 2 which seems to correspond to the minimum detection limit (Table 2).

Table 2. Percentile distribution of values for each parameter of interest.

Percentile	TSS	TN	TPO4	CHLA	DO
100%	76	5.98	0.47	246.3	16.1
99%	17	2.34	0.238	48.6	11.39
95%	4	1.51	0.121	23	9.2
90%	2	1.23	0.081	15	8.16
75%	2	0.94	0.044	6.9	6.43
50%	2	0.73	0.023	3.2	4.59
25%	2	0.55	0.011	3	2.97
10%	2	0.37	0.009	3	1.89
5%	2	0.27	0.007	3	1.34
1%	2	0.24	0.004	3	0.63
0%	2	0.01	0.0032	3	0.25

The second component of the optimization was to assess the spatial distribution of samples and the correlation among stations for each of the parameters of interest. The intent of using PCA was to identify stations within the basin that were highly correlated with respect to the parameter measurements over time indicating the potential that there may be some spatial redundancy in the sampling design. The PCA analysis requires no missing values so data were averaged quarterly for each station/ parameter set. Further, since fewer samples occurred for stations CORKN, CORKS, CORKSW, CORKSCRD, TAMBR90 and CHKMATE, these stations were not included in the PCA analysis.

Four station groupings (strata) could be identified using the PCA analysis (Table 3). These groups were labeled strata A, B, C, D for convenience. Strata X includes stations that were not significantly correlated with any of the PCA factors identified in the analysis. The correlation of each station with the PCA factors is given in Appendix CCWQ-1 for all parameters combined and by parameter in Appendix CCWQ-2.

Table 3. List of strata identified using PCA on the CCWQ parameters of interest (TPO4, TN, TSS, CHLA, DO).

Strata A	Strata B	Strata C	Strata D	Strata X
BARRIVN	BC13	BC1	BC15	BC2
BC10	BC17	BC16	BC3	BC22
BC11	BC18	BC20	COCAT41	BC23
BC12	BC19	BC25	ECOCORIV	BC5
BC7	BC21	BC4	GGC_858	BC6
COCEOF31	BC24			COCPALM
FAKA	GATOR			CORK@846
FAKAUPOI				FAKA858
BC14				GGC@858
BC26				HALDCRK
BC8				LELY
BC9				MONROE
GGCAT31				

Stations located in strata B tended to be located along the Tamiami canal while Strata D stations were located in the upper NW corner of the Project area. Otherwise the PCA groupings did not strongly group stations, which were located in close spatial proximity. To further investigate spatial correlations, stations located in close proximity to one another were evaluated for each parameter of interest using Spearmans rank correlation. Two groups of stations: BC20,BC21, FAKA and FAKAUPOI in the SW project area; and, stations in the upper NW corner of the project area including BC13, BC14, BC15, COCEOF31, COCPALM, COCAT41, ECOCORIV were evaluated using Spearman rank correlation. From these analyses, BC20 andBC21 were significantly correlated with each other for all parameters of interest while the FAKA and FAKAUPOI stations were less correlated with each other than with BC20 and BC21 (Appendix 4). For parameters TN and TPO4, station COCEOF31 was highly correlated with BC14 and BC15 but only with BC13 for TN.

A final spatial correlation test was run on TYPE 1 stations against the other stations in the project to identify stations that may be providing information similar to that provided by a particular Type 1 station. Results of this comparison suggested that several stations were correlated with Cork_846 but the significance of these correlations was parameter dependent. (Appendix 5). In general, there were few consistencies across parameters to identify stations that appeared to be redundant with any of the Type 1 stations.

Recommendations:
The CCWQ project data has only been available since 2001 and the time series of data analyzed is not adequate to evaluate trends in water quality. Therefore, optimization was undertaken with respect to identifying the sampling frequency necessary to identify basin-wide changes in the long term median values for each parameter of interest and in identifying any stations that are providing redundant information. The CCWQ project is currently focused on providing baseline information on water quality in an area experiencing large scale residential and commercial development. Incorporating flow data was beyond the scope of this study, so inference regarding water quality parameters was assessed using nutrient concentration information. The CCWQ project covers an extremely large area of Southwest Florida including drainage basin canals and relatively un-impacted wetland areas. Attempts to identify contiguous station groupings using Principal Components Analysis resulted in four station groupings that though explained approximately 25% of the variation in the data across parameters of interest. Moreover, correlation tests suggested that those stations in close proximity were not necessarily correlated for all parameters

of interest.

From an optimization perspective, the CCWQ project presents several challenges including a short time series of data and temporally inconsistent data collection across the stations included in the project. Even so the, the sampling frequency appears adequate to assess basin-wide changes in median condition across all stations. However, given the large area, diversity of water types, and changes being experienced in the project area, it is unlikely that the entire area will be evaluated for basin-wide changes in median condition. It is more likely from a management perspective to evaluate changes for a particular sub-area within this project. Thus, consideration should be given to identifying these areas and defining a sampling frequency that evaluates stations within these areas in close temporal proximity (i.e. improve synoptic sampling).

Several of the stations within this project are designated as Type 1 stations that address specific mandates associated with permit requirements in the area. Several of the Type 2 and Type 3 stations appear to be co-located with these stations although sampling of these stations is not necessarily coordinated to minimize temporal differences in sampling with the Type 1 stations. This sampling design reduced the ability of this study to evaluate information redundancy between the Type II/II stations with the Type 1 stations. Even so, the PCA and correlation analysis suggested that close proximity stations BC20 and BC21 and BC9 and BC10 were providing similar information. The PCA analysis also identified several stations located along the Tamiami Canal (Strata B in Table 3) as co-varying similarly but not in close proximity as well as three stations (ECOCORIV, CACAT41, and BC15) in the NW corner of the study area (Strata D in Table 3) [].

Trend analysis was not conducted for this project as the time series of data was not long enough to evaluate trends over time. By 2006 enough data will have been collected to evaluate the power of the sampling program to evaluate trends in water quality at individual stations within the project area. These additional data will provide valuable insights into stations which may be providing redundant information with the project area and help to optimize the project. Identifying specific goals for the project such as determining changes from a specified baseline condition or evaluating data with respect to specific water quality targets would help refine the sampling program's objectives and enhance future optimizations. Further, identifying sub-areas within the project within which to make inferences about change would also be beneficial.

References

Hunt, CD. Field, J, Rust, S. 2006. Surface Water Quality Monitoring Network Optimization Comprehensive Report. Final report to the South Florida Water Management District. February 2006.

Rust SW. 2005. Power Analysis Procedure for Trend Detection with Accompanying SAS Software. Battelle Report to South Florida Water Management District, November 2005.

Appendix CCWQ-1

PCA based on all parameters of interest

Strata A	Strata B	Strata C	Strata D	Strata X
BARRIVN	BC13	BC1	BC15	BC2
BC10	BC17	BC16	BC3	BC22
BC11	BC18	BC20	COCAT41	BC23
BC12	BC19	BC25	ECOCORIV	BC5
BC7	BC21	BC4	GGC_858	BC6
COCEOF31	BC24			COCPALM
FAKA	GATOR			CORK@846
FAKAUPOI				FAKA858
BC14				GGC@858
BC26				HALDCRK
BC8				LELY
BC9				MONROE
GGCAT31				

Parameters of interest combined

Station	Factor1		Factor2		Factor3		Factor4	
BARRIVN	0.66940	*	0.63382		0.08544		0.11458	
BC1	0.15977		0.17363		0.81463	*	0.25658	
BC10	0.76269	*	0.24024		0.14092		0.39365	
BC11	0.66459	*	0.45092		0.37438		0.23432	
BC12	0.89391	*	0.06512		0.08939		0.20196	
BC13	0.26494		0.86611	*	0.21581		0.03086	
BC14	0.93051	*	0.15491		0.11343		0.21724	
BC15	0.49948		0.12628		0.00422		0.70237	*
BC16	0.04722		0.53838		0.77734	*	0.16972	
BC17	0.31411		0.79605	*	0.27627		0.07996	
BC18	0.22749		0.82875	*	0.14235		0.21658	
BC19	0.14177		0.91337	*	0.27795		0.16953	
BC20	-0.04078		0.62860		0.69251	*	0.26298	
BC21	0.25074		0.74366	*	0.37262		0.34571	
BC24	0.10361		0.78256	*	0.52882		0.22635	
BC25	-0.06105		0.39796		0.83970	*	0.22497	
BC26	0.82189	*	0.13363		0.04604		0.30549	
BC3	0.14382		0.16320		0.26949		0.86075	*
BC4	0.40862		0.39208		0.68819	*	0.26430	
BC7	0.90882	*	0.06595		0.08232		0.28849	
BC8	0.95445	*	0.06273		0.10773		0.05839	
BC9	0.86164	*	0.25080		0.07105		0.21322	
COCAT41	0.55437		0.35126		0.18239		0.66714	*
COCEOF31	0.93569	*	0.12492		0.07238		0.18225	
ECOCORIV	0.23445		0.05499		0.30155		0.70406	*
FAKA	0.88434	*	0.16192		0.27389		0.15829	
FAKAUPOI	0.77547	*	0.45316		0.28259		0.14037	
GATOR	0.07776		0.65929	*	0.48392		0.03578	
GGC_858	0.47355		0.10574		0.08926		0.66116	*
GGCAT31	0.92972	*	0.20156		0.19132		0.18319	
OKALA858	0.00986		0.82632	*	0.48165		0.07066	

Appendix CCWQ-2
PCA by Parameter

Parameter =CHLA

Station	Factor1		Factor2		Factor3		Factor4	
BARRIVN	0.07245		0.74670	*	-0.14917		-0.22842	
BC1	0.96110	*	-0.12049		-0.00735		-0.05940	
BC10	0.04153		0.04469		0.69602	*	0.16075	
BC13	0.35719		0.82370	*	-0.17747		-0.09648	
BC14	-0.10455		-0.06443		0.87786	*	-0.04157	
BC16	0.91636	*	0.24706		-0.10849		-0.10556	
BC17	0.29950		0.78008	*	-0.27547		-0.10477	
BC18	0.18251		0.75924	*	0.11811		-0.23732	
BC19	0.44922		0.83923	*	-0.23217		-0.10253	
BC2	0.71547	*	-0.34596		-0.10915		0.16110	
BC20	0.88524	*	0.36178		-0.09066		-0.01361	
BC22	0.82284	*	0.27717		0.03541		0.24614	
BC23	0.82365	*	0.48402		-0.10880		-0.08336	
BC24	0.76300	*	0.57822		-0.00257		-0.21026	
BC25	0.97234	*	0.08571		-0.04862		-0.06737	
BC26	-0.14968		-0.09376		0.74819	*	0.46282	
BC3	0.26115		-0.72578	*	0.22799		0.11004	
BC4	0.87961	*	0.11297		0.03862		-0.02198	
BC5	0.90256	*	0.29066		-0.21690		0.10265	
BC6	0.16894		-0.26032		0.46543		0.71760	*
BC7	-0.28295		-0.24083		0.11273		0.82733	*
COCAT41	0.14777		-0.11415		0.01757		0.72439	*
COCEOF31	-0.25350		-0.12587		0.86937	*	0.02831	
ECOCORIV	0.21581		-0.77732	*	0.01603		-0.25069	
FAKAUPOI	0.55837		0.69615	*	0.03655		0.09886	
GGC_858	-0.06230		-0.27997		0.79121	*	-0.01756	
HALDCRK	0.88018	*	-0.35430		0.10493		0.12656	
LELY	0.87867	*	0.16280		0.20170		0.03209	
MONROE	0.97179	*	0.08942		-0.04226		-0.13230	
OKALA858	0.66833	*	0.64528		-0.14387		-0.19109	

Parameter =Dissolved Oxygen

Station	Factor1		Factor2		Factor3		Factor4	
BARRIVN	0.81013	*	0.26218		0.09117		0.21580	
BC10	0.83401	*	0.17396		0.23996		0.41095	
BC11	0.78030	*	0.45853		0.27645		-0.00568	
BC12	0.95068	*	0.16133		-0.00409		0.01674	
BC14	0.79746	*	0.34159		0.42377		-0.06102	
BC15	0.46258		0.81816	*	0.29168		-0.03232	
BC16	0.79544	*	0.27450		0.12685		0.30184	
BC18	0.29442		0.29848		0.68841	*	0.25240	
BC19	0.72562	*	0.16823		0.58735		0.24642	
BC20	0.48681		-0.09271		0.69752	*	0.46347	
BC21	-0.05413		0.66014	*	0.37327		0.45444	
BC22	0.03920		-0.03787		0.46235		0.79351	*
BC23	0.91401	*	0.31863		-0.00941		0.15748	
BC25	0.31096		0.83569	*	-0.20559		-0.06181	
BC26	0.46638		0.67592	*	-0.04145		-0.45588	
BC3	0.17149		-0.33059		0.02631		0.83900	*
BC4	0.42920		0.17545		0.09257		0.83468	*
BC5	-0.10011		0.30490		0.08085		0.76613	*
BC6	-0.11853		-0.15540		-0.92828	*	-0.17602	
BC7	0.78831	*	0.16935		0.10647		0.27021	
BC8	0.90656	*	0.09746		0.31086		0.00931	
BC9	0.82668	*	0.42190		0.10192		0.22053	
COCAT41	0.21839		0.81181	*	0.25950		0.27227	
COCEOF31	0.79511	*	0.50755		0.24579		-0.06316	
COCPALM	0.22901		0.67495	*	0.40745		0.00029	
CORK_846	0.78562	*	0.39057		0.11823		0.02489	
ECOCORIV	0.59533		0.75953	*	0.00871		-0.13023	
FAKA858	0.42207		0.82230	*	-0.03957		0.24736	
FAKAUPOI	0.52834		-0.08950		0.71228	*	0.25656	
GATOR	-0.52135		0.05382		0.65930	*	0.06399	
GGCAT31	0.71143	*	0.50537		0.29723		0.07098	
HALDCRK	0.58299		0.70351	*	-0.11507		0.18794	
MONROE	-0.19539		0.79286	*	0.46598		-0.05600	

Parameter =Total Nitrogen

Station	Factor1		Factor2		Factor3		Factor4	
BARRIVN	0.43375		0.16807		0.40169		-0.78603	*
BC1	-0.09077		-0.25426		0.80327	*	0.11938	
BC10	0.19426		-0.80411	*	0.08649		0.46101	
BC11	-0.18579		0.90943	*	-0.29799		0.16812	
BC12	0.03257		0.12338		-0.40699		-0.77232	*
BC13	-0.02942		0.90936	*	0.21445		-0.00964	
BC14	-0.44477		0.88354	*	0.07044		-0.01628	
BC15	-0.08600		0.14351		0.88349	*	-0.08496	
BC16	0.39176		0.06234		0.77602	*	0.34388	
BC18	0.87642	*	-0.07911		0.30594		0.23546	
BC19	0.81841	*	0.15424		-0.24025		0.38097	
BC2	-0.85838	*	0.03750		0.41061		0.14302	
BC20	0.93974	*	-0.30535		-0.05020		-0.01055	
BC21	0.77847	*	-0.55393		-0.02907		0.16599	
BC22	0.38696		0.34887		0.77575	*	-0.31862	
BC24	0.19373		-0.12924		-0.76793	*	0.13250	
BC25	0.92394	*	0.29184		0.18340		-0.10588	
BC26	-0.65272	*	0.46160		-0.47141		0.04832	
BC3	-0.63440		-0.03403		0.76523	*	0.10013	
BC4	-0.74771	*	0.65912	*	-0.02726		-0.05554	
BC7	-0.29170		0.41403		-0.12813		-0.65431	*
BC8	-0.19521		0.37485		-0.26922		-0.75999	*
BC9	-0.29029		0.15323		-0.20848		0.77145	*
COCAT41	-0.42994		0.69684	*	0.38848		-0.27025	
COCEOF31	-0.04846		0.79154	*	0.18107		-0.44064	
COCPALM	0.31683		0.18431		-0.41562		0.72900	*
CORK_846	0.40590		0.57557		-0.69392	*	-0.07493	
FAKA	0.01647		0.82334	*	0.10446		0.01718	
FAKA858	0.08540		0.93607	*	-0.26799		-0.14677	
FAKAUPOI	0.61553		-0.03838		0.75562	*	0.07039	
GATOR	0.24630		-0.17822		-0.45883		0.77762	*
GGCAT31	-0.71849	*	0.49530		-0.29327		-0.11138	
HALDCRK	0.04812		0.67027	*	0.02812		-0.47812	
LELY	0.92221	*	0.07036		-0.24611		-0.04052	
MONROE	0.24099		0.49544		0.24514		0.78566	*

OKALA858	0.83390	*	0.06721		0.46797		0.10229	

Parameter = TPO4

Station	Factor1		Factor2		Factor3		Factor4	
BARRIVN	0.50330		-0.38531		0.71732	*	-0.02210	
BC1	0.95611	*	0.20188		-0.03430		-0.04043	
BC10	-0.15305		-0.04372		-0.31187		-0.83581	*
BC11	-0.04209		-0.74743	*	-0.60013		-0.28147	
BC12	-0.66107	*	0.36038		-0.06151		-0.13224	
BC13	0.66487	*	-0.51163		-0.00135		0.53932	
BC14	-0.46892		0.18275		0.76360	*	-0.39106	
BC15	-0.29013		0.30852		0.86934	*	0.19767	
BC16	0.52426		-0.67168	*	-0.36223		0.14393	
BC17	0.44785		-0.77510	*	-0.41883		-0.09646	
BC18	0.95296	*	-0.23425		-0.14523		0.12516	
BC19	0.94284	*	-0.22103		-0.19457		0.15421	
BC2	0.70681	*	0.64591		-0.27888		0.05565	
BC20	0.81419	*	-0.39524		-0.23311		0.26879	
BC21	0.94878	*	-0.24826		-0.14099		0.13377	
BC22	0.79886	*	0.38792		0.43965		0.00430	
BC23	0.23114		-0.03574		0.84769	*	-0.34169	
BC24	-0.13054		0.14311		0.96877	*	0.05324	
BC26	-0.41054		0.16502		0.88338	*	0.02399	
BC3	0.27975		0.36867		0.87409	*	-0.02413	
BC4	0.66853	*	-0.14752		-0.21713		0.60167	
BC5	0.17772		0.71520	*	-0.35206		0.55202	
BC7	-0.04522		0.91946	*	0.08262		-0.23445	
BC8	-0.38615		-0.46179		0.24834		-0.75892	*
BC9	-0.29822		-0.76065	*	-0.57121		-0.02902	
COCAT41	0.46693		-0.34743		-0.09654		0.77706	*
COCEOF31	-0.35496		0.06263		0.86513	*	-0.25337	
COCPALM	-0.50252		-0.38190		-0.11458		0.76609	*
ECOCORIV	-0.24269		0.52187		0.75629	*	-0.30992	
FAKA	-0.49687		0.45381		-0.25787		0.67448	*
FAKAUPOI	0.96501	*	-0.19299		-0.12882		0.11684	
GATOR	0.72007	*	-0.51248		-0.27829		0.22661	
GGC_858	-0.19037		0.87219	*	0.29992		-0.25139	
GGCAT31	-0.35360		0.88082	*	0.05891		-0.06303	
HALDCRK	0.00854		0.82389	*	0.52243		0.14403	
LELY	0.93768	*	0.29286		0.00947		-0.05244	
MONROE	0.48384		-0.71129	*	-0.36711		0.17252	

OKALA858	0.74693	*	0.21184		-0.38580		0.49517	

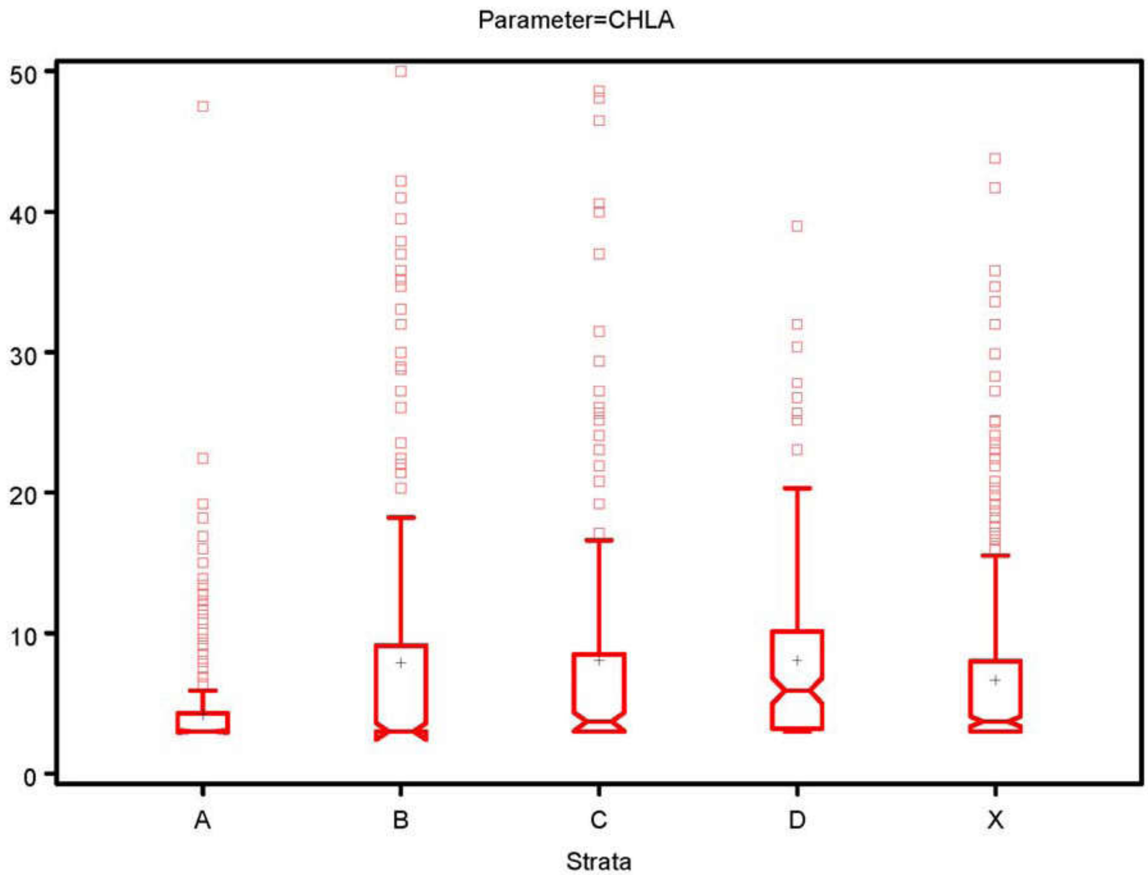
Parameter = Total Suspended Solids

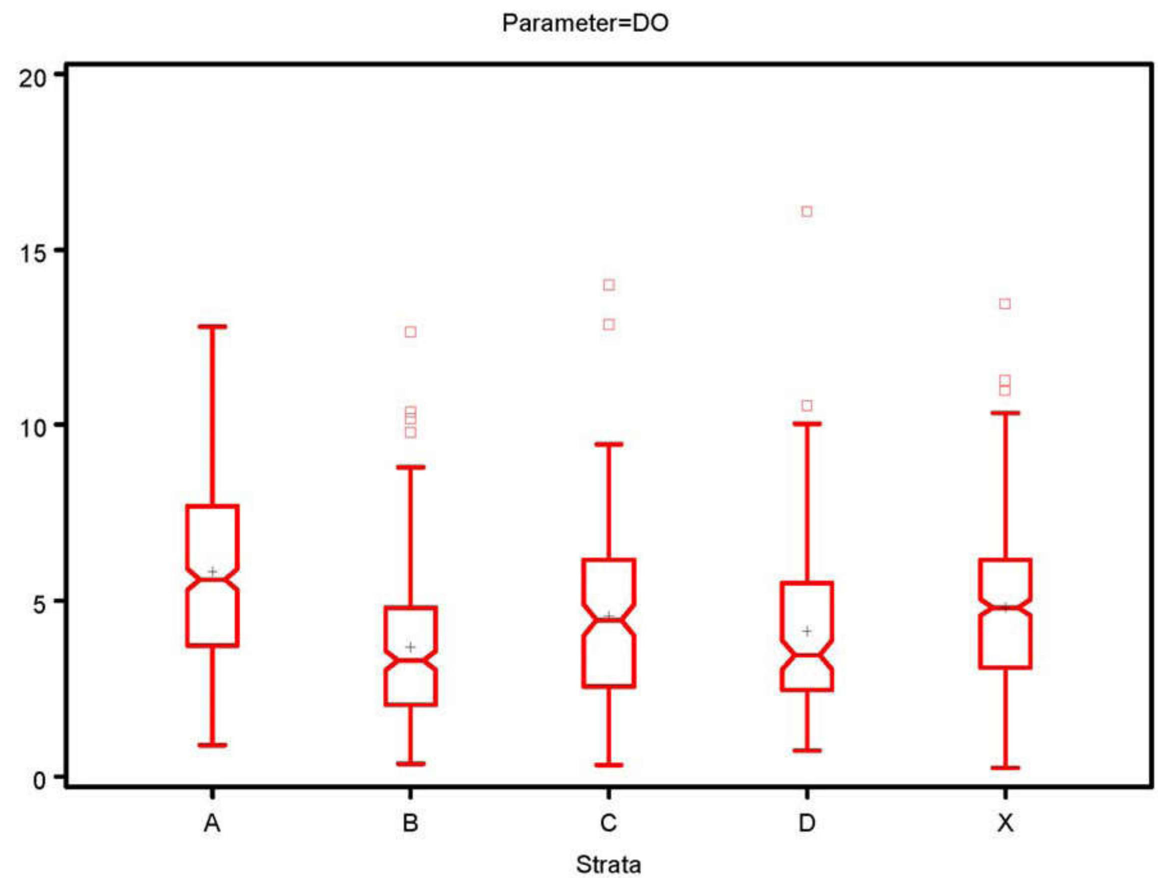
Station	Factor1		Factor2		Factor3		Factor4	
BARRIVN	-0.15761		-0.15701		0.94258	*	-0.12953	
BC1	0.04391		-0.21386		-0.19041		0.93121	*
BC11	0.99583	*	-0.06818		-0.01876		0.04792	
BC12	-0.10134		0.97950	*	-0.07197		-0.06372	
BC15	-0.23149		-0.18610		-0.17956		0.90294	*
BC16	0.99583	*	-0.06818		-0.01876		0.04792	
BC17	0.99583	*	-0.06818		-0.01876		0.04792	
BC18	0.99063	*	-0.08670		0.08706		0.03395	
BC19	0.99583	*	-0.06818		-0.01876		0.04792	
BC2	0.16467		-0.21058		-0.18461		0.91005	*
BC20	0.97378	*	0.01286		0.20707		0.00906	
BC21	0.32696		-0.18360		0.89659	*	-0.10143	
BC22	0.99708	*	-0.04557		-0.02050		0.04660	
BC24	0.99583	*	-0.06818		-0.01876		0.04792	
BC25	0.99583	*	-0.06818		-0.01876		0.04792	
BC4	0.99583	*	-0.06818		-0.01876		0.04792	
BC5	0.44987		-0.20707		-0.16901		0.81952	*
BC6	-0.12397		0.98253	*	-0.08763		-0.07912	
BC7	-0.10134		0.97950	*	-0.07197		-0.06372	
BC8	-0.15761		-0.15701		0.94258	*	-0.12953	
COCAT41	0.99583	*	-0.06818		-0.01876		0.04792	
COCEOF31	-0.10134		0.97950	*	-0.07197		-0.06372	
COCPALM	0.99583	*	-0.06818		-0.01876		0.04792	
FAKAUPOI	-0.15761		-0.15701		0.94258	*	-0.12953	
GATOR	0.99583	*	-0.06818		-0.01876		0.04792	
GGCAT31	-0.10134		0.97950	*	-0.07197		-0.06372	
HALDCRK	-0.10134		0.97950	*	-0.07197		-0.06372	
LELY	0.92396	*	0.02676		-0.14243		0.14439	
MONROE	0.99583	*	-0.06818		-0.01876		0.04792	
OKALA858	0.99583	*	-0.06818		-0.01876		0.04792	

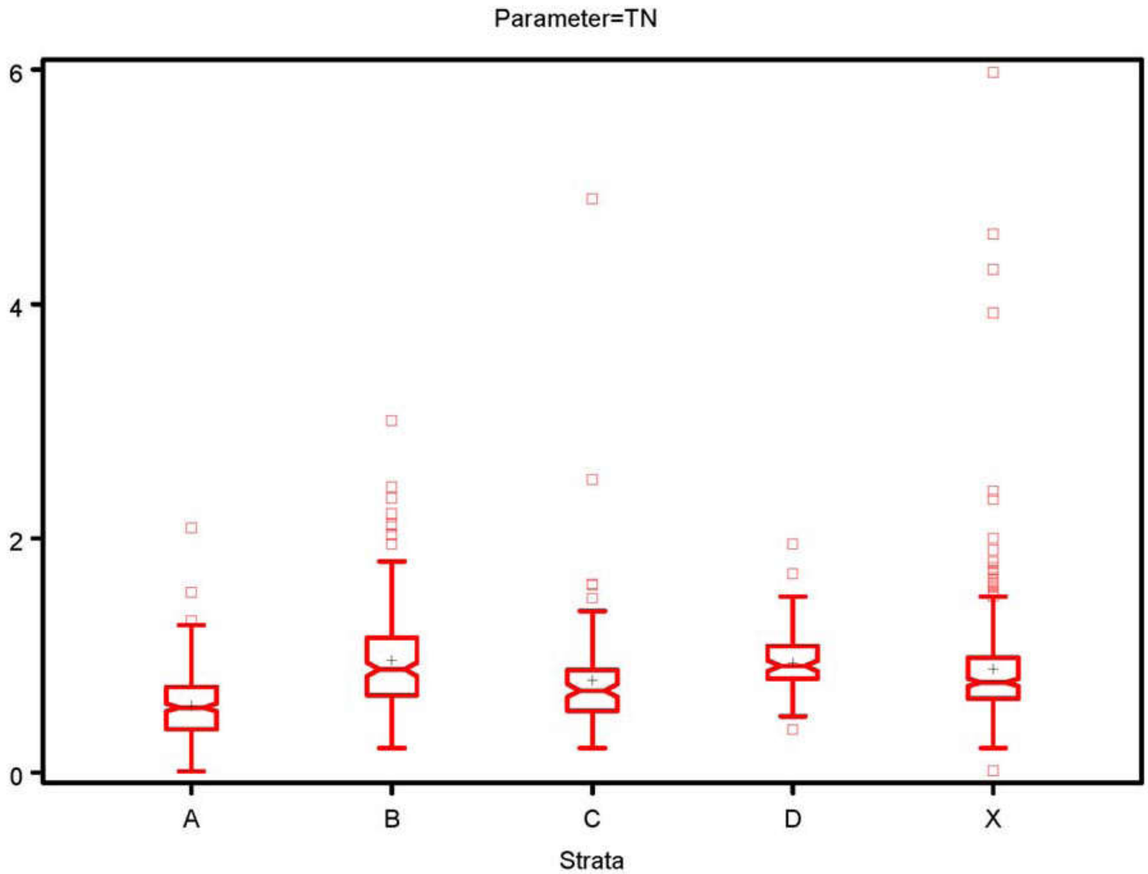
Appendix-3
PCA based box plots

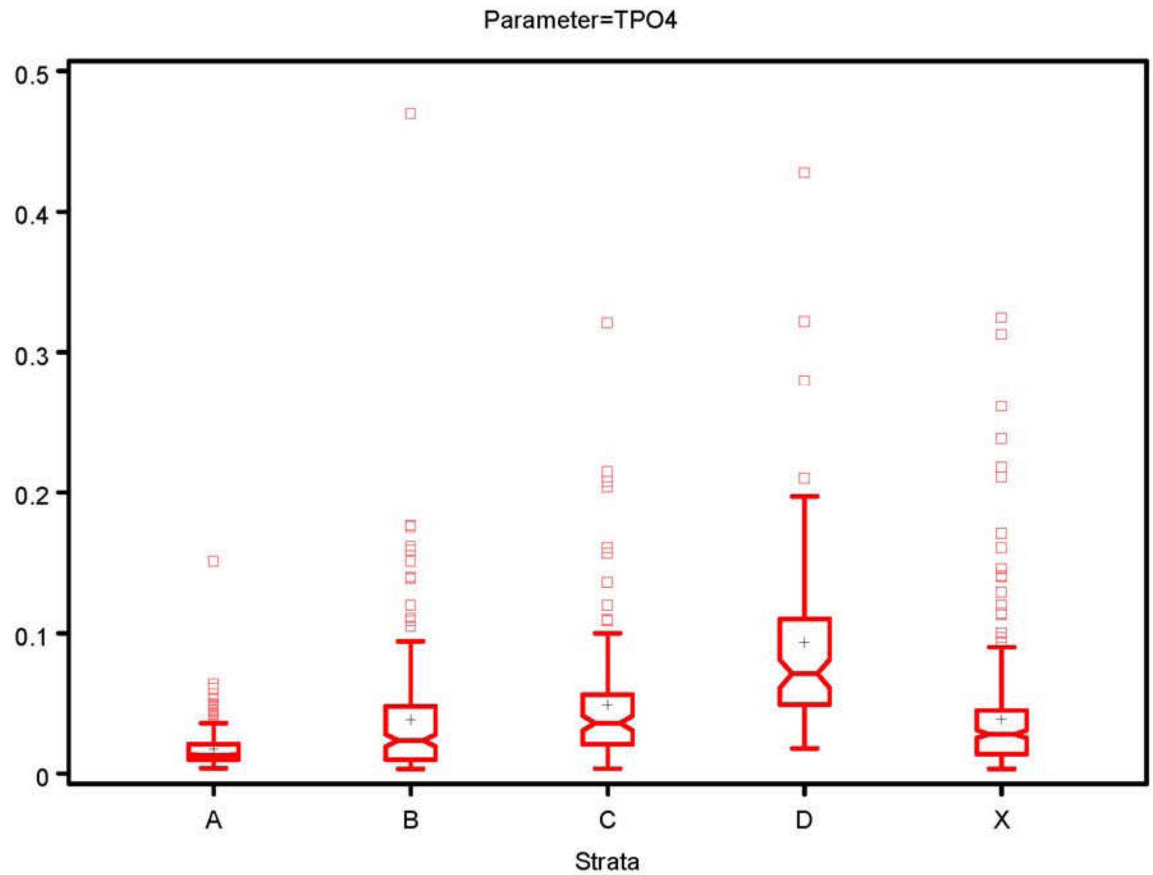
Stationos assocaited with each strata

Strata A	Strata B	Strata C	Strata D	Strata X
BARRIVN	BC13	BC1	BC15	BC2
BC10	BC17	BC16	BC3	BC22
BC11	BC18	BC20	COCAT41	BC23
BC12	BC19	BC25	ECOCORIV	BC5
BC7	BC21	BC4	GGC_858	BC6
COCEOF31	BC24			COCPALM
FAKA	GATOR			CORK@846
FAKAUPOI				FAKA858
BC14				GGC@858
BC26				HALDCRK
BC8				LELY
BC9				MONROE
GGCAT31				


Parameter=CHLA
50
40
30
20
10
0
A
B
C
D
X
Strata


Parameter=DO
20
15
10
5
0
A
B
C
D
X
Strata


Parameter=TN
6
4
2
0
A
B
C
D
X
Strata


Parameter=TPO4
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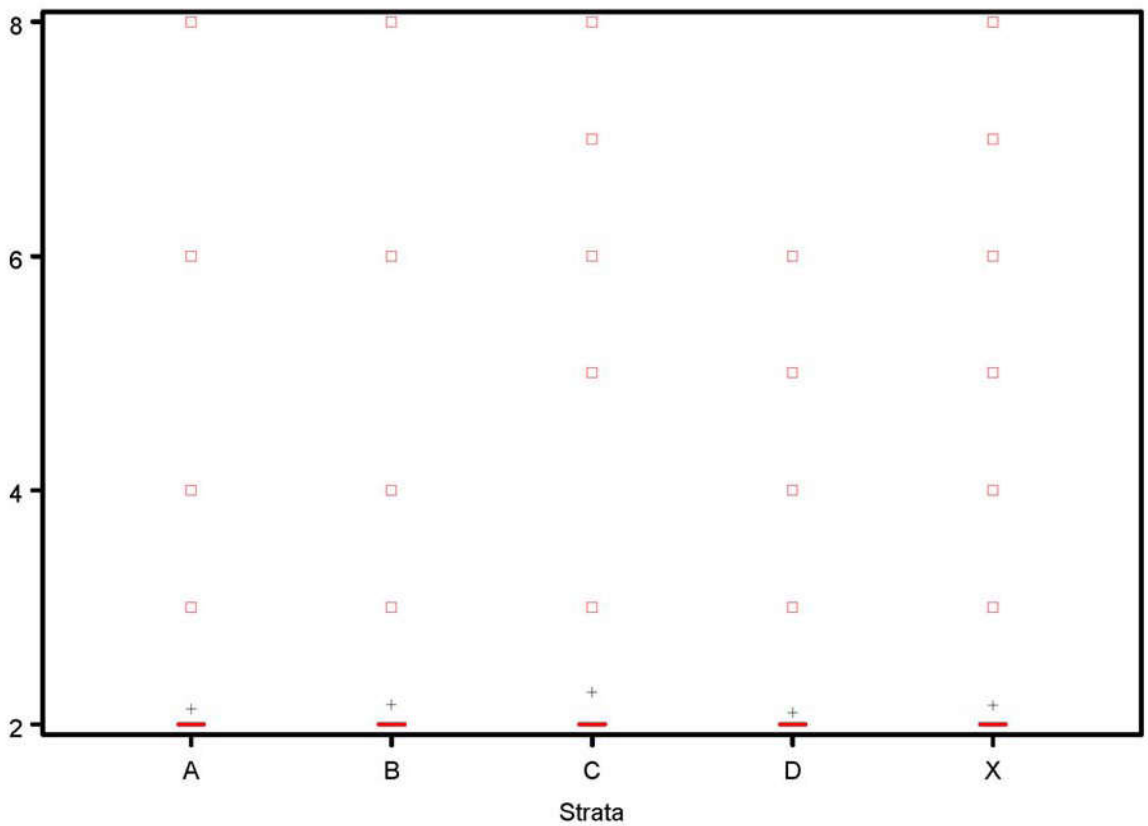
0.4
0.3
0.2
0.1
0
A
B
C
D
X
Strata

Parameter=TSS



Appendix -4
Station Correlations

The CORR Procedure

Parameter=TSS

4 Variables:	FAKA	FAKAUPOI	BC20	BC21

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
	FAKA	**FAKAUPOI**	**BC20**	**BC21**
FAKA	1.00000 26	-0.10403 0.6131 26	-0.17456 0.3937 26	-0.10394 0.6133 26
FAKAUPOI	-0.10403 0.6131 26	1.00000 27	0.19577 0.3378 26	0.47964 0.0114 27
BC20	-0.17456 0.3937 26	0.19577 0.3378 26	1.00000 26	0.61157 0.0009 26
BC21	-0.10394 0.6133 26	0.47964 0.0114 27	0.61157 0.0009 26	1.00000 27

The SAS System

The CORR Procedure

Parameter=TPO4

4 Variables:	FAKA	FAKAUPOI	BC20	BC21

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
	FAKA	**FAKAUPOI**	**BC20**	**BC21**
FAKA	1.00000 24	0.31687 0.1407 23	0.19420 0.3865 22	0.23492 0.2692 24
FAKAUPOI	0.31687 0.1407 23	1.00000 23	0.68004 0.0007 21	0.57814 0.0039 23
BC20	0.19420 0.3865 22	0.68004 0.0007 21	1.00000 23	0.73972 <.0001 22
BC21	0.23492 0.2692 24	0.57814 0.0039 23	0.73972 <.0001 22	1.00000 24

The SAS System

The CORR Procedure

Parameter=TN

4 Variables:	FAKA	FAKAUPOI	BC20	BC21

Spearman Correlation Coefficients, N = 23 Prob > |r| under H0: Rho=0				
	FAKA	**FAKAUPOI**	**BC20**	**BC21**
FAKA	1.00000	0.66634 0.0005	0.34770 0.1040	0.16766 0.4445
FAKAUPOI	0.66634 0.0005	1.00000	0.38601 0.0689	0.19445 0.3740
BC20	0.34770 0.1040	0.38601 0.0689	1.00000	0.61318 0.0019
BC21	0.16766 0.4445	0.19445 0.3740	0.61318 0.0019	1.00000

The SAS System

The CORR Procedure

Parameter=DO

4 Variables:	FAKA	FAKAUPOI	BC20	BC21

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations				
	FAKA	**FAKAUPOI**	**BC20**	**BC21**
FAKA	1.00000 35	0.52633 0.0012 35	0.67227 <.0001 35	0.64372 <.0001 33
FAKAUPOI	0.52633 0.0012 35	1.00000 35	0.65770 <.0001 35	0.34291 0.0507 33
BC20	0.67227 <.0001 35	0.65770 <.0001 35	1.00000 35	0.47861 0.0048 33
BC21	0.64372 <.0001 33	0.34291 0.0507 33	0.47861 0.0048 33	1.00000 33

The SAS System

The CORR Procedure

Parameter=CHLA

4 Variables:	FAKA FAKAUPOI BC20 BC21

Spearman Correlation Coefficients, N = 36 Prob > |r| under H0: Rho=0				
	FAKA	**FAKAUPOI**	**BC20**	**BC21**
FAKA	1.00000	0.25464 0.1339	0.04619 0.7891	-0.09631 0.5763
FAKAUPOI	0.25464 0.1339	1.00000	0.39977 0.0157	0.38089 0.0219
BC20	0.04619 0.7891	0.39977 0.0157	1.00000	0.61247 <.0001
BC21	-0.09631 0.5763	0.38089 0.0219	0.61247 <.0001	1.00000

The SAS System

The CORR Procedure

Parameter=TSS

7 Variables:	BC13	BC14	BC15	COCEOF31	COCPALM	COCAT41	ECOCORIV

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations							
	BC13	**BC14**	**BC15**	**COCEOF31**	**COCPALM**	**COCAT41**	**ECOCORIV**
BC13	1.00000 24	. . 24	-0.06281 0.7706 24	-0.04545 0.8368 23	-0.04545 0.8368 23	-0.06893 0.7605 22	. . 23
BC14	. . 24	. . 26	. . 26	. . 25	. . 25	. . 22	. . 25
BC15	-0.06281 0.7706 24	. . 26	1.00000 26	-0.06014 0.7752 25	-0.06014 0.7752 25	-0.06893 0.7605 22	. . 25
COCEOF31	-0.04545 0.8368 23	. . 25	-0.06014 0.7752 25	1.00000 25	-0.04167 0.8432 25	-0.06893 0.7605 22	. . 25
COCPALM	-0.04545 0.8368 23	. . 25	-0.06014 0.7752 25	-0.04167 0.8432 25	1.00000 25	0.65482 0.0009 22	. . 25
COCAT41	-0.06893 0.7605 22	. . 22	-0.06893 0.7605 22	-0.06893 0.7605 22	0.65482 0.0009 22	1.00000 22	. . 22
ECOCORIV	. . 23	. . 25	. . 25	. . 25	. . 25	. . 22	. . 25

The SAS System

The CORR Procedure

Parameter=CHLA

7 Variables:	BC13	BC14	BC15	COCEOF31	COCPALM	COCAT41	ECOCORIV

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations							
	BC13	**BC14**	**BC15**	**COCEOF31**	**COCPALM**	**COCAT41**	**ECOCORIV**
BC13	1.00000 35	0.10064 0.5774 33	-0.01905 0.9135 35	0.18291 0.2929 35	0.01621 0.9264 35	0.34917 0.0430 34	0.09134 0.6018 35
BC14	0.10064 0.5774 33	1.00000 34	0.33179 0.0552 34	0.79581 <.0001 34	0.09790 0.5817 34	0.23094 0.1888 34	0.44468 0.0084 34
BC15	-0.01905 0.9135 35	0.33179 0.0552 34	1.00000 36	0.31149 0.0644 36	0.09496 0.5817 36	0.17169 0.3240 35	0.10780 0.5314 36
COCEOF31	0.18291 0.2929 35	0.79581 <.0001 34	0.31149 0.0644 36	1.00000 36	0.10700 0.5345 36	0.40069 0.0171 35	0.46851 0.0040 36
COCPALM	0.01621 0.9264 35	0.09790 0.5817 34	0.09496 0.5817 36	0.10700 0.5345 36	1.00000 36	0.26428 0.1250 35	-0.03863 0.8230 36
COCAT41	0.34917 0.0430 34	0.23094 0.1888 34	0.17169 0.3240 35	0.40069 0.0171 35	0.26428 0.1250 35	1.00000 35	0.34400 0.0430 35
ECOCORIV	0.09134 0.6018 35	0.44468 0.0084 34	0.10780 0.5314 36	0.46851 0.0040 36	-0.03863 0.8230 36	0.34400 0.0430 35	1.00000 36

The SAS System

The CORR Procedure

Parameter=DO

7 Variables:	BC13 BC14 BC15 COCEOF31 COCPALM COCAT41 ECOCORIV

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations							
	BC13	**BC14**	**BC15**	**COCEOF31**	**COCPALM**	**COCAT41**	**ECOCORIV**
BC13	1.00000 34	0.64626 <.0001 32	0.60484 0.0003 31	0.65941 <.0001 31	0.27402 0.1358 31	0.68909 <.0001 32	0.47493 0.0052 33
BC14	0.64626 <.0001 32	1.00000 33	0.78198 <.0001 30	0.90031 <.0001 30	0.48392 0.0067 30	0.58783 0.0003 33	0.49398 0.0035 33
BC15	0.60484 0.0003 31	0.78198 <.0001 30	1.00000 32	0.73896 <.0001 32	0.44267 0.0112 32	0.73735 <.0001 30	0.67621 <.0001 31
COCEOF31	0.65941 <.0001 31	0.90031 <.0001 30	0.73896 <.0001 32	1.00000 32	0.43808 0.0122 32	0.57795 0.0008 30	0.51966 0.0027 31
COCPALM	0.27402 0.1358 31	0.48392 0.0067 30	0.44267 0.0112 32	0.43808 0.0122 32	1.00000 32	0.39586 0.0304 30	0.43170 0.0153 31
COCAT41	0.68909 <.0001 32	0.58783 0.0003 33	0.73735 <.0001 30	0.57795 0.0008 30	0.39586 0.0304 30	1.00000 33	0.57613 0.0005 33
ECOCORIV	0.47493 0.0052 33	0.49398 0.0035 33	0.67621 <.0001 31	0.51966 0.0027 31	0.43170 0.0153 31	0.57613 0.0005 33	1.00000 34

The SAS System

The CORR Procedure

Parameter=TN

7 Variables:	BC13	BC14	BC15	COCEOF31	COCPALM	COCAT41	ECOCORIV

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	BC13	BC14	BC15	COCEOF31	COCPALM	COCAT41	ECOCORIV
BC13	1.00000 22	0.64676 0.0011 22	0.29836 0.1774 22	0.71493 0.0002 22	0.28790 0.1939 22	0.57070 0.0055 22	0.11095 0.6230 22
BC14	0.64676 0.0011 22	1.00000 23	0.36940 0.0828 23	0.60758 0.0021 23	0.22580 0.3002 23	0.47437 0.0222 23	0.28338 0.1901 23
BC15	0.29836 0.1774 22	0.36940 0.0828 23	1.00000 23	0.50322 0.0144 23	0.03884 0.8603 23	0.25136 0.2473 23	0.13861 0.5282 23
COCEOF31	0.71493 0.0002 22	0.60758 0.0021 23	0.50322 0.0144 23	1.00000 23	0.32484 0.1304 23	0.38298 0.0713 23	0.14853 0.4988 23
COCPALM	0.28790 0.1939 22	0.22580 0.3002 23	0.03884 0.8603 23	0.32484 0.1304 23	1.00000 23	0.05468 0.8043 23	0.21795 0.3178 23
COCAT41	0.57070 0.0055 22	0.47437 0.0222 23	0.25136 0.2473 23	0.38298 0.0713 23	0.05468 0.8043 23	1.00000 23	0.39797 0.0600 23
ECOCORIV	0.11095 0.6230 22	0.28338 0.1901 23	0.13861 0.5282 23	0.14853 0.4988 23	0.21795 0.3178 23	0.39797 0.0600 23	1.00000 23

The SAS System

The CORR Procedure

Parameter=TPO4

7 Variables:	BC13 BC14 BC15 COCEOF31 COCPALM COCAT41 ECOCORIV

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	BC13	BC14	BC15	COCEOF31	COCPALM	COCAT41	ECOCORIV
BC13	1.00000 20	-0.14291 0.5478 20	0.15932 0.5023 20	0.01888 0.9370 20	0.10132 0.6708 20	0.57455 0.0081 20	-0.44014 0.0521 20
BC14	-0.14291 0.5478 20	1.00000 25	0.64218 0.0010 23	0.89419 <.0001 22	0.44577 0.0376 22	-0.18028 0.4342 21	0.57533 0.0064 21
BC15	0.15932 0.5023 20	0.64218 0.0010 23	1.00000 24	0.75000 <.0001 22	0.41334 0.0559 22	0.10288 0.6487 22	0.39582 0.0682 22
COCEOF31	0.01888 0.9370 20	0.89419 <.0001 22	0.75000 <.0001 22	1.00000 22	0.37170 0.1066 20	-0.15805 0.5057 20	0.64580 0.0021 20
COCPALM	0.10132 0.6708 20	0.44577 0.0376 22	0.41334 0.0559 22	0.37170 0.1066 20	1.00000 23	0.43091 0.0453 22	0.08508 0.7066 22
COCAT41	0.57455 0.0081 20	-0.18028 0.4342 21	0.10288 0.6487 22	-0.15805 0.5057 20	0.43091 0.0453 22	1.00000 22	-0.48969 0.0207 22
ECOCORIV	-0.44014 0.0521 20	0.57533 0.0064 21	0.39582 0.0682 22	0.64580 0.0021 20	0.08508 0.7066 22	-0.48969 0.0207 22	1.00000 22

Appendix-5
Correlations with TYPE 1 Stations

Correlation By Parameter

The CORR Procedure

Parameter=TSS

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	BC7	BC8	BC12	BC13	BC14	BC15	COCAT41	COCEOF31	CORK_846
ECOCORIV	. . 25	. . 25	. . 25	. . 23	. . 25	. . 25	. . 22	. . 25	. . 23
FAKA	-0.10854 0.6056 25	-0.07207 0.7264 26	-0.07207 0.7264 26	-0.08233 0.7088 23	. . 25	-0.10854 0.6056 25	0.26574 0.2443 21	-0.07860 0.7150 24	. . 24
FAKA858	-0.04545 0.8368 23	-0.04348 0.8401 24	. . 24	-0.05000 0.8296 21	. . 23	0.65727 0.0007 23	. . 19	-0.04762 0.8333 22	. . 24
FAKAUPOI	-0.08327 0.6859 26	0.69338 <.0001 27	-0.05547 0.7835 27	-0.06287 0.7704 24	. . 26	0.43715 0.0255 26	-0.06893 0.7605 22	-0.06019 0.7750 25	. . 25
GATOR	-0.10394 0.6133 26	-0.06920 0.7316 27	-0.06920 0.7316 27	-0.07860 0.7150 24	. . 26	-0.10394 0.6133 26	0.74880 <.0001 22	-0.07520 0.7209 25	. . 25
GGC_858	-0.04545 0.8368 23	-0.04348 0.8401 24	. . 24	-0.05000 0.8296 21	. . 23	-0.06573 0.7657 23	-0.08072 0.7425 19	-0.04762 0.8333 22	. . 24
GGCAT31	-0.05769 0.7795 26	-0.03846 0.8489 27	-0.03846 0.8489 27	-0.04348 0.8401 24	. . 26	-0.05769 0.7795 26	-0.06893 0.7605 22	1.00000 <.0001 25	. . 25
HALDCRK	-0.05769 0.7795 26	-0.03846 0.8489 27	-0.03846 0.8489 27	-0.04348 0.8401 24	. . 26	-0.05769 0.7795 26	-0.06893 0.7605 22	1.00000 <.0001 25	. . 25
LELY	-0.10229 0.6506 22	-0.09732 0.6587 23	-0.09732 0.6587 23	-0.10779 0.6419 21	. . 22	0.40916 0.0586 22	0.33365 0.1505 20	0.40421 0.0692 21	. . 21
MONROE	-0.06014 0.7752 25	-0.04000 0.8462 26	-0.04000 0.8462 26	-0.04545 0.8368 23	. . 25	-0.06014 0.7752 25	0.72457 0.0002 21	-0.04348 0.8401 24	. . 24
OKALA858	-0.08320 0.6862 26	-0.05543 0.7836 27	-0.05543 0.7836 27	-0.06281 0.7706 24	. . 26	-0.08320 0.6862 26	0.44785 0.0366 22	-0.06014 0.7752 25	. . 25
TAMBR90	. . 19	. . 20	. . 20	. . 17	. . 19	. . 19	. . 15	. . 18	. . 18

Correlation By Parameter

The CORR Procedure

Parameter=CHLA

39 With Variables:	BARRIVN BC1 BC10 BC11 BC16 BC17 BC18 BC19 BC2 BC20 BC21 BC22 BC23 BC24 BC25 BC26 BC3 BC4 BC5 BC6 BC9 CHKMATE COCPALM CORKN CORKS CORKSCRD CORKSW ECOCORIV FAKA FAKA858 FAKAUPOI GATOR GGC_858 GGCAT31 HALDCRK LELY MONROE OKALA858 TAMBR90
9 Variables:	BC7 BC8 BC12 BC13 BC14 BC15 COCAT41 COCEOF31 CORK_846

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	BC7	BC8	BC12	BC13	BC14	BC15	COCAT41	COCEOF31	CORK_846
BARRIVN	-0.10807	-0.11123	0.12331	0.61073	-0.32599	-0.32164	0.18696	-0.33866	0.37966
	0.5429	0.5311	0.4872	0.0002	0.0686	0.0636	0.2975	0.0501	0.0268
	34	34	34	33	32	34	33	34	34
BC1	-0.04615	-0.01547	-0.08900	0.24094	-0.03819	-0.11489	0.47062	0.21598	0.09828
	0.7955	0.9308	0.6167	0.1632	0.8302	0.5046	0.0043	0.2058	0.5685
	34	34	34	35	34	36	35	36	36
BC10	0.27764	0.16844	-0.03106	0.14845	0.45982	0.42206	0.35446	0.25979	0.25654
	0.1119	0.3410	0.8616	0.3947	0.0062	0.0103	0.0367	0.1260	0.1310
	34	34	34	35	34	36	35	36	36
BC11	-0.05048	-0.09396	0.08649	0.07016	0.01663	-0.17170	0.20258	-0.07727	0.40626
	0.7768	0.5971	0.6267	0.6888	0.9256	0.3167	0.2432	0.6542	0.0139
	34	34	34	35	34	36	35	36	36
BC16	-0.28130	-0.11242	-0.24531	0.36019	-0.22377	-0.30823	0.11728	-0.43873	0.58666
	0.1128	0.5333	0.1688	0.0364	0.2106	0.0716	0.5089	0.0084	0.0002
	33	33	33	34	33	35	34	35	35
BC17	-0.06784	-0.23513	-0.19494	0.10597	-0.20314	-0.19559	-0.00696	-0.35182	0.50119
	0.7076	0.1878	0.2770	0.5509	0.2569	0.2601	0.9688	0.0382	0.0022
	33	33	33	34	33	35	34	35	35
BC18	-0.16659	-0.24646	-0.00173	0.24745	-0.19794	-0.20909	-0.04521	-0.35265	0.53140
	0.3464	0.1600	0.9922	0.1518	0.2618	0.2210	0.7965	0.0349	0.0009
	34	34	34	35	34	36	35	36	36
BC19	-0.28385	-0.25014	-0.15915	0.39056	-0.12132	-0.39671	-0.00466	-0.36458	0.52236
	0.1094	0.1603	0.3763	0.0224	0.5012	0.0183	0.9791	0.0313	0.0013
	33	33	33	34	33	35	34	35	35
BC2	0.06138	0.12088	0.19452	0.26745	0.03110	0.15109	0.44633	0.14838	0.00294
	0.7344	0.5028	0.2780	0.1262	0.8636	0.3863	0.0081	0.3950	0.9866
	33	33	33	34	33	35	34	35	35
BC20	-0.04856	-0.10035	-0.04970	0.34939	-0.16590	-0.32721	0.21816	-0.23519	0.44599
	0.7851	0.5723	0.7801	0.0397	0.3484	0.0514	0.2080	0.1673	0.0064
	34	34	34	35	34	36	35	36	36
BC21	0.02704	0.16577	0.04437	0.29264	-0.27533	-0.10812	0.29571	-0.41032	0.23910
	0.8794	0.3488	0.8032	0.0880	0.1150	0.5302	0.0846	0.0129	0.1602
	34	34	34	35	34	36	35	36	36
BC22	0.02454	-0.05199	-0.00862	0.66251	0.07476	0.25290	0.35286	0.07646	-0.07456
	0.8939	0.7775	0.9626	<.0001	0.6843	0.1490	0.0440	0.6673	0.6752
	32	32	32	33	32	34	33	34	34

Correlation By Parameter

The CORR Procedure

Parameter=CHLA

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations	BC7	BC8	BC12	BC13	BC14	BC15	COCAT41	COCEOF31	CORK_846
BC23	-0.07357 0.6792 34	0.01400 0.9374 34	-0.03996 0.8225 34	0.66287 <.0001 35	0.09785 0.5820 34	-0.06890 0.6897 36	0.42214 0.0115 35	0.18502 0.2800 36	0.19258 0.2605 36
BC24	-0.27363 0.1174 34	-0.29684 0.0882 34	-0.15490 0.3817 34	0.30790 0.0720 35	-0.19029 0.2811 34	-0.37326 0.0249 36	0.20132 0.2462 35	-0.32939 0.0498 36	0.72274 <.0001 36
BC25	-0.17819 0.3133 34	-0.21871 0.2140 34	-0.21778 0.2160 34	0.40127 0.0169 35	-0.14491 0.4135 34	0.05694 0.7415 36	0.40621 0.0155 35	-0.10383 0.5467 36	0.15561 0.3648 36
BC26	0.34306 0.0739 28	-0.26144 0.1790 28	-0.16744 0.3944 28	0.23216 0.2256 29	0.47036 0.0115 28	0.34095 0.0652 30	0.20427 0.2878 29	0.41051 0.0242 30	0.24089 0.1997 30
BC3	0.31078 0.0736 34	0.13729 0.4388 34	0.27321 0.1180 34	0.04320 0.8053 35	0.33050 0.0563 34	0.40841 0.0134 36	0.17464 0.3157 35	0.43000 0.0089 36	-0.27471 0.1049 36
BC4	0.04763 0.7924 33	0.21497 0.2296 33	-0.00102 0.9955 33	0.16083 0.3635 34	0.34127 0.0519 33	0.01393 0.9367 35	-0.01790 0.9200 34	0.07948 0.6499 35	0.35563 0.0360 35
BC5	-0.10107 0.5757 33	-0.28668 0.1058 33	-0.14782 0.4117 33	0.46395 0.0057 34	-0.02609 0.8854 33	-0.09067 0.6045 35	0.35248 0.0409 34	0.03097 0.8598 35	0.14450 0.4076 35
BC6	0.31683 0.0679 34	-0.25727 0.1419 34	-0.07999 0.6529 34	0.05353 0.7601 35	-0.05770 0.7458 34	0.36749 0.0275 36	0.33557 0.0488 35	0.09746 0.5717 36	-0.00790 0.9635 36
BC9	0.26563 0.1289 34	-0.11033 0.5345 34	0.17261 0.3290 34	0.01814 0.9176 35	0.02817 0.8743 34	0.10008 0.5614 36	0.12939 0.4588 35	-0.13266 0.4405 36	0.16300 0.3422 36
CHKMATE	-0.29062 0.4850 8	-0.35150 0.3932 8	-0.15776 0.7091 8	0.11442 0.7694 9	0.35371 0.3504 9	0.07900 0.8399 9	0.22831 0.5546 9	0.02875 0.9415 9	0.60198 0.0863 9
COCPALM	0.03893 0.8270 34	-0.06405 0.7190 34	0.23299 0.1848 34	0.01621 0.9264 35	0.09790 0.5817 34	0.09496 0.5817 36	0.26428 0.1250 35	0.10700 0.5345 36	0.09679 0.5744 36
CORKN	-0.05326 0.8918 9	-0.24550 0.5243 9	-0.36824 0.3295 9	0.19011 0.5989 10	0.08236 0.8211 10	-0.32757 0.3555 10	0.10288 0.7773 10	-0.15571 0.6675 10	0.69305 0.0263 10
CORKS	-0.28347 0.4963 8	-0.14286 0.7358 8	-0.21598 0.6075 8	0.57208 0.1075 9	-0.24550 0.5243 9	-0.13750 0.7243 9	0.00000 1.0000 9	-0.30619 0.4229 9	0.14302 0.7136 9
CORKSCRD	-0.21095 0.6160 8	-0.42524 0.2936 8	0.51433 0.1922 8	0.49346 0.1770 9	-0.35611 0.3469 9	0.58983 0.0946 9	0.18227 0.6388 9	-0.15228 0.6957 9	-0.53347 0.1391 9
CORKSW	-0.05357 0.8997 8	-0.21598 0.6075 8	-0.32653 0.4299 8	0.47673 0.1945 9	0.06819 0.8616 9	-0.34376 0.3650 9	0.09535 0.8072 9	-0.05103 0.8963 9	0.11918 0.7601 9

Correlation By Parameter

The CORR Procedure

Parameter=CHLA

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations	BC7	BC8	BC12	BC13	BC14	BC15	COCAT41	COCEOF31	CORK_846
ECOCORIV	0.05385 0.7623 34	0.04272 0.8104 34	0.08665 0.6261 34	0.09134 0.6018 35	0.44468 0.0084 34	0.10780 0.5314 36	0.34400 0.0430 35	0.46851 0.0040 36	0.07499 0.6638 36
FAKA	0.46448 0.0057 34	-0.00684 0.9694 34	0.03153 0.8595 34	0.14318 0.4119 35	0.36900 0.0317 34	0.27645 0.1026 36	0.34120 0.0449 35	0.25314 0.1363 36	0.16326 0.3414 36
FAKA858	-0.16366 0.3708 32	-0.15265 0.4042 32	-0.40706 0.0208 32	0.35082 0.0453 33	0.25164 0.1647 32	0.07260 0.6833 34	0.02192 0.9036 33	0.23665 0.1778 34	0.18865 0.2853 34
FAKAUPOI	0.18638 0.2912 34	-0.06607 0.7105 34	-0.02178 0.9027 34	0.36502 0.0311 35	0.06101 0.7318 34	0.01052 0.9515 36	0.08317 0.6348 35	-0.15621 0.3629 36	0.31165 0.0643 36
GATOR	-0.11605 0.5341 31	-0.09981 0.5932 31	-0.19661 0.2891 31	0.19251 0.2912 32	-0.11513 0.5374 31	-0.23611 0.1859 33	-0.03280 0.8585 32	-0.39051 0.0247 33	0.63247 <.0001 33
GGC_858	0.00711 0.9692 32	0.09835 0.5923 32	0.13396 0.4648 32	0.00759 0.9665 33	0.58307 0.0005 32	0.23499 0.1810 34	0.27973 0.1149 33	0.62289 <.0001 34	0.06692 0.7069 34
GGCAT31	-0.10542 0.5593 33	-0.11595 0.5205 33	-0.21959 0.2195 33	0.42606 0.0120 34	0.57424 0.0005 33	0.07759 0.6578 35	0.35505 0.0394 34	0.54132 0.0008 35	0.19589 0.2594 35
HALDCRK	0.15937 0.3680 34	0.18643 0.2911 34	0.09779 0.5822 34	0.03205 0.8550 35	-0.05114 0.7739 34	0.12695 0.4606 36	0.24340 0.1588 35	0.10707 0.5343 36	-0.23491 0.1679 36
LELY	-0.12101 0.5241 30	0.02301 0.9039 30	0.20630 0.2741 30	0.59990 0.0003 32	0.32392 0.0808 30	0.19020 0.2971 32	0.43940 0.0134 31	0.36630 0.0392 32	0.08924 0.6272 32
MONROE	-0.17338 0.3509 31	-0.21224 0.2517 31	-0.30520 0.0950 31	0.35468 0.0464 32	-0.00071 0.9970 31	0.06458 0.7210 33	-0.03650 0.8428 32	0.02511 0.8897 33	0.06294 0.7279 33
OKALA858	-0.07435 0.6760 34	-0.21850 0.2144 34	-0.29119 0.0948 34	0.40625 0.0155 35	0.05269 0.7673 34	-0.26354 0.1204 36	0.10385 0.5527 35	-0.23397 0.1696 36	0.60278 0.0001 36
TAMBR90	-0.36824 0.0918 22	-0.18555 0.4084 22	0.28114 0.2050 22	-0.31543 0.1527 22	-0.11642 0.5968 23	-0.04155 0.8507 23	0.14147 0.5197 23	-0.05657 0.7976 23	-0.00298 0.9892 23

Correlation By Parameter

The CORR Procedure

Parameter=DO

39 With Variables:	BARRIVN BC1 BC10 BC11 BC16 BC17 BC18 BC19 BC2 BC20 BC21 BC22 BC23 BC24 BC25 BC26 BC3 BC4 BC5 BC6 BC9 CHKMATE COCPALM CORKN CORKS CORKSCRD CORKSW ECOCORIV FAKA FAKA858 FAKAUPOI GATOR GGC_858 GGCAT31 HALDCRK LELY MONROE OKALA858 TAMBR90
9 Variables:	BC7 BC8 BC12 BC13 BC14 BC15 COCAT41 COCEOF31 CORK_846

Spearman Correlation Coefficients
Prob > \|r\| under H0: Rho=0
Number of Observations

	BC7	BC8	BC12	BC13	BC14	BC15	COCAT41	COCEOF31	CORK_846
BARRIVN	0.44704 0.0080 34	0.42962 0.0112 34	0.36528 0.0336 34	0.29700 0.0988 32	0.36906 0.0410 31	0.34157 0.0647 30	0.28381 0.1218 31	0.52448 0.0029 30	0.42598 0.0169 31
BC1	0.57923 0.0005 32	0.45811 0.0084 32	0.45536 0.0088 32	0.41678 0.0197 31	0.61720 0.0003 30	0.49144 0.0068 29	0.47157 0.0085 30	0.49156 0.0068 29	0.27907 0.1353 30
BC10	0.75990 <.0001 32	0.69673 <.0001 32	0.65127 <.0001 32	0.24274 0.1883 31	0.62581 0.0002 31	0.48424 0.0078 29	0.40351 0.0244 31	0.65213 0.0001 29	0.57794 0.0007 31
BC11	0.69596 <.0001 30	0.67334 <.0001 30	0.71017 <.0001 30	0.55721 0.0017 29	0.74433 <.0001 29	0.57021 0.0019 27	0.54816 0.0021 29	0.86351 <.0001 27	0.60039 0.0006 29
BC16	0.70283 <.0001 30	0.79083 <.0001 30	0.68447 <.0001 30	0.17421 0.3572 30	0.58653 0.0008 29	0.42739 0.0207 29	0.29416 0.1214 29	0.65073 0.0001 29	0.53717 0.0032 28
BC17	-0.11639 0.5402 30	-0.04473 0.8144 30	0.05953 0.7547 30	0.04495 0.8135 30	-0.10692 0.5809 29	-0.00148 0.9939 29	-0.10595 0.5844 29	0.00049 0.9980 29	0.14581 0.4591 28
BC18	0.40271 0.0223 32	0.42416 0.0155 32	0.30572 0.0888 32	0.23450 0.2042 31	0.48192 0.0070 30	0.55512 0.0015 30	0.28107 0.1324 30	0.54606 0.0018 30	0.40869 0.0224 31
BC19	0.62049 0.0002 31	0.65255 <.0001 31	0.51094 0.0033 31	0.29369 0.1152 30	0.70132 <.0001 29	0.64345 0.0001 30	0.34902 0.0635 29	0.74789 <.0001 30	0.45639 0.0099 31
BC2	0.53832 0.0015 32	0.41313 0.0188 32	0.34079 0.0563 32	0.58229 0.0006 31	0.59537 0.0005 30	0.53616 0.0027 29	0.58949 0.0006 30	0.47899 0.0086 29	0.31516 0.0898 30
BC20	0.53327 0.0012 34	0.60753 0.0001 34	0.34545 0.0454 34	0.23529 0.1875 33	0.57515 0.0006 32	0.54637 0.0015 31	0.49954 0.0036 32	0.63454 0.0001 31	0.47626 0.0059 32
BC21	0.35652 0.0452 32	0.33123 0.0641 32	0.10227 0.5775 32	0.36452 0.0438 31	0.35840 0.0518 30	0.53014 0.0026 30	0.57076 0.0010 30	0.34598 0.0611 30	0.28554 0.1194 31
BC22	0.66929 <.0001 29	0.42266 0.0224 29	0.26456 0.1655 29	0.24581 0.1987 29	0.51341 0.0052 28	0.24908 0.2102 27	0.48289 0.0092 28	0.41008 0.0336 27	0.55542 0.0026 27

Correlation By Parameter

The CORR Procedure

Parameter=DO

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	BC7	BC8	BC12	BC13	BC14	BC15	COCAT41	COCEOF31	CORK_846
BC23	0.62607 0.0002 31	0.65894 <.0001 31	0.66579 <.0001 31	0.24960 0.1757 31	0.57998 0.0008 30	0.48325 0.0079 29	0.22586 0.2301 30	0.72407 <.0001 29	0.53461 0.0028 29
BC24	0.26636 0.1475 31	0.28715 0.1173 31	0.25650 0.1637 31	0.44321 0.0142 30	0.17777 0.3473 30	0.19187 0.3280 28	0.34517 0.0617 30	0.34442 0.0727 28	0.44175 0.0145 30
BC25	0.44143 0.0114 32	0.20935 0.2502 32	0.09276 0.6136 32	0.38411 0.0329 31	0.32161 0.0777 31	0.37605 0.0371 31	0.52153 0.0026 31	0.28597 0.1189 31	0.64522 <.0001 33
BC26	0.02600 0.8955 28	0.02354 0.9054 28	-0.01889 0.9240 28	0.19600 0.3272 27	0.00763 0.9699 27	0.20653 0.3114 26	0.20247 0.3111 27	0.06156 0.7651 26	0.43772 0.0198 28
BC3	0.10606 0.5701 31	-0.10425 0.5768 31	-0.03247 0.8624 31	0.18111 0.3382 30	0.14975 0.4381 29	0.18968 0.3337 28	0.08401 0.6648 29	-0.08583 0.6641 28	-0.18206 0.3445 29
BC4	0.61250 0.0002 31	0.29055 0.1128 31	0.27039 0.1412 31	0.53192 0.0025 30	0.53300 0.0029 29	0.42529 0.0241 28	0.71052 <.0001 29	0.43964 0.0192 28	0.51737 0.0041 29
BC5	0.18401 0.3053 33	0.04864 0.7881 33	-0.04362 0.8095 33	0.53231 0.0017 32	0.21373 0.2483 31	0.35555 0.0538 30	0.50600 0.0037 31	0.17503 0.3549 30	0.05536 0.7674 31
BC6	-0.20567 0.2670 31	-0.48614 0.0056 31	-0.03629 0.8463 31	-0.16169 0.3848 31	-0.40334 0.0271 30	-0.13448 0.4867 29	-0.27325 0.1440 30	-0.41168 0.0265 29	-0.19192 0.3186 29
BC9	0.77775 <.0001 32	0.78735 <.0001 32	0.71971 <.0001 32	0.39016 0.0300 31	0.72447 <.0001 31	0.60936 0.0005 29	0.46536 0.0083 31	0.77137 <.0001 29	0.68357 <.0001 31
CHKMATE	0.78333 0.0125 9	0.68333 0.0424 9	0.73333 0.0246 9	0.28333 0.4600 9	0.56667 0.1116 9	0.14286 0.7358 8	0.15000 0.7001 9	0.30952 0.4556 8	0.44312 0.2715 8
COCPALM	0.47005 0.0076 31	0.46239 0.0088 31	0.34664 0.0561 31	0.27402 0.1358 31	0.48392 0.0067 30	0.44267 0.0112 32	0.39586 0.0304 30	0.43808 0.0122 32	0.05304 0.7769 31
CORKN	-0.00606 0.9867 10	-0.03030 0.9338 10	-0.28485 0.4250 10	0.26061 0.4671 10	0.03030 0.9338 10	0.13333 0.7324 9	0.87879 0.0008 10	-0.18333 0.6368 9	0.69457 0.0379 9
CORKS	0.43333 0.2440 9	0.26667 0.4879 9	0.13333 0.7324 9	0.45000 0.2242 9	0.41667 0.2646 9	0.59524 0.1195 8	0.58333 0.0992 9	0.14286 0.7358 8	0.47619 0.2329 8
CORKSCRD	-0.26667 0.4879 9	-0.60000 0.0876 9	-0.76667 0.0159 9	-0.43333 0.2440 9	-0.60000 0.0876 9	-0.30952 0.4556 8	0.16667 0.6682 9	-0.52381 0.1827 8	0.14286 0.7358 8
CORKSW	0.61925 0.0753 9	0.24268 0.5292 9	0.08368 0.8305 9	-0.27615 0.4720 9	-0.03347 0.9319 9	0.05988 0.8880 8	0.04184 0.9149 9	-0.19162 0.6494 8	0.49103 0.2166 8

Correlation By Parameter

The CORR Procedure

Parameter=DO

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	BC7	BC8	BC12	BC13	BC14	BC15	COCAT41	COCEOF31	CORK_846
ECOCORIV	0.49453 0.0034 33	0.43520 0.0114 33	0.54311 0.0011 33	0.47493 0.0052 33	0.49398 0.0035 33	0.67621 <.0001 31	0.57613 0.0005 33	0.51966 0.0027 31	0.40452 0.0240 31
FAKA	0.65062 <.0001 34	0.70945 <.0001 34	0.52116 0.0016 34	0.47961 0.0047 33	0.62353 0.0001 32	0.58911 0.0005 31	0.50156 0.0034 32	0.71378 <.0001 31	0.41063 0.0196 32
FAKA858	0.39827 0.0265 31	0.38617 0.0319 31	0.20750 0.2627 31	0.29080 0.1190 30	0.29970 0.1076 30	0.50506 0.0044 30	0.53945 0.0021 30	0.43930 0.0151 30	0.70492 <.0001 32
FAKAUPOI	0.48376 0.0037 34	0.46650 0.0054 34	0.23545 0.1801 34	0.35461 0.0429 33	0.57698 0.0005 32	0.33306 0.0671 31	0.27259 0.1312 32	0.44964 0.0112 31	0.25976 0.1511 32
GATOR	-0.15273 0.4378 28	-0.08567 0.6647 28	-0.34405 0.0730 28	0.00345 0.9858 29	-0.24664 0.2149 27	0.02017 0.9221 26	0.01252 0.9506 27	-0.24248 0.2327 26	0.03044 0.8827 26
GGC_858	0.47968 0.0063 31	0.35737 0.0484 31	0.51185 0.0032 31	0.30800 0.0978 30	0.40058 0.0283 30	0.39858 0.0291 30	0.36528 0.0472 30	0.52343 0.0030 30	0.54662 0.0012 32
GGCAT31	0.80263 <.0001 30	0.82254 <.0001 30	0.62372 0.0002 30	0.42563 0.0190 30	0.83409 <.0001 29	0.73874 <.0001 28	0.46865 0.0103 29	0.87611 <.0001 28	0.60808 0.0006 28
HALDCRK	0.55363 0.0015 30	0.39608 0.0303 30	0.38451 0.0359 30	0.58449 0.0007 30	0.55524 0.0018 29	0.55727 0.0021 28	0.63164 0.0002 29	0.62067 0.0004 28	0.40123 0.0343 28
LELY	0.33128 0.0983 26	0.25538 0.2080 26	0.14361 0.4840 26	0.49328 0.0089 27	0.31538 0.1246 25	0.33154 0.1054 25	0.35706 0.0797 25	0.29473 0.1527 25	0.16237 0.4381 25
MONROE	-0.18559 0.3540 27	-0.18437 0.3573 27	-0.23203 0.2442 27	0.11056 0.5754 28	-0.21231 0.2978 26	0.16846 0.4208 25	-0.02839 0.8905 26	-0.12813 0.5416 25	0.04656 0.8251 25
OKALA858	0.54058 0.0017 31	0.44646 0.0118 31	0.44818 0.0115 31	0.42652 0.0188 30	0.49994 0.0049 30	0.55016 0.0024 28	0.61066 0.0003 30	0.61848 0.0005 28	0.58885 0.0006 30
TAMBR90	-0.32932 0.1562 20	-0.15639 0.5103 20	-0.32117 0.1674 20	-0.22857 0.3324 20	-0.30226 0.1952 20	0.13684 0.5764 19	-0.13539 0.5693 20	-0.19842 0.4155 19	-0.01404 0.9545 19

Correlation By Parameter

The CORR Procedure

Parameter=TN

39 With Variables:	BARRIVN BC1 BC10 BC11 BC16 BC17 BC18 BC19 BC2 BC20 BC21 BC22 BC23 BC24 BC25 BC26 BC3 BC4 BC5 BC6 BC9 CHKMATE COCPALM CORKN CORKS CORKSCRD CORKSW ECOCORIV FAKA FAKA858 FAKAUPOI GATOR GGC_858 GGCAT31 HALDCRK LELY MONROE OKALA858 TAMBR90
9 Variables:	BC7 BC8 BC12 BC13 BC14 BC15 COCAT41 COCEOF31 CORK_846

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	BC7	BC8	BC12	BC13	BC14	BC15	COCAT41	COCEOF31	CORK_846
BARRIVN	0.41125 0.0572 22	0.31893 0.1480 22	0.24110 0.2797 22	0.06003 0.7960 21	0.04179 0.8535 22	0.06049 0.7891 22	0.13661 0.5444 22	0.28138 0.2046 22	-0.01243 0.9574 21
BC1	0.02863 0.9046 20	-0.16937 0.4753 20	0.24621 0.2954 20	-0.17626 0.4704 19	0.07469 0.7543 20	0.14802 0.5334 20	-0.25019 0.2874 20	0.03804 0.8735 20	0.00226 0.9924 20
BC10	-0.45990 0.0313 22	-0.54056 0.0094 22	-0.40625 0.0606 22	-0.12752 0.5717 22	-0.09772 0.6574 23	0.11499 0.6013 23	-0.08327 0.7056 23	-0.11202 0.6108 23	-0.08990 0.6907 22
BC11	0.05096 0.8218 22	-0.10088 0.6551 22	-0.22238 0.3199 22	0.40232 0.0634 22	0.67212 0.0004 23	0.21397 0.3269 23	0.18623 0.3949 23	0.45691 0.0284 23	0.19722 0.3790 22
BC16	-0.08175 0.7176 22	-0.06738 0.7657 22	0.02752 0.9032 22	0.00141 0.9950 22	0.19069 0.3835 23	0.33259 0.1210 23	0.14254 0.5165 23	0.08439 0.7019 23	-0.01246 0.9561 22
BC17	0.02600 0.9086 22	0.14314 0.5251 22	0.11983 0.5953 22	0.04156 0.8543 22	0.41535 0.0487 23	0.23893 0.2722 23	-0.07494 0.7340 23	0.16844 0.4423 23	0.24851 0.2648 22
BC18	-0.06731 0.7660 22	-0.01444 0.9492 22	-0.02201 0.9226 22	-0.02404 0.9154 22	-0.22233 0.3079 23	0.01583 0.9428 23	-0.07669 0.7280 23	0.03958 0.8577 23	0.02717 0.9045 22
BC19	0.18921 0.4114 21	0.10221 0.6593 21	0.33023 0.1437 21	-0.29876 0.1883 21	-0.29683 0.1798 22	-0.26258 0.2378 22	-0.06927 0.7594 22	-0.12012 0.5944 22	0.23543 0.3043 21
BC2	-0.12500 0.6101 19	-0.16615 0.4966 19	-0.06584 0.7889 19	0.33938 0.1683 18	0.31305 0.1919 19	-0.03961 0.8721 19	0.14575 0.5516 19	0.21083 0.3863 19	0.05558 0.8212 19
BC20	0.10787 0.6328 22	0.04789 0.8324 22	0.24093 0.2801 22	-0.16086 0.4745 22	-0.52082 0.0108 23	-0.42977 0.0407 23	-0.28957 0.1802 23	-0.19297 0.3777 23	0.26084 0.2410 22
BC21	0.00509 0.9821 22	-0.03452 0.8788 22	0.07064 0.7547 22	-0.38468 0.0771 22	-0.50668 0.0136 23	-0.05986 0.7862 23	-0.06208 0.7784 23	-0.12070 0.5833 23	0.19474 0.3852 22
BC22	0.25375 0.2545 22	0.13873 0.5381 22	-0.00029 0.9990 22	-0.11825 0.6002 22	0.16126 0.4623 23	0.12995 0.5545 23	0.04950 0.8225 23	0.21832 0.3169 23	-0.00850 0.9701 22

Correlation By Parameter

The CORR Procedure

Parameter=TN

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations									
	BC7	**BC8**	**BC12**	**BC13**	**BC14**	**BC15**	**COCAT41**	**COCEOF31**	**CORK_846**
BC23	0.27278 0.2194 22	0.33815 0.1237 22	0.01739 0.9388 22	0.22474 0.3146 22	0.12934 0.5564 23	0.17034 0.4371 23	-0.17480 0.4250 23	0.35454 0.0969 23	0.16605 0.4602 22
BC24	-0.08003 0.7233 22	-0.08208 0.7165 22	0.08167 0.7179 22	-0.10322 0.6476 22	0.01139 0.9589 23	-0.15067 0.4926 23	0.09822 0.6557 23	0.06037 0.7844 23	0.61523 0.0023 22
BC25	-0.09532 0.6811 21	0.01531 0.9475 21	0.25476 0.2651 21	0.00748 0.9743 21	-0.14411 0.5223 22	-0.22037 0.3244 22	0.04243 0.8513 22	0.01301 0.9542 22	0.56698 0.0059 22
BC26	0.37177 0.1287 18	0.32626 0.1864 18	0.18950 0.4514 18	0.34247 0.1642 18	0.33891 0.1558 19	-0.06945 0.7775 19	0.07381 0.7639 19	0.15209 0.5342 19	0.18198 0.4559 19
BC3	0.00226 0.9925 20	-0.00642 0.9786 20	-0.32866 0.1571 20	0.38945 0.0993 19	0.25245 0.2829 20	0.27769 0.2359 20	0.26611 0.2568 20	0.33233 0.1523 20	-0.31974 0.1694 20
BC4	0.25216 0.2835 20	0.32077 0.1679 20	0.04267 0.8582 20	0.57155 0.0106 19	0.62156 0.0034 20	0.14114 0.5528 20	0.36182 0.1170 20	0.33271 0.1518 20	-0.01848 0.9384 20
BC5	0.10249 0.6672 20	-0.11849 0.6188 20	-0.08120 0.7336 20	0.04088 0.8680 19	0.31283 0.1793 20	0.29992 0.1989 20	0.02186 0.9271 20	0.41070 0.0721 20	0.14458 0.5431 20
BC6	0.17891 0.4256 22	0.15502 0.4909 22	0.45268 0.0344 22	-0.32250 0.1432 22	-0.02623 0.9054 23	0.14515 0.5087 23	-0.08952 0.6846 23	-0.08012 0.7163 23	0.20543 0.3591 22
BC9	-0.13688 0.5436 22	-0.28871 0.1926 22	-0.25195 0.2580 22	0.19208 0.3918 22	0.27489 0.2043 23	0.12126 0.5815 23	0.20440 0.3495 23	0.12027 0.5846 23	0.18692 0.4049 22
CHKMATE	0.21429 0.6103 8	-0.03593 0.9327 8	0.24398 0.5604 8	0.09524 0.8225 8	0.02381 0.9554 8	-0.33333 0.4198 8	0.20360 0.6287 8	0.29941 0.4713 8	0.23810 0.5702 8
COCPALM	-0.18321 0.4144 22	-0.01556 0.9452 22	-0.17776 0.4287 22	0.28790 0.1939 22	0.22580 0.3002 23	0.03884 0.8603 23	0.05468 0.8043 23	0.32484 0.1304 23	0.36523 0.0946 22
CORKN	0.02395 0.9551 8	0.31325 0.4499 8	-0.15954 0.7059 8	0.43115 0.2862 8	0.23953 0.5678 8	0.16767 0.6915 8	0.15663 0.7111 8	0.53012 0.1765 8	0.88624 0.0034 8
CORKS	0.01802 0.9694 7	-0.19091 0.6818 7	-0.26179 0.5707 7	0.18019 0.6990 7	-0.01802 0.9694 7	0.01802 0.9694 7	-0.02727 0.9537 7	0.41443 0.3553 7	0.43245 0.3325 7
CORKSCRD	0.07143 0.8790 7	-0.30632 0.5040 7	-0.03706 0.9371 7	-0.28571 0.5345 7	-0.28571 0.5345 7	-0.67857 0.0938 7	-0.45047 0.3104 7	-0.07143 0.8790 7	0.07143 0.8790 7
CORKSW	-0.21429 0.6445 7	-0.45047 0.3104 7	-0.44475 0.3174 7	-0.03571 0.9394 7	-0.25000 0.5887 7	0.28571 0.5345 7	-0.21622 0.6414 7	0.17857 0.7017 7	0.28571 0.5345 7

Correlation By Parameter

The CORR Procedure

Parameter=TN

Spearman Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations									
	BC7	**BC8**	**BC12**	**BC13**	**BC14**	**BC15**	**COCAT41**	**COCEOF31**	**CORK_846**
ECOCORIV	0.15537 0.4899 22	0.11862 0.5991 22	0.16520 0.4625 22	0.11095 0.6230 22	0.28338 0.1901 23	0.13861 0.5282 23	0.39797 0.0600 23	0.14853 0.4988 23	-0.01249 0.9560 22
FAKA	0.26096 0.2408 22	0.04867 0.8297 22	0.00637 0.9776 22	0.02205 0.9224 22	-0.03366 0.8788 23	0.20010 0.3600 23	-0.20900 0.3385 23	0.22706 0.2975 23	0.04897 0.8287 22
FAKA858	0.43498 0.0553 20	0.25793 0.2722 20	0.24109 0.3058 20	0.04751 0.8423 20	0.20339 0.3765 21	-0.27051 0.2356 21	0.09997 0.6664 21	-0.09603 0.6788 21	0.45843 0.0366 21
FAKAUPOI	0.13820 0.5396 22	-0.00283 0.9900 22	-0.00522 0.9816 22	-0.27329 0.2185 22	-0.39698 0.0607 23	0.09936 0.6520 23	-0.36670 0.0852 23	-0.19524 0.3720 23	-0.23079 0.3014 22
GATOR	-0.11532 0.6093 22	-0.06337 0.7794 22	0.27236 0.2201 22	-0.29319 0.1854 22	-0.18861 0.3887 23	-0.27677 0.2011 23	0.13851 0.5285 23	-0.37076 0.0816 23	0.31135 0.1584 22
GGC_858	0.18223 0.4292 21	0.32128 0.1556 21	0.21680 0.3452 21	0.05111 0.8259 21	0.36629 0.0936 22	0.06084 0.7880 22	0.05689 0.8014 22	0.01669 0.9412 22	0.44115 0.0453 21
GGCAT31	0.43281 0.0442 22	0.42186 0.0505 22	0.17468 0.4369 22	0.02291 0.9194 22	0.22046 0.3121 23	0.05693 0.7964 23	0.07921 0.7194 23	0.05000 0.8208 23	0.04786 0.8325 22
HALDCRK	0.30090 0.1736 22	0.34900 0.1114 22	0.24384 0.2741 22	-0.06729 0.7661 22	0.23323 0.2842 23	-0.13261 0.5464 23	0.31395 0.1446 23	0.24814 0.2536 23	0.20385 0.3629 22
LELY	-0.34385 0.1624 18	0.09524 0.7070 18	0.17551 0.4860 18	-0.31429 0.1900 19	-0.22261 0.3596 19	-0.28735 0.2329 19	-0.30479 0.2045 19	-0.26681 0.2695 19	0.36401 0.1375 18
MONROE	-0.12069 0.6023 21	-0.13481 0.5602 21	-0.14936 0.5182 21	0.10384 0.6542 21	0.44265 0.0391 22	0.29522 0.1823 22	0.25325 0.2555 22	0.28191 0.2037 22	0.23941 0.2959 21
OKALA858	-0.29688 0.1797 22	-0.24837 0.2651 22	-0.13083 0.5617 22	0.18074 0.4209 22	-0.19539 0.3716 23	-0.21036 0.3353 23	0.14024 0.5233 23	0.23786 0.2744 23	0.32161 0.1444 22
TAMBR90	0.34856 0.1858 16	0.21223 0.4300 16	0.21078 0.4333 16	-0.02511 0.9265 16	0.47877 0.0519 17	0.41830 0.0947 17	0.32064 0.2096 17	0.24524 0.3428 17	-0.06130 0.8216 16

Correlation By Parameter

The CORR Procedure

Parameter=TPO4

39 With Variables:	BARRIVN BC1 BC10 BC11 BC16 BC17 BC18 BC19 BC2 BC20 BC21 BC22 BC23 BC24 BC25 BC26 BC3 BC4 BC5 BC6 BC9 CHKMATE COCPALM CORKN CORKS CORKSCRD CORKSW ECOCORIV FAKA FAKA858 FAKAUPOI GATOR GGC_858 GGCAT31 HALDCRK LELY MONROE OKALA858 TAMBR90
9 Variables:	BC7 BC8 BC12 BC13 BC14 BC15 COCAT41 COCEOF31 CORK_846

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	BC7	BC8	BC12	BC13	BC14	BC15	COCAT41	COCEOF31	CORK_846
BARRIVN	0.34921 0.0944 24	0.50316 0.0104 25	0.13873 0.5084 25	0.49009 0.0332 19	0.15017 0.4940 23	0.01446 0.9491 22	0.54398 0.0108 21	-0.04428 0.8529 20	-0.38417 0.1044 19
BC1	0.34141 0.1299 21	-0.00524 0.9820 21	-0.33355 0.1395 21	-0.12585 0.5970 20	0.15874 0.4919 21	0.34362 0.1174 22	0.17143 0.4456 22	0.15629 0.5105 20	0.37539 0.1133 19
BC10	0.17999 0.4112 23	0.38084 0.0730 23	-0.08766 0.6908 23	-0.01554 0.9512 18	0.50927 0.0131 23	0.30054 0.1741 22	-0.35542 0.1241 20	0.56883 0.0089 20	0.43296 0.0565 20
BC11	0.12724 0.5726 22	0.29066 0.1894 22	-0.09311 0.6802 22	-0.15275 0.5583 17	0.33792 0.1240 22	0.06815 0.7691 21	0.19753 0.4176 19	0.25211 0.2978 19	0.07692 0.7543 19
BC16	-0.03136 0.8843 24	0.09384 0.6627 24	-0.15096 0.4814 24	0.50734 0.0224 20	-0.19351 0.3649 24	-0.29832 0.1668 23	0.65659 0.0009 22	-0.15372 0.5059 21	-0.26606 0.2569 20
BC17	-0.01276 0.9539 23	0.13677 0.5240 24	-0.02694 0.9005 24	0.42475 0.0619 20	-0.15308 0.4856 23	-0.34218 0.1100 23	0.50410 0.0167 22	-0.15686 0.4971 21	-0.42187 0.0639 20
BC18	0.10097 0.6632 21	0.13146 0.5598 22	-0.00289 0.9898 22	0.58513 0.0136 17	-0.24979 0.2622 22	-0.16446 0.4884 20	0.74832 0.0004 18	-0.16182 0.5081 19	-0.12506 0.6100 19
BC19	0.07176 0.7510 22	0.24483 0.2602 23	-0.03987 0.8567 23	0.66278 0.0037 17	-0.22156 0.3217 22	-0.12039 0.6032 21	0.67867 0.0014 19	-0.14147 0.5635 19	-0.15371 0.5298 19
BC2	0.29834 0.2014 20	-0.14913 0.5303 20	-0.01778 0.9407 20	-0.05020 0.8383 19	-0.01623 0.9458 20	0.15598 0.4996 21	0.00748 0.9743 21	0.23433 0.3342 19	0.50882 0.0311 18
BC20	-0.05044 0.8281 21	0.31663 0.1511 22	0.12465 0.5805 22	0.59493 0.0092 18	-0.38351 0.0861 21	-0.22761 0.3211 21	0.53690 0.0147 20	-0.43574 0.0622 19	-0.33628 0.1724 18
BC21	0.22638 0.3110 22	0.34281 0.1093 23	0.05960 0.7871 23	0.54367 0.0241 17	-0.13265 0.5562 22	-0.00784 0.9731 21	0.66374 0.0019 19	-0.21614 0.3741 19	-0.15259 0.5329 19
BC22	0.25773 0.2593 21	-0.10563 0.6486 21	-0.20299 0.3775 21	0.12907 0.6215 17	0.35677 0.1124 21	0.40969 0.0728 20	0.20775 0.4081 18	0.48079 0.0372 19	0.44317 0.0655 18

Correlation By Parameter

The CORR Procedure

Parameter=TPO4

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	BC7	BC8	BC12	BC13	BC14	BC15	COCAT41	COCEOF31	CORK_846
BC23	0.36107 0.1178 20	0.33650 0.1469 20	0.09532 0.6894 20	0.07806 0.7659 17	0.25139 0.2717 21	-0.07250 0.7680 19	-0.01719 0.9478 17	0.21501 0.3767 19	0.13379 0.5966 18
BC24	-0.08223 0.7304 20	-0.15169 0.5232 20	-0.39630 0.0837 20	0.37422 0.1260 18	-0.09657 0.6855 20	0.13058 0.5726 21	0.42228 0.0636 20	0.03044 0.9016 19	0.42235 0.0716 19
BC25	0.44158 0.0760 17	-0.00865 0.9737 17	-0.16791 0.5195 17	-0.27853 0.2790 17	0.26694 0.2842 18	0.40062 0.0995 18	0.11249 0.6568 18	0.25000 0.3332 17	0.47516 0.0463 18
BC26	0.14762 0.5464 19	0.20269 0.3914 20	0.00573 0.9809 20	-0.01406 0.9588 16	0.66460 0.0019 19	0.67117 0.0023 18	-0.05904 0.8219 17	0.65946 0.0040 17	0.67345 0.0022 18
BC3	0.48445 0.0304 20	0.19492 0.4102 20	-0.06745 0.7775 20	-0.02464 0.9203 19	0.48320 0.0309 20	0.30491 0.1789 21	-0.15355 0.5064 21	0.64579 0.0028 19	0.34386 0.1624 18
BC4	0.18596 0.4325 20	0.11377 0.6330 20	-0.39803 0.0822 20	0.21992 0.3515 20	0.13592 0.5569 21	0.33171 0.1418 21	0.58835 0.0050 21	0.13341 0.5750 20	0.46958 0.0425 19
BC5	0.20994 0.3610 21	-0.18830 0.4137 21	-0.08037 0.7291 21	-0.15443 0.5157 20	0.03680 0.8742 21	0.23982 0.2824 22	0.30469 0.1680 22	0.11396 0.6324 20	0.67768 0.0014 19
BC6	-0.06882 0.7930 17	-0.12435 0.6230 18	-0.01983 0.9377 18	0.03440 0.8957 17	0.02827 0.9142 17	0.34524 0.1606 18	0.60362 0.0080 18	0.14954 0.5668 17	0.58654 0.0169 16
BC9	0.09317 0.6800 22	0.51608 0.0117 23	0.03288 0.8816 23	0.19556 0.4519 17	0.13515 0.5487 22	0.01967 0.9326 21	0.07835 0.7499 19	0.14096 0.5649 19	-0.01463 0.9526 19
CHKMATE	0.14726 0.7278 8	-0.09697 0.8193 8	-0.25934 0.5351 8	-0.17857 0.7017 7	0.42169 0.2981 8	0.16667 0.6932 8	0.88095 0.0039 8	0.28571 0.5345 7	0.46382 0.3542 6
COCPALM	-0.00171 0.9940 22	0.17890 0.4257 22	0.23224 0.2983 22	0.10132 0.6708 20	0.44577 0.0376 22	0.41334 0.0559 22	0.43091 0.0453 22	0.37170 0.1066 20	0.24791 0.3061 19
CORKN	-0.03740 0.9366 7	-0.27524 0.5502 7	-0.48617 0.2686 7	0.10000 0.8729 5	-0.11765 0.8243 6	-0.20000 0.7040 6	0.94286 0.0048 6	-0.10000 0.8729 5	0.10260 0.8696 5
CORKS	-0.11595 0.8268 6	-0.11595 0.8268 6	0.23191 0.6584 6	0.00000 1.0000 5	-0.11595 0.8268 6	0.14286 0.7872 6	-0.25714 0.6228 6	-0.70000 0.1881 5	-0.10000 0.8729 5
CORKSCRD	0.20000 0.7471 5	0.20000 0.7471 5	-0.20000 0.7471 5	-0.20000 0.7471 5	-0.30000 0.6238 5	0.54286 0.2657 6	0.25714 0.6228 6	-0.30000 0.6238 5	0.40000 0.5046 5
CORKSW	-0.63775 0.1731 6	-0.63775 0.1731 6	0.46382 0.3542 6	-0.50000 0.3910 5	0.00000 1.0000 6	-0.37143 0.4685 6	-0.08571 0.8717 6	-0.60000 0.2848 5	0.20000 0.7471 5

Correlation By Parameter

The CORR Procedure

Parameter=TPO4

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	BC7	BC8	BC12	BC13	BC14	BC15	COCAT41	COCEOF31	CORK_846
ECOCORIV	0.29291	0.06830	0.33834	-0.44014	0.57533	0.39582	-0.48969	0.64580	0.38276
	0.1975	0.7686	0.1336	0.0521	0.0064	0.0682	0.0207	0.0021	0.1058
	21	21	21	20	21	22	22	20	19
FAKA	0.24818	0.36995	0.51484	0.03236	0.16587	0.09416	-0.17038	0.24498	0.02040
	0.2654	0.0823	0.0119	0.9019	0.4607	0.6848	0.4856	0.3121	0.9339
	22	23	23	17	22	21	19	19	19
FAKA858	-0.03863	-0.04605	-0.22450	0.01977	0.13750	0.14130	0.02492	0.19839	0.27316
	0.8830	0.8607	0.3863	0.9400	0.5864	0.5760	0.9218	0.4453	0.2728
	17	17	17	17	18	18	18	17	18
FAKAUPOI	0.35875	0.50362	-0.04633	0.78413	-0.16705	0.03328	0.59152	-0.00529	-0.04244
	0.1103	0.0169	0.8378	0.0002	0.4575	0.8892	0.0097	0.9828	0.8630
	21	22	22	17	22	20	18	19	19
GATOR	-0.26003	-0.05841	-0.12526	0.48636	-0.40393	-0.44306	0.62525	-0.31985	-0.37919
	0.2308	0.7863	0.5598	0.0347	0.0559	0.0389	0.0024	0.1692	0.1094
	23	24	24	19	23	22	21	20	19
GGC_858	0.16221	-0.09515	-0.37376	-0.53178	0.63989	0.62263	-0.31620	0.49503	0.68411
	0.5070	0.6984	0.1149	0.0340	0.0024	0.0044	0.2163	0.0367	0.0012
	19	19	19	16	20	19	17	18	19
GGCAT31	0.34012	0.43939	-0.16777	-0.00362	0.31250	0.54032	0.00301	0.22678	0.54536
	0.1542	0.0598	0.4924	0.9886	0.1927	0.0139	0.9899	0.3655	0.0192
	19	19	19	18	19	20	20	18	18
HALDCRK	0.35237	0.12429	0.00622	-0.00982	0.30419	0.56459	-0.06582	0.40123	0.49478
	0.1515	0.6232	0.9804	0.9702	0.2197	0.0118	0.7889	0.1104	0.0435
	18	18	18	17	18	19	19	17	17
LELY	0.52756	0.10781	-0.18541	-0.10914	0.40738	0.52408	0.02381	0.55482	0.63161
	0.0295	0.6804	0.4762	0.6874	0.1046	0.0256	0.9253	0.0257	0.0065
	17	17	17	16	17	18	18	16	17
MONROE	-0.12076	0.05289	0.09978	0.33099	-0.11708	-0.37666	0.51139	-0.10393	-0.34078
	0.5831	0.8061	0.6427	0.1663	0.5947	0.0840	0.0178	0.6628	0.1415
	23	24	24	19	23	22	21	20	20
OKALA858	0.07885	-0.22054	-0.30787	0.18242	-0.15498	0.01789	0.53819	0.02203	0.25132
	0.7411	0.3501	0.1867	0.4548	0.5141	0.9386	0.0118	0.9287	0.2993
	20	20	20	19	20	21	21	19	19
TAMBR90	-0.08789	0.06459	-0.19051	0.01211	0.00517	-0.37534	0.34436	-0.19159	-0.38411
	0.7554	0.8122	0.4797	0.9672	0.9849	0.1680	0.2088	0.5117	0.1751
	15	16	16	14	16	15	15	14	14

Correlation By Parameter

The CORR Procedure

Parameter=TSS

39 With Variables:	BARRIVN BC1 BC10 BC11 BC16 BC17 BC18 BC19 BC2 BC20 BC21 BC22 BC23 BC24 BC25 BC26 BC3 BC4 BC5 BC6 BC9 CHKMATE COCPALM CORKN CORKS CORKSCRD CORKSW ECOCORIV FAKA FAKA858 FAKAUPOI GATOR GGC_858 GGCAT31 HALDCRK LELY MONROE OKALA858 TAMBR90
9 Variables:	BC7 BC8 BC12 BC13 BC14 BC15 COCAT41 COCEOF31 CORK_846

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	BC7	BC8	BC12	BC13	BC14	BC15	COCAT41	COCEOF31	CORK_846
BARRIVN	-0.05769 0.7795 26	1.00000 <.0001 27	-0.03846 0.8489 27	-0.04348 0.8401 24	. . 26	-0.05769 0.7795 26	-0.06893 0.7605 22	-0.04167 0.8432 25	. . 25
BC1	0.21841 0.3288 22	-0.13147 0.5598 22	-0.13147 0.5598 22	-0.12354 0.5937 21	. . 21	0.44474 0.0434 21	0.46376 0.0342 21	-0.12354 0.5937 21	. . 20
BC10	. . 26	. . 27	. . 27	. . 24	. . 26	. . 26	. . 22	. . 25	. . 25
BC11	-0.05769 0.7795 26	-0.03846 0.8489 27	-0.03846 0.8489 27	-0.04348 0.8401 24	. . 26	-0.05769 0.7795 26	0.72375 0.0001 22	-0.04167 0.8432 25	. . 25
BC16	-0.10854 0.6056 25	-0.07207 0.7264 26	-0.07207 0.7264 26	-0.08233 0.7088 23	. . 25	-0.10854 0.6056 25	0.74909 <.0001 21	-0.07860 0.7150 24	. . 24
BC17	-0.05769 0.7795 26	-0.03846 0.8489 27	-0.03846 0.8489 27	-0.04348 0.8401 24	. . 26	-0.05769 0.7795 26	-0.06893 0.7605 22	-0.04167 0.8432 25	. . 25
BC18	-0.10394 0.6133 26	0.50743 0.0069 27	-0.06920 0.7316 27	-0.07860 0.7150 24	. . 26	-0.10394 0.6133 26	0.39809 0.0665 22	-0.07520 0.7209 25	. . 25
BC19	0.34318 0.0931 25	-0.07211 0.7263 26	-0.07211 0.7263 26	-0.08239 0.7086 23	. . 25	-0.10860 0.6053 25	0.30576 0.1777 21	-0.07866 0.7149 24	. . 24
BC2	0.31279 0.1564 22	-0.08644 0.7021 22	-0.08644 0.7021 22	-0.09097 0.6949 21	. . 21	0.60645 0.0036 21	0.30550 0.1781 21	-0.09097 0.6949 21	. . 20
BC20	0.20461 0.3265 25	0.36815 0.0642 26	-0.09688 0.6378 26	-0.11130 0.6132 23	. . 25	-0.14615 0.4857 25	0.25234 0.2698 21	0.31812 0.1298 24	. . 24
BC21	-0.08320 0.6862 26	0.72058 <.0001 27	-0.05543 0.7836 27	-0.06281 0.7706 24	. . 26	-0.08320 0.6862 26	-0.09977 0.6587 22	-0.06014 0.7752 25	. . 25
BC22	-0.12246 0.5512 26	-0.08146 0.6863 27	-0.08146 0.6863 27	-0.09277 0.6664 24	. . 26	-0.12246 0.5512 26	0.74154 <.0001 22	0.39900 0.0482 25	. . 25

Correlation By Parameter

The CORR Procedure

Parameter=TSS

Spearman Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	BC7	BC8	BC12	BC13	BC14	BC15	COCAT41	COCEOF31	CORK_846
BC23	. . 26	. . 27	. . 27	. . 24	. . 26	. . 26	. . 22	. . 25	. . 25
BC24	0.31267 0.1199 26	-0.06923 0.7315 27	-0.06923 0.7315 27	-0.07866 0.7149 24	. . 26	-0.10400 0.6131 26	0.29312 0.1855 22	-0.07524 0.7208 25	. . 25
BC25	-0.06281 0.7706 24	-0.06014 0.7752 25	. . 25	-0.06893 0.7605 22	. . 24	-0.09074 0.6733 24	0.44183 0.0511 20	-0.06573 0.7657 23	. . 25
BC26	-0.07246 0.7550 21	-0.06893 0.7605 22	. . 22	-0.08072 0.7425 19	. . 21	-0.07246 0.7550 21	-0.08560 0.7356 18	-0.07637 0.7490 20	. . 22
BC3	. . 23	. . 23	. . 23	. . 22	. . 22	. . 22	. . 22	. . 22	. . 21
BC4	0.35801 0.0859 24	-0.07860 0.7150 24	-0.07860 0.7150 24	-0.09097 0.6949 21	. . 23	-0.08233 0.7088 23	0.30550 0.1781 21	. . 23	. . 22
BC5	0.34009 0.1039 24	-0.07866 0.7149 24	-0.07866 0.7149 24	-0.08239 0.7086 23	. . 23	0.37814 0.0752 23	0.27320 0.2186 22	-0.08239 0.7086 23	. . 22
BC6	-0.13429 0.5316 24	-0.08883 0.6728 25	-0.08883 0.6728 25	-0.06573 0.7657 23	. . 24	-0.07866 0.7149 24	-0.09977 0.6587 22	0.60422 0.0023 23	. . 23
BC9	. . 26	. . 27	. . 27	. . 24	. . 26	. . 26	. . 22	. . 25	. . 25
CHKMATE	. . 9	. . 9	. . 9	-0.14286 0.7358 8	. . 9	. . 9	0.53995 0.1672 8	-0.12500 0.7486 9	. . 9
COCPALM	-0.06014 0.7752 25	-0.04167 0.8432 25	-0.04167 0.8432 25	-0.04545 0.8368 23	. . 25	-0.06014 0.7752 25	0.65482 0.0009 22	-0.04167 0.8432 25	. . 23
CORKN	. . 9	. . 9	. . 9	-0.14286 0.7358 8	. . 9	. . 9	0.75593 0.0300 8	-0.12500 0.7486 9	. . 9
CORKS	. . 8	. . 8	. . 8	. . 7	. . 8	. . 8	. . 7	. . 8	. . 8
CORKSCRD	. . 7	. . 7	. . 7	-0.16667 0.7210 7	. . 7	. . 7	1.00000 <.0001 7	-0.16667 0.7210 7	. . 7
CORKSW	. . 8	. . 8	. . 8	. . 7	. . 8	. . 8	. . 7	. . 8	. . 8

Caloosahatchee Estuary Water Quality

Optimization Leader: Mike Wessel, Janicki Environmental
Statistician: Mike Wessel, Janicki Environmental

Project Code: CESWQ

Type: Type II

Mandate or Permit:

- Comprehensive Conservation and Management Plan (CCMP) of the South West Florida Regional Planning Council
- Surface Water Improvement and Management Act (Lake Okeechobee SWIM Plan) Chapter 373.451-373.4595, F.S.
- FL Watershed Restoration Act (403.067 FS) (TMDLs/MFLs/PLRGs)
- WRDA 2000, PL 106-541, Title VI, Section 601 (Comprehensive Everglades Restoration Program)

Project Start Date: Originally began in 1998 with a few stations, but was re-designed in January 2002

Division Manager: Coastal Ecosystem Division: Sean Sculley (Acting)

Program Manager: Peter Doering

Points of Contact: Peter Doering, Dan Crean, Bob Chamberlain, Nathan Ralph

Field Point of Contact: Nathan Ralph

Spatial Description:
The Caloosahatchee River and Estuary extends approximately 70 miles from Lake Okeechobee to San Carlos Bay on Florida's southwest coast. The freshwater portion of the river (between structure S-77 and S-79) is monitored as part of the Caloosahatchee River Project (Project CR). The CESWQ project evaluates water quality in the tidal portion of the river (west of the S-79 structure) and into the lower Caloosahatchee Estuary. There is some overlap between CESWQ and CR in that CESWQ station CES01 is close to the S-79 sampling station from Project CR. The CESWQ Project began in 1998. Historically, up to 11 fixed locations have been sampled for CESWQ. CES01 is the easternmost station (at the S-79 structure). Stations CES02 through CES11 are located west of this station along the river and into the lower portions of the estuary with CES11 being the most western station. Four of the fixed eleven stations (CES01, CES03, CES04 and CES06) are being sampled monthly. Five additional stations are randomly selected using the EPA's EMAP stratified random sampling design with stations being selected randomly within a grid. These random stations are included in the Charlotte Harbor National Estuary Program's Water Quality Network.

Sampling location CES01 may overlap with sampling station S-79 from the CR project. Additionally, the Rookery Bay water quality monitoring project (ROOK) sampled by FIU may contain overlapping stations. In particular, CES08 is not sampled regularly for CESWQ, but this station is sampled monthly under Project ROOK. At the time Project ROOK began (1999), CES08 was being sampled regularly and was purposefully included in ROOK to allow some comparability between programs. Prior to optimization, a map showing the sampling stations for Project ROOK and CESWQ will need to be reviewed to identify additional stations containing data that may be used.

Project Purpose, Goals and Objectives:
Project CESWQ has two distinct components that are used to meet the requirements specified in the mandates above. One component of this program involves monthly water quality sampling from the 4 fixed stations and 5

randomly located stations to better understand how water quality issues are affecting the Caloosahatchee River and receiving estuaries. This information will also help to support the Charlotte Harbor National Estuary Program by establishing a baseline and long-term data set for the area from Estero Bay through the lower end of Charlotte Harbor. This component of the project is currently being collected by Lee County Environmental Laboratory.

The second component of the CESWQ project is an event driven sampling effort to quantify the effects of freshwater releases from Lake Okeechobee into the Caloosahatchee River Estuary. During the drought of 2001, essential tape grass habitat in the Upper Caloosahatchee Estuary was lost due to elevated salinity. In an effort to restore this habitat and maintain healthy salinity levels within the system, the Corps and District have been conducting freshwater releases through the S-79 structure if salinity is determined to be detrimental. Large volumes of freshwater are also released through the structure in response to events (storms) which require movement of water out of the watershed and Lake Okeechobee for flood control. Therefore, the specific goal of the project is to quantify spatial and temporal changes in salinity and other indicative water quality parameters, which are altered by freshwater releases through the S-79 structure to the Caloosahatchee River Estuary. Sampling is conducted upon request of the District's program manager at up to eleven sampling locations (CES01 through CES11).

Sampling Frequency and Parameters Sampled:
Currently, Lee County collects monthly samples for Project CESWQ. The four fixed stations (CES01, CES03, CES04 and CES06) for project CESWQ are sampled monthly (via grab samples) for total Kjeldahl nitrogen, ammonia, nitrate+nitrite, total phophorus, orthophosphate, silicate, turbidity, total suspended solids, total organic carbon, color and chlorophyll a. Samples are collected at 0.5 meters from the surface and 0.5 meters from the bottom. In situ measurements are taken at both surface and bottom and include: pH, dissolved oxygen, salinity, conductivity, and temperature. A secchi depth measurement is also recorded for the sampling station.

The five random stations sampled by Lee County for Project CESWQ are sampled monthly (via grab samples) for total Kjeldahl nitrogen, total dissolved Kjeldahl nitrogen, ammonia, nitrate+nitrite, total phophorus, orthophosphate, silicate, turbidity, total suspended solids, total dissolved solids, total organic carbon, color, chlorophyll a and photosynthetically active radiation. For locations where sample depth is greater than 3 meters, samples are collected at 0.5 meters from the surface and 0.5 meters from the bottom. For locations less than 3 meters total depth, a single sample at 0.5 meters from the surface is collected. In situ measurements, including salinity, temperature, conductivity, pH and dissolved oxygen are also collected both at the surface and bottom. A secchi depth measurement and light attenuation coefficients are taken at each sampling location.

The event-driven sampling for the CESWQ project is conducted at designated stations within a single day timeframe. Grab samples at 0.5 meter from the surface are used to collect total nitrogen, total phosphorus and chlorophyll a. However, total nitrogen and total phosphorus are only collected at station CES01 whereas chlorophyll a is collected at all sampling locations. In situ vertical profiles of temperature, salinity, pH, dissolved oxygen, and photosynthetically active radiation are also collected at all stations. The District sub-contracts the event-driven Caloosahatchee release monitoring. This effort is currently being conducted by TetraTech.

The CESWQ program manager did not believe any additional parameters would be necessary in the future for this monitoring program.

Current and Future Data Uses:
These data are often used together with those from Project CR since the stations for CESWQ are directly downstream of the CR project. The data from the CESWQ project are used in many of the same District reports, models and operations that reference data from the CR projects. Current reports/models which rely on data collected from the Caloosahatchee Estuary Water Quality project include:

- South Florida Environmental Report (SFER)
- CERP update and design/assessment of CERP projects in the C-43 basin and surrounding area
- Southwest Florida Feasibility Study
- DHI watershed model of the C-43 basin

- CH3D Hydrodynamic model of the Caloosahatchee
- MIKE SHE/MIKE II Model of the Tidal Caloosahatchee

The event-driven data from this project are reported directly to operations at weekly manager meetings. This information is also critical and is used to alert the crab fishing industry of low dissolved oxygen events.

Because the C-43 Basin is a CERP Project and has been listed as an Acceler8 project, data from the CESWQ Project will play a major role in the design and assessment of the CERP projects in the C-43 Basin and surrounding areas. The RECOVER Monitoring and Assessment Plan (MAP) has also identified sampling stations within the boundaries of the Caloosahatchee River and Estuary System to be monitored on a long-term basis.

In addition to CERP and RECOVER related activities, future data from the Caloosahatchee River Estuary Monitoring Program will be used to support critical loads for the C43 basin, water quality targets, and TMDL development. Outside of the District, EPA's Charlotte Harbor National Estuary Program is a key end-user of this information.

Identified Optimization Opportunities:

Discussions with District staff identified some potential opportunities for optimization. Additionally, questions were generated that will provide useful for guiding the optimization.

- Are the data from S-79 (Project CR) and CES01 (Project CESWQ) similar? Can one of these stations be used for both projects?
- What is the spatial and temporal variability in salinity and other water quality parameters in the estuary? Do stations represent redundant sampling from a gradient perspective?
- Where in the estuary does the influence of water released from S-79 end?

Parameters Measured During Routine Monitoring of Project CESWQ

Station	TKN	TDKN	NH4	NOX	TPO4	OPO4	SiO2	TURB	TSS	TDS	TORGC	COLOR	CHLA	CHLA2
CES01*	m	m	m	m	m	m	m	m	m	m	m	m	m	m
CES03*	m	m	m	m	m	m	m	m	m	m	m	m	m	m
CES04*	m	m	m	m	m	m	m	m	m	m	m	m	m	m
CES06*	m	m	m	m	m	m	m	m	m	m	m	m	m	m

Station	PH	DO	TEMP	SALIN	SCOND	PAR (K)	SECCI
CES01*	m	m	m	m	m	m	m
CES03*	m	m	m	m	m	m	m
CES04*	m	m	m	m	m	m	m
CES06*	m	m	m	m	m	m	m

*Fixed sampling station; m = monthly; gray shading indicates a Type 2 station

Parameters Measured During Event-based Monitoring for Project CESWQ

Station	TN	TPO4	CHLA	PH	DO	TEMP	SALIN	PAR (K)
CES01	req	req	req	req	req	req	req	req
CES02			req	req	req	req	req	req
CES03			req	req	req	req	req	req
CES04			req	req	req	req	req	req
CES05			req	req	req	req	req	req
CES06			req	req	req	req	req	req
CES07			req	req	req	req	req	req
CES08			req	req	req	req	req	req
CES09			req	req	req	req	req	req
CES10			req	req	req	req	req	req
CES11			req	req	req	req	req	req

req = upon request of the District Program manager; gray shading indicates a Type 2 station

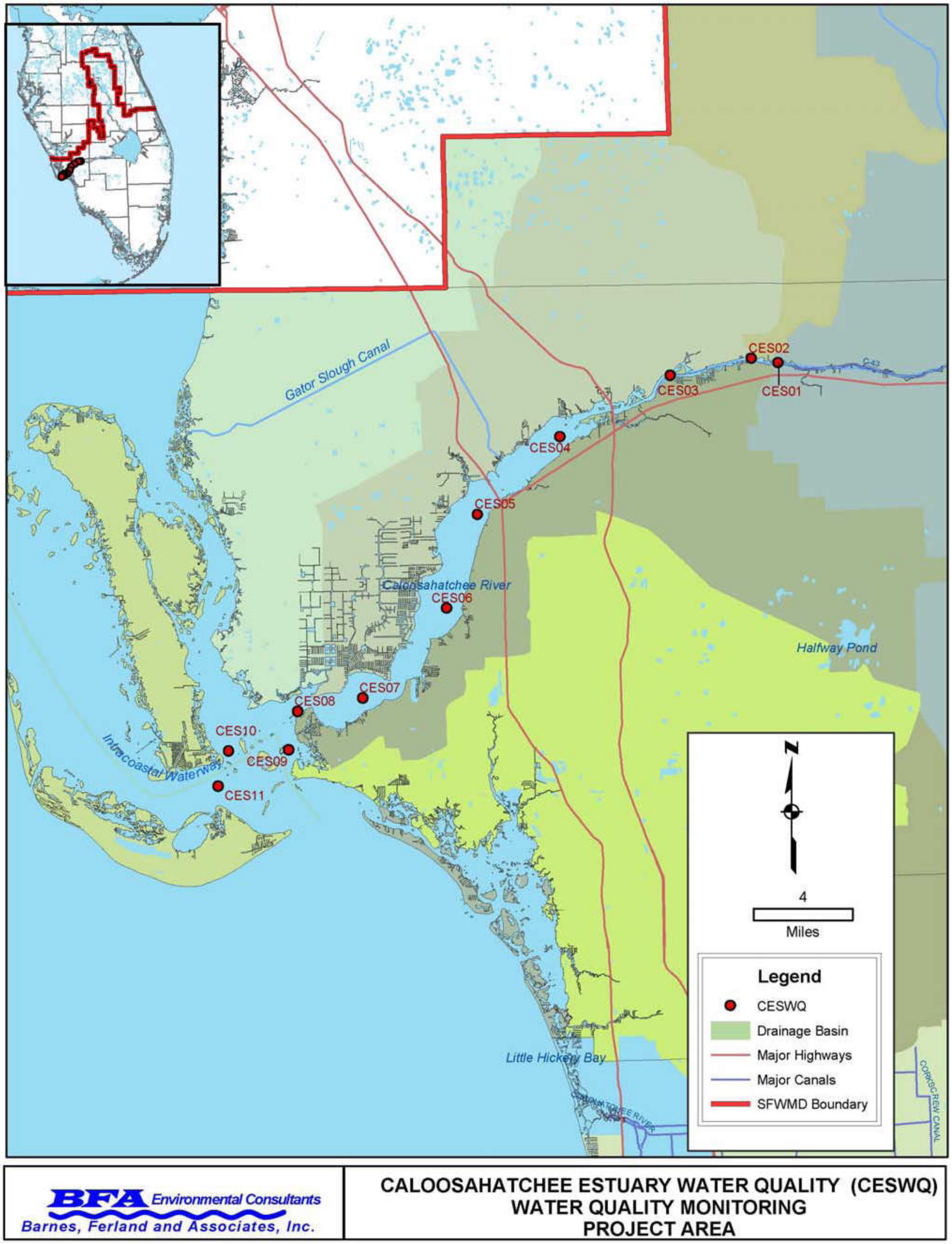


Figure 1. CESWQ Sampling Locations

Optimization analysis:
Optimization of the CESWQ water quality monitoring project was undertaken with respect to the specific tasks outlined above and detailed in the optimization plan modified and approved in September 20005. Briefly, the spatial and temporal adequacy of the CESWQ project was evaluated with respect to being able to detect changes between time periods, being able to detect trends in water quality parameters by station within the project, assessing information redundancies among stations and identifying stations located in proximity to potential point source discharges. The parameters identified for optimization in this project were:

Parameter	Units	DBHydro Code
Salinity	PPT	98
Dissolved Oxygen	mg/L	8
Chlorophyll a Corrected	mg/M3	112
TPO4	mg/L	25
TKN	mg/L	21
TN calculated	mg/L	Calculated sum of codes 18+20+21

- To estimate power and detectable effect size of the current monitoring program, Monte Carlo simulation using the nonparametric sign test was used to estimate the detectable change in median value for each parameter of interest across stations corresponding to a significant shift in the distribution from baseline levels (i.e. long-term median condition) given the current sampling effort. Further, the test was constructed to establish whether or not a given magnitude of change would result in an observable 20% change in long term median value.

- To estimate the power to detect a trend for a given water quality parameter, Monte Carlo simulations were performed using the Kendall Tau Test for Trend. This procedure is being documented as a statistical evaluation tool for the SFWMD and the procedure will be outlined in detail in separate documentation. Briefly, the simulations result in an estimate of the slope (time series trend) that can be detected for a given monitoring routine using the current annual effort and under alternative sampling strategies. Again a 20% change in slope was used as a target change for detection.

- The binomial test was used to identify stations where the probability of encountering a value larger than the long term median (for all stations combined) was significantly greater than 50 percent. A significant result using the one tailed binomial test may signify an area of increased parameter concentration associated with a possible point source discharge. For dissolved oxygen, the left-sided binomial test was used to test for a significantly greater than 50 percent chance of collecting a dissolved oxygen value lower than the long term median.

The CESWQ project has undergone a series of sampling design changes related to the establishment of a Minimum Flow and Level (MFL) for the Caloosahatchee Estuary. Low level freshwater releases from the S79 structure are now being conducted at the request of the District to regulate the upstream incursion of a 10 ppt salinity isohaline. Event based monitoring is now being conducted in conjunction with these low level releases from S79. This shift in the sampling strategy was evidenced in the dataset during 2003. Further, a reservoir is scheduled to be constructed between monitoring stations S78 and S79 in the CR project to facilitate low level releases and minimize the need for flood control releases during periods of heavy rainfall. Incorporating flow data into the analysis was beyond the scope of this study. Therefore, the focus of this optimization was on optimizing the sampling frequency necessary to detect changes in water quality parameters with respect to a 20% change from long term median and estimating the ability to detect changes in slope over 5 year time frame. However, long term (i.e. 5 years) data only exist for station CES01, CES03, CES04 and CES06 from the fixed grab sampling component of the sampling program. Other stations are sampled on an event based sampling frequency which began in 2003. Therefore, trend detection will be performed only for grab sample data with a five year sampling frequency which included the 4 stations mentioned previously and the parameters: Dissolved Oxygen, Salinity, TPO4, TKN, TNc and corrected Chla.

The first component of the optimization was to examine the project-wide distribution for each parameter of interest, calculate the long term median value for each parameter of interest and generate a simulation dataset that could be used to test the effectiveness of the current monitoring sampling design to estimate changes in water quality parameters of interest to the district. Details of the sign test methods are conveyed in the master document. Briefly, the sign test simulation exercise is meant to demonstrate the ability of a sampling program to detect changes from a baseline value under a given sampling frequency. The long term median value was used to represent a baseline value and the test was constructed as a one-sample test to estimate the power to detect a change in the median value for each water quality variable of interest. Since there is only variability associated with one group of data for the comparison, the test is more powerful than a two- sample test where uncertainty is expressed in the distribution of each comparison group. Further, the sign test simulations do not account for serial auto-correlation which can be present in monitoring data. The presence of significant auto correlation, if not accounted for, can yield unrealistically optimistic assessments of the sample size necessary to detect changes. However, from a regulatory perspective, auto-correlation is usually not considered when assessing whether or not a water body is meeting or exceeding a given water quality target (e.g., Impaired Waters Rule F.A.C. 62-303.320). Auto-correlation is not considered in the sign test simulations but is considered in the test for trend analysis presented later in this document.

Table 1 provides a summary of the simulation results using the Sign Test to estimate the effect size detectable under the current monitoring strategy and identify the number of years of data required to detect a twenty percent change in magnitude from the baseline condition. Data included all samples collected as part of the CESWQ project from 1998 through 2004. When present, vertical profile data were averaged for each station/collection date combination prior to creating the simulation pool for analysis. The sample size (Nobs) was then calculated as the average annual number of samples for collections from 2000-2004.

Table 1. Results of Monte Carlo simulation using the Sign Test to determine the effect size and number of samples to detect a 20% change in long term median value (Target) with 80% power.

Parameter	Average Nobs/Year	Long Term Median Value	Annual Percent Change Detected	Number of Samples to Detect Shift to Target
Chla corrected	74	6.3	53.5	380
Dissolved Oxygen	124	6.05	16.2	100
TKN	72	0.95	23.4	120
TN calculated	62	1.16	37.7	185
TPO4	70	0.11	29.9	280

Results suggest that the basin-wide sampling frequency was sufficient to detect annual changes of 20% in the basin-wide median value only for DO. The parameters TPO4 ,TKN, and TNc had more uncertainty resulting in a larger sample size required to detect a 20% change in median for this parameter but suggested that a 20% change in median could be detected in 5 years if autocorrelation was not present in the data. For corrected Chla the sampling frequency was insufficient to detect a 20% change in 5 years. While sampling frequency regarding basin-wide inferences on a 5 year window appears to be sufficient for all parameters except Chla, there was significant between station variability within the Caloosahatchee Estuary. (Appendix CR-1 box plots) that influenced the power of the sampling program.

To examine the sign test power analysis on a more refined spatial scale, a second analysis was performed using data collected only from stations CES03 and CES04 to identify sample sizes necessary to detect changes in median corrected Chla concentrations in an area of special concern regarding a Valued Ecosystem Component (i.e. a large area of tape grass, *Vallisneria Americana*) established under the MFL. Again, the sign test was used in a Monte Carlo simulation approach to estimate the power to detect a change in median for Chla. Results indicated that a

20% change from the median value of 6.89 would require more than 5 years worth of data collection at 30 samples/year. Between station Spearmans rank correlations suggested that Chla concentrations at upstream stations were correlated with the two stations downstream and one station upstream while the more estuarine stations downstream were only correlated with stations immediately adjacent to them (Table 2). The exception to this was station CES04 which was correlated significantly with two upstream stations and one downstream station.

Table 2. Correlation table for Parameter Chla in the CESWQ project.

Station	Corr CES01	Corr CES02	Corr CES03	Corr CES04	Corr CES05	Corr CES06	Corr CES07	Corr CES08
CES01	1.00 **	0.52 *	0.62 **	0.39	0.50	0.10	0.05	-0.25
CES02	0.52 *	1.00 **	0.79 **	0.64 **	0.29	0.37	0.17	-0.17
CES03	0.62 **	0.79 **	1.00 **	0.76 **	0.40	0.09	0.05	-0.25
CES04	0.39	0.64 **	0.76 **	1.00 **	0.61 **	0.33	0.24	-0.29
CES05	0.50	0.29	0.40	0.61 **	1.00 **	0.77 **	0.37	0.09
CES06	0.10	0.37	0.09	0.33	0.77 **	1.00 **	0.71 **	0.29
CES07	0.05	0.17	0.05	0.24	0.37	0.71 **	1.00 **	0.42 *
CES08	-0.25	-0.17	-0.25	-0.29	0.09	0.29	0.42 *	1.00 **

* Prob > |r| Under HC: RHO=0 < 0.01
** Prob > |r| Under HC: RHO=0 < 0.001

The second component of the optimization was to assess the power to detect time series trends for the water quality parameters of interest. Data collected from 1998 to 2003 at fixed station sampling sites were analyzed using the entire time series for each parameter which was first modeled to estimate the seasonal variability and autocorrelation in the data. A simulation dataset was then generated from which samples could be pulled representing a 5 year time series. For each replicate trial, the Kendall Tau Test for Trend was used to estimate the annual percent change in slope that could be detected under the current sampling design. Alternative sampling frequencies were assessed by selecting additional samples from the simulated time-series to increase the number of samples per year in the simulation trials while capturing the seasonal signal and serial auto-correlation aspects of the data. The all data were natural log transformed prior to analysis except for DO which exhibited a relatively normal distribution.

For parameters salinity and DO, the annual percentage change in slope detectable was in the 50 percent range except for station CES01 salinity which is predominantly freshwater. Trends in salinity and dissolved oxygen in the future will more likely be assessed from data collected using in situ profiles rather than grab samples but unfortunately a long term time series was unavailable for these parameters for collect methods other than grab samples. Corrected CHLa was consistently in the 30-40 percent APC range for stations CES01-CES03 and less powerful at the downstream station CES06 indicating it is highly unlikely that trends could be detected at this station. The APC values for TKN ranged from 7.6 -11.4 percent depending on station while the calculated TNc values were more difficult to model using the mixed model approach resulting in non-convergence in stations CES03 and CES04. When convergence of the mixed model was reached the APC estimates were very similar. Similarly, convergence for TPO4 was problematic at all stations but CES01.

Table 3. Results of Monte Carlo simulation using the Kendall Tau Test for Trend on a 5 year time series to determine the effect size for change in slope parameter.

Station	Parameter	Number of samples per year	Slope Estimate	Annual Percent Change Detectable	Can You Detect a Trend in 5 Years?
CES01	CHLa	8	0	31.6	N
CES01	DO	8	0	58.9	N
CES01	Salinity	9	0	11.0	N

CES01	TKN	24	0	11.4	N
CES01	TNc	6	0	11.4	N
CES01	TPO4	9	0	3.5	Y
CES03	CHLa	8	0	40.5	N
CES03	DO	8	0	61.7	N
CES03	Salinity	9	0	63.4	N
CES03	TKN	9	0	8.0	N
CES03	TNc	8	0	NC**	NC**
CES03	TPO4	9	0	NC**	NC**
CES04	CHLa	8	0	40.7	N
CES04	DO	8	0	43.9	N
CES04	Salinity	9	0	55.3	N
CES04	TKN	9	0	7.6	N
CES04	TNc	8	0	NC**	NC**
CES04	TPO4	9	0	NC**	NC**
CES06	CHLa	8	0	93.8	N
CES06	DO	8	0	54.5	N
CES06	Salinity	9	0	47.1	N
CES06	TKN	9	0	8.0	N
CES06	TNc	7	0	8.1	N
CES06	TPO4	9	0	NC**	NC**

NC** = non convergence of the mixed model

To identify areas of potential concern with respect to point source discharges, the binomial test was used to identify stations which consistently recorded values for a specific parameter higher than the long term median value for that parameter when combining all stations. For DO, the binomial test was used to test for a significantly greater than 50% probability of collecting a value lower than the long term median for all stations.

Table 4. Stations with statistically greater than 50% probability of recording a value above the long term median for all grab sample stations.

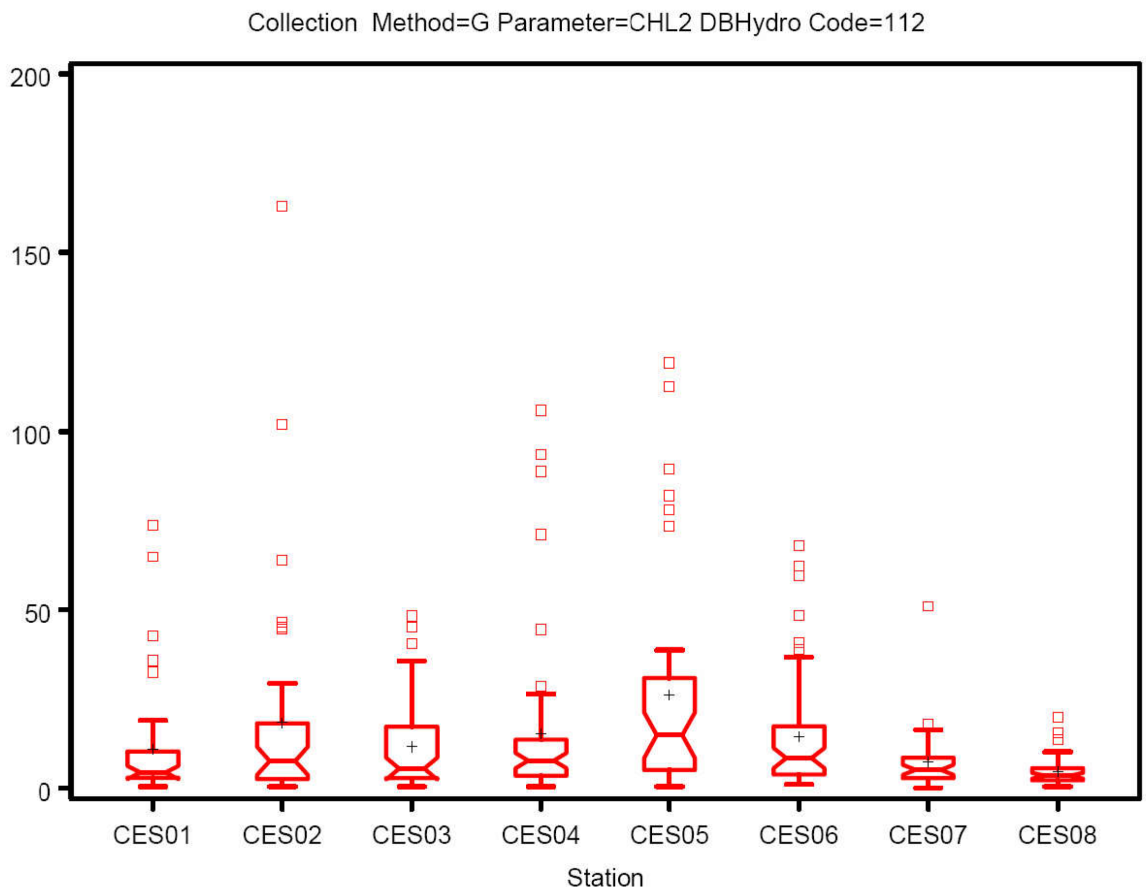
Parameter	DO	TKN	NOx	TNc
CES01	X	X	X	X
CES02	X			X
CES03	X	X		X

Recommendations:

The Caloosahatchee Estuary project is an important part of the South Florida's Water Quality Monitoring Network. The estuarine portion of the Caloosahatchee connects the upstream C-43 basin and waters leaving Lake Okeechobee with the Charlotte Harbor Estuary. The data collected in this project are used to monitor water quality leaving the upstream C-43 basin, estimate nutrient concentrations within the estuary and detect exceedance of water quality targets as established by rule for MFL criteria. The data collection effort has become highly proactive over time to include assessments of controlled flow releases from the S79 structure and their impacts on downstream water quality. Since the C-43 basin will be undergoing major reconstruction with the incorporation of a reservoir between S78 and S79, continued water quality monitoring will be necessary to provide information on potential impacts of the reservoir on water quality at S79 and into the Caloosahatchee estuary. Incorporating flow data was beyond the scope of this study, reducing the ability of these efforts to identify the downstream limits of effects from S79. Further the limited time series of data under the new (2003) sampling design limited our ability to make inferences regarding possible water quality trends. The routine sampling conducted at stations CES01, CES03, CES04, and CES06 suggested that only large rates of change in water quality targets would be detected under the current design. When examining basin-wide changes with respect to long term median values, the system had more power to detect changes in median condition but this may not be the aim of the study with respect to the specific criterion established for the MFL which is to protect a specific area of the river where a large bed of low salinity submerged aquatic vegetation (SAV) exists. The criterion for the MFL is based on salinity and the salinity isohaline is managed using a flow control strategy.

The CESWQ project sampling design was changed in 2003 in an attempt to deal with specific issues related to flow control strategies from S79 and support the MFL established for the Caloosahatchee in 2002. The estuary is sampled currently with 3 sampling strategies including a fixed-station, stratified-random and event-based sampling protocol. Based on the analysis presented in this study, the fixed station sampling aspect of the program provides little information with respect to the ability to detect changes in water quality parameters over time. The sampling frequency is reportedly monthly but was found to be less than monthly in the year 2003 for several of the parameters identified. However, station CES01 is an important station to estimate the nutrient loading into the estuarine portion of the Caloosahatchee from S79. Therefore, one alternative to fixed station sampling would be to continue to sample CES01 as a fixed station and allocate the remaining fixed station effort into the stratified random sampling effort for the CESWQ project. The event based sampling is necessary to establish a relationship between flow releases and downstream water quality though the current time series of data is not long enough to evaluate its effectiveness. The C-43 basin alterations, including the construction of a reservoir designed to address downstream water quality issues in the Caloosahatchee estuary will necessitate future optimizations. Once the reservoir is completed and a year or two of sampling has been conducted, the CESWQ project should re-evaluated with respect to optimizing this aspect of the sampling program. While stations S79 and CES01 are in close proximity to one another, there are individual project requirements that reduce the potential for using only one station to estimate water quality for both projects. The S79 sampling station is required under a no degradation clause of the mandate for the C-43 basin while CES01 serves as an important station for estimating the nutrient concentrations entering the Caloosahatchee estuary and is sampled with greater frequency than the S79 structure.

Appendix CESWQ-1
Box Plots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50
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CES01
CES02
CES03
CES04
CES05
CES06
CES07
CES08
Station

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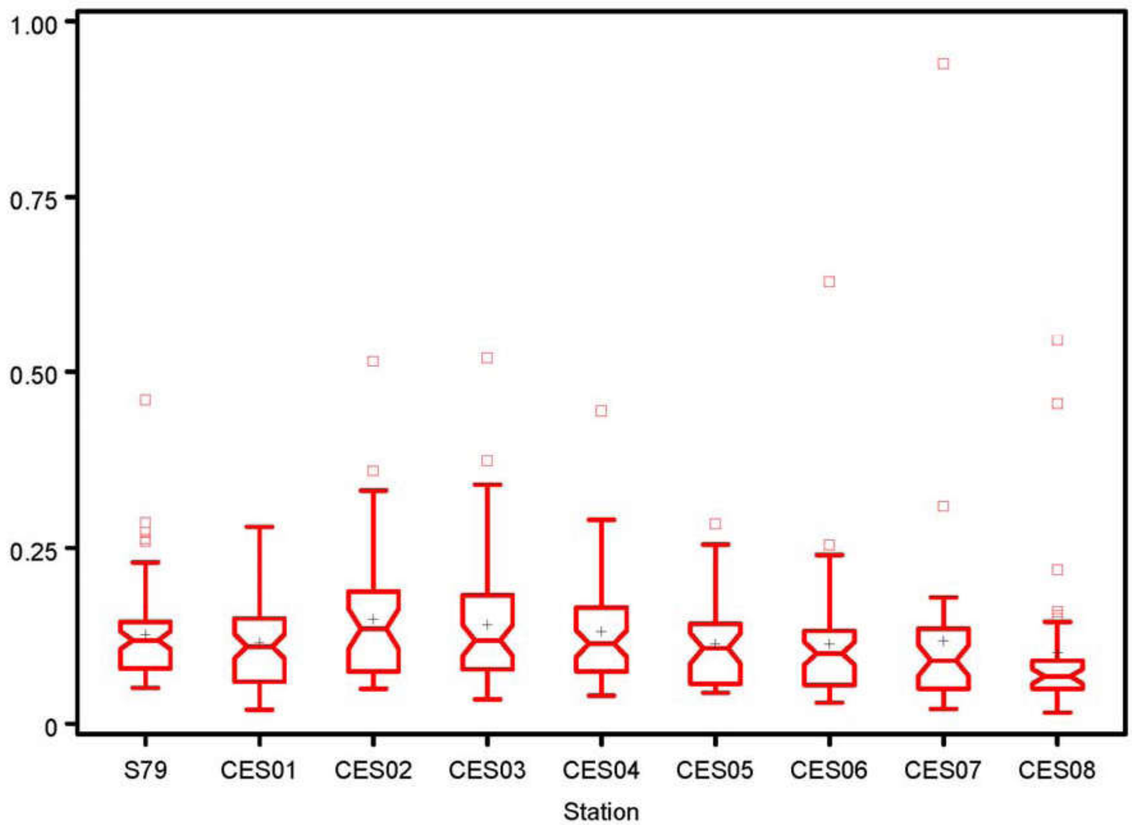

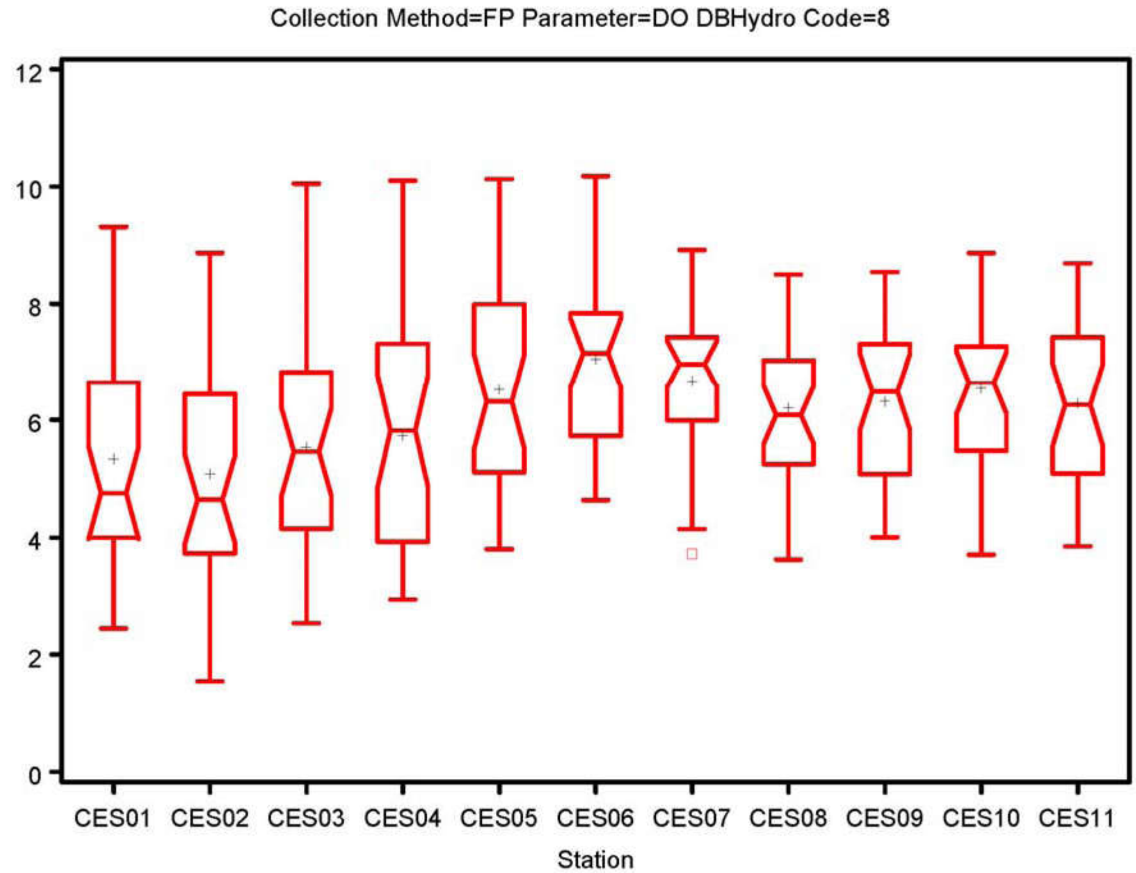
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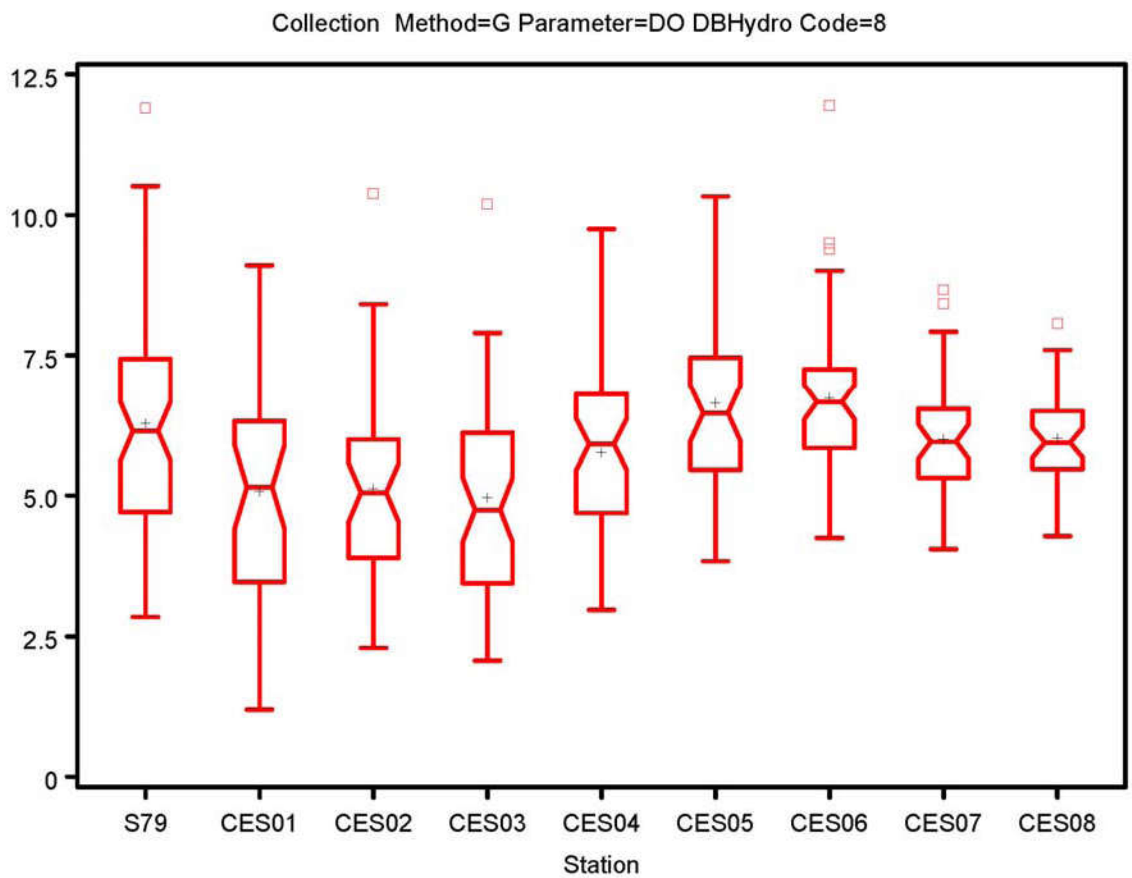
CES10
CES11
Station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CES08
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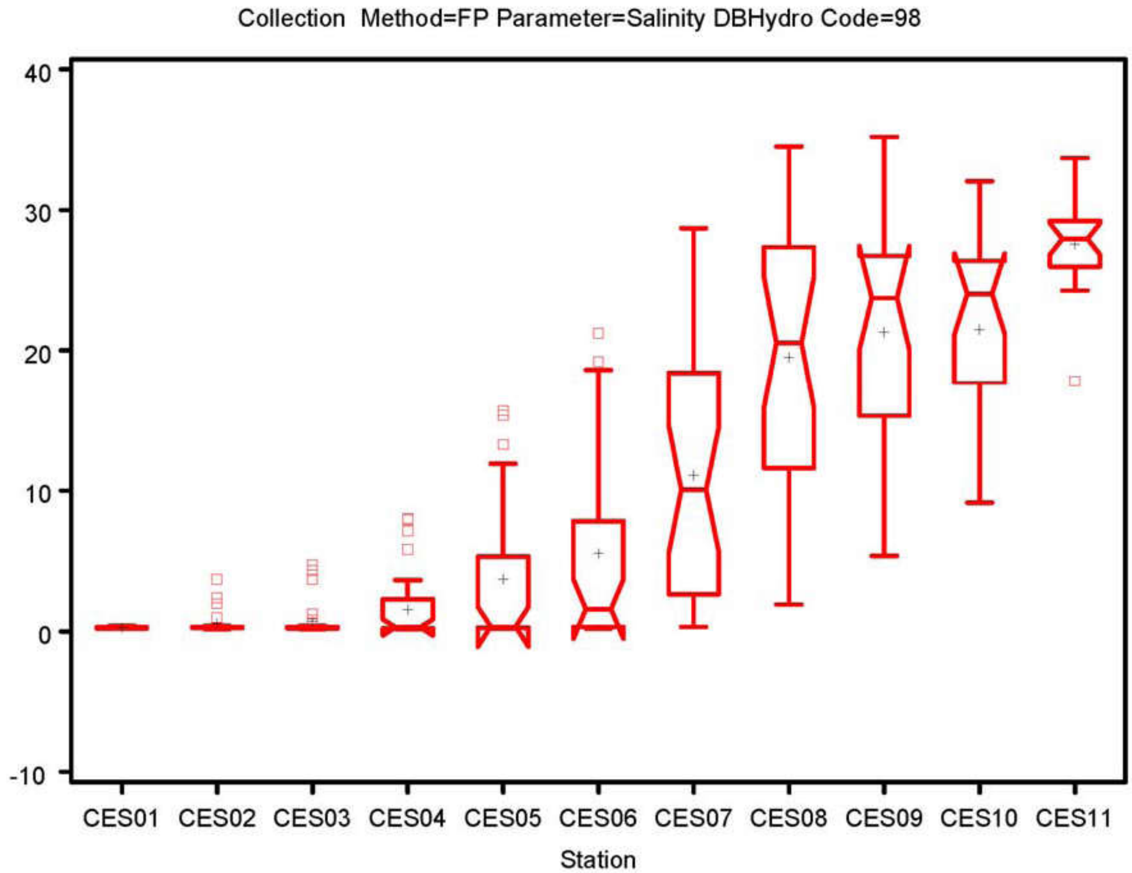
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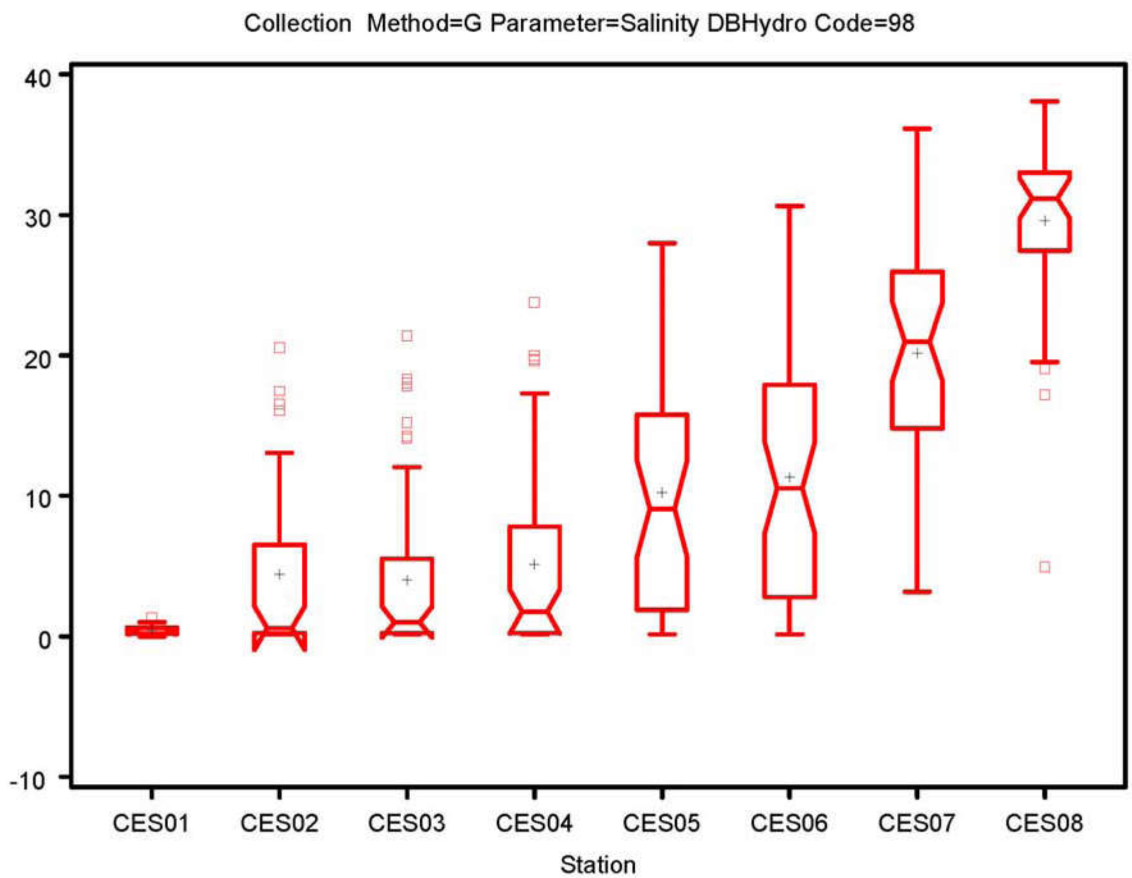
CES09
CES10
CES11
Station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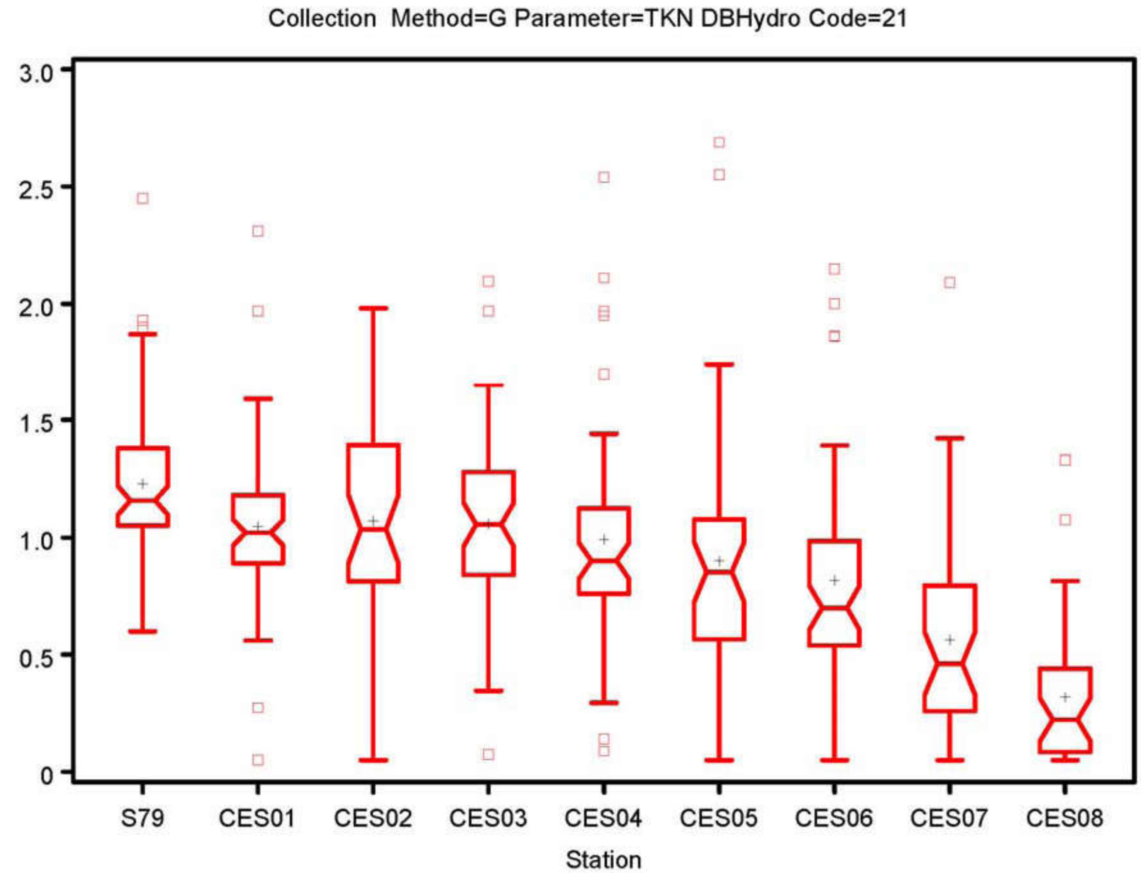
Station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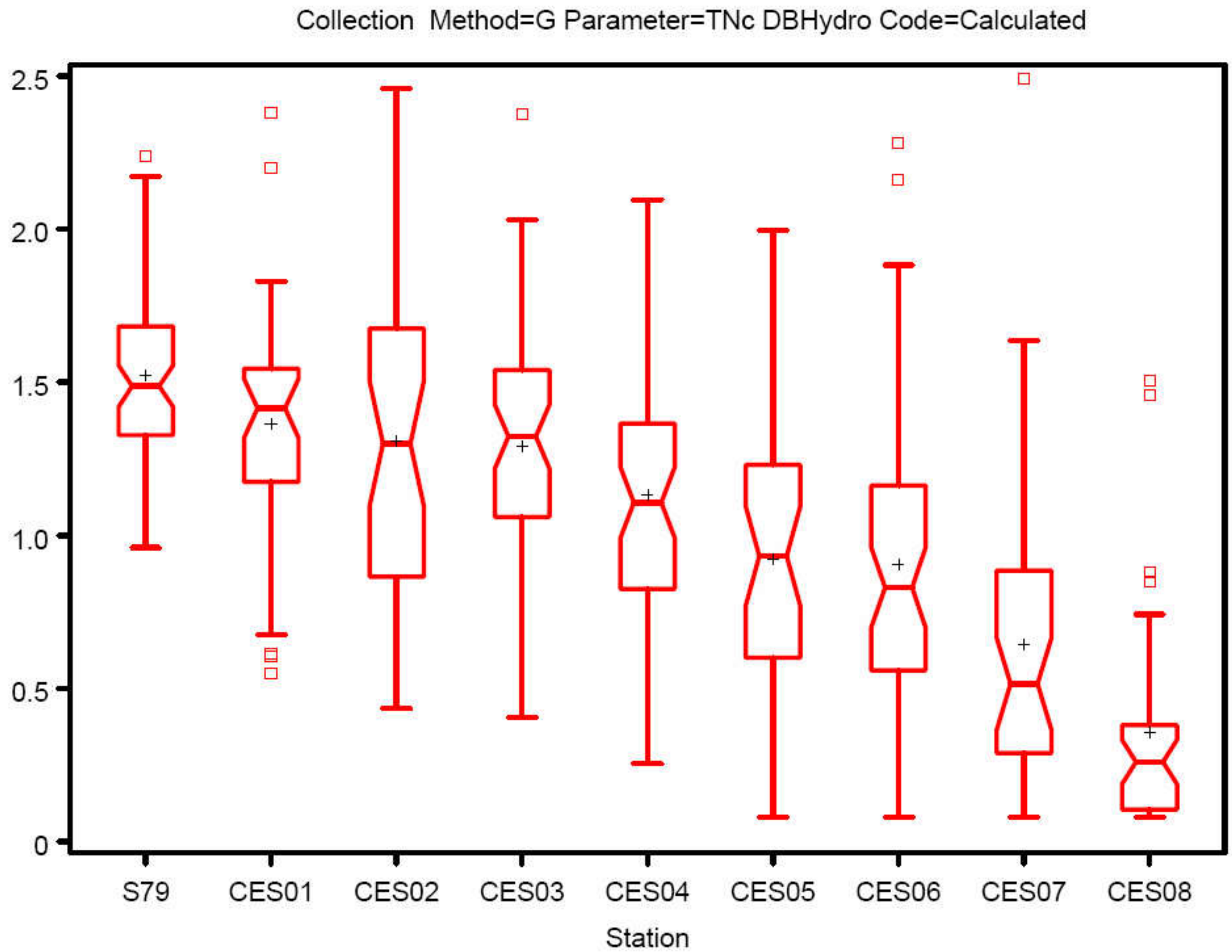
CES08
Station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1.0
0.5
0
S79
CES01
CES02
CES03
CES04
CES05
CES06
CES07
CES08
Station

Caloosahatchee River

Optimization Leader: Mike Wessel, Janicki Environmental
Statistician: Mike Wessel, Janicki Environmental

Project Code: CR

Type: Type II

Mandate/Permit:

- Lake Okeechobee Protection Act (LOPA) Chapter 00-130,
- Surface Water Improvement and Management Act (Lake Okeechobee SWIM Plan) Chapter 373.451-373.4595, F.S.
- Florida Watershed Restoration Act (403.067 FS) – (TMDLs/MFLs/PLRGs),
- WRDA 2000, PL 106-541, Title VI, Section 601 (Comprehensive Everglades Restoration Program)

Project Start Date: 1979

Division Manager: Coastal Ecosystems Division: Sean Sculley (Acting)

Program Manager: Peter Doering

Points of Contact: Dan Crean, Bob Chamberlain, Patrick Davis

Field Point of Contact: Patrick Davis

Spatial Description:
The Caloosahatchee River and Estuary extends approximately 70 miles from Lake Okeechobee to San Carlos Bay on Florida's southwest coast. The Caloosahatchee River water quality monitoring program (CR) extends from Lake Okeechobee west to the coastal structure (i.e., structure S-79) that releases fresh water to the Caloosahatchee Estuary. The CR project monitors the freshwater portion of the river (i.e., the C-43 canal between structure S-77 and S-79) whereas the CESWQ project monitors the tidal portion of the Caloosahatchee River and Estuary west of structure S-79. The sampling stations within the Project CR are located within the C-43 basin. Water from Lake Okeechobee flows west through the S-77 structure into the C-43 canal/Caloosahatchee River. Water quality is monitored at several structures along the length of the C-43/Calossahatchee River including the S-235, S-47D, S-78 and S-79. Sampling station CR-00.2T corresponds to structure S-235 which is a small culvert type structure on the southwest side of Lake Okeechobee on LD-1 near the S-77 structure. Sampling station CR-04.8T corresponds to structure S-47D which is a small spillway gated structure located on the C-19 canal. This structure serves as a major entry point to the Caloosahatchee River from the C-43 drainage basin/watershed. The remaining sampling locations correspond directly to the structures (i.e., S-78 and S-79), both of which are large spillway gates and boat lock structures.

Only one sampling location appears to have overlap with other monitoring programs. Sampling station S-79 corresponds to sampling station CES01 from Project CESWQ. Although not currently sampled for the CR project, the CR Program manager suggested that data from Station S-77 may be valuable in the optimization since this station is the structure releasing water directly from Lake Okeechobee into the C-43 canal/Caloosahatchee River.

Project Purpose, Goals and Objectives:
The purpose of the Caloosahatchee River water quality monitoring program is to implement long-term monitoring in the Caloosahatchee River to respond to the mandates presented above. The ultimate goal of this program is to protect and enhance the estuaries that receive freshwater regulatory releases from Lake Okeechobee through the Caloosahatchee River. Therefore several objectives of the project include:

1. assessing Lake Okeechobee, tributary and C-43 basin nutrient concentration inputs and loading to the Caloosahatchee River;

2. evaluating concentration inputs and loads to the Caloosahatchee River estuary from the river; and
3. determining long and short term trends in total phosphorus and other water quality parameters to identify potential problem areas in terms of water quality degradation and nutrient loadings.

Sampling Frequency and Parameters Sampled:
All stations for the Caloosahatchee River Monitoring Project are sampled on a bi-monthly basis and are collected regardless of flow. No autosamplers are used in this project and samples are collected via grabs. Parameters collected in the grabs include: alkalinity, ammonia, calcium, chloride, color, magnesium, nitrite, nitrite+nitrate, orthophosphate, potassium, sodium, silica, sulfate, total iron, total Kjeldahl nitrogen, total phosphorus, total suspended solids and turbidity. In-situ measurements of physical parameters (water depth, temperature, pH, dissolved oxygen, and specific conductivity) are made simultaneously with the grab samples.

The CR program manager did not believe any additional parameters would be necessary in the future for this monitoring program.

Current and Future Data Uses:
Water quality data from the Caloosahatchee River are used to determine the effect of Lake Okeechobee discharges and tributary impacts on the Caloosahatchee River. The data from this project are used in a number of District reports, models, and operations. Current reports/models which rely on data collected from the Caloosahatchee River include:

- South Florida Environmental Report (SFER)
- CERP update
- Southwest Florida Feasibility Study
- DHI watershed model of the C-43 basin
- CH3D Hydrodynamic model of the Caloosahatchee

Because the C-43 Basin is a CERP Project and has been listed as an Acceler8 project, data from the CR Project will play a major role in the design and assessment of the CERP projects in the C-43 Basin and surrounding areas. The RECOVER Monitoring and Assessment Plan (MAP) has also identified sampling stations within the boundaries of the Caloosahatchee River and Estuary System to be monitored on a long-term basis.

In addition to CERP and RECOVER related activities, future data from the Caloosahatchee River Monitoring Project will be used to support critical loads for the C43 basin, water quality targets (i.e., Chlorophyll a target for the Caloosahatchee nutrient loading relationship with S-79), and TMDL development.

Identified Optimization Opportunities:

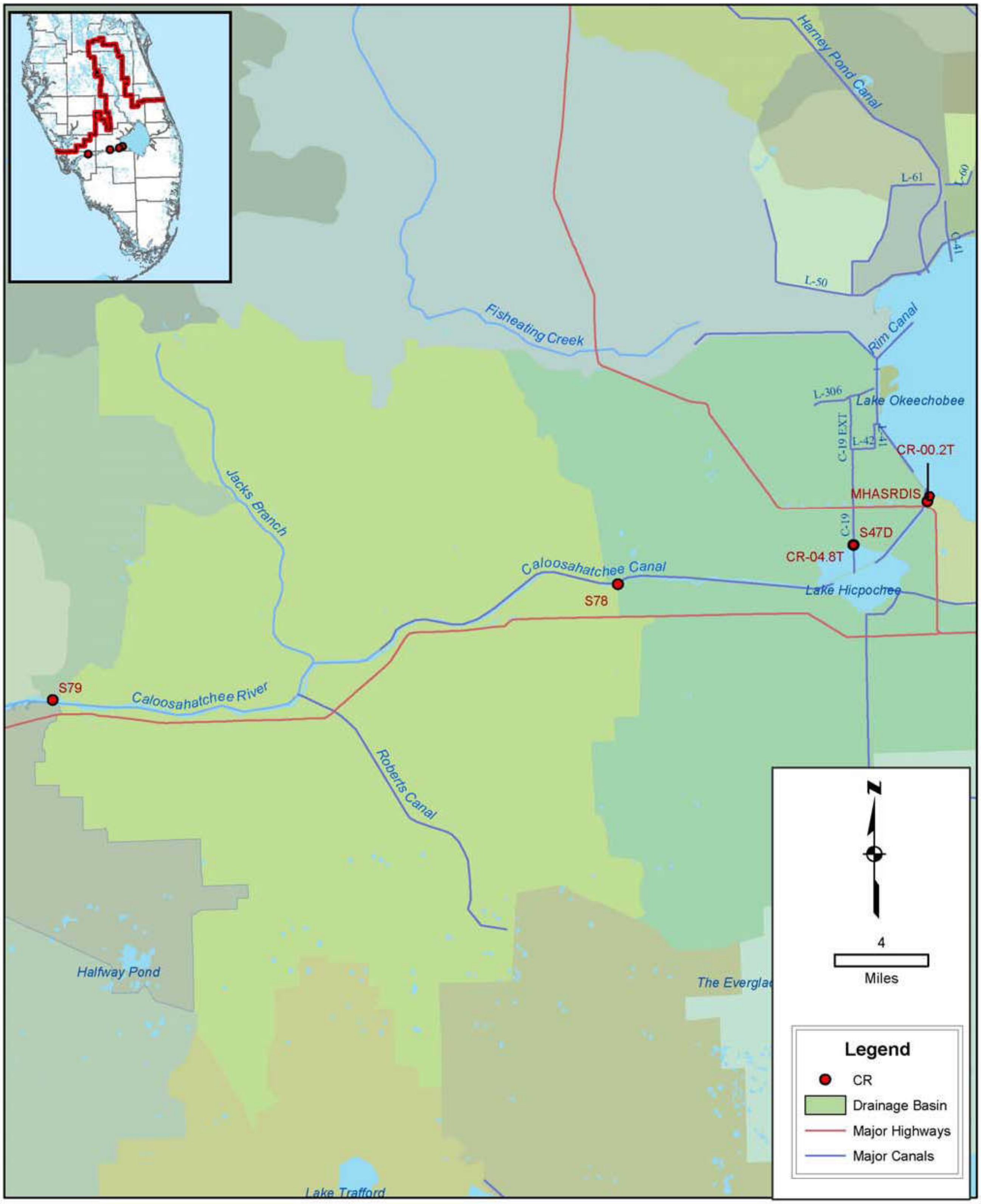
Discussions with District staff identified some potential opportunities for optimization. Additionally, questions were generated that will provide useful for guiding the optimization.

- Are the data from S-79 (Project CR) and CES01 (Project CESWQ) similar? Can one of these stations be used for both projects?
- Do the data from these sampling locations reflect changes along the river? How similar are the data spatially and temporally?
- Are the differences among each site sufficient to identify potential problem areas along the river?

Parameters Measured for Project CR

Station	ALKA	CA	CL	K	MG	NA	TOT FE	COLOR	TKN	NH4	NO2	NOX	OPO4	TPO4	SIO2	SO4	TURB	TSS	DO	H2OT	PH	SCOND
CR-00.2T	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm
CR-04.8T	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm
S-78	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm
S-79	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm	bm

bm = bimonthly; gray shading indicates a Type 2 station



BFA Environmental Consultants
Barnes, Ferland and Associates, Inc.

CALOOSAHATCHEE RIVER (CR)
WATER QUALITY MONITORING
PROJECT AREA

Figure 1. CR Sampling Locations

Optimization analysis:
Optimization of the CR water quality monitoring project was undertaken with respect to the specific tasks outlined above and detailed in the optimization plan modified and approved in September 2005. Briefly, the spatial and temporal adequacy of the CR project was evaluated with respect to being able to detect changes between time periods, being able to detect trends in water quality parameters by station within the project, assessing information redundancies among stations and identifying stations located in proximity to potential point source discharges. The parameters identified for optimization for this project were:

Parameter	Units	DBHydro Code
Color	PCU	13
TNc	mg/L	Calculated as code 21+20+18
TPO4	mg/L	25
TSS	mg/L	16

- To estimate power and effect size of the current monitoring program, Monte Carlo simulation using the nonparametric Sign Test was used to estimate the detectable change in median value for each parameter of interest across stations (i.e. CR-00.2T, CR-04.8T, S78, S79) that would correspond to a significant shift in the distribution from current levels (i.e. long-term median condition) given the current sampling effort. Further, the test was constructed to establish whether or not a given magnitude of change would result in an observable difference from a water quality target (e.g. DO standard of 5.0 mg/L) or when a target was unavailable a 20 % change in long term median was used as the target value.

- To estimate the power to detect a trend for a given water quality parameter, Monte Carlo simulations were performed using the Kendall Tau Test for Trend. This procedure is being documented as a statistical evaluation tool for the SFWMD and the procedure will be outlined in detail in separate documentation (Rust 2005). Briefly, the simulations result in an estimate of the slope (trend) that can be detected for a given monitoring routine using the current annual effort and under alternative sampling strategies. Again a 20% change in slope was used as a targeted change for assessment for trend detection.

- The binomial test was used to identify stations where the probability of encountering a value larger than the long term median (for all stations combined) was significantly greater than 50 percent. A significant result using the one tailed binomial test may signify an area of increased parameter concentration associated with a possible point source discharge.

The C-43 basin is undergoing changes to the hydrologic cycle as a reservoir is scheduled to be constructed between monitoring stations S78 and S79 and a no degradation clause in the permit will require that these sites remain active to assess water quality on either side of the reservoir. Therefore, the focus of this optimization was on optimizing the sampling frequency necessary to detect changes in water quality parameters with respect to a 20% change from long term median.

The first component of the optimization was to examine the project-wide distribution for each parameter of interest, calculate the long term median value for each parameter of interest and generate a simulation dataset that could be used to test the effectiveness of the current monitoring sampling design. The sign test simulation exercise is meant to demonstrate the ability of a sampling program to detect changes from a baseline value. The long term median value was used to represent a baseline value and the test was constructed as a one- sample test to detect a change in the median value for each water quality variable of interest. Since there is only variability associated with one group of data for the comparison, the test is more powerful than a two- sample test where variability is expressed in the distribution of each comparison group. Further, the sign test simulations do not account for serial or seasonal auto-correlation which can often be present in monitoring data. The presence of auto correlation if not accounted for can yield unrealistically optimistic assessments of the sample size necessary to detect changes. However, since the CR project is only sampled bimonthly auto-correlation is not considered in the sign test simulations but is considered in the test for trend analysis presented later in this document.

Table 1 provides a summary of the simulation results using the Sign Test to estimate the effect size detectable under the current monitoring strategy and identify the number of samples required to detect a twenty percent change in magnitude from the baseline condition. Data included all samples collected as part of the CR project. When present, vertical profile data were averaged for each station/collection date combination prior to creating the simulation pool for analysis. The sample size (Nobs) was then calculated as the average annual number of samples for collections from 2000-2004. The annual percent change detected is the relative magnitude of change (i.e., relative to the long term median) that can be detected with 80% power given the average annual sampling frequency.

Table 1. Results of Monte Carlo simulation using the Sign Test to determine the effect size and number of samples to detect a 20% change in long term median value (Target) with 80% power for stations CR-00.2T, CR-04.8T, S78, and S79.

Parameter	Nobs/Year	Long Term Median Value	Annual Percent Change Detected	Number of Samples to Detect Shift to Target
Color (PCU)	24	82.00	29.6	48
TNc (mg/L)	24	1.61	18.7	20
TPO4 (mg/L)	24	0.11	35.2	125
TSS (mg/L)	24	3.00	5.0	6

Results suggest that the sampling frequency necessary to detect a given change from the median was parameter dependent. A relatively small magnitude of change could be detected for TSS while the variation in TPO4 resulted in many more samples being required to detect a 20% change in the long term median value. One objective of the optimization was to see if including data from S77 would increase the confidence of inference for the CR project with respect to detecting changes in WQ parameters. To do that another simulation was run including data from S77. The station S77 was sampled much more frequently for many parameters of interest. Results of simulation suggest that including S77 data into analysis of concentration data may not improve inference with regard to detecting changes in WQ concentrations (Table 2).

Table 2. Results of Monte Carlo simulation using the Sign Test to determine the effect size and number of samples to detect a 20% change in long term median value (Target) with 80% power for all CR stations and station S77.

Parameter	Nobs/Year	Long Term Median Value	Percent Change Detectable in One Year	Number of Samples to Detect Shift to Target
Color (PCU)	50	70.00	23.5	65
TNc (mg/L)	50	1.61	10.0	30
TPO4 (mg/L)	50	0.09	36.5	135
TSS (mg/L)	50	4.00	27.5	85

The second component of the optimization was to assess the power to detect trends in the water quality parameters of interest at individual stations. For the CR project, samples have been routinely collected since 1992 so the entire time series was modeled to estimate the seasonal variability and autocorrelation for each station in the CR project. A simulation dataset was generated from which samples could be pulled representing 5 year time series segments. For each replicate trial, the Seasonal Kendall Tau test for trend was used to estimate the annual percent change in slope that could be detected under the current sampling design and under alternative sampling frequencies (Table 3). This procedure is described in detail in Rust (2005).

Table 3. Results of Monte Carlo simulation using the Seasonal Kendall Tau Test for Trend on a 5 year time series to determine the effect size for change in slope parameter.

Station	Parameter	Number of samples per year	Slope Estimate	Annual Percent Change Detectable	Can You Detect a Trend in 5 Years?

S77	Color (PCU)	12	0	32.4	No
S77	TN (mg/L)	12	0	12.3	No
S77	TPO4 (mg/L)	12	0	NC**	NC**
S77	TSS (mg/L)	12	0.083	34.7	No
CR-00.2T	Color (PCU)	6	0	21.6	No
CR-00.2T	TN (mg/L)	6	0	14.6	No
CR-00.2T	TPO4 (mg/L)	6	0	2.4	Yes
CR-00.2T	TSS (mg/L)	6	0.0573	46.5	No
CR-04.8T	Color (PCU)	6	0	32.6	No
CR-04.8T	TN (mg/L)	6	0	14.5	No
CR-04.8T	TPO4 (mg/L)	6	0	9.1	No
CR-04.8T	TSS (mg/L)	6	0	23.8	No
S78	Color (PCU)	6	0	30.0	No
S78	TN (mg/L)	6	0	8.7	No
S78	TPO4 (mg/L)	6	0	3.2	Yes
S78	TSS (mg/L)	6	0	38.4	No
S79	Color (PCU)	6	0	19.0	No
S79	TN (mg/L)	6	0	6.1	No
S79	TPO4 (mg/L)	6	0	4.0	Yes
S79	TSS (mg/L)	6	0	24.0	No

** NC = non-convergence of mixed model

For the parameter TPO4, three stations in the CR project and station S77 showed that a change of less than 20% was detectable over a 5-year window. Station CR-04.8T was the exception to this with only an approximately 50% change detectable over the 5-year window. Not coincidently this station also recorded the highest average concentrations for TPO4 (Appendix CR-1 boxplot). A time series trend was evident only for TSS in Station CR-00.2T and S77. The positive slope indicated an increasing trend for these parameters over the 10+ years of sampling at these two stations. For most parameters, variability in the slope estimate was high indicating that only a large slope would be detectable for most parameters.

To identify areas of potential concern with respect to point source discharges the Binomial test was used to identify stations which consistent recorded values for a specific parameter higher than the long term median value for that parameter when combining all stations. These results are presented in Table 4.

Table 4. Results of one way binomial test used to identify stations with greater than 50% probability of recording a value above the long term median for all stations.

Parameter	S77	CR-00.2T	CR-04.8T	S78	S79
Color (PCU)			X		
TN (mg/L)		X			
TPO4 (mg/L)			X		X
TSS (mg/L)	X				

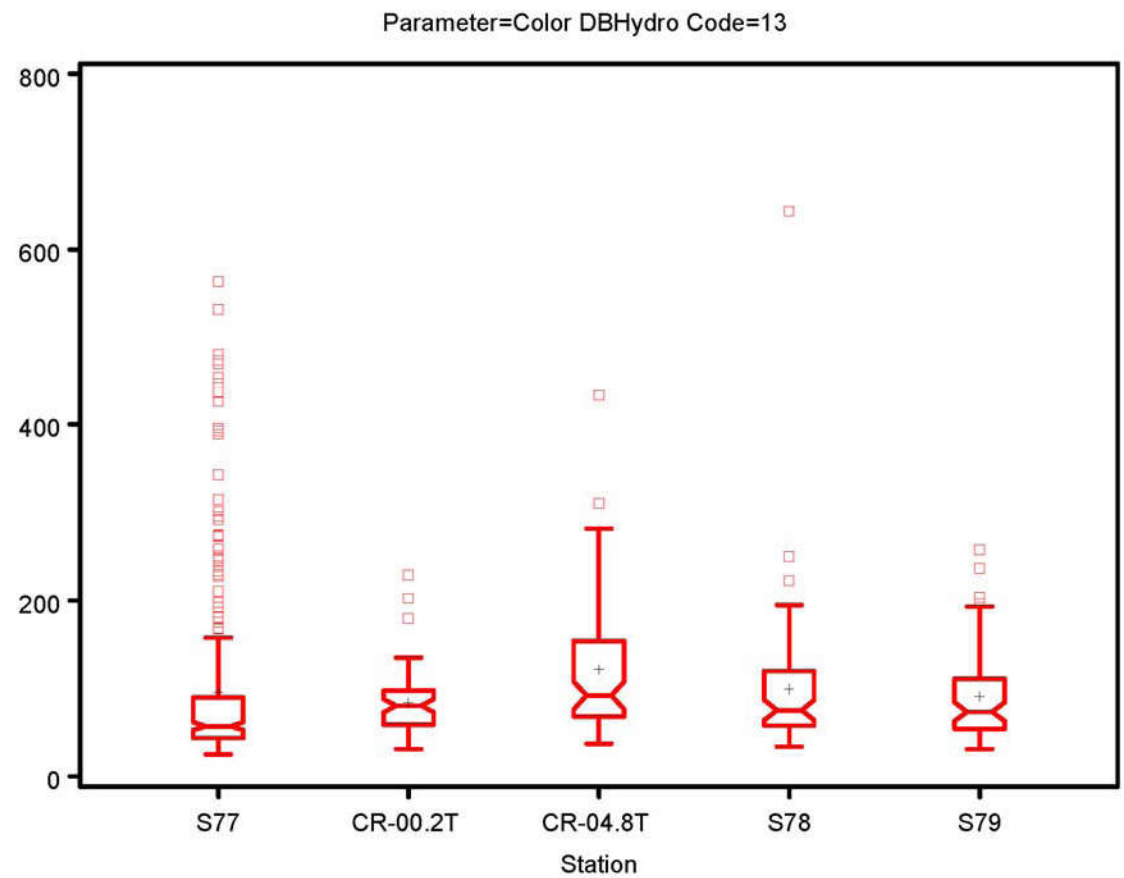
Binomial test results and box plots (Appendix CR) suggest that TPO4 concentrations tended to be higher with progression west from Lake Okeechobee. Each of the other parameters was more evenly distributed across stations however, for TSS there was only one station where there was significant variation in TSS (See box plots: Appendix CR-1).

Recommendations:

The Caloosahatchee River project is an important part of the South Florida's Water Quality Monitoring Network. The data are used to calculate the loading inputs from the C-43 basin into the estuarine portion of the Caloosahatchee River. Since the C-43 basin will be undergoing major reconstruction with the incorporation of a reservoir between S78 and S79, continued water quality monitoring will be necessary to provide information on potential impacts of the reservoir on water quality at S79 and into the Caloosahatchee estuary. Incorporating flow data was beyond the scope of this study, so inference regarding nutrient loading was derived using nutrient concentration information. Station CR-04.8T consistently recorded higher than average Color and TPO4 concentrations suggesting that this station measures a significant source of nutrients inputs into the C-43 basin. Stations S77 and CR-00.2T recorded generally lower values than stations farther west except for station S77 for the parameter TSS. It was reported that S77 is not sampled as part of the CR project. While inclusion of S77 station in with the CR project would increase the number of samples for analysis, it does not appear to increase the precision of the estimate of nutrient concentrations in the basin as evidenced by no increase in power in the optimization analysis. Seasonal variation appeared to be the primary source of uncertainty in estimating TPO4 and for most stations, no time trend was evident.

From an optimization perspective, if the goal was only to estimate nutrient loading into the estuarine waters of the Caloosahatchee, sampling effort could be concentrated on the western portions of the basin at stations S78 and S79. However, to identify sources of nutrient inputs within the C-43 basin, the other stations are necessary and valuable as evidenced by the higher concentrations of TPO4 detected at the CR0.48T. Optimization of the CR project is dependent on the specific needs regarding calculating nutrient loading for the project area. This optimization has established that each station in the CR project provides valuable information with respect to identifying areas of increased nutrient concentration within the project. Sampling could be shifted to the western sampling stations if the goal were only to calculate nutrient loads leaving the basin into the estuarine portions of the Caloosahatchee River. Station S77 does not appear to contribute significantly to the assessment for the CR project and only influences the calculations for TSS. A further recommendation would be to discontinue measuring TSS at all stations other than S78 and S79 since a reservoir is to be constructed which will affect the TSS values leaving the C-43 basin. Lastly, in future optimizations NOx should be considered. Based on the Box plots it appears that NOx values increased at stations S79; however, TN and TKN appeared to be consistent with other stations or declining at S79. Because of the industrialized nature of the C-43 basin, the NOx parameter may be a valuable additional indicator of downstream water quality. The optimization opportunity regarding stations S79 and CES01 will be addressed in the CESWQ project update.

Appendix CR-1
BOX-PLOTS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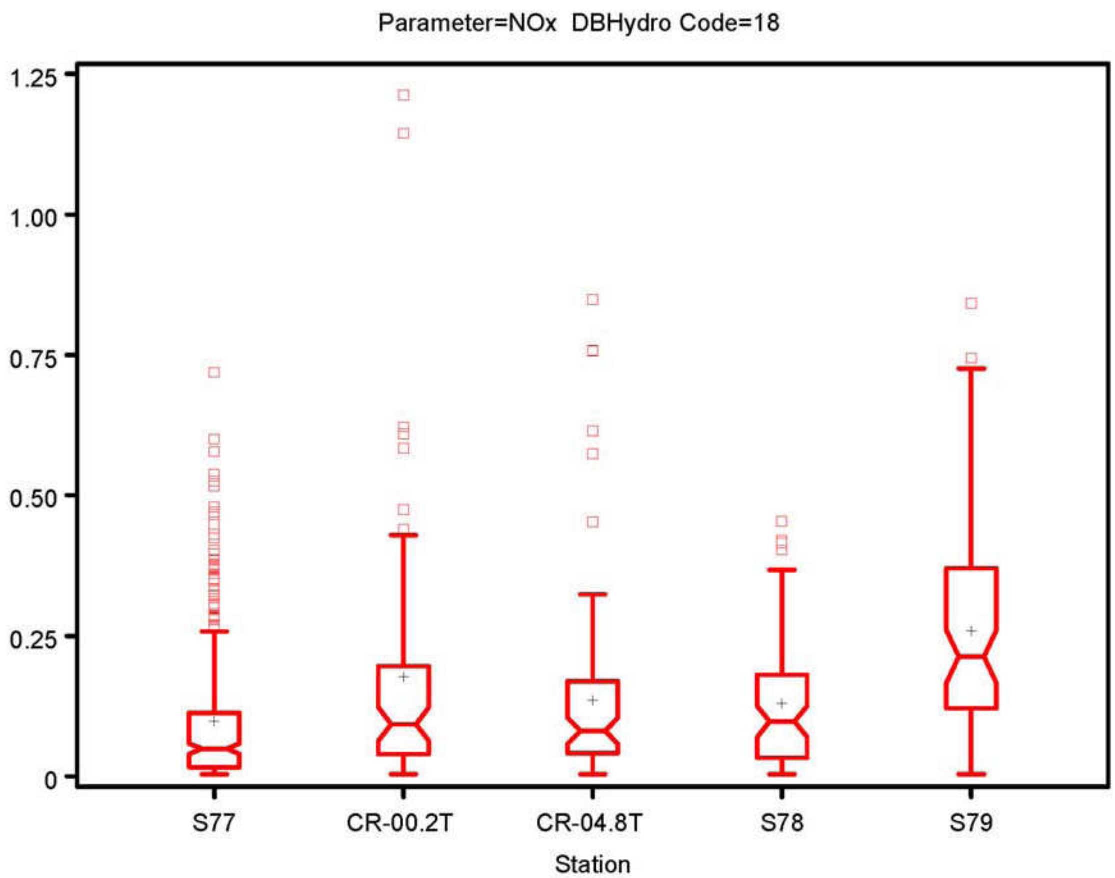
400
200
0
S77
CR-00.2T
CR-04.8T
S78
S79
Station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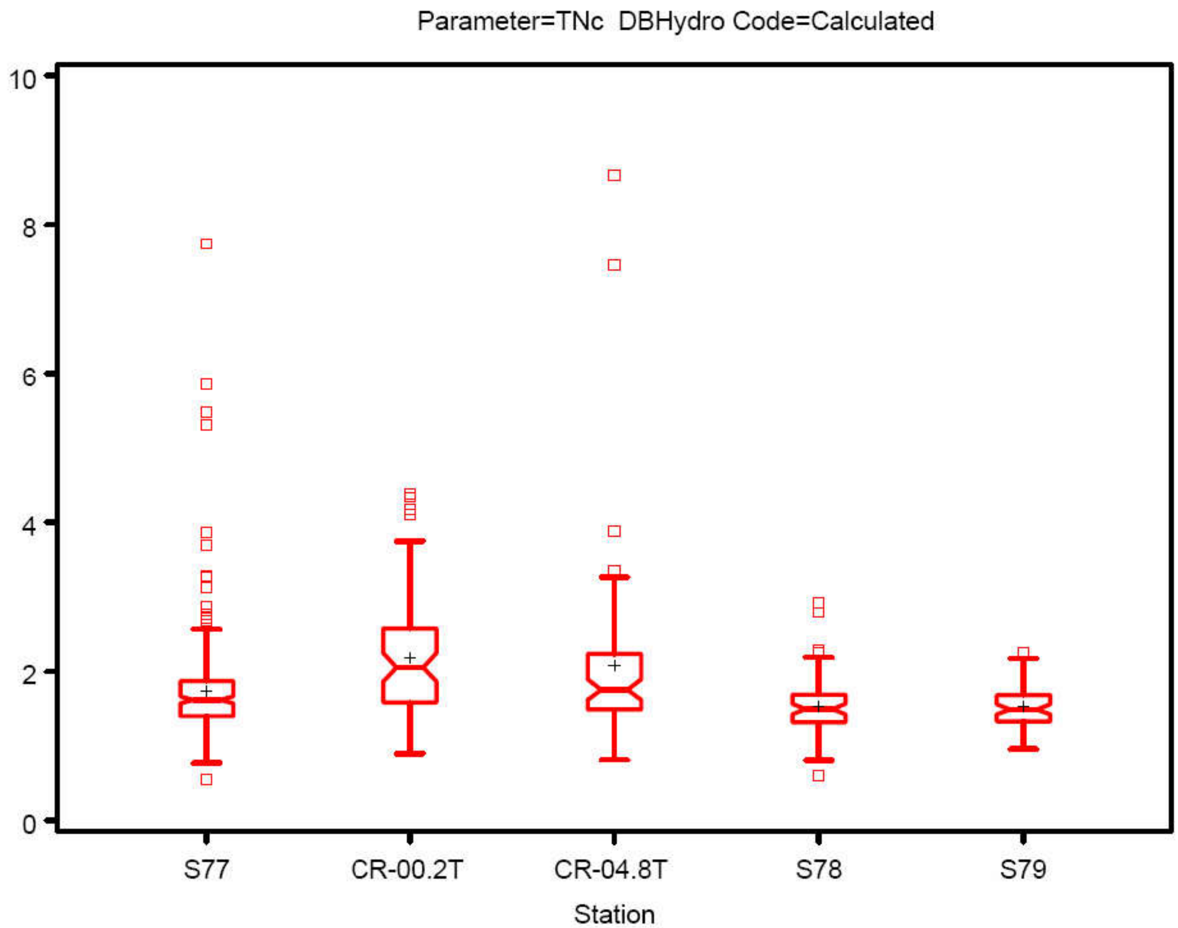
0.50
0.25
0
S77
CR-00.2T
CR-04.8T
S78
S79
Station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6
4
2
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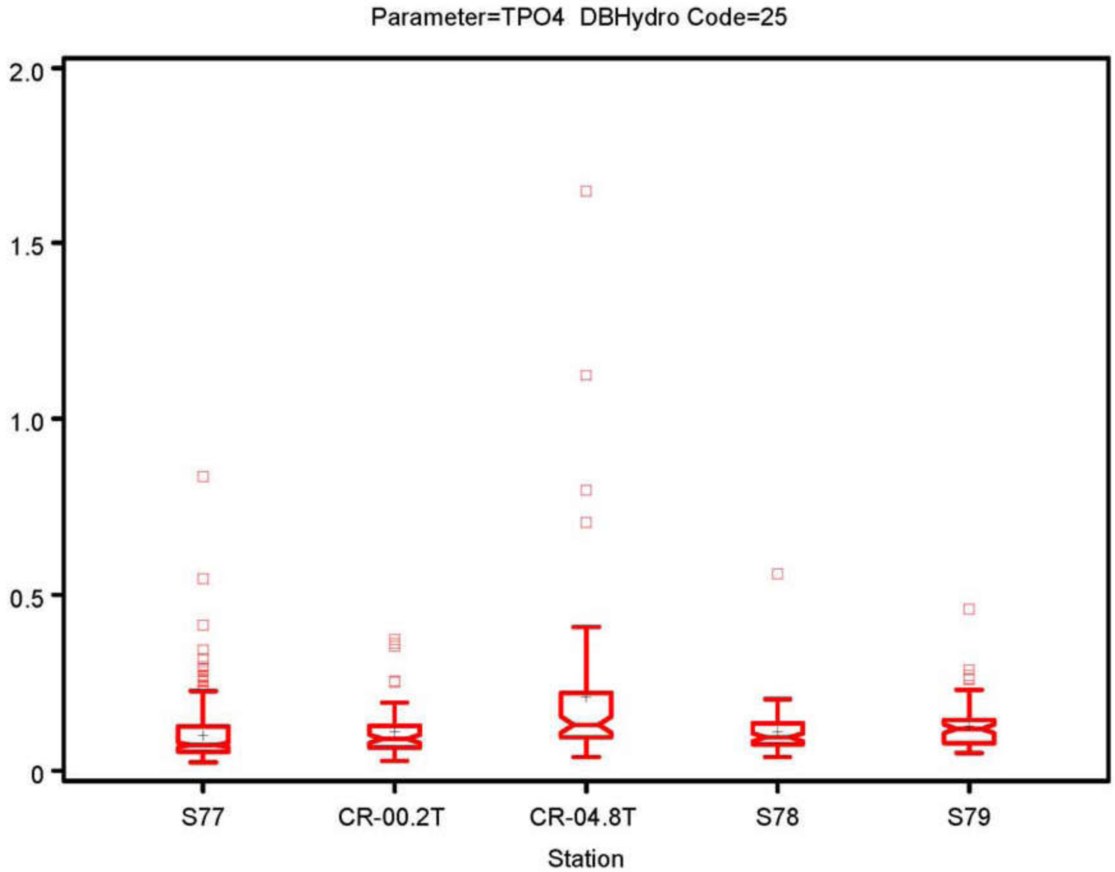
S77
CR-00.2T
CR-04.8T
S78
S79
Station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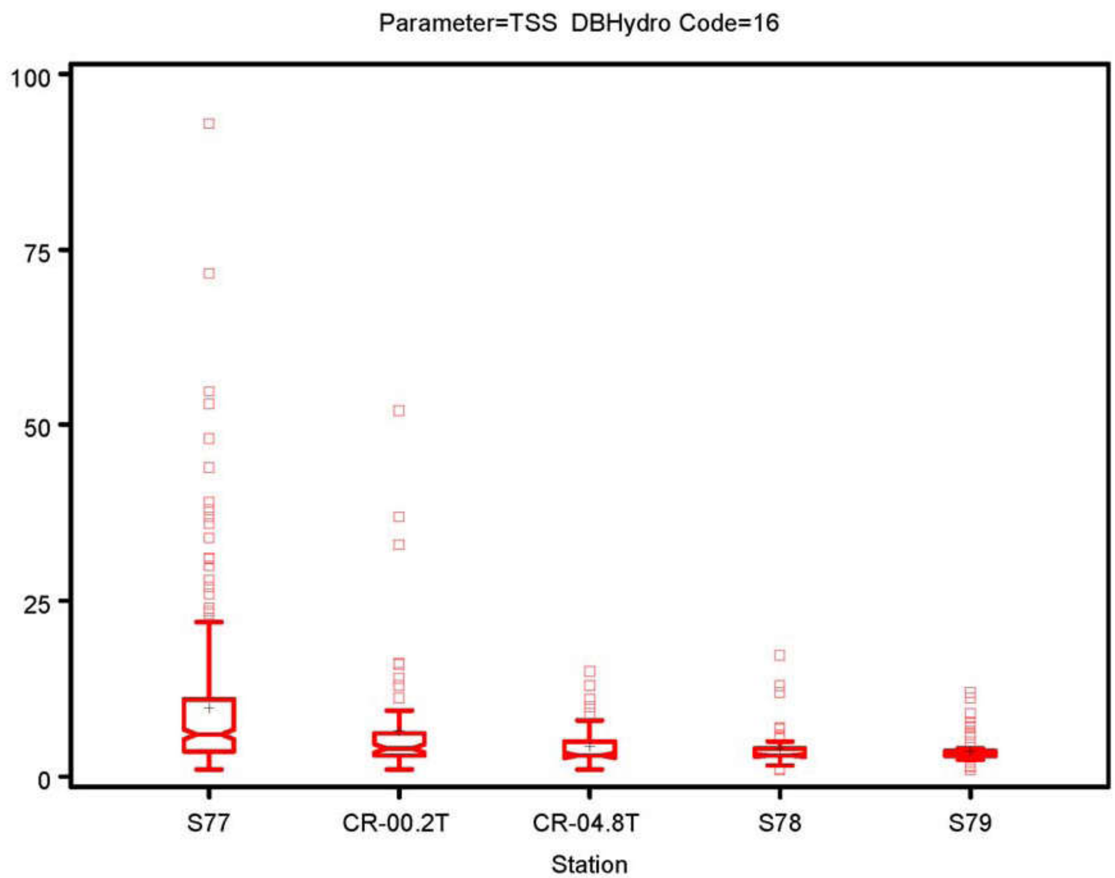
1.0
0.5
0
S77
CR-00.2T
CR-04.8T
S78
S79
Station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25
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S77
CR-00.2T
CR-04.8T
S78
S79
Station