Draft South Florida Canal Aquatic Life Study

October 29, 2012

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Background and Introduction

The Central & Southern Florida (C&SF) Project, which was authorized by Congress in 1948, has dramatically altered the waters of south Florida. The current C&SF Project includes 2600 miles of canals, over 1300 water control structures, and 64 pump stations[1]. The C&SF Project, which is operated by the South Florida Water Management District (SFWMD), provides water supply, flood control, navigation, water management, and recreational benefits to south Florida. As a part of the C&SF, there are four major canals running from Lake Okeechobee to the lower east coast – the West Palm Beach Canal (42 miles long), Hillsboro Canal (51 miles), North New River Canal (58 miles) and Miami canal (85 miles). In addition, there are many more miles of primary, secondary and tertiary canals operated as a part of or in conjunction with the C&SF or as a part of other water management facilities within the SFWMD. Other entities operating associated canals include counties and special drainage districts.

There is a great deal of diversity in the design, construction and operation of these canals. The hydrology of the canals is highly manipulated by a series of water control structures and levees that have altered the natural hydroperiods and flows of the South Florida watershed on regional to local scales. Freshwater and estuarine reaches of water bodies are delineated by coastal salinity structures operated by the SFWMD. Thus, freshwater and estuarine connectivity is highly altered. During the wet season (approximately June thru October), discharges to tide through coastal salinity structures may be frequent and large, while during the dry season (approximately November through May) discharges are less frequent and may be of smaller volume.

To maintain the water-handling capacity of the water control system, a great deal of vegetation management is necessary, since dense vegetation greatly decreases the hydraulic conductivity of the canal system. Each year, millions of dollars are spent for plant management in Florida's canal systems. Methods used to control aquatic vegetation in canals include mechanical harvesting, biocontrol methods such as grass carp, and herbicide application. Additionally, the various canal locations and surrounding land uses impact the water quality, soil type and topography of the canals.

Conceptual Model

Prior to the C&SF Project, freshwater drainage in south Florida primarily flowed south through slough systems of various sizes, up to and including the Miami and New Rivers, known as "transverse glades", characterized by thickly vegetated riparian zones, relatively shallow depths, and usually low velocity, but variable flow. Flowing waters in post-drainage south Florida primarily include anthropogenically created canals, which were constructed from uplands, wetlands or existing transverse glades primarily for flood control, navigation, or water supply. Drivers and stressors influencing biological expectations for canal systems include geomorphic condition (physical canal design, which is different from the natural system), hydrology (highly managed flow regime), routine canal management activities (vegetation

[1] South Florida Water Management District, 2010. Canals in South Florida: A Technical Support Document.

removal), water quality (potentially degraded), and others (exotic taxa, limited connectivity) (Figure 1). Biological attributes that are most directly affected by these stressors include periphyton, phytoplankton, zooplankton, aquatic plant communities, epibenthic invertebrates, and fish.

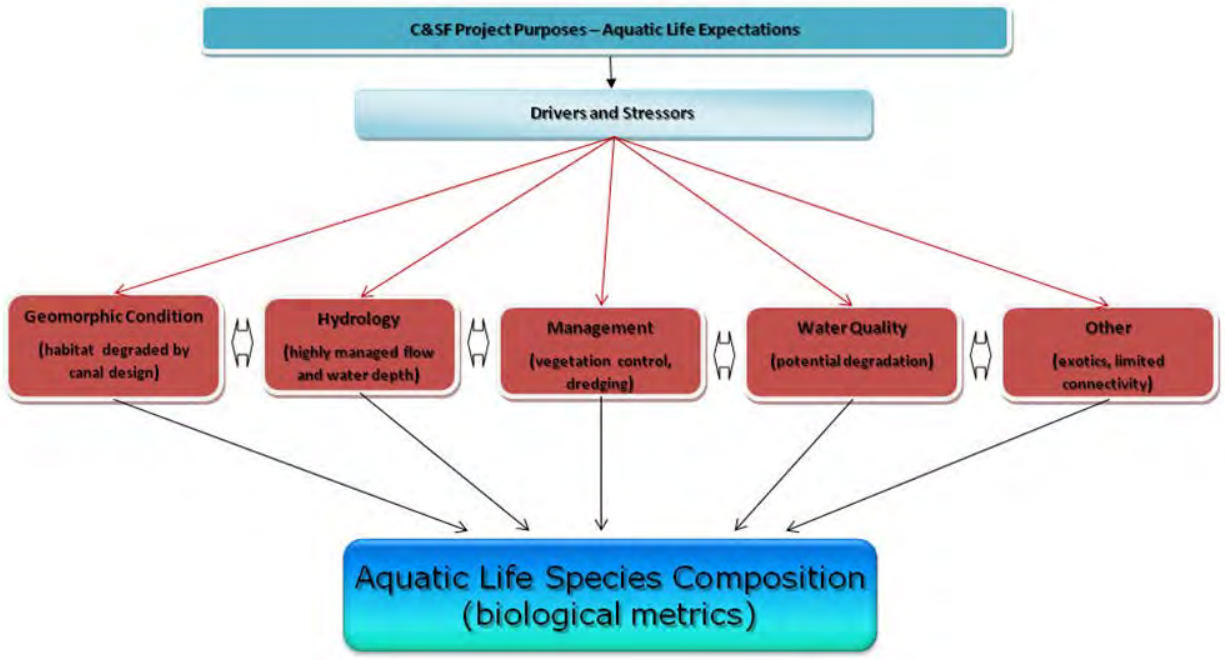


Figure 1. Conceptual model for south Florida canals biological expectations.

Consistent with this conceptual model, aquatic life expectations for canals are different that those for natural, flowing waters. Due to the physical nature of canals, their hydrology, the aquatic vegetation maintenance activities, and the resultant effects on dissolved oxygen (DO) and other chemical constituents of the canals, the aquatic life in canals cannot be expected to be the same as that of natural, flowing waters. The existing biological expectations for natural streams [e.g., as measured by the Stream Condition Index (SCI)] are likely inappropriate (unachievable) for most canals, predominantly due to the habitat and hydrologic modifications in canals. Although the 10 individual SCI metrics (e.g., taxa richness, filter-feeders, % tolerant taxa) may provide useful information in canals, the expectations for these metrics must be better defined for canals. Biological response to nutrients in canals may be very different than in natural water bodies and may vary greatly among canals. Consistent with the conceptual model, factors other than nutrients may be more influential in limiting biological health in canal systems, and where canals do respond to nutrients, the response can be highly dependent on physical and hydrologic characteristics and management of the canal, all of which may change over time. As a result, the canals do not provide optimal habitat for aquatic organisms generally found in natural streams and the species of aquatic organisms present in canals typically tend to be indicative of the stressful physical conditions resulting from canal construction (morphology, hydrology) and ongoing maintenance (routine habitat removal, water management practices).

South Florida Canal Aquatic Life Study

To perform a comprehensive assessment of south Florida canals and the aquatic life associated with those canals, the Department will initiate a South Florida Canal Aquatic Life Study. The assessment will focus only on the freshwater portions of south Florida canals (i.e., all monitoring stations will be upstream of any salinity control structures. The objectives associated with the study are:

1. Assess aquatic life in South Florida canals;
2. Determine interrelationships between aquatic life in canals and other variables that affect aquatic life;
3. Evaluate the differences in conditions for South Florida canals; and
4. Collect information that can be used to guide management decisions.

It is the Department's intent to implement this study through a collaborative approach, with input and assistance from the variety of stakeholders with expertise on the assessment of aquatic life in south Florida canals and/or responsibility for their operation and maintenance.

OVERALL APPROACH

The Department proposes to collect physical, biological, and water quality data over a three-year period for canals in the southern part of Florida in an effort to better define aquatic life use expectations for south Florida canals. The sampling effort will involve:

- Establishing sites that are representative of conditions present in specific canals and regional influences, selected as described below;
- Identifying physical, chemical and biological conditions at the representative sites;
- Using data from the above to develop and calibrate the conceptual model described above; and
- Establishing sites for a "Before-After-Control-Impact" (BACI) Study to assess the relative effect of management practices on biological expectations, including biological recovery time from stress associated with routine maintenance of canals.

Establishing Physical, Chemical, and Biological Conditions Representative of Regional Influences

During the three-year period, flow and water quality data will be obtained at representative sites every year of the study so there will be adequate information to characterize chemical and flow conditions across south Florida. The Department, working with the SFWMD and other interested parties, will catalog all flow gauges and all routine monitoring stations from canals across south Florida. Where there does not appear to be adequate coverage from representative sites, the Department will deploy additional flow meters and add routine monitoring stations with the goal of collecting adequate flow and chemistry data at the end of the three year period to characterize water quality conditions. Cataloging of flow gauges and monitoring stations would occur in October-November 2012, such that any additional gauges and stations can be deployed in December 2012 concurrent with the initiation of the first year's targeted biological monitoring.

DEP will conduct the aquatic life studies in each of the three years in a smaller geographic subset of the larger south Florida area. However, since biological sampling requires significantly more effort than water quality sampling, the biological studies will be rotated across south Florida to ensure complete coverage. The first year's effort is critical for development of aquatic life collection methods suitable to south Florida canals and the development of robust statistical methods to assess the interrelationships between canal variables and the associated aquatic life. These methods will then be applied to additional geographic areas during the second and third year of the study. The lower east coast counties (Martin, Palm Beach and St. Lucie) are all similar in geology and are thought to have a similar range of canals, land uses (agriculture to urban), and associated water quality. Therefore, the first year of data collection and assessment will focus on those three counties. Candidate canals for this initial phase of the study will include canals with sufficient water quality data (a minimum of three years) to adequately characterize the water quality of the canals.

Once candidate canals have been selected and monitoring has been initiated in the initial year, assessment will begin to select candidate canals for biological monitoring in subsequent years of the study. Subsequent year's monitoring and assessment will also be performed at groups of candidate canals in regions with similar geology, canal types, and water quality. It is envisioned that biological data will be collected at canals with adequate flow and water quality monitoring data for characterization. It is the Department's intent to maximize utilization of water quality data from existing monitoring programs (e.g., SFWMD, Miami-Dade County, Broward County programs) in this effort in order to avoid duplicating efforts and make the most efficient use of existing information. Once routine water quality stations and flow gauges are catalogued, the Department will be able to assess whether additional gauges and stations are needed.

"Before-After-Control-Impact" (BACI) Study

To quantitatively assess the influence of routine canal maintenance, including factors such as water level manipulations and aquatic vegetation removal (both in-canal habitat and the riparian zone), a Before-After-Control-Impact" (BACI) Study will also be conducted. The BACI Study will "piggyback" on top of the ongoing ambient monitoring described above. With assistance from the SFWMD in establishing sites, DEP will sample a representative canal both before and after scheduled management activities to allow for pre- and post- assessment. Triplicate bioassessment stations will be established, both away from and within areas receiving treatment (routine management activities), which will be sampled pre- and post- treatment (for approximately 6 months) to determine affects of the human management activities over time. Parameters sampled will include those described below (see C-17 and C-18 sampling discussion).

Analysis of variance (ANOVA) will be used to determine potentially significant time effects, treatment effects, and time by treatment interactions. The ANOVA approach has terms for "treatment" (control versus test), "time" (each sample date), "treatment by time" interaction, and error. Because triplicate stations will be sampled (three contiguous 100 m stretches), it is anticipated that variability due to effects of treatment (should they occur, consistent with the conceptual model) may be distinguished

from variability inherent in the system. For example purposes, Figure 2 depicts potential results from such a study.

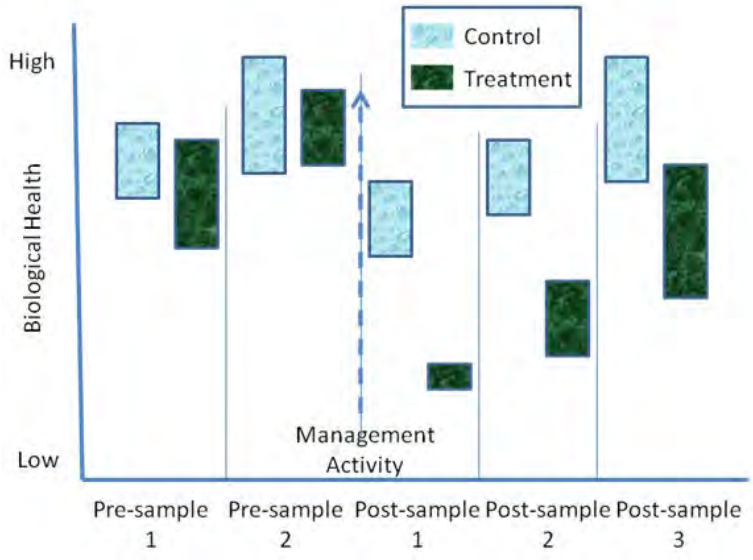


Figure 2. Example of potential results from the proposed BACI study. In this example, while pre-activity treatment samples were not significantly different from the control, post-activity treatment events 1, 2, and 3 were significantly different from the control, and there was a significant treatment by time interaction.

Implementation Approach

This study will be implemented through an adaptive implementation process, which will include public workshops throughout implementation of the study to inform and seek input from interested parties. The initial schedule calls for development of sampling methods and development of a monitoring plan in August-November 2012, with initiation of the initial year of sampling in December 2012. During development of the monitoring plan, existing data sources will be catalogued and plans to utilize data from those sources will be developed. Also during development of the plan, discussions will be initiated with a variety of stakeholders regarding potential areas of collaboration and stakeholder sources of information that would be instructive for the study. Initial public meetings will be held in West Palm Beach, Florida on November 1, 2012 to present the draft study to interested stakeholders and solicit input on the study design. Initial discussions with the Florida Fish and Wildlife Conservation Commission (FWCC) have indicated that the FWCC is interested in collaborating with the Department by monitoring fish populations in selected canals in conjunction with the Department's monitoring.

CATALOGUING FLOW AND WATER QUALITY DATA

Using geographic information systems (GIS) coverages, the Department will identify and plot locations of flow gauges and routine water quality monitoring stations so that geographic coverage of currently available hydrologic and water quality information for south Florida canals is known. The Department will evaluate existing canal data to identify spatial and temporal patterns and to determine the adequacy of coverage in south Florida. Additional flow gauges and routine monitoring stations will be added to areas that do not have adequate coverage.

YEAR ONE TRI-COUNTY EVALUATION

Department GIS staff provided a 24K, quality-assured GIS data layer of canals in the pilot area based on the U.S. Geologic Survey National Hydrography Dataset line work, with improvements reflecting quality assured available local data sources. The following GIS coverages (see associated pdf file of GIS coverages) were identified through an initial scoping process:

Table 1 – GIS Coverages for the South Florida Canal Aquatic Life Study

Coverage	Discussion
Canal Study Phase One 24K National Hydrography Dataset Canals	This is a detailed coverage of all canals in the study area – the Department is in the process of going through the coverage to identify which of these are Class III and may provide an appropriate site for the proposed monitoring.
Catchments	The SFWMD catchments represent individually delineated areas drained by a body of water, such as a stream or canal. This coverage was used in conjunction with the associated land use coverage (see below) and the primary canals within each catchment to develop a list of candidate canals.
SFWMD Land use 2008-2009	This coverage identifies 21 land uses. The area and percentage of each land use within each catchment was calculated. It is anticipated that land use would affect water quality and potentially hydrology and aquatic life in the associated canals and would provide a means to perform an initial selection of candidate canals.
STORET stations on canals	This coverage identifies canal STORET stations in the tri -county area. Sites that had data collected since the year 2000 and sites that monitored outside of storm water treatment areas were included, leaving 955 stations.
SBIO Biological Monitoring	This coverage identifies monitoring sites at which biological monitoring has been done to track macroinvertebrates as indicators for water quality in canals. There are 90 sites in the tri-county area.
Geology	This coverage identifies the underlying geology type – types are shelly sand & clay, peat, and limestone. Since the underlying geology of a canal might affect aquatic life, candidate canals were selected to encompass the range of geology types.
Soils	This coverage identifies the hydrologic soil group for the area – there are 4 groups (ABCD), which identify the runoff potential of the soil when thoroughly wet (from low, mod low, mod high, high respectively). Since this would also relate to water quality & quantity and therefore aquatic life, soil types need to be taken into consideration on candidate study canal selection.
Municipalities	This coverage identifies the 43 municipalities in the proposed study area – most of these are in marine waters & would not be relevant. The coverage will be used by the Department to help us identify local stakeholders with an interest in the study.
WBIDs	This coverage identifies the WBIDs in the proposed study area and also notes whether the WBID is impaired. in addition to identifying whether the WBID is impaired, the Department will also identify what the source of impairment and ensure that candidate canals for study are in both impaired and unimpaired areas.
BMAPS	This coverage identifies Basin Management Action Plans in the study area. The St. Lucie estuary BMAP/Watershed Protection Plan is the only BMAP in the study area.
298s	This coverage identifies the 30 Chapter 298 Special Drainage Districts located in the study area. This coverage will be used by the Department to identify local interested stakeholders.
OFWs & Managed Lands	The Outstanding Florida Water coverage is all either estuarine or fresh water marshes such as the Everglades. The Florida Natural Area Inventory lands denote “natural” areas managed by a federal, state, local or private entity. Canals within these areas were evaluated for their potential as candidates for best possible biological condition in a canal.
1° & 2° Canal Ownership	The majority of the canals seem to be part of the SFWMD’s primary canal system. The only others listed are the M canal (City of WPB) and the Lake Worth Drainage District canals, both of which connect to the SFWMD primaries.
Structures	This coverage identifies a number of structure types, including pumps.

Land Use represented by the SFWMD 2008-9 GIS layer, and classified by the Florida Land Use and Land Cover Classification System (FLUCCS) was intersected with the catchments. Land use acreage was summarized by catchment and calculated by area and percentage (see associated spreadsheet incorporated as Appendix A). The data were then used to calculate the total percent of agricultural, urban and natural lands in each catchment. Urban land use was calculated as the total of the 1000 series FLUCCS codes, agricultural land use was calculated as the total of the 2000 series FLUCCS codes, and natural land use was calculated as the total of the 3000 through 6000 series FLUCCs codes. In

addition, the FLUCCS codes were used to calculate the Landscape Development Intensity (LDI) index[2] for each catchment as a measure of human disturbance in the catchment. The data were then used to select a set of candidate canals to be monitored. The selection process used the above information to select an initial suite of candidate canals that spanned a broad range of human disturbance (LDI scores ranged from ~2 - ~ 7) and a variety of land uses (predominantly agricultural, predominantly urban, predominantly natural and mixes of each), while also taking into account spatial variability in the study region.

Data Analysis/Discussion

2012 Synoptic Sampling in South Florida Canals

In anticipation of the need to conduct a study on south Florida canals, in February and March of 2012, Department field staff, conducted a synoptic sampling exercise at a single site on 29 randomly-selected canals (Table 2) in southeastern Florida (Figure 3).

[2] The LDI is a 1-10 scale numeric index based on the ecological principle that the intensity of human dominated land uses in a landscape affects ecological processes of natural communities. Natural landscapes with little or no agricultural or urban development will likely have intact ecological systems and processes and will score lower on the LDI than more intense land uses, which will score higher. The LDI was developed specifically as an index of human disturbance, and has been shown to provide predictive capability regarding nutrient loading. Reference: Brown, MT and MB Vivas, 2005. Landscape Development Intensity Index. Environmental Monitoring and Assessment 101:289-309.

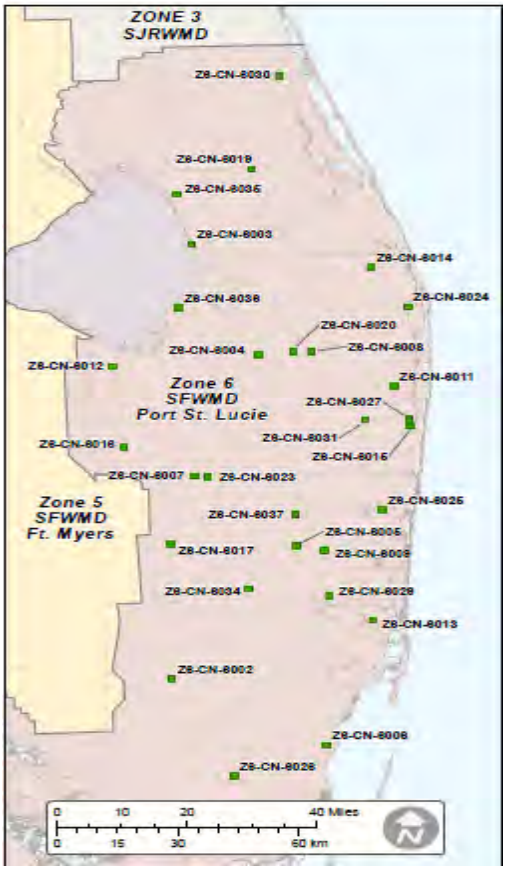


Figure 3. Locations of the synoptic samplings conducted in February and March.

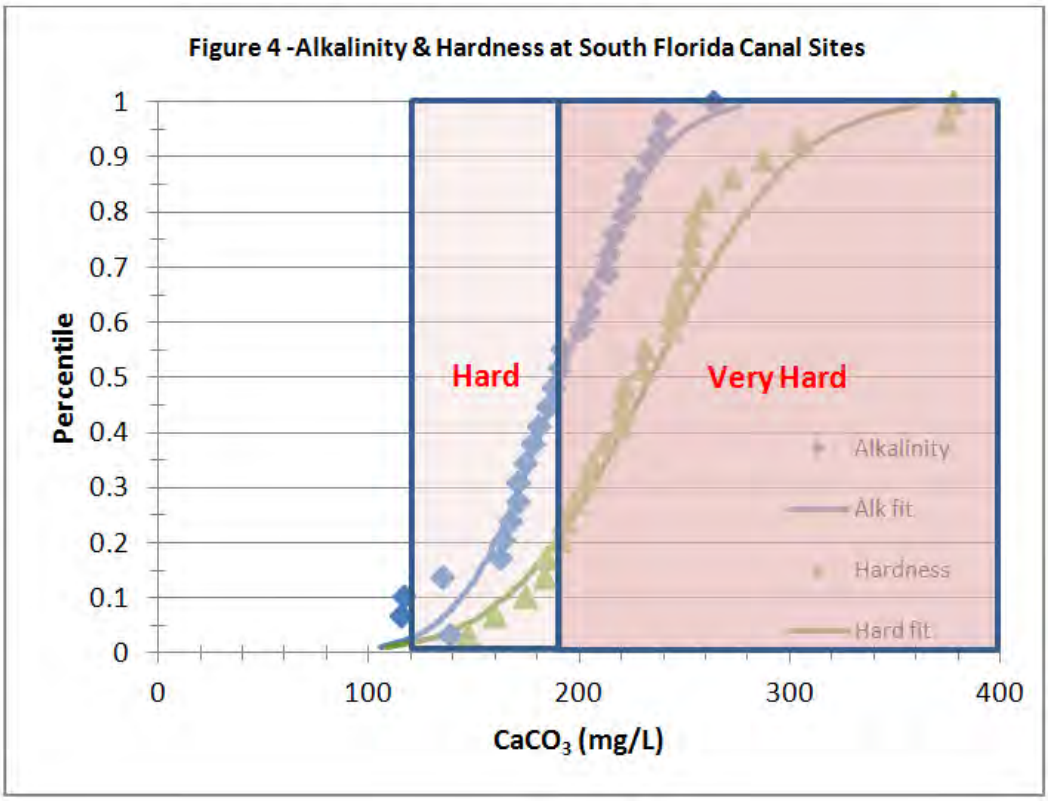
Station	Waterbody Name	STORET ID	Sample Date
Z8-CN-8003	LAKE O RIM CANAL	41345	2/7/2012
Z8-CN-8030	BELCHER CANAL	41367	2/7/2012
Z8-CN-8004	L-13 (OCEAN CANAL)	41346	2/8/2012
Z8-CN-8020	C-51 (WPB CANAL)	41360	2/8/2012
Z8-CN-8012	L-1E (WEST CANAL OFF MIAMI CANAL)	41353	2/9/2012
Z8-CN-8016	L-24 (MIAMI CANAL)	41357	2/9/2012
Z8-CN-8008	C-51 (WPB CANAL)	41350	2/21/2012
Z8-CN-8014	LOXAHATCHEE RIVER	41355	2/21/2012
Z8-CN-8024	C-17 CANAL	41362	2/21/2012
Z8-CN-8011	L-8 CANAL	41352	2/22/2012
Z8-CN-8015	E-4 CANAL	41356	2/22/2012
Z8-CN-8007	Holeyland Seepage Canal	41349	2/27/2012
Z8-CN-8023	L-6 CANAL	41361	2/27/2012
Z8-CN-8027	L-30 CANAL	41365	2/27/2012
Z8-CN-8006	L-31E CANAL	41348	3/6/2012
Z8-CN-8013	C-8 (BISCAYNE CANAL)	41354	3/6/2012
Z8-CN-8029	N FORK SNAKE CREEK CANAL	41366	3/6/2012
Z8-CN-8005	L-35 CANAL	41347	3/7/2012
Z8-CN-8009	N NEW RIVER CANAL	41351	3/7/2012
Z8-CN-8026	L-31N CANAL	41364	3/7/2012
Z8-CN-8019	C-23 CANAL	41359	3/8/2012
Z8-CN-8002	L-29 (TAMIAMI CANAL)	41344	3/20/2012
Z8-CN-8017	I-75 CANAL	41358	3/21/2012
Z8-CN-8025	C-14 CANAL	41363	3/21/2012
Z8-CN-8031	E-1WN CANAL	41368	3/21/2012
Z8-CN-8034	C-304 CANAL	41369	3/21/2012
Z8-CN-8035	L-64 CANAL	41370	3/22/2012
Z8-CN-8036	UNKNOWN NAME CANAL	41371	3/22/2012
Z8-CN-8037	L-35B CANAL	41372	3/22/2012

Table 2. Station name, location, and sampling date for synoptic sampling.

Grab samples were collected and analyzed for alkalinity, hardness, specific conductance, DO, transparency (Secchi depth), turbidity, color, chlorophyll *a*, nitrogen species, and phosphorus species.

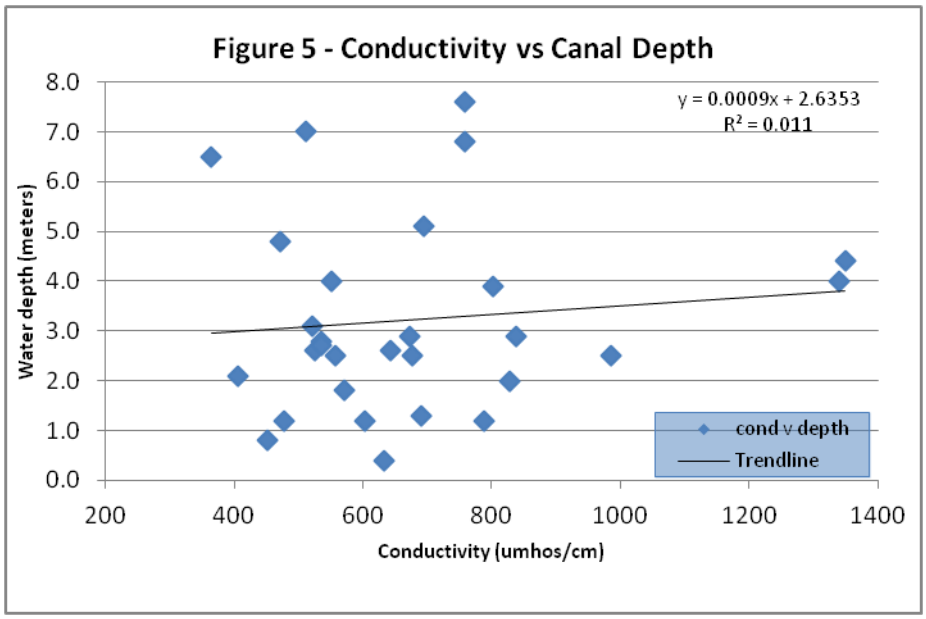
Water depths in the sampled canals ranged from less than 1 meter (m) to nearly 8 m. Water depths are a function of rainfall, operation of control structures, and canal depth. The 50th percentile depth was approximately 3 m.

Alkalinity is the measure of water's acid neutralization capacity and provides a measure of the water's buffering capacity. The dissociation of calcium carbonate, magnesium carbonate, or other carbonate-containing compounds entering the surface water through weathering of carbonate-containing rocks and minerals (e.g., limestone and calcite) contributes to water's buffering capacity. Canal waters are often comprised of mineral-rich agricultural runoff and groundwater, which results in higher levels of alkalinity in these waters. In general, most of the sample locations were characterized by very hard water as shown in Figure 4**.**



The current Class III water quality criterion specifies that alkalinity shall not be lowered below 20 milligrams of calcium carbonate per liter (mg $CaCO_3$/L). All of the samples achieved this criterion.

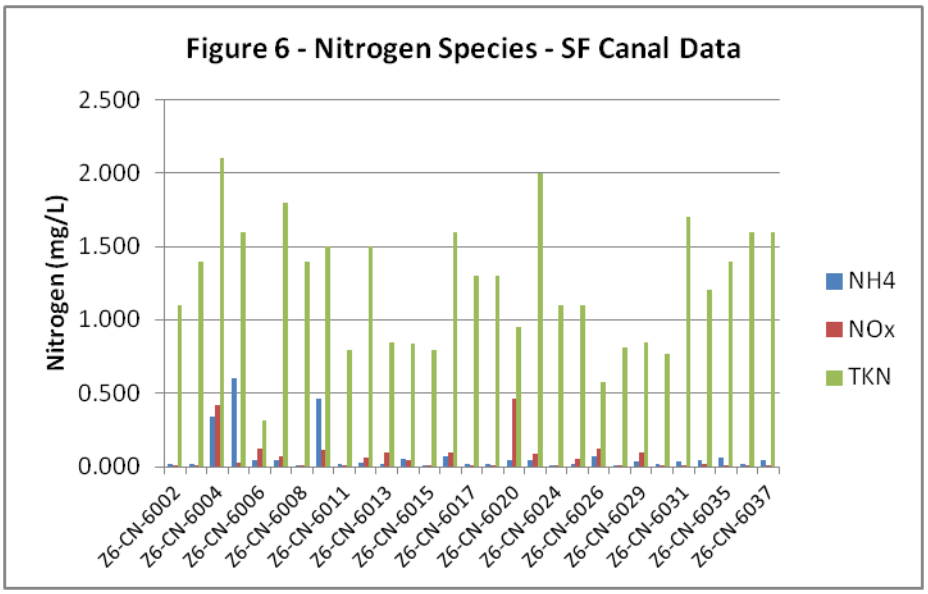
Specific conductance is a measure of water's ability to conduct an electrical current, and it is the total concentration of ionized substances, such as sodium and chloride. Specific conductance varies with the number and type of ions. Specific conductance ranged from ~400 micromhos per centimeter (µmhos/cm) to ~1400 µmhos/cm with the 50th percentile at ~650 µmhos/cm. Elevated levels of specific conductance may be linked to groundwater intrusion (connate seawater) into canal surface waters, potentially associated with water management activities. The data from this monitoring effort did not indicate a significant relationship between specific conductance and canal depth (Figure 5).

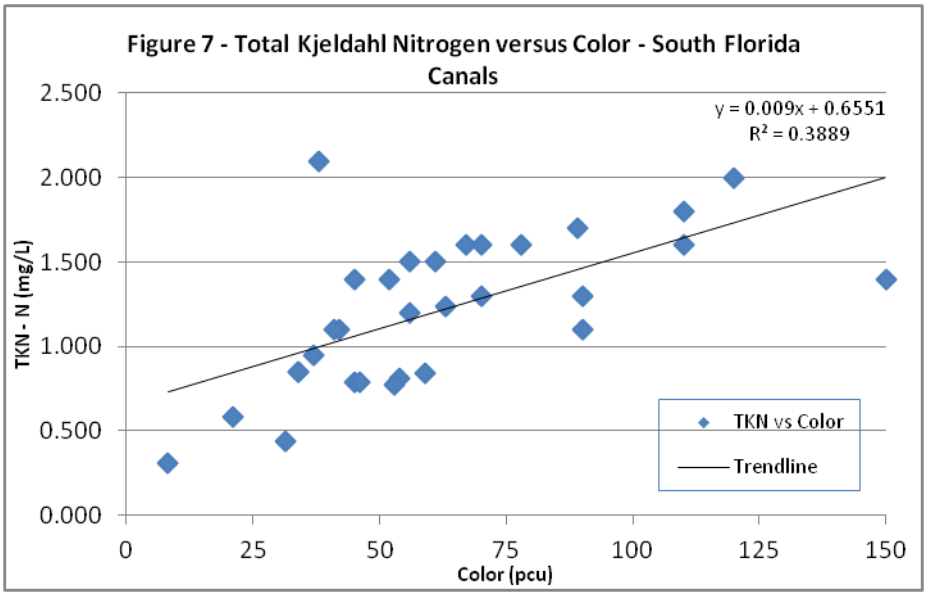


Dissolved oxygen (DO) levels varied widely between ~4 milligrams per liter (mg/L) to ~13 mg/L. DO concentrations are expected to be seasonally dependent as they are affected by factors such as temperature and water velocity; however this singe sampling event is insufficient to evaluate such factors.

Chlorophyll *a* levels ranged from close to 0 µg/L to ~70 µg/L. These concentrations are expected to vary seasonally as algae populations fluctuate with changes in temperature and water residence time, as well as changes in the availability of nitrogen and phosphorus**.** An analysis of chlorophyll *a* and transparency data reveals that there may be a relationship (R^2 = 0.3036) between the two parameters. The data suggest that as chlorophyll *a* concentrations increase, the transparency decreases. This may be due, in part, to the fact that when chlorophyll levels are higher, there is an increase in algal-derived turbidity (shading), which can decrease the transparency. As expected, a strong relationship between transparency and turbidity (algal plus inorganic particles) exists (R^2 = 0.75).

Nitrogen species—ammonia, nitrate + nitrite (NO_x), and total Kjeldahl nitrogen (TKN)—were all analyzed, and values of Total Nitrogen ranged from <0.5 mg/L to ~2.5 mg/L. The largest fraction of nitrogen at all of the sites was TKN (Figure 6), indicating that most of the nitrogen present is in organic or particulate form. A regression of TKN versus color (Figure 7) suggests that a significant amount of the nitrogen may be attributable to tannic and/or humic substances which naturally occur in canals due to the adjacent wetlands present.

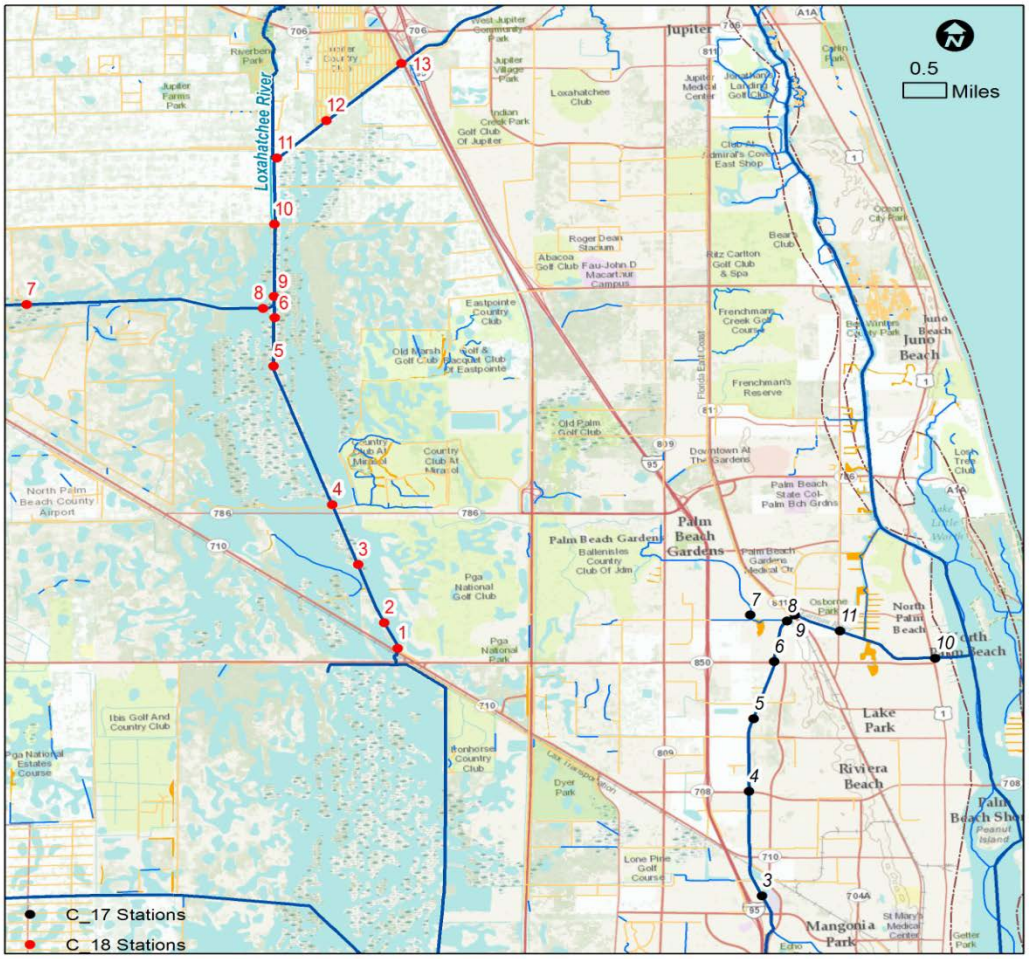




C-17 and C-18 Sampling

Beginning in February 2012 and continuing through the present, DEP's Office of Ecosystem Projects in West Palm Beach, in collaboration with Tallahassee's Watershed Evaluation Team (WET) Section, collected monthly samples along the C-17 and C-18 canals. Thirteen sites were sampled on the C-18, and 8 sites were sampled on the C-17 (Figure 8).

Figure 8 – C-17/C-18 Canal Monitoring Sites



These two canals were chosen as representatives of the best possible water quality and associated biological condition (C-18) and more potentially degraded water quality and biological condition (C-17). Land use surrounding the C-18 canal is mostly natural (remnant Everglades marsh), while land use surrounding the C-17 canal is heavily urbanized. Grab samples were collected and analyzed for alkalinity, hardness, specific conductance, DO, transparency (Secchi depth), turbidity, color, chlorophyll *a*, nitrogen species, and phosphorus species. Data have been analyzed through August 2012 thus far. Graphs of select data analyses described below for these data are presented in Appendix A (attached).

Approximately 80% of phosphorus is in the organic or particulate form (ortho-phosphorus is typically at or near the detection limit) and TP in the C-17 canal is significantly greater than in the C-18 canal[3]. TP decreases downstream and is temporally and seasonably variable in the C-17 canal, but increases downstream in the C-18 and is not temporally or seasonably variable. For nitrogen, organic and other reduced forms of nitrogen (TKN) greatly exceed oxidized forms (NO_x) and no significant spatial or temporal patterns exist.

[3] All significance described in this section is at $p < 0.05$ unless specified otherwise.

Chlorophyll *a* is significantly higher in C-17 (median= 22 µg/L) than in the C-18 (median= 8.2 µg/L) and appears to decrease downstream in C-17, while increasing in C-18. There are no temporal trends in chlorophyll *a*. Chlorophyll *a* is strongly correlated with TP (R^2= 0.6542); however, the correlation could be influenced by other differences between canals since the C-17 data tend to cluster toward one end of the regression while the C-18 cluster toward the other end.

Dissolved oxygen is not significantly different between the C-17 and C-18, although biochemical oxygen demand (BOD) is significantly higher in the C-17. Dissolved oxygen percent saturation exhibited strong temporal and seasonal trends, with high values occurring in the winter and low values in the summer months.

There is a significant increasing trend in alkalinity from upstream to downstream in the C-18, but not for the C-17. Alkalinity is generally higher in the winter (dry) months than the summer (wet) months. These patterns are thought to be influenced by surrounding land use (more marsh area surrounding the upstream of the C-18) and hydrology (more dilution and less influence of carbonate-rich groundwater during wet season than in dry season). Turbidity is significantly higher in C-17 than in C-18 and is strongly correlated with TP and chlorophyll a ($R^2 \approx 0.6$).

Based on a power analysis of the data, review of the variance at individual stations, and logistical considerations, it was determined that it would be appropriate to continue with sampling at three stations on the C-17 canal and four stations on the C-18 canal as a part of the South Florida Canal Aquatic Life Study.

Biological Sampling Events

Biological sampling was performed at the C-17 canal and the C-18 canal in May and August, 2012. The intent of the sampling was to conduct a preliminary evaluation of field biological sampling methods in canals and evaluate the data to see if the biological data indicated any differences in aquatic life in the two canal systems. The Stream Condition Index (SCI) was sampled and analyzed according to FDEP SOP SCI 1000. The SCI is composed of ten metrics, eight of which decrease in response to human disturbance, with two metrics (% very tolerant and % dominant) increasing in response to human disturbance. In Chapter 62-303.430, a waterbody is determined to NOT be biologically impaired if the average score of at least two temporally independent SCIs is 40 or higher, with neither of the two most recent scores less than 35. Note that the SCI has not yet been calibrated for the Everglades Bioregion, therefore SCI scores are currently being used to compare relative biological condition between sites. Habitat Assessment (HA) scores were calculated according to FDEP SOP FT 3000, Lake Vegetation Survey (LVS) Coefficient of Conservatism (C of C) scores and occurrences of Florida Exotic Pest Plant Council (FLEPPC) taxa were calculated according to FDEP SOP FS 7320, and Rapid Periphyton Survey scores were calculated according to FDEP SOP FS 7230. Scores of > 100 for the HA, > 2.5 for the LVS C of C, <25% LVS FLEPPC taxa, and < 25% RPS Rank 4-6 are generally considered indicative of non-problematic conditions for those metrics.

In May, FDEP staff sampled two sites on C-18 and two sites on C-17 for the above metrics. FDEP also conducted a multi-day sampling event in August for both the C-17 and C-18 canals for the above

metrics. Repeat samplings occurred at sites 1 and 4 in C-18 and site 6 in C-17. Data from those sampling efforts are summarized in Table 3. More detailed data and plots for selected parameters are provided in Attachment B. Although this is a limited initial sampling effort, the data suggest that there are significant differences between canals in a number of the metrics used and that these appear to be appropriate metrics to assess aquatic life conditions in south Florida canals.

Table 3 – Biological Sampling Scores for the C-17 & C-18 Canals

Canal	Date	SCI		HA		LVS C of C		LVS FLEPPC		% RPS 4-6 (>6 mm)	
		Average	Std Dev	Average	Std Dev	Average	Std Dev	Average	Std Dev	Average	Std Dev
C-17	May-12	11.00		26.50	3.54	1.74		69.80		21.20	
	Aug-12	25.33	4.93	56.00	6.56	1.51	0.53	66.80	14.94	0.00	0.00
	Both Dates	21.75	8.22	44.20	16.90	1.57	0.45	67.55	12.29	5.30	10.60
C-18	May-12	41.50	4.95	41.50	19.09	3.20	0.54	29.45	0.64	0.00	0.00
	Aug-12	43.33	9.81	45.67	5.03	2.84	0.91	36.93	17.65	0.00	0.00
	Both Dates	42.60	7.44	44.00	10.44	2.99	0.72	33.94	13.14	0.00	0.00

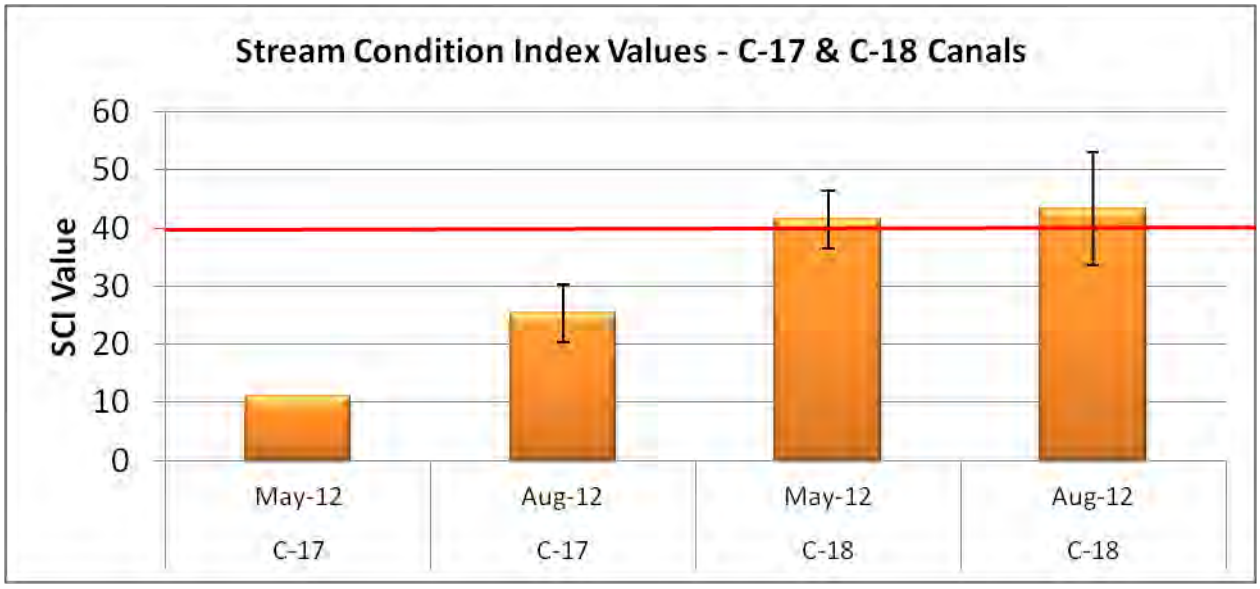


Figure 9. Comparison of Stream Condition Index (SCI) scores from C-17 and C-18 collected during May and August, 2012.

Note that SCI scores were consistently higher at C-18 (average of 40.6) than C-17 (average of 21.8), suggesting that this method can distinguish between canals that have different surrounding land use and water quality. Additionally, the C of C and FLEPPC scores were higher at C-18 than C-17, indicating that the C-18 plant community also was of higher quality than C 17. RPS scores indicated that algal mats were not an issue at either canal during the sampling period.

Plan of Study

GIS data for SFWMD primary canals in St. Lucie, Martin and Palm Beach Counties were used to select the initial suite of candidate canals and potential monitoring sites for the study. Selection of candidate canals was primarily based on getting a representative set of canals with a range of LDIs and land uses that are geographically distributed throughout the three counties but the logistics of the monitoring (i.e., locations of boat ramps, accessibility of sites) were also considered. Initial candidate canals are set forth in Table 4 and Figure 10 below.

Table 4 – South Florida Canal Aquatic Life Study Candidate Canals

Canals	Location	Land use	Stations
C-25	N St. Lucie County	Mix of ag (54%), urban (24%), natural (16%) - ag is predominantly tree crops (citrus) and improved pasture.	1. W end of C-25, @ junction of C-25 extension 2. E end of C-25, upstream of Ft. Pierce farm canal 3. Center of C-25 canal 4. Two lateral canals to be selected from field visit
C-23	St. Lucie/Martin County line	Mostly Ag (76% - mix of improved pasture, some probable citrus), some natural (19%), 3% urban	1. NW segment of C-23, W of junction with C-24 2. E end of C-23, upstream of Bessey Creek 3. Center of C-23 canal 4. Two lateral canals to be selected from field visit
C-44	Central Martin County	Mix of ag (57 %), urban (9%), natural (32%) - ag is predominantly improved pasture, tree crops (citrus) and open rural lands	1. W end of C-44, downstream of lock at Lake O 2. E end of C-44, upstream of South Fork of St. Lucie R. 3. Center of C-44 canal 4. Two lateral canals to be selected from field visit
C-17	E Central PB County to Lake Worth Lagoon	Mostly urban (69%) - LDI >6	Existing sample canal - see Figure 3
C-18	W or C-17 Canal in PB County	Mostly natural (77 %) - LDI ~2	Existing sample canal - see Figure 3
M canal	PB County from L-8 to L Mangonia	Mostly natural (88 %) - LDI <2	
Dupuis canal	Canal along power break between Corbett & Dupuis tracts	Very natural - LDI ~1	Need to check suitability of this canal - no obvious laterals - possibly only two sites
Miami Canal (L24 & 25) L-21, L-26, L-1E	W PB County - Main canal + 3 laterals	Predominantly ag (98%) - western EAA	1. Two stations on Miami canal 2. One station each on L-21, L-26, L1E
West Palm Beach Canal (L-10)	C PB County - no laterals	Predominantly ag (95%) - eastern EAA	1. N part of canal, S of Lake O 2. Center part of canal 3. S end of canal, upstream of L-8 reservoir
C-51 Canal	C PB County - runs along S of Southern Blvd.	Heavily urbanized (70-79%)	1. W end of canal, near Wellington discharge 2. E end of canal, near junction with E-4 3. Center of canal, near S-155 divide structure 4. One station on E-1 lateral 5. One station on E-3 lateral
L-23W	E of LNWR	Mix of ag, urban and natural	One station on L-23W
C-16 (Boynton Canal)	from E-1 canal E of LNWR to Boynton Beach	Mostly urban (72%)	1. W end of canal, near juncture with E-1 2. E end of canal, near juncture with E-4 3. One station on E-2W lateral 4. One station on E-3 lateral
Hillsboro Canal	PB/Hillsboro County line	Mostly urban (75%)	1. W end of canal, downstream of WCAs 2. E end of canal, near juncture with E-4 3. Center of canal, near juncture with E-2W 4. E-1 lateral canal, N or S of Hillsboro 5. E-3 canal, N or S of Hillsboro

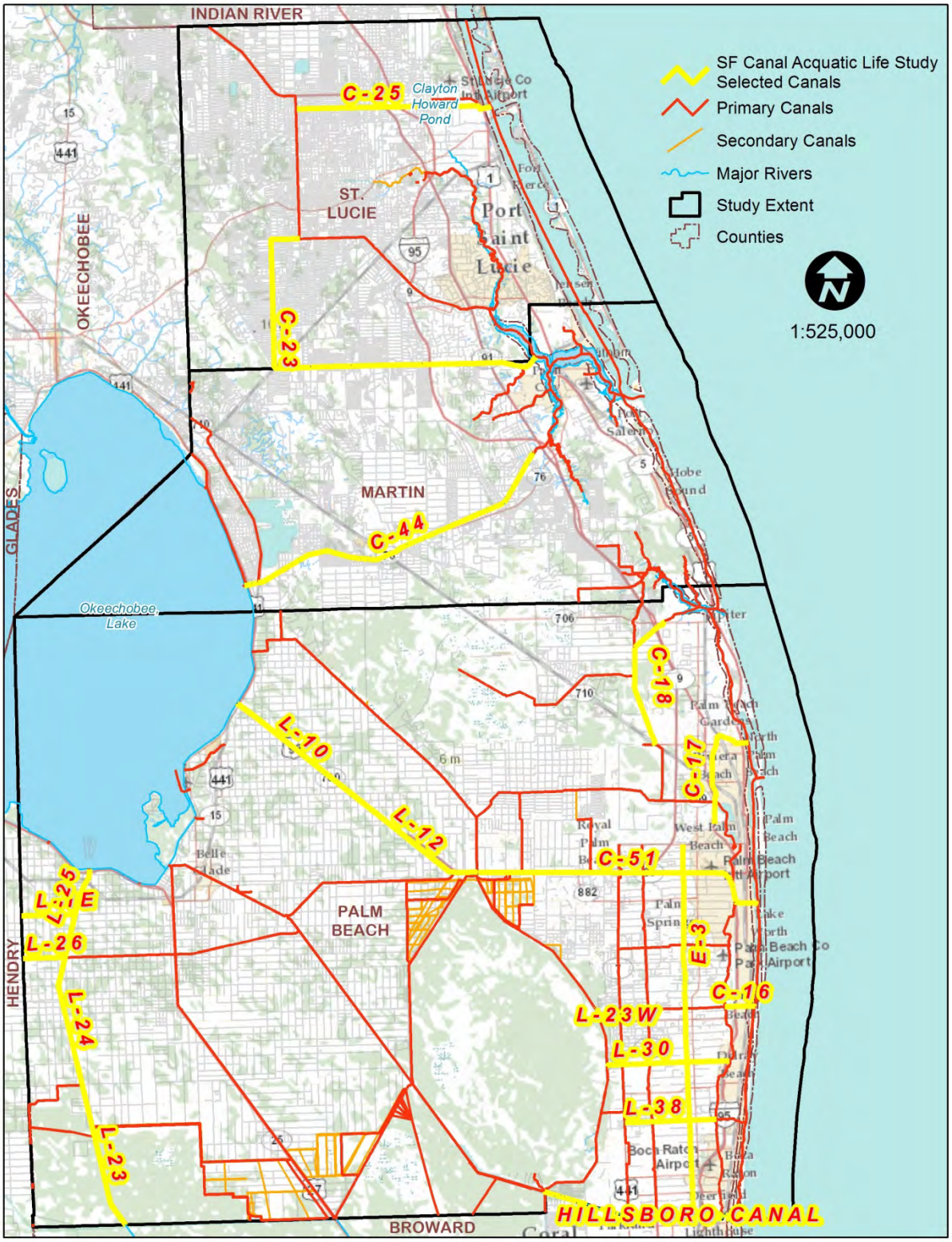
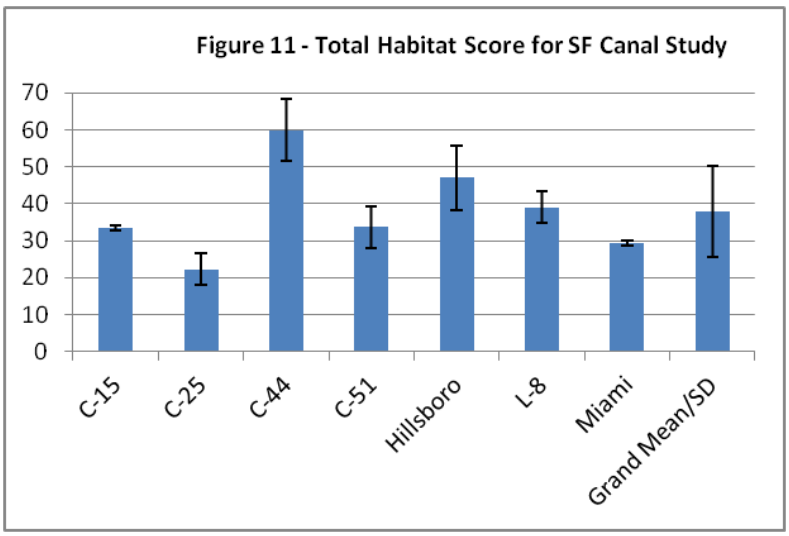


Figure 10 – Initial candidate canals for sampling under SFCALS

A monitoring site evaluation survey was conducted for candidate canals August 13-16, 2012 to assess the suitability of candidate canals and sample sites, and to establish the logistics for sampling site access, etc. Since it is expected that habitat would be a significant factor affecting the aquatic life in canals, an initial assessment of habit scores collected during the scoping survey was conducted to determine the appropriate number of monitoring sites needed per canal. The initial assessment indicated that 2-4 sites are generally sufficient to characterize a canal, since there is significantly more variability between canals than within canals (Figure 11).



After considering information collected during the site evaluation survey and consultation with the FWCC, further revisions to the canal list and samples sites were made and the final set of proposed canals/sites to be monitored are set forth in Table 5 and Figure 12.

Table 5 – Final Draft Canals and Sites to be Monitored

Canal	Sites	Storet Codes	Number of Stations
Miami	Miami site 1 Miami site 2 Miami site 3 L-1E		4
L-8	L-8 site 1 L-8 Site 2		2
Hillsboro	Hillsboro site 1 Hillsboro site 2 Hillsboro site 3 E-2W		4
C-15	C-15 site 1 C-15 site 2 C-15 site 3 E-4 site 1 E-4 site 2		5
C-51	C-51 site 1 C-51 site 2 C-51 site 3 Flyover canal		4
C-17	C-17 site 1 (existing site 4) C-17 site 2 (existing site 7) C-17 site 3 (existing site 8)		3
C-18	C-18 site 1 (existing site 2)		3

	C-18 site 2 (existing site 5) C-18 site 3 (existing site 10) C-18 site 4 (existing site 13)	
C-44	C-44 site 1 C-44 site 2 C-44 site 3 C-44 site 4 C-44 lateral 1 C-44 lateral 2	6
C-23	C-23 site 1 C-23 site 2 C-23 site 3 C-23 site 4	4
C-25	C-25 site 1 C-25 site 2 C-25 site 3 C-25 site 4	4
Total		40

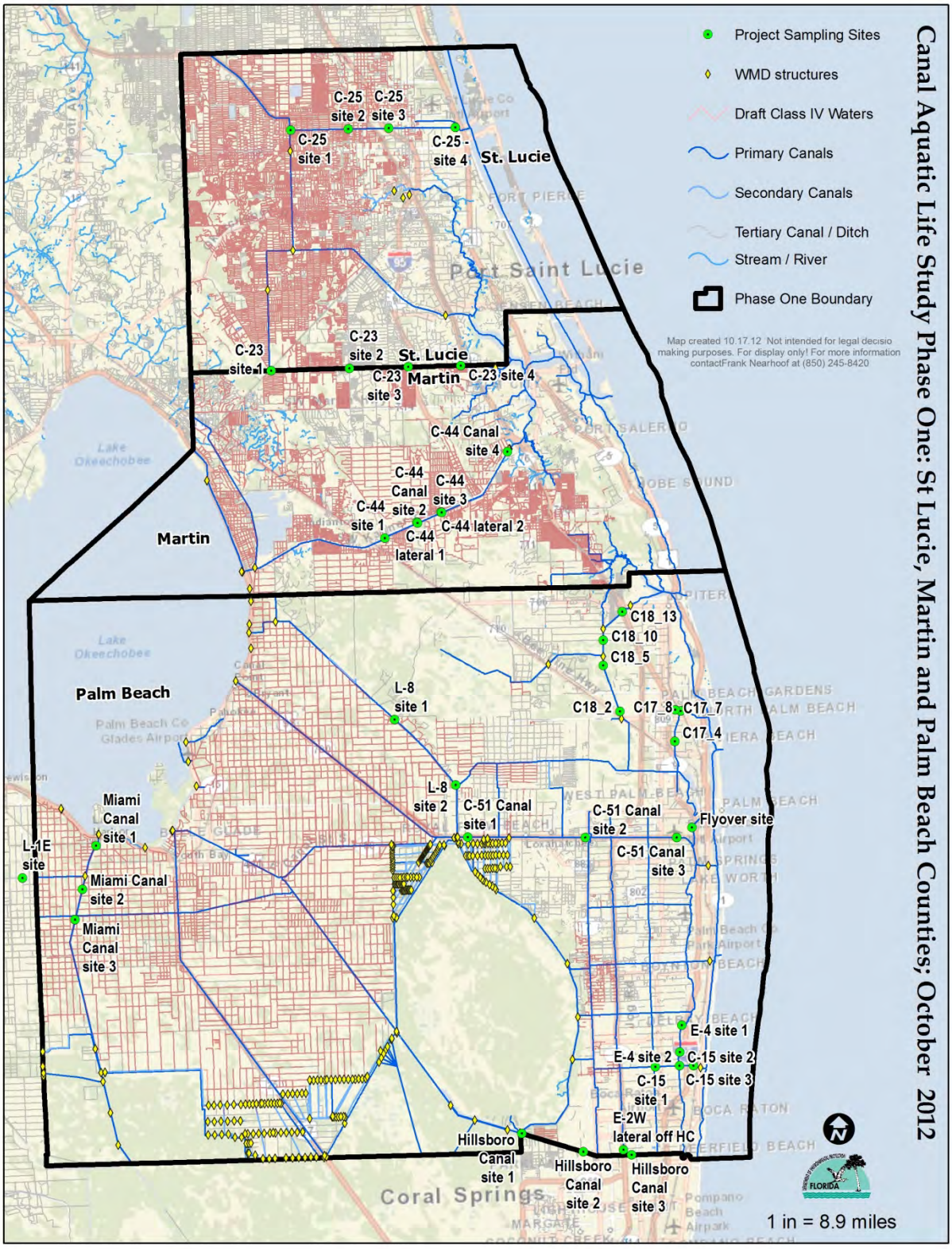


Figure 12 – Final Proposed South Florida Canal Aquatic Life Study Monitoring Sites

Following final canal/site selection, a draft initial three month sampling schedule was created (Table 6).

Table 6 – Initial Three Month Sampling Schedule

		M	Tu	W	Th	F
2012	DEC	**3**	**4**	**5**	**6**	**7**
		C-25 Canal (4 sites)	C-23 Canal (4 sites)	C-44 Canal (6 sites)	Data compilation & analysis	Data compilation & analysis
		10	**11**	**12**	**13**	**14**
		Sampling Preparation	C-17 Canal (3 sites)	C-18 Canals (4 sites)	Data compilation & analysis	Sampling Preparation
		17	**18**	**19**	**20**	**21**
		Miami/L-1E Canals (4 sites)	Hillsboro Canal (4 sites)	C-15/E4 Canals (5 sites)	Data compilation & analysis	Data compilation & analysis
		24	**25**	**26**	**27**	**28**
		Sampling Preparation	State Holiday	L-8/C-51W (4 sites)	C-51E/Flyover Canals (2 sites)	Sampling Preparation
	Jan	**31**	**1**	**2**	**3**	**4**
		C-25/C-23 Canal*	State Holiday	C-44 Canal	Sampling Preparation	Retrieve sondes from C-25/C-23
		7	**8**	**9**	**10**	**11**
		C-17/C-18 Canals*	Miami/L-1E Canals	Data compilation & analysis	Sampling Preparation	Retrieve sondes from C-17/C-18
		14	**15**	**16**	**17**	**18**
		Hillsboro Canal*	Data compilation & analysis	L-8/C-51W	Sampling Preparation	Retrieve sondes from Hillsboro
		21	**22**	**23**	**24**	**25**
		State Holiday	C-15/E4 Canals*	Data compilation & analysis	Data compilation & analysis	Retrieve sondes from C-15/E-4
		28	**29**	**30**	**31**	**1**
		Data compilation & analysis	Data compilation & analysis	Data compilation & analysis	Data compilation & analysis	Sampling Preparation
	Feb	**4**	**5**	**6**	**7**	**8**
		C-44 Canal*	C-25/C-23 Canal	Data compilation & analysis	Sampling Preparation	Retrieve sondes from C-44
		11	**12**	**13**	**14**	**15**
		Miami/L-1E Canals*	C-17/C-18 Canals	Data compilation & analysis	Sampling Preparation	Retrieve sondes from Miami/L-1E
		18	**19**	**20**	**21**	**22**
		L-8/C-51W*	Hillsboro Canal	C-15/E4 Canals	Data compilation & analysis	Retrieve sondes from L-8/C-51W
		25	**26**	**27**	**28**	**1**
		Data compilation & analysis	State Holiday	Data compilation & analysis	Data compilation & analysis	Data compilation & analysis

Quarterly Biological Sampling and monthly WQ sampling

Monthly WQ sampling only (note - monthly data available for Hillsboro Canal from Broward County). Note- data sondes would be deployed for sample dates indicated with an *.

Data compilation & analysis involves compilation of flow & stage data for assessed canals, in addition to information on management (e.g., herbiciding, re-grading, etc.) and data from sampling. Once BACI study sites are established, these dates can be used for that monitoring

Sampling Preparation is preparation of sample kits, etc. for upcoming sample event

Water quality and biological data will be collected at study monitoring sites. Water quality will be collected monthly, and biological data will be collected quarterly. Water quality and biological parameters will include:

Parameter	Matrix	DESCRIPTION	Analysis Method
Turbidity	Water	Turbidity in aqueous matrices	EPA 180.1 Rev. 2.0
Color	Water	True Color measured at 450 nm	SM 2120 B
NO_x	Water	Nitrite/Nitrate in aqueous matrices as mg N/L	EPA 353.2 Rev. 2.0
TP	Water	Total Phosphorus in aqueous matrices as mg P/L	EPA 365.1 Rev. 2.0
TKN	Water	Total Kjeldahl Nitrogen in aqueous matrices	EPA 351.2 Rev. 2.0
TOC	Water	Nonpurgeable Organic Carbon in aqueous matrices	SM 5310 B-00
Dominant algal taxa in bloom or mat	Biological	Assessment of dominant algal taxa in bloom or mat sample	SOP-AB05
Diatoms in phytoplankton	Biological	No. of diatom taxa of quantitative phytoplankton sample	SOP-AB05_1
Wet taxa in phytoplankton	Water	No. of wet taxa of quantitative phytoplankton sample.	SOP-AB05
Chlorophyll *a*	Water	Phytoplankton chlorophyll-a (corrected for phaeophytin) and phaeophytin by spectrophotometry	SM 10200 H (mod.)
Recon of macroinvertabrate taxa	Biological	No. taxa of freshwater macroinverts, bioreconnaissance	SOP-IZ06
Quantitative macroinvertebrates	Biological	No. taxa of freshwater macroinverts, qualitative sampling, 20 dipnets.	SOP-IZ06
Habitat assessment	Biological	Habitat Assessments	DEP SOP FT 3000
LVS	Biological	Linear Vegetation Survey	DEP SOP FS 7320
RPS	Biological	Rapid Periphyton Survey	DEP SOP FS 2330
Temperature	Meter		DEP SOP FT 1400
ph	Meter		DEP SOP FT 1100
Dissolved oxygen	Meter		DEP SOP FT 1500
Conductivity	Meter		DEP SOP FT 1200

YEARS TWO AND THREE AREA EVALUATION

Following initiation of sampling in year one (November 2012), design will be initiated on additional monitoring to be conducted in years two and three. It is envisioned that year two will involve expanding the coverage area to include canals in Broward and Dade Counties, in addition to canals in the Lake Okeechobee Watershed. Year three will involve expanding the coverage area to include canals in the lower west coast area (from the Caloosahatchee River south). As noted previously, assessment of data from these expanded areas will be done to identify monitoring data gaps in order to initiate any additional monitoring at the inception of the project in order to ensure sufficient data.

COMPILATION OF DATA AND ASSESSMENT OF THREE YEAR STUDY

The study will include a Final Report, in which all methods will be described and results and conclusions presented. The Final Report will also include a compilation of all data associated with the study.