W. Clark Lake Workshop

1001 Sarasota Center Blvd. (BOB, Training Room), Sarasota, FL
10/3/07

Objectives:	• To understand the local and regional "networking" of water giving rise to the water quality conditions observed in W. Clark Lake. • To evaluate potential restoration alternatives for restoring water quality in W. Clark Lake.
8:30-9:00	Registration
9:00-9:15	Introduction – Tom Singleton, DEP Order Lunches
9:15-10:45	Overview of W. Clark Lake Watershed (30 minutes each presenter) • Hydrologic Setting (historic and present) – Dave Tomasko, PBS&J • Water Quality Conditions – Ralph Montgomery, PBS&J • TMDL and Pollutant Loading – Jeff Herr, PBS&J
10:45-11:00	Workshop Process – Tom Singleton, DEP
11:00-11:15	Break
11:15-12:15	Small Group Sessions – Problem Defining (1 hour each group) • Group 1: Hydrologic Setting (historic and present) – Dave Tomasko, PBS&J • Group 2: Water Quality – Ralph Montgomery, PBS&J • Group 3: Pollutant Loading – Jeff Herr, PBS&J
12:15-1:00	Lunch
1:00-2:00	Plenary – Small Group Presentations (20 minutes each group)
2:00-2:15	Break
2:15-3:45	Small Group Sessions – Solution Defining (1.5 hours each group) • Group 1: Red Bug Slough restoration alternatives – Dave Tomasko, PBS&J • Group 2: Mirror Lake restoration alternatives – Ralph Montgomery, PBS&J • Group 3: E. and W. Clark Lake restoration alternatives – Jeff Herr, PBS&J
3:45-4:45	Plenary – Small Group Presentations (20 minutes each group)
4:45-5:00	Wrap-up – Tom Singleton, FDEP

Historical and Present Hydrologic Setting for West Clark Lake Watershed

David A. Tomasko, Ph.D.
Manager, Watershed Sciences and Assessment Program

Overview of Presentation

- Applying lessons learned from first workshop to a more local scale
- Overview of current watershed and water quality conditions within West Clark Lake
- Historical watershed characteristics
- Implications and impacts of changes in watershed

Lessons Learned

- TMDL / B-MAP process is too important not to do it right
- Unfortunately, there are issues that must be acknowledged that complicate our efforts
  - Water quality "impairments" that can reflect natural conditions
  - Pollutant loading models can have significant uncertainties
  - Water quality models where "calibration" is simply curve fitting
  - Yet, implications to local governments can be very significant
- However, despite questions, some activities are straight forward
  - Value of stormwater BMPs
  - Value of Low Impact Development
  - Other activities on stormwater and/or wastewater

The challenge

- Not rushing into "fixes" that are premature
- Not creating "paralysis by analysis"

- What can you do with what you know?
- What else do you need to know?
- How do you get that additional information?

To know what to do

- Know what you have
  - Land use
  - Potential loading sources
  - Status and trends in water quality
  - Spatial differences in water quality
  - Phenomena not visible in aerial photography (i.e., not mapped)
- Know what you used to have
  - Land use
  - Potential loading sources
  - Water quality

Overview of West Clark Lake – its watershed and water quality

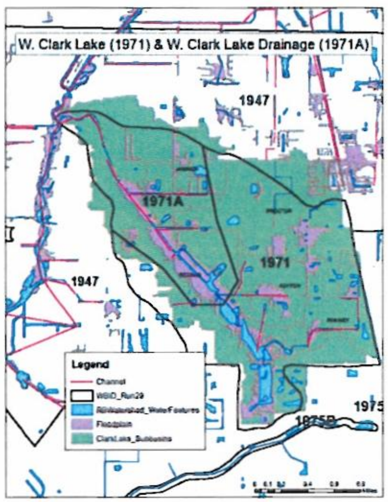
W. Clark Lake watershed –

2.2 square miles, or,

4% of Philippi Creek watershed

Four "lakes"

Mirror Lake
East Clark Lake
West Clark Lake
Redbug Slough Lake



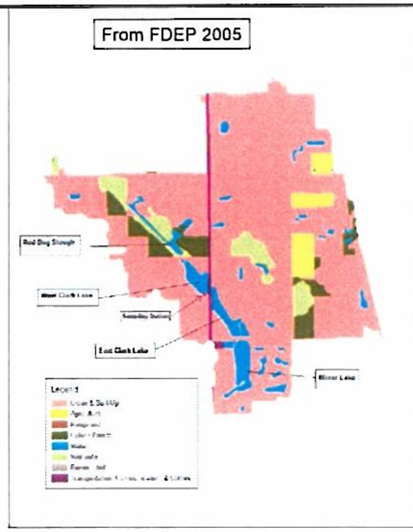
W. Clark Lake verified impaired due to exceedance (even 1 yr) of TSI > 60 during 1997 to mid 2004 (from FDEP 2005)

Table 2.1. Measured Data and TSI for West Clark Lake (WBID 1971)

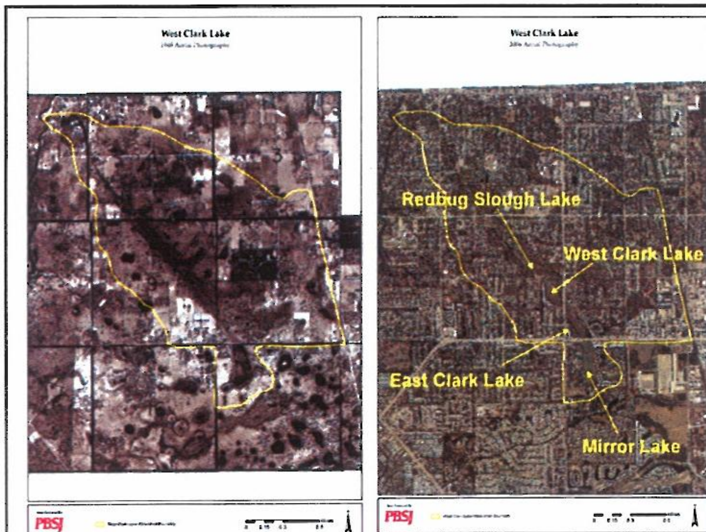
Month	TP	TN	Chla	TSI
Jan 2003				
Feb 2003				
Mar 2003	0.18	1.72	65	
Average	**0.18**	**1.72**	**65**	**74.1**
Apr 2003	0.23	2.20	4.3	57.2
May 2003	0.14	2.10	5.7	57
Jun 2003	0.11	1.90	22	65.1
Average	**0.16**	**2.07**	**10.67**	**62**
Jul 2003	0.26	1.80	55	73.4
Aug 2003	0.2	1.51	46	70.5
Sep 2003	0.26	1.60	55	72.1
Average	**0.24**	**1.64**	**52.67**	**72.1**
Oct 2003	0.4	1.02	88	70.7
Nov 2003				
Dec 2003	0.265	1.70	4.6	54.9
Average	**0.3325**	**1.36**	**46.3**	**69.2**
Annual Average	**0.23**	**1.70**	**43.66**	**69.35**

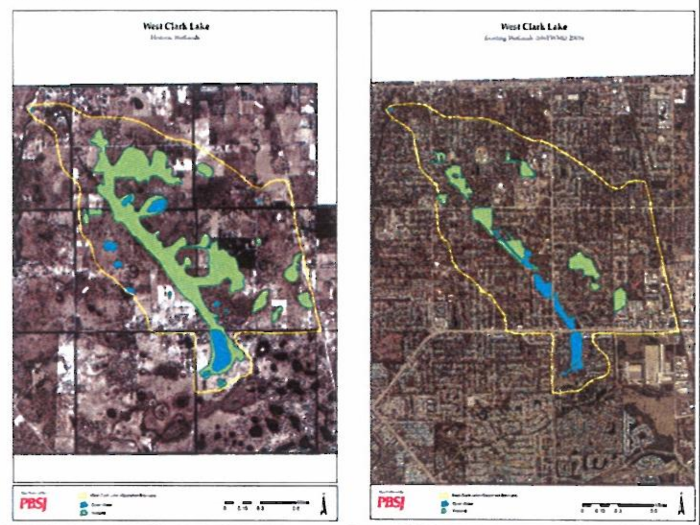
Major land use is urban & built up.

Note location of water quality station. Is it more reflective of E. Clark Lake?



Overview of historical land use

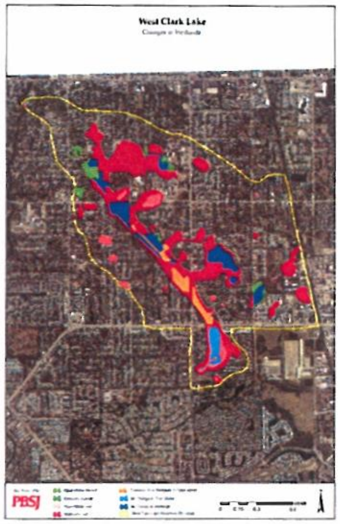




1948 to 2005:

Open water losses (pink) and gains (orange). With total mostly unchanged - from 49 to 48 acres

Wetlands decline (red) from 380 to 99 acres (74% decline)



Land use changes

- Open water filled to become urban
- Open water created from uplands (stormwater ponds)
- Open water created from wetlands

- Wetlands lost due to conversion to uplands
- Wetlands lost due to conversion to open water

Implications of changes in watershed

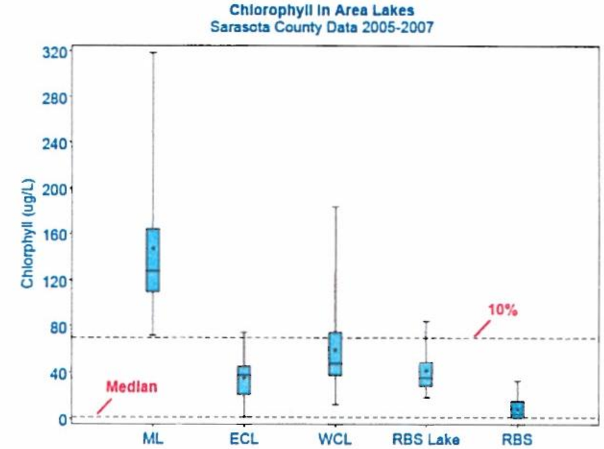
- If the W. Clark Lake used to be a marsh / slough system…
  - Should we expect it to meet water quality standards for a natural lake?
  - Is it now functioning as a wet detention pond?
  - Is W. Clark Lake functioning to improve downstream water quality?
- With 74% wetland loss…
  - Would hydrologic loads increase?
  - Would pollutant loads increase?
  - Would filtration benefit decrease?
  - Can we recover / reverse some of these impacts?

Clearly, land use has changed on a watershed–wide level.

Are there differences in water quality within the greater West Clark Lake watershed?

Locations of the various lakes

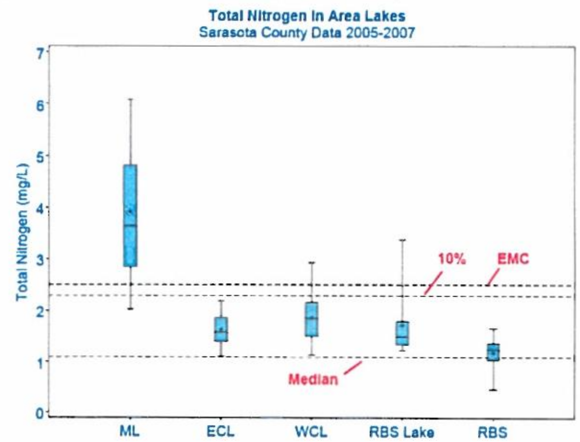
Mirror Lake much higher Chl-a than other lakes in watershed



Local variation in Chl-a

- Mirror Lake much higher than others
- Redbug Slough not too bad, actually
- Nutrient dynamics and nutrient loading to Mirror Lake needs to be understood
- Water quality "processing" through WCL, ECL and RBS needs to be understood

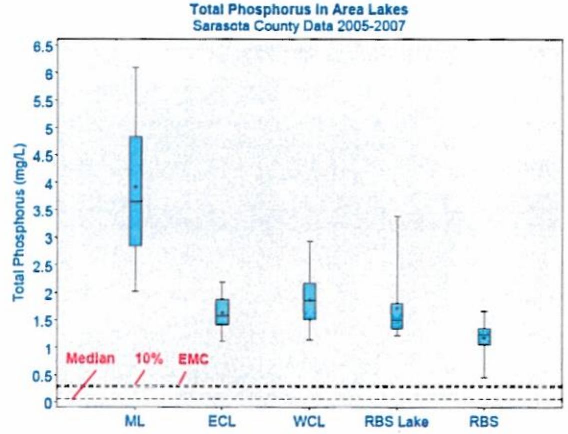
TMDL focuses on nitrogen.
High levels of TN not explained by stormwater alone.



Excess nitrogen sources?

- TMDL calls for replacement of septic tanks
- TMDL discusses bird colony
- Impacts of sediments?
- Impacts of N-fixing blue-greens?
- Sediments from bird colony?
- Sediments from bird colony and N-fixers?
- Other unknowns?
- TN levels quite "normal" down by Redbug Slough

Phosphorus levels more of an "outlier" than nitrogen.
Doesn't source of nitrogen also have to account for phosphorus?



Implications of water quality findings

- More detailed assessment required (Ralph's presentation)
- Loading source of TN – if it doesn't also load TP (i.e., TMDL for OSDS's) is something else needed (Jeff's presentation)
- Restoration scenarios to be discussed later
  - Does outflow into Philippi Creek need to be "cleaned up"?
  - What common sense actions should be undertaken with knowledge we possess right now?

Water Quality Conditions

Greater West Clark Lake System Status and Trends in Water Quality

Ralph Montgomery, Kristin Maki,
&
Emily Keenan

PBS&J

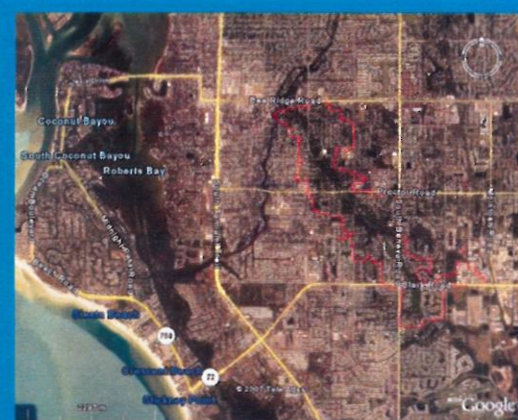
Primary Water Quality Objectives

- What information do we have and what do we know?
- What can we do with the available information?
- What inferences can be drawn from and what are the implications of observed patterns?
- What additional information is required?
- What are the next steps to be implemented?

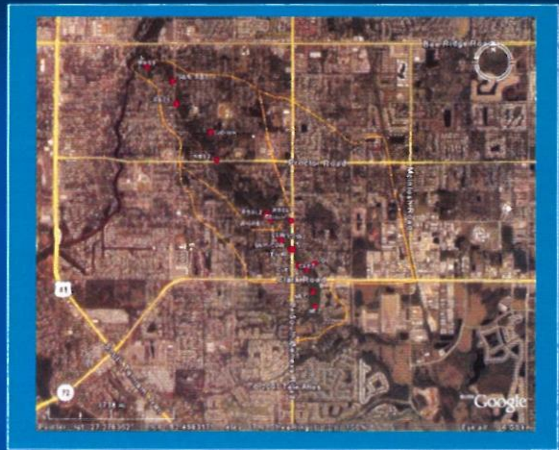
Approach

- Assess status and trends in water quality
  - Mirror Lake
  - East Clark Lake
  - West Clark Lake
  - Red Bug Slough Lake
- Contrast water quality in these four systems
- Compare with status and trends in Phillippi Creek & Roberts Bay

Relative Location of West Clark Lake Watershed

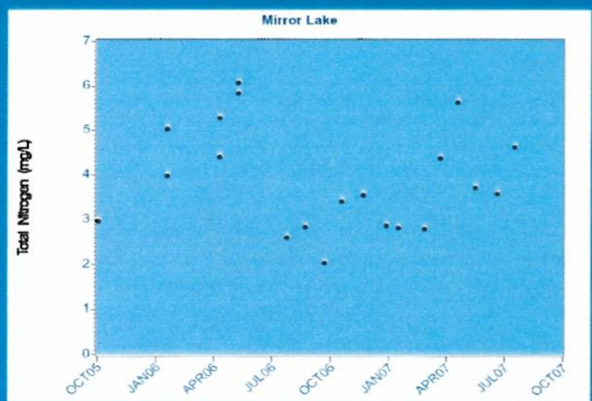


Water Quality Monitoring Sites

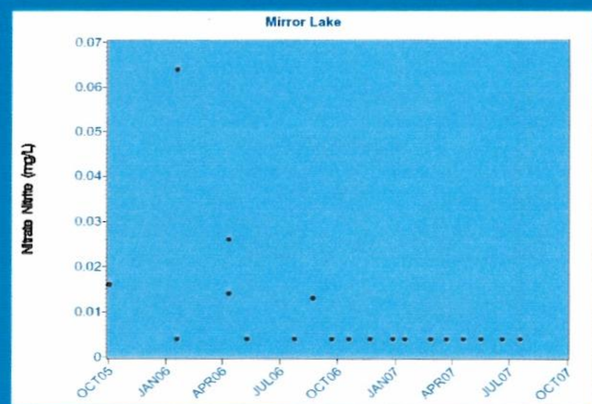


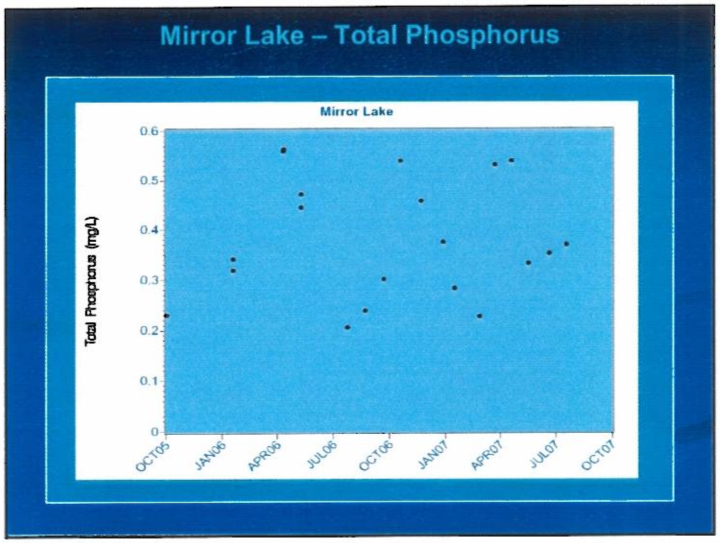
Mirror Lake

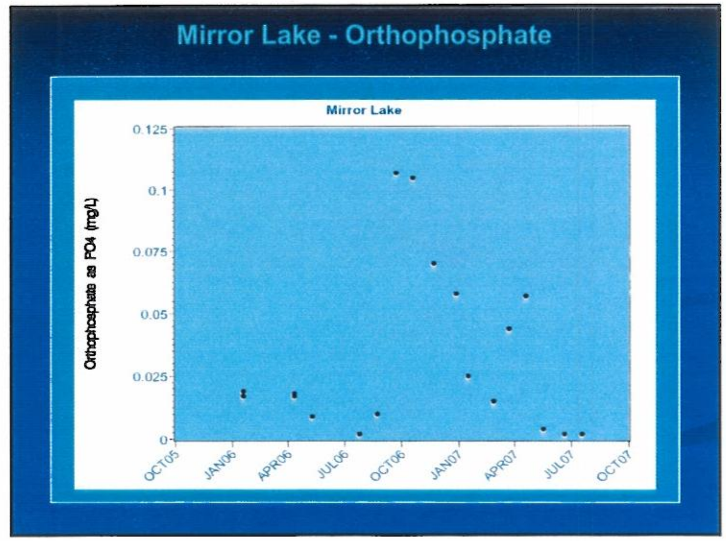
Mirror Lake – Total Nitrogen

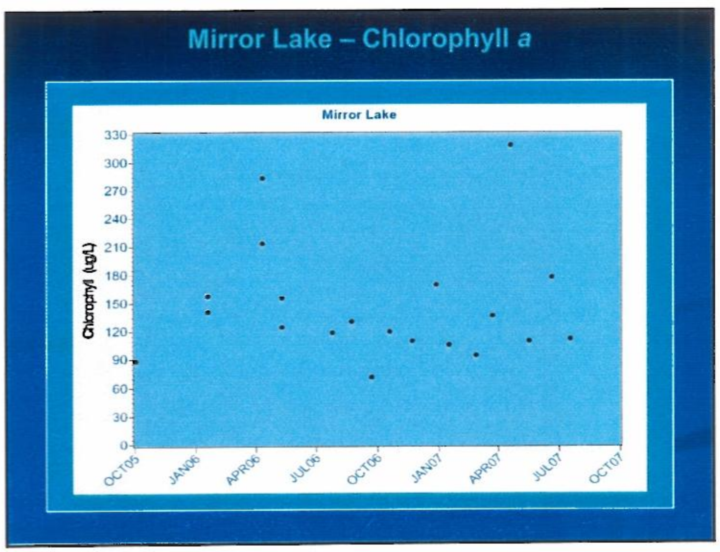


Mirror Lake – Nitrate+Nitrite



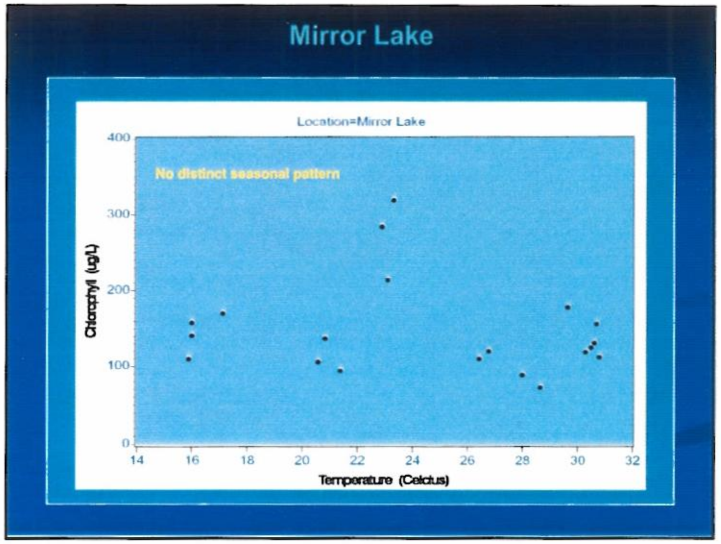


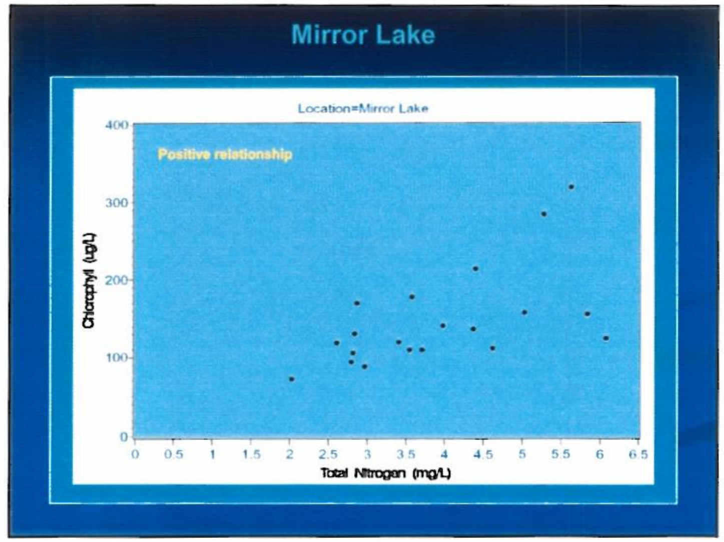


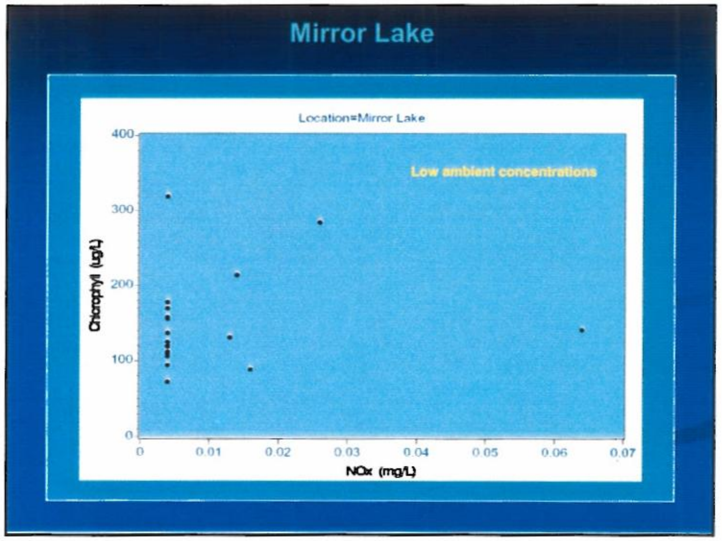


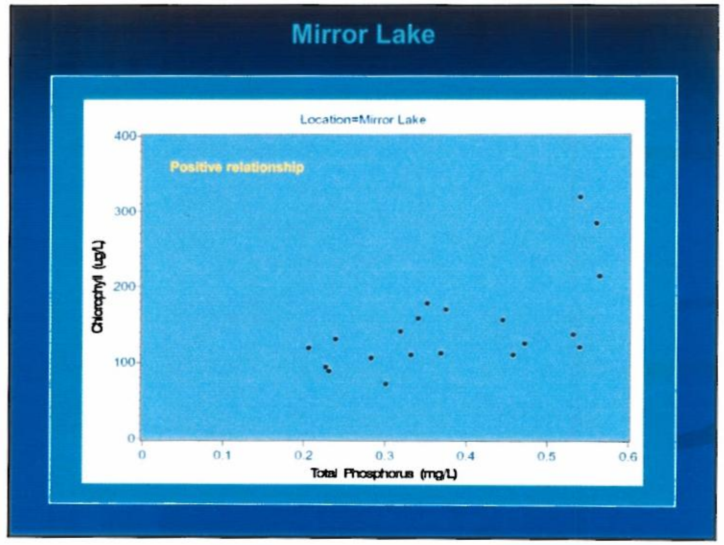
Relationships Between Chlorophyll *a* and other Water Quality Parameters

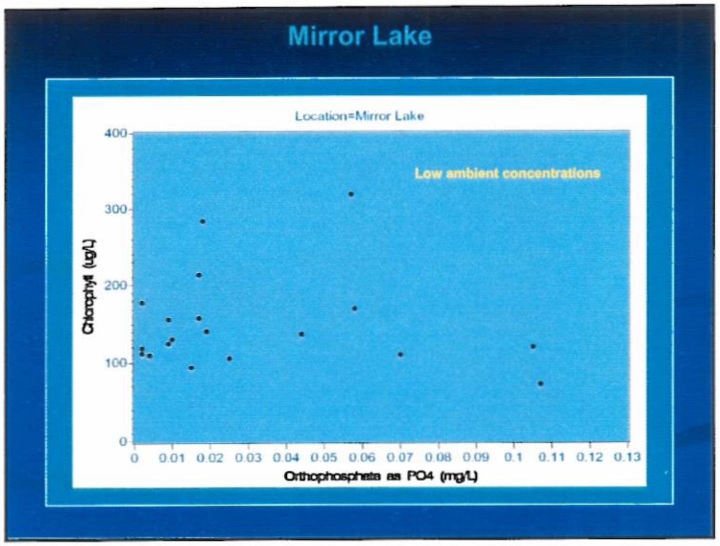
- Chlorophyll a versus
  - Temperature
  - Total Nitrogen
  - Nitrate + Nitrite Nitrogen
  - Total Phosphorus
  - Orthophosphate

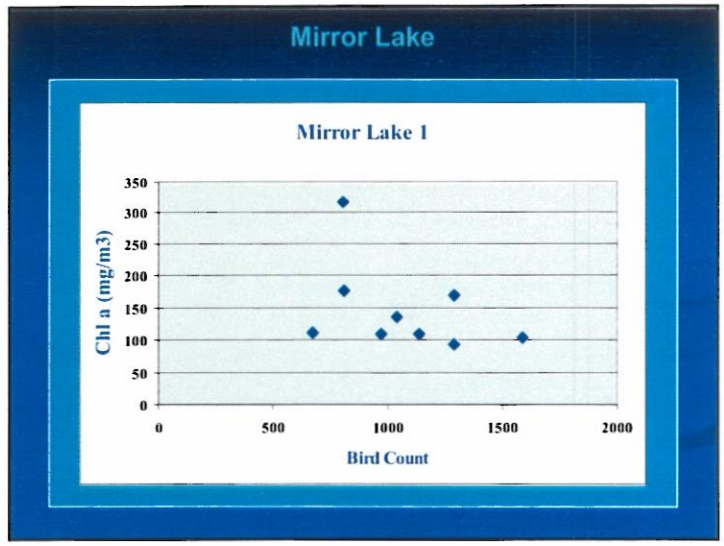

Mirror Lake
Location=Mirror Lake
No distinct seasonal pattern
Chlorophyll (ug/L)
Temperature (Celcius)

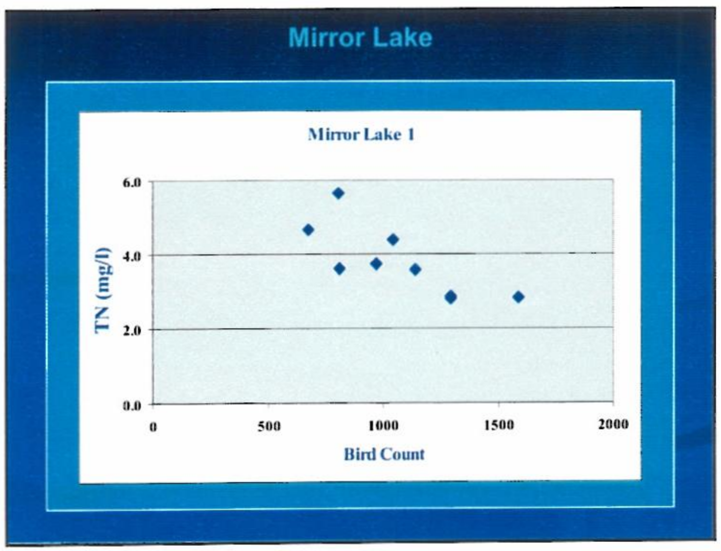

Mirror Lake
Location=Mirror Lake
Positive relationship
Chlorophyll (ug/L)
Total Nitrogen (mg/L)

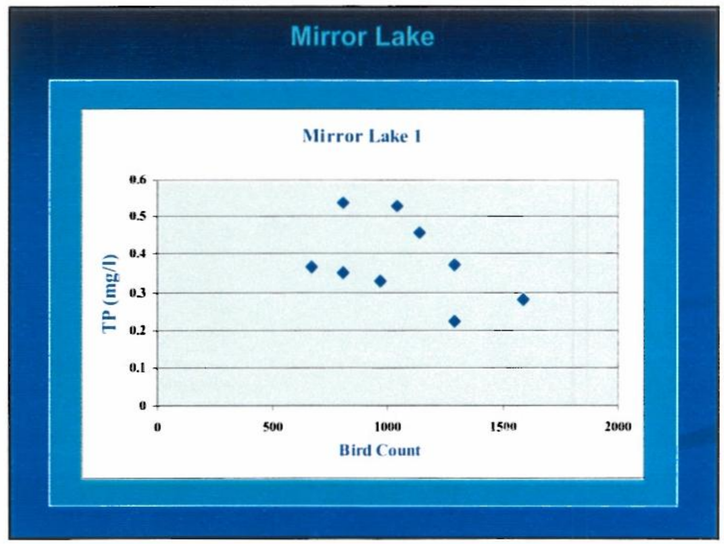

Mirror Lake
Location=Mirror Lake
Low ambient concentrations
Chlorophyll (ug/L)
NOx (mg/L)


Mirror Lake
Location=Mirror Lake
Positive relationship
Chlorophyll (ug/L)
Total Phosphorus (mg/L)


Mirror Lake
Location=Mirror Lake
Low ambient concentrations
Chlorophyll (ug/L)
Orthophosphate as PO4 (mg/L)


Mirror Lake
Mirror Lake 1
Chl a (mg/m3)
Bird Count

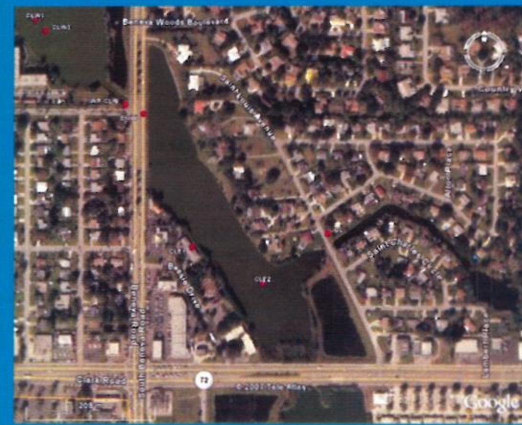

Mirror Lake
Mirror Lake 1
TN (mg/l)
Bird Count


Mirror Lake
Mirror Lake 1
TP (mg/l)
Bird Count

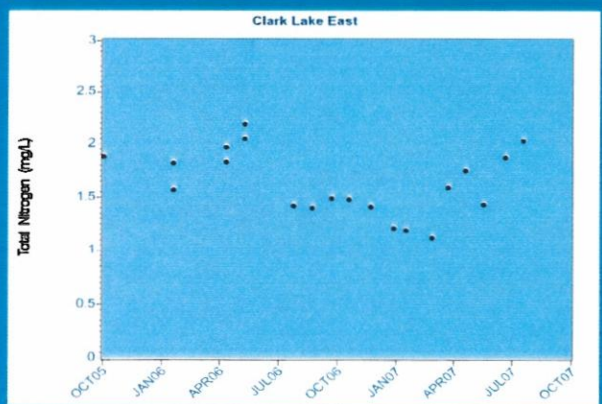
Mirror Lake - Summary

- Not enough long-term data to determine seasonal patterns or trends
- Indications of positive relationships between chlorophyll and both TN & TP
- Generally very low inorganic nitrogen and phosphorus levels
- Bird count data not directly related to chlorophyll levels (internal recycling?)
- High nutrients in organic sediments

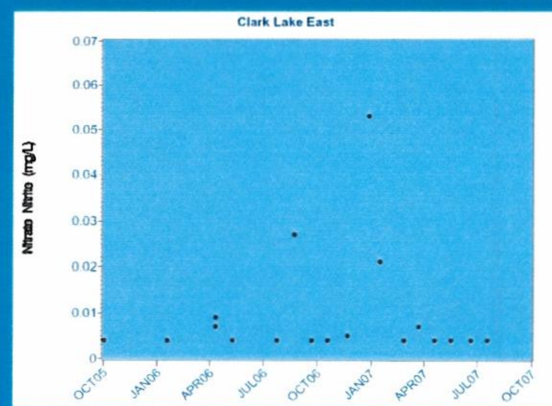
East Clark Lake



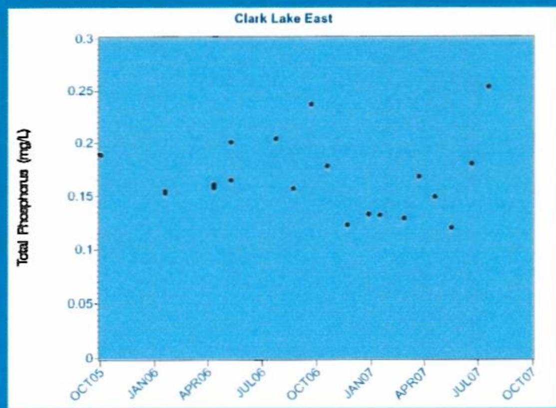
East Clark Lake – Total Nitrogen



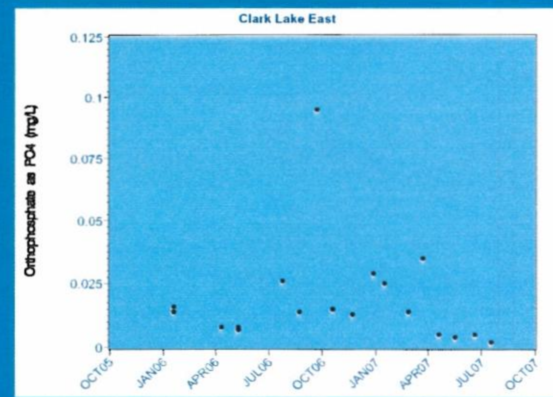
East Clark Lake – Nitrate+Nitrite



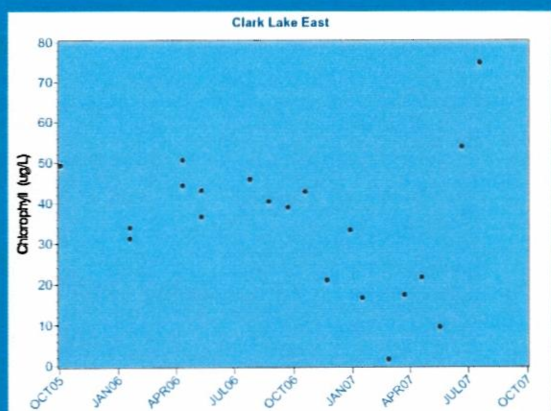
East Clark Lake – Total Phosphorus



East Clark Lake - Orthophosphate

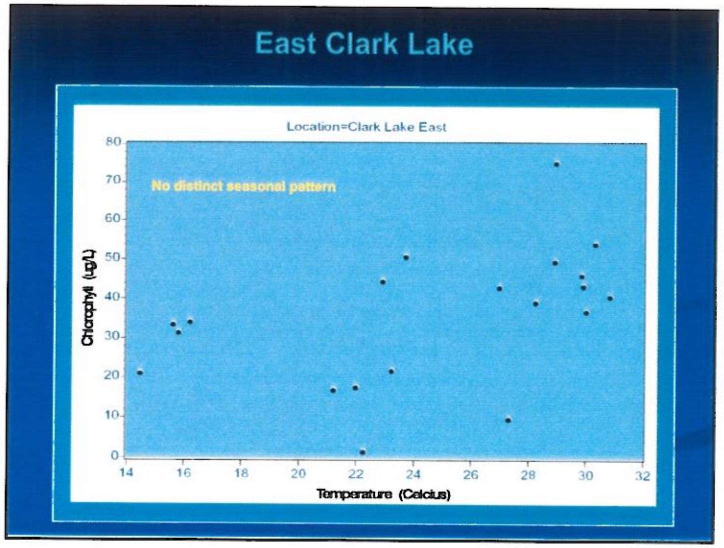


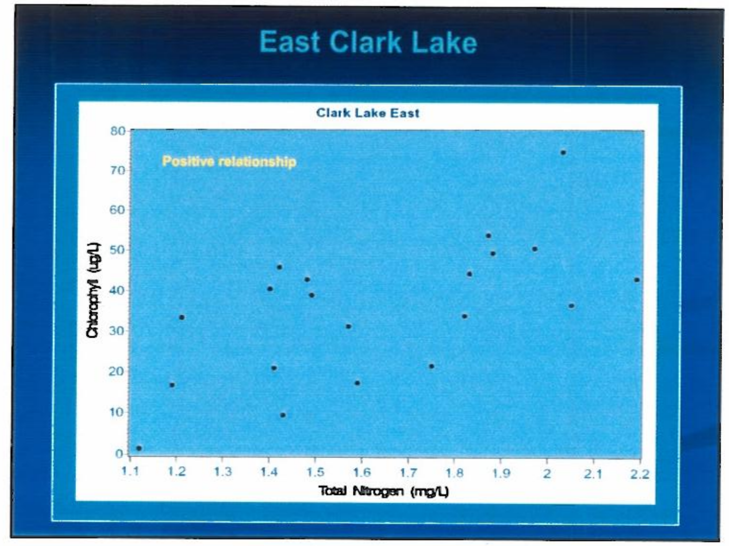
East Clark Lake – Chlorophyll *a*

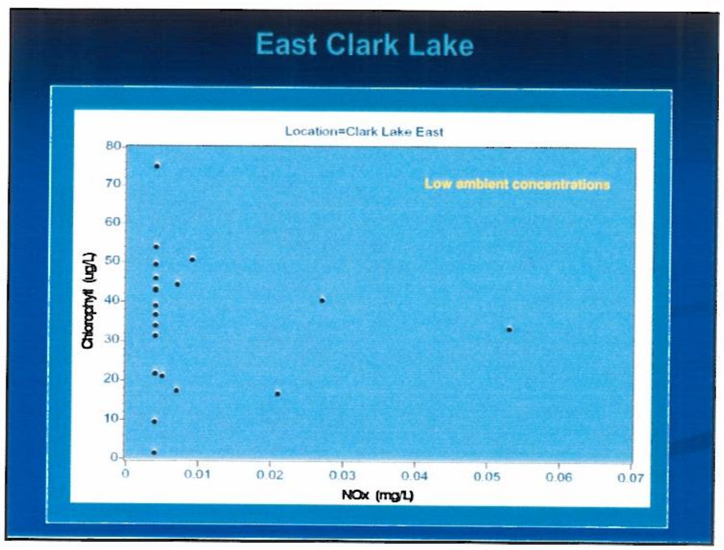


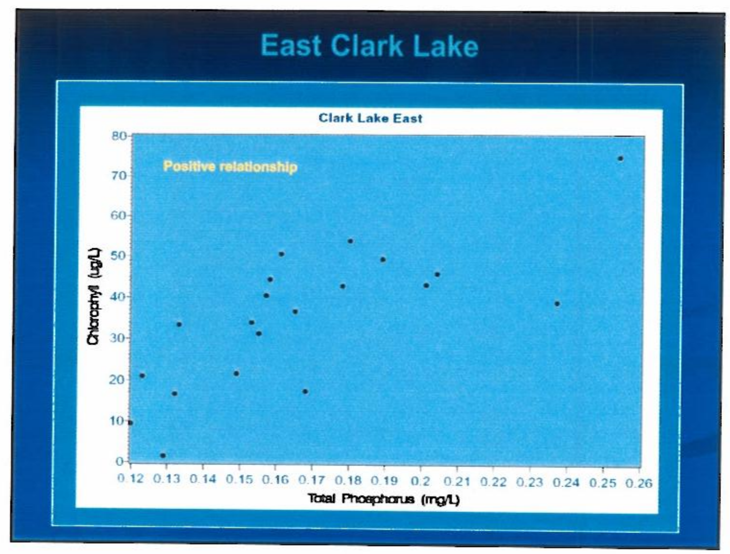
Relationships Between Chlorophyll *a* and other Water Quality Parameters

- Chlorophyll a versus
  - Temperature
  - Total Nitrogen
  - Nitrate + Nitrite Nitrogen
  - Total Phosphorus
  - Orthophosphate

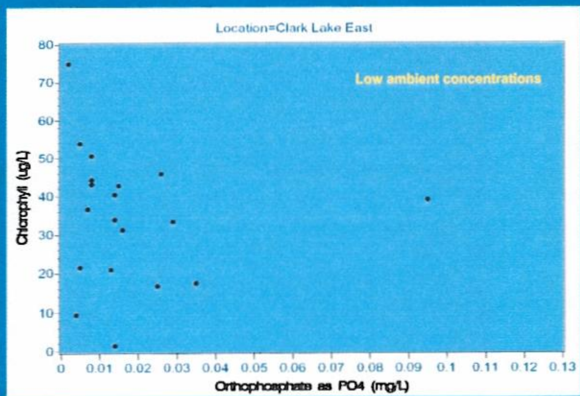

East Clark Lake
Location=Clark Lake East
No distinct seasonal pattern
Chlorophyll (ug/L)
Temperature (Celcius)


East Clark Lake
Clark Lake East
Positive relationship
Chlorophyll (ug/L)
Total Nitrogen (mg/L)


East Clark Lake
Location=Clark Lake East
Low ambient concentrations
Chlorophyll (ug/L)
NOx (mg/L)


East Clark Lake
Clark Lake East
Positive relationship
Chlorophyll (ug/L)
Total Phosphorus (mg/L)

East Clark Lake

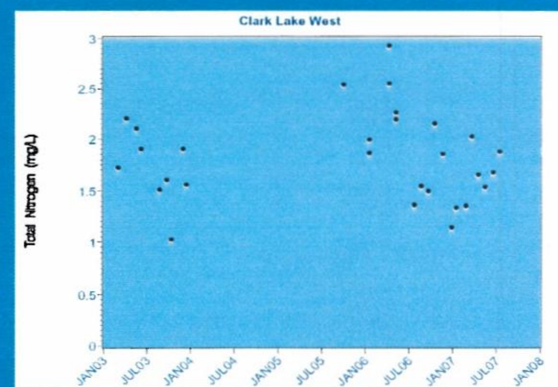


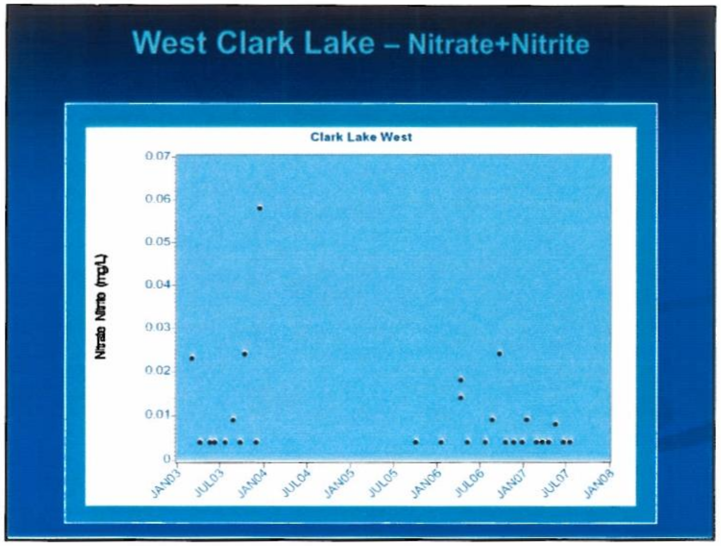
East Clark Lake - Summary

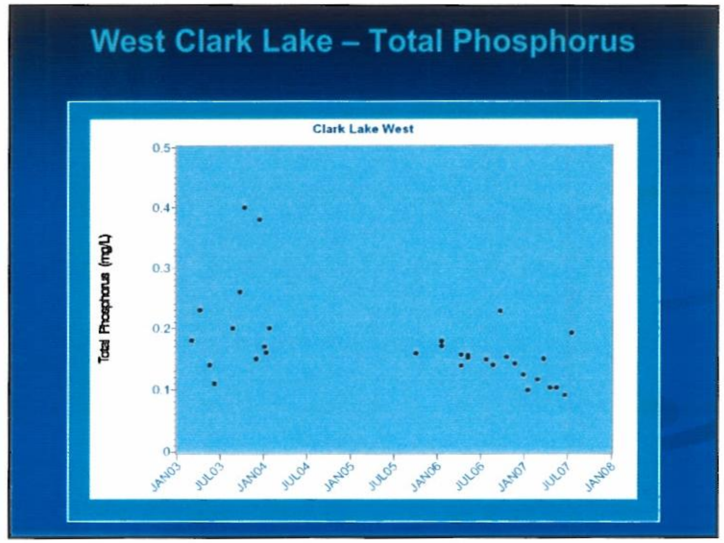
- Not enough long-term data to determine seasonal patterns or trends
- Indications of positive relationships between chlorophyll and both TN & TP
- Generally very low inorganic nitrogen and phosphorus levels

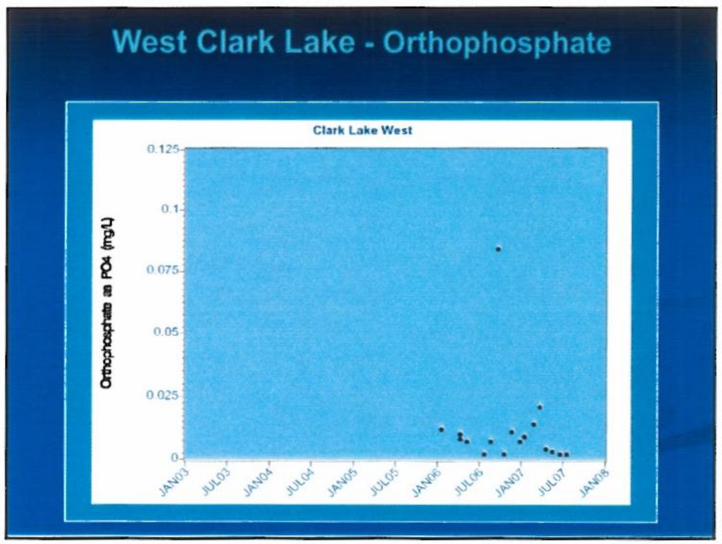
West Clark Lake

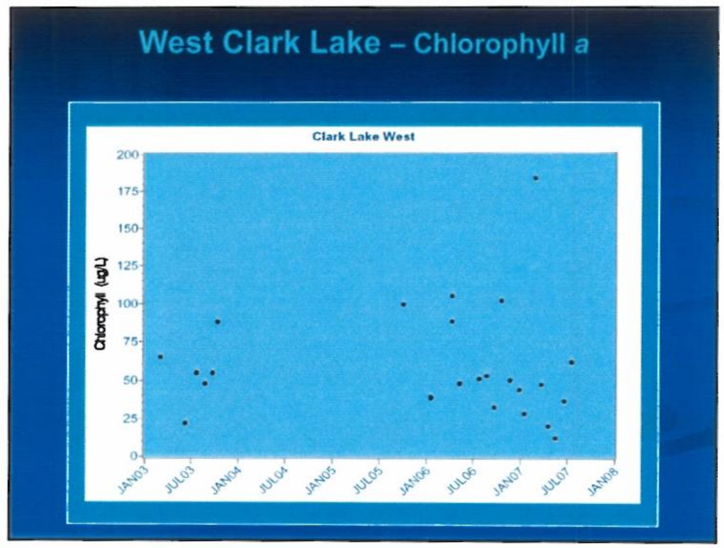
West Clark Lake – Total Nitrogen




West Clark Lake – Nitrate+Nitrite
Clark Lake West
Nitrate Nitrite (mg/L)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
JAN03
JUL03
JAN04
JUL04
JAN05
JUL05
JAN06
JUL06
JAN07
JUL07
JAN08


West Clark Lake – Total Phosphorus
Clark Lake West
Total Phosphorus (mg/L)
0.5
0.4
0.3
0.2
0.1
0
JAN03
JUL03
JAN04
JUL04
JAN05
JUL05
JAN06
JUL06
JAN07
JUL07
JAN08

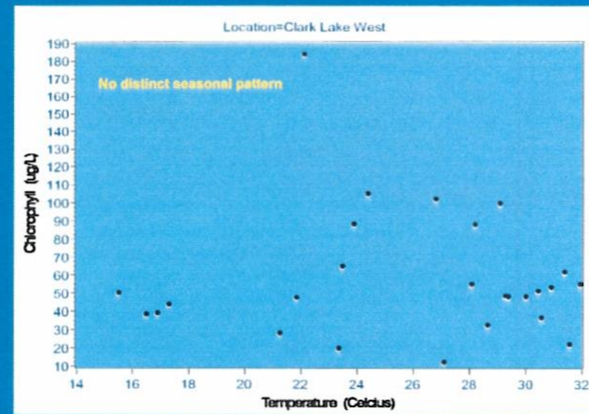

West Clark Lake - Orthophosphate
Clark Lake West
Orthophosphate as PO4 (mg/L)
0.125
0.1
0.075
0.05
0.025
0
JAN03
JUL03
JAN04
JUL04
JAN05
JUL05
JAN06
JUL06
JAN07
JUL07
JAN08


West Clark Lake – Chlorophyll a
Clark Lake West
Chlorophyll (ug/L)
200
175
150
125
100
75
50
25
0
JAN03
JUL03
JAN04
JUL04
JAN05
JUL05
JAN06
JUL06
JAN07
JUL07
JAN08

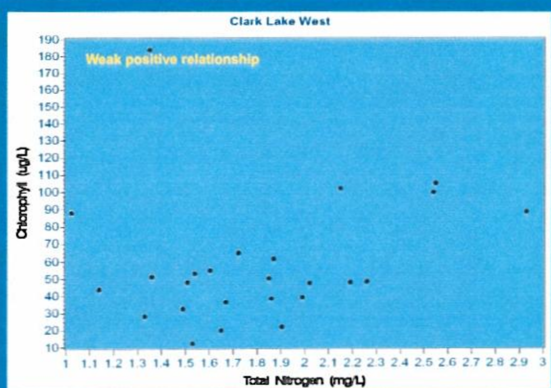
Relationships Between Chlorophyll *a* and other Water Quality Parameters

- Chlorophyll a versus
  - Temperature
  - Total Nitrogen
  - Nitrate + Nitrite Nitrogen
  - Total Phosphorus
  - Orthophosphate

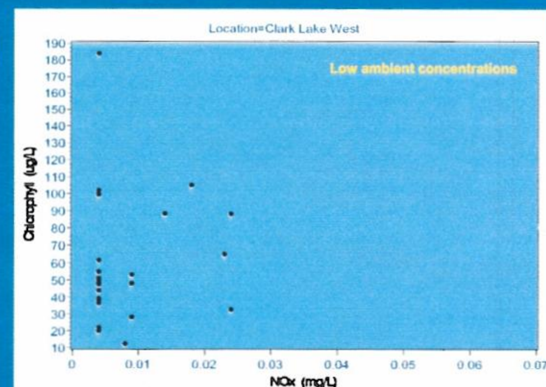
West Clark Lake



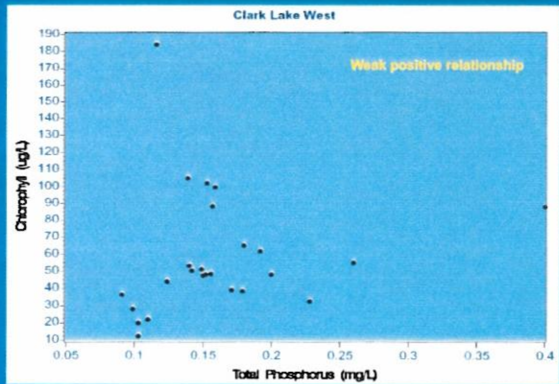
West Clark Lake



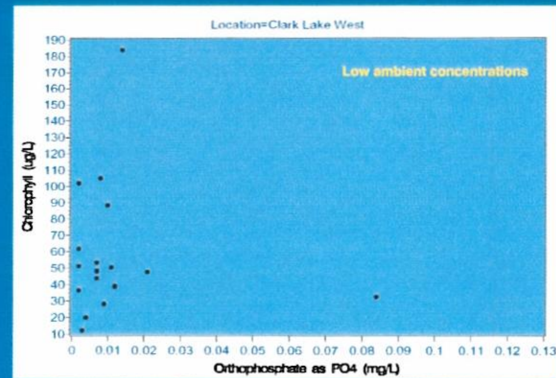
West Clark Lake



West Clark Lake



West Clark Lake



West Clark Lake - Summary

- Not enough long-term data to determine seasonal patterns or trends
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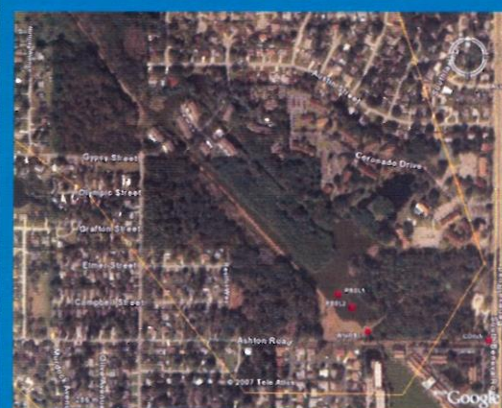
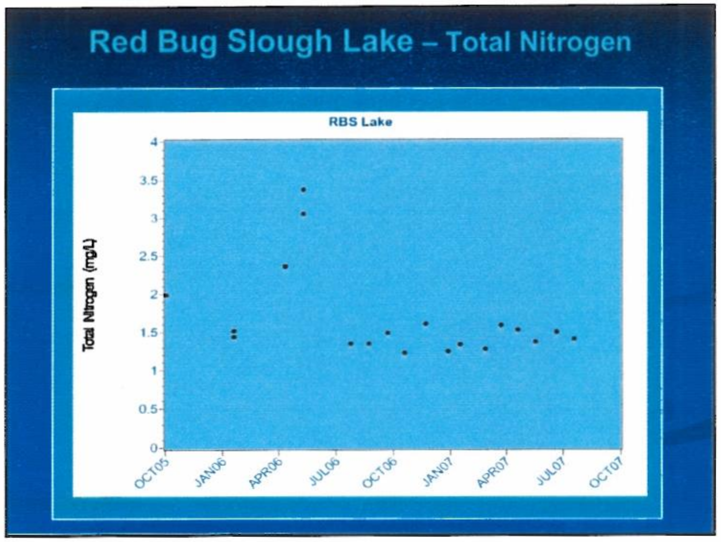
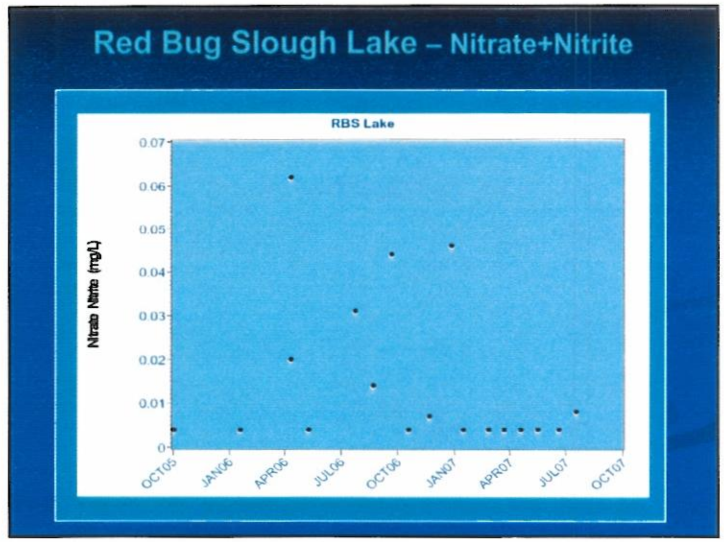
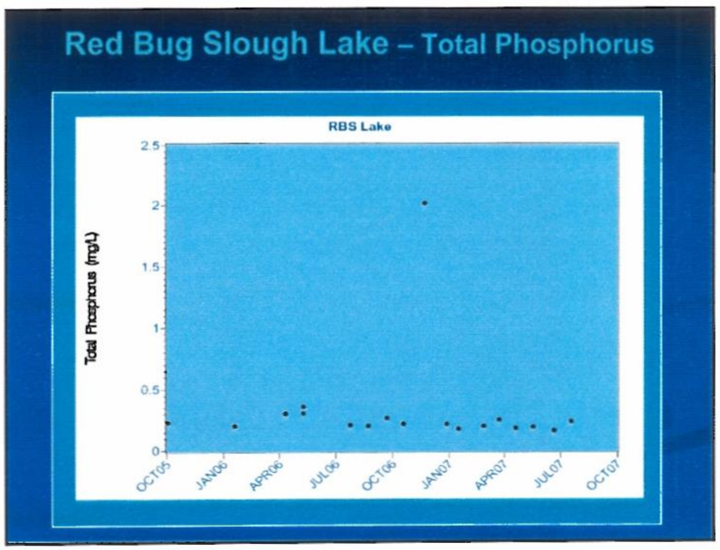
- Generally very low inorganic nitrogen and phosphorus levels

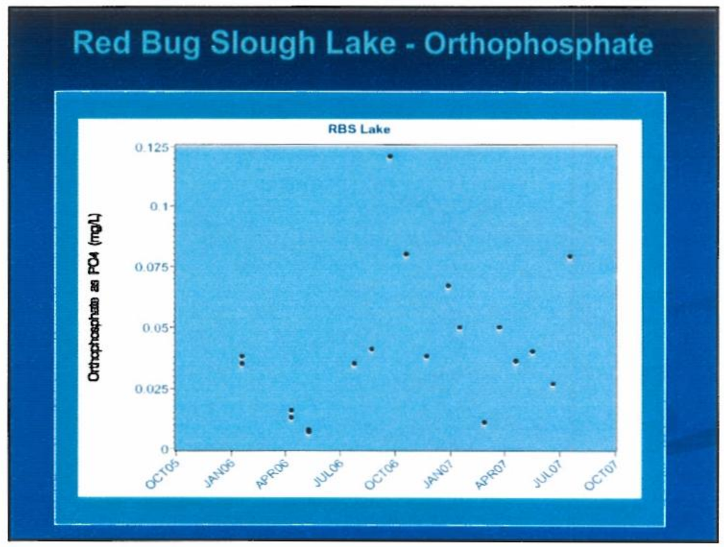
Red Bug Slough Lake



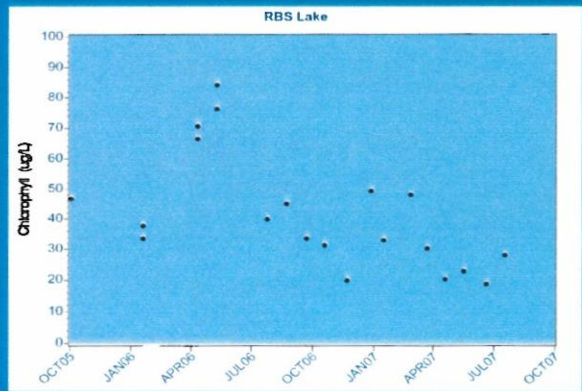

Red Bug Slough Lake – Total Nitrogen
RBS Lake
Total Nitrogen (mg/L)
0
0.5
1
1.5
2
2.5
3
3.5
4
OCT05
JAN06
APR06
JUL06
OCT06
JAN07
APR07
JUL07
OCT07


Red Bug Slough Lake – Nitrate+Nitrite
RBS Lake
Nitrate Nitrite (mg/L)
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
OCT05
JAN06
APR06
JUL06
OCT06
JAN07
APR07
JUL07
OCT07


Red Bug Slough Lake – Total Phosphorus
RBS Lake
Total Phosphorus (mg/L)
0
0.5
1
1.5
2
2.5
OCT05
JAN06
APR06
JUL06
OCT06
JAN07
APR07
JUL07
OCT07


Red Bug Slough Lake - Orthophosphate
RBS Lake
Orthophosphate as PO4 (mg/L)
0
0.025
0.05
0.075
0.1
0.125
OCT05
JAN06
APR06
JUL06
OCT06
JAN07
APR07
JUL07
OCT07

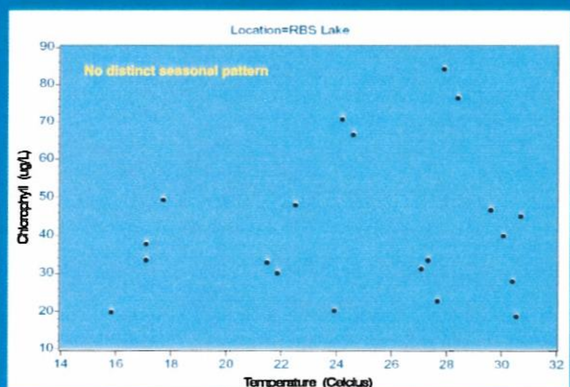
Red Bug Slough Lake – Chlorophyll *a*



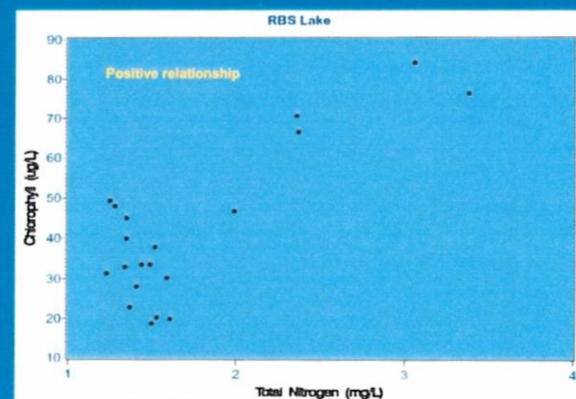
Relationships Between Chlorophyll *a* and other Water Quality Parameters

- Chlorophyll a versus
  - Temperature
  - Total Nitrogen
  - Nitrate + Nitrite Nitrogen
  - Total Phosphorus
  - Orthophosphate

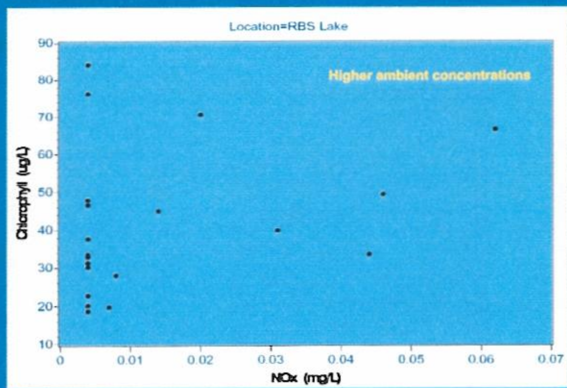
Red Bug Slough Lake



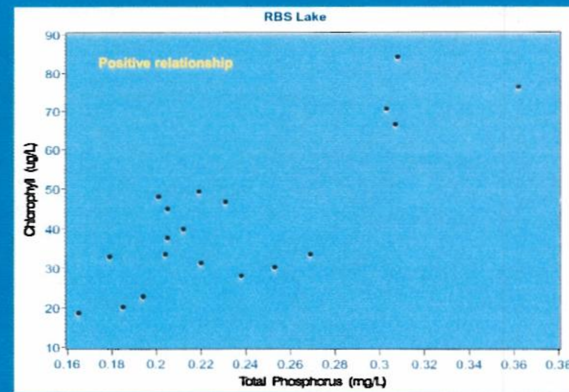
Red Bug Slough Lake



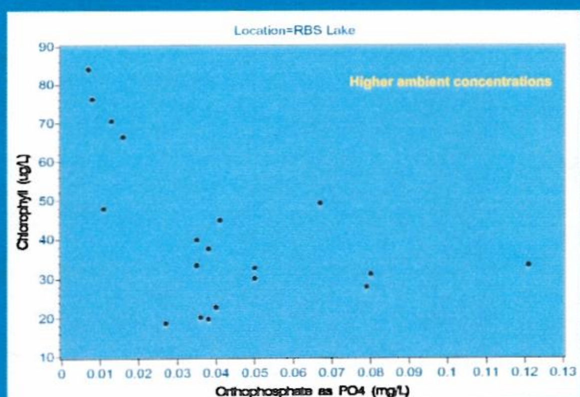
Red Bug Slough Lake



Red Bug Slough Lake



Red Bug Slough Lake



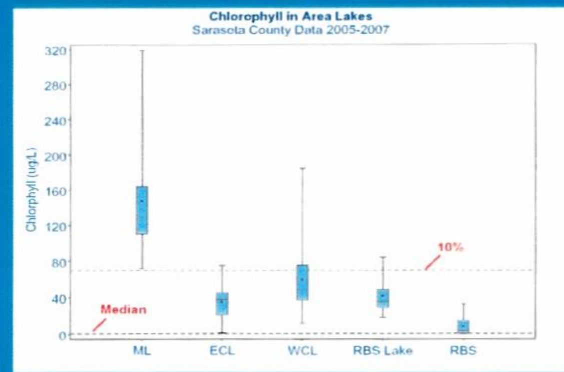
Red Bug Slough Lake - Summary

- Not enough long-term data to determine seasonal patterns or trends
- Indications of positive relationships between chlorophyll and both TN & TP

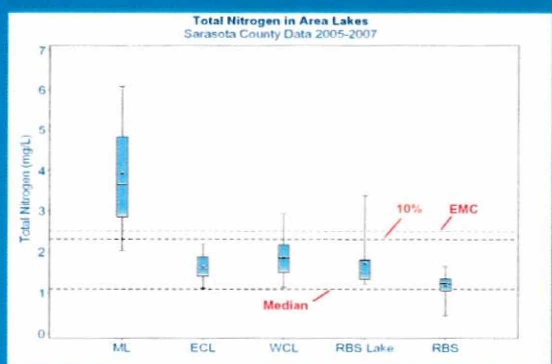
Graphical Comparisons Among Basins

- Chlorophyll *a*
- Total Nitrogen
- Nitrate + Nitrite Nitrogen
- Total Phosphorus
- Orthophosphate

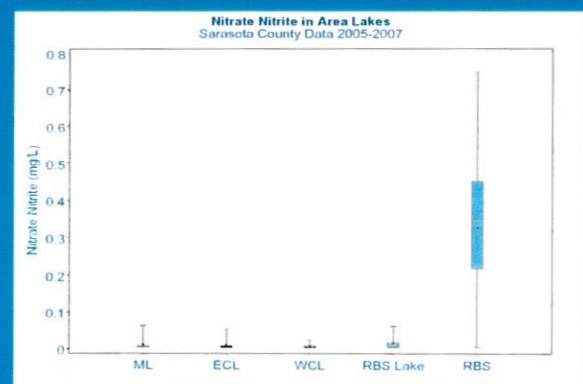
Comparisons Among West Clark Lake System Water Bodies



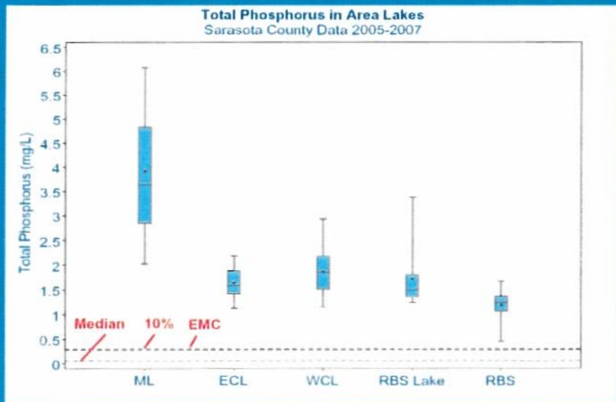
Comparisons Among West Clark Lake System Water Bodies



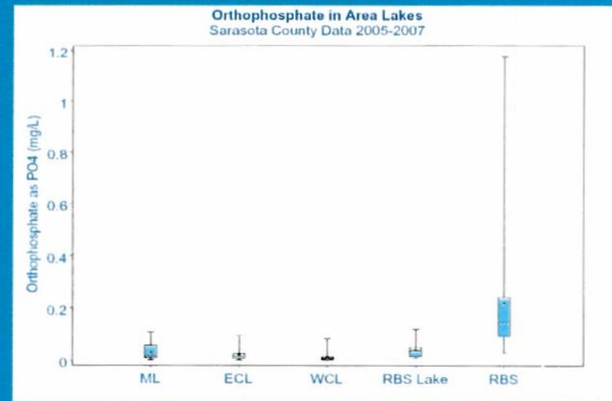
Comparisons Among West Clark Lake System Water Bodies



Comparisons Among West Clark Lake System Water Bodies



Comparisons Among West Clark Lake System Water Bodies

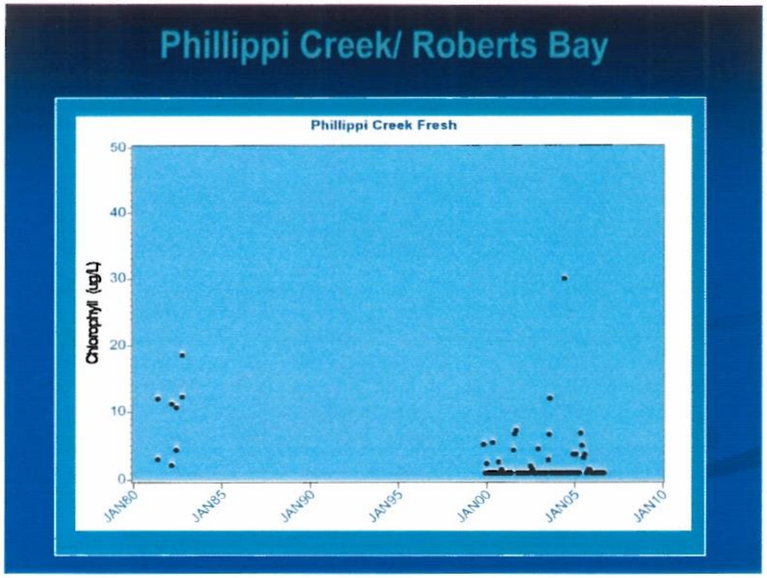


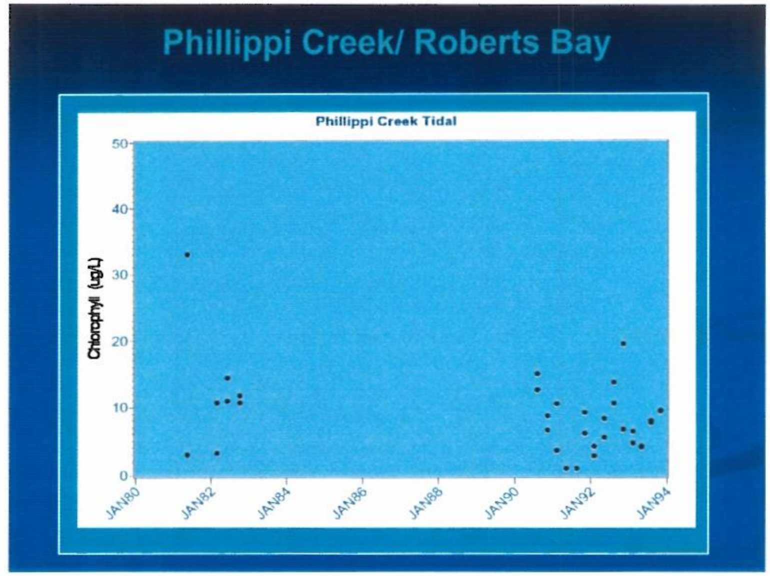
Comparisons Among West Clark Lake System Water Bodies

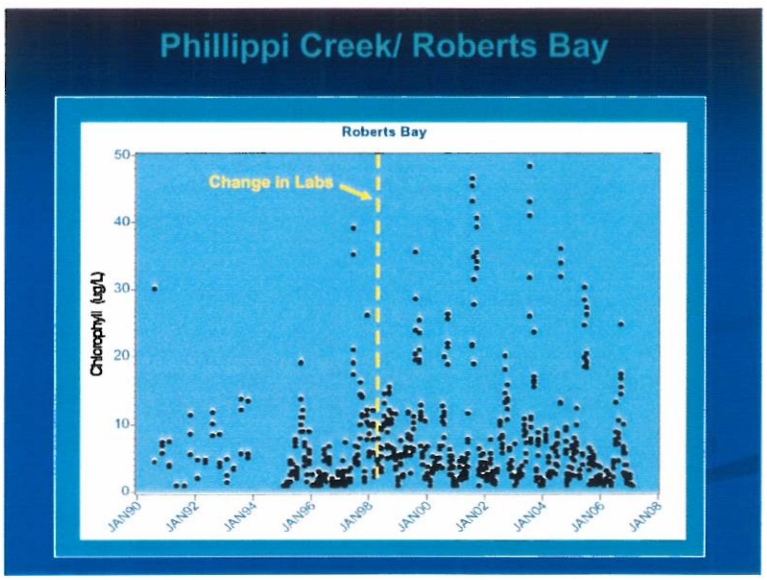
Surface Water	Mean Annual Residence Time (days)
Mirror Lake	46
E. Clark Lake	5.0
W. Clark Lake	4.6
Red Bug Slough	0.9

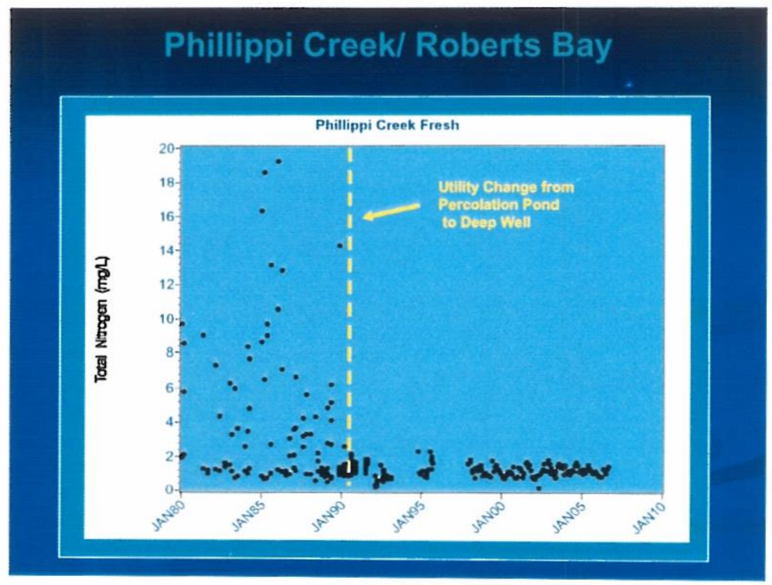
Water Quality in Mirror Lake is strongly influenced by internal nutrient recycling

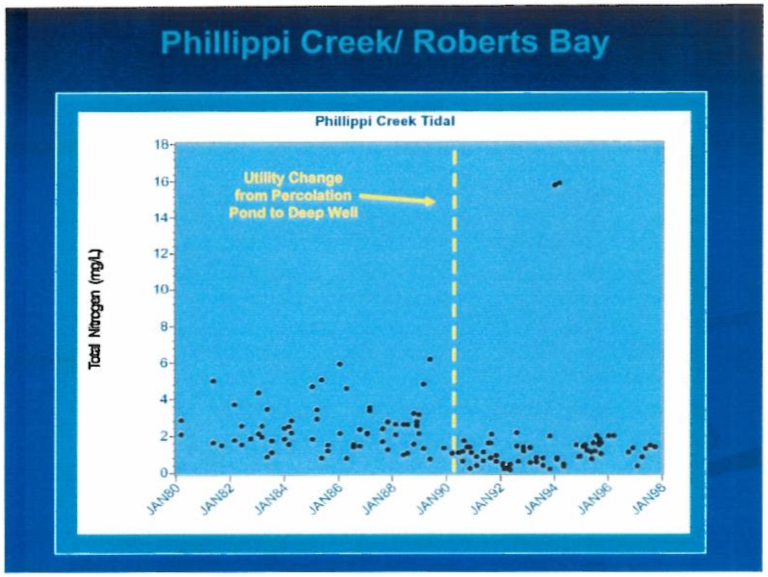
Phillippi Creek/ Roberts Bay

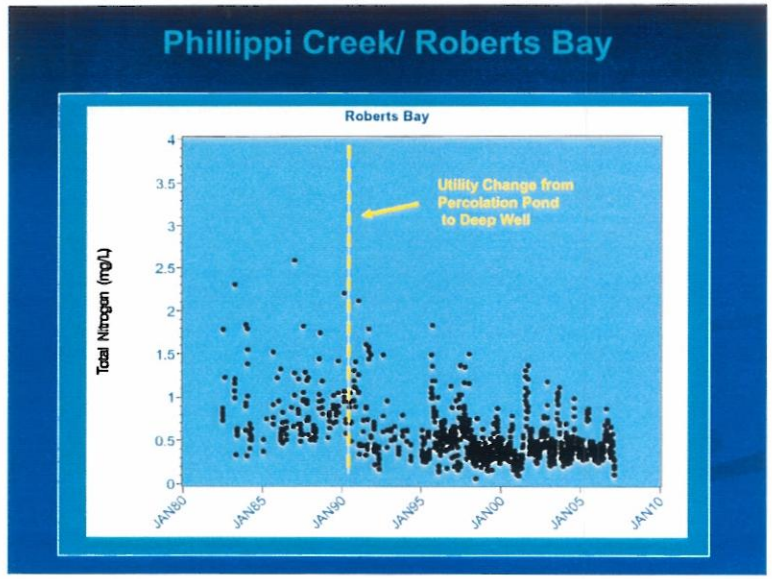

Phillippi Creek/ Roberts Bay
Phillippi Creek Fresh
Chlorophyll (ug/L)
50
40
30
20
10
0
JAN80
JAN85
JAN90
JAN95
JAN00
JAN05
JAN10

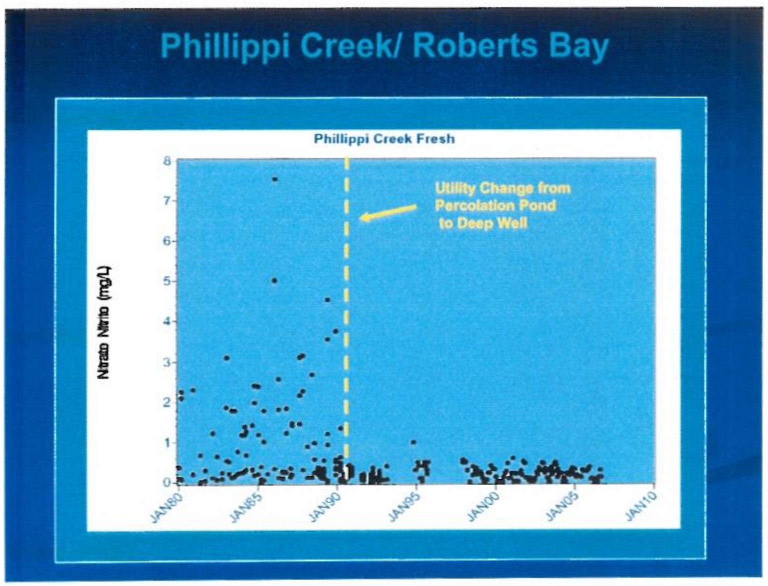

Phillippi Creek/ Roberts Bay
Phillippi Creek Tidal
Chlorophyll (ug/L)
50
40
30
20
10
0
JAN80
JAN82
JAN84
JAN86
JAN88
JAN90
JAN92
JAN94

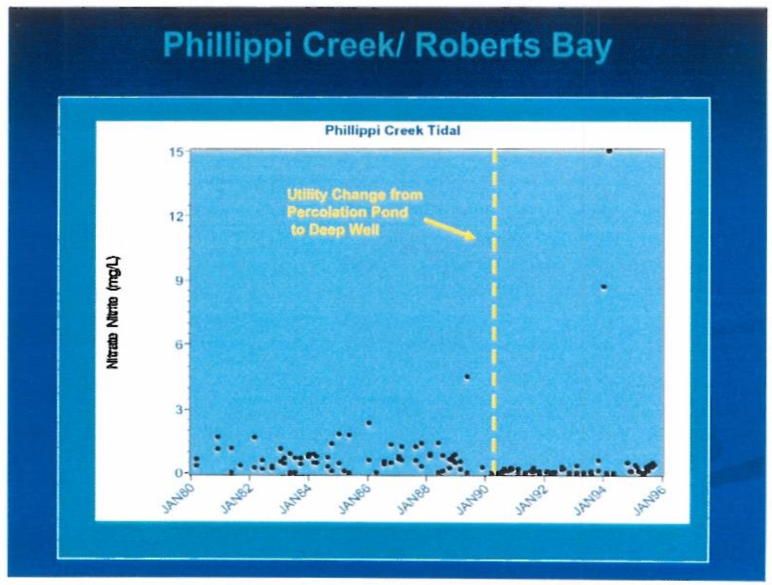

Phillippi Creek/ Roberts Bay
Roberts Bay
Change in Labs
Chlorophyll (ug/L)
50
40
30
20
10
0
JAN90
JAN92
JAN94
JAN96
JAN98
JAN00
JAN02
JAN04
JAN06
JAN08


Phillippi Creek/ Roberts Bay
Phillippi Creek Fresh
Utility Change from
Percolation Pond
to Deep Well
Total Nitrogen (mg/L)
20
18
16
14
12
10
8
6
4
2
0
JAN80
JAN85
JAN90
JAN95
JAN00
JAN05
JAN10

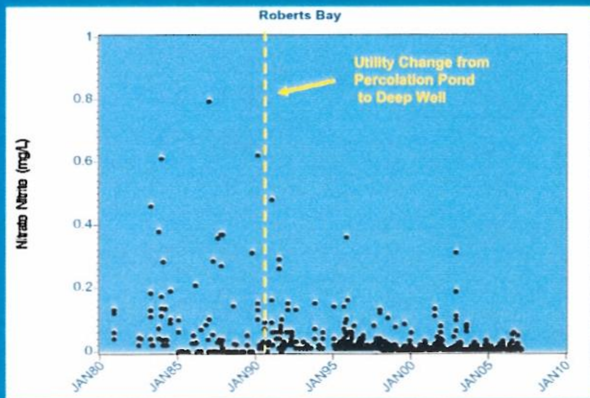

Phillippi Creek/ Roberts Bay
Phillippi Creek Tidal
Utility Change from Percolation Pond to Deep Well
Total Nitrogen (mg/L)
JAN80 JAN82 JAN84 JAN86 JAN88 JAN90 JAN92 JAN94 JAN96 JAN98


Phillippi Creek/ Roberts Bay
Roberts Bay
Utility Change from Percolation Pond to Deep Well
Total Nitrogen (mg/L)
JAN80 JAN85 JAN90 JAN95 JAN00 JAN05 JAN10


Phillippi Creek/ Roberts Bay
Phillippi Creek Fresh
Utility Change from Percolation Pond to Deep Well
Nitrate Nitrite (mg/L)
JAN80 JAN85 JAN90 JAN95 JAN00 JAN05 JAN10


Phillippi Creek/ Roberts Bay
Phillippi Creek Tidal
Utility Change from Percolation Pond to Deep Well
Nitrate Nitrite (mg/L)
JAN80 JAN82 JAN84 JAN86 JAN88 JAN90 JAN92 JAN94 JAN96

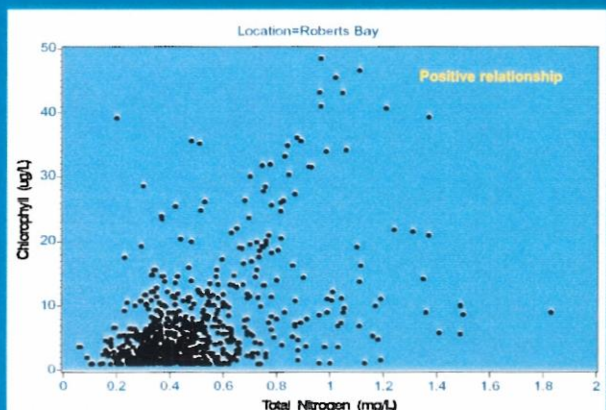
Phillippi Creek/ Roberts Bay



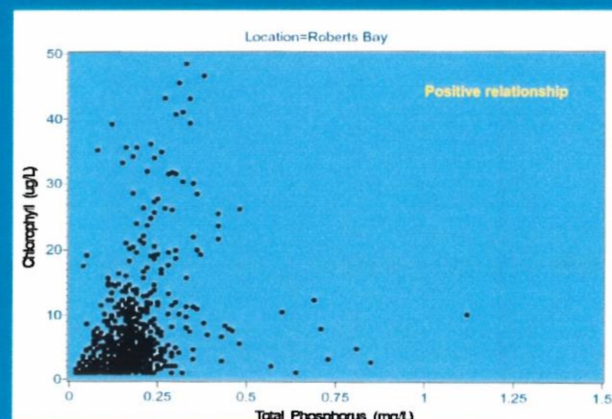
Phillippi Creek/Roberts Bay - Summary

- Apparent increase in chlorophyll *a* over time
  - Associated with change in labs?
  - Opposite of observed declines in nitrogen inputs
- Decline in nitrogen inputs appears to correspond with utility's removal of percolation pond discharges to Phillippi Creek

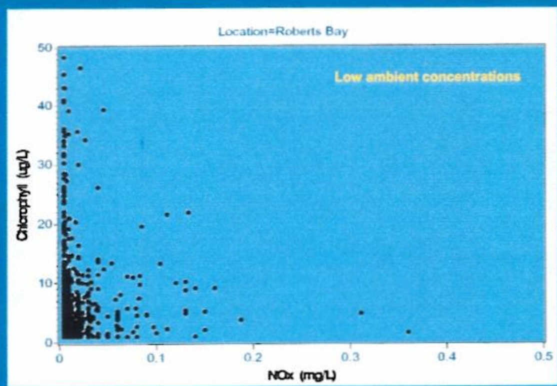
Roberts Bay – Chlorophyll *a* Patterns



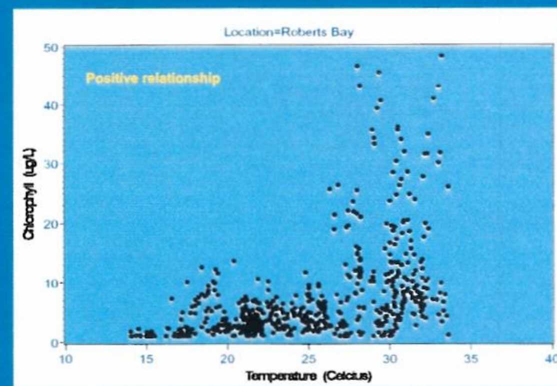
Roberts Bay – Chlorophyll *a* Patterns



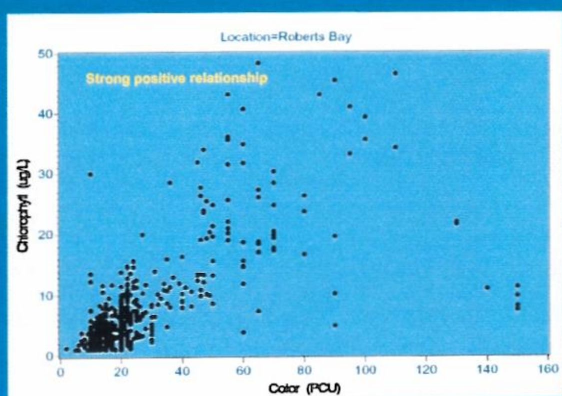
Roberts Bay – Chlorophyll *a* Patterns



Roberts Bay – Chlorophyll *a* Patterns



Roberts Bay – Chlorophyll *a* Patterns



Summary of Roberts Bay Chlorophyll *a* Patterns

- Chlorophyll levels are positively related to both TN and TP concentrations
- The highest chlorophyll levels correspond with very low inorganic nitrogen concentrations
- The highest chlorophyll levels correspond with the highest temperatures (rainfall?)
- There is a direct positive relationship between color (nutrient inputs) and chlorophyll

TMDL and Pollutant Loading

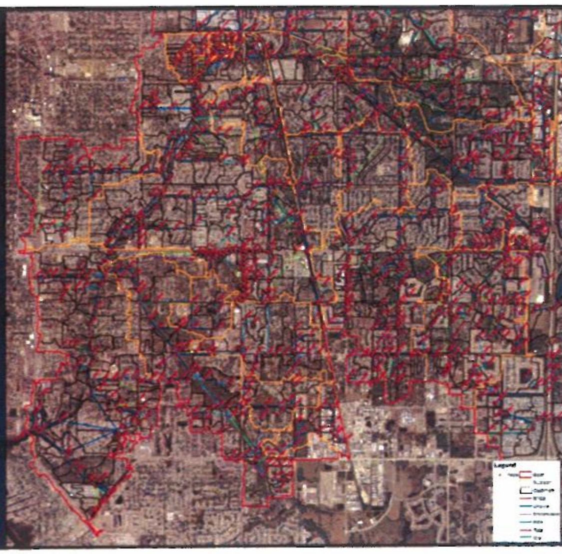
West Clark Lake TMDL Workshop

October 3, 2007

TMDL and Pollutant Loadings

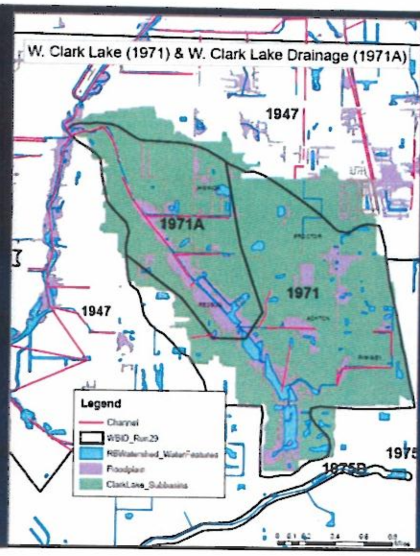
Presentation Outline

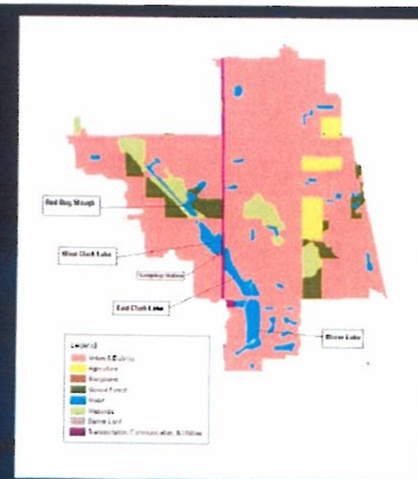
- Overview of FDEP TMDL assumptions, calculations and results
- Uncertainties in analysis
- Significance of uncertainties on TMDL and management actions



TMDL Overview

- Nutrient TMDL (November 3, 2005) for West Clark Lake
- Impaired for nutrients
  - TSI > 60 in 2003 (color > 60 PCU)
- 2003 only year with sufficient data to calculate TSI
- Water quality in 2003
  - Mean chlorophyll a = 43.66 µg/L
  - Mean total phosphorus (TP) = 0.23 mg/L
  - Mean total nitrogen (TN) = 1.70 mg/L





Map of Clark Lake basin and land use categories.

Watershed Land Cover Distribution

Land Use Category	Lake Mirror	East Clark	West Clark	Red Bug S.
	acres	acres	acres	acres
Urban and built-up	14.0	136.9	4.0	15.2
Low Density Residential	11.7	42.8	0.0	5.9
Medium Density Residential	32.0	181.8	92.0	469.8
High Density Residential	43.2	0.1	238	31.2
Agriculture	0.0	21.4	0.0	22.0
Rangeland	0.0	0.0	0.0	0.0
Forest	0.0	28.6	7.9	32.7
Water	25.2	22.0	12.3	16.1
Wetlands	0.0	35.6	1.1	7.4
Barren Land	0.0	0.0	0.0	33.1
Transportation, Communications, and Utilities	1.3	1.2	9.9	0.0
Acreage =	124.4	470.4	150.9	663.4

Lake and Watershed Areas

Surface Water	Lake Area (acres)	Watershed Area (acres)	Watershed : Lake Area Ratio
Mirror Lake	16.9	107	6.3
E. Clark Lake	11.0	440	40
W. Clark Lake	8.2	152	18.5
Red Bug Slough	9.3	633	68

Lakes with smaller watershed to lake areas typically have better water quality. Mirror Lake has the smallest ratio but has the poorest water quality.

Key Hydrologic Assumptions

- Only watershed flow gauge available at Proctor Street downstream of Red Bug Slough
- Included entire upstream watershed in hydrologic analysis including Red Bug Slough
- Modeled water flow rates and water volumes entering and leaving each lake
- Used "Digital Filter" to separate runoff from baseflow

*** 2003 Annual Rainfall at several gauges ~ 65 inches**
Average Annual Rainfall ~ 49 inches (33% less)
Rainfall in 2003 much higher than average.

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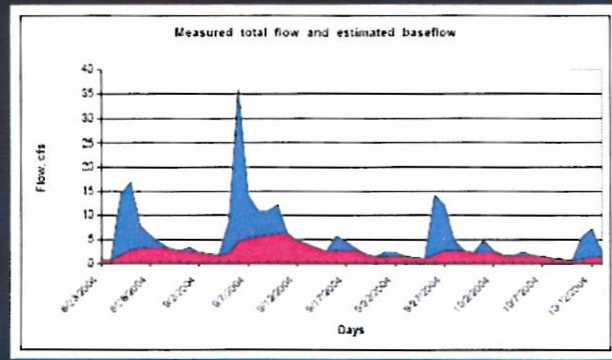

A fragment of total hydrograph observed in Red Bug Slough in 2004 with overlaid baseflow component estimated by Digital Filter. The difference between those two (visible blue area) is surface runoff.

PBSJ

Calculated Monthly Total Discharges from Four Lakes (cubic feet):

	Lake Mirror	East Clark	West Clark	Red Bug S.
	cf	cf	cf	cf
January	579,080	2,869,478	3,729,410	6,523,004
February	392,001	1,554,503	1,931,704	3,340,592
March	673,801	2,726,528	3,396,586	5,833,350
April	816,719	3,405,853	4,234,235	7,324,100
May	1,602,767	6,951,151	8,659,498	15,252,615
June	7,556,682	33,764,215	41,989,802	74,396,440
July	1,361,771	5,585,188	7,015,716	12,070,945
August	2,425,180	9,569,428	11,756,925	19,996,549
September	2,298,580	10,020,805	12,656,889	21,701,945
October	605,508	2,541,632	3,189,236	5,613,382
November	751,582	3,240,202	4,042,605	7,155,678
December	1,532,767	6,731,181	8,382,825	14,786,148
	20,596,438	88,980,164	110,894,431	193,993,887
	473 ac ft	2043 ac ft	2546 ac ft	4453 ac ft
	A = 124 ac	A = 594 ac	A = 745 ac	A = 1378 ac
	d = 3.8 ft	d = 3.4 ft	d = 3.4 ft	d = 3.2 ft
	46"	41"	41"	38"

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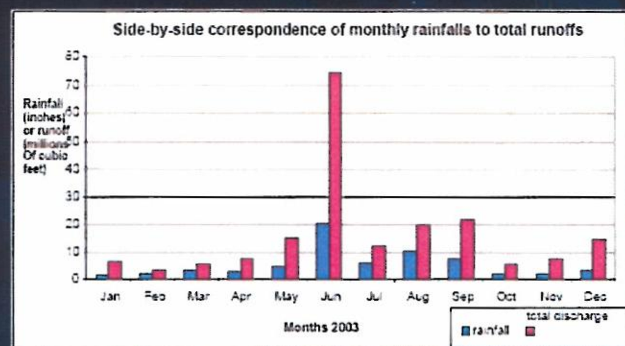

Total flows aggregated in monthly sums and the corresponding monthly rainfalls. In June 2003, 20.51" of rain was recorded in the Lakes basin that made June an unusually wet month. **The discharge in June may have been as much as 3-5 times average, much of rainfall direct to runoff.**

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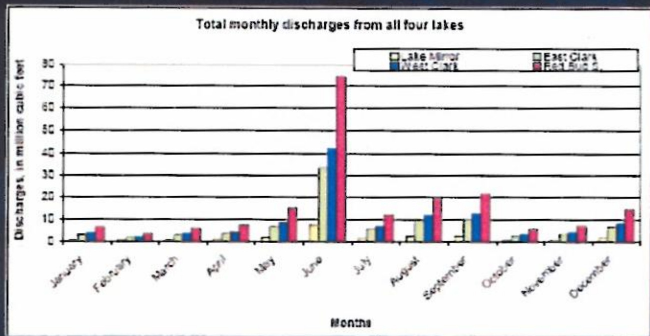

Discharges from four lakes in 2003 assessed by mathematical model.

The discharge in June may have been as much as 3-5 times average.

PBSJ

Lake Residence Time Based on TMDL Discharge Volumes in 2003

Surface Water	Mean Annual RT (days)	June RT (days)
Mirror Lake	46	10
E. Clark Lake	5.0	1.1
W. Clark Lake	4.6	1.0
Red Bug Slough	0.9	0.2

Lakes or ponds with longer residence times typically have better water quality.
Mirror Lake has the longest residence time but has the poorest water quality.
Most of the Mirror Lake watershed receives stormwater treatment.
This indicates Mirror Lake has excessive internal or groundwater loading.

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Nutrient Mass Balance Methodology

The mass balance equation was formulated as follow:

Sedimentation - internal load = point source incoming load + nonpoint source incoming load + ground water load + rainfall load – export load - increase of suspended mass

- No known point source loads in watershed
- Red Bug Slough removed from analysis because it was not needed to evaluate West Clark Lake

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Nutrient Loading Assumptions

- Runoff EMCs from Southwest Florida used
- Septic tanks/groundwater loading modeled
- Developed regression equation to calibrate model to measured chlorophyll a values in 2003

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Bird Species Identified at Lake Mirror, Count, and Predicted Nutrient Contribution. Weight: ratio is related to average Canadian goose.

				Annual Nutrient Production (lbs.)	
Species	Count	Weight (lbs.)	Weight Ratio	TP	TN
Double Crested Cormorant	265	3.70	0.66	68.64	219.94
Anhinga	35	2.97	0.53	7.28	23.32
White Ibis	312	2.00	0.36	43.69	139.97
Glossy Ibis	148	1.34	0.24	13.91	44.65
Common Egret	3	2.25	0.40	0.47	1.51
Snowy Egret	42	0.81	0.14	2.39	7.65
Black-crowned Night Heron	1	1.81	0.32	0.13	0.41
Little Blue Heron	16	0.75	0.13	0.84	2.69
Louisiana Heron	1	0.69	0.12	0.05	0.15
Tri-Colored Heron	1	0.81	0.14	0.06	0.18
Total	824			137.45 (11% of total to WCL)	440.39 (4% of total to WCL)

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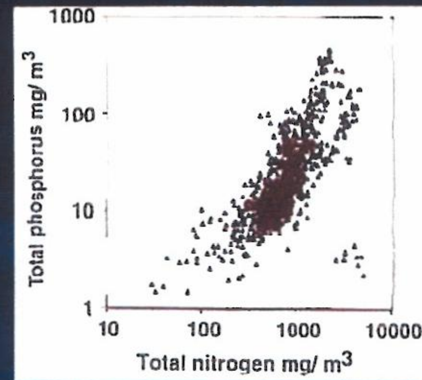
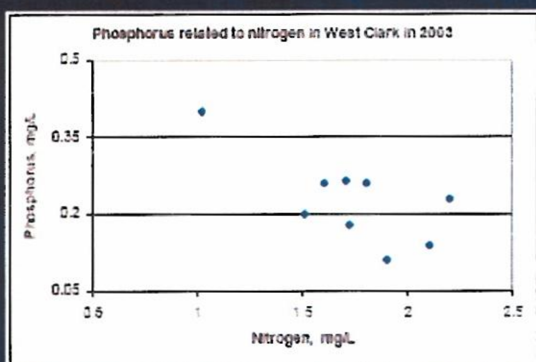


Average annual total nitrogen concentrations and average annual total phosphorus concentrations in several Florida lakes

Typically both nutrient concentrations increase.

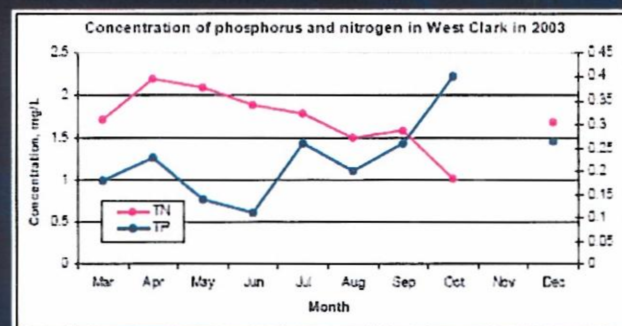
PBSJ



Nutrient concentrations measured in West Clark Lake during 2003

Based on limited data, the N concentration in West Clark Lake commonly decreases as the P concentration increases. This is difficult to explain.

PBSJ



Concentration of phosphorus and nitrogen measured in West Clark Lake in 2003

Time series data shows an inverse relationship between TN and TP during part of 2003. TP increases and TN decreases during wet months.

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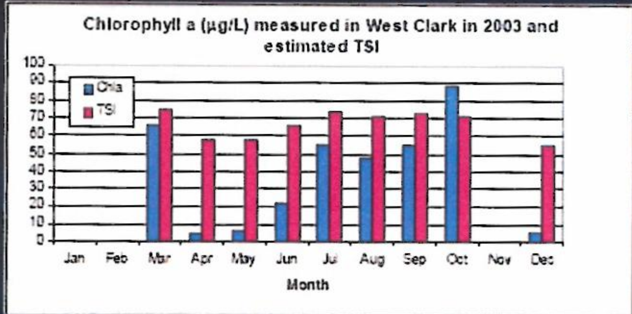

Chlorophyll a measured in West Clark Lake in 2003 and TSI determined from concentration of phosphorus, nitrogen, and chlorophyll. **Some months had much lower chlorophyll values although nutrient concentrations remained relatively high.**

PBS&J

Estimated Sources of Nutrients to West Clark Lake (kg)							
	Surface Runoff		Septic Tank	Ground Water		Upstream Inflow	
	TN	TP	TN	TN	TP	TN	TP
Jan	7.6	1	23.6	12.6	4.8	141.4	15.9
Feb	4.3	0.4	13.2	5.7	4.1	76.7	9.6
Mar	12.4	1.5	19.2	7.1	4.7	134.7	16.3
Apr	18.2	2.4	23.5	37.7	8.7	222.3	25.6
May	31.7	4.3	44.6	38.9	3.7	415.7	29.7
Jun	255.6	52.2	88.7	67.8	0	1810.9	148.5
Jul	24.8	3	32.8	16.2	15.7	285	46.5
Aug	67.2	9	41.2	0	9.1	429.4	57.1
Sep	73.7	10.3	47.9	8.7	19.3	458	79.5
Oct	5.9	0.6	19.4	0	16.3	106.2	35.4
Nov	8.7	1	24.7	0	10.6	130.3	33.9
Dec	34.6	4.8	38.8	22.5	12.7	334.2	55
Total	645.7	90.5	417.6	217.2	109.7	4544.8	553

Estimated nutrients loads into West Clark Lake for Current Condition. Contribution of septic tanks was separated from ground water. **Septic tanks are typically associated only with the release of TN.**

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Estimated Natural Condition TMDL Surface Water Nutrient Concentrations in West Clark Lake

	TP (mg/L)	TN (mg/L)	Chl-a (µg/L)	TSI
Annual Average	0.016	0.61	7.7	43.9

PBS&J

TMDL Allocation for Reductions in TP and TN in Surface Water Runoff

WID	Parameter	WLA		LA (lbs/year)	MOS	TMDL (lbs/year)	*Percent Reduction
		Waste Water (lbs/year)	*Stormwater (% reduction)				
1971	TN	NA	*25%	7,611	Implicit	7,610	*25%
1971	TP	NA	*25%	1,480	Implicit	1,480	*25%

* Percent reduction is based only on reductions from the current condition for surface water runoff from all contributing basins. The Load Allocation is from all basins and sources including ground water. Overall TN percent reduction including elimination of septic tanks in West Clark Lake, East Clark Lake, and Mirror Lake basins is 59.5. Overall reduction in TP is 10.8 percent.

- Margin of Safety included conservative modeling assumptions and fact that 2003 rainfall was 13% - 34 % > average
- TMDL suggests removal of all septic tanks in watershed and 25% reduction in stormwater TP and TN loads

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Uncertainties in TMDL Analysis
Hydrology

- Based on significantly above average rainfall
  - 65 inches for year (2003)
  - 20 inches in June
  - 3 inches in March and April
  - 4+ inches in May
  - 10 Inches in August
- Division of water volumes from all sources modeled (estimated)

Uncertainties in TMDL Analysis
Nutrient Loadings

- All source nutrient concentrations estimated
- Assumes septic tanks significantly increase TN loads in groundwater; septic tank loads unknown
- Bird loadings estimated; bird loadings may have significantly changed nutrient concentrations in lake bottom sediments
- Lake Mirror sediments may be a significant nutrient source
- Higher TN values don't correlate to higher TP values

Uncertainties in TMDL Analysis
Nutrient Loadings

- During summer higher discharges, TP increases and TN decreases
- Higher TP can't be explained by runoff or GW (septic). Values of TP higher than runoff or GW
- 4 months with very low chlorophyll a have high TSIs
- All nutrient loads may be overestimated due to 65 inches of rainfall in 2003
- Existing BMPs and natural treatment areas not considered in analysis

Uncertainties in TMDL Analysis
Nutrient Loadings

- Large percentage of nutrient loads to W. Clark Lake from upstream sources
- Are nutrient loads primarily from Mirror Lake or E. Clark Lake or both?
- Which nutrient sources are the most significant?
  - Runoff
  - Sediments
  - Groundwater/septic tanks
  - Birds

Significance of Uncertainties on TMDL and Best Management Actions

- TP may be more important than TN
- Removing septic tanks may not result in desired nutrient load reduction and water quality improvement
- Mirror Lake may contribute significantly more nutrient load due to bird island and lake sediments
- Additional stormwater treatment may not be necessary and/or may not provide required nutrient load reduction
- May be possible to provide additional treatment, if necessary, in the existing or modified surface water system

Group Assignments

Small Group Assignments

Group 1: (12) Hydrologic Setting (historic and present) – Dave Tomasko, PBS&J

Mark Alderson, SBEP
John Ryan, WQ/TMDL, SC
Mike Jones, Red Bug Slough, SC
Jane Grogg, Neighborhoods, SC
Hans Zarbock, Jones Edmunds
Emily Hyfield, PBS&J
Lizanne Garcia, SWFWMD
Jeff Weber, Red Bug Slough Land Mgr., SC
Scott Woodman, Flood Planning, SC
David Coley, GIS, SC
Rob Dwyer, FDOT Maintenance
Ed Wolfe, Long-range Planning, SC

Group 2: (12) Water Quality – Ralph Montgomery, PBS&J

Kelly Westover, Watershed Planning, SC
Sam Heyes, Field Drainage Ops., SC
Sherry Phillips-Smith, GIS Drainage
David Pearce, Attorney, SC
Brenda Bair, Septic Tank Replacement, SC
Tony Janicki, Janicki Environmental
Manny Lopez, SWFWMD
Kathy Meaux, WQ Sampling, SC
Brian Beatty, Long-range Planning, SC
Rob Wright, Neighborhoods, SC
Laura Ammeson, WWTP, SC
Kristin Maki, PBS&J

Group 3: (11) Pollutant Loading – Jeff Herr, PBS&J

Gary Raulerson, SBEP
John Czahoroski, Field Ops. Mgr., SC
Jon Perry, Pollutant Loading Model, SC
Robert Bresciani, Stormwater Review, SC
Brett Cunningham, Jones Edmunds, SC
Ryan Kormanic, WWTP Inspector, SC
Veronica Craw, SWFWMD
Warren Davis, SW Mgr., SC
Jody Kirkman, WWTP Planning, SC
Rene Janneman, NPDES MS4, SC
Larry Ritchie, FDOT, NPDES/MS4

How do we workshop?

- participate
- ask questions
- generate lots of ideas
- make simple, clear statements
- work together in agreement and disagreement
- think with a "fresh view"
- have fun!

AM Tasks: Problem Defining (11:15-12:15)

- Group 1 – AM Session: Hydrologic Setting (historic and present) – Dave Tomasko, PBS&J

In the presentation this morning you learned that 74% of the wetlands in the greater W. Clark Lake watershed have been lost. The following tasks are designed to evaluate the impact of these losses on the movement of water through the watershed and the impact on water quality:

Task 1: Overlay the historic wetlands and open water map (vellum) on the 2006 aerial photograph. On the map (vellum), identify and color-in with cross-hatching the following areas:

- Places where wetlands have been filled for development (cross-hatch red);
- Places where wetlands have been excavated to create open water; (cross-hatch blue);
- Places where wetlands have been gained (cross-hatch green);
- Places where open water has been lost (cross-hatch red).

Task 2: On the flip-chart list the water resource impacts associated with each type of loss and gain identified in Task 1.

Task 3: Overlay the sub-basin boundaries and channel feature map (vellum) on the map produced in Task 1. Identify and map key drainage features, using arrows to show the direction of flow in pipes and channels and stars to identify weirs.

Task 4: Write brief descriptions on the map prepared in Task 3 explaining how the impacts identified in Task 2, along with drainage features identified in Task 3, influence the:

- Movement of water through the sub-basins and the interconnected lakes, and;
- Water quality in each of the sub-basins.

Task 5: Identify opportunities for hydrologic and water quality restoration.

- Group 2 – AM Session: Identification of Sources Influencing Water Quality in the Greater W. Clark Lake Watershed – Ralph Montgomery, PBS&J

In the presentations this morning, you learned about:

- Long-term and seasonal patterns in water quality with each of the four larger water bodies in the West Clark Lake system (Mirror Lake, East Clark Lake, West Clark Lake and Red Bug Slough Lake)

- Long-term and seasonal patterns in water quality within the freshwater and brackish areas of Phillippi Creek, as well as Robert's Bay

The primary objective of this session will be to have the working group identify and rank those potential nutrient sources and physical hydrographical conditions that may account for the observed existing water quality conditions within each of the four catchment basins.

Task 1: Mirror Lake
- What are the expected primary sources?
- What are the expected responses from these sources?
- Are these expected responses chronic or more seasonal?
- What additional specific parameters and data are needed to specifically identify the relative contributions of these sources?

Task 2: East Clark Lake
- What are the expected primary sources?
- What are the expected responses from these sources?
- Are these expected responses chronic or more seasonal?
- What additional specific parameters and data are needed to specifically identify the relative contributions of these sources?

Task 3: West Clark Lake
- What are the expected primary sources?
- What are the expected responses from these sources?
- Are these expected responses chronic or more seasonal?
- What additional specific parameters and data are needed to specifically identify the relative contributions of these sources?

Task 4: Red Bug Slough
- What are the expected primary sources?
- What are the expected responses from these sources?
- Are these expected responses chronic or more seasonal?
- What additional specific parameters and data are needed to specifically identify the relative contributions of these sources?

Task 5: Develop a tabular summary of key similarities and differences among potential sources, responses and these four catchments.

Task 6: Phillippi Creek / Robert's Bay – Depending on time, the group will then focus on broader issues related to these catchments relative to the larger system, and what are the primary resources of concern?

- <u>Group 3 – AM Session</u>: "What If" Scenarios for Restoring Water Quality in the Greater W. Clark Lake Watershed – Jeff Herr, PBS&J

In the presentations this morning, you learned that the sources and magnitudes of pollutants to W. Clark Lake are largely unknown. You also learned that a vast majority of the pollutant loads to W. Clark Lake are probably from inflow to the lake from upstream sources. The following tasks are designed to identify and evaluate "what if" scenarios for restoring water quality in the greater W. Clark Lake watershed. Potential restoration actions may vary significantly depending on the actual major sources of pollutant loads to W. Clark Lake.

Task 1: Identify the potential major pollutant load sources to W. Clark Lake. Indicate the location of each input on vellum overlaid on the 2006 aerial photograph (with sub-basin delineations, nodal stormwater diagram and 100 year flood plain) with a direction arrow (red marker). Draw a line around the horizontal limits of the source on the vellum and write the source name adjacent to the arrow (red marker).

Task 2: On the flip-chart, list the potential major pollutant load sources to W. Clark Lake identified in Task 1 across the top of the chart to create columns.

Task 3: On the flip chart, under the pollutant source, list potential restoration actions to reduce the specific pollutant load associated with each source.

Task 4: On another vellum overlaid on the same 2006 aerial, highlight the limits of each existing stormwater treatment pond (green marker), surface water system (blue marker), and undeveloped land area (brown marker) within the W. Clark Lake watershed. Estimate the surface area of each element and write the name and approximate area of each element on the vellum.

Task 5: Calculate the potential water storage volume for each one ft. of depth for each element identified in Task 4. Record the name and volume of each element on the flip chart.

Task 6: Consider how each identified element could be used for reducing pollutant loads to W. Clark Lake. Record this information on the flip chart under the appropriate element.

Task 7: Refer back to the list of potential restoration actions on the flip chart from Task 3. Further consider and discuss the potential effectiveness and ability to implement each potential restoration action. Record the major issues discussed for each potential restoration action on the flip chart.

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PM Tasks: Solution Defining (2:15-3:45)

- Group 1 – PM Session: Redbug Slough hydrologic restoration – Dave Tomasko, PBS&J

In the presentation this morning, you learned about 74% of the historic wetlands in the greater West Clark Lake watershed have been lost. Also, you learned that much of the historic slough itself has been converted to open water features. Within Redbug Slough, a dredged canal now cuts through former wetlands. A weir located south of Proctor Road elevates water levels in upstream portions of the West Clark Lake watershed, perhaps as far upstream as the culvert that directs flows from East Clark Lake into West Clark Lake. Adjacent to the dredged canal in Redbug Slough lie historic wetlands that are now separated by a berm lying on the southwestern edge of the canal. Through a possible combination of changes in weir elevation and/or breaches in the berm alongside the dredged canal, it would be possible to redirect flows into this historical wetland.

Task 1: Identify and map the opportunities to restore hydrologic function in Redbug Slough downstream of W. Clark Lake.

Using tools such as LiDAR or photogrammetry it would be possible to develop an assessment of cumulative areas of wetlands restored, with varying elevations. These methods could be used to calculate areas inundated with varying surface water elevations, including scenarios where the weir elevation is not altered, but areas of the berm would be "breached" to allow for inundation of former fringing wetlands.

The benefits of various potential scenarios will be assessed, both in terms of habitat restoration and/or water quality improvement.

Group 2 – PM Session: Mirror Lake Water Quality Restoration – Ralph Montgomery, PBS&J

In the preceding presentations and working groups, sources and magnitudes of pollutants to Mirror Lake were identified and discussed, as well as the potential restoration alternatives. The following tasks are designed to further specifically evaluate water quality restoration alternatives in the Mirror Lake watersheds. Among the catchments, Mirror Lake is characterized by having the smallest watershed, but by far the worst water quality of the four systems. The following tasks are designed to identify and evaluate "what if" scenarios for directly restoring water quality Mirror Lake and subsequently to the downstream segments of the greater watershed. Different potential restoration actions are expected to diverge significantly depending on the previously identified sources of pollutant loads to the lake, and the expected responses.

Task 1: Review and use the previously developed information by the study groups to further identify the potential major pollutant load sources to Mirror Lake. The expected information should include the location, and direction of inputs on the 2006 aerial photograph (with nodal stormwater diagrams) delineating the major sources of inputs.

Task 2: Review the 2006 aerial photograph, highlight the limits of existing stormwater treatment ponds, surface water systems, septic tanks, and developed/undeveloped land areas within the Mirror Lake watershed. Further define the relative areas of influence of each of these elements on the photograph.

Task 3: Evaluate recommended actions that might be taken to address and reduce pollutant loads to Mirror Lake from each of the identified pollutant sources.

Task 4: Determine if additional alternatives might be available specifically for the Mirror Lake system.

Task 5: Further consider and then rank the potential effectiveness and ability to implement each potential restoration action. Summarize the major issues discussed for each potential restoration action on the flip chart.

- <u>Group 3 – PM Session</u>: E. and W. Clark Lake water quality restoration – Jeff Herr, PBS&J

In the presentation this morning you learned that 78% of the TN and 73% of the TP load to W. Clark Lake comes from E. Clark Lake and Mirror Lake. You also were provided a summary of potential restoration alternatives for the W. Clark Lake watershed. The following tasks are designed to further evaluate water quality restoration alternatives in the E. and W. Clark Lake watersheds to improve water quality in E. and W. Clark Lake.

Task 1: Review the aerial photograph and vellum mark-ups and flip charts prepared by Group 3 in the morning session.

Task 2: Review the limits of existing stormwater treatment areas, surface water areas, and undeveloped land which could be used to restore hydrologic function and to provide additional storage in the E. Clark Lake watershed prepared by Group 3 in the morning session. Also review the estimated storage volume provided by each one ft. depth increment for each storage element in the E. Clark Lake watershed.

Task 3: On the storage area vellum prepared in the morning session, identify locations where structural modifications would be required to provide additional storage and record these locations on the vellum (black marker). Record if the modification involves a new structural feature or a modification to an existing feature and write a brief description of the required feature change on the vellum (black marker).

Task 4: Using the vellum with one ft. topographic contours overlaid on the aerial photograph, evaluate the possibility of increasing normal water levels in each potential storage element. Identify areas with increased flooding potential if water levels are raised. Highlight the areas where raising the water level appears feasible and record the potential depth increase on vellum overlaid on the aerial photograph (blue marker).

Task 5: Estimate the surface area for each viable storage element. Note that these values may have been estimated by Group 3 in the morning session. Using the depth from Task 4, estimate the potential storage volume for each element and the total potential storage in the E. Clark Lake watershed including the lake water volume provided and record the name and volume of each element on the flip chart.

Task 6: Using the provided existing annual inflow volume and watershed storage volume, calculate the existing average annual residence time and record the value on the flip chart.

Task 7: Using the provided existing annual inflow volume and the total potential storage in the E. Clark Lake watershed from Task 5, calculate the potential residence time and record the value on the flip chart.

Task 8: Using the pollutant removal efficiency curves for wet detention systems, estimate the pollutant removal efficiencies for total phosphorus (TP) and total nitrogen (TN) for the current residence time and the potential residence time. Record these values on the flip chart. Record the potential increase in pollutant removal efficiencies for TP and TN on the flip chart.

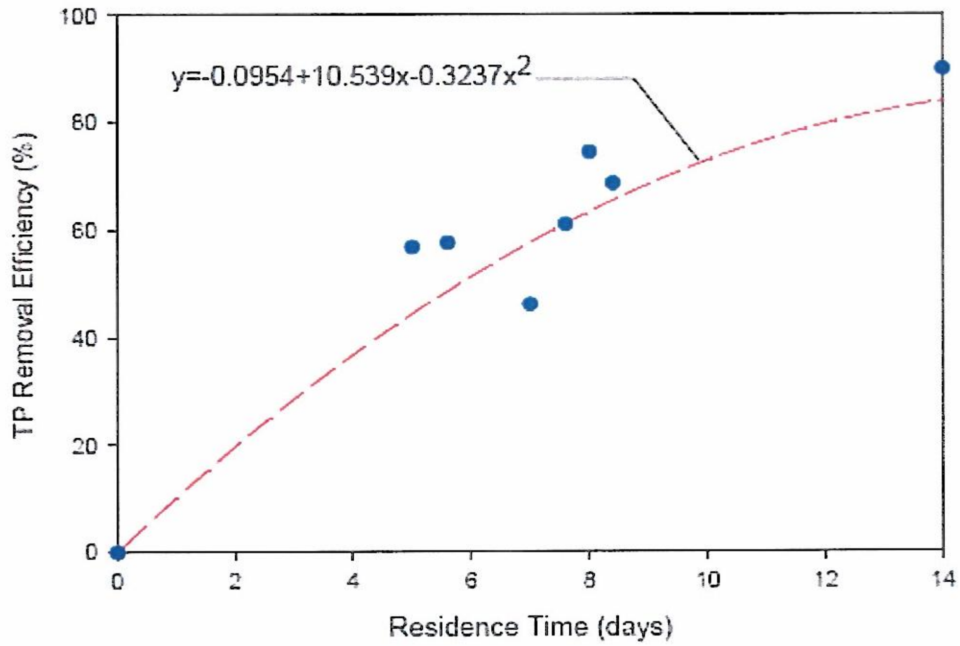
Task 9: Consider and discuss any other potential restoration actions in the E. and W. Lake watershed. Record the potential restoration actions and major issues discussed for each potential restoration action on the flip chart.

Existing Surface Water Storage Volume

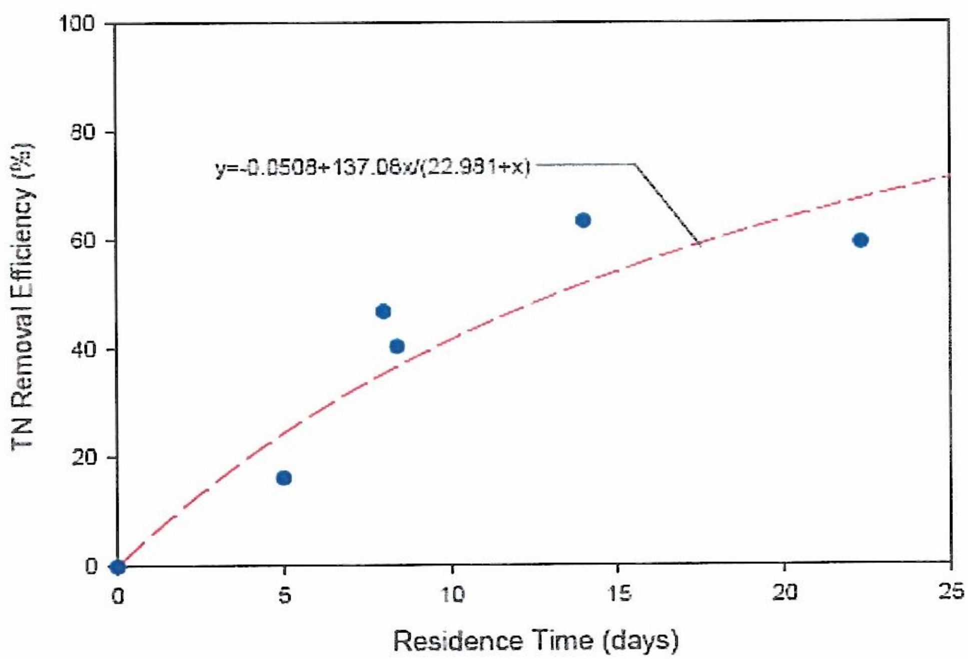
Surface Water	Storage Volume (ac-ft)
Mirror Lake	60
E. Clark Lake	28
W. Clark Lake	32
Red Bug Slough	11.5

Calculated Discharge Volumes from TMDL for June 2003 and Total for 2003

Surface Water	June Discharge Volume (ac-ft)	Total Discharge Volume (ac-ft)
Mirror Lake	173	473
E. Clark Lake	775	2,043
W. Clark Lake	964	2,546
Red Bug Slough	1,708	4,453



TP REMOVAL EFFICIENCY AS A FUNCTION OF RESIDENCE TIME



TN REMOVAL EFFICIENCY AS A FUNCTION OF RESIDENCE TIME

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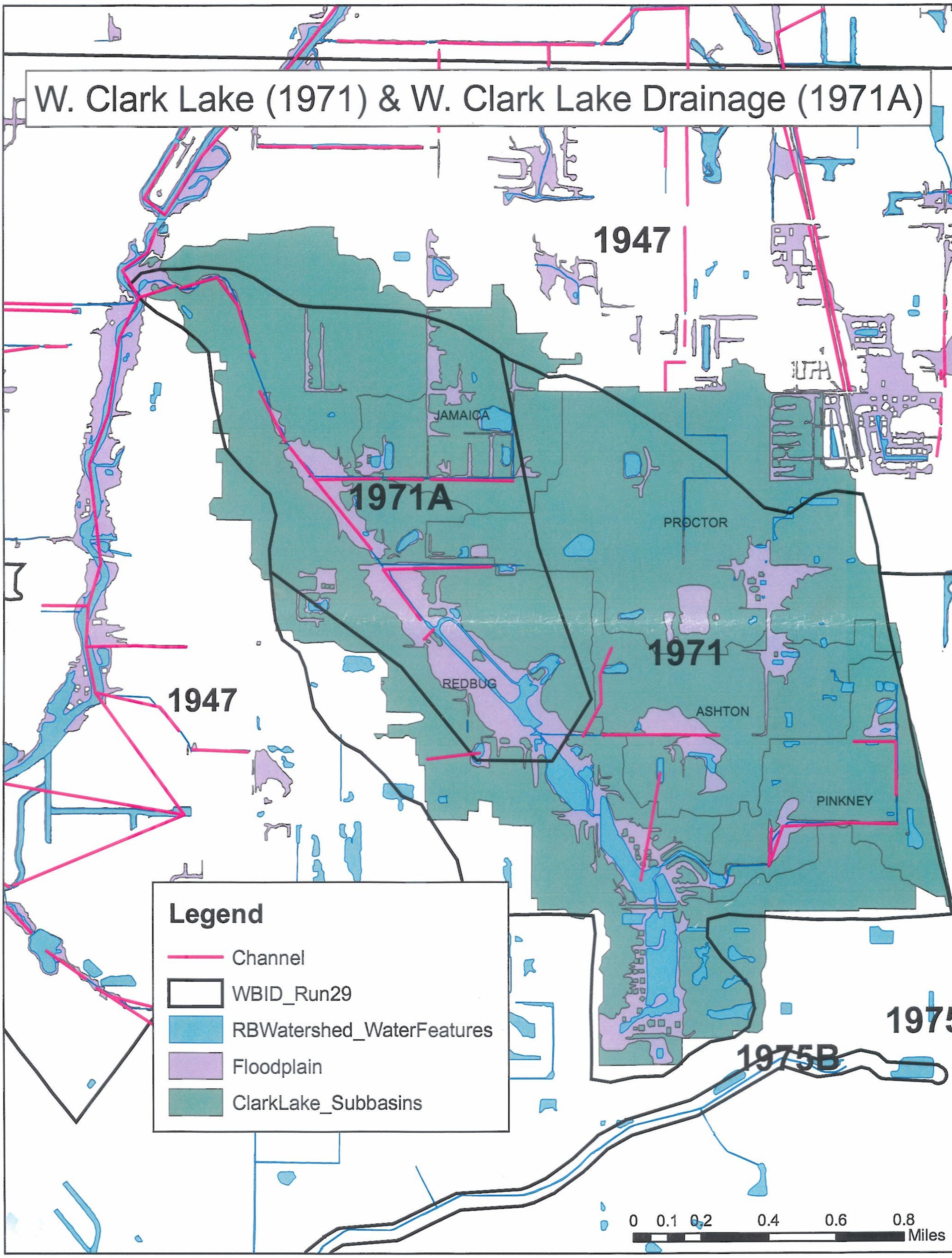
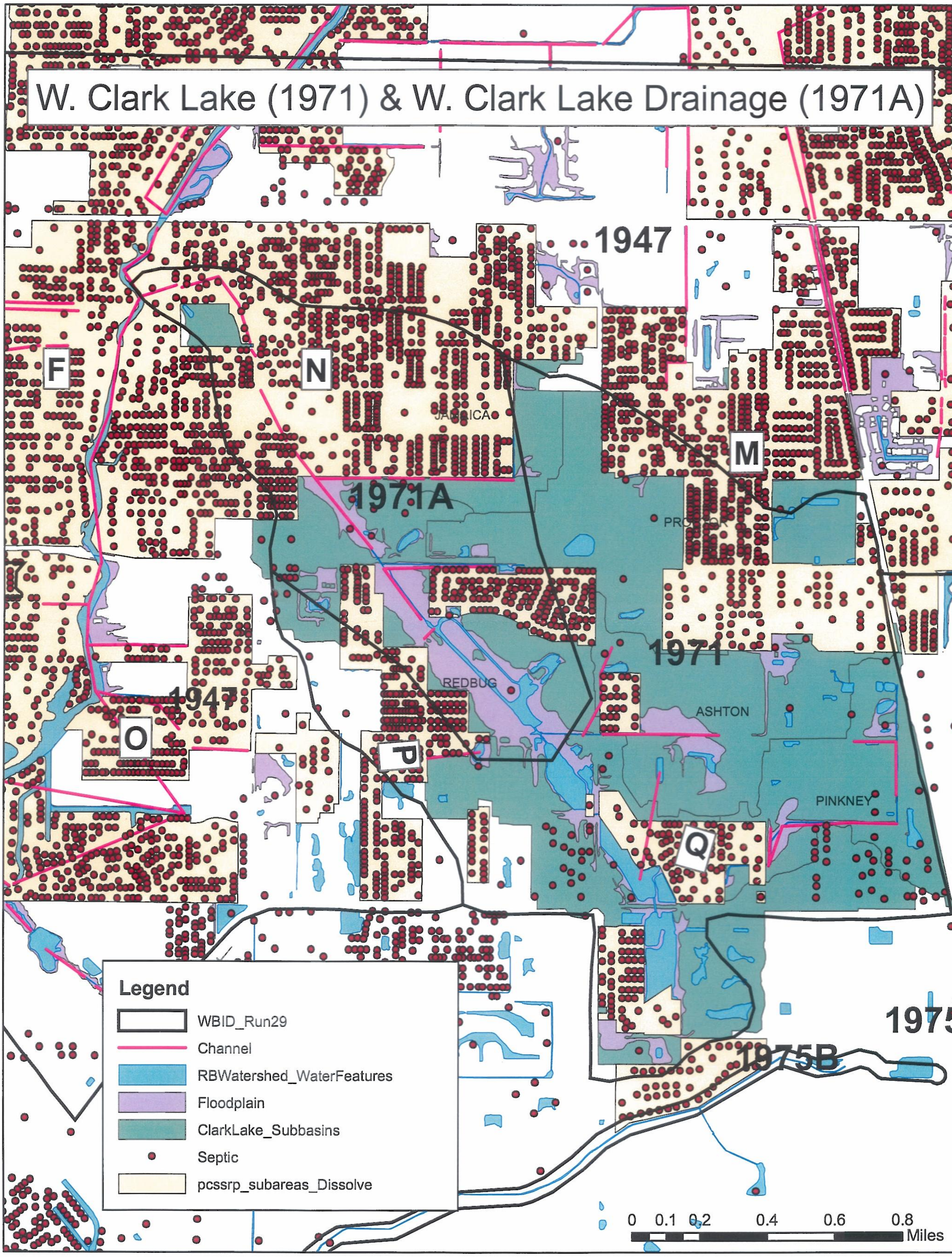
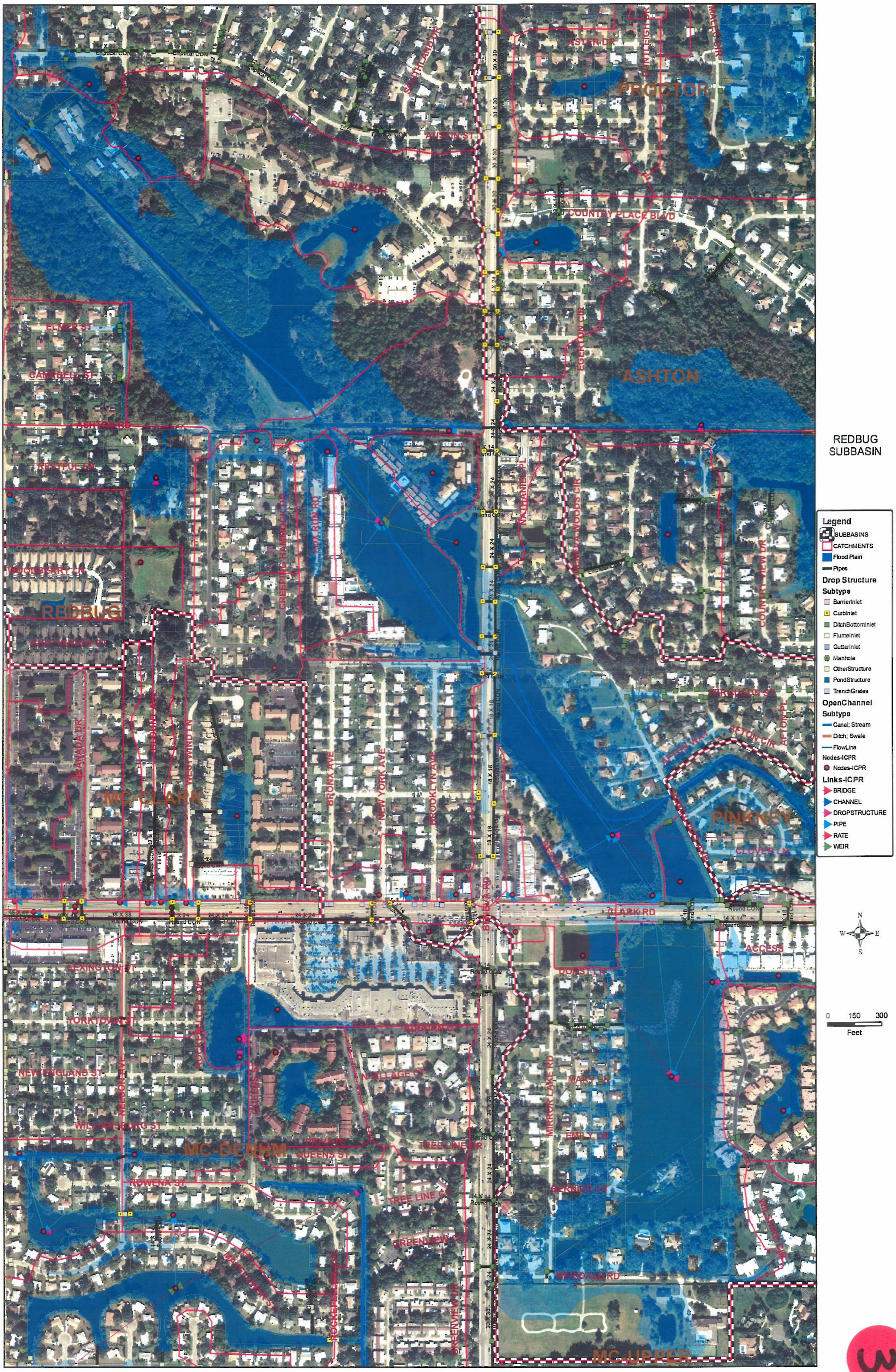

W. Clark Lake (1971) & W. Clark Lake Drainage (1971A)
1947
1971A
JAMAICA
PROCTOR
1971
REDBUG
ASHTON
PINKNEY
1947
1975
1975B
Legend
Channel
WBID_Run29
RBWatershed_WaterFeatures
Floodplain
ClarkLake_Subbasins
0 0.1 0.2 0.4 0.6 0.8
Miles

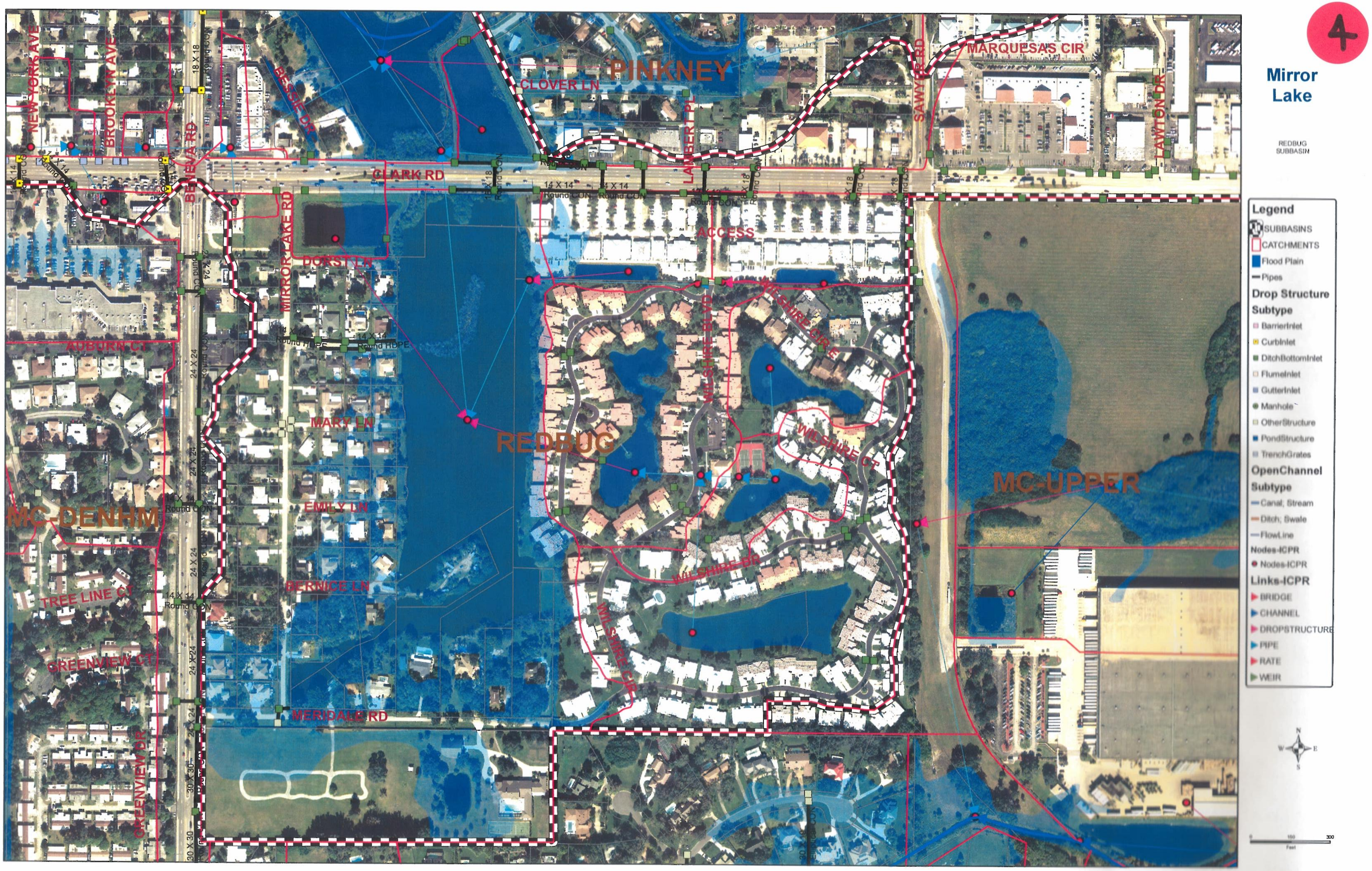


W. Clark Lake (1971) & W. Clark Lake Drainage (1971A)
1947
F
N
M
JAMAICA
1971A
PROCTOR
1971
REDBUG
ASHTON
1947
O
P
PINKNEY
Q
1975
1975B
Legend
WBID_Run29
Channel
RBWatershed_WaterFeatures
Floodplain
ClarkLake_Subbasins
Septic
pcssrp_subareas_Dissolve
0 0.1 0.2 0.4 0.6 0.8
Miles

2

REDBUG SUBBASIN

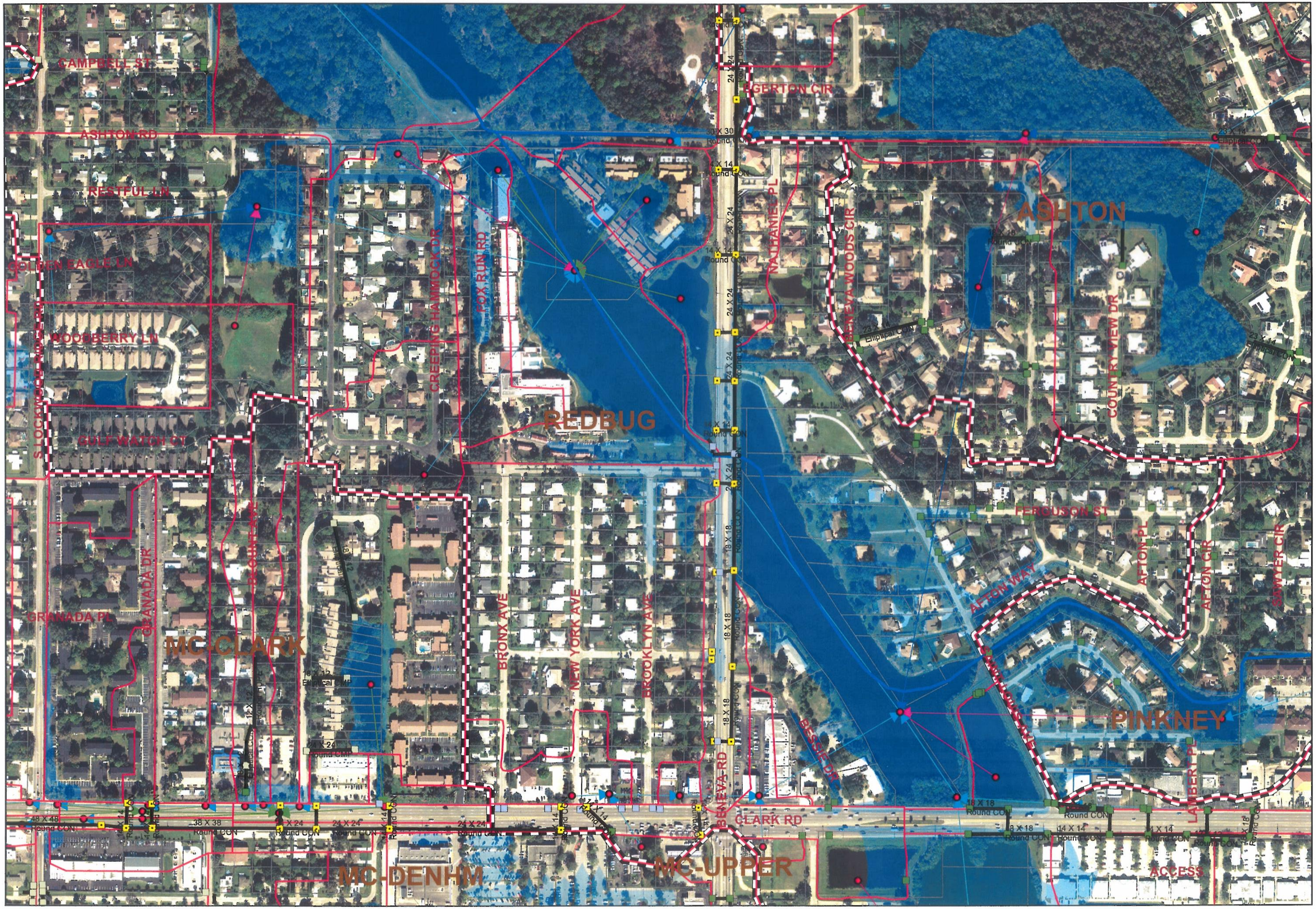



4
Mirror Lake
REDBUG SUBBASIN
PINKNEY
REDBUG
MC-UPPER
MC-DENHM
CLARK RD
CLOVER LN
MARQUESAS CIR
SAWYER RD
LAWTON DR
LAMBERT PL
BESSIE DR
BENEVA RD
NEW YORK AVE
BROOKLYN AVE
MIRROR LAKE RD
DORST LN
ACCESS
WILSHIRE BLVD
WILSHIRE CIR E
WILSHIRE CT
WILSHIRE DR
WILSHIRE CIR
AUBURN CT
MARY LN
EMILY LN
BERNICE LN
MERIDALE RD
TREE LINE CT
GREENVIEW CT
GREENVIEW DR
14 X 14 Round CON
14 X 14 Round HDPE
24 X 24
30 X 30
18 X 18
Legend
SUBBASINS
CATCHMENTS
Flood Plain
Pipes
Drop Structure Subtype
BarrierInlet
CurbInlet
DitchBottomInlet
FlumeInlet
GutterInlet
Manhole
OtherStructure
PondStructure
TrenchGrates
OpenChannel Subtype
Canal; Stream
Ditch; Swale
FlowLine
Nodes-ICPR
Nodes-ICPR
Links-ICPR
BRIDGE
CHANNEL
DROPSTRUCTURE
PIPE
RATE
WEIR
N
W
E
S
0
150
300
Feet

5

West Clark Lake

REDBUG SUBBASIN



Legend

- SUBBASINS
- CATCHMENTS
- Flood Plain
- Pipes

Drop Structure Subtype

- BarrierInlet
- CurbInlet
- DitchBottomInlet
- FlumeInlet
- GutterInlet
- Manhole
- OtherStructure
- PondStructure
- TrenchGrates

OpenChannel Subtype

- Canal; Stream
- Ditch; Swale
- FlowLine

Nodes-ICPR

- Nodes-ICPR

Links-ICPR

- BRIDGE
- CHANNEL
- DROPSTRUCTURE
- PIPE
- RATE
- WEIR

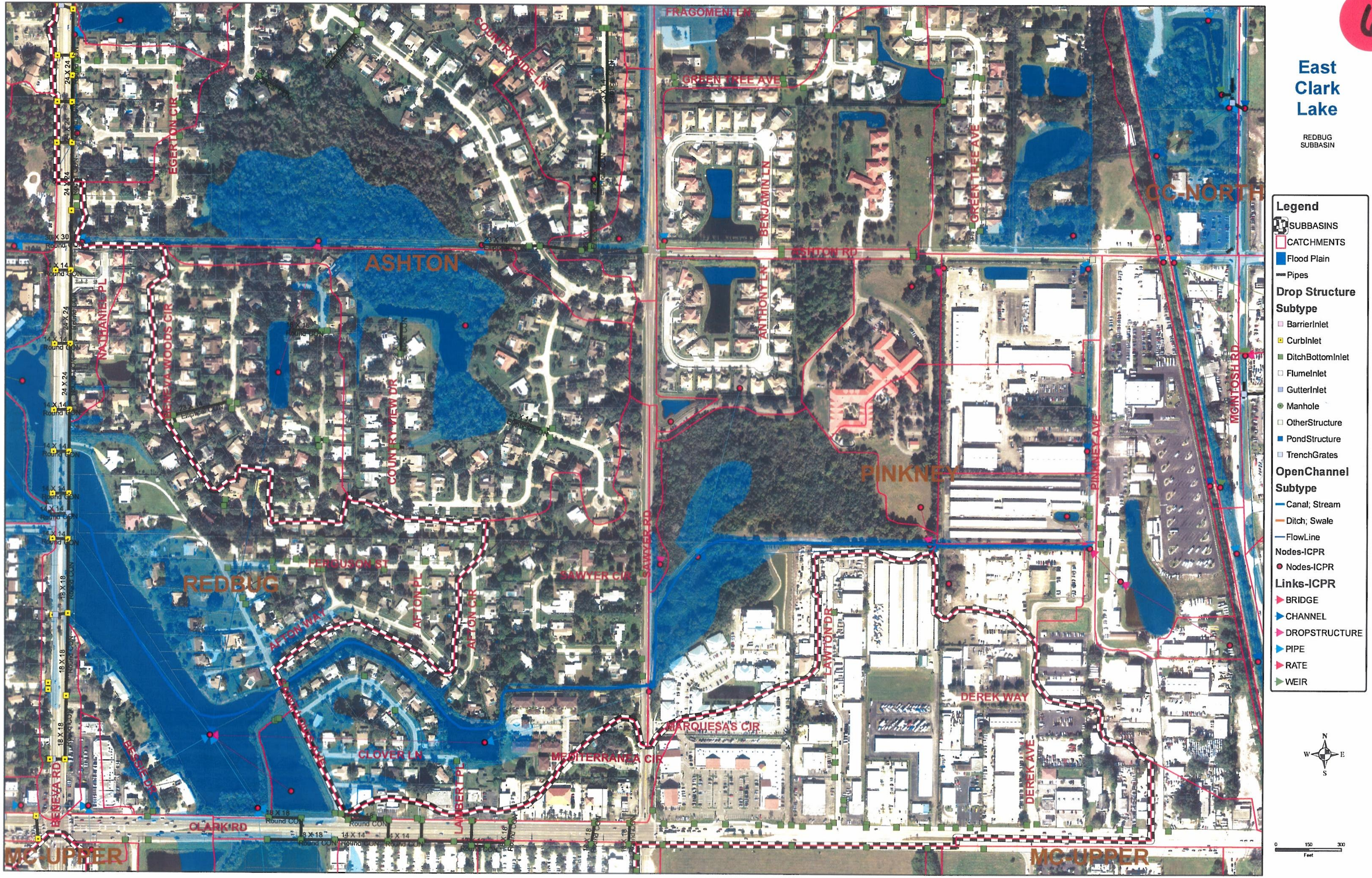
N E S W

0 150 300 Feet

6

East Clark Lake

REDBUG SUBBASIN



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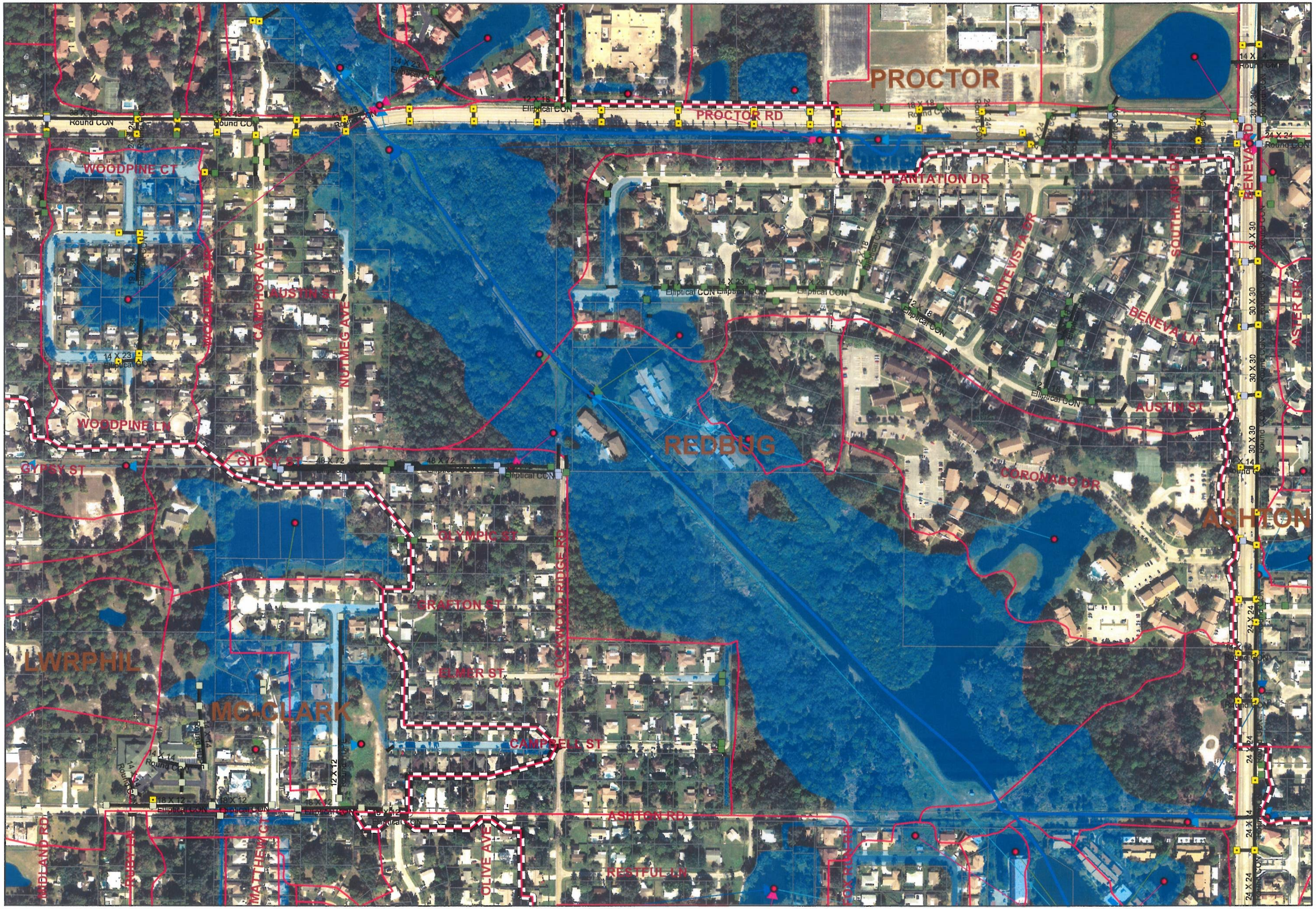
Redbug

REDBUG SUBBASIN



Legend

- SUBBASINS
- CATCHMENTS
- Flood Plain
- Pipes

Drop Structure Subtype

- BarrierInlet
- CurbInlet
- DitchBottomInlet
- FlumeInlet
- GutterInlet
- Manhole
- OtherStructure
- PondStructure
- TrenchGrates

OpenChannel Subtype

- Canal; Stream
- Ditch; Swale
- FlowLine

Nodes-ICPR

- Nodes-ICPR

Links-ICPR

- BRIDGE
- CHANNEL
- DROPSTRUCTURE
- PIPE
- RATE
- WEIR

N W E S

0 150 300 Feet