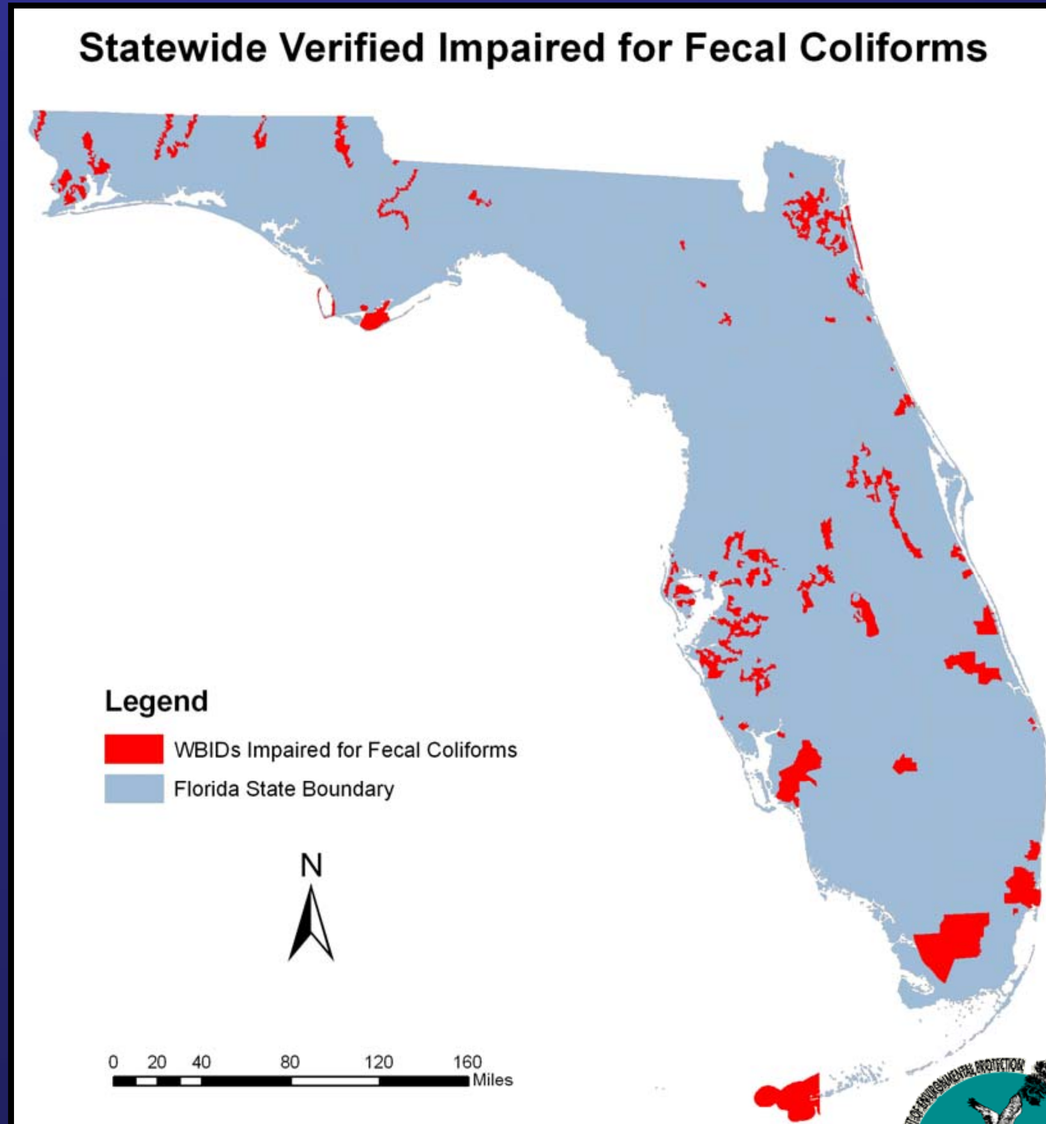

Strategic Approach
and
Case Studies

Overview

- Issue in Florida
- Project Areas
- Development of Two Approaches / Tools
- Decision-Support Tool
- Identification of Sources using Weight-of-Evidence Approach
- Case Studies

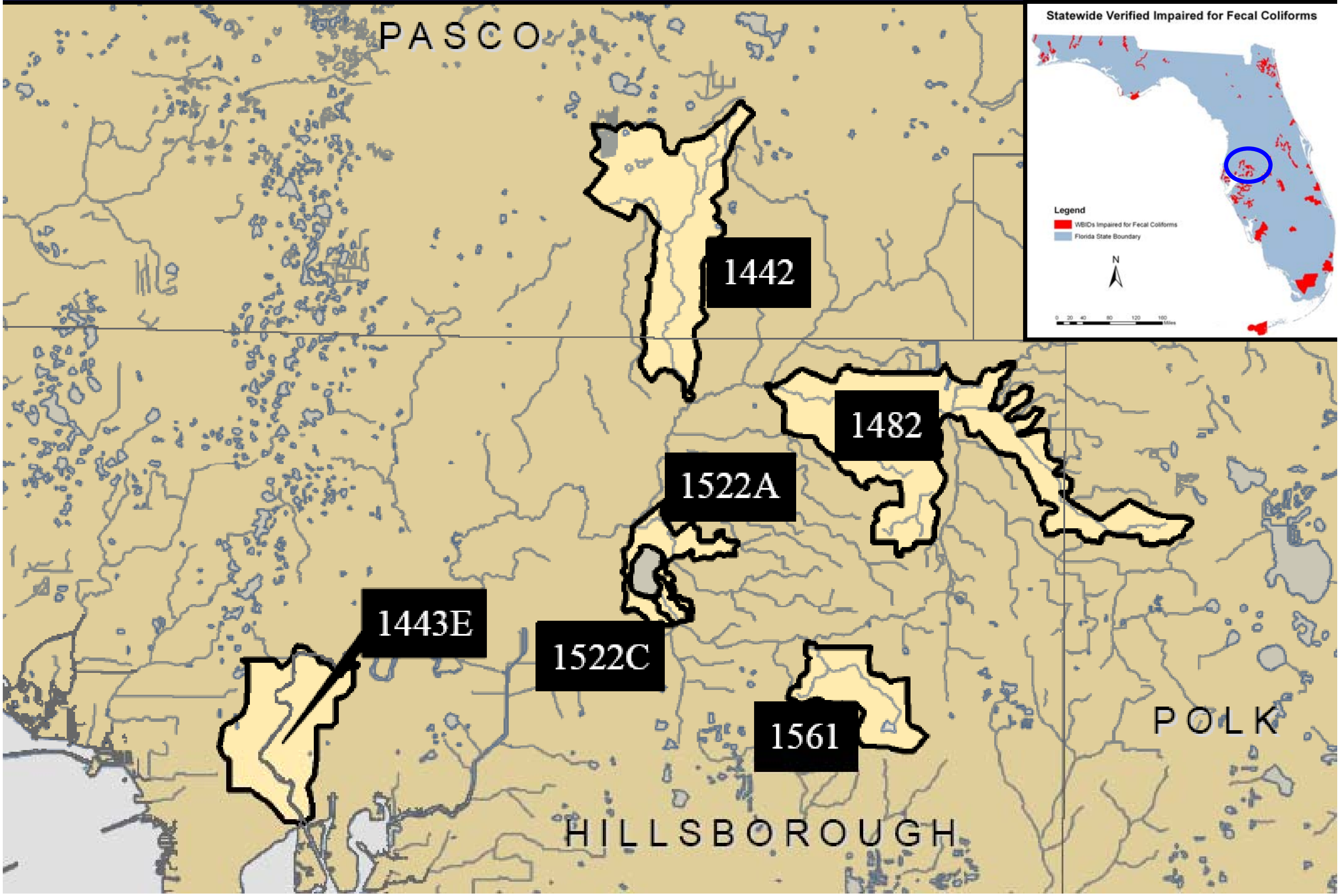
Issue in Florida

226 WBIDs verified as impaired for fecal coliform contamination in Florida

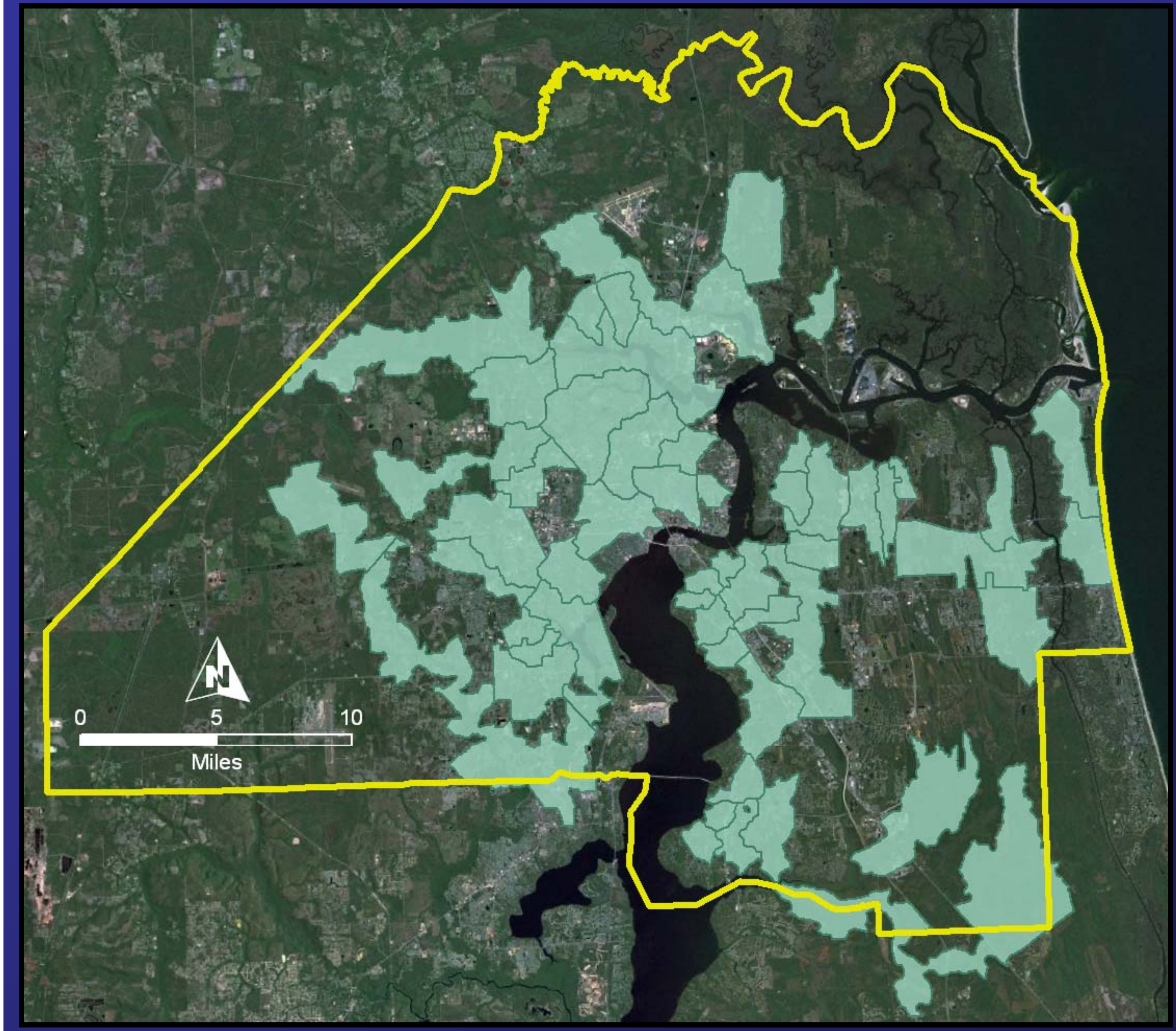


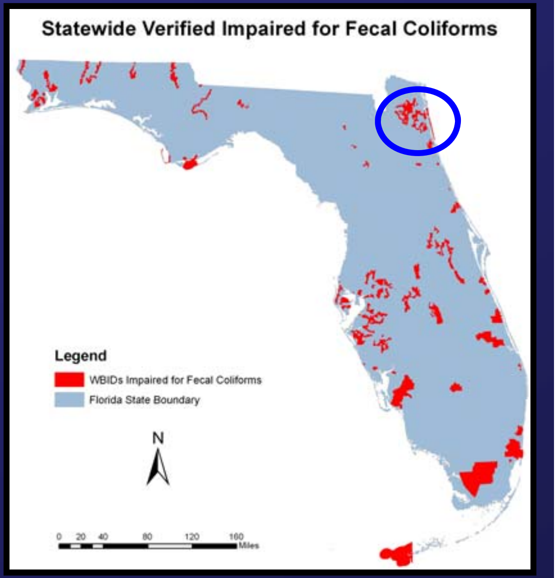
Project Areas

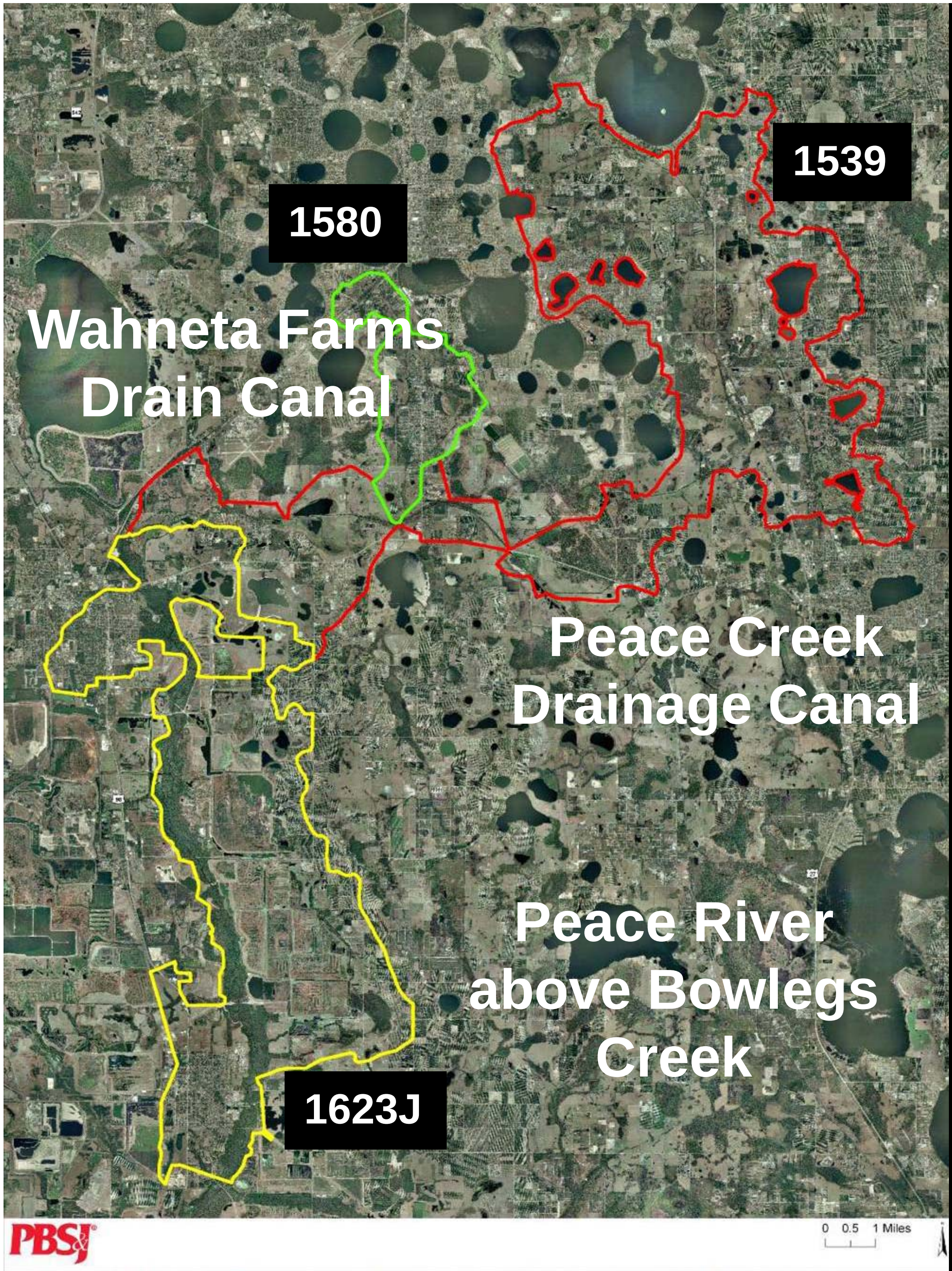
Hillsborough River Watershed (6 WBIDs)



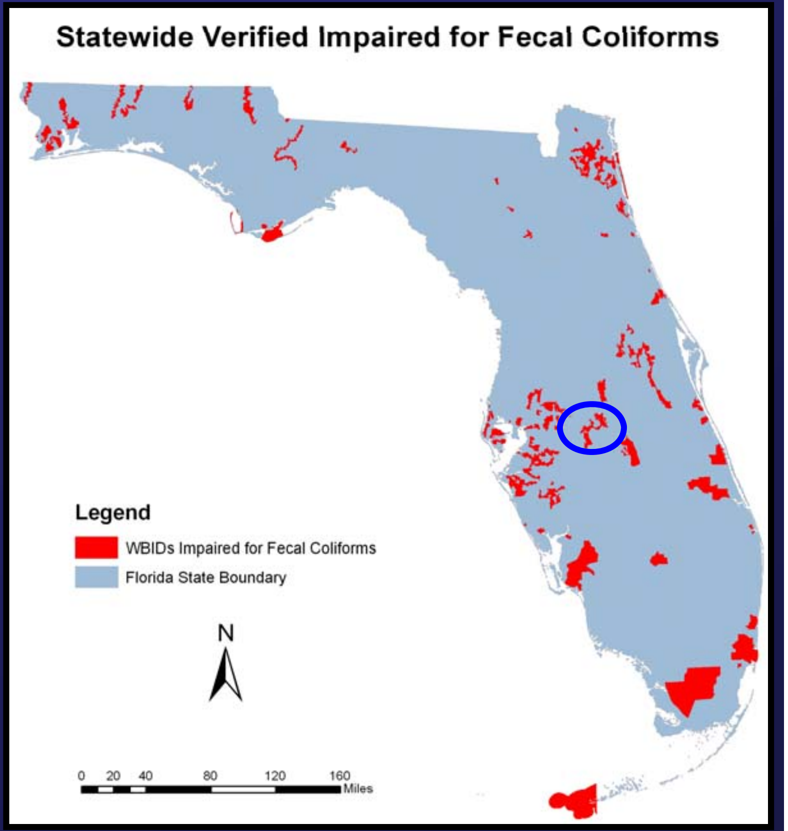
Lower St. Johns River (55 WBIDs)

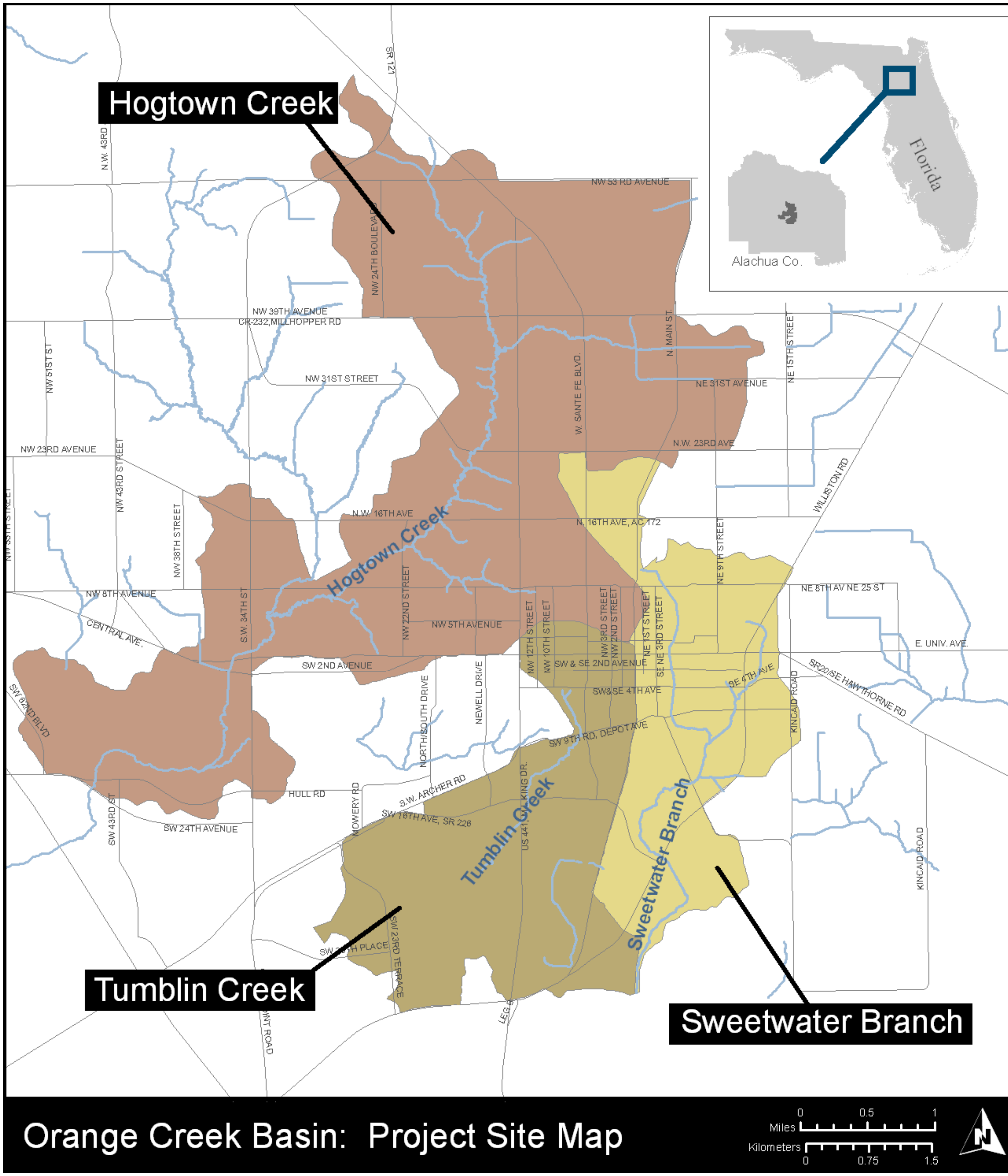




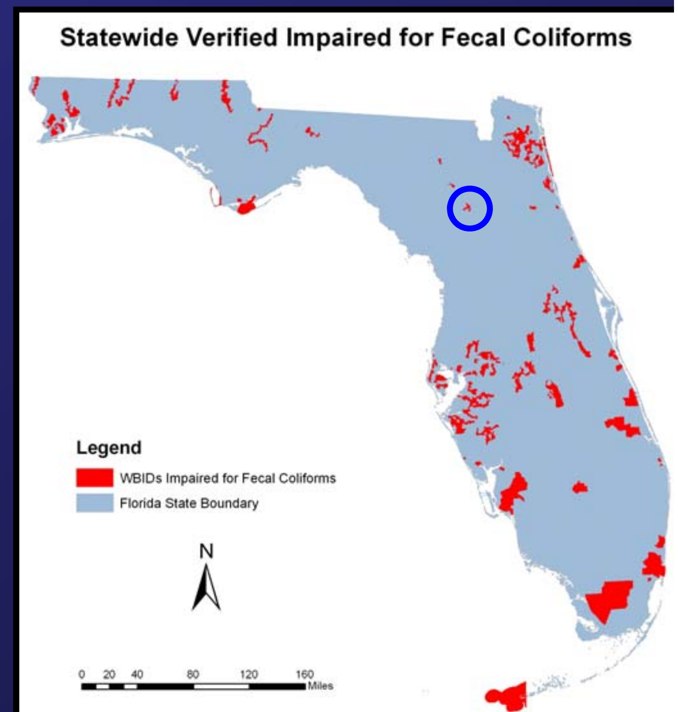


Upper Peace Creek (3 WBIDs)





Orange Creek (3 Basins)



Where is the pollution coming from?

What can we do with the information we have today?

Developed Two Approaches / Tools

Identification of sources of fecal coliform contamination using weight-of-evidence

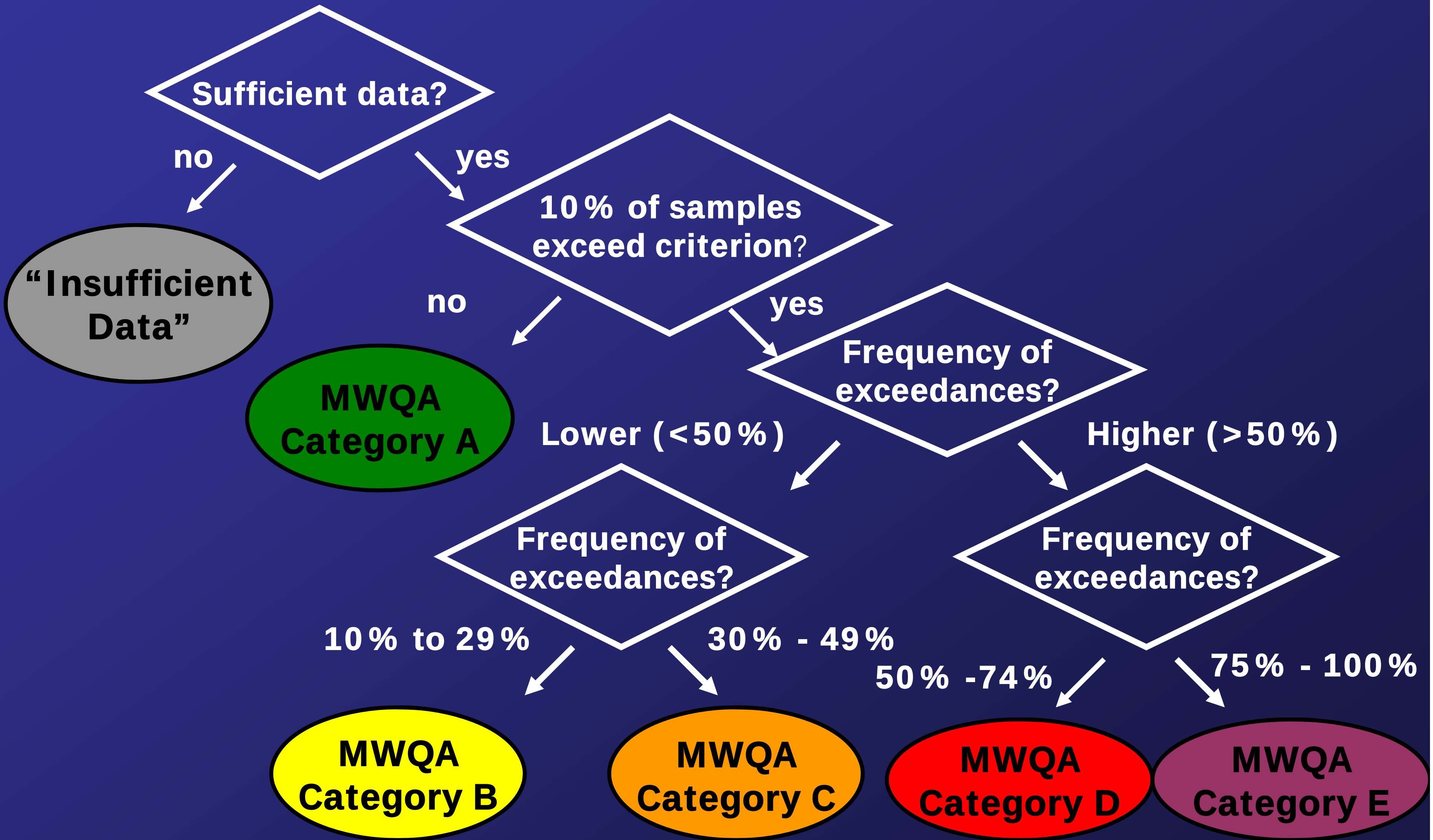
Decision Support Tool developed to guide potential additional sampling and help prioritize basins for management action

Designed for state-wide application

Tested in the Hillsborough River watershed

Decision-Support Tool for Guiding Additional Sampling and Prioritizing Management Actions

Decision Support Tool



Prioritization of WBIDs (and sites within WBIDs) for management action

				Human Fecal MST Markers		Ruminant Fecal MST Marker	
Sub-Basin	WBID	Monitoring Location	Classi-fication Matrix Outcome	No. Sampling Dates	% Dates Marker(s) Detected	No. Sampling Dates	% Dates Marker Detected
Lower Hillsborough River	1443E	**DHR4A**	D5	5	100 %	5	20 %
		HR3	D4	5	80 %	5	20 %
		DHR5	D4	2	50 %	2	0 %
		DHR8	D3	4	50 %	4	0 %
		HR2	C4	3	67 %	3	0 %
		HR4	C4	3	67 %	3	0 %
		DHR7	C3	5	60 %	5	60 %
		DHR6	C3	3	33 %	3	0 %
		HR1 REF	B3	3	100 %	8	0 %
		HR5	B3	5	60 %	5	0 %
		DHR10	A4	1	100 %	1	0 %
Blackwater Creek	1482	**BW3**	D4	4	75 %	1	0 %
		BW2	D4	3	67 %	3	100 %
		DBW4	A3	1	100 %	1	0 %
		BW5A	A3	2	50 %	2	0 %
		BW1 REF	A2	7	43 %	6	17 %
Baker Creek	1552C	**BK2**	D3	6	67 %	6	67 %
		BK1	C3	7	57 %	7	29 %
		BK3	C2	2	50 %	2	0 %
		BK4	A4	1	100 %	1	0 %
		BK5	A3	2	100 %	2	0 %
Flint Creek	1552A	**FL2**	C2	6	50 %	6	0 %
		FL1	C2	5	20 %	5	0 %
		FL3	A3	6	33 %	6	0 %
Spartman Branch	1561	**SB1**	D3	6	17 %	6	0 %
		SB2	D2	5	20 %	6	0 %
		DSB3	C2	2	0 %	2	50 %
		SB3	B2	4	25 %	4	0 %
New River	1442	**NR2**	C3	7	29 %	7	29 %
		NR1	C2	2	0 %	2	50 %
		NR3	C2	2	0 %	2	50 %

Identification of Sources using Weight-of-Evidence Approach

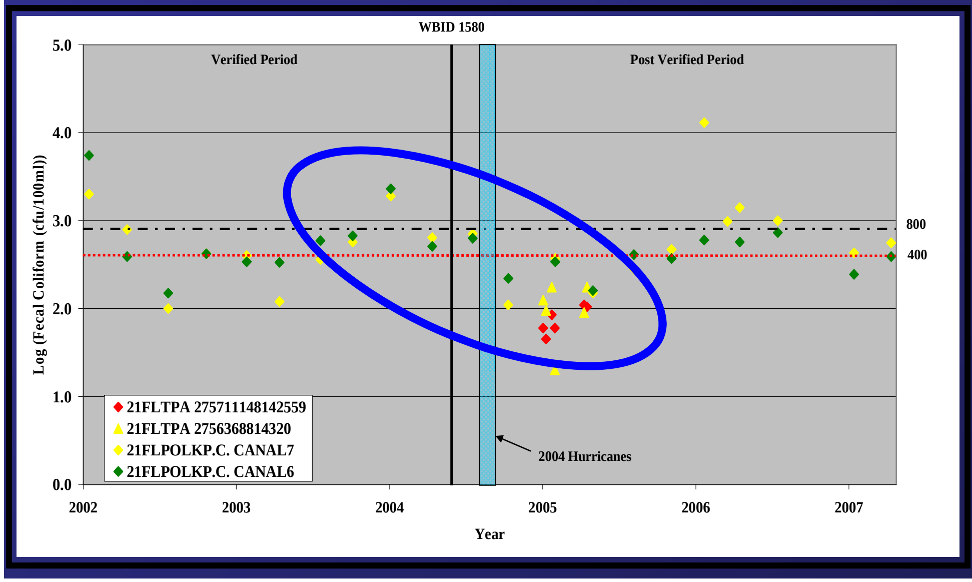
Weight-of-Evidence Approach

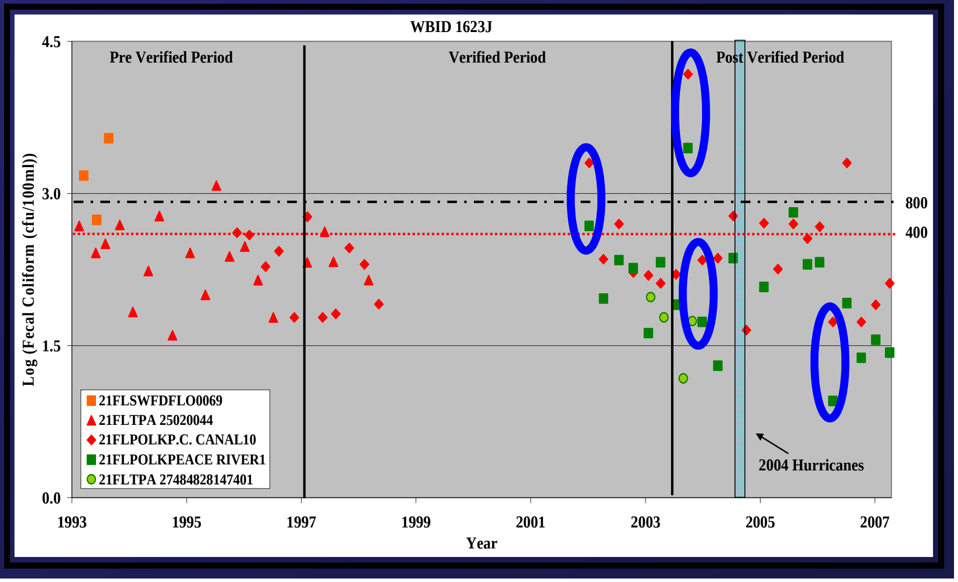
- Phase I
  - Target efforts
  - Discriminate potential sources
  - Effectively select the “right” tests
  - Limit costs associated with sampling
- Phase II
  - First used in six LSJR tributaries
  - Modified for Hillsborough River
  - Further modified for additional LSJR basins

Three Components of the Initial Screening Process

Initial Screening

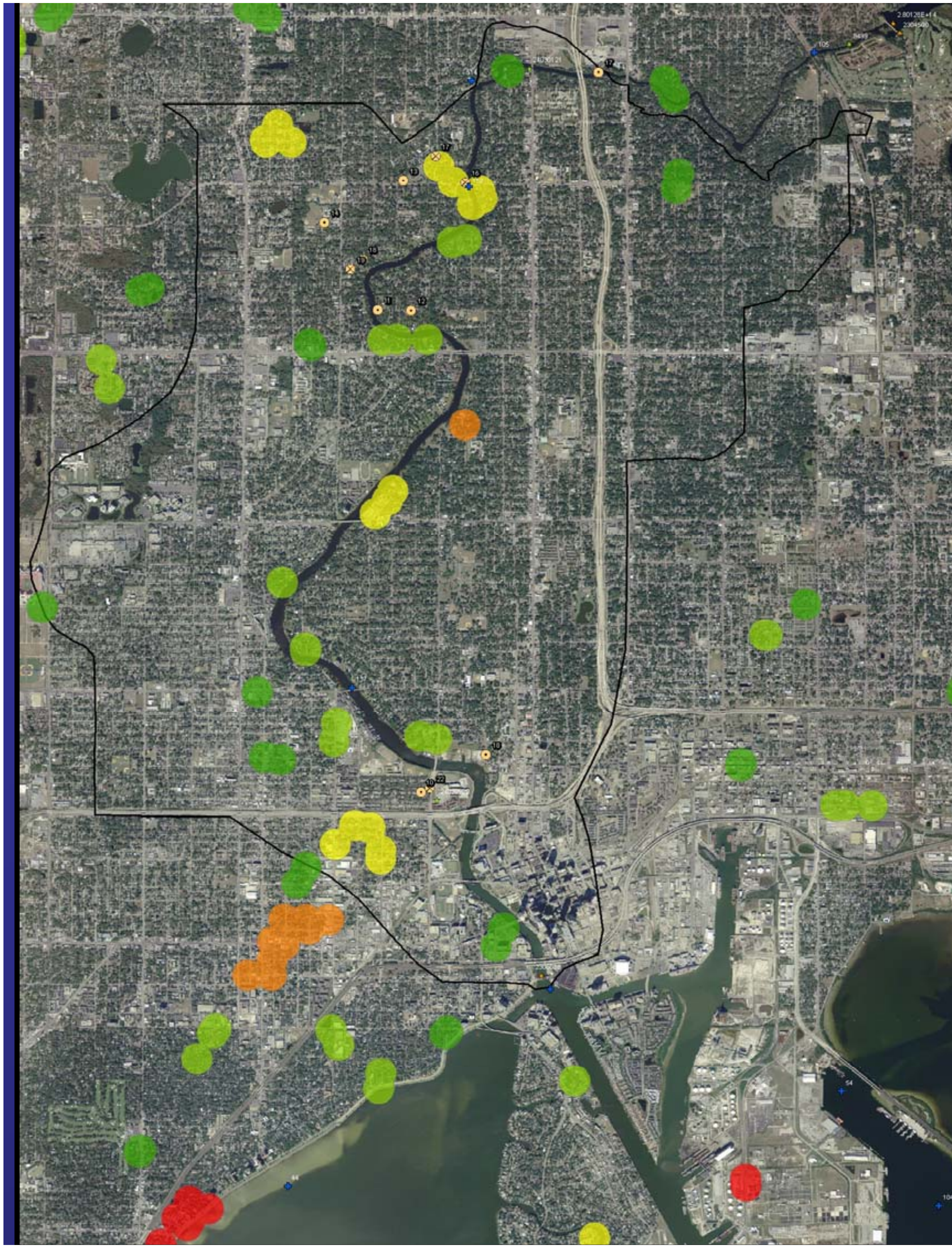
- Detailed review of long-term datasets
  - Chronic or episodic exceedances
  - Correlation with other physical parameters (e.g., turbidity)
  - Correlation with rainfall
  - Potential for transport from upstream stations/other tributaries





Initial Screening

2. Compilation and evaluation of GIS data
   - Land use
   - Soil type
   - Long-term monitoring stations
   - Red line properties (prone to flooding)
   - Landfills
   - Infrastructure
     - Stormwater
     - Septic Tanks
     - Sanitary Sewer
   - Potential illicit discharges
   - Septic tank repair permits
   - Sanitary Sewer Overflows
   - Permitted discharges



City of Tampa

Areas of Repetitive Reported SSOs

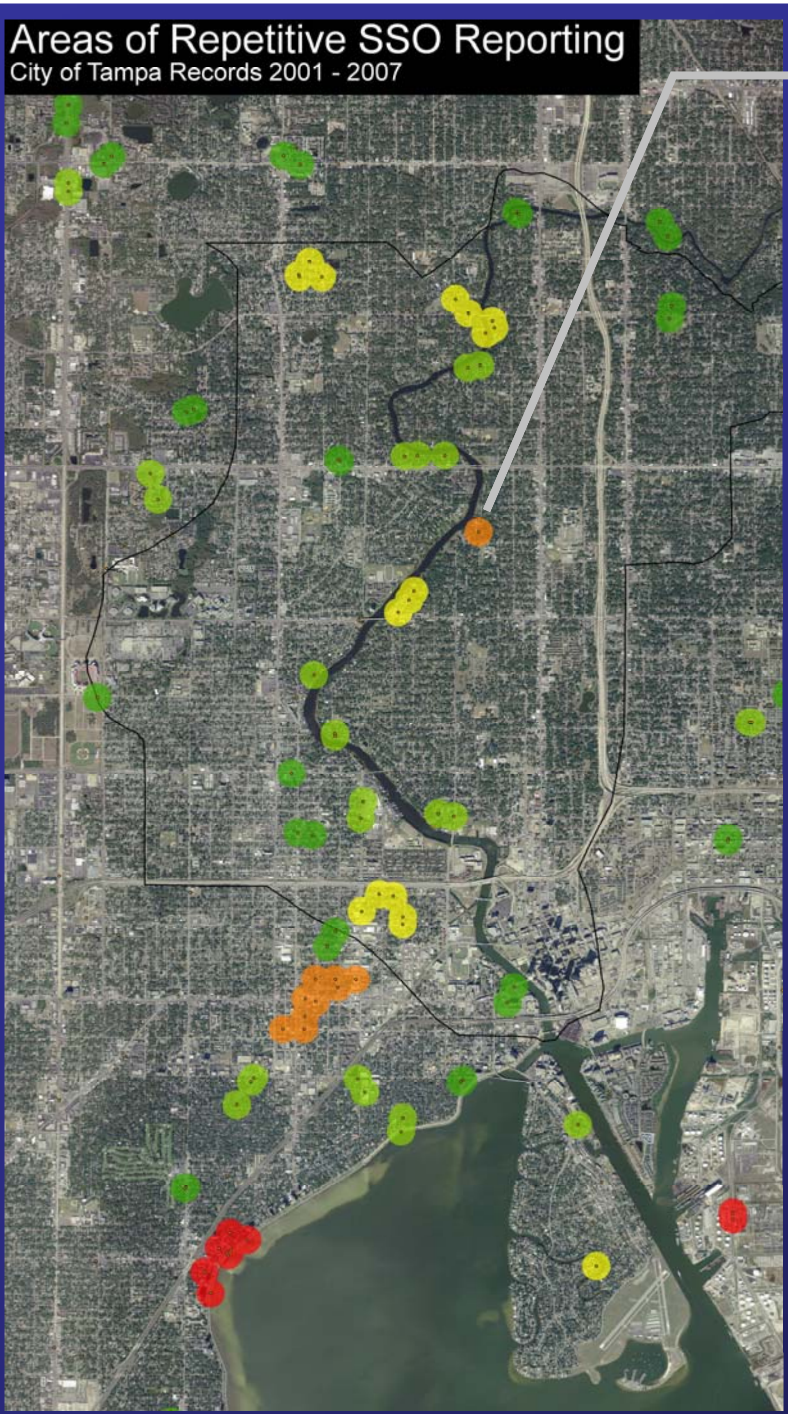
2001-2007

0 1,150 2,300 Feet

Number of Reports

2 | 3 - 4 | 5 - 7 | 8 - 11 | 12 - 18

Shaded regions represent multiple and/or repetitive overflow reports. A 500-ft buffer defines adjacency.



- **10 Reported events (2001-2006) at same location**
- **Pump station and associated gravity lines**
- **Mechanical failure, infiltration/inflow due to extreme rainfall**
- **200 – 94,800 gallons**
- **Most drained directly into river**

(COT Data 2001 – 2007)

Initial Screening

3. Collaboration with local stakeholders
   - One-on-one interviews
   - Project Workshop
     - Presentation of results to date
     - Maps-on-the Table exercise
     - Organize field effort
       - Brainstorm and document additional potential sources
       - Build trust and consensus among stakeholders
       - Increase accountability of stakeholders

Three Components of the Field Implementation Process

Field Implementation

1. **Field Reconnaissance**
   - Internal field review
   - Walk the WBIDs exercise
     - Confirmation of potential sources

     - “Boots on the ground” knowledge
     - Education and accountability of stakeholders
     - Selection and verification of sampling locations

     - Build consensus

Field Implementation

2. Use of decision tree based on “toolbox” of MST methods and weight-of-evidence
   - Improvement of existing methods
     - Indicator organisms in sediments
     - Identification of old vs. new sources
   - New available methods
     - Improved human markers (HPyV)
     - Addition of horse-specific *Bacteroides*
     - Addition of qPCR methods
     - Infrared Thermal Imagery
   - Methods that still need improvement
     - Fluorometry

Field Implementation

3. Collaboration with local stakeholders
   - Bi-monthly meetings with BMAP Steering Committee
     - Dissemination of results
     - Ideas for upcoming sampling events
     - Build consensus and accountability
   - Continual communication and field visits
     - Updates on local water quality issues
     - Field and infrastructure reconnaissance requests

Analysis of Results

Methods and regulatory aspects of MST are still being developed

Weight-of-Evidence and flexibility in the approach are requirements for this type of investigation

Application of the Weight-of-Evidence Approach in the Hillsborough River Basin

Toolbox of MST Methods Used in Hillsborough River Watershed

PCR Tests

Bacteroides – an anaerobic fecal bacterium (separate tests for human, ruminant, horse)

Enterococcus faecium esp gene

- Gene for virulence factor of bacterium found in humans

Human polyomavirus

- Nonpathogenic (harmless) virus shed in urine; high carrier rate in human population & ubiquitous in sewage

Application of Methods

- Month 1
  - Use of indicator suite and advanced MST techniques simultaneously at all stations
- Months 2-8
  - ~50% of samples were re-tested using advanced MST techniques each month
  - Increased testing in some WBIDs and decreased testing in others
  - Sediments tested at 6-9 stations each month

Basic Factors for Consideration

1. When to Sample
   - Wet and dry seasons
   - Monthly
   - Within 3-7 days of significant rainfall events (when possible)
   - During out-going tide (Hillsborough River)
2. Where to Sample
   - Long-term monitoring stations
   - Bracket potential contamination sources
   - Land-use classification
   - Tributary organization
   - Safety and Accessibility

Basic Factors for Consideration

3. **What and How to Sample**
   - Water column by grab sample method

     (Standard Methods for the Examination of Water and Wastewater [9060A])
   - Sediment samples using Ponar®, if necessary
   - Additional field data
     - Temperature, conductivity, DO, pH, turbidity
   - Transport on ice to qualified laboratory for analysis

MST Sampling in the Hillsborough River Basin

- USF
  - 20 “Fixed” Stations
    - Sample using 2 Teams (USF / PBS&J)
    - Entire indicator suite (3 samples)
    - 6-9 sediment samples / month
    - Advanced MST analysis
- Additional Lab
  - 17-28 “Flexible” Stations
    - Sample using FDEP personnel
    - Fecal coliforms only
    - No sediments or advanced MST analysis

USF ~ 68 samples/month

FDEP/Lab = 20 samples/month

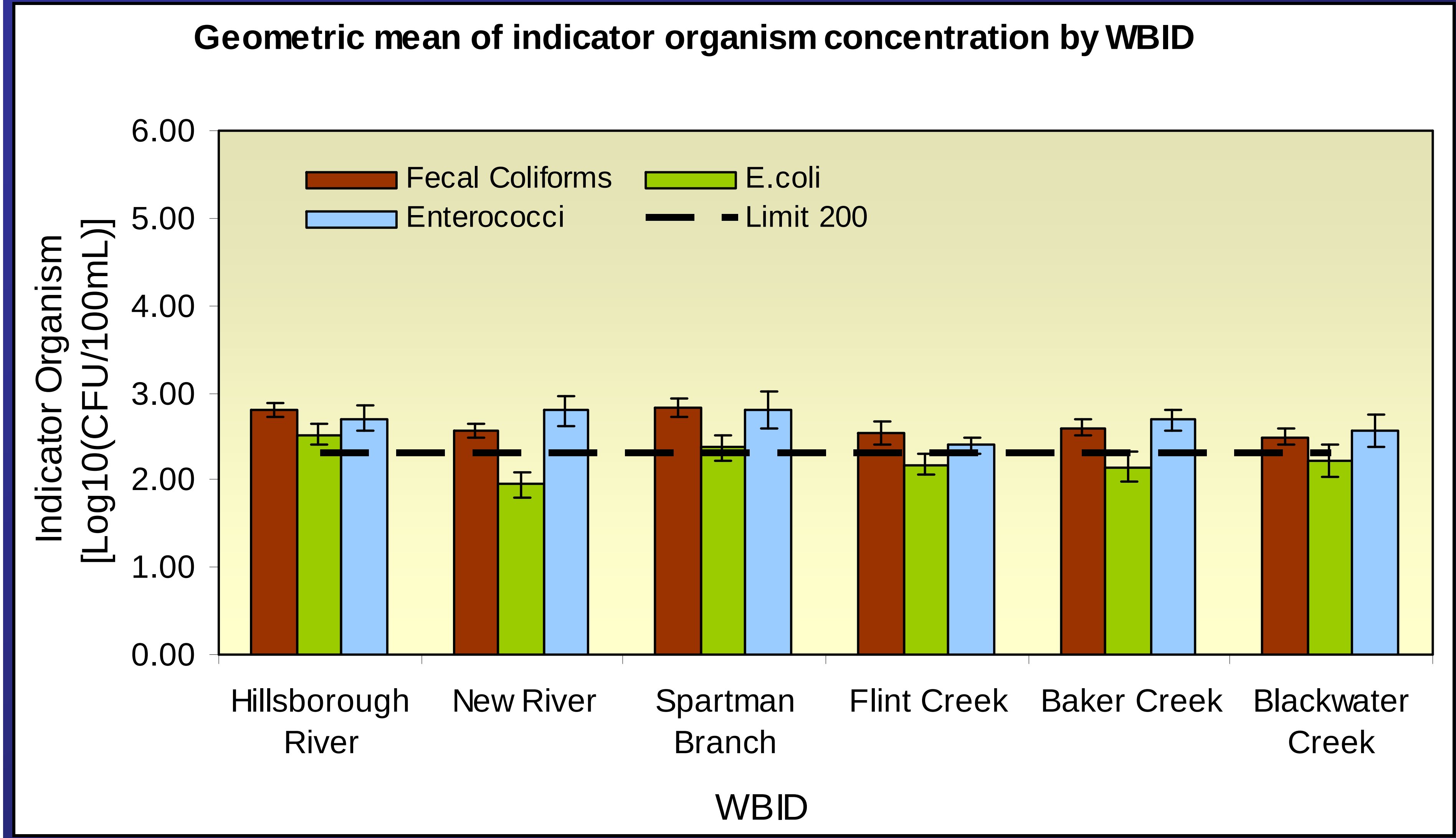
Case Studies

Impairment at Station Level

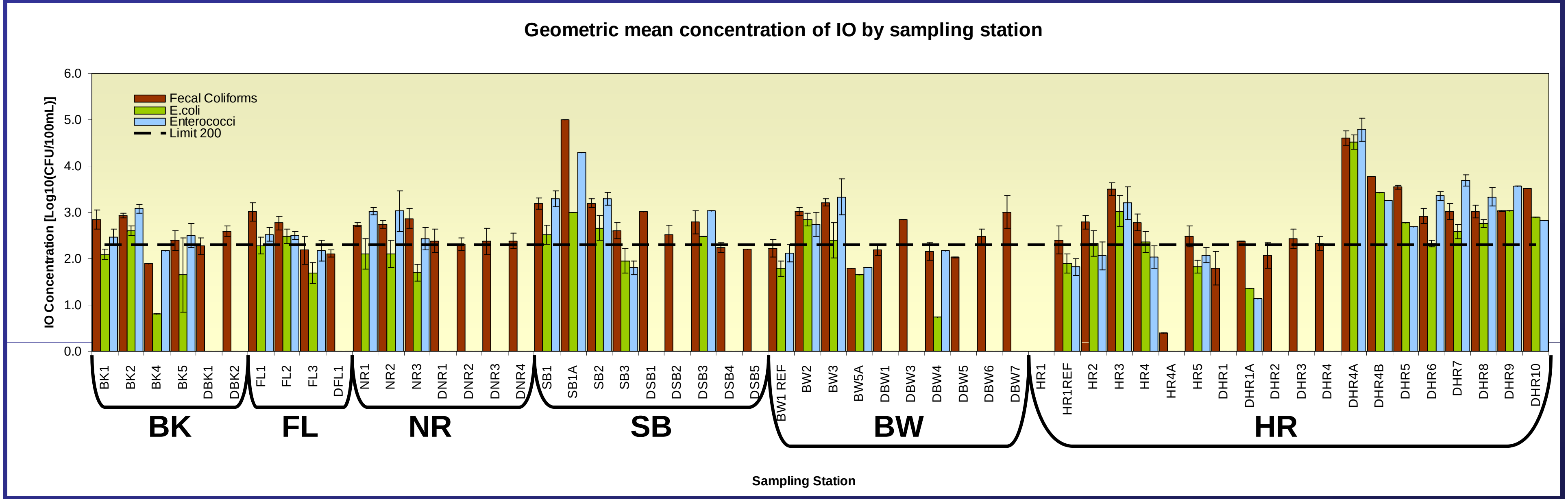
Collaboration with Local Stakeholders

Hillsborough River Watershed

Geometric Mean Concentration of Indicator Organism by WBID



Geometric Mean Concentration of Indicator Organism by Sampling Station




PASCO
1442
Lower
Hillsborough
River
1482
1522A
1443E
1522C
1561
POLK
HILLSBOROUGH

Classification Matrix Outcome

Lower Hillsborough River

				Human Fecal MST Markers		Ruminant Fecal MST Marker	
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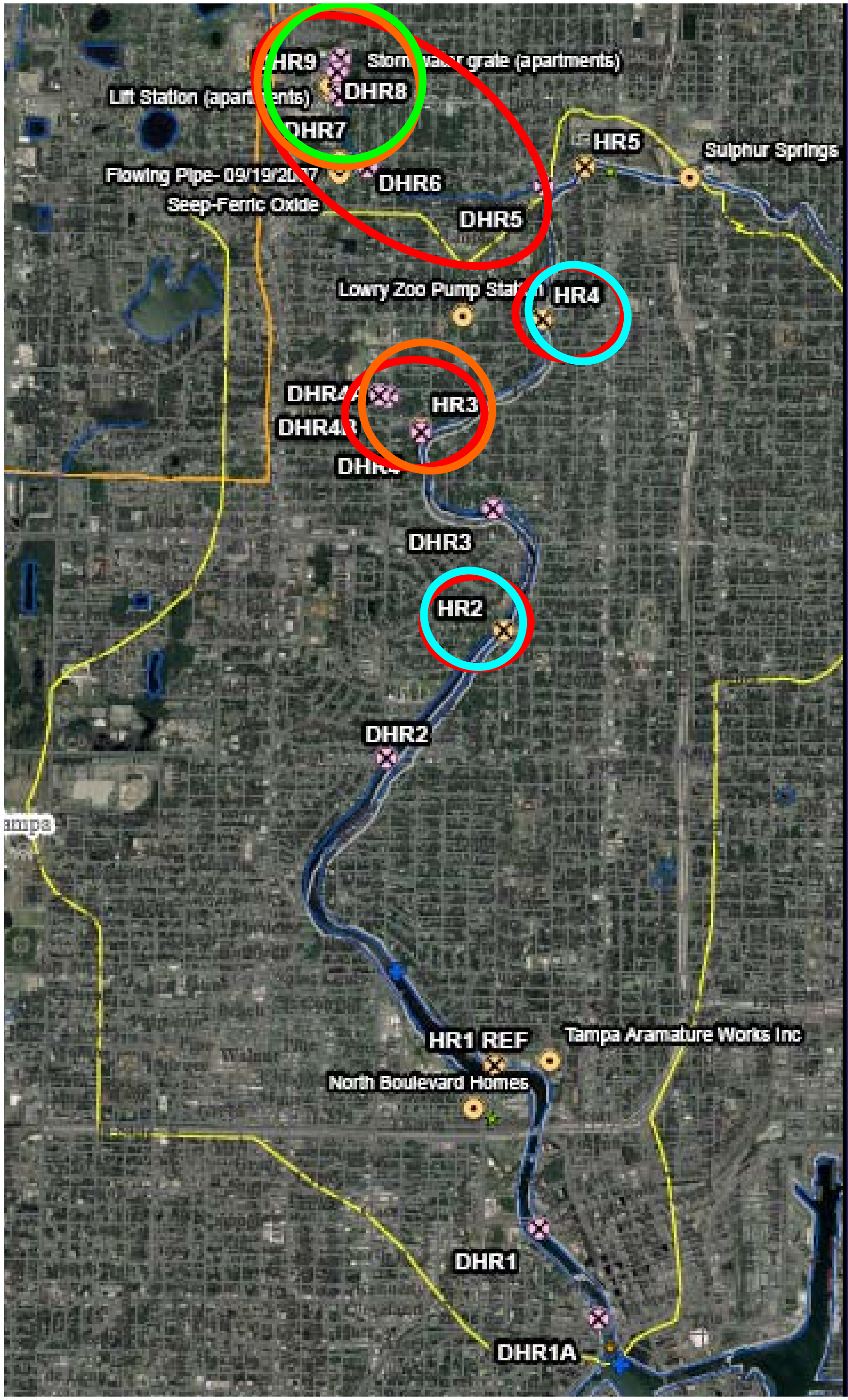
		HR1 REF	B3	3	100 %	8	0 %
		HR5	B3	5	60 %	5	0 %
		DHR10	A4	1	100 %	1	0 %

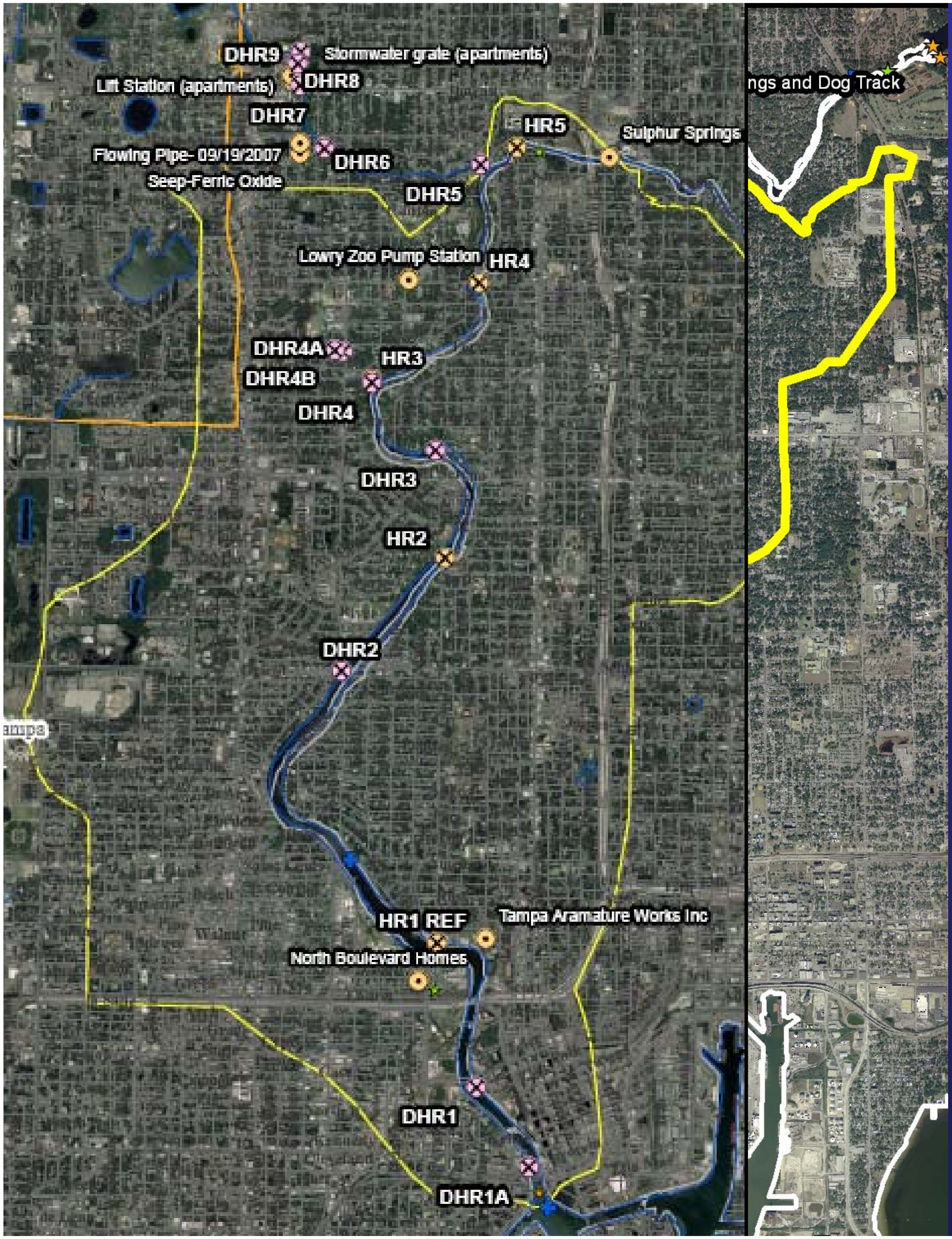
Station	H-Bac	esp	HPyV	R-Bac	Hr-Bac
HR1	2/3	1/3	0/3	0/6	0/6
HR2	1/3	2/3	0/3	0/3	0/3
HR3	2/5	2/5	0/5	1/5	0/5
DHR4A	4/5	0/5	1/5	1/5	1/5
HR4	1/3	2/3	0/3	0/3	0/3
HR5	1/5	2/5	0/3	0/3	0/3
DHR5	0/2	1/2	0/2	0/2	0/2
DHR6	0/3	0/3	1/3	0/3	1/3
DHR7	3/5	0/5	0/3	3/5	0/3
DHR8	1/4	0/4	1/4	0/4	0/4
DHR9	0/2	0/2	0/2	0/1	0/1
DHR10	1/1	0/1	0/1	0/1	0/1



- **Human-specific markers at every site tested (except DHR9)**
  - **Often coincided with IO exceedances**
- **Extremely elevated IO concentrations in sediments at several stations**
- **Ruminant sources apparent but relatively insignificant**

Most Likely Sources

1. **Sanitary Sewer and SSOs**
2. **OSTDS**
3. **Illicit Discharges**
4. **Stormwater (as a conveyance system)**



Lower Hillsborough River WBID 1443E

North-to-South flow

One main channel

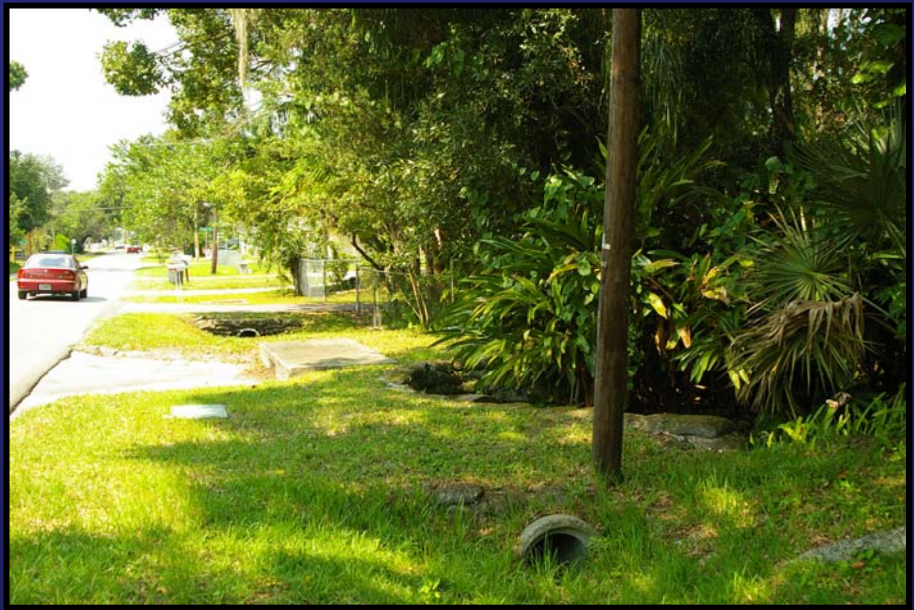
Potential human impacts likely throughout WBID

Lower Hillsborough River

HR1 Ref

HR2

HR3



DHR4a

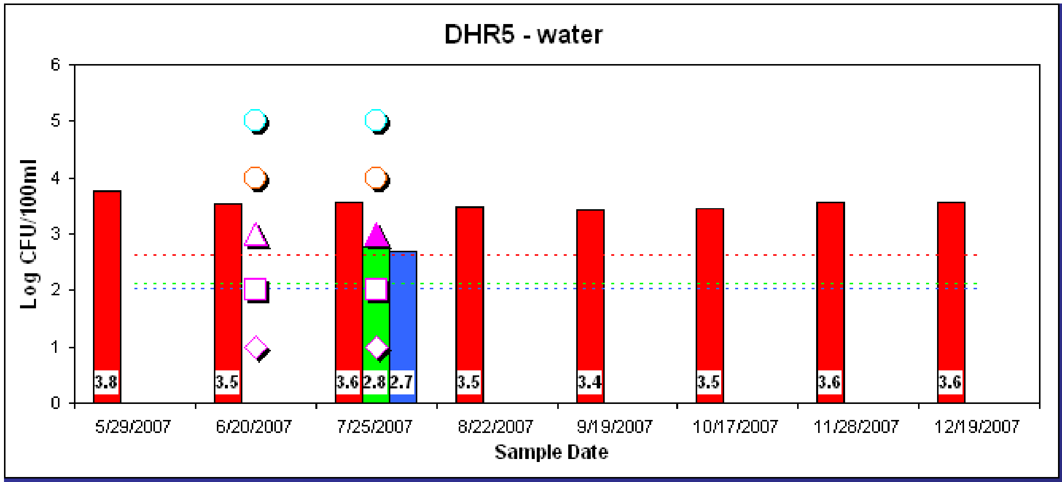
HR4

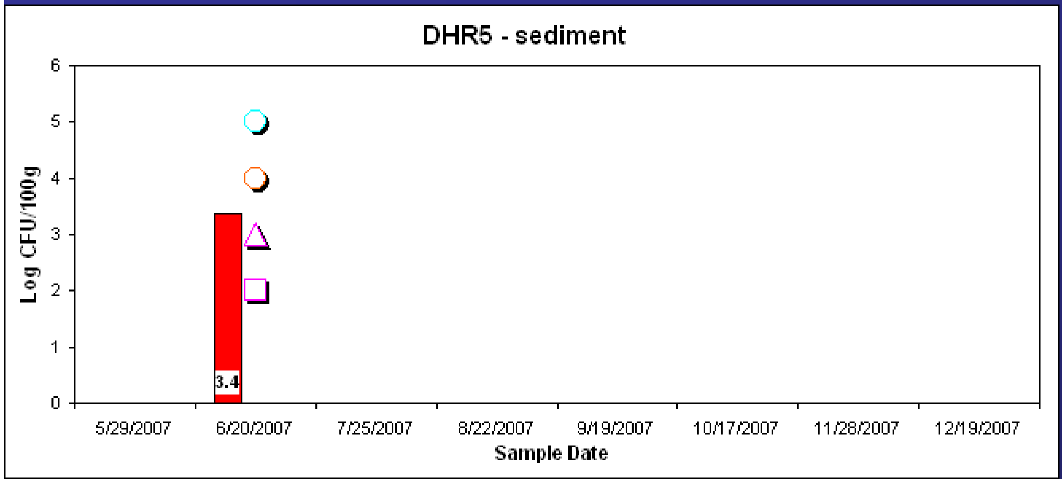
HR5

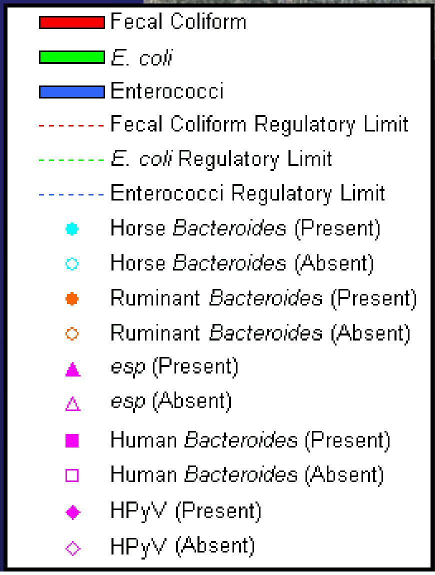
DHR6

DHR7

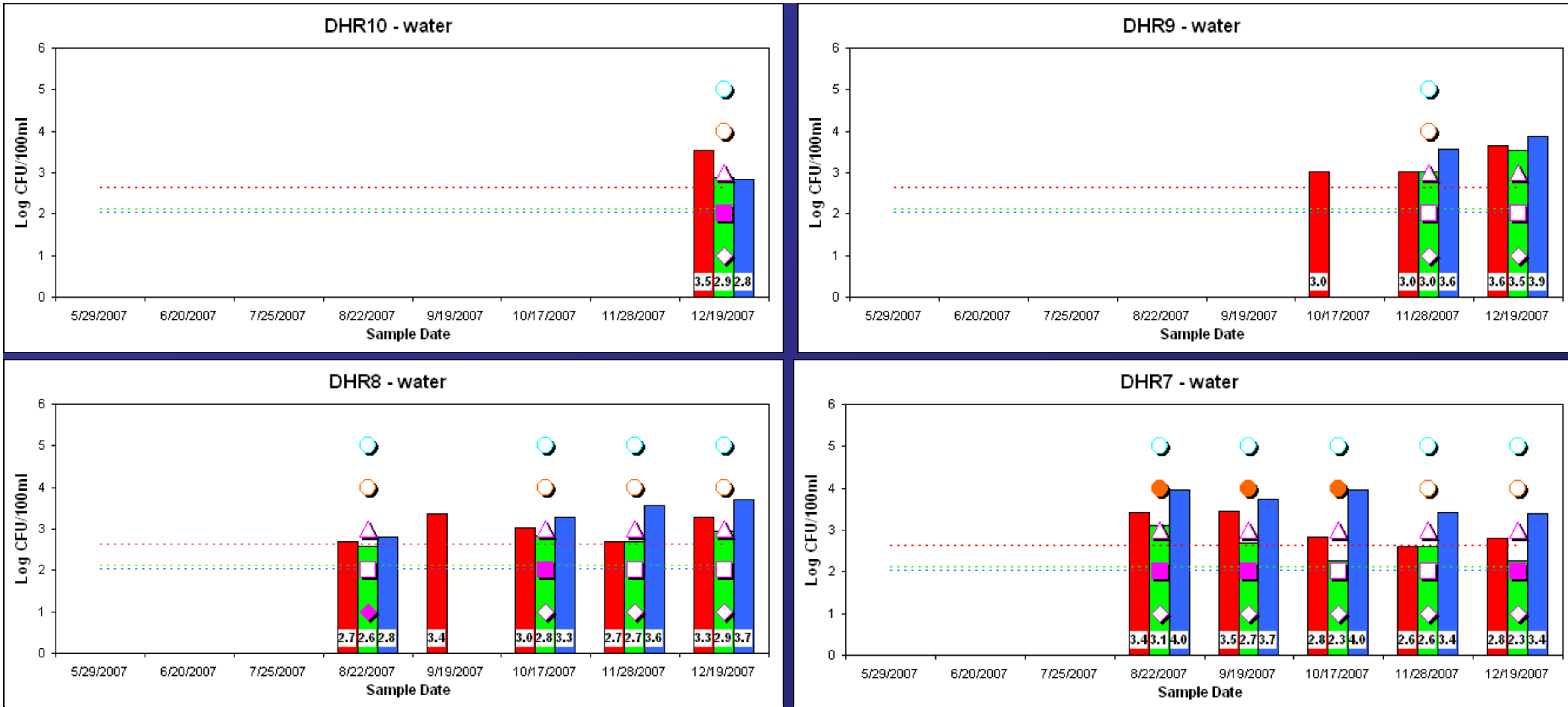
DHR8

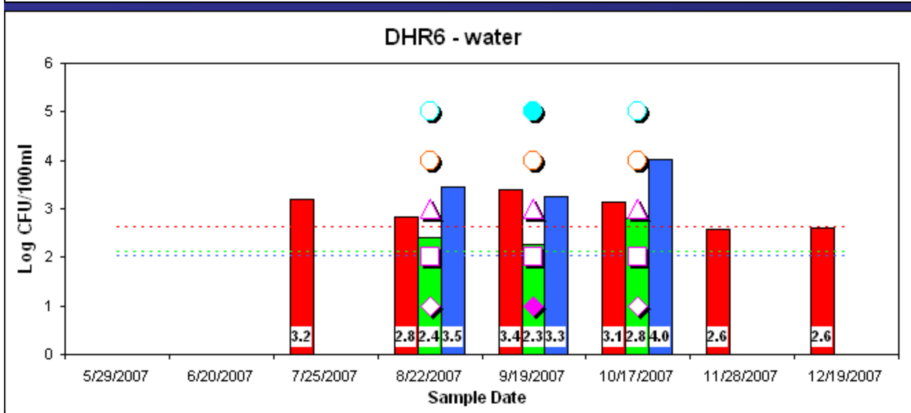


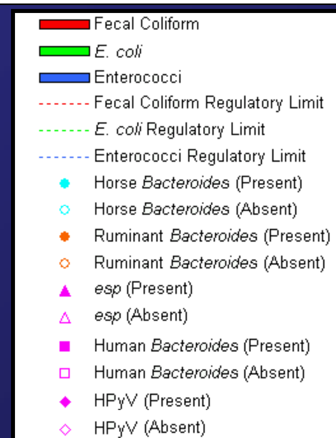




Kirby Creek at Hillsborough River



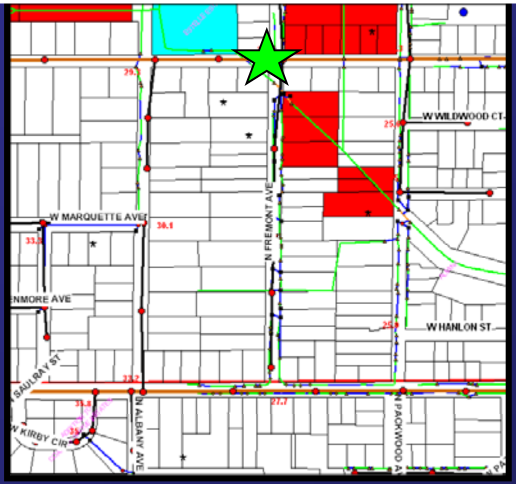


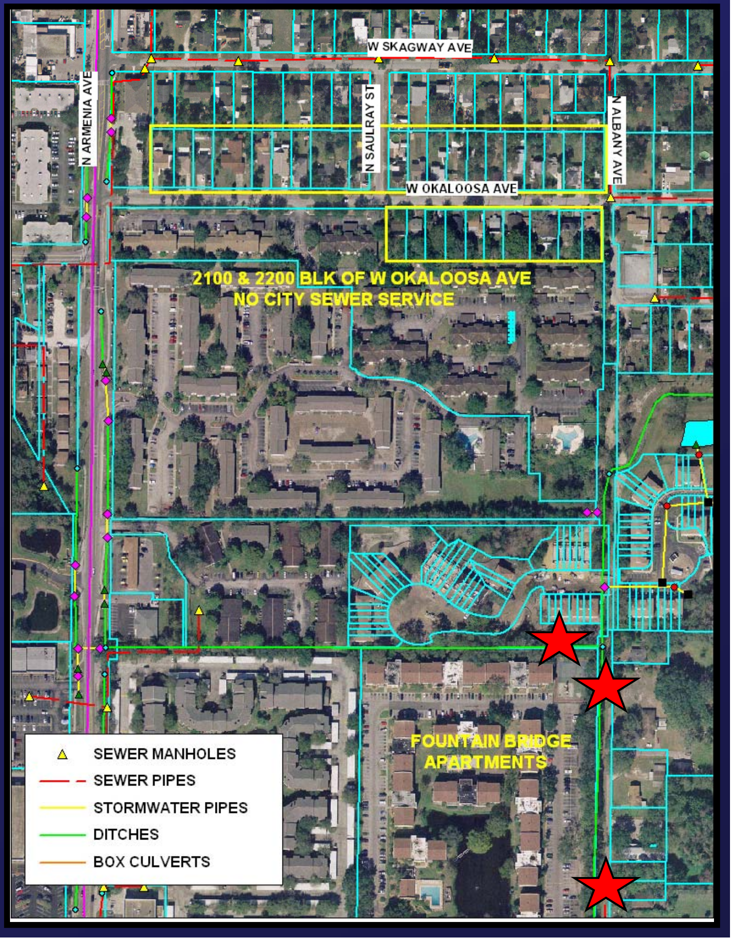


Mixture of MST markers but land use information suggests human sources throughout Kirby Creek

COT Investigation of Upper Kirby Creek

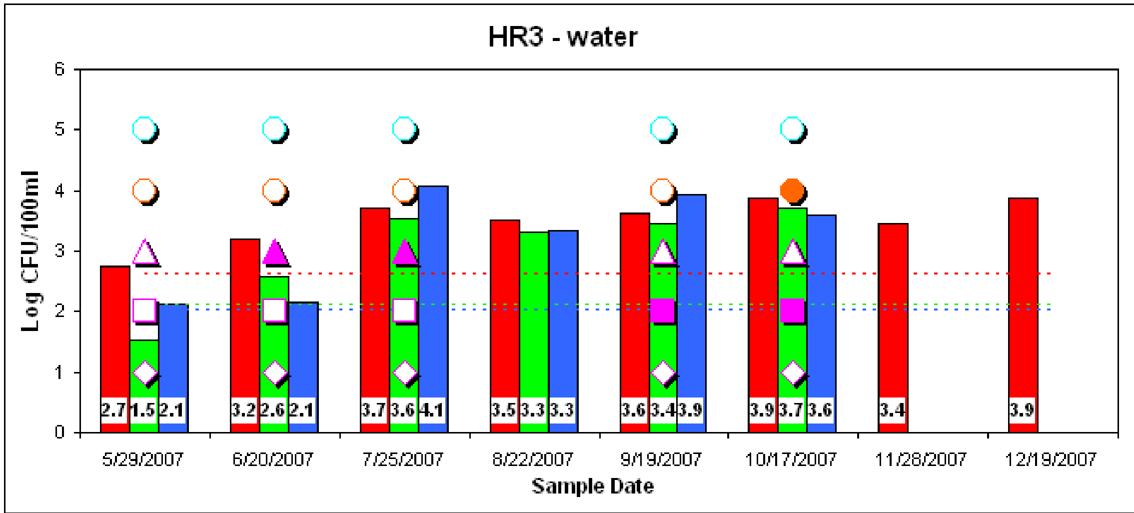
- **Drainage system investigated upstream of DHR7on Feb. 11, 2008**
  - Flow in connecting ditch system after ~2 weeks with no appreciable rainfall
  - Stormwater grate (DHR10) full but no evidence of odor or sewage
  - Onsite retention pond appeared normal
- **Redline properties identified**
- **Parcels within COT limits that do not have sewer accounts upstream of DHR8 (outlined in yellow)**

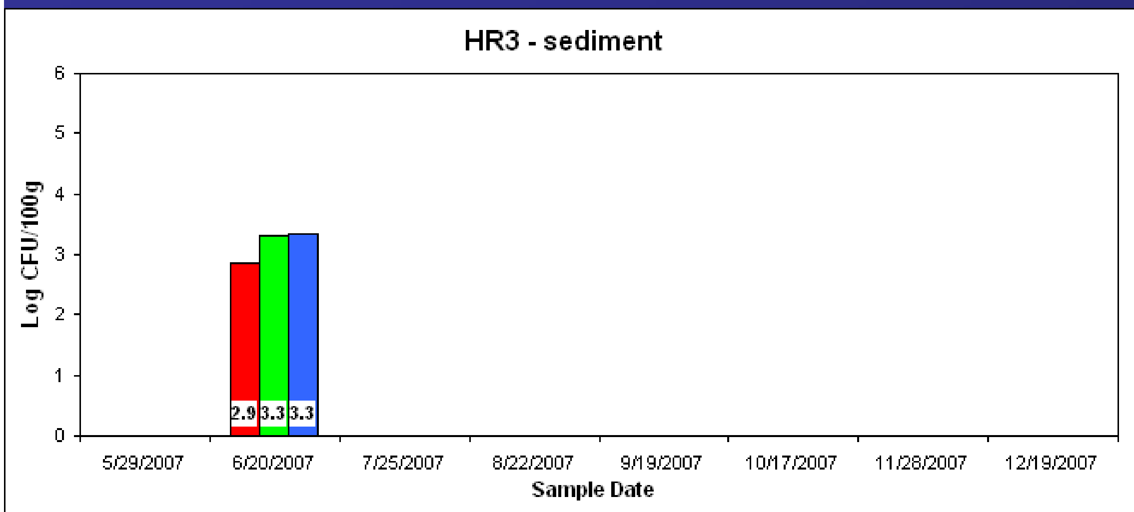


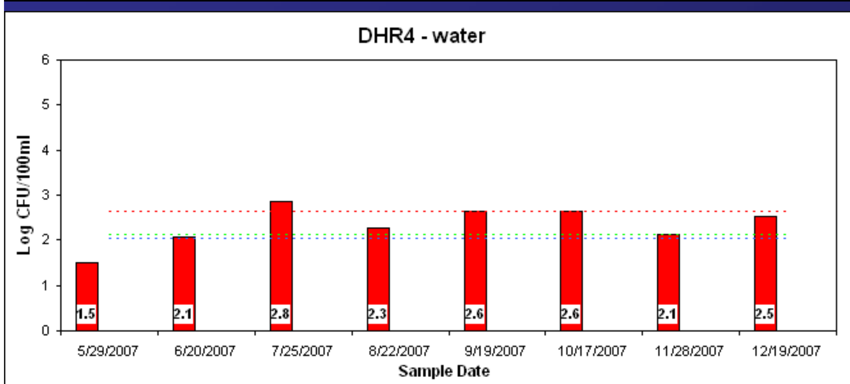


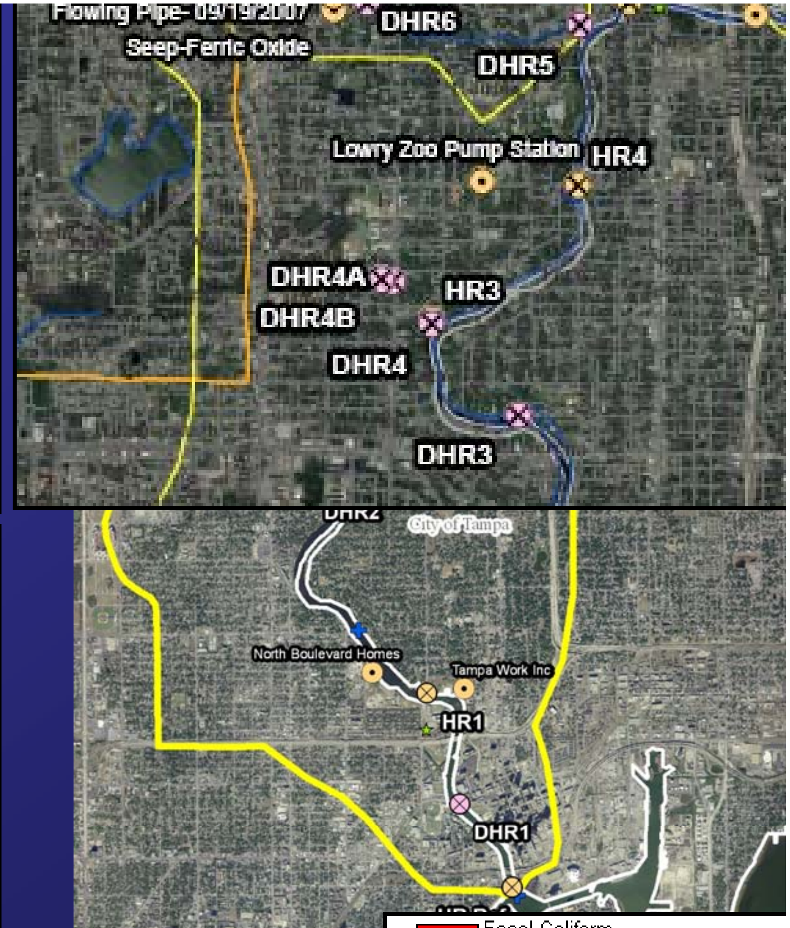
Additional COT Investigations of Midstream Kirby Creek

- **Flowing pipe connected to water softener-letter sent to resident**
- **Pond overflow pipe identified and left as is**
- **Groundwater seep identified in ditch**
  - **Ferric oxide where bottom of ditch interfaces with groundwater**



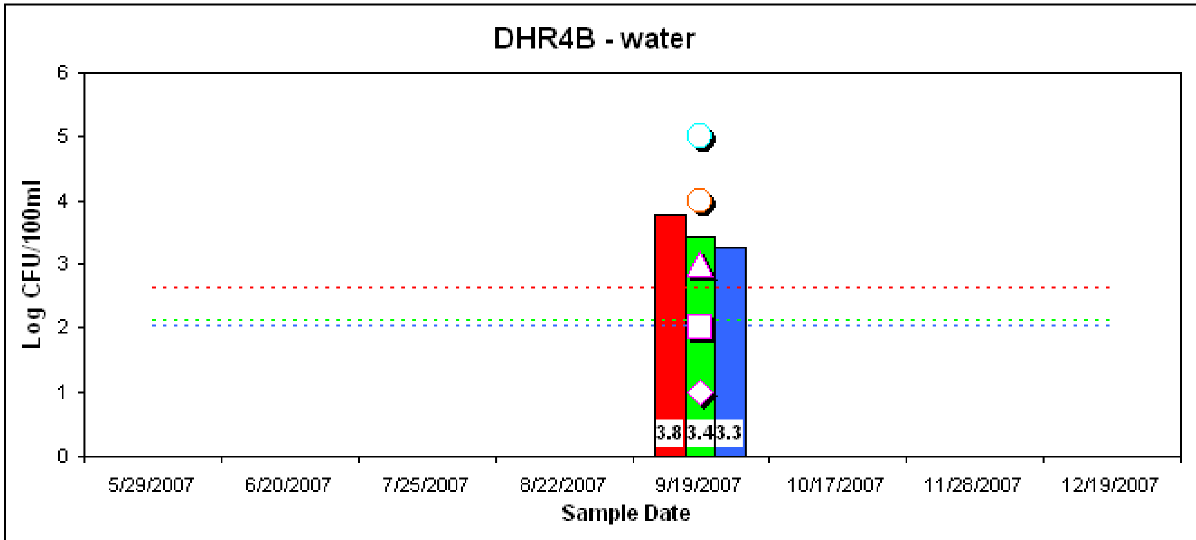


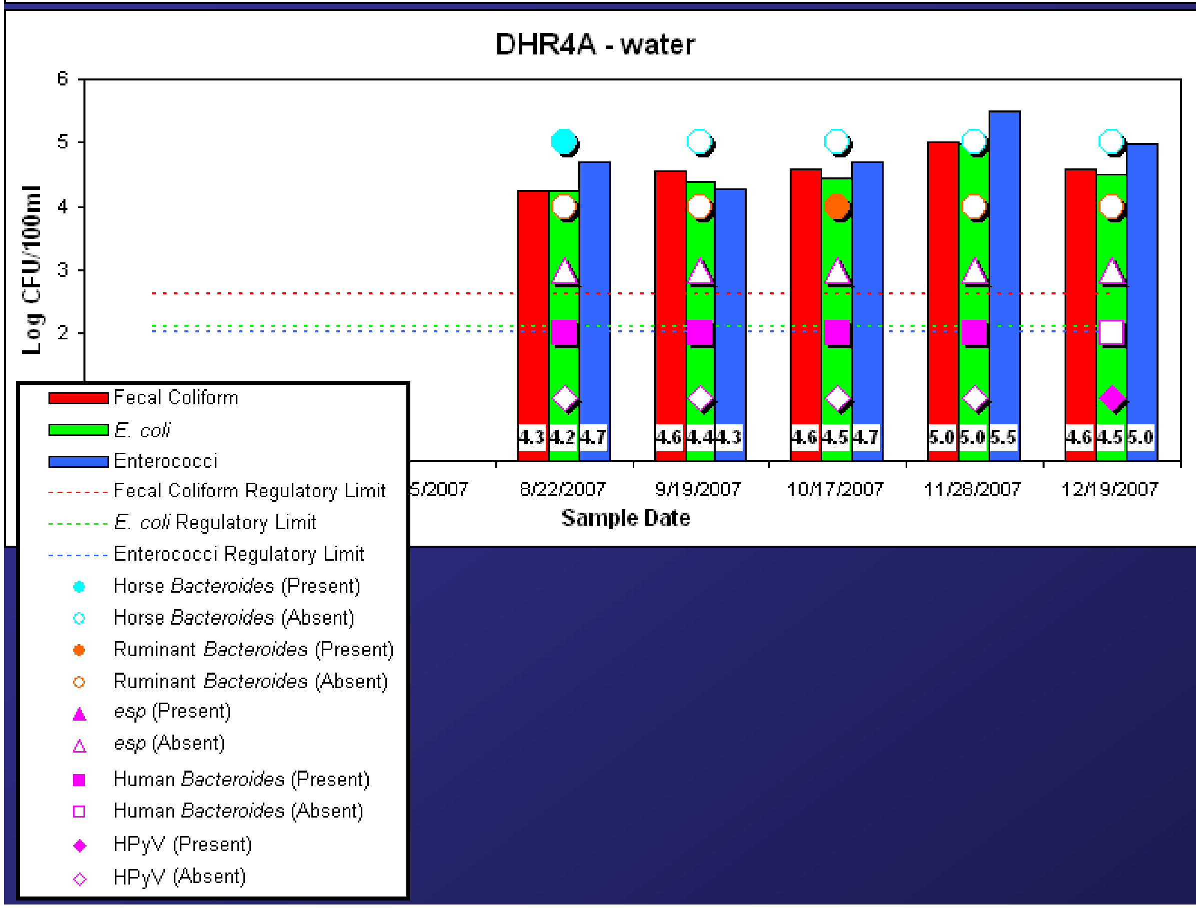




Fecal Coliform
E. coli
Enterococci
Fecal Coliform Regulatory Limit
E. coli Regulatory Limit
Enterococci Regulatory Limit
Horse *Bacteroides* (Present)
Horse *Bacteroides* (Absent)
Ruminant *Bacteroides* (Present)
Ruminant *Bacteroides* (Absent)
esp (Present)
esp (Absent)
Human *Bacteroides* (Present)
Human *Bacteroides* (Absent)
HPyV (Present)
HPyV (Absent)

West Jean Street Tributary at Lower Hillsborough River

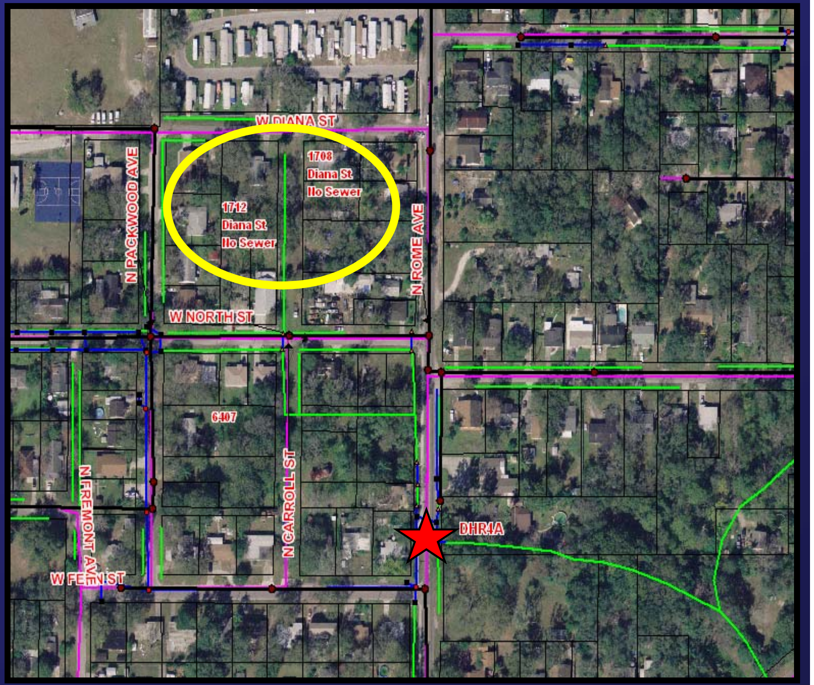




Consistent and extremely high counts isolated to DHR4A when no flow from upstream

COT/HCHD Investigation of West Jean Street Tributary

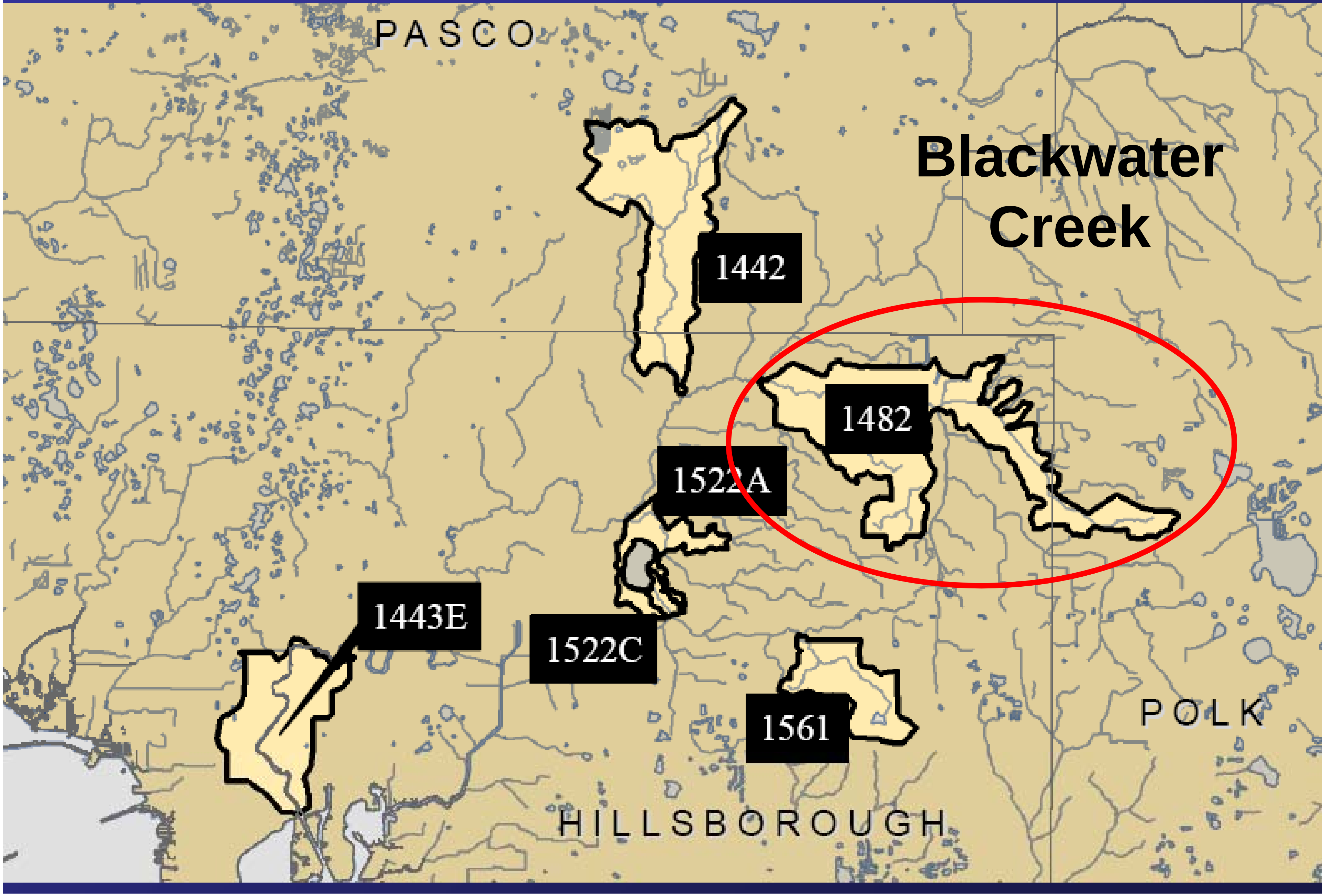
- Slipped joint identified ~225ft west of station DHR4A (likely only taking in water)
- Parcels within COT limits that do not have sewer accounts upstream of DHR4A (yellow circle)
- Standing water and brief sewage odor observed by COT at DHR4A in February 2008 despite lack of flow in contributing ditch, indicates local source
- Kennel of 4-5 dogs and 2 tents observed upstream by COT
- HCHD observed no evidence of OSTDS within at least 1 block north and south of DHR4A



HCHD and EPCHC Investigation

- Black corrugated pipe observed upstream between HR3 and DHR4A (March 25, 2008) by EPCHC
- Line of dark green grass led to residence and an area of the yard that was “soft and spongy”
- Samples downstream of pipe showed fecal coliform and enterococci exceedances
- HCHD found no evidence of sanitary nuisance (April 4, 2008)
  - Will attempt to contact owner about mandatory sewer connection due to proximity of available infrastructure

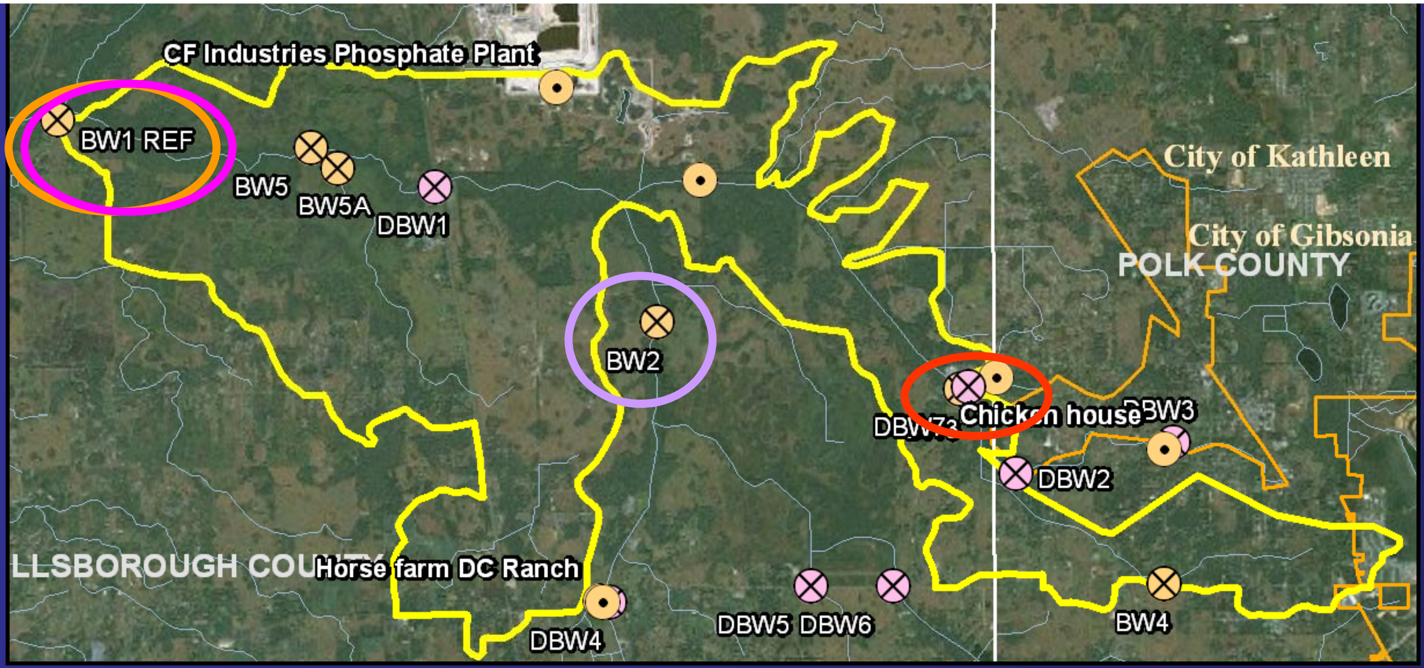
Blackwater Creek (1482)



Classification Matrix Outcome Blackwater Creek

					Human Fecal Markers		Ruminant Fecal Marker	
Sub-Basin	WBID	Monitoring Location	Updated Classi-fication Matrix Outcome	Sample Size (n) for Updated MWQA Score	No. Sampling Dates	% Dates Marker(s) Detected	No. Sampling Dates	% Dates Marker Detected
Blackwater Creek	1482	**BW3**	D4	4	4	75 %	1	0 %
		BW2	D4	8	3	67 %	3	100 %
		DBW4	A3	7	1	100 %	1	0 %
		BW5A	A3	2	2	50 %	2	0 %
		BW1 REF	A2	8	7	43 %	6	17 %

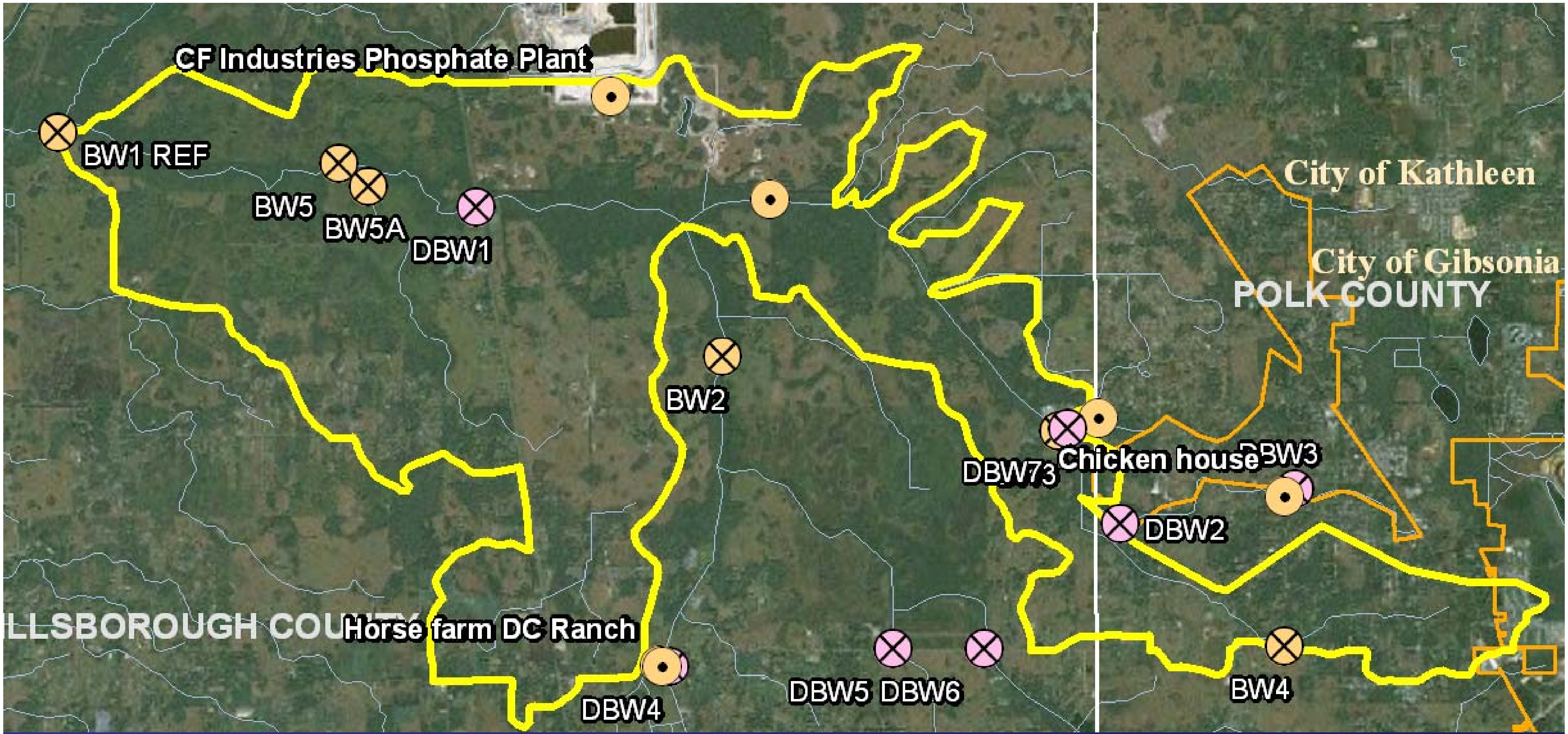
Station	H-Bac	Esp	HPyV	R-Bac	Hr-Bac
BW1	2/5	0/5	1/5	0/4	0/4
BW5A	1/2	0/1	0/1	0/1	0/1
BW5	0/1	0/0	0/0	0/0	0/0
BW2	1/3	1/3	0/3	3/3	0/3
DBW4	0/1	1/1	0/1	0/1	1/1
BW3	1/4	1/4	1/4	0/1	0/1
BW4	0/1	0/1	0/1	0/1	0/1



- **Mixture of human-, ruminant- and horse-specific markers**
- **Extremely elevated IO concentrations in sediments at several stations**

Most Likely Sources

1. **Sanitary Sewer / MHP Wastewater Facilities**
2. **Cattle**
3. **OSTDS**
4. **Wildlife**



Blackwater - WBID 1482

East-to-West flow

Several tributary streams intersect the main channel

Potential source changes with area of WBID

Blackwater Creek

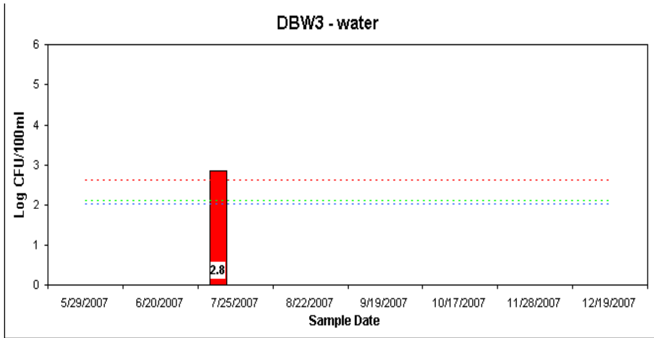
BW1
Ref

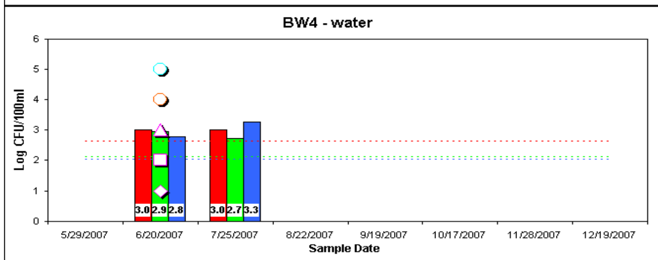
BW3

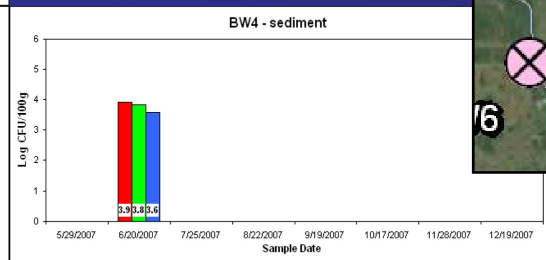
BW2

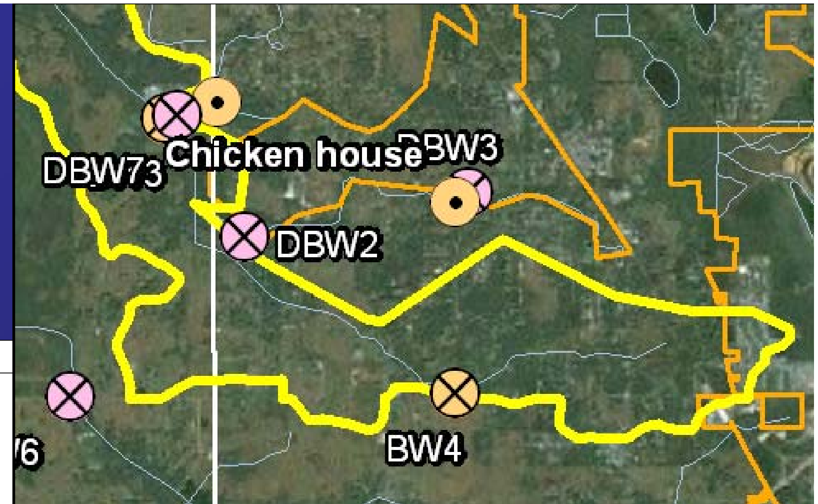
BW4

Station	Month Added	Dry	No Flow
DBW3	May	May, June, August, October	July, September
BW4	June	N/A	June, July
DBW2	May	Always	N/A
BW3	May	May, June, November, December	August
DBW7	September	November, December	N/A
DBW6	July	N/A	N/A
DBW5	July	July	N/A
DBW4	June	N/A	N/A
BW2	May	N/A	N/A
DBW1	May	May	N/A
BW5A	October	N/A	October
BW5	October	N/A	October
BW1 Ref	May	N/A	May, September, December

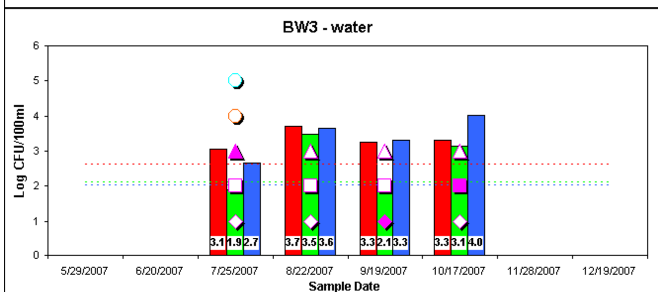


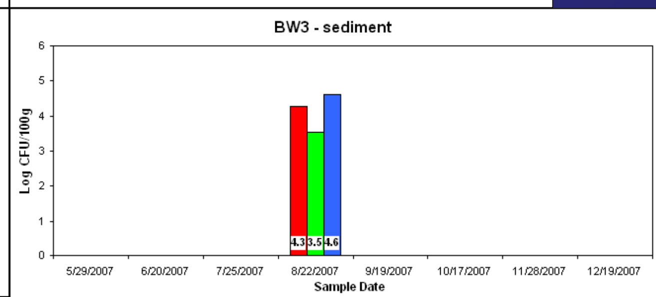




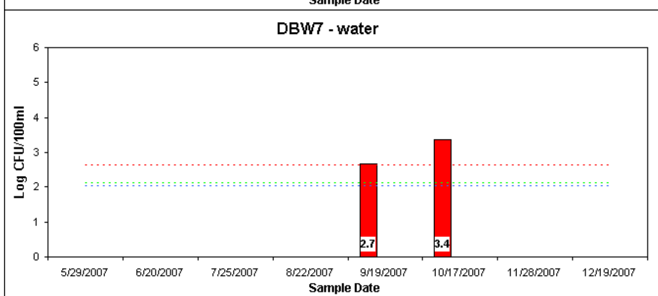


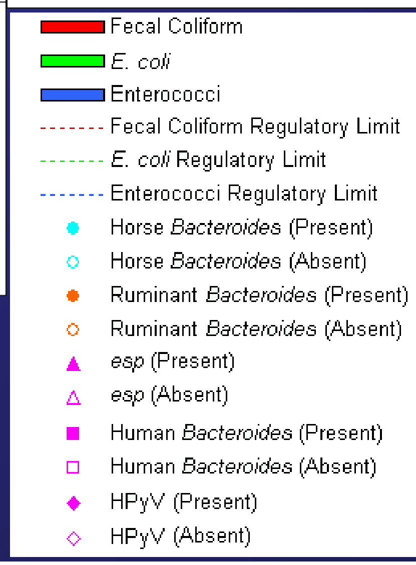
- Limited data due to lack of water and/or no flow





- All three human markers detected at BW3 (except Aug. when no flow but highest levels)



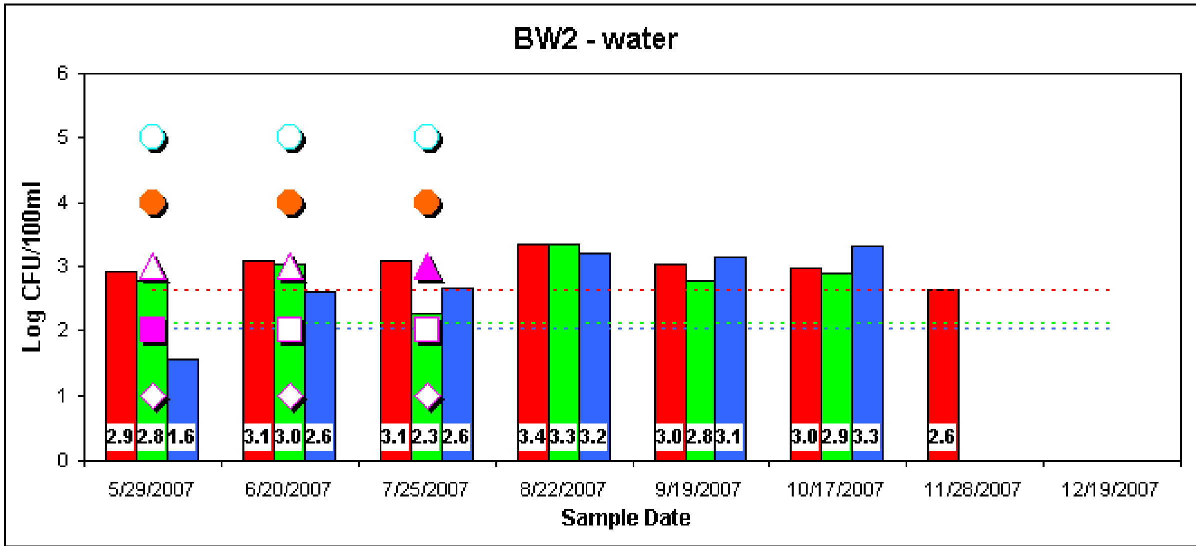


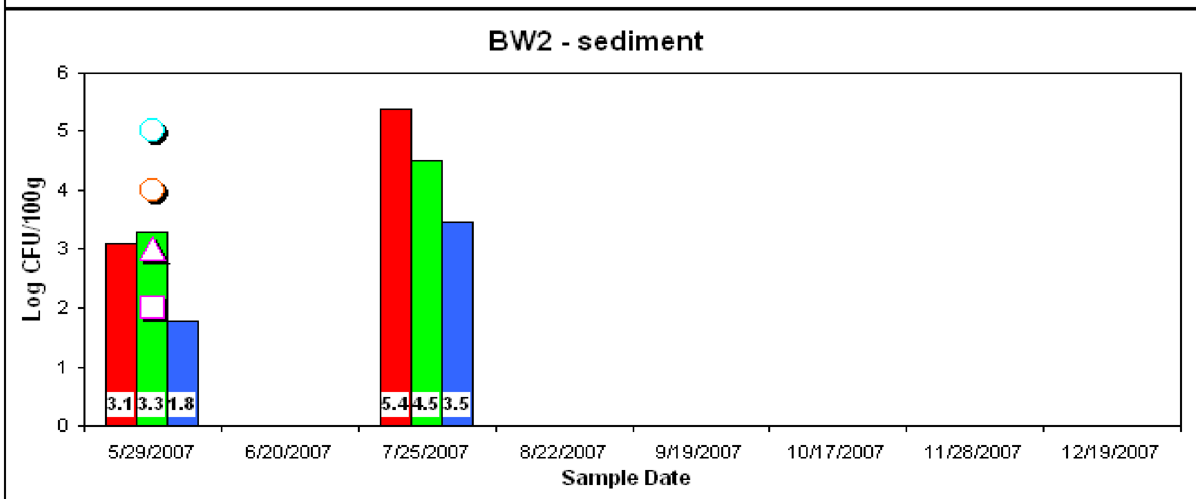
- All IOs show exceedances

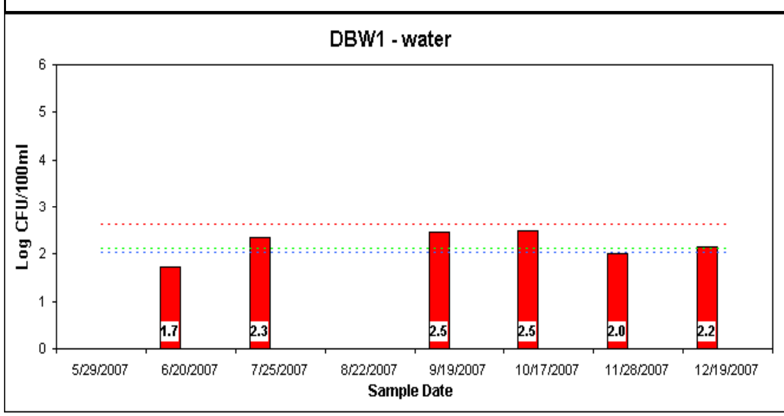
Likely multiple human sources

DEP/EPCHC Investigation

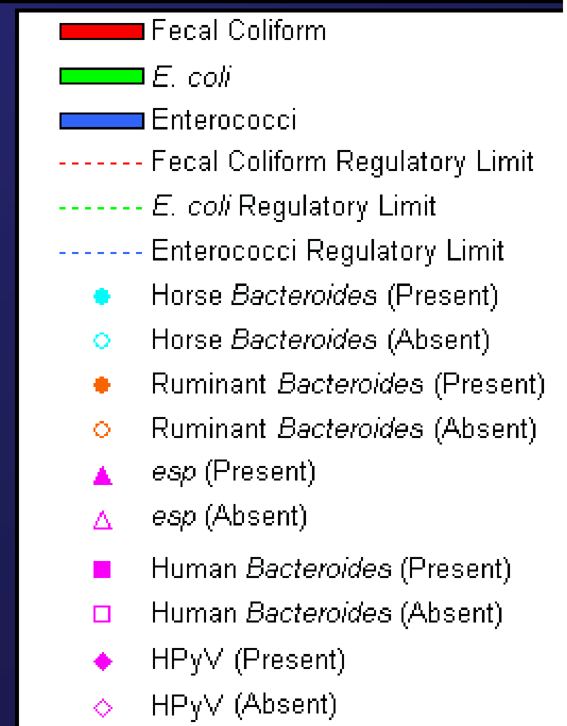
- Facility currently undergoing re-permitting for new 5-year cycle (including new temporary pond)
- Using temporary pond to gain freeboard; little freeboard observed still
  - May continue to be an issue in rainy season

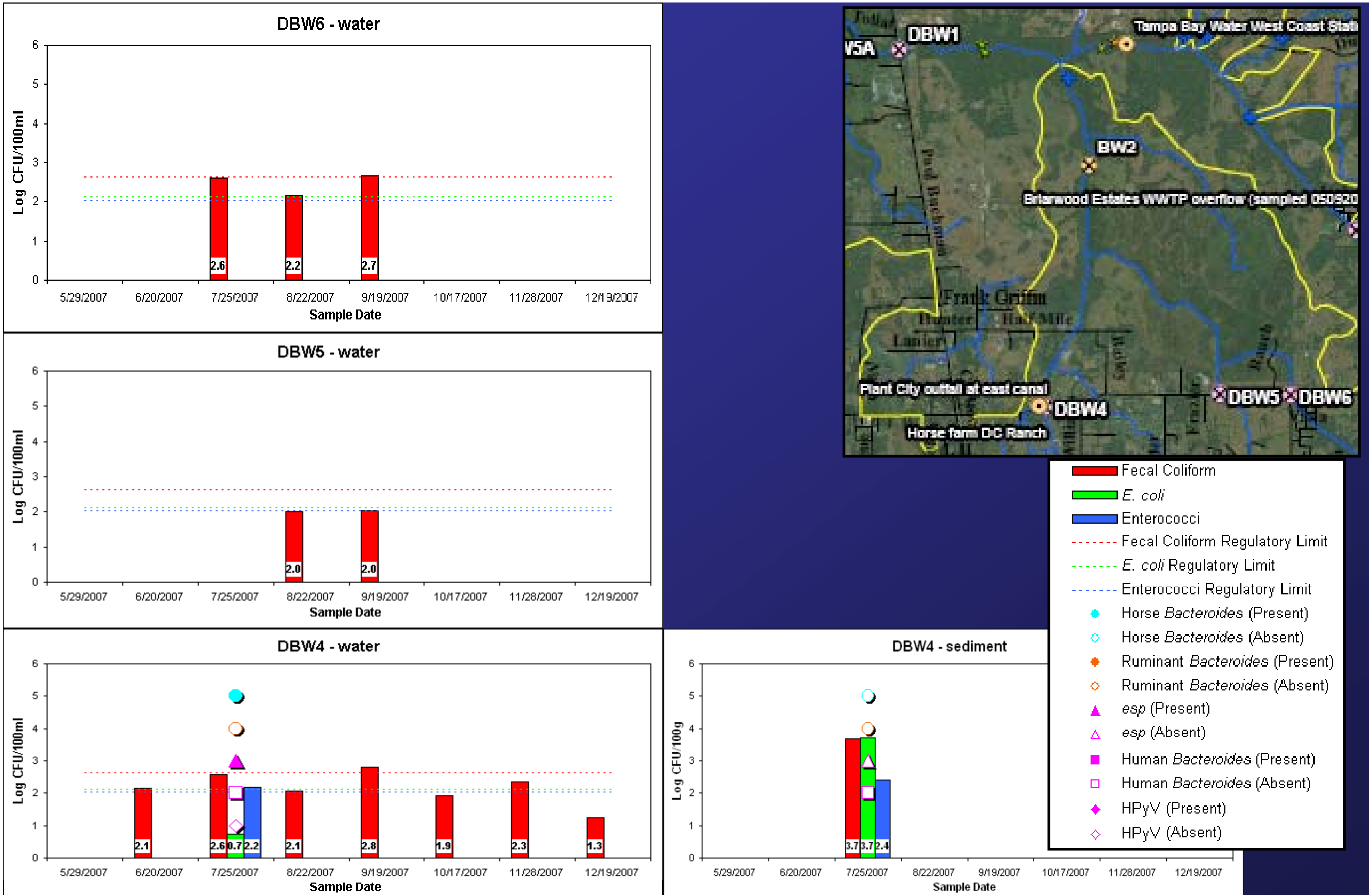




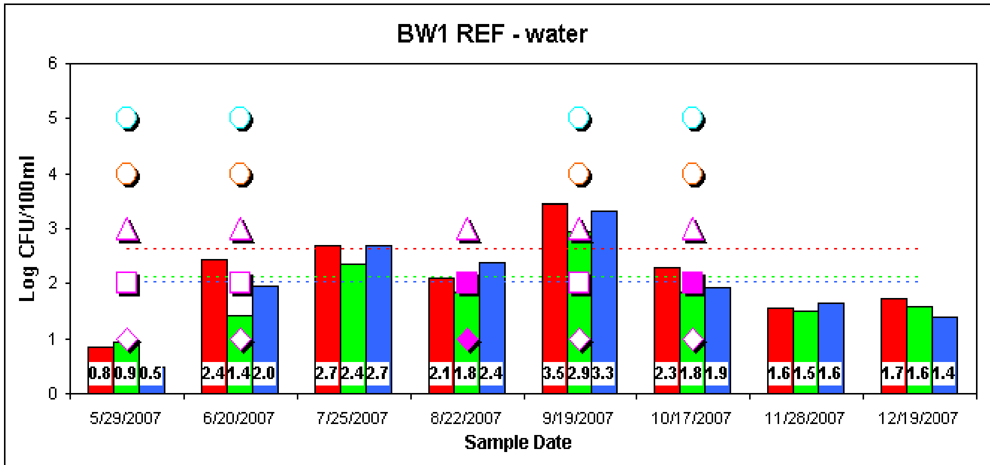


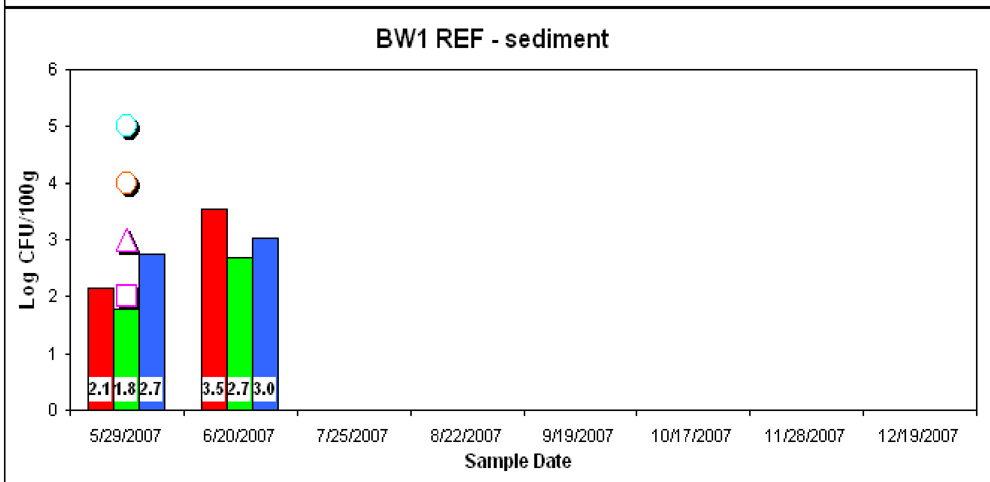
Unexpected human markers





Human markers explained by upstream station (no exceedances)

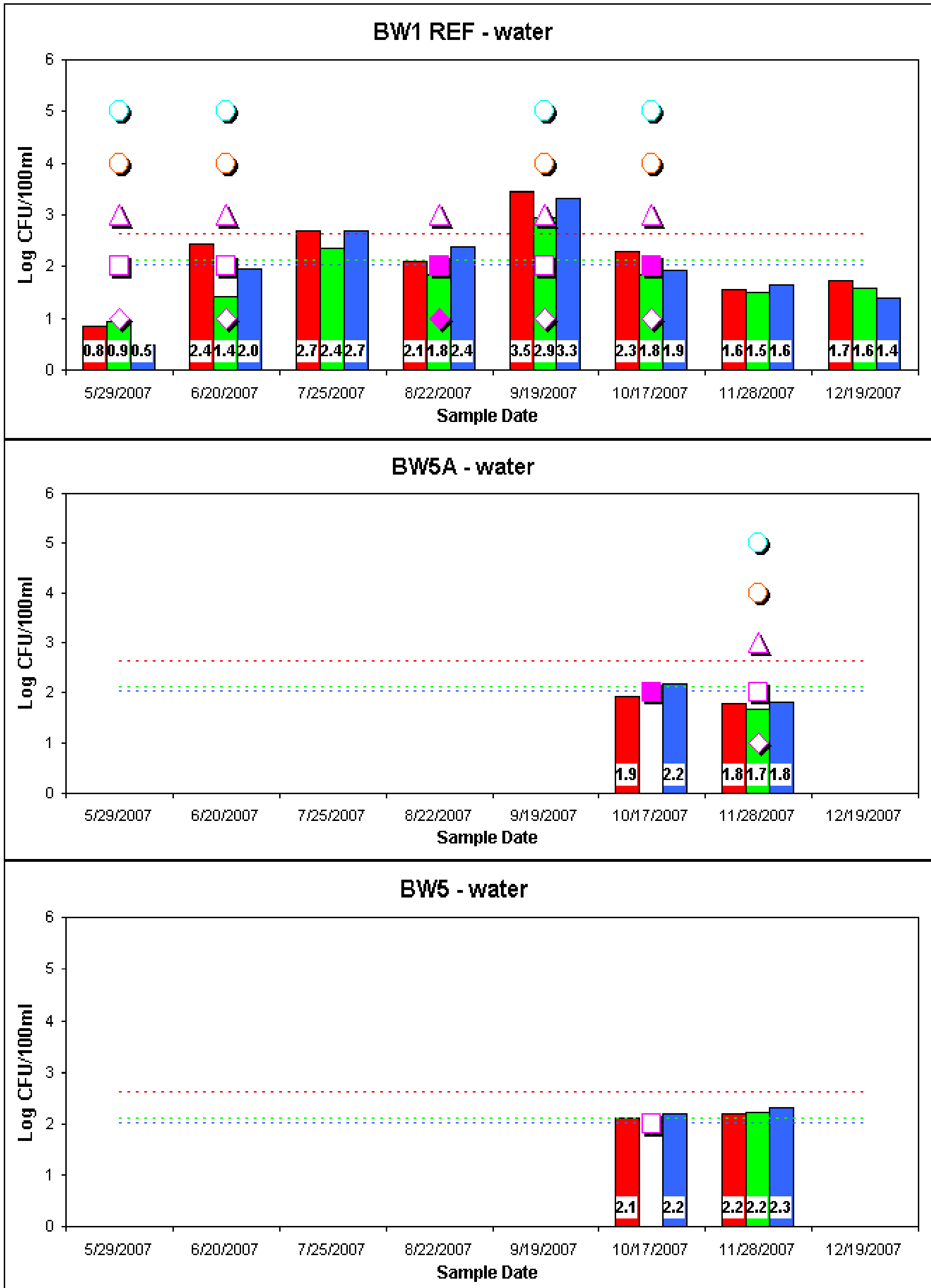


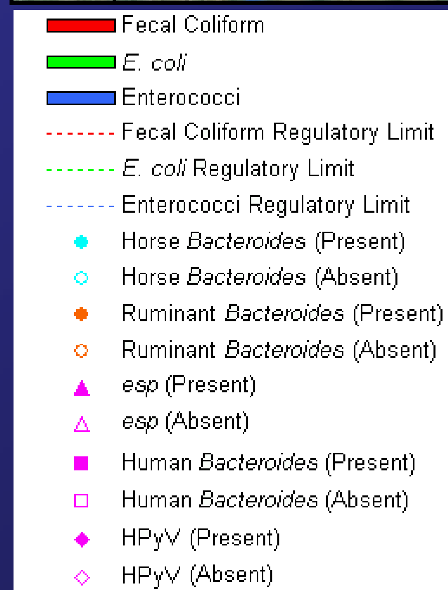


- Fecal Coliform
- *E. coli*
- Enterococci
- Fecal Coliform Regulatory Limit
- *E. coli* Regulatory Limit
- Enterococci Regulatory Limit
- Horse *Bacteroides* (Present)
- Horse *Bacteroides* (Absent)
- Ruminant *Bacteroides* (Present)
- Ruminant *Bacteroides* (Absent)
- *esp* (Present)
- *esp* (Absent)
- Human *Bacteroides* (Present)
- Human *Bacteroides* (Absent)
- HPyV (Present)
- HPyV (Absent)

Episodic exceedances at BW1

All 3 human markers at BW1; not associated with highest levels but during times of flow



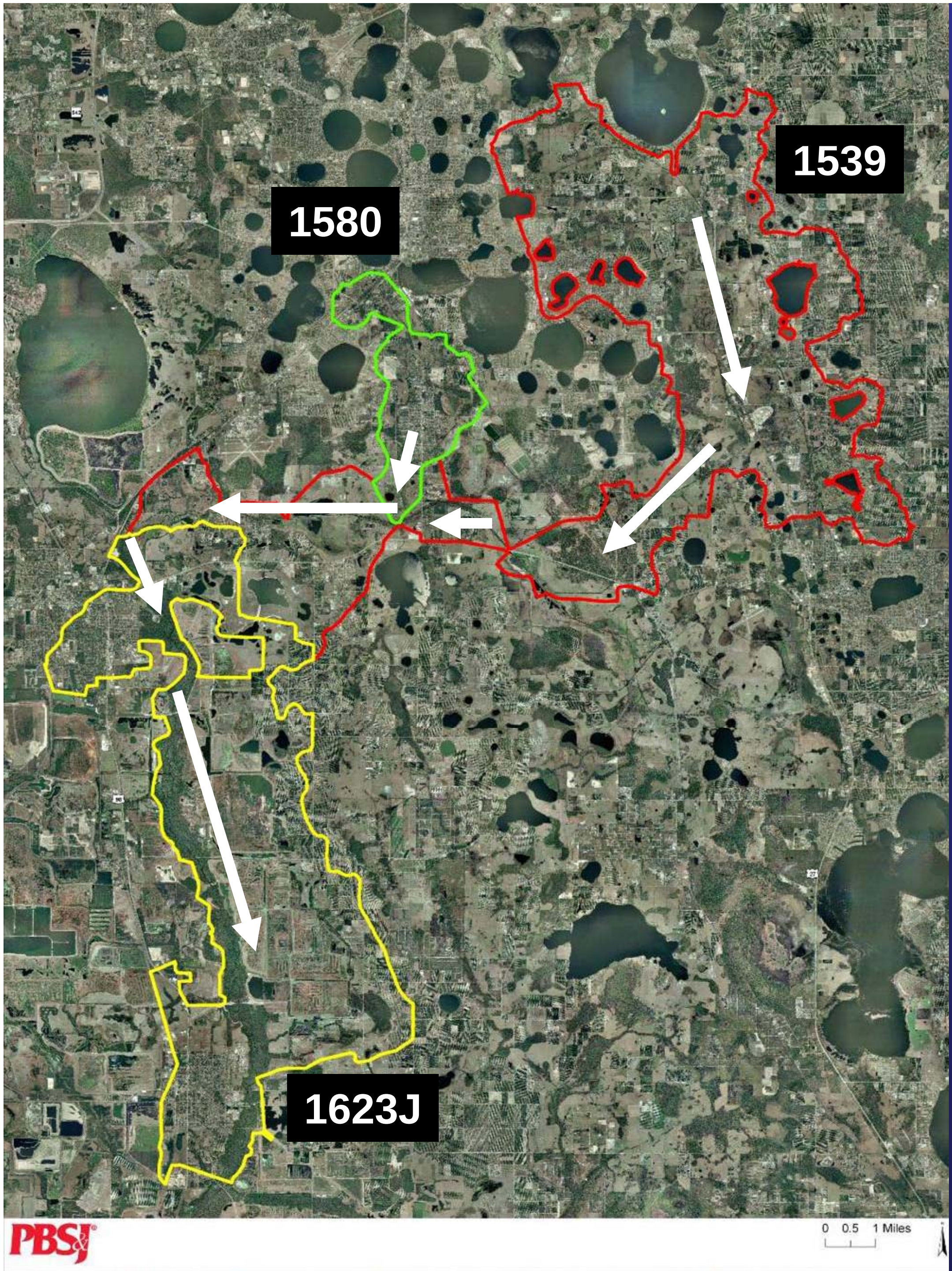


Exceedances likely due to upstream human source

Case Studies

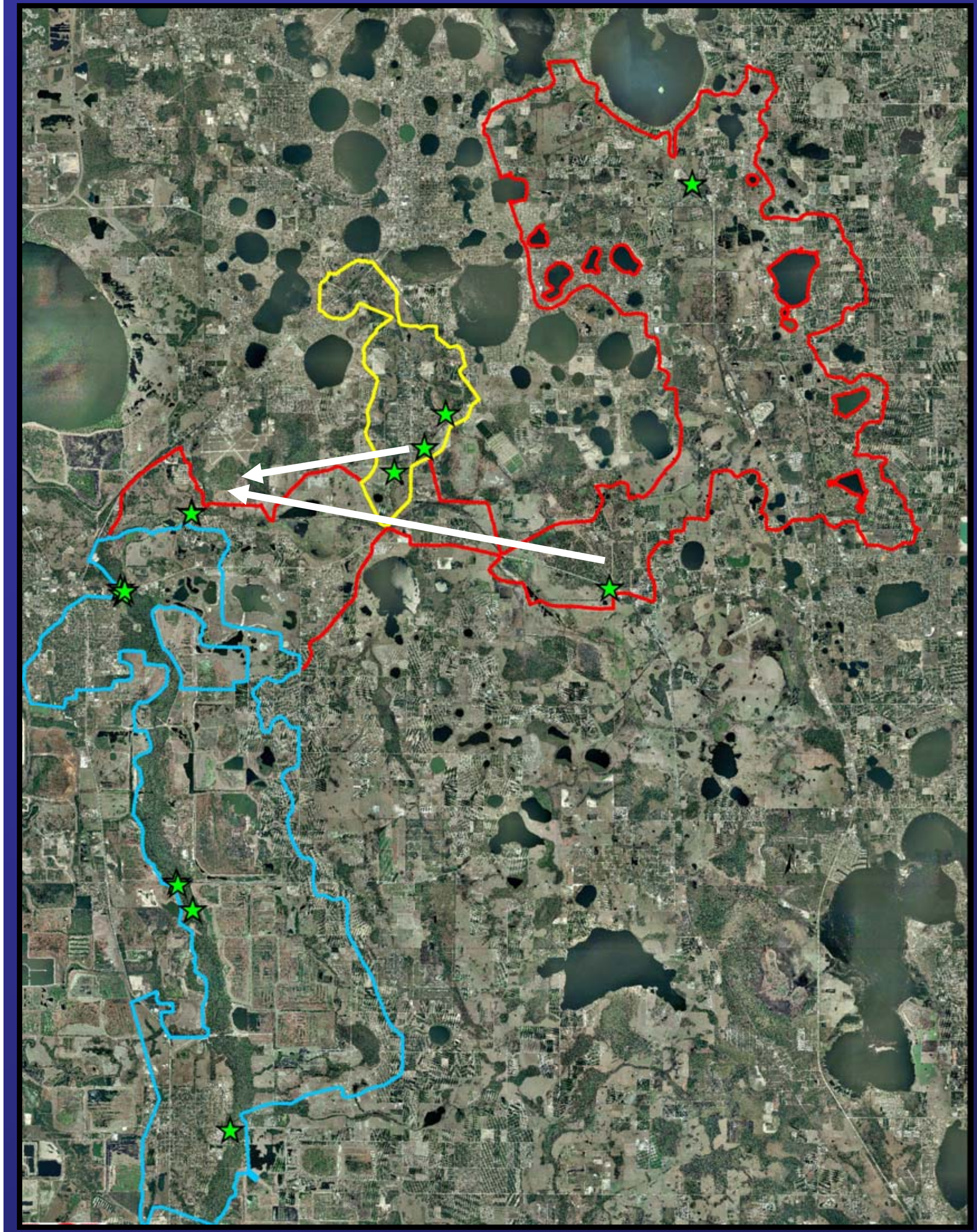
Impairment at Station Level

Upper Peace Creek



Part of an interconnected system which receives flow from upstream watersheds and transfers flow downstream

Redefine sampling methodology to better determine potential for transport



Transport?

Statistical Comparison of fecal coliform concentrations between stations

- – Upstream to Midstream- No significant relationship
- – Midstream to Downstream- significant increasing
- – Wahneta Farm Drain Canal downstream to Downstream- significant increasing

Case Studies

Collaboration with Local Stakeholders

Upper Peace Creek

City of Winterhaven
Tour of WWTP #3

FDACS

- Dissemination of key educational information to project team
- Leadership in education of stakeholders in implementing BMPs
- Facilitation for meetings and accessing local ranches
- Inclusion of Draft Summary of Agricultural Operations and Practices in Final Report

Case Studies

Limitations due to lab capacity and incorporation of improved MST assays

Lower St. Johns River

Academic MST Lab

PROs

1. Reputable lab
2. Lower cost
3. Collaboration in field
4. Collaboration in evaluation and synthesis of information
5. Report review
6. Excellent, trustworthy working relationship

CONs

1. Limited capacity
2. Limited funding for updating equipment and assays

Commercial MST Lab

PROs

1. Reputable lab
2. Higher capacity
3. More funding for updating equipment and assays

CONs

1. Higher cost
2. Lack of collaboration in field
3. Lack of data synthesis
4. Working relationship not yet established

Suggestions

1. Work to increase lab capacity and sharing of data among labs
2. Lab inter-calibration / method validation project