WATER QUALITY MONITORING
Demonstration of Remediation Methods

Florida Keys Canals

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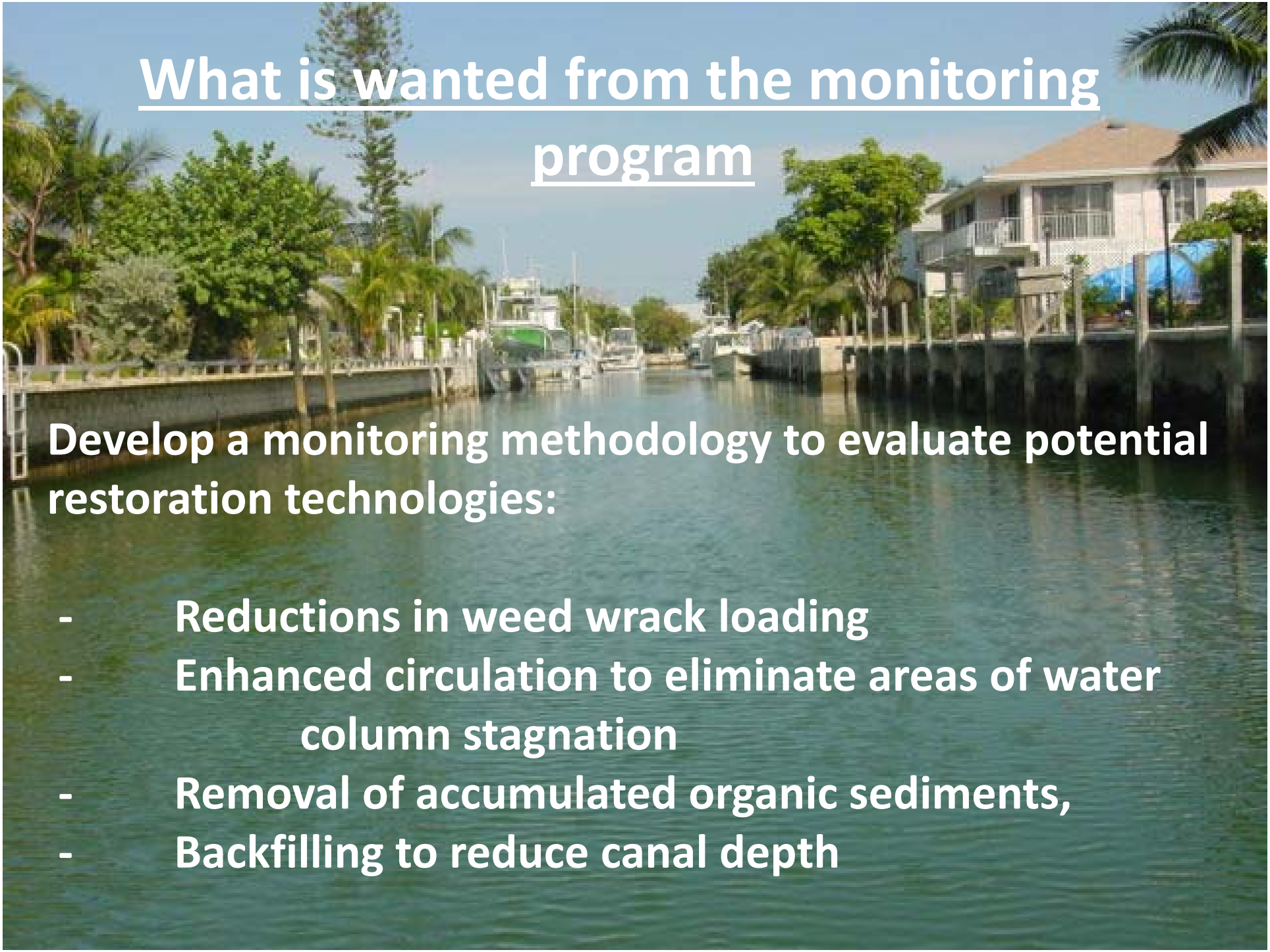
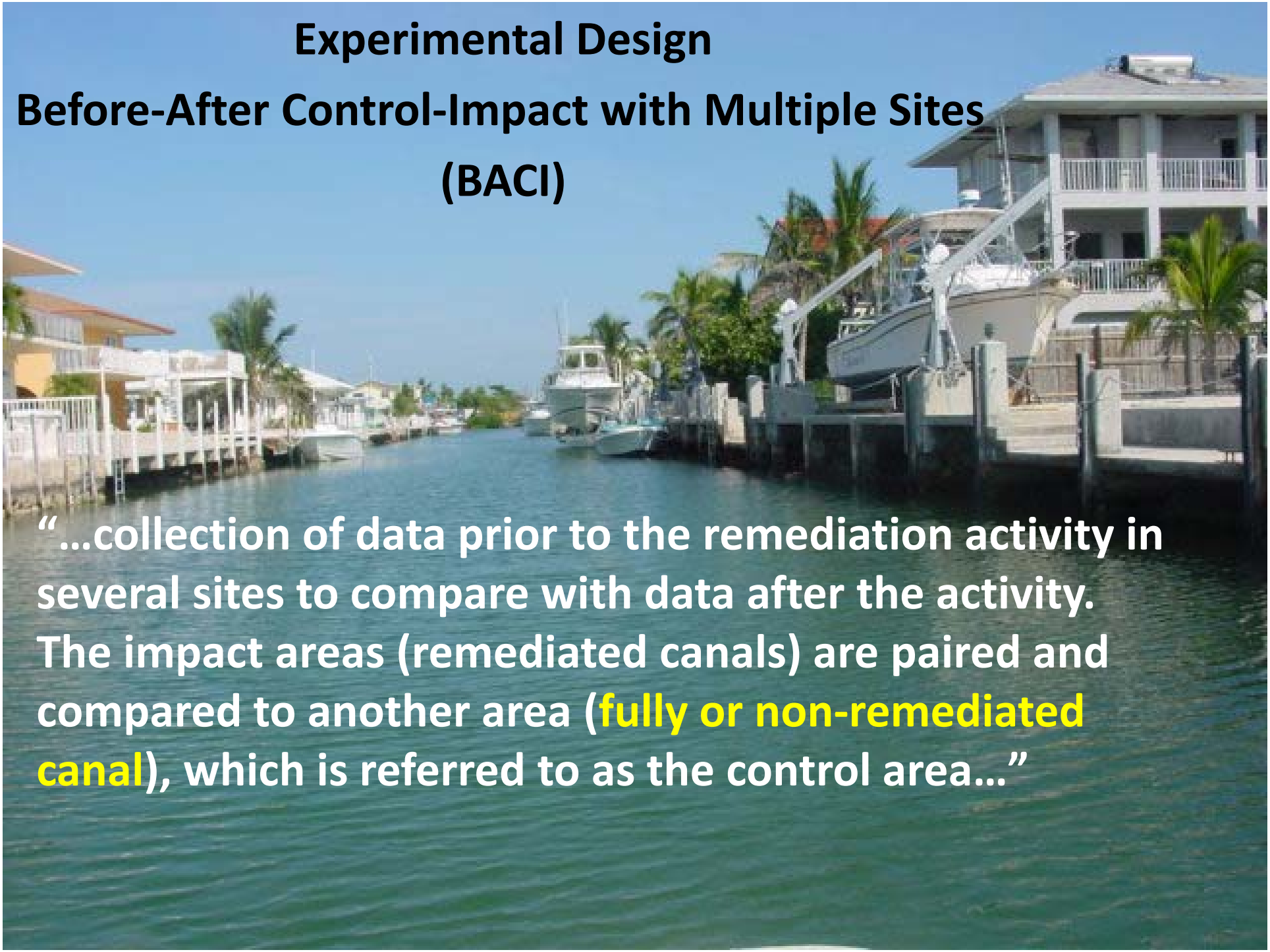


What is wanted from the monitoring program

Develop a monitoring methodology to evaluate potential restoration technologies:

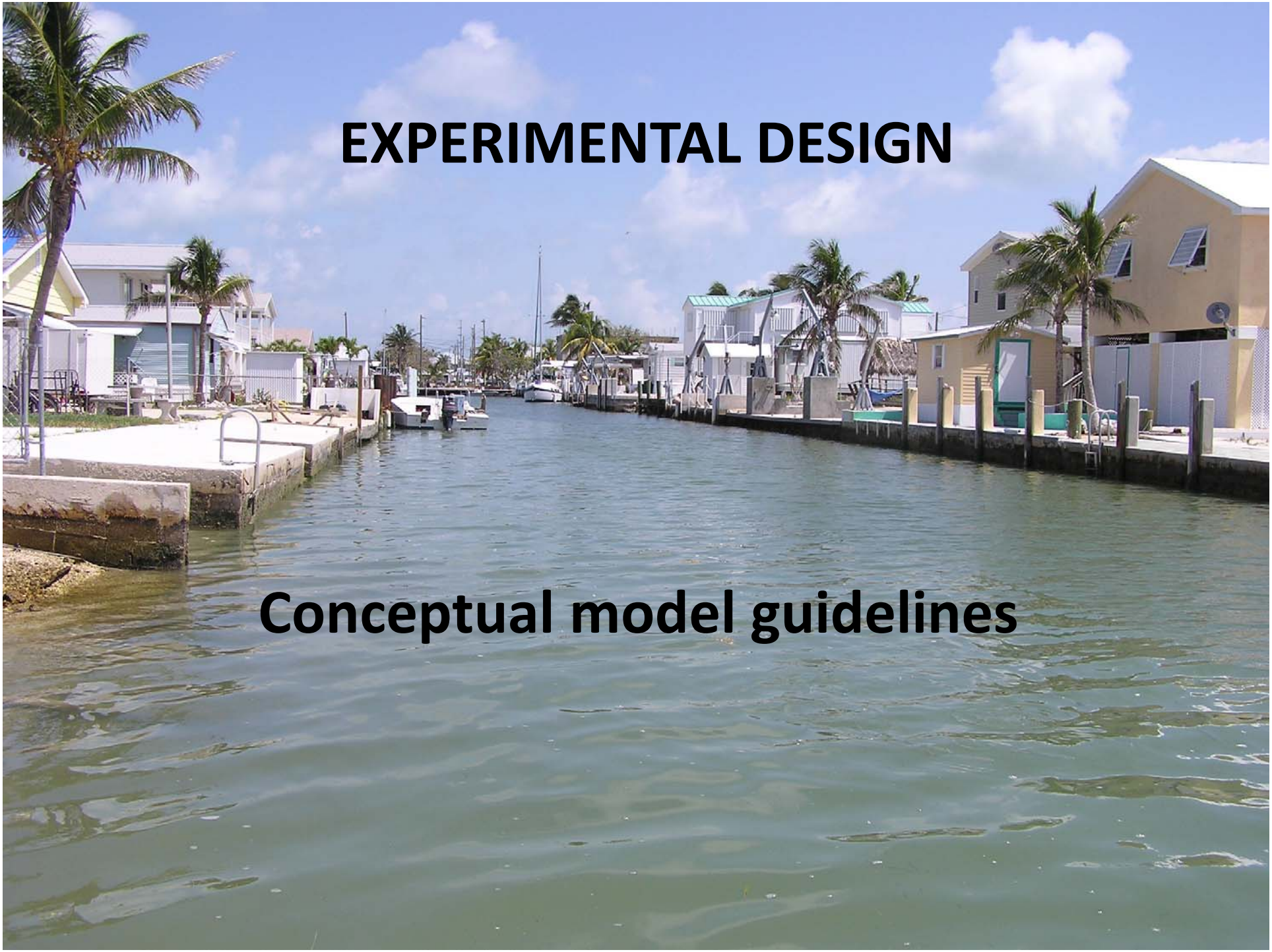
- **Reductions in weed wrack loading**
- **Enhanced circulation to eliminate areas of water column stagnation**
- **Removal of accumulated organic sediments,**
- **Backfilling to reduce canal depth**



Experimental Design

Before-After Control-Impact with Multiple Sites (BACI)

"…collection of data prior to the remediation activity in several sites to compare with data after the activity. The impact areas (remediated canals) are paired and compared to another area (fully or non-remediated canal), which is referred to as the control area…"



EXPERIMENTAL DESIGN

Conceptual model guidelines

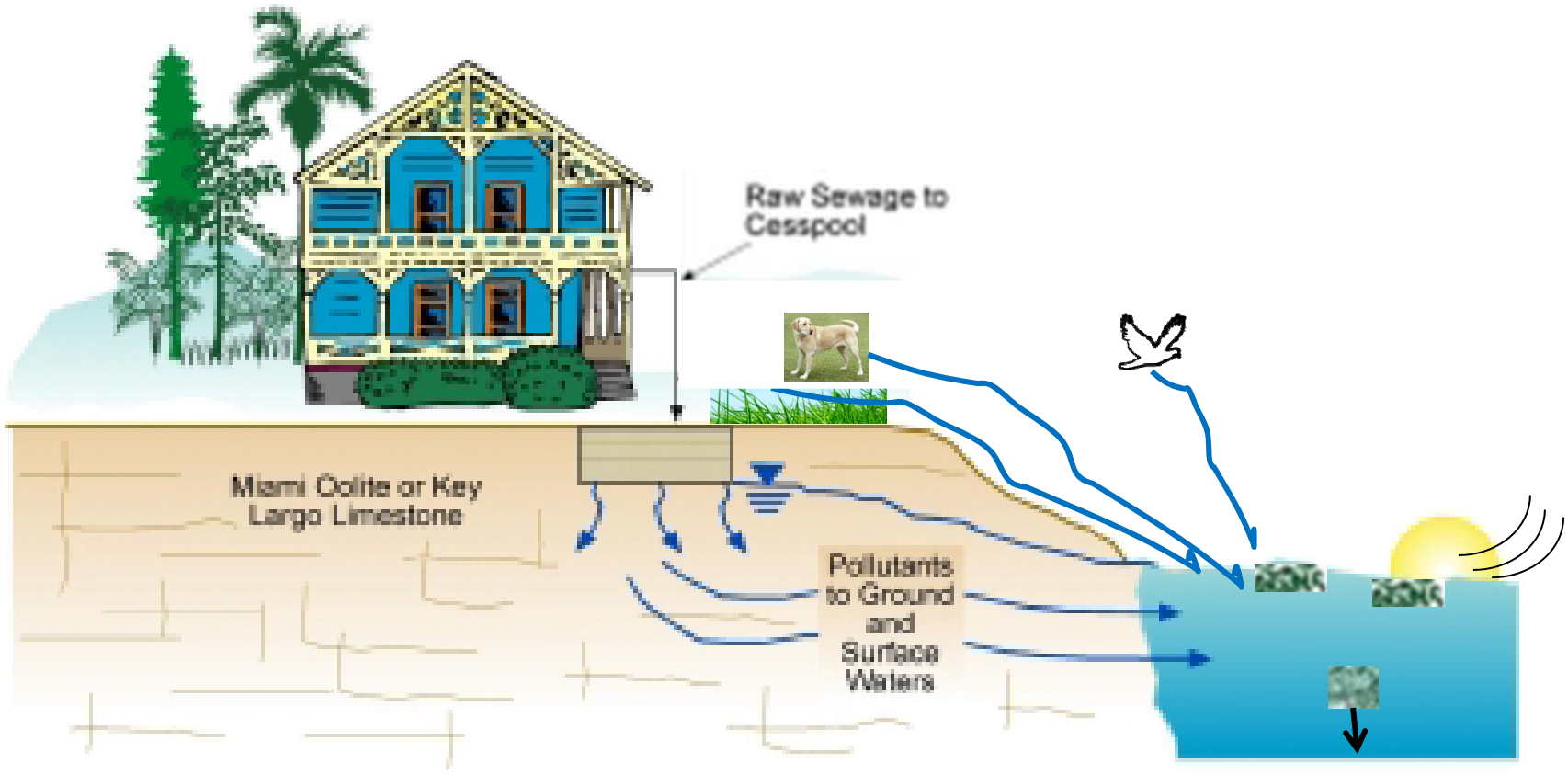


EXHIBIT 3-11
Early onsite wastewater systems in the Keys were cesspools or seepage pits, and provide little, if any, wastewater treatment.

Conceptual model guidelines

ACTION	GOAL	CONSEQUENCES	EXPECTED CHANGE	INDEX TOOLKIT
Reduce Weed Wrack Loading	**Reduce Organic Matter Load**	**DOM, POM and Nutrients decline. Decomposer Bacteria change**	**P declines**	**P**
			N declines	**N**
			BOD declines	**BOD, TOC**
			CHLa declines	**CHLa; Phyto-PAN**
			DO increases	**DO & %DO sat**
			DOM changes	**DOM; Parafac**
			Stratification	**CTD cast profiles**
			Bacteria type	**qPCR**

Parafac = DOM Parallel Factor Analysis to separate DOM into terrestrial humic-like, microbial-derived humic-like, and protein-like components.

qPCR = Quantitative Polymerase Chain Reaction (qPCR) assays for microbial source tracking of fecal contamination of surface waters (separates bird, dog, human source).

Conceptual model guidelines….

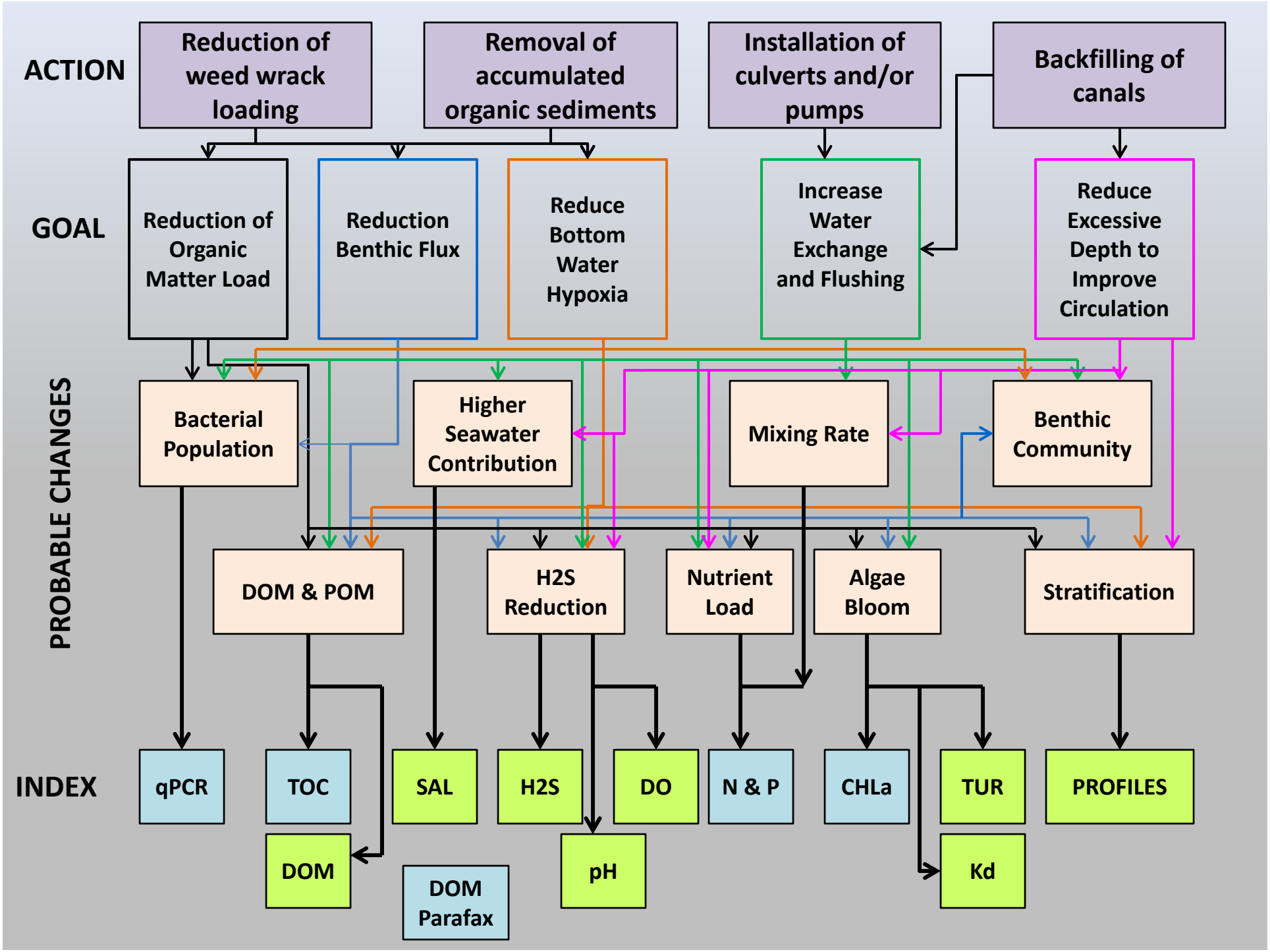
ACTION	GOAL	CONSEQUENCES	EXPECTED CHANGE	INDEX TOOLKIT
Installation of culverts	Reduce flushing time. Increase water circulation	Mixing increases Stratification declines Nutrient load declines Benthic community changes	P declines N declines BOD declines CHLa declines DO increases DOM changes Stratification Bacteria type Turbidity declines Salinity changes	Kd P N BOD, TOC CHLa; Phyto-PAN DO & %DO sat DOM; Parafax CTD cast profiles qPCR

Conceptual model guidelines….

ACTION	GOAL	CONSEQUENCES	EXPECTED CHANGE	INDEX TOOLKIT
Organic Sediment Removal	Reduce benthic flux & hypoxia Reduce chemical stratification	DOM and POM reduction Oxygen demands (organic /chemical) decline Hydrogen sulfide declines	P declines N declines BOD declines CHLa declines DO increases DOM changes H2S generation Stratification Bacteria type Turbidity declines Salinity changes	Kd P N BOD, TOC CHLa; Phyto-PAN DO & %DO sat DOM; Parafax CTD cast profiles qPCR H2S pH

Conceptual model guidelines….

ACTION	GOAL	CONSEQUENCES	EXPECTED CHANGE	INDEX TOOLKIT
Backfilling	Reduce excessive depth to improve circulation and reduce hypoxia	Stratification declines Oxygenation improves Hydrogen sulfide reduced	Light penetration P declines N declines BOD declines CHLa declines DO increases DOM changes H2S generation Stratification Bacteria type Turbidity declines Salinity changes	Kd P N BOD, TOC CHLa; Phyto-PAN DO & %DO sat DOM; Parafax CTD cast profiles qPCR H2S pH Redox


ACTION
Reduction of weed wrack loading
Removal of accumulated organic sediments
Installation of culverts and/or pumps
Backfilling of canals
GOAL
Reduction of Organic Matter Load
Reduction Benthic Flux
Reduce Bottom Water Hypoxia
Increase Water Exchange and Flushing
Reduce Excessive Depth to Improve Circulation
PROBABLE CHANGES
Bacterial Population
Higher Seawater Contribution
Mixing Rate
Benthic Community
DOM & POM
H2S Reduction
Nutrient Load
Algae Bloom
Stratification
INDEX
qPCR
TOC
SAL
H2S
DO
N & P
CHLa
TUR
PROFILES
DOM
DOM Parafax
pH
Kd

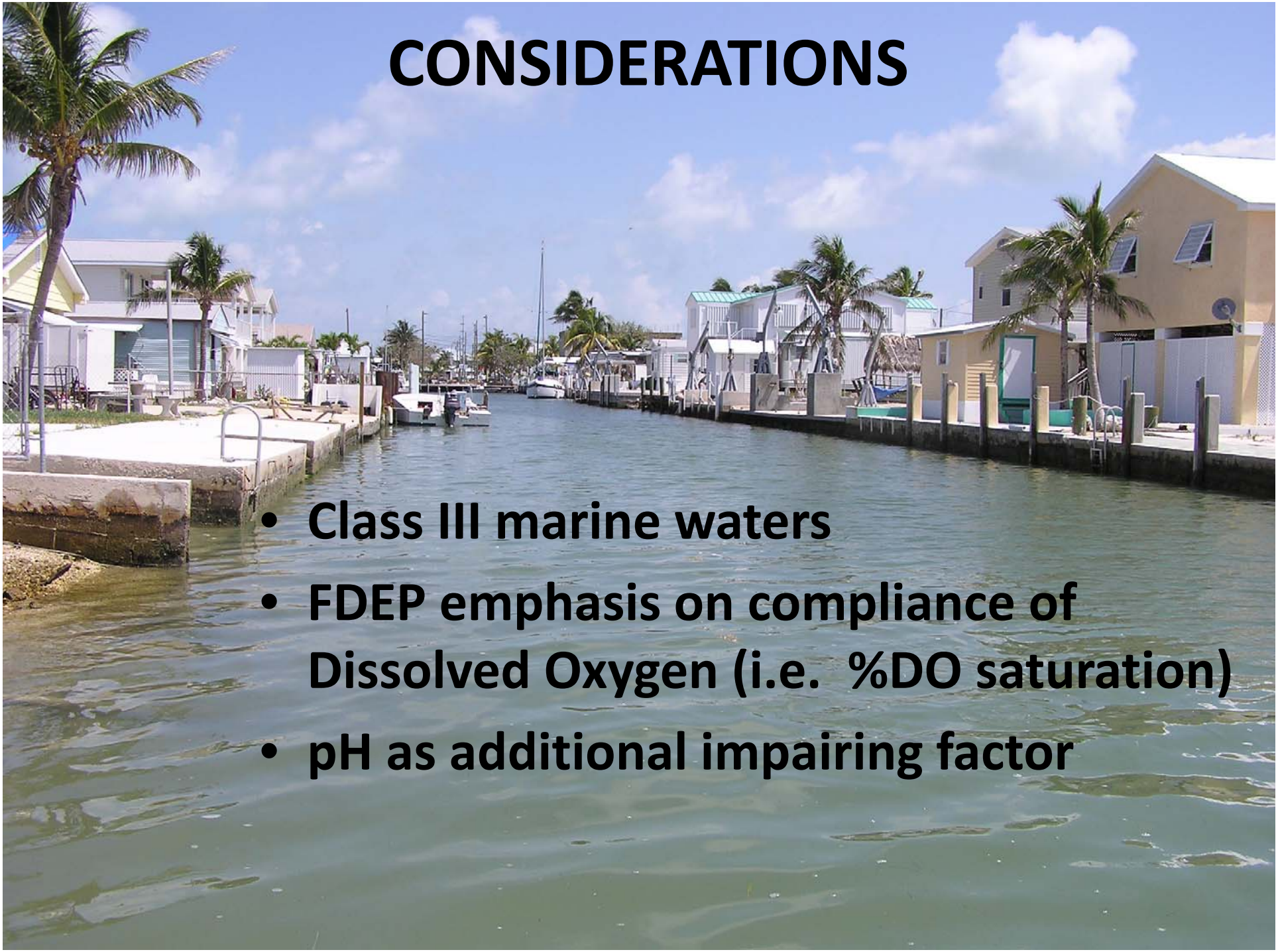
Selected Canal Demonstration Projects
Monroe County and Village of Islamorada
December 20, 2013

Weed Barrier	Organic Removal	Culvert Installation	Pumping	Backfilling
#266 Big Pine **Doctor's Arm Subdivision** between Witters and Bailey Lanes **#263 Control**	**#266 Big Pine** **Doctor's Arm Subdivision** between Witters and Bailey Lanes **#263 Control**	**#459 Geiger** **Boca Chica Ocean Shores Subdivision** between BocaChica Road and Jay Lane **#458 Control**	**#278 Big Pine** **Eden Pines Colony Subdivision** Pine Ave **# 286 Control**	**#29 Key Largo** **Sexton Cove Estates Subdivision** between Bunting and Pigeon Drives **#28 Control**
#137 Plantation Key **Treasure Harbor** MM 87 between Treasure Harbor Drive and Galleon Road **#132 Control**	**#290 Big Pine** between Avenue I and Avenue J **#293 Control**	**#277 Big Pine** **Tropical Bay Subdivision** between Watson and Sunset Roads **#282 Control**		
288 Big Pine **Hollerich Subdivision** between Hollerich and Hibiscus Drives **#287 Control**		**NEW DEP GRANT PROJECT** **#472 Geiger** **Geiger Mobile Homes Subdivision** between Caribbean Drive and Venus Lane **#476 Control**		
#148 Lower Matecumbe Key **Mate-Lido Beach** MM 76 between Ocean and Sea Lanes **#147 Control**				

CONSIDERATIONS

- Extension to three (3) years
- EPA comments and recommendations
- Nutrient levels are not expected to improve until adequate waste water treatment and storm water management systems are implemented

CONSIDERATIONS



- Class III marine waters
- FDEP emphasis on compliance of Dissolved Oxygen (i.e. %DO saturation)
- pH as additional impairing factor

(a) 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;
2. The seven-day average DO percent saturation shall not be below 51 percent more than once in any twelve week period; and
3. The 30-day average DO percent saturation shall not be below 56 percent more than once per year.

1.- 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.- 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

3.- To calculate a 30-day average DO percent saturation, there shall be a minimum of **three full days of diel data with at least one day of data collected in three different weeks** of the 30-day period

REFORMULATION

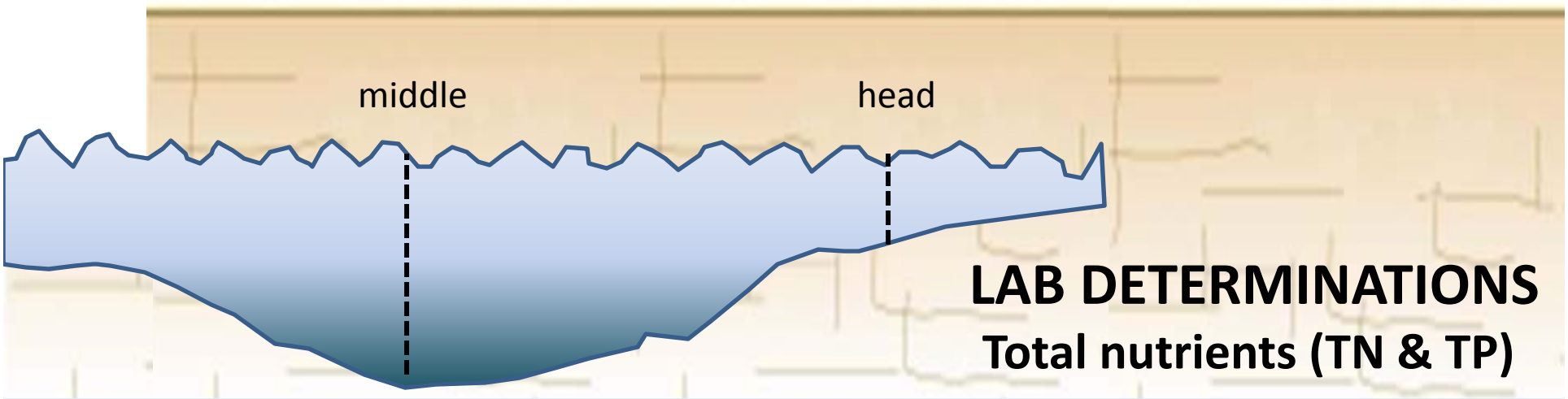
Reduce number of control canals

FDEP offered nutrient analysis

Hybrid program=water analysis+ parameters

Selected Canal Demonstration Projects Monroe County and Village of Islamorada					
Weed Barrier	**Organic Removal**	**Weed Barrier and Organic Removal**	**Culvert Installation**	**Pumping**	**Backfilling**
#137 Plantation Key Treasure Harbor	#290 Big Pine. Between Av I and J	#266 Big Pine. Dr. Arm Subdivision	#459 Geiger. Boca Chica Ocean Shores Subdivision	#278 Big Pine. Eden Pines Colony Subdivision	#29 Key Largo. Sexton Cove Estates Subdivision
#288 Big Pine. Hollerich Subdivision			#277 Big Pine. Tropical Bay Subdivision		
#148 Lower Matecumbe Key. Mate-Lido Beach			#472 Geiger. Geiger Mobile Homes Subdivision		
# 132 Control Canal	**# 293 Control Canal**	**#132/293 Control**	**# 458 Control Canal**	**# 286 Control Canal**	**# 28 Control Canal**

What and where to measure?



LAB DETERMINATIONS

Total nutrients (TN & TP)

PROFILES

Dissolved Oxygen	Depth	Salinity
%DO Saturation	Turbidity	Temperature
Light Attenuation	CDOM	**pH**

DIEL

Dissolved Oxygen, Turbidity, Conductivity, Salinity, Temperature, pH

Calendar

Profiles	BEFORE
Diel	
Analysis FIU WQ	
	REMEDIATION
	6 month
Profiles	SURVEY 1
Diel	
Analysis FIU WQ	
	3 month
Profiles	SURVEY 2
Analysis FIU WQ	
	3 month
Profiles	SURVEY 3
Diel	
Analysis FDEP WQ	
	3 month
Profiles	SURVEY 4
Analysis FIU WQ	
	3 month
Profiles	SURVEY 5
Diel	
Analysis FIU WQ	
	3 month
Profiles	SURVEY 6
Analysis FDEP WQ	
	3 months
Profiles	SURVEY 7
Diel	
Analysis FIU WQ	
	3 months
Profiles	SURVEY 9
Diel	
Analysis FDEP WQ	
FINAL REPORT	

Water Quality	DIEL	PROFILES
430	180	288

Scorecard

Monthly Report

TOPIC	GRADE	SUMMARY	LONG TERM	SHORT TERM
	65		▲	◀▶
	85		▼	▲
	35		▼	▼

TOPIC= % Oxygen Saturation; Clarity; Nutrients

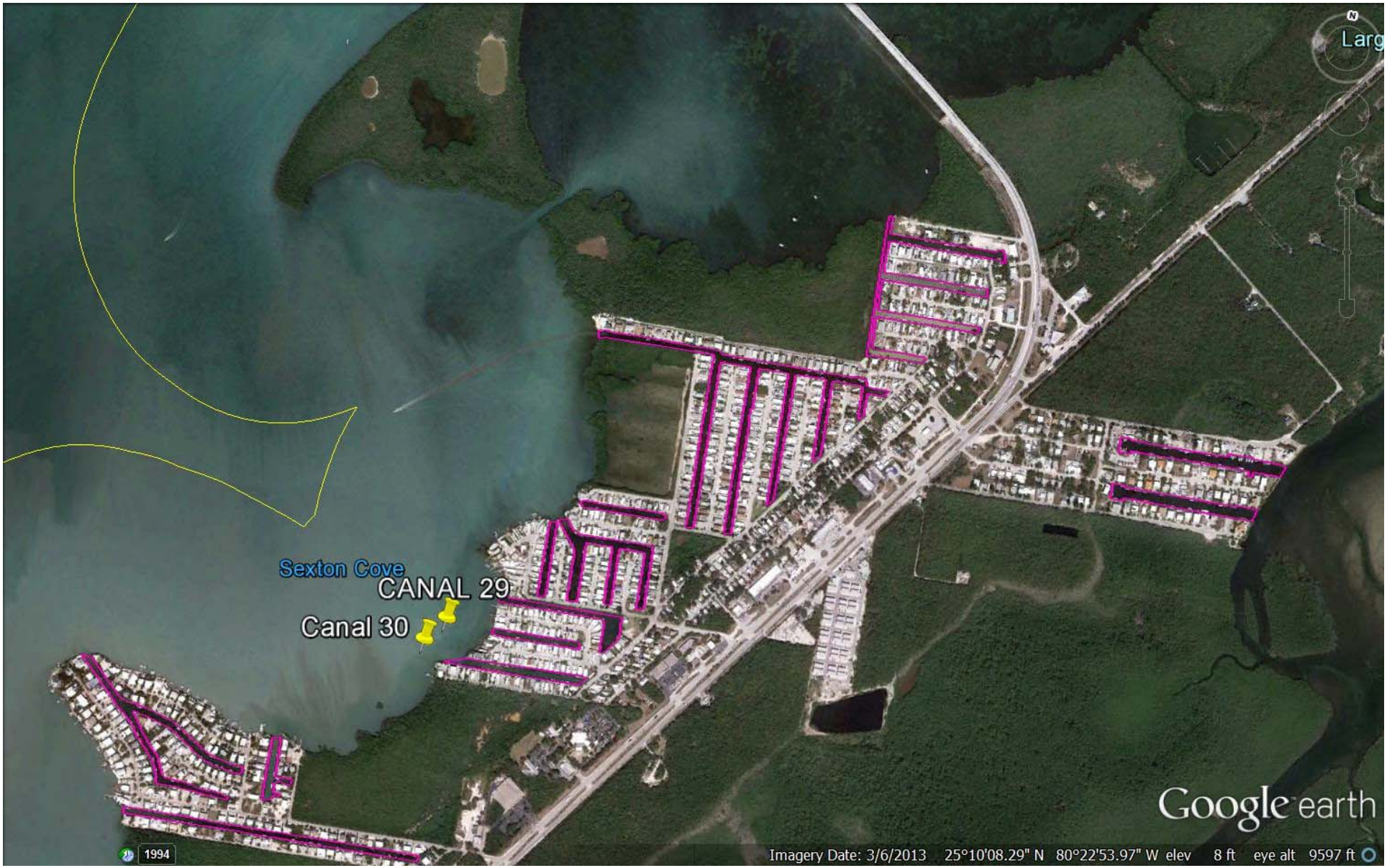
GRADE= Calculated in relation to established target for healthy water body

SUMMARY= Brief description on trend, events, short term

LONG-TERM= Linear Trend for whole Period of Record

SHORT-TERM= Relative position of last survey

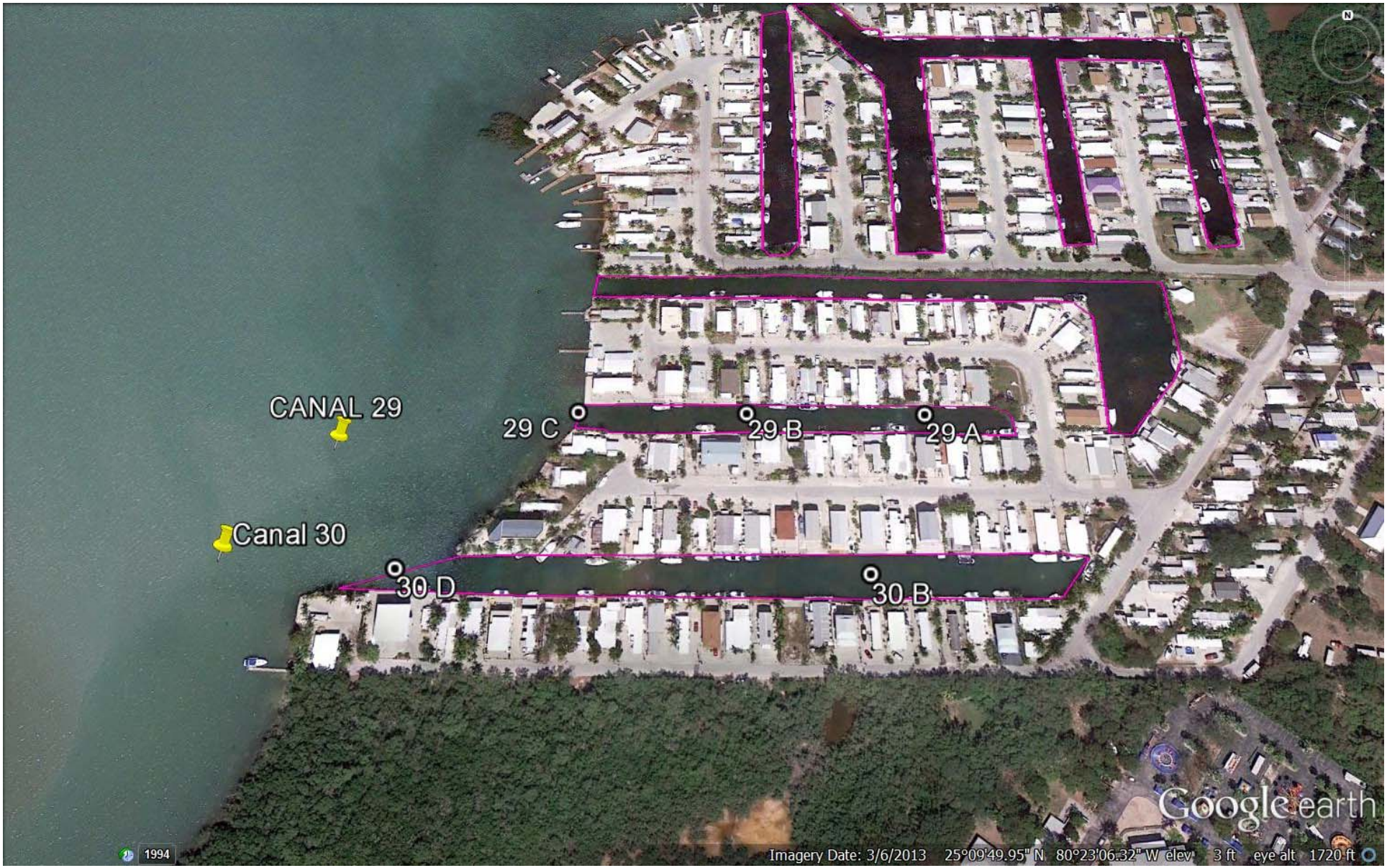
Preliminary Assessment

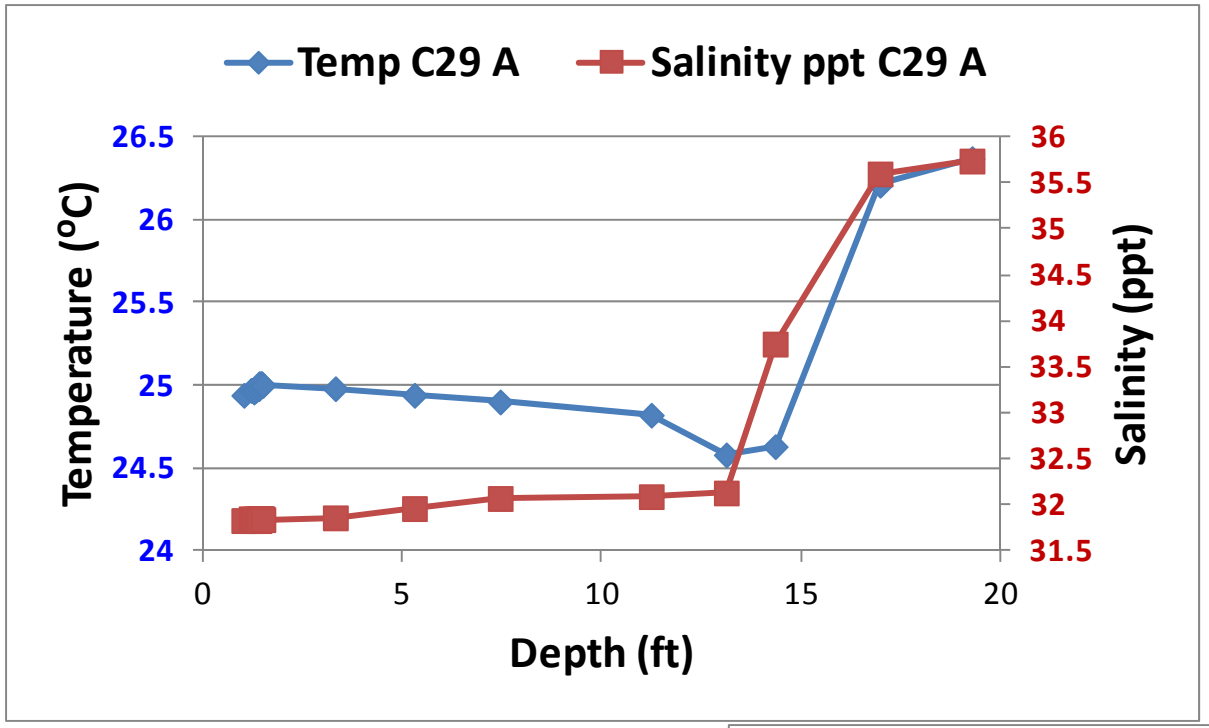

Sexton Cove
CANAL 29
Canal 30
Google earth
1994
Imagery Date: 3/6/2013 25°10'08.29" N 80°22'53.97" W elev 8 ft eye alt 9597 ft

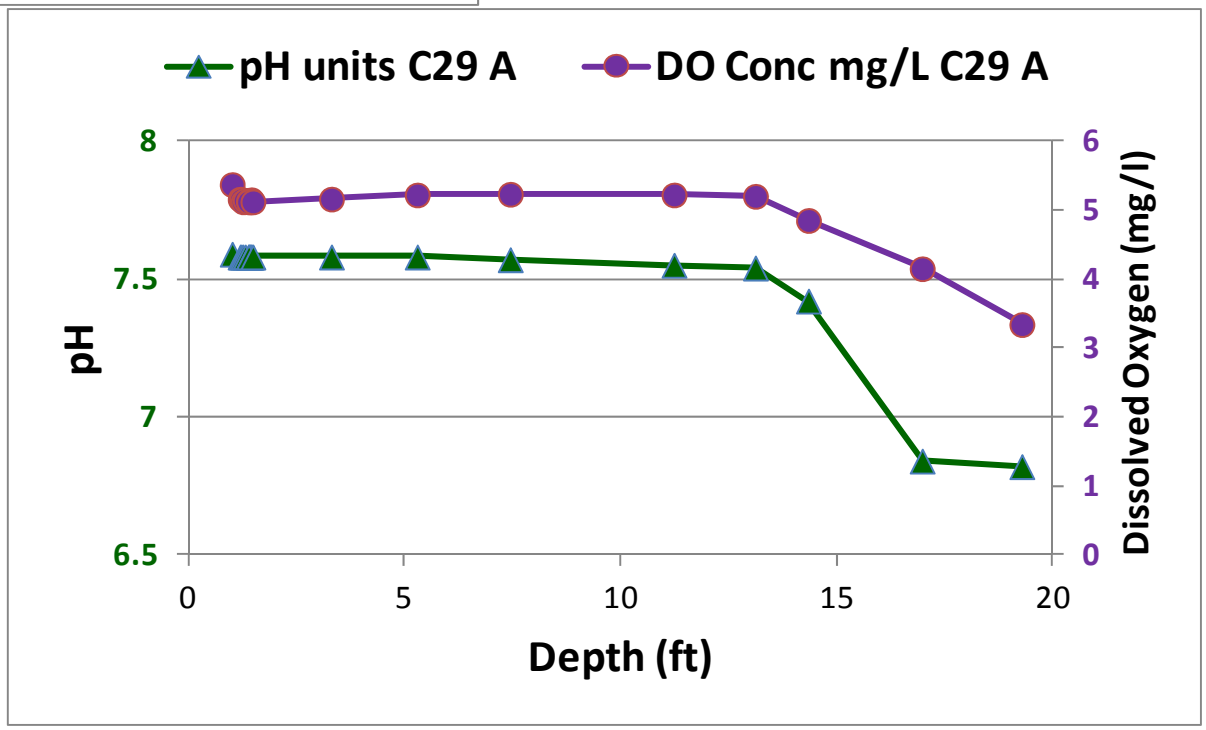
Key Largo

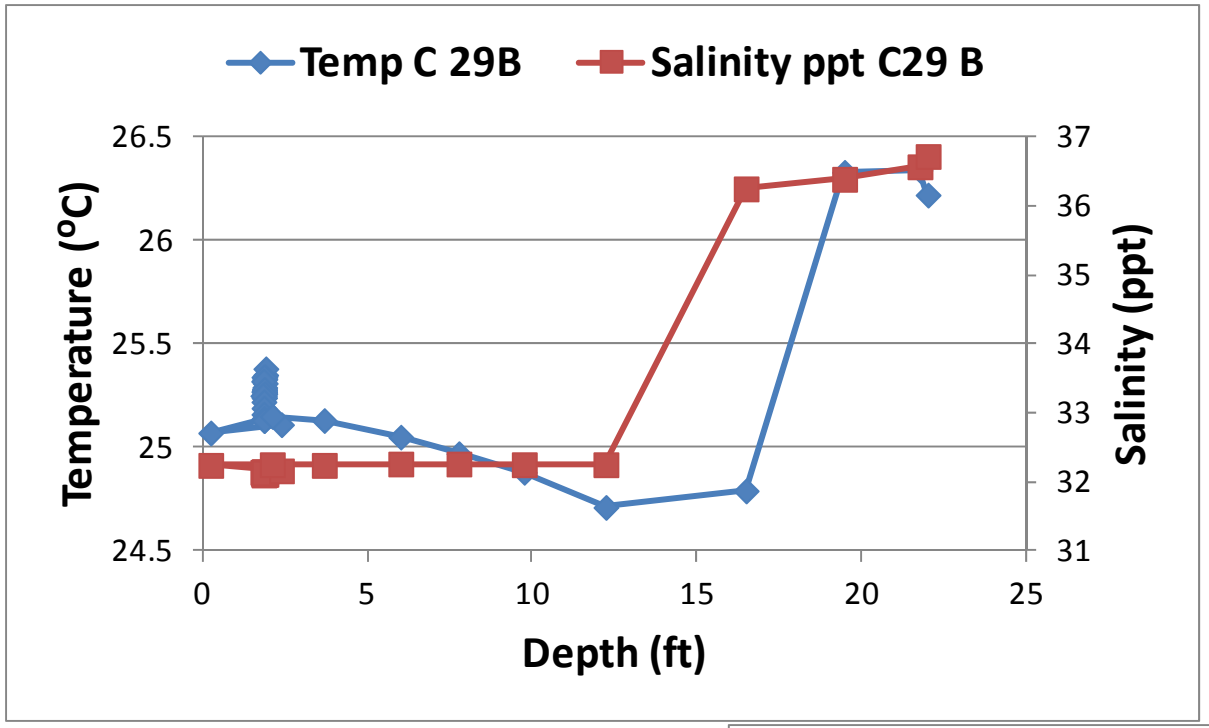
(Sexton Cove Estates)

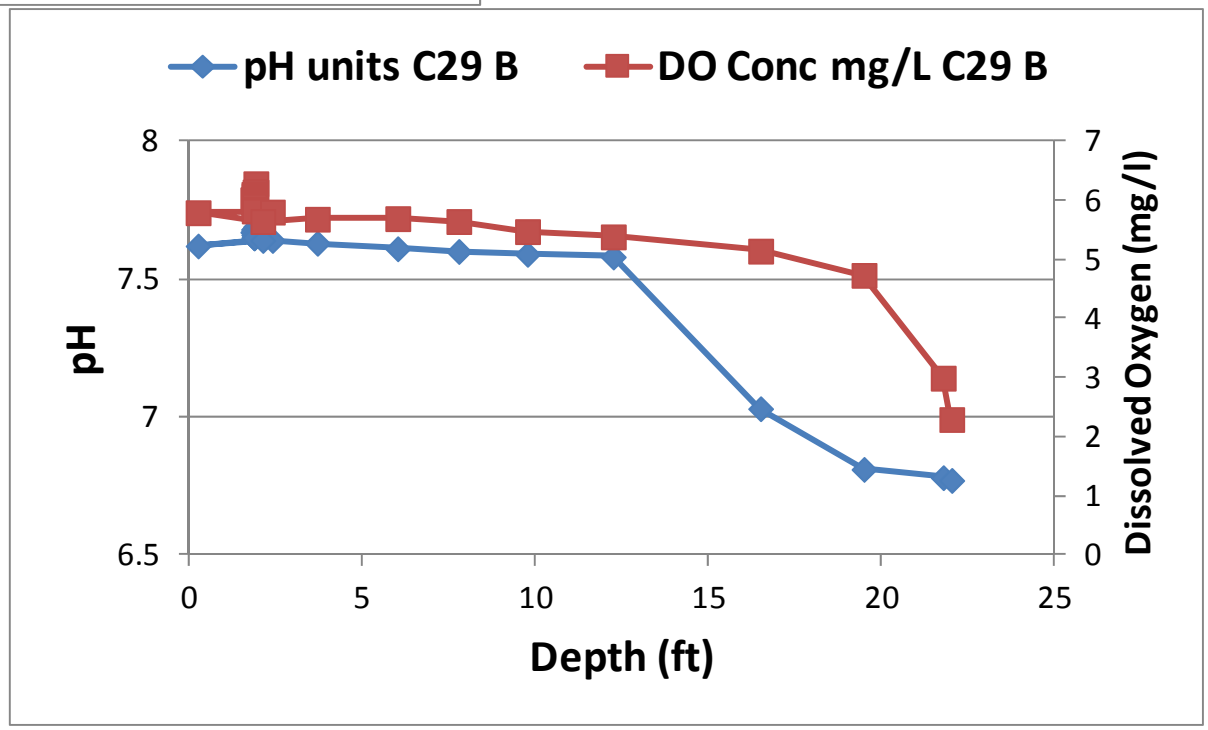
- BACKFILLING: Canal 29
  - 3 profiles
    - A (12')=2
    - B (27')=3
    - C (3')=1 Total=6 samples
- CONTROL: Canal 30
  - 2 profiles
    - B (23')= 3
    - D (3')= 1 Total=4 samples

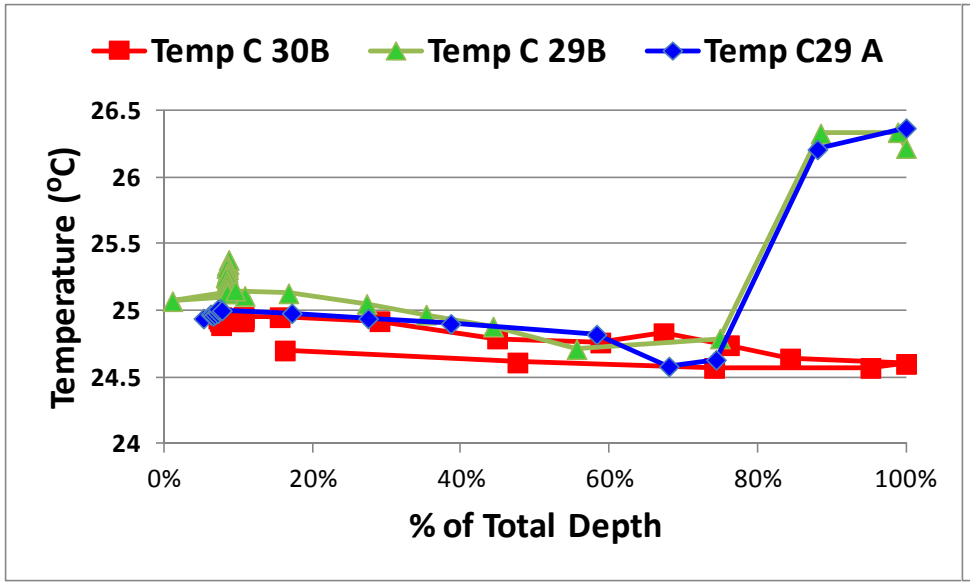

CANAL 29
29 C
29 B
29 A
Canal 30
30 D
30 B
Google earth
1994
Imagery Date: 3/6/2013 25°09'49.95" N 80°23'06.32" W elev 3 ft eye alt 1720 ft

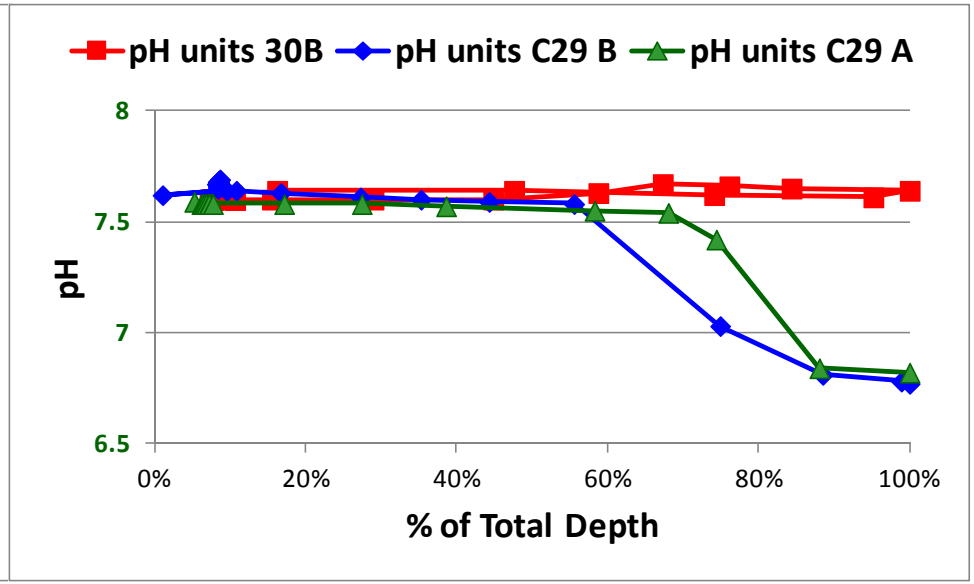

Temp C29 A
Salinity ppt C29 A
Temperature (°C)
26.5
26
25.5
25
24.5
24
36
35.5
35
34.5
34
33.5
33
32.5
32
31.5
Salinity (ppt)
0
5
10
15
20
Depth (ft)

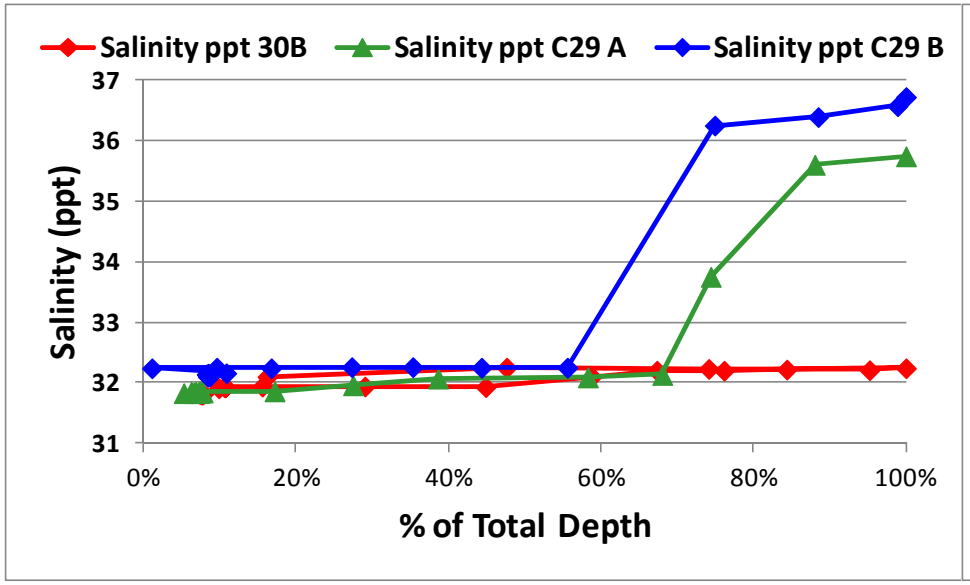

pH units C29 A
DO Conc mg/L C29 A
pH
8
7.5
7
6.5
6
5
4
3
2
1
0
Dissolved Oxygen (mg/l)
0
5
10
15
20
Depth (ft)

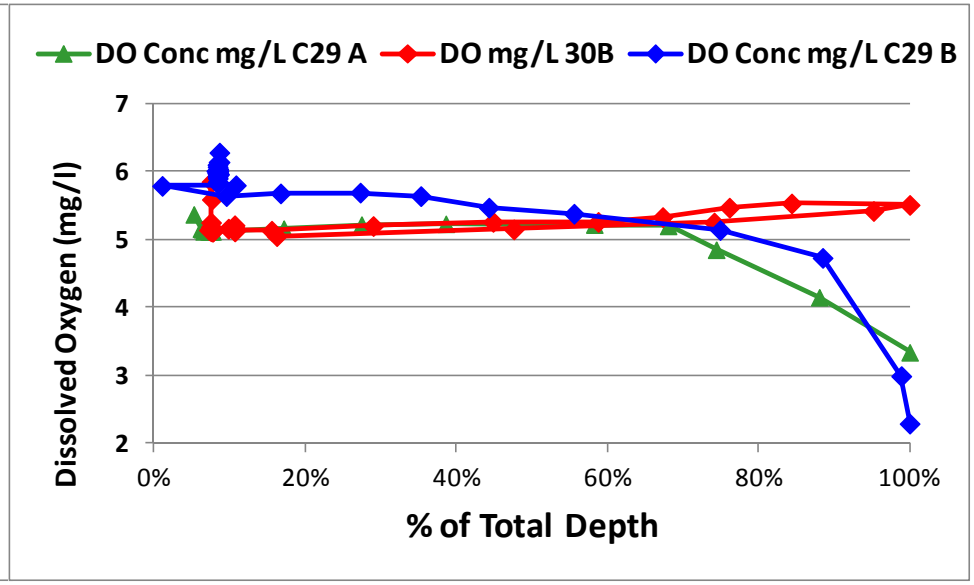

Temp C 29B
Salinity ppt C29 B
Temperature (°C)
Salinity (ppt)
Depth (ft)
26.5
26
25.5
25
24.5
37
36
35
34
33
32
31
0
5
10
15
20
25


pH units C29 B
DO Conc mg/L C29 B
pH
Dissolved Oxygen (mg/l)
Depth (ft)
8
7.5
7
6.5
7
6
5
4
3
2
1
0
0
5
10
15
20
25


Temp C 30B
Temp C 29B
Temp C29 A
Temperature (°C)
26.5
26
25.5
25
24.5
24
0%
20%
40%
60%
80%
100%
% of Total Depth


pH units 30B
pH units C29 B
pH units C29 A
pH
8
7.5
7
6.5
0%
20%
40%
60%
80%
100%
% of Total Depth


Salinity ppt 30B
Salinity ppt C29 A
Salinity ppt C29 B
Salinity (ppt)
37
36
35
34
33
32
31
0%
20%
40%
60%
80%
100%
% of Total Depth


DO Conc mg/L C29 A
DO mg/L 30B
DO Conc mg/L C29 B
Dissolved Oxygen (mg/l)
7
6
5
4
3
2
0%
20%
40%
60%
80%
100%
% of Total Depth

Thank you….

Field Crew

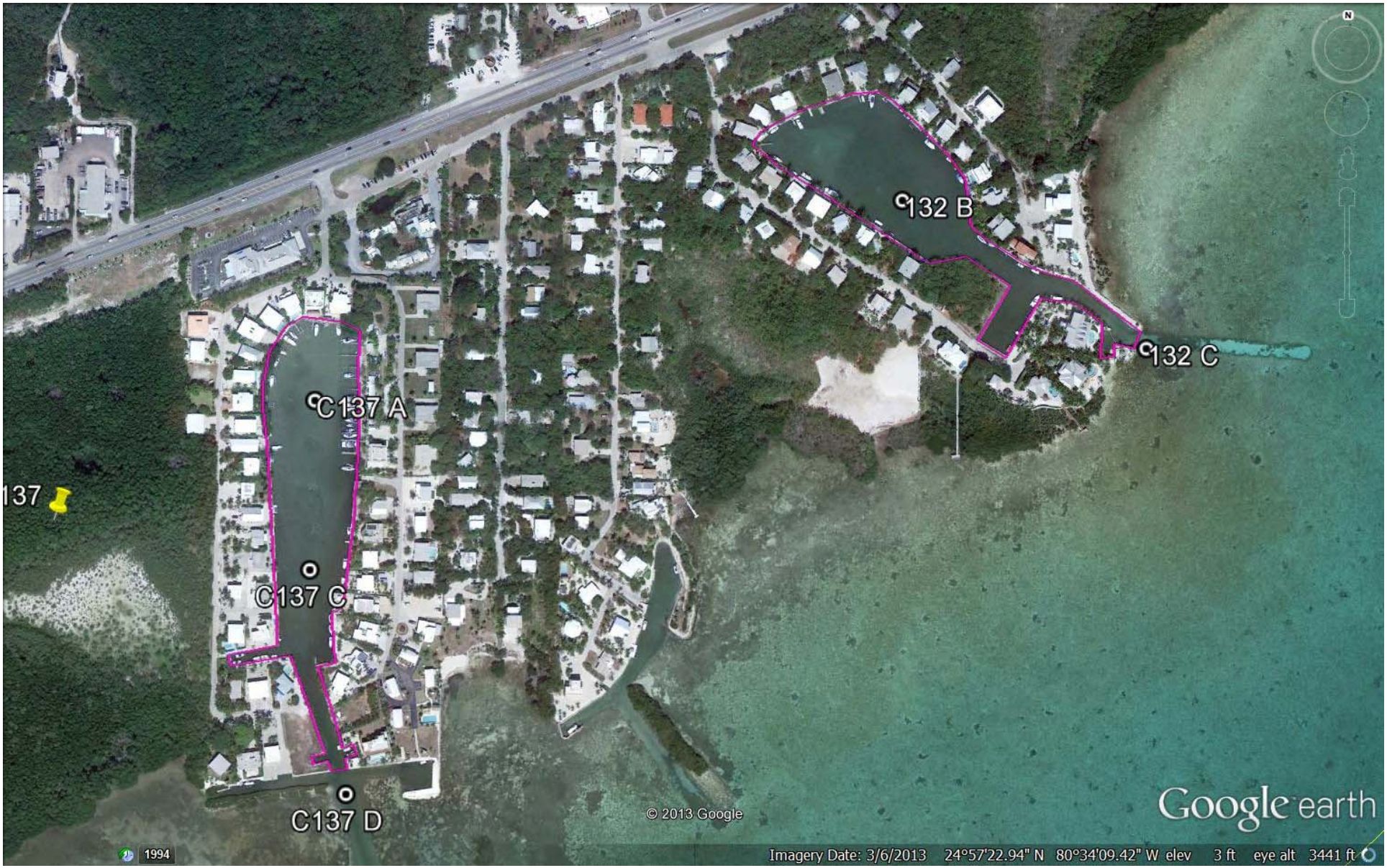
Jeff Absten
Nathan Lehmkuhl
Vicki McGee
Sandro Stumpf

Henry O. Briceño
Florida International University Southeast
Environmental Research Center
bricenoh@fiu.edu

Plantation Key

(Treasure Harbor)

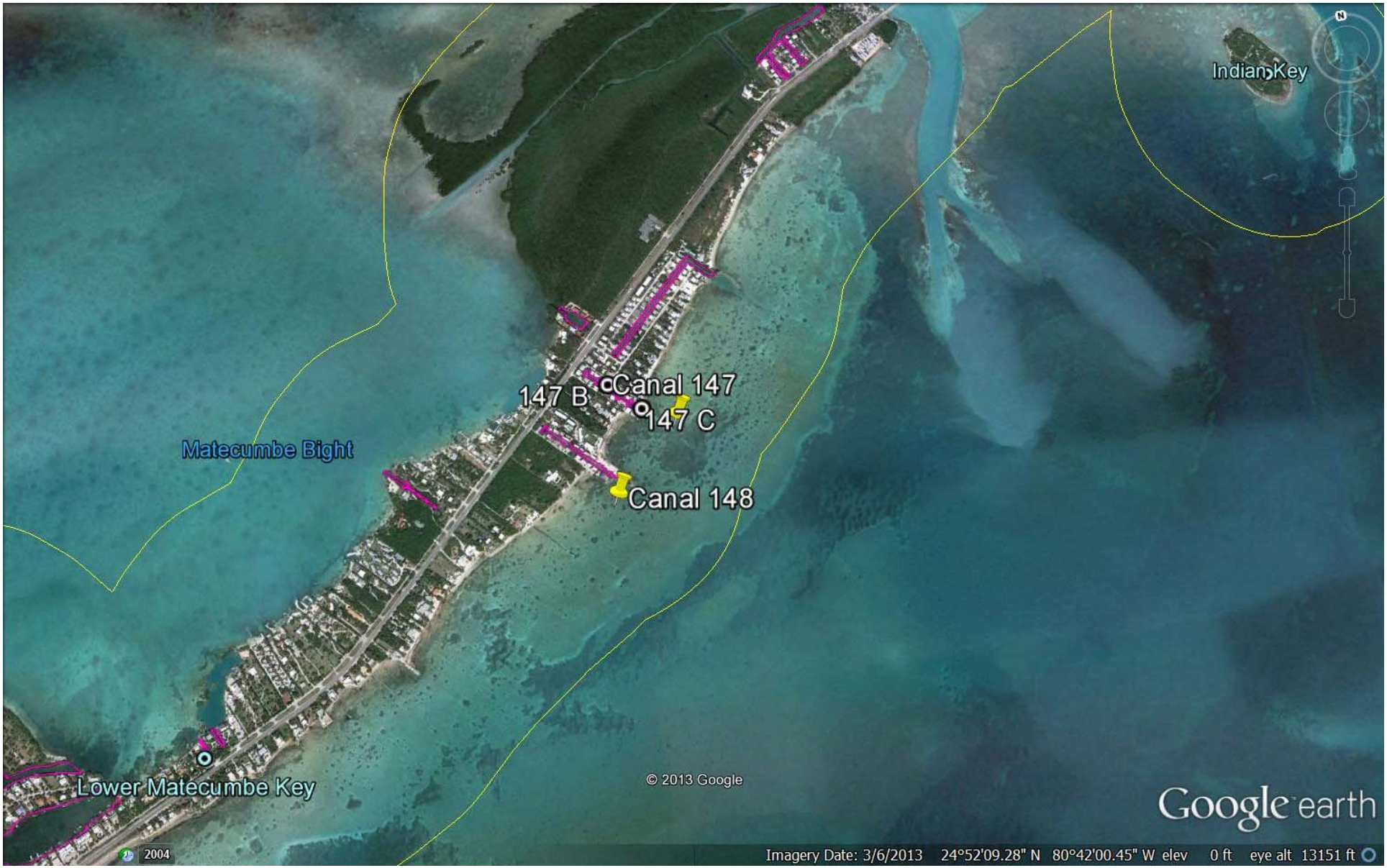
- WEED BARRIER: Canal 137
  - 3 profiles
    - A (14'?)=2
    - C (14')=3
    - D (3'?)=1 Total=5 samples
- CONTROL: Canal 132
  - 2 profiles
    - B (10')= 3
    - D (3'?)= 1 Total=4 samples

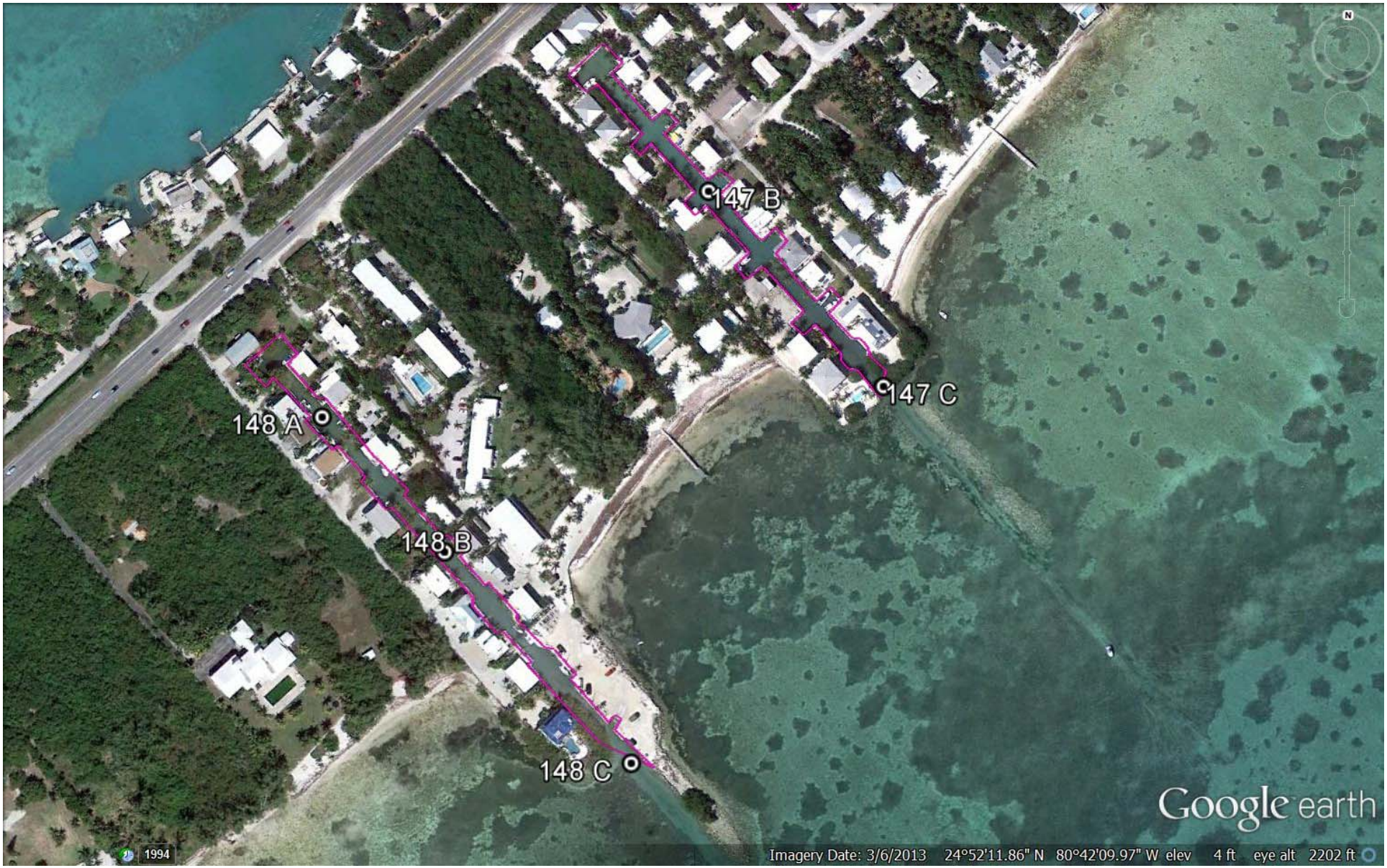

132 B
132 C
C137 A
137
C137 C
C137 D
© 2013 Google
Google earth
1994
Imagery Date: 3/6/2013 24°57'22.94" N 80°34'09.42" W elev 3 ft eye alt 3441 ft

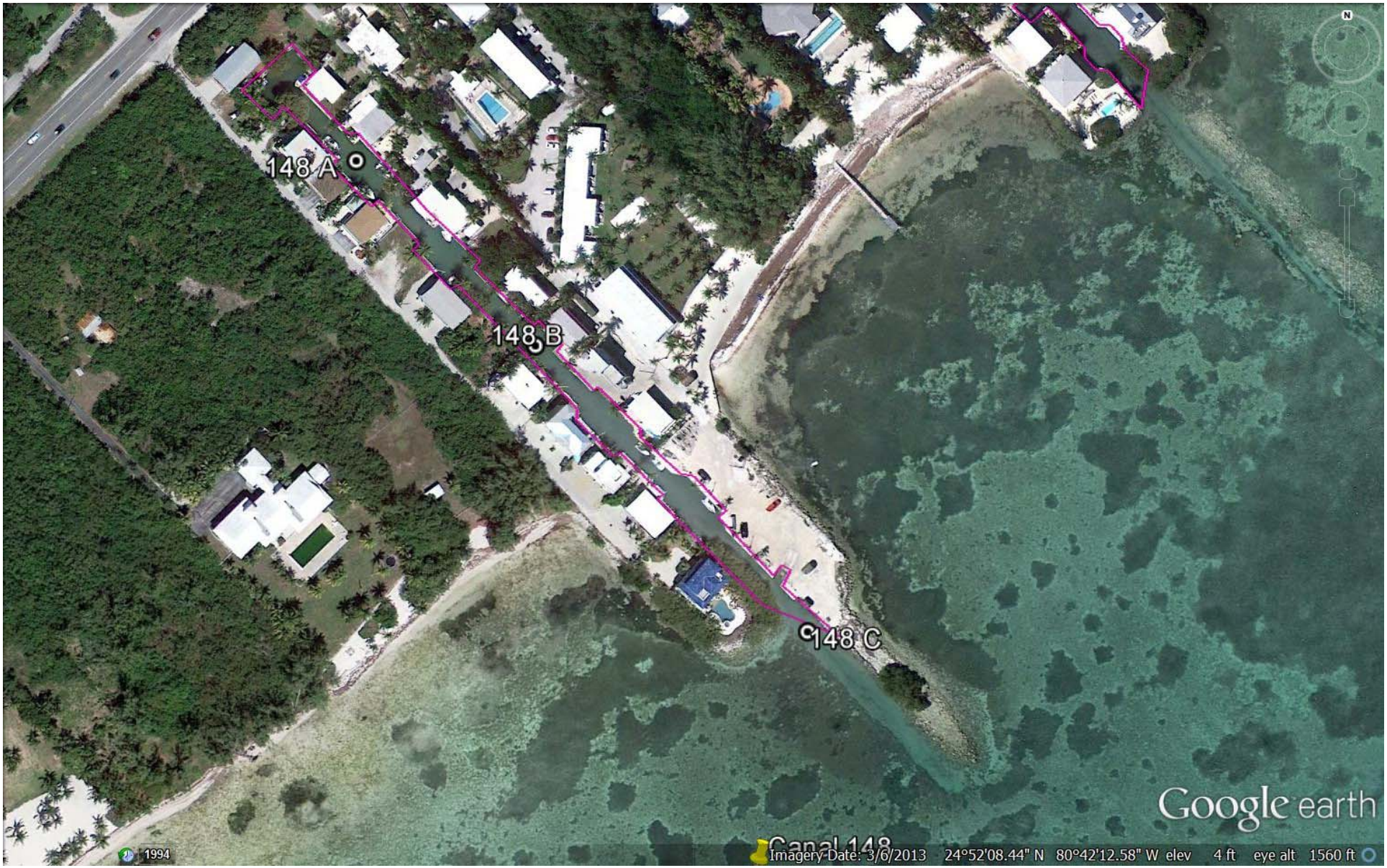
Lower Matecumbe Key

(Mate Lido Beach)

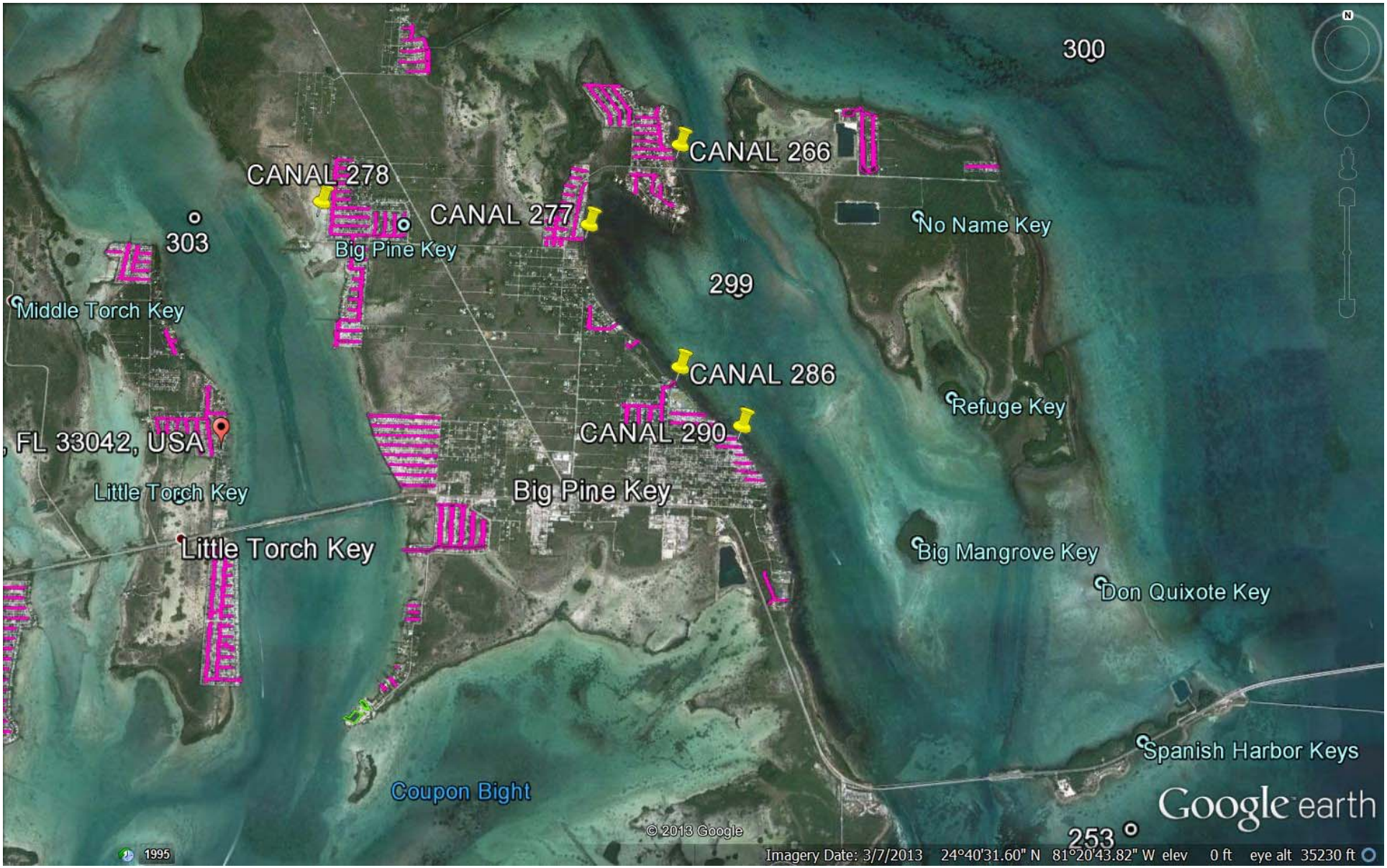
- WEED BARRIER: Canal 148
  - 3 profiles
    - A (9'?)=2
    - B (9')=3
    - C (3'?)=1 Total=6 samples
- CONTROL: Canal 147
  - 2 profiles
    - B (10')= 3
    - C (3'?)= 1 Total=4 samples


Indian Key
Canal 147
147 B
147 C
Matecumbe Bight
Canal 148
Lower Matecumbe Key
© 2013 Google
Google earth
2004
Imagery Date: 3/6/2013 24°52'09.28" N 80°42'00.45" W elev 0 ft eye alt 13151 ft


147 B
147 C
148 A
148 B
148 C
Google earth
1994
Imagery Date: 3/6/2013 24°52'11.86" N 80°42'09.97" W elev 4 ft eye alt 2202 ft


148 A
148 B
148 C
Google earth
1994
Imagery Date: 3/6/2013 24°52'08.44" N 80°42'12.58" W elev 4 ft eye alt 1560 ft

BIG PINE

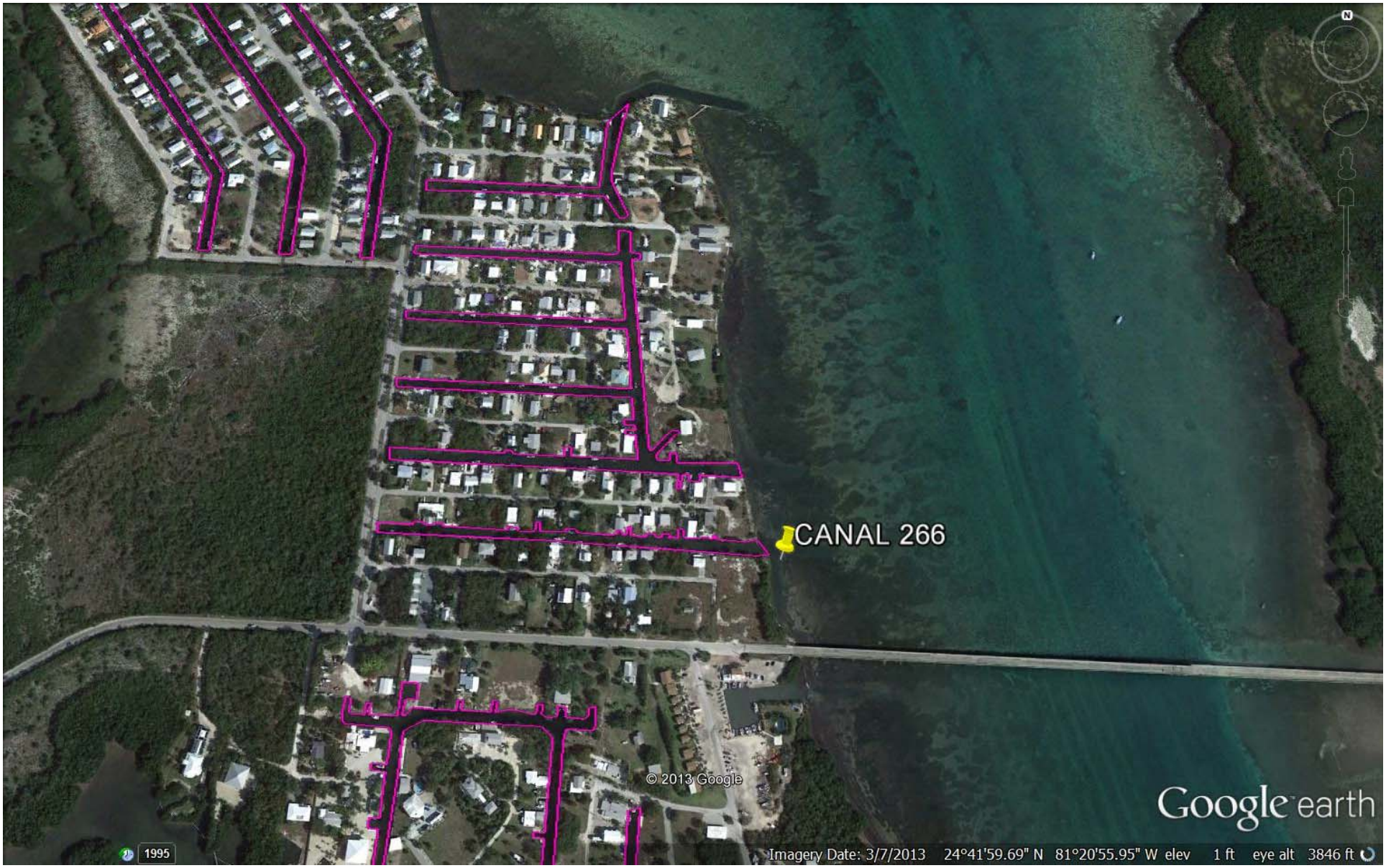

300
CANAL 266
CANAL 278
CANAL 277
303
Big Pine Key
No Name Key
299
Middle Torch Key
CANAL 286
Refuge Key
CANAL 290
, FL 33042, USA
Little Torch Key
Big Pine Key
Little Torch Key
Big Mangrove Key
Don Quixote Key
Spanish Harbor Keys
Coupon Bight
© 2013 Google
253
Google earth
1995
Imagery Date: 3/7/2013 24°40'31.60" N 81°20'43.82" W elev 0 ft eye alt 35230 ft

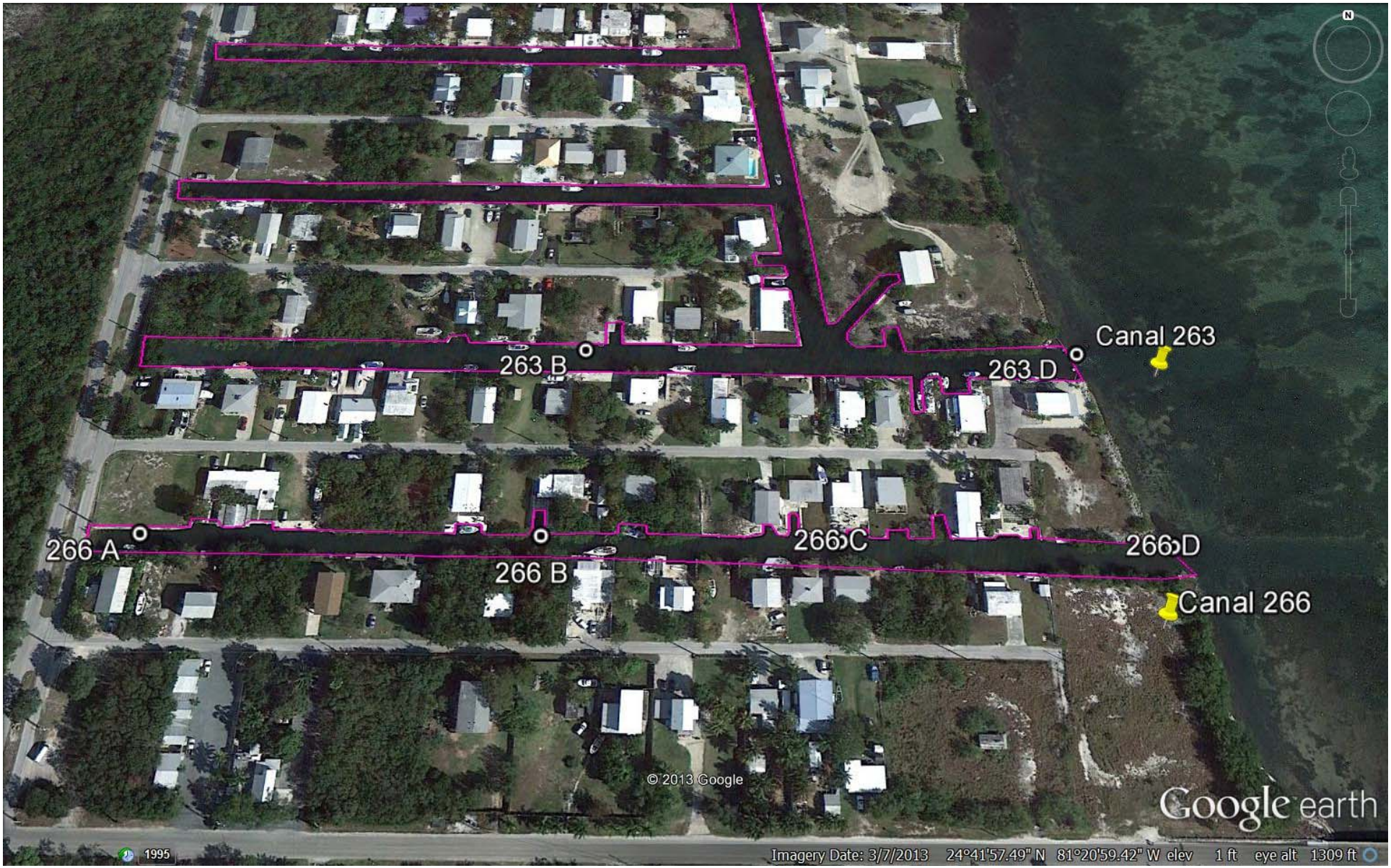
Big Pine

(Doctor's Arm Subdivision)

- WEED BARRIER &/or ORGANIC REMOVAL: Canal 266
  - 4 profiles
    - A (11'?)=3
    - B (11')=3
    - C (11')=3
    - D (3'?)=1 Total=10 samples
- CONTROL: Canal 263
  - 2 profiles
    - B (14')= 3
    - D (3'?)= 1 Total=4 samples

BIG PINE


CANAL 266
© 2013 Google
Google earth
1995
Imagery Date: 3/7/2013 24°41'59.69" N 81°20'55.95" W elev 1 ft eye alt 3846 ft

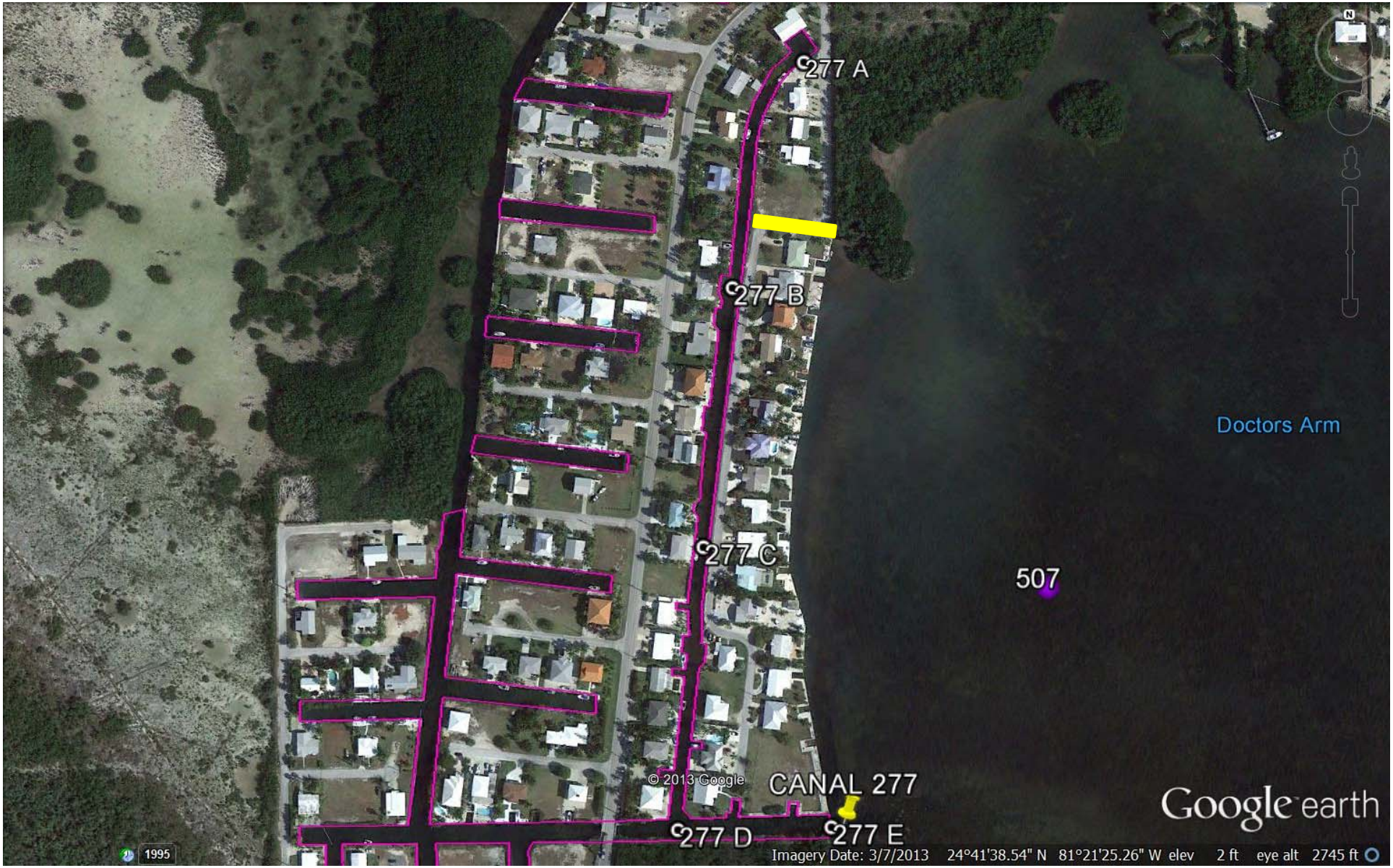

263 B
263 D
Canal 263
266 A
266 B
266 C
266 D
Canal 266
© 2013 Google
Google earth
1995
Imagery Date: 3/7/2013 24°41'57.49" N 81°20'59.42" W elev 1 ft eye alt 1309 ft

Big Pine

(Tropical Bay Subdivision)

- CULVERT INSTALLATION: Canal 277
  - 5 profiles
    - A (20'?)=4
    - B (20'?)=4
    - C (20'?)=4
    - D (20'?)=4
    - E (3'?)=1

Total=13 samples

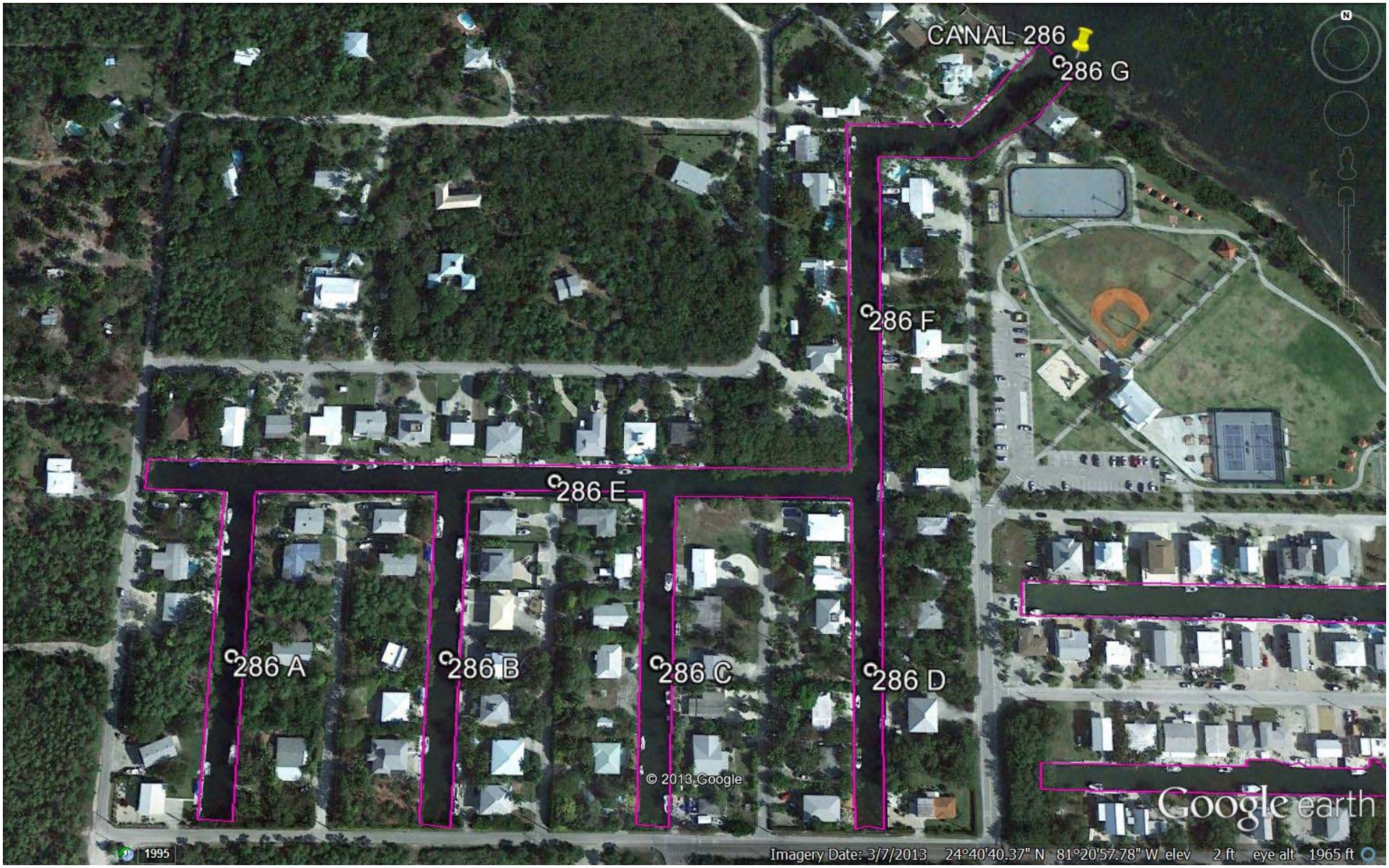

277 A
277 B
277 C
277 D
277 E
Doctors Arm
507
CANAL 277
© 2013 Google
Google earth
1995
Imagery Date: 3/7/2013 24°41'38.54" N 81°21'25.26" W elev 2 ft eye alt 2745 ft

Big Pine

(Whispering Pines Subdivision)

- PUMPING: Canal 286
  - 7 profiles
    - A (20’?)=4
    - B (20’?)=4
    - C (20’?)=4
    - D (20’?)=4
    - E (20’?)=4
    - F (20’)?=4
    - G (3’)=1

Total=25 samples

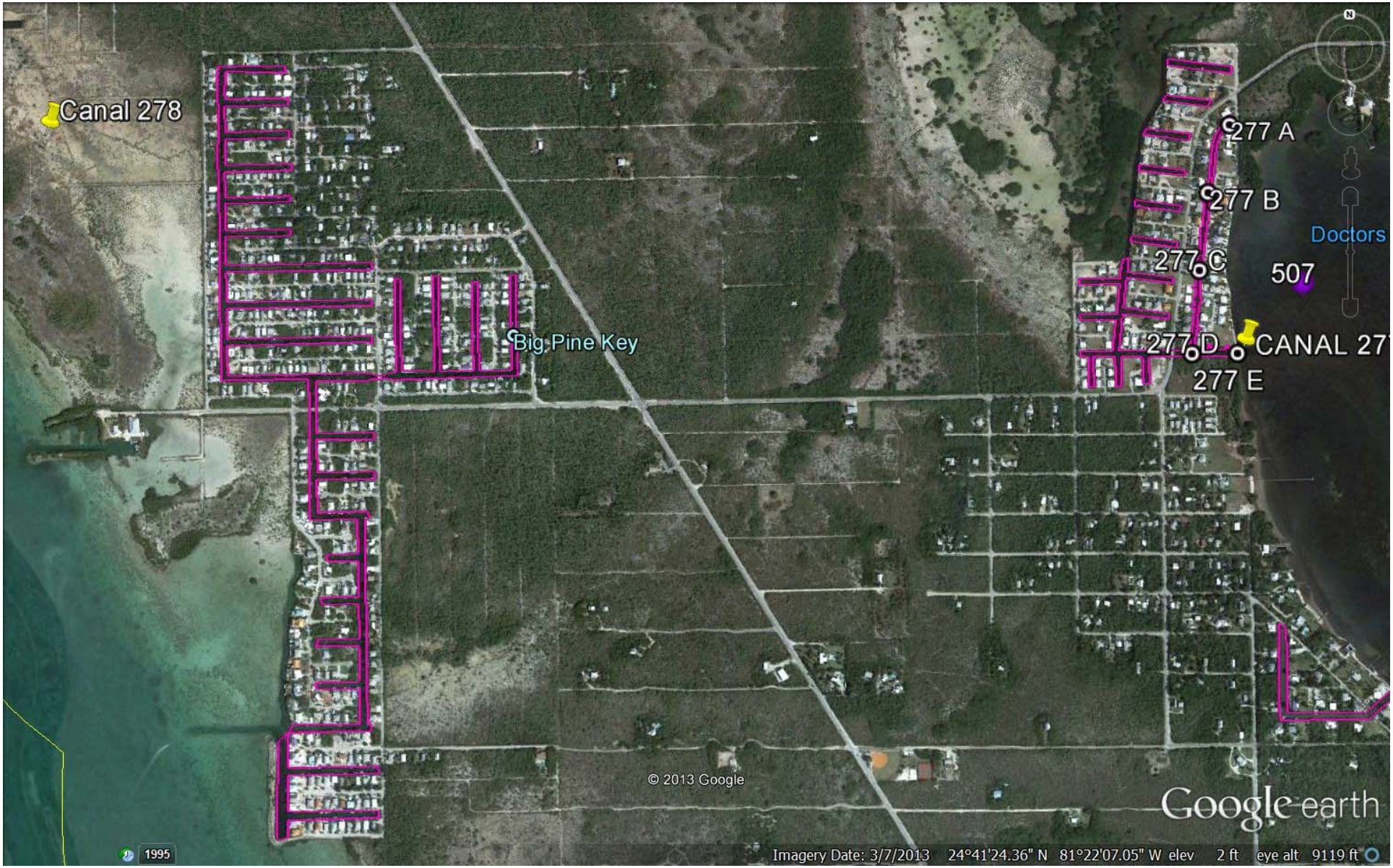

CANAL 286
286 G
286 F
286 E
286 A
286 B
286 C
286 D
© 2013 Google
Google earth
1995
Imagery Date: 3/7/2013 24°40'40.37" N 81°20'57.78" W elev 2 ft eye alt 1965 ft

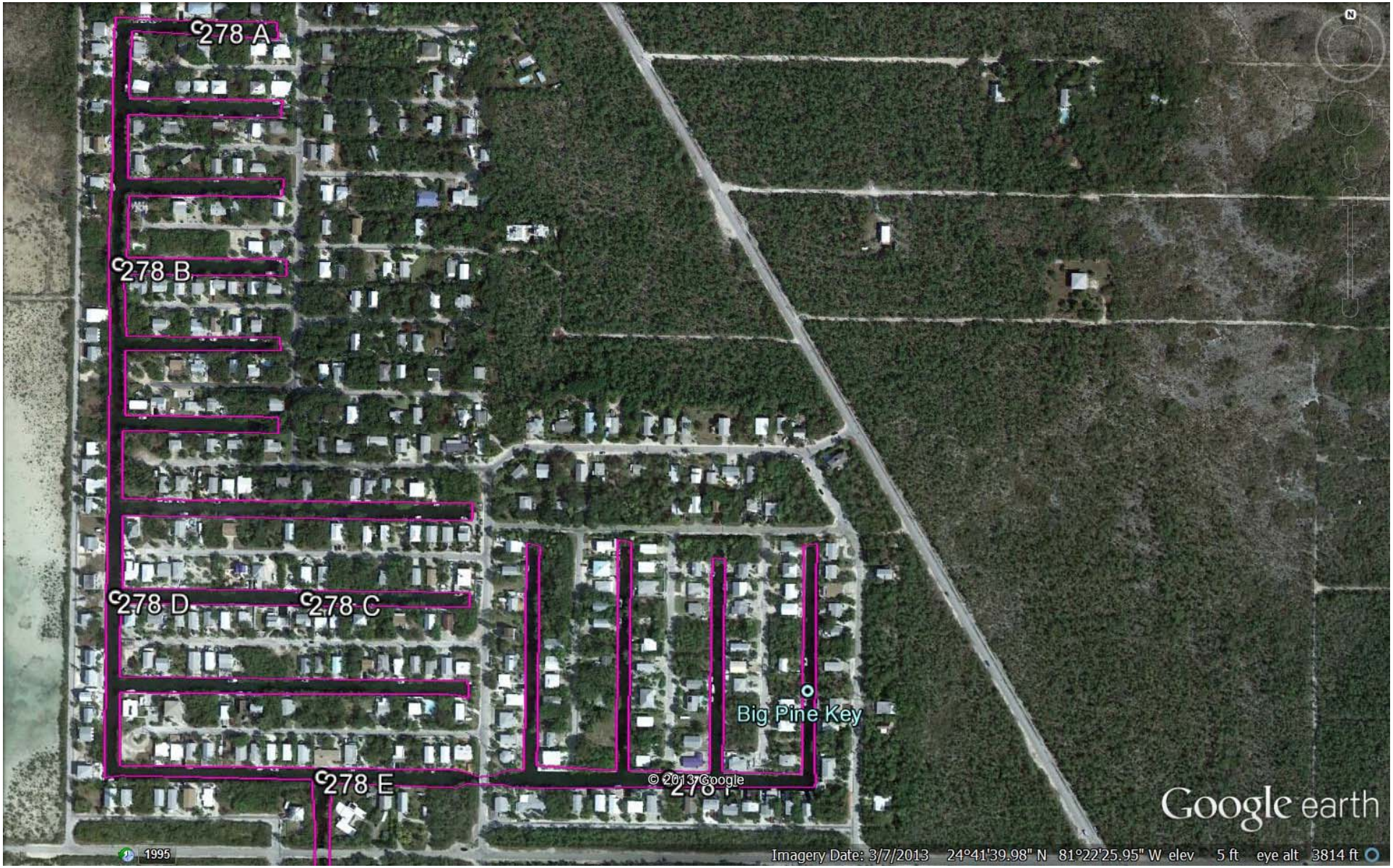
Big Pine

(Eden Pines Colony)

- PUMPING: Canal 278
  - 9 profiles
    - A (13’?)=3
    - B (13’?)=3
    - C (13’?)=3
    - D (13’?)=3
    - E (13’?)=3
    - F (13’?)=3
    - G (13’?)=3
    - H (13’)= 3
    - I (3’)=1

Total=25 samples


Canal 278
277 A
277 B
277 C
277 D
277 E
Doctors
507
CANAL 27
Big Pine Key
© 2013 Google
Google earth
1995
Imagery Date: 3/7/2013 24°41'24.36" N 81°22'07.05" W elev 2 ft eye alt 9119 ft


278 A
278 B
278 D
278 C
278 E
278 F
Big Pine Key
© 2013 Google
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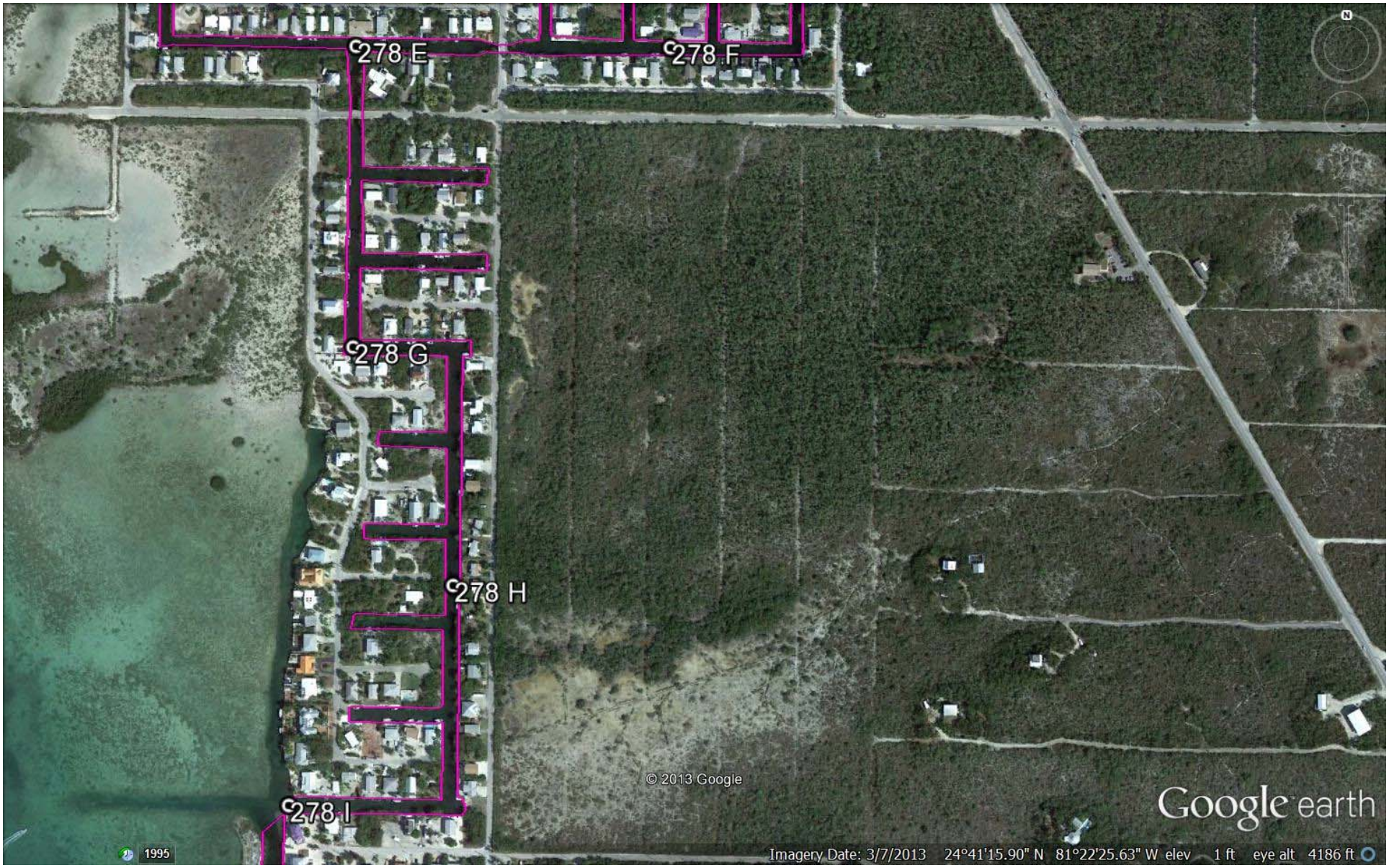
Imagery Date: 3/7/2013 24°41'39.98" N 81°22'25.95" W elev 5 ft eye alt 3814 ft


278 E
278 F
278 G
278 H
278 I
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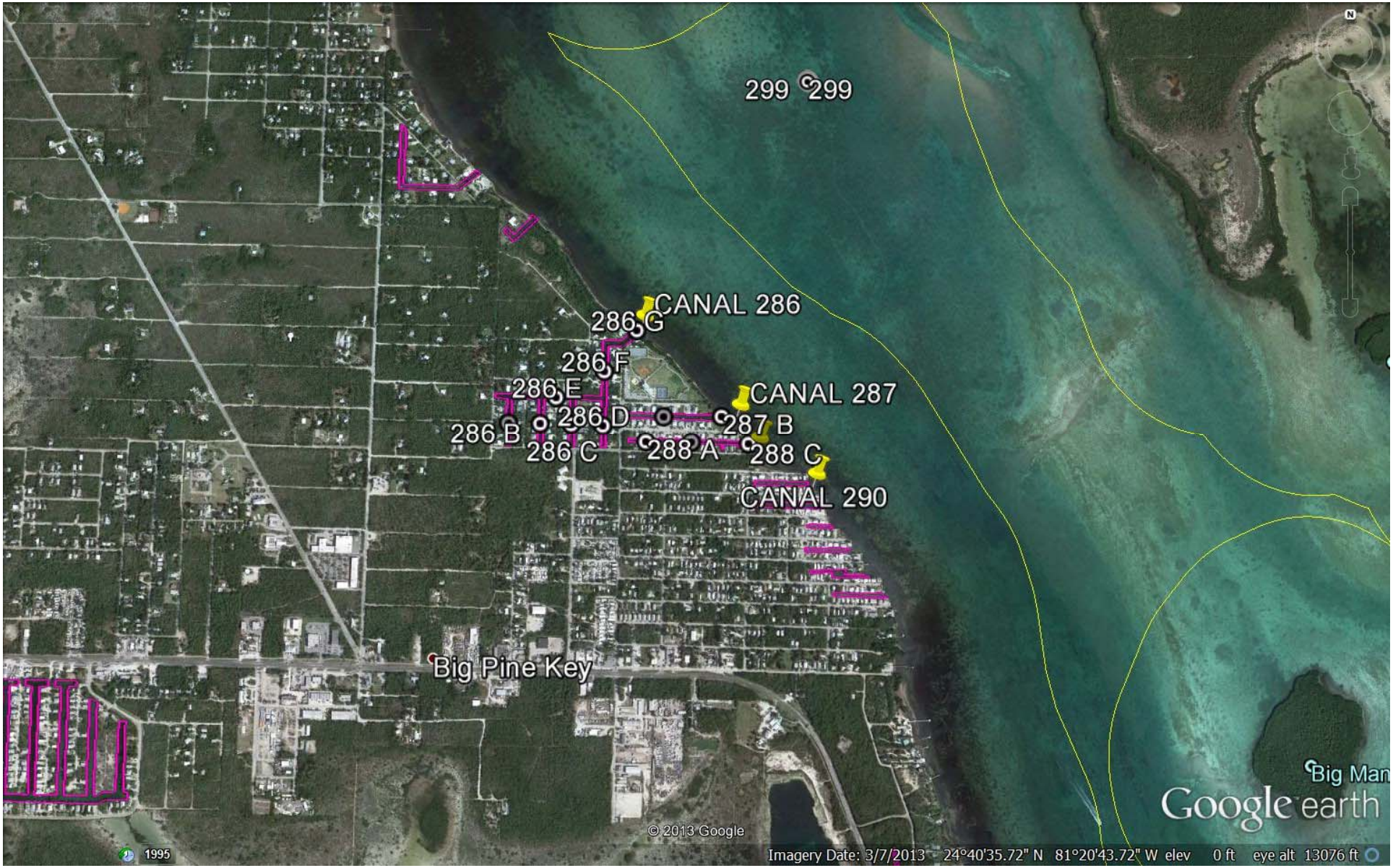
Imagery Date: 3/7/2013 24°41'15.90" N 81°22'25.63" W elev 1 ft eye alt 4186 ft

Big Pine
(Hollerich Subdivision)

- WEED BARRIER: Canal 288
  - 3 profiles
    - A (18'?)=4
    - B (18')=4
    - C (3'?)=1 Total=9 samples
- CONTROL: Canal 287
  - 2 profiles
    - B (14')= 3
    - D (3'?)= 1 Total=4 samples


299
299
CANAL 286
286 G
286 F
286 E
CANAL 287
286 D
287 B
286 B
286 C
288 A
288 C
CANAL 290
Big Pine Key
Big Man
Google earth
© 2013 Google
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Imagery Date: 3/7/2013 24°40'35.72" N 81°20'43.72" W elev 0 ft eye alt 13076 ft


286 F
287 A
287 B
CANAL 287
288 A
288 B
288 C
CANAL 288
CANAL 290
© 2013 Google
Google earth
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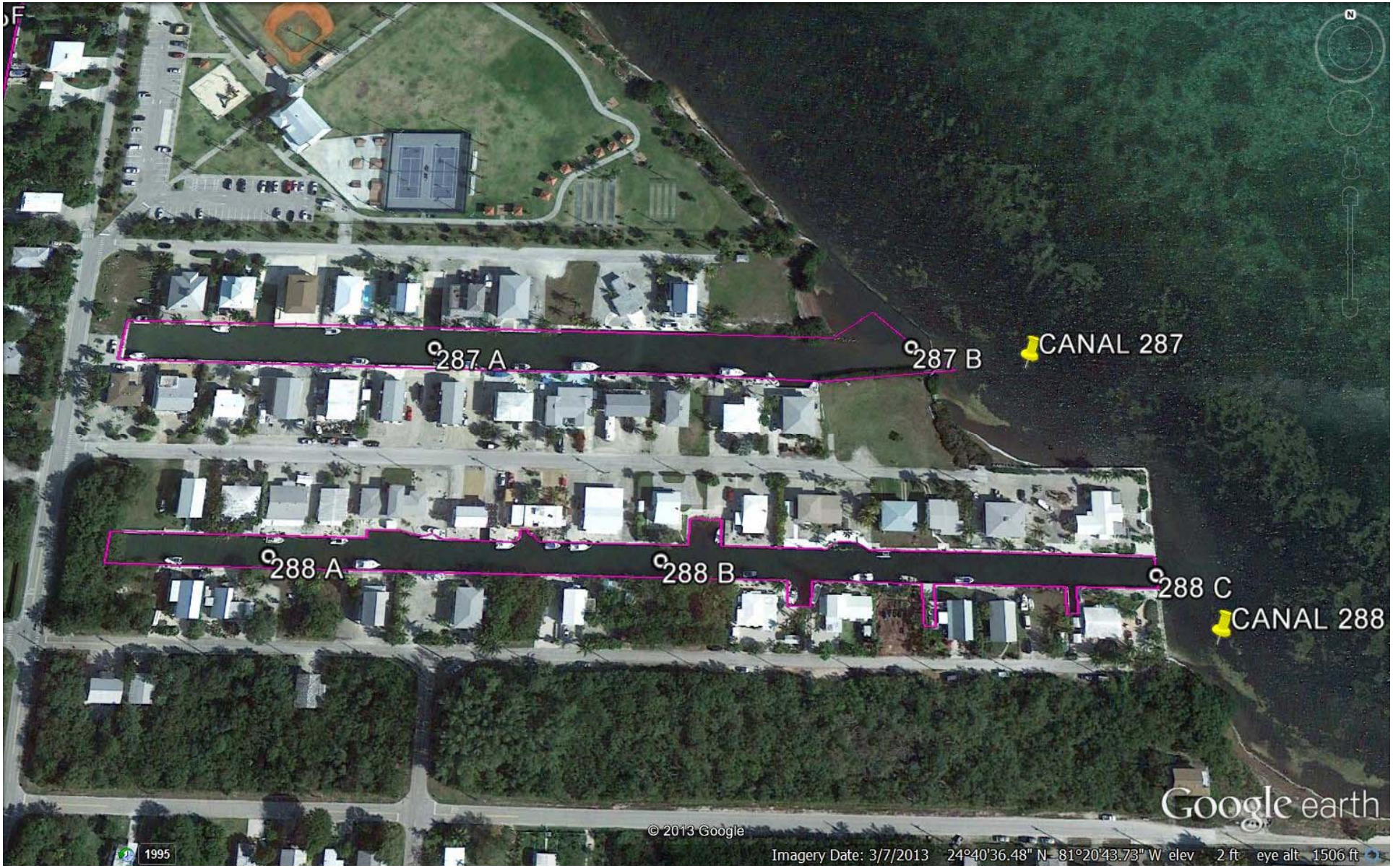
Imagery Date: 3/7/2013 24°40'34.68" N 81°20'39.56" W elev 1 ft eye alt 2455 ft


287 A
287 B
CANAL 287
288 A
288 B
288 C
CANAL 288
© 2013 Google
Google earth
1995
Imagery Date: 3/7/2013 24°40'36.48" N 81°20'43.73" W elev 2 ft eye alt 1506 ft

Big Pine
()

- ORGANIC REMOVAL: Canal 290
  - 3 profiles
    - A (8’?)=3
    - B (8’)=3
    - C (3’?)=1 Total=7 samples
- CONTROL: Canal 293
  - 2 profiles
    - A (15’)= 3
    - B (3’?)= 1 Total=4 samples


290 A
290 B
290 C
CANAL 290
CANAL 293
293 A
293 B
Google earth
1995
Imagery Date: 3/7/2013 24°40'29.37" N 81°20'32.55" W elev 1 ft eye alt 775 ft

GEIGER

(Boca Chica Ocean Shores)

- CULVERT INSTALLATION: Canal 459
  - 3 profiles
    - A (9’?)=3
    - B (9’)=3
    - C (3’?)=1 Total=7 samples
- CONTROL: Canal 458
  - 2 profiles
    - A (15’)= 3
    - B (3’?)= 1 Total=4 samples

Geiger Key


Big Coppitt Key
Big Coppitt Key
East Rockland Key
East Rockland Key
Little
CANAL 459
Bird Key
Geiger Key
CANAL 472
Saddlehill Key
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Google earth
1994
Imagery Date: 3/7/2013 24°35'11.40" N 81°39'22.48" W elev -1 ft eye alt 12531 ft


458 A
458 B
CANAL 458
459 A
459 B
CANAL 459
459 C
Google earth
1994
Imagery Date: 3/7/2013 24°35'05.51" N 81°38'56.20" W elev 0 ft eye alt 863 ft