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Water Quality Monitoring Project for Demonstration of Canal Remediation Methods Florida Keys- Report of activities: September 7th, 2016

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WATER QUALITY MONITORING PROJECT FOR DEMONSTRATION OF CANAL REMEDIATION METHODS FLORIDA KEYS

Report of activities: September 7th, 2016

Presented to:
Florida Keys National Marine Sanctuary Steering Committee

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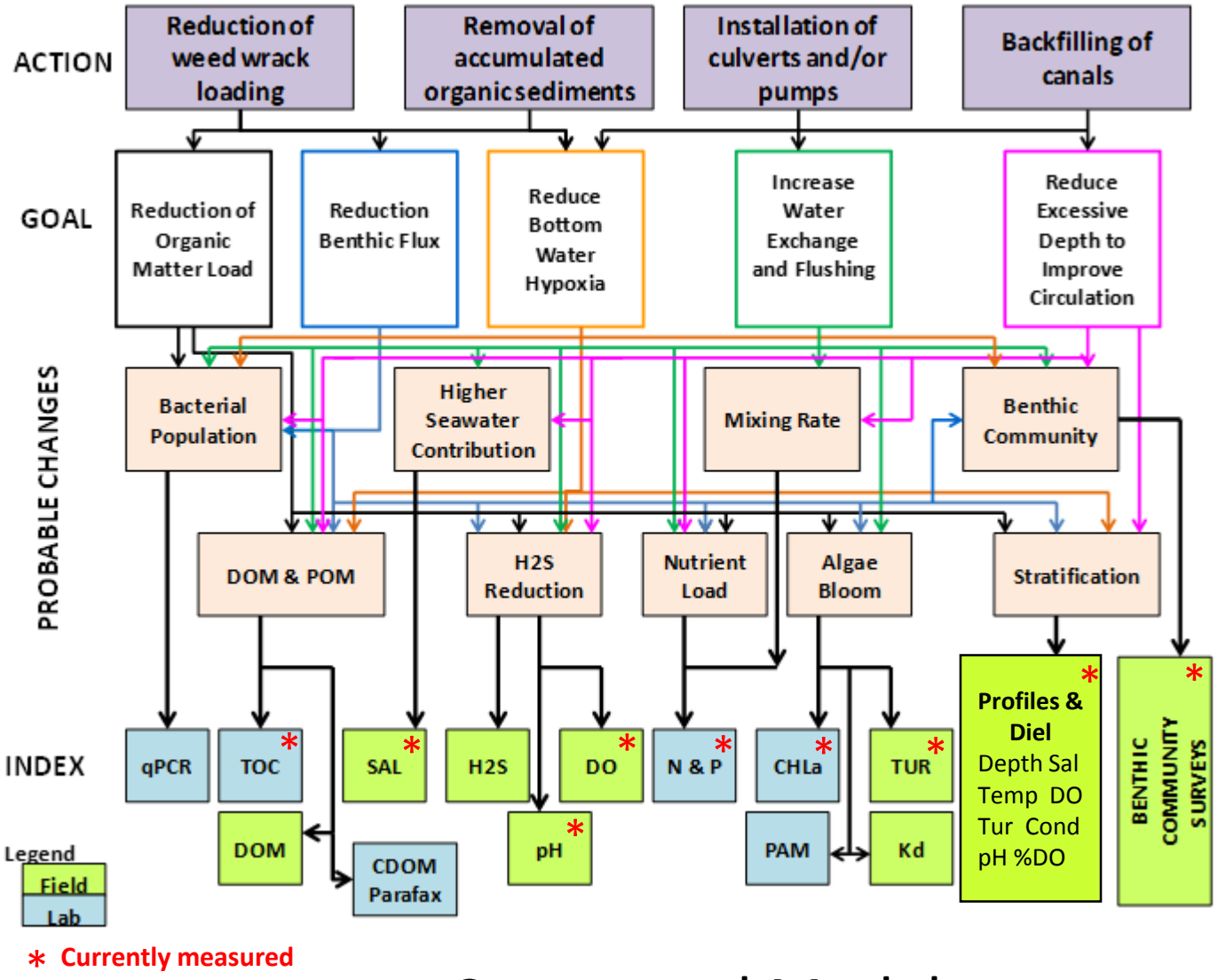
WATER QUALITY MONITORING PROJECT FOR DEMONSTRATION OF CANAL REMEDIATION METHODS FLORIDA KEYS

Objective

To provide data needed to make unbiased, statistically rigorous statements about the status and temporal trends of water quality parameters in the remediated canals



Conceptual Model

STRATEGY for MONITORING

Monitor Water Quality (Physical-Chemical Properties)

- Vertical profiles at selected canal sites
- Continuous 24 (72) hour recording (Diels) of physical-chemical data

Tracing Canal recovery trajectory

Comparing Remediated canal water to Control canal waters

Assessing Status with respect to established Target levels

- % Dissolved Oxygen Saturation (*Rule 62-302.533, F.A.C.)*

- Nutrient concentration, especially Total Phosphorous and Total Nitrogen (FK RAD)

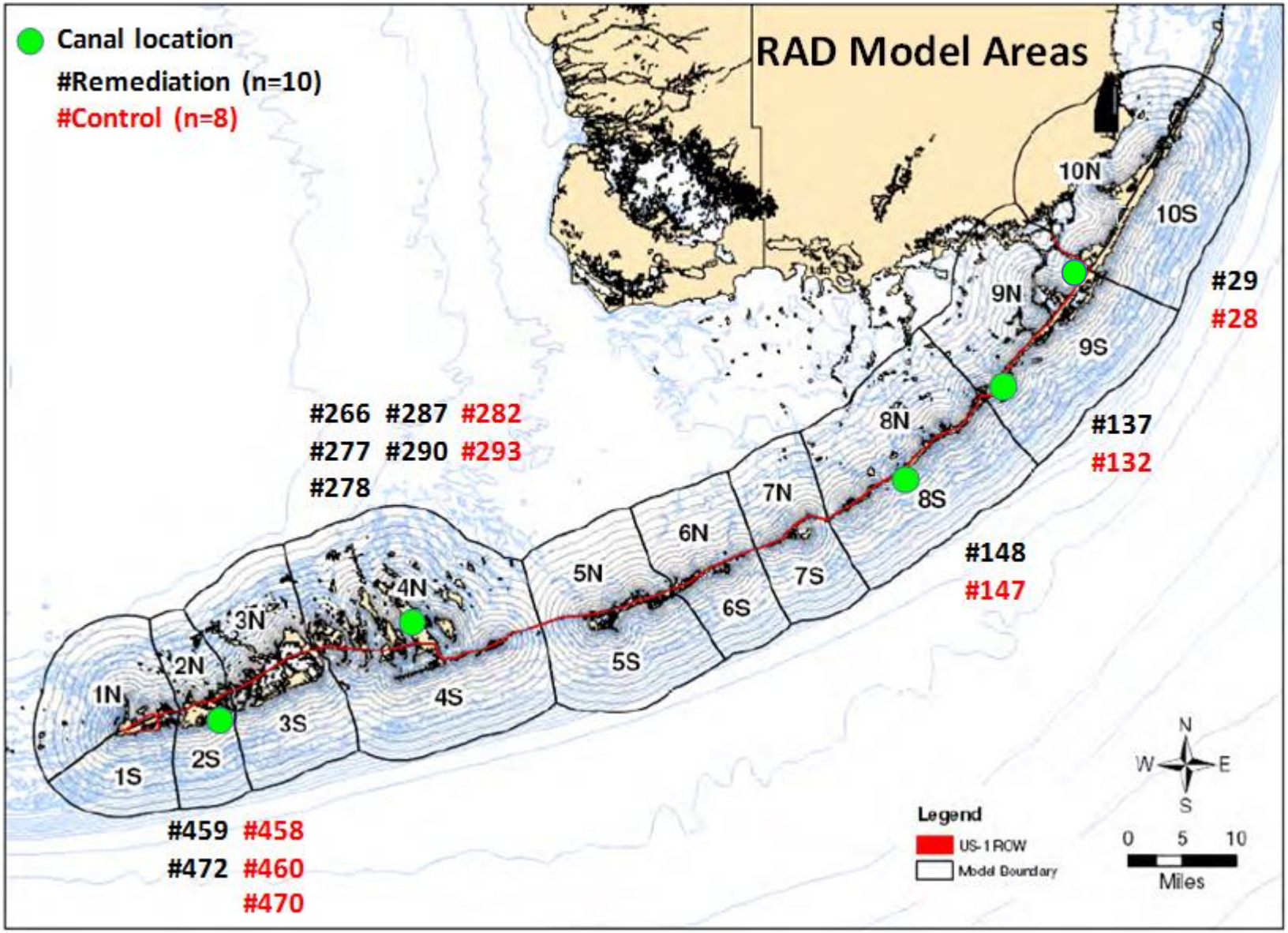
Dissolved Oxygen water quality targets according to *Rule 62-302.533, F.A.C.*

OBJECTIVES: Monitor improvement and assess compliance
Minimum DO saturation levels shall be as follows:

1. ***The daily average percent DO saturation shall not be below 42 percent saturation in more than 10 percent of the values***
   "A full day of diel data shall consist of 24 hours of measurements collected at a regular time interval of no longer than one hour."

2. ***The seven-day average DO percent saturation shall not be below 51 percent more than once in any twelve week period***
   "To calculate a seven-day average DO percent saturation, there shall be a minimum of three full days of diel data collected within the seven-day period, ……with each sample measured at least four hours apart."

Florida Keys RAD Model Areas



Water quality targets according to the FKRAD program

Project	Canal #	Model Zone	TP (µg/l)	TN (µg/l)
Backfilling	29	9N	8	324
Weed Barrier	137	9S	7	123
Culvert installation	472	2S	8	135
Weed Barrier	287	4N	12	221
Organic removal	290	4N	12	221
Weed Barrier / organic removal	266	4N	12	221
Culvert installation	277	4N	12	221
Weed Barrier	148	8S	8	124
Pumping	278	4N	12	221
Culvert installation	459	2S	8	135

WATER QUALITY MONITORING PROJECT FOR DEMONSTRATION OF CANAL REMEDIATION METHODS FLORIDA KEYS

Implementation

The execution of the project includes two phases:

1) Before remediation: Characterization Stage

2) After remediation: Tracking Recovery Trajectory Stage

ADAPTIVE MANAGEMENT

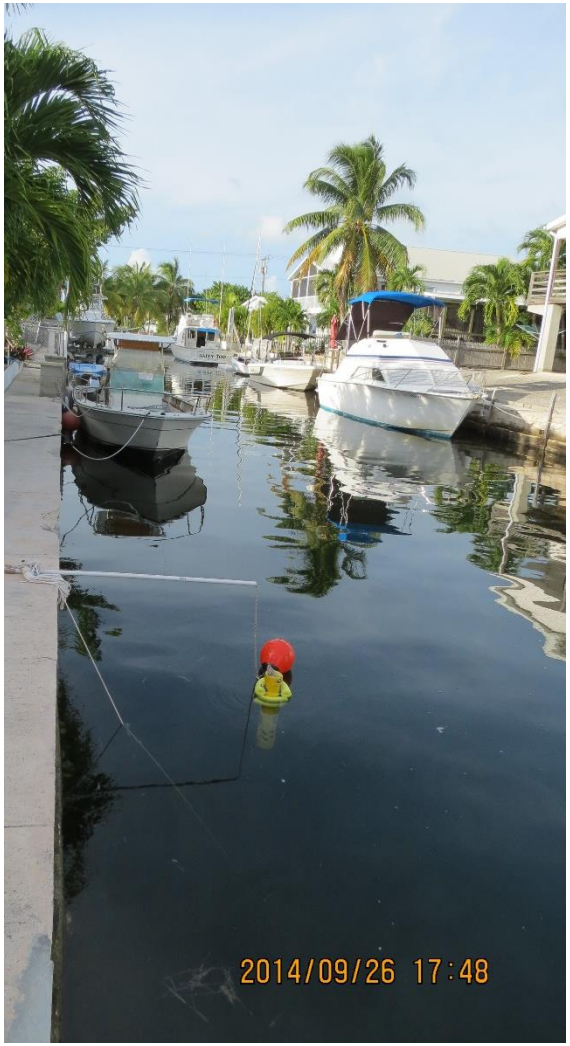
Canals are extremely complex systems whose water quality is affected by natural and human stressors. Hence, the early warning that we might be forced to apply “adaptive monitoring” has become a reality.

We have observed that temporal variability in water column properties is greater than spatial variability. In other words measurements in two separate canals may be similar while measurements in one individual canal performed in different dates may be radically different. Hence, to account for more variance additional measurements at different dates were required to characterize canal waters, and diel measurements had to be increased from 24 hours to 72 hours.

ADAPTIVE MANAGEMENT

Increasing the length of diel measurements to make our conclusions more statistically robust also render a more complete dataset which may be used for testing compliance with FDEP Dissolved Oxygen regulations (*Rule 62-302.533, F.A.C.)*

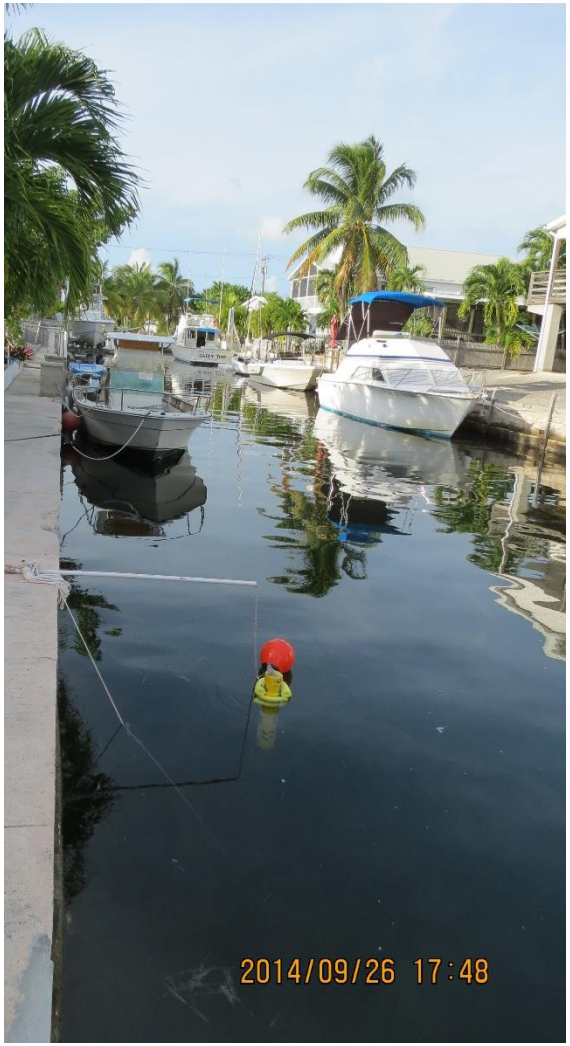
Demonstration canals included in this report



FIU photo by J. Duquesnel – Canal #472

- **First project**: Backfilling at **Canal #29** in Sexton Cove in Key Largo. Completed in July 2015.
- **Second project**: Culvert Installation to connect **Canals #472** and #470, on Geiger Key. Initially completed in April 2015, was later closed until May 2016.
- **Third project**: Combined Organic Removal and Air Curtain Installation on **Canal #266** at Drs. Arm and Avenue J in Big Pine Key. Completed in May 2016.

Demonstration canals included in this report



FIU photo by J. Duquesnel – Canal #472

- **Fourth project**: Organic Muck Removal Project on **Canal #290** Avenue I on Big Pine Key. Completed in March 2016.
- **Fifth project**: Installation of a culvert under a roadway and private property connected two portions of **Canal #277**. Completed in May 2016.
- **Sixth project**: Air Curtain Weed Gate Installation for **Canal #287** in Atlantic Estates on Big Pine Key. Completed June 2016.

Canal #29. Remediation technology: Backfilling. Completed Jul-15

%DO Saturation

			Pre-remediation		Post-remediation		
			31-Mar-14	16-Oct-14	4-Feb-16	28-Apr-16	27-Aug-16
% Dissolved Oxygen Saturation	**Surface water**	**29**					
		Control 28					
	Bottom water	**29**					
		Control 28					

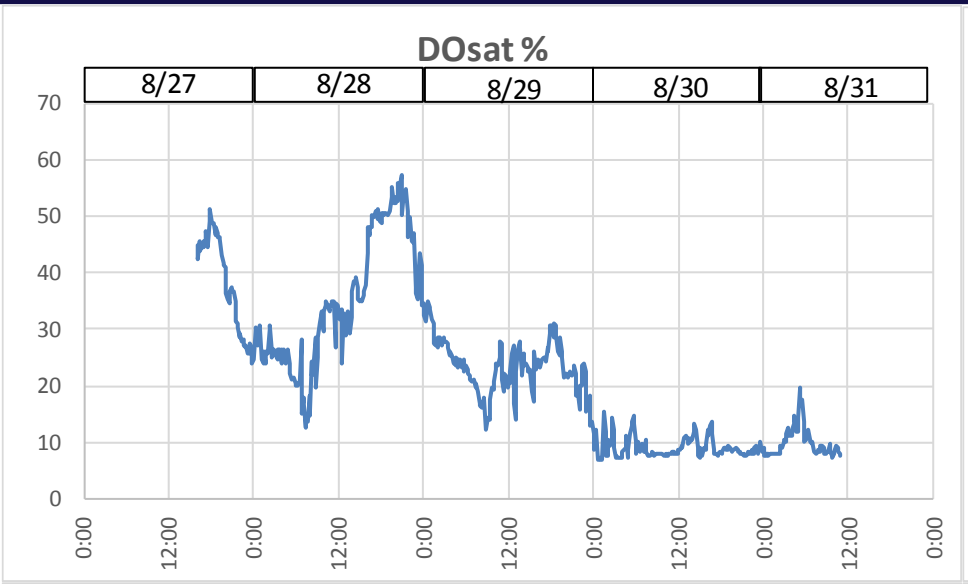
LEGEND

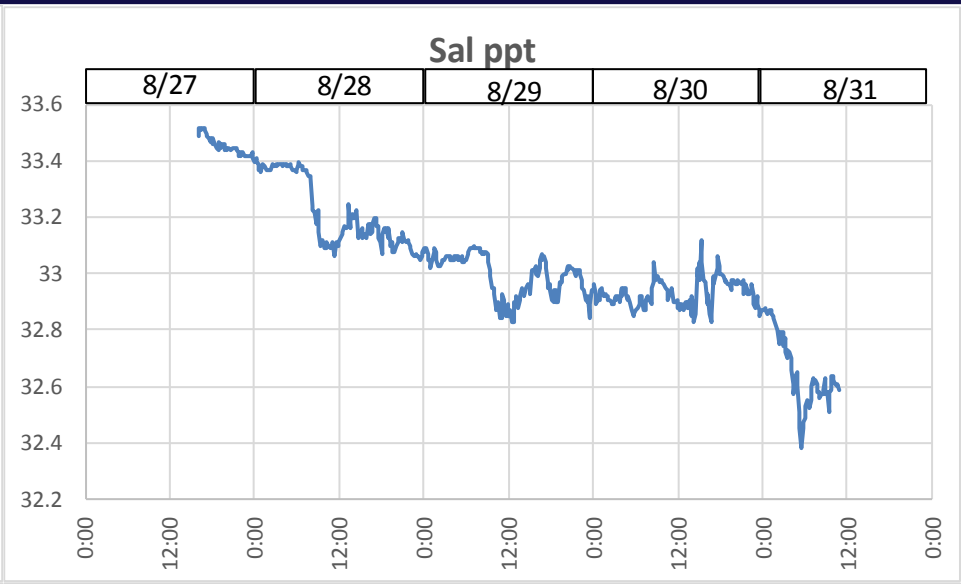
Above Target

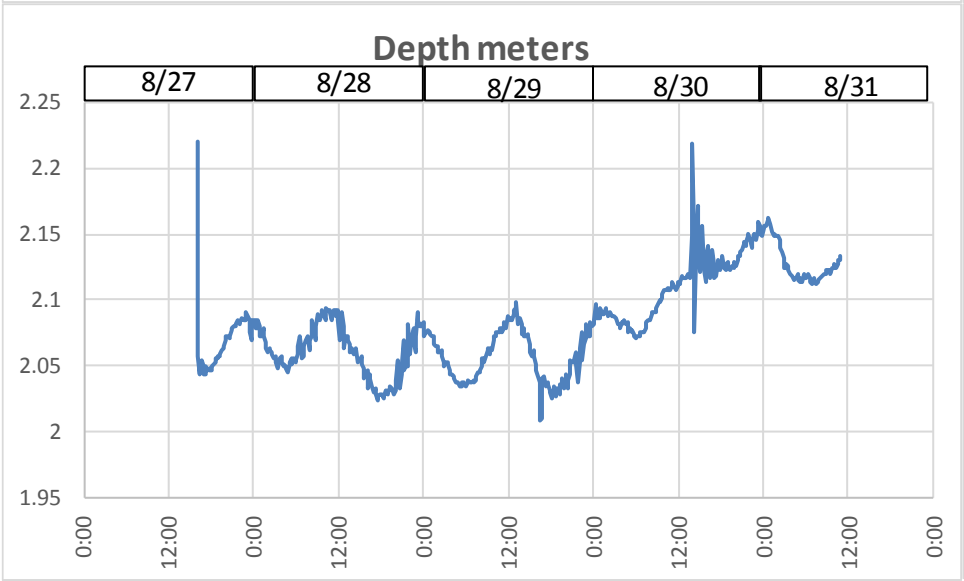
Below Target

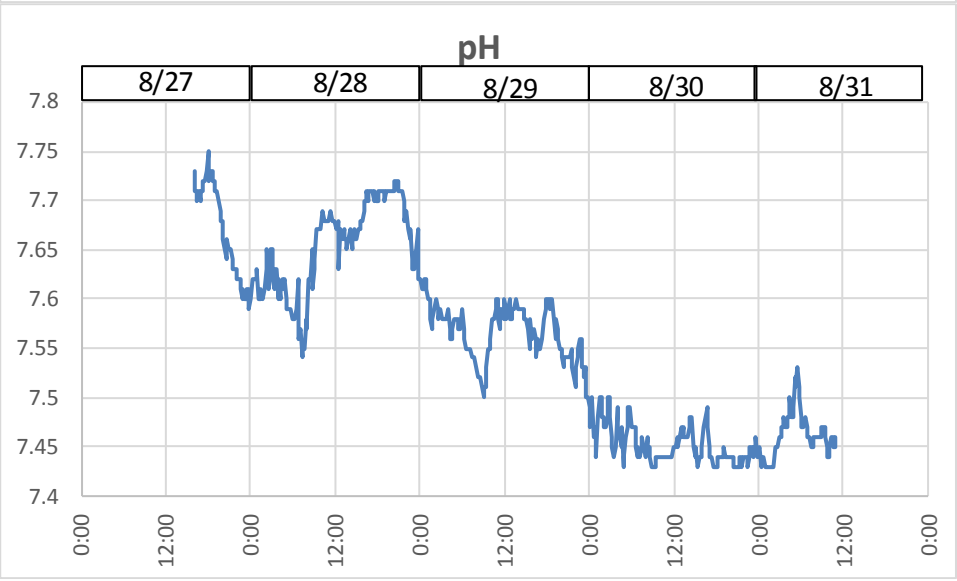
Oxygenation has improved significantly in bottom waters of the remediated canal. Bottom DO declined in Aug 2016 due to storm Hermine.

- Surface waters well oxygenated before and after remediation
- Surveys show increase %DO saturation in shallower new bottom waters after the canal's depth was risen from 35 feet to just 8 feet
- Rain and wind during TS Hermine may have caused a drop in %DOSat


DOsat %
8/27
8/28
8/29
8/30
8/31
70
60
50
40
30
20
10
0
0:00
12:00


Sal ppt
8/27
8/28
8/29
8/30
8/31
33.6
33.4
33.2
33
32.8
32.6
32.4
32.2
0:00
12:00


Depth meters
8/27
8/28
8/29
8/30
8/31
2.25
2.2
2.15
2.1
2.05
2
1.95
0:00
12:00


pH
8/27
8/28
8/29
8/30
8/31
7.8
7.75
7.7
7.65
7.6
7.55
7.5
7.45
7.4
0:00
12:00

Canal #29. Remediation technology: Backfilling. Completed Jul-15

Nutrients

			Pre-remediation		Post-remediation	
			31-Mar-14	16-Oct-14	4-Feb-16	
Total Phosphorus	**29**	**Surface water**				
	Control 28					
	29	**Bottom water**				
	Control 28					
Total Nitrogen	**29**	**Surface water**				
	Control 28					
	29	**Bottom water**				
	Control 28					

LEGEND

- **Above Target**
- **Below Target**

TN has always been in compliance while TP still remains too high

- Pre-remediation and first post-remediation surveys rendered TP concentrations out of compliance
- Surface and Bottom TN concentrations in compliance in all events before and after remediation

Canal #472. Remediation technology: Culvert installation. Completed May-15 and was closed shortly after, unplugged May-16

			Pre-remediation		Post-remediation			
					Culvert open		Culvert closed	Culvert open
			22-May-14	25-Oct-14	4-May-15	7-May-15	4-Aug-15	20-May-16
% Dissolved Oxygen Saturation	**472**	**Surface water**						
	Control 458							
	Connection 470							
	472	**Bottom water**						
	Control 458							
	Connection 470							

LEGEND

- Above Target
- Below Target

Mixed results. No definitive improvement trend for bottom waters after re-opening culvert

- Surface waters well oxygenated during monitoring before and after remediation. Heavy seaweed build up observed in late May 2015
- %DO saturation increased in bottom waters of remediated canal when culvert was opened the first time indicating an enhancement of natural tidal flushing

Canal #472. Remediation technology: Culvert installation. Completed

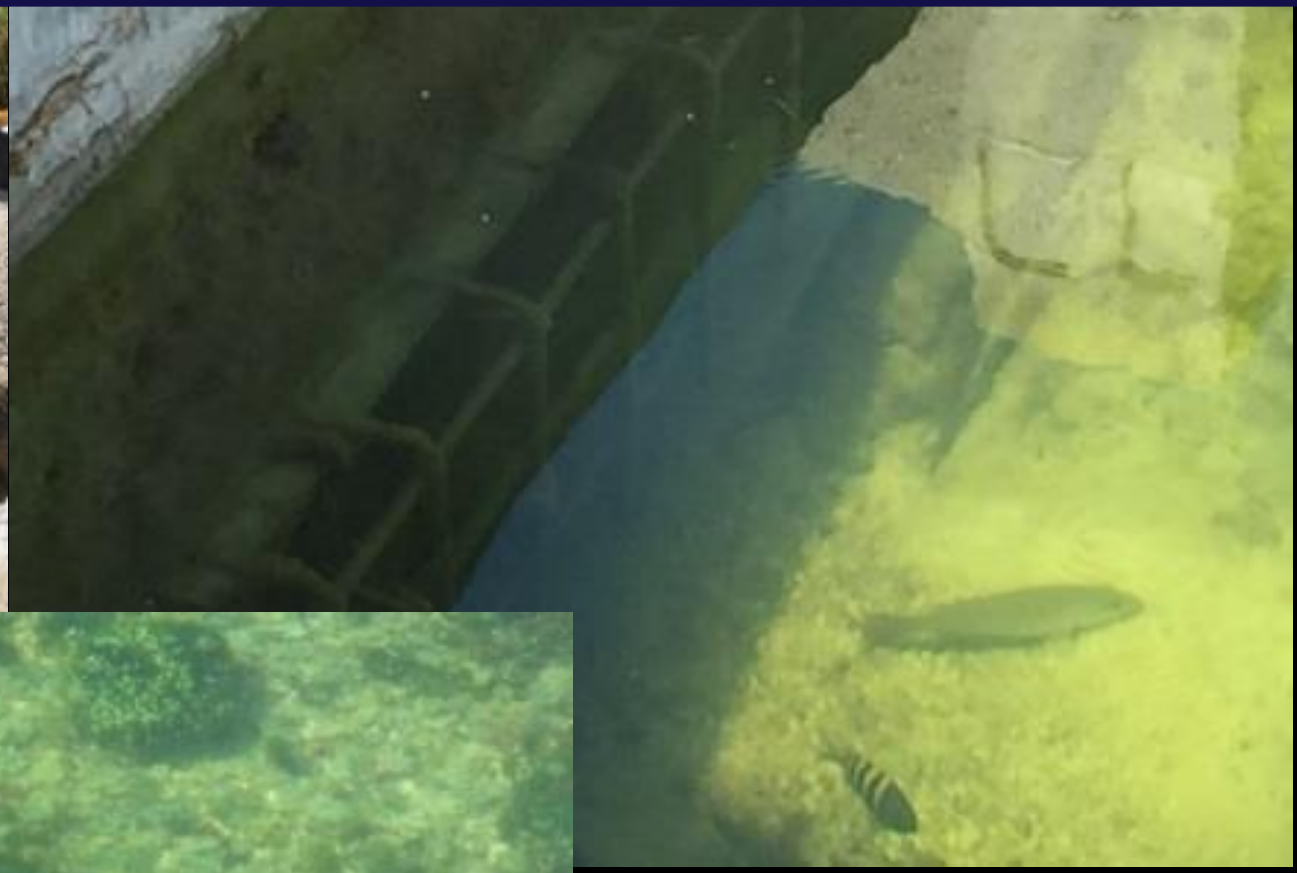
			Pre-remediation		Post-remediation			
					Culvert open		Culvert closed	Culvert open
			9-May-14	15-Oct-14	29-Apr-15	29-Jun-15	1-Aug-15	20-May-16
Total Phosphorus	**472**	**Surface water**						
	Control 458							
	Connection 470							
	472	**Bottom water**						
	Control 458							
	Connection 470							
Total Nitrogen	**472**	**Surface water**						
	Control 458							
	Connection 470							
	472	**Bottom water**						
	Control 458							
	Connection 470							

LEGEND

- **Above Target**
- **Below Target**

No definitive improvement trend yet. New survey will be performed during Sep 2016

- Surface and Bottom TP concentrations out of compliance in most events before and after remediation
- Pre-remediation surveys rendered TN concentrations out of compliance



Pictures: Monroe County website

Canal #266. Remediation technology: Weed barrier/organic removal. Completed May-2016

			Pre-remediation		Post-remediation
			7-May-14	14-Oct-14	21-Jun-16
% Dissolved Oxygen Saturation	**266**	**Surface water**			
	Control 293				
	266	**Bottom water**			
	Control 293				

LEGEND

- **Above Target**
- **Below Target**

No improvement trend yet.
New survey will be performed during Sep 2016

- Pre and post-remediation surveys showed highly variable %DO saturation in surface waters
- Pre and post-remediation surveys rendered %DO saturation in bottom waters out of compliance

Canal #266. Remediation technology: Weed barrier/organic removal. Completed May-2016

			Pre-remediation		Post-remediation
Total Phosphorus	**266**	**Surface water**			
	Control 293				
	266	**Bottom water**			
	Control 293				
Total Nitrogen	**266**	**Surface water**			
	Control 293				
	266	**Bottom water**			
	Control 293				

LEGEND

- **Above Target**
- **Below Target**

No data post-remediation available

- Surface and Bottom waters rendered TP and TN concentrations out of compliance before remediation

Canal #290. Remediation technology: Organic removal. Completed Mar-16.

			Pre-remediation			Post-remediation
			8-Jun-14	22-Sep-14	17-Aug-15	24-Jun-16
% Dissolved Oxygen Saturation	**290**	**Surface water**				
	Control 293					
	290	**Bottom water**				
	Control 293					

LEGEND

- Above Target
- Below Target

Mixed results. No improvement observed yet.

- Surface waters do not meet %DO saturation target either in most events during monitoring before or after remediation. Notice that an existing air curtain weed gate owned by the homeowners was reinstalled, but some seaweed has entered the remediated canal
- Vacuum dredging was usd to remove 5 feet of organic muck. Following removal of the muck, a 6-inch sand layer was added to allow for benthic habitat proliferation

Canal #290. Remediation technology: Organic removal. Completed Mar-16.

			Pre-remediation			Post-remediation
			7-May-14	14-Oct-14	24-Jun-15	
Total Phosphorus	**290**	**Surface water**				
	Control 293					
	290	**Bottom water**				
	Control 293					
Total Nitrogen	**290**	**Surface water**				
	Control 293					
	290	**Bottom water**				
	Control 293					

LEGEND

- **Above Target**
- **Below Target**

Remediation ended May 2016. Waiting for water chemistry test results

- Surface and Bottom waters rendered TP and TN concentrations out of compliance before remediation
- Beginning of chemical analyses to occur 6 months after remediation.

Canal #277. Remediation technology: Culvert installation. 20-Apr-2016

			Pre-remediation				Post-remediation
			6-Jun-14	23-Sep-14	14-Aug-15	7-Feb-16	30-Jun-16
% Dissolved Oxygen Saturation	**277**	**Surface water**					
	Control 282						
	277	**Bottom water**					
	Control 282						

LEGEND

- Above Target
- Below Target

No clear improving trend yet. Perhaps too early to detect significant changes

- Surface waters well oxygenated most of the time during monitoring before and after remediation. Water clarity with fish visible at the culvert entrance (MC, Jun 2016), although no differences in turbidity in S/B water has been observed after remediation
- Abundant blue-green algae mats floating on surface (#282) and abundant floating manatee grass present in canal #277
- %DO saturation in bottom waters of remediated canal remains below target values approx. 2 months after culvert was opened the first time

Canal #277. Remediation technology: Culvert installation. 20-Apr-2016

			Pre-remediation				Post-remediation
			7-May-14	15-Oct-14	24-Jun-15	17-Feb-16	
Total Phosphorus	**277**	**Surface water**					
	Control 282						
	277	**Bottom water**					
	Control 282						
Total Nitrogen	**277**	**Surface water**					
	Control 282						
	277	**Bottom water**					
	Control 282						

LEGEND

- Above Target
- Below Target

Waiting for results from test to be performed on Sep 2016

- Surface and Bottom TP concentrations out of compliance in most events before remediation
- Pre-remediation surveys rendered TN concentrations out of compliance

Canal #287. Remediation technology: Weed barrier. Completed Jun-16

			Pre-remediation				Post-remediation
			7-May-14	14-Oct-14	24-Jun-15	18-Feb-16	21-Jun-16
% Dissolved Oxygen Saturation	**287**	**Surface water**					
	Control 293						
	287	**Bottom water**					
	Control 293						

LEGEND

- Above Target
- Below Target

No clear improving trend yet. Perhaps too early to detect significant changes

- Surface waters well oxygenated during monitoring before and after remediation.
- %DO saturation in bottom waters of remediated canal remains below target values two weeks after the installation of the air curtain weed gate. Lots of suspended organic debris, settled on floats and sondes

Canal #287. Remediation technology: Weed barrier. Completed Jun-16

			Pre-remediation				Post-remediation
			7-May-14	14-Oct-14	24-Jun-15	18-Feb-16	
Total Phosphorus	**287**	**Surface water**					
	Control 293						
	287	**Bottom water**					
	Control 293						
Total Nitrogen	**287**	**Surface water**					
	Control 293						
	287	**Bottom water**					
	Control 293						

LEGEND

- **Above Target**
- **Below Target**

Waiting for results from test to be performed on Sep 2016

- Surface and Bottom waters rendered TP and TN concentrations out of compliance before remediation in both, control and treated canal

LESSONS LEARNED

- While actions like culvert installation and/or putting air bubblers in place may improve water quality, events like strong winds bringing seaweed wreck or increased stormwater contribution due to storms may temporally impair water quality.

- Water in backfilled canals remain turbid for a long time after remediation (more than a year in Canal #29 so far). Perhaps the use of coarser-grained fill material could help speeding up the recovery process in future projects.

LESSONS LEARNED

- Water quality in surface waters is usually good, except when events of water column overturn occur
- Water column in canals is commonly stratified. Deeper waters are hypoxic or anoxic, turbid, cooler and commonly saltier than surface waters.
- Nutrient concentrations in canal waters are significantly higher than surrounding (halo) waters.

Canal #	Project	Model Zone	FKC-01 Mar 14	FKC-02 Oct 14	FKC-03 Apr 15	FKC-04 Jul 15	Construction Jul 15	Construction Jan 16	FKC-05 Feb 16	Construction May 16	FKC 06-Ph I Apr 16	Construction June 16	FKC-06-Ph II Jun 16	TS Hermine Aug 16	FKC-07 Sep 16
29	Backfilling	10N													
137	Weed Barrier			Nov-14											
148		8S													
266	Weed Barrier / organic removal	4N						Jan-16 muck removal		May-16 Weed Barrier					
277	Culvert installation	4N													
459		2S													
472		3S		Apr-15			Culvert plugged			Culvert unplugge					
278	Pumping	4N													
287	Air Curtain Weed Gate	4N										Jun-16			
290	Organic removal (air curtain)	4N								Mar-16					

Remediation

Water sampling, Profiles & Diel

Only Diel

Tentative work schedule

Project	Canal #	*FKC-07*
Backfilling	29	Sep-16 D&N S&B
CONTROL	28	Sep-16 D&N S&B
Weed Barrier	137	Sep-16 D&N S&B
CONTROL	132	Sep-16 D&N S&B
Culvert installation	472	Sep-16 D&N S&B
Connection to 472-NEW	470	Sep-16 D&N S&B
CONTROL	458	Sep-16 D&N S&B
Air Curtain Weed Gate	287	Sep-16 D&N S&B
Organic removal (air curtain by homeowners)	290	Sep-16 D&N S&B
Weed Barrier / organic removal	266	Sep-16 D&N S&B
CONTROL	293	Sep-16 D&N S&B
Culvert installation	277	Sep-16 D&N S&B
CONTROL	282	Sep-16 D&N S&B

Legend: D (3-day Diels), S&B (Surface and Bottom water), N (Nutrient analysis)

Tentative deliverables schedule

Task	Due date following work execution	Deliverable
Quarterly monitoring FKC-06	90 days	Progress report
Reporting	90 days of the period end date	Bi-annual report
Quarterly monitoring FKC-07	90 days	Progress report
Quarterly monitoring FKC-08	90 days	Progress report
Quarterly monitoring FKC-09	90 days	Progress report
Reporting	90 days of the project period end date	Final report