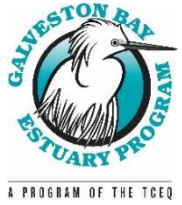
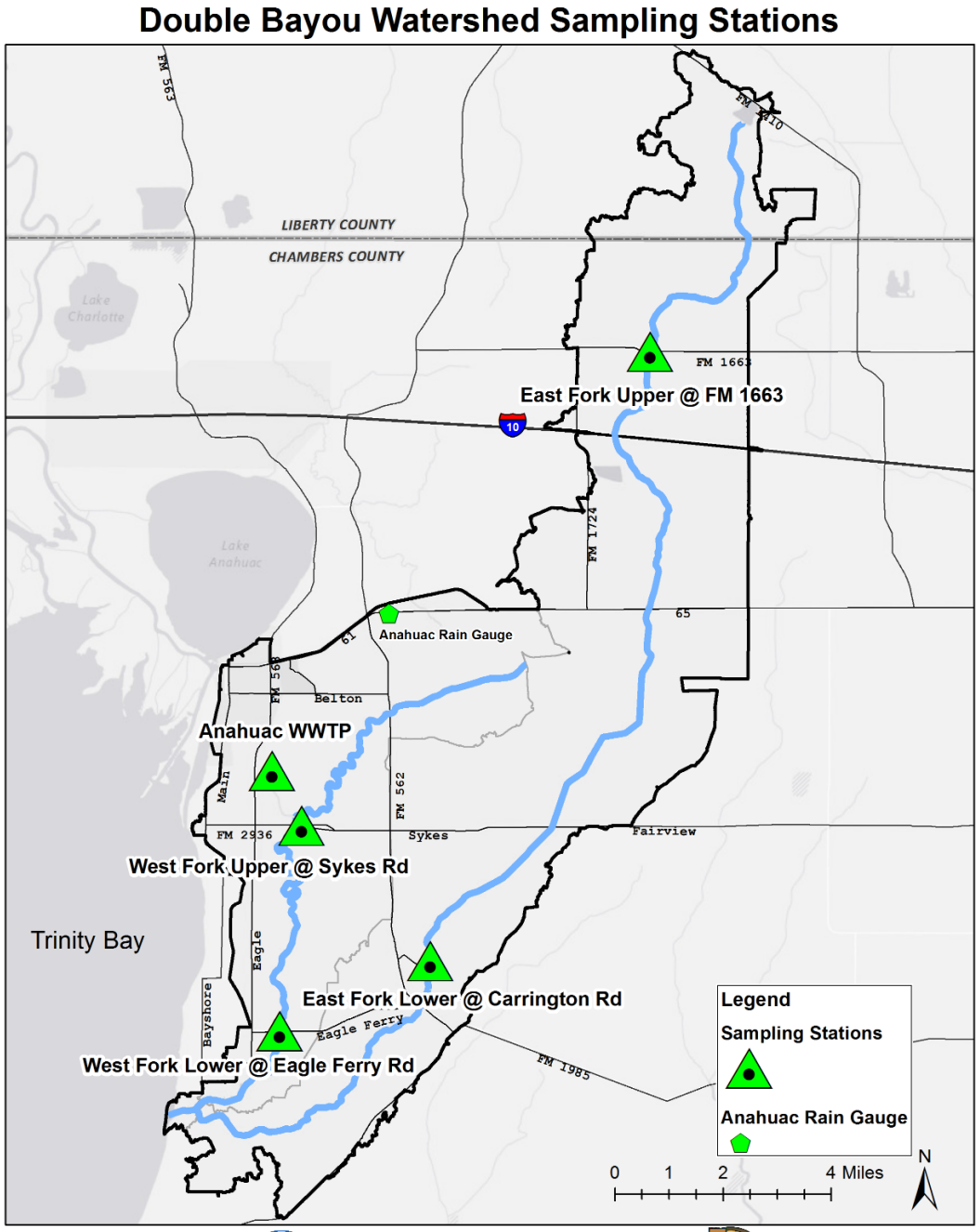
Double Bayou WPP: Water Quality and Load Reduction Goals

Double Bayou Watershed Partnership Stakeholder Meeting
August 18th, 2015
Stephanie Glenn, Ph.D., HARC



SAMPLING STATIONS

- Five Stations
  - Two on each Fork, one at Anahuac WWTF
- Sampling results: October 22nd, 2013 –May 20th, 2015 (previous results 10/22/2013-8/12/2014)
- Sampling results include 30 to 31 routine events (sampling @ twice a month) and 7 targeted rain events at each station (189 total samples)



DOUBLE BAYOU WATERSHED PARTNERSHIP

HARC

Shead Conservation Solutions

TSSWCB

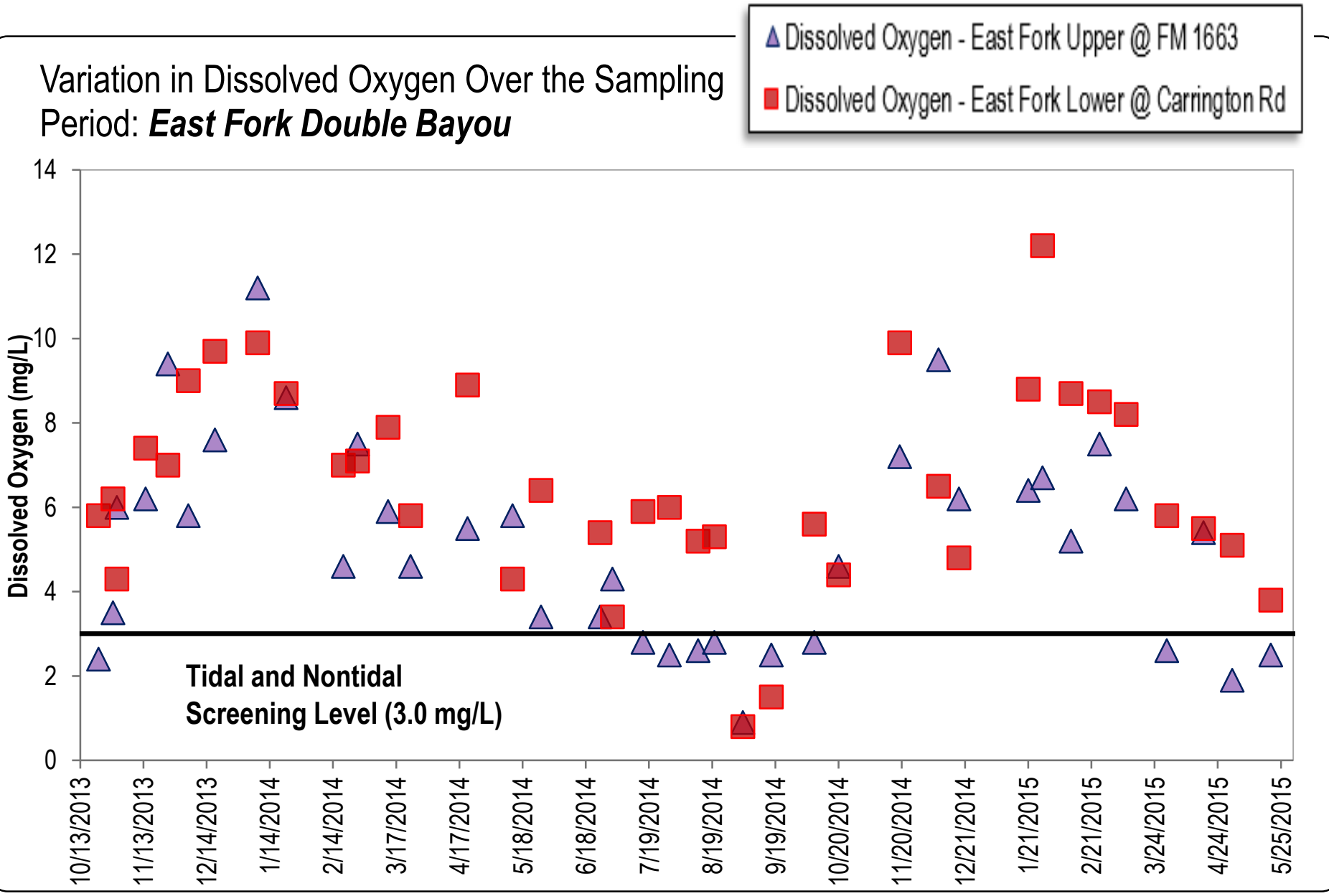
USGS science for a changing world

Dissolved Oxygen

- **Two Methods of Sampling**
  - **"Grab" sampling (includes routine and targeted rain event)**
    - **Only get one sample a day (typically 9 am -5 pm)**
    - **Shows greater range over a longer time period**
  - **24-hour sampling**
    - **For a period of 24 hours (or more), takes one sample every 15 minutes**
    - **Captures the highest highs and lowest lows of the day – really shows entire range of DO**
    - **Limited to that one day (less long-term range)**
- **If available, TCEQ uses 24-hour data for criteria assessment. If no/limited 24-hour data are available, TCEQ will use Grab samples with screening parameters for assessment.**

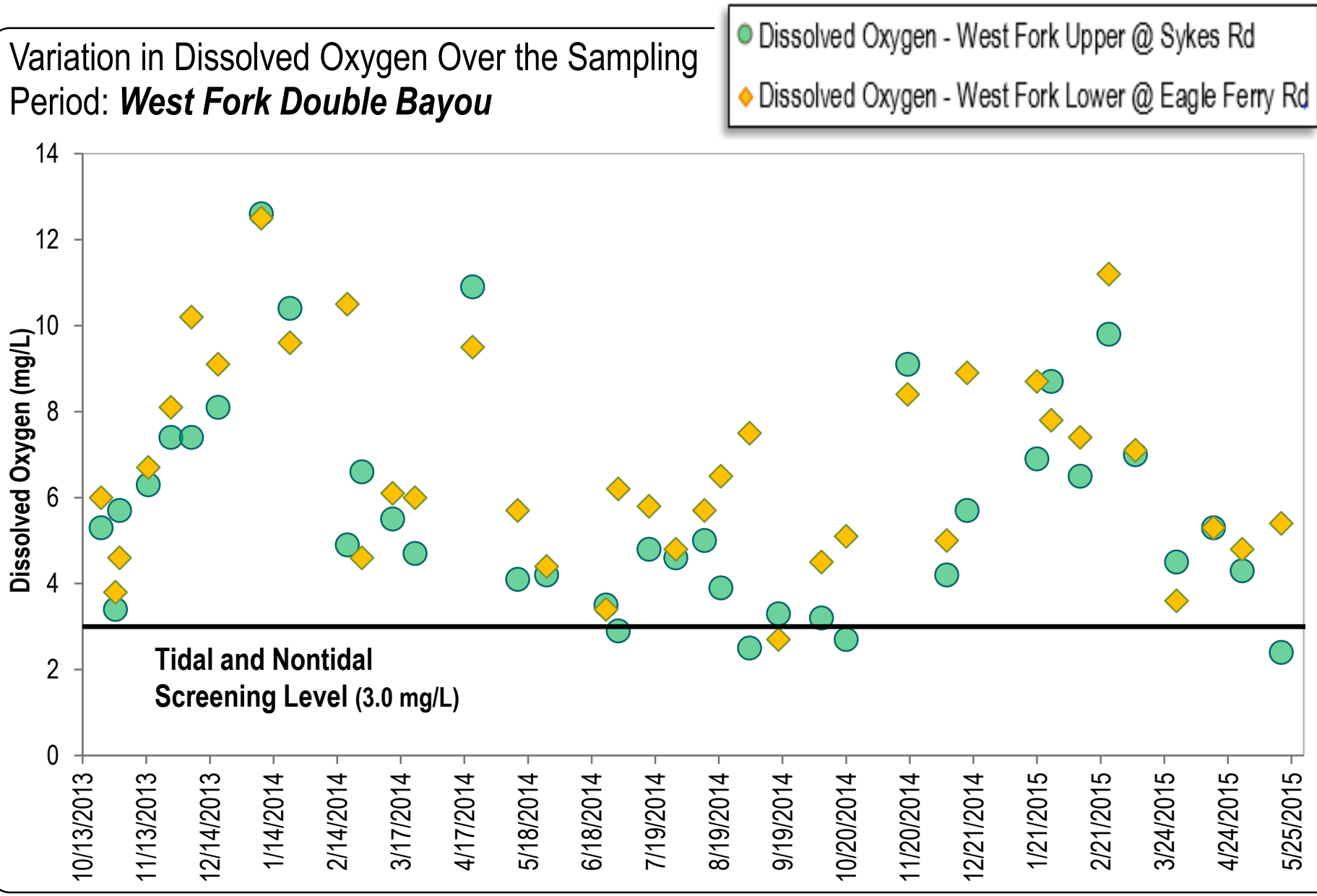
DOUBLE BAYOU WATERSHED PARTNERSHIP

Dissolved Oxygen – Grab Samples

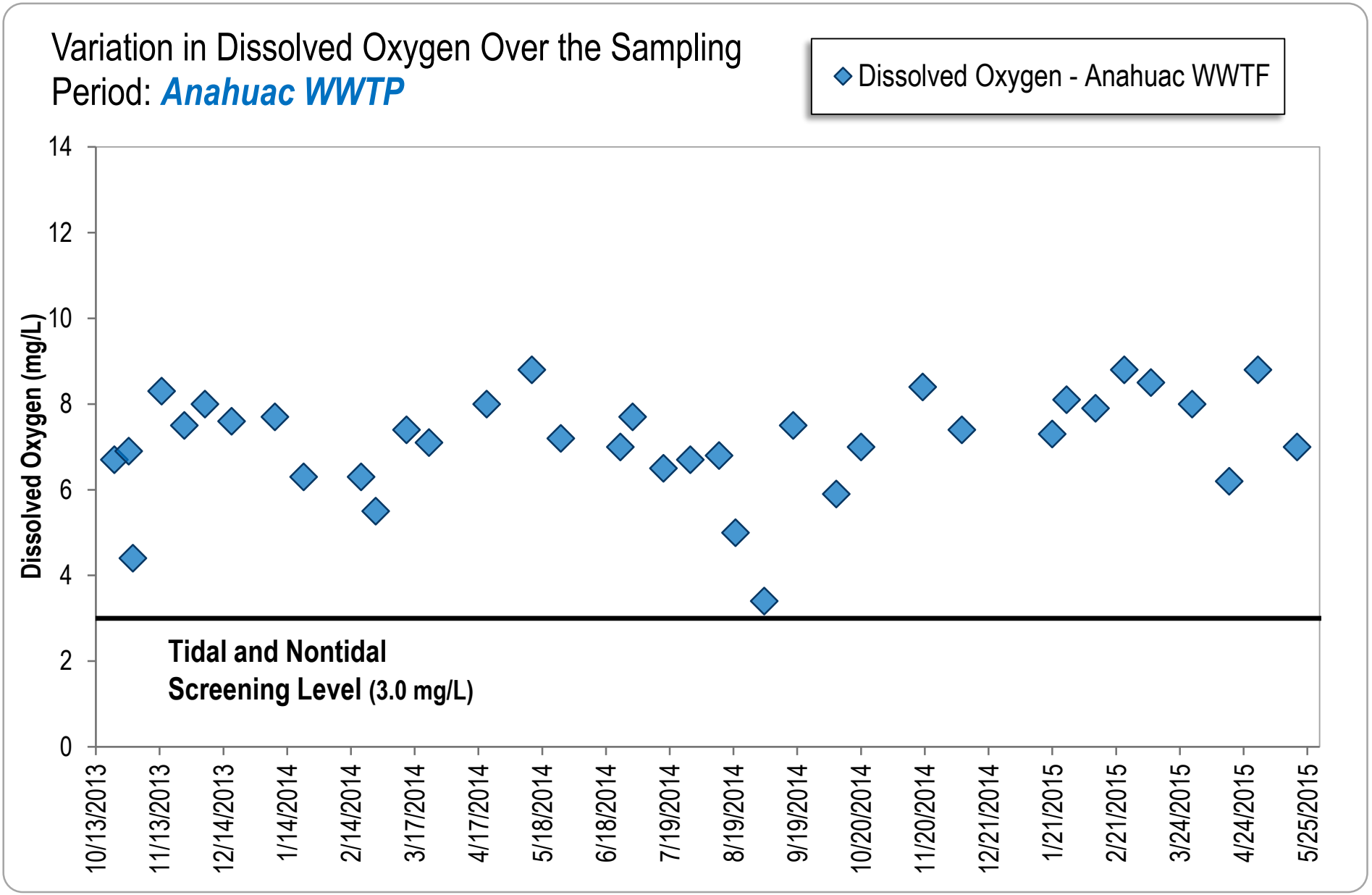


Dissolved Oxygen – Grab Samples

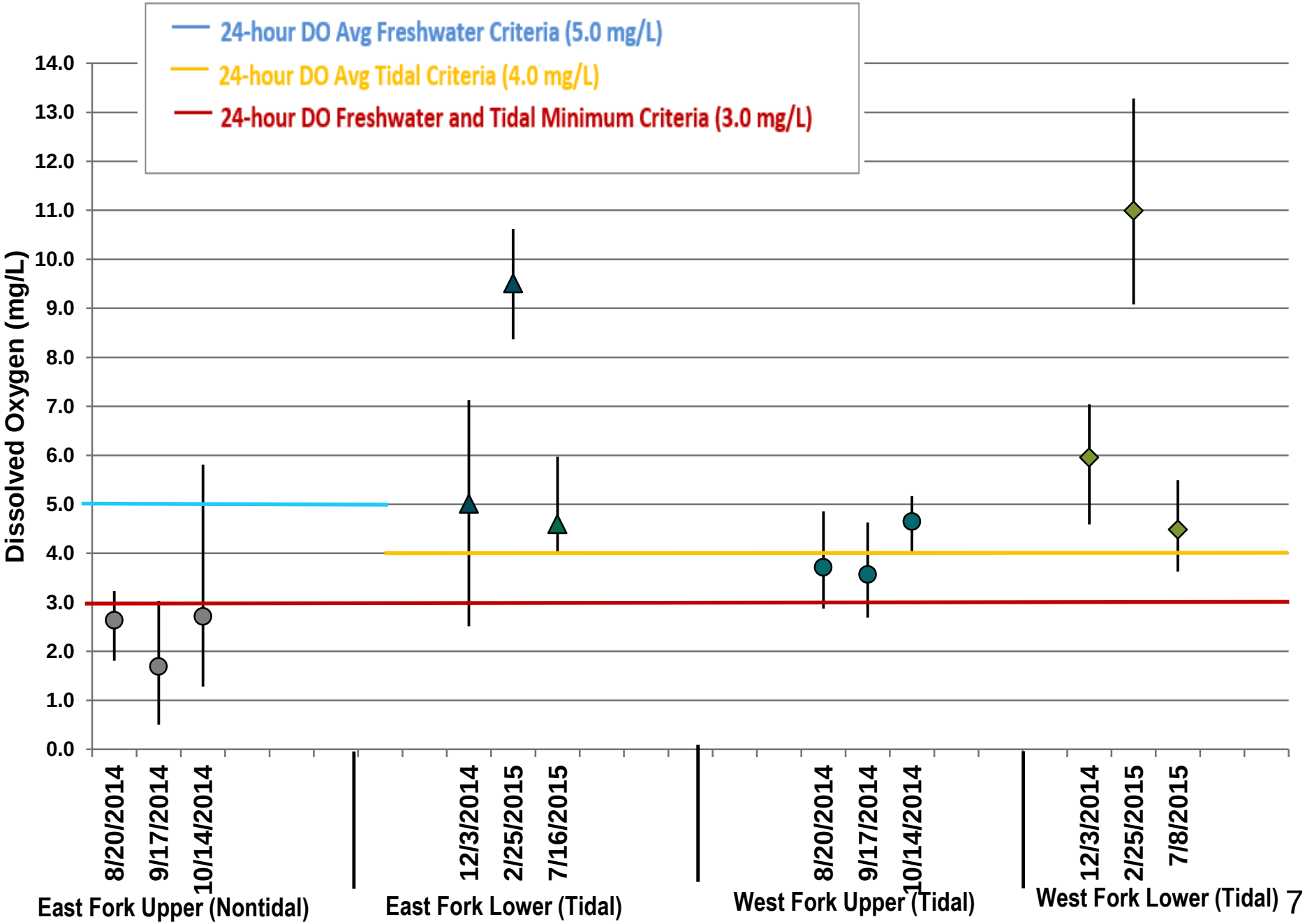
Variation in Dissolved Oxygen Over the Sampling Period: ***West Fork Double Bayou***



Dissolved Oxygen – Grab Samples



Dissolved Oxygen – 24-hour Sampling



Dissolved Oxygen

- 24-hour samples (East and West Forks Upper) suggest fluctuations throughout the day problematic for aquatic life
- Grab samples show samples for all stations (except WWTP) at concentrations below the screening level
- Percent Exceedances (% below screening level) for grab samples are greatest overall in samples collected in the Summer (June-Aug) and Fall (Sept-Nov)

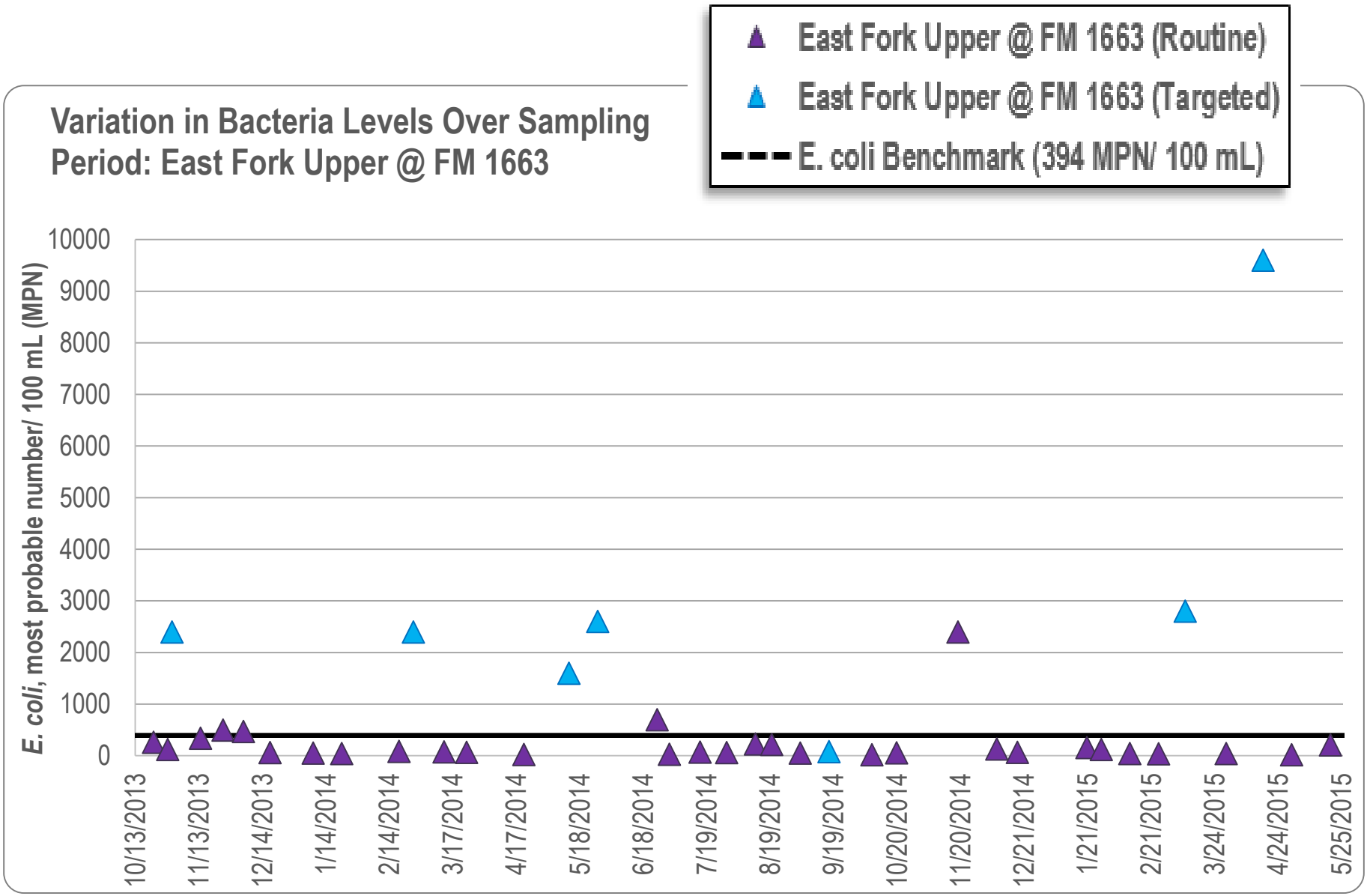
DOUBLE BAYOU WATERSHED PARTNERSHIP

BACTERIA

- *Escherichia Coli* (*E. coli*)
  - Rod shaped bacteria - digestive tracks of warm blooded animals
  - Fresh water samples
- Enterococcus
  - Spherical shaped bacteria - digestive tracks of warm blooded animals
  - Tidal water samples
- Indicate possibility of presence of disease-causing pathogens
- Sampling Units for Bacteria
  - SELECT - Colony-forming units (CFUs)
  - Culture tests report results in Most Probable Number (MPN)/100 mL
- Targeted Rain Event sampling often shows “worst-case” scenario of bacteria levels; can identify sources of bacteria not seen during routine sampling weather conditions

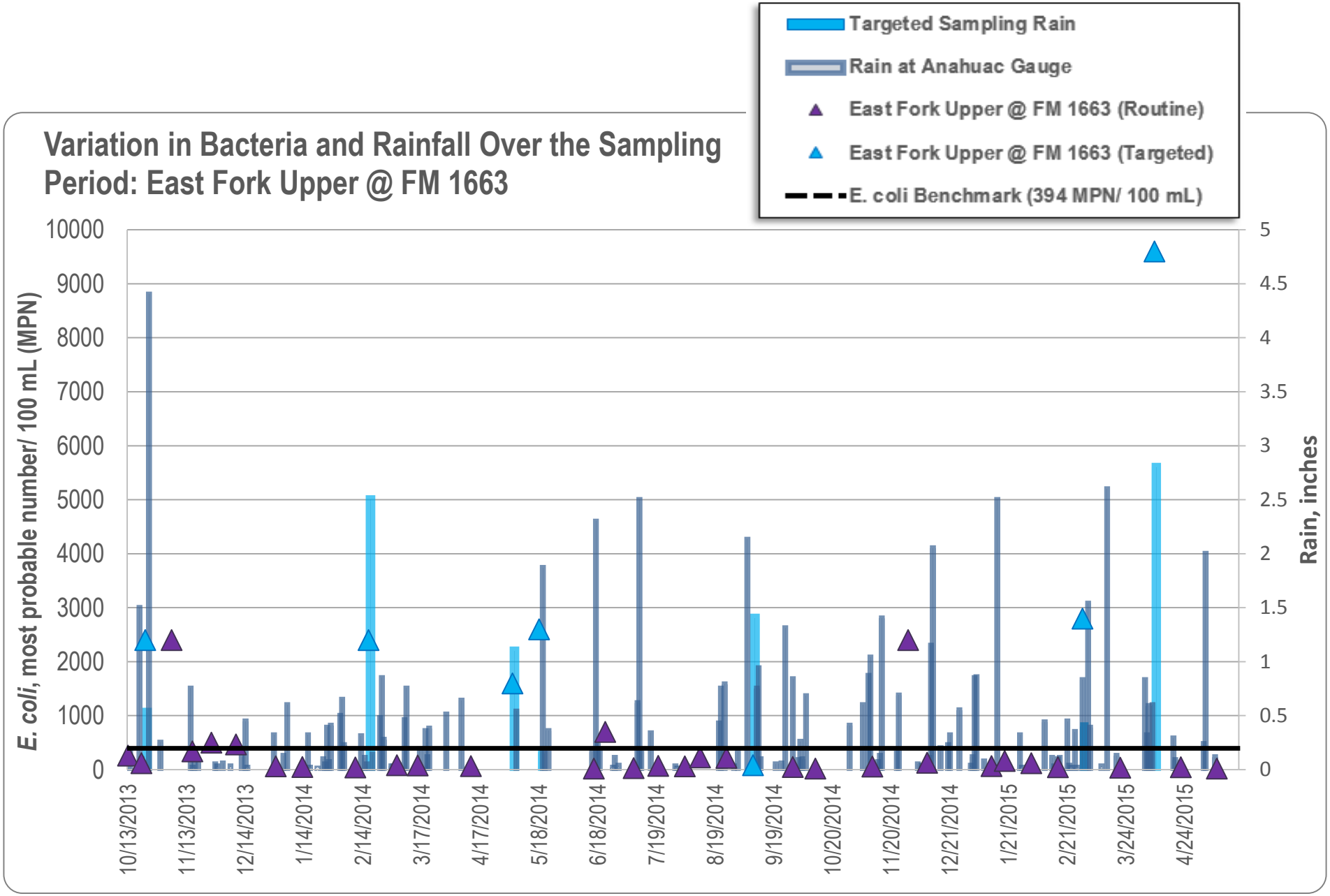
DOUBLE BAYOU WATERSHED PARTNERSHIP

Variation in Bacteria Levels Over Sampling Period: East Fork Upper @ FM 1663



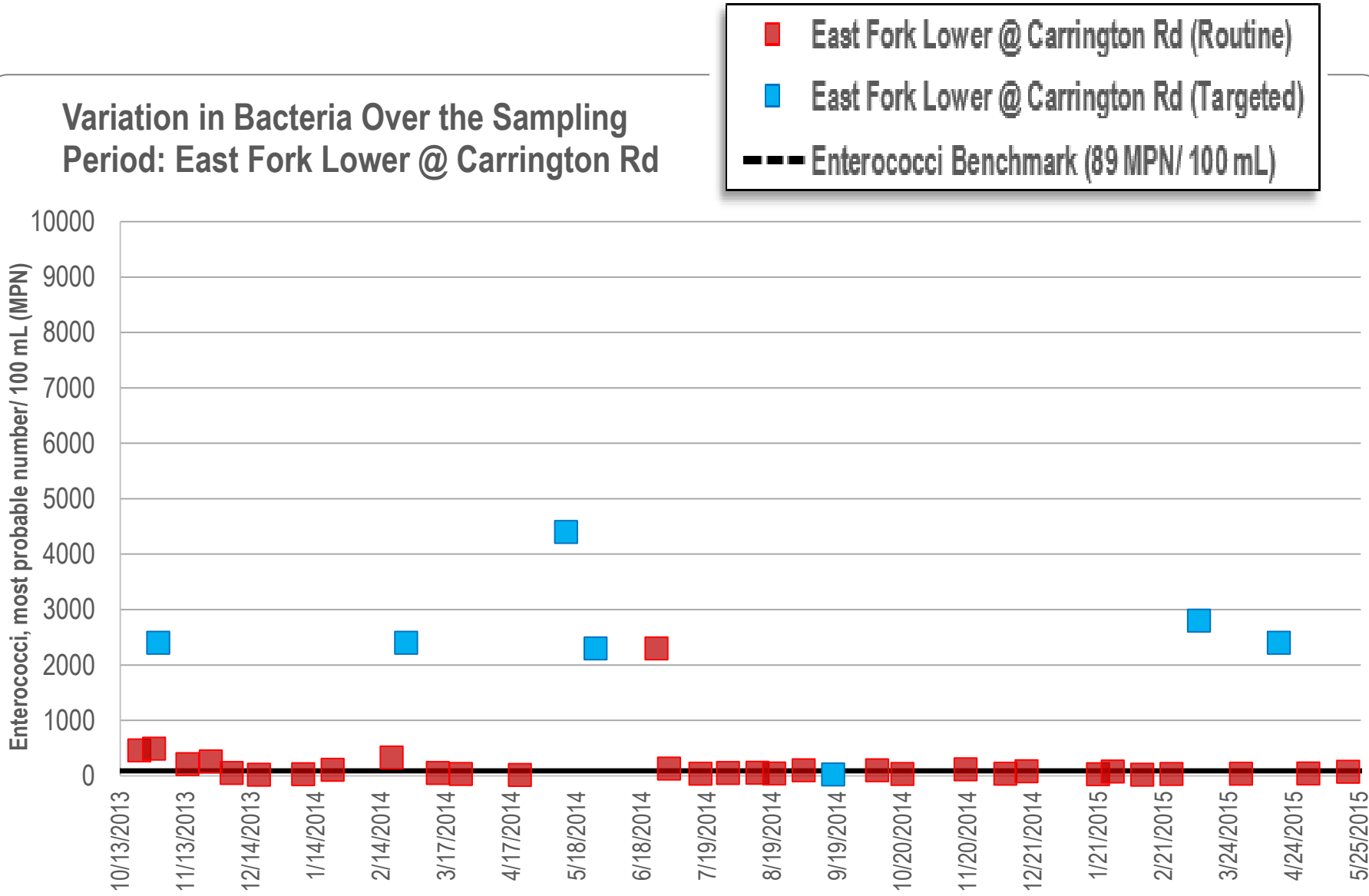
DOUBLE BAYOU WATERSHED PARTNERSHIP

Variation in Bacteria and Rainfall Over the Sampling Period: East Fork Upper @ FM 1663



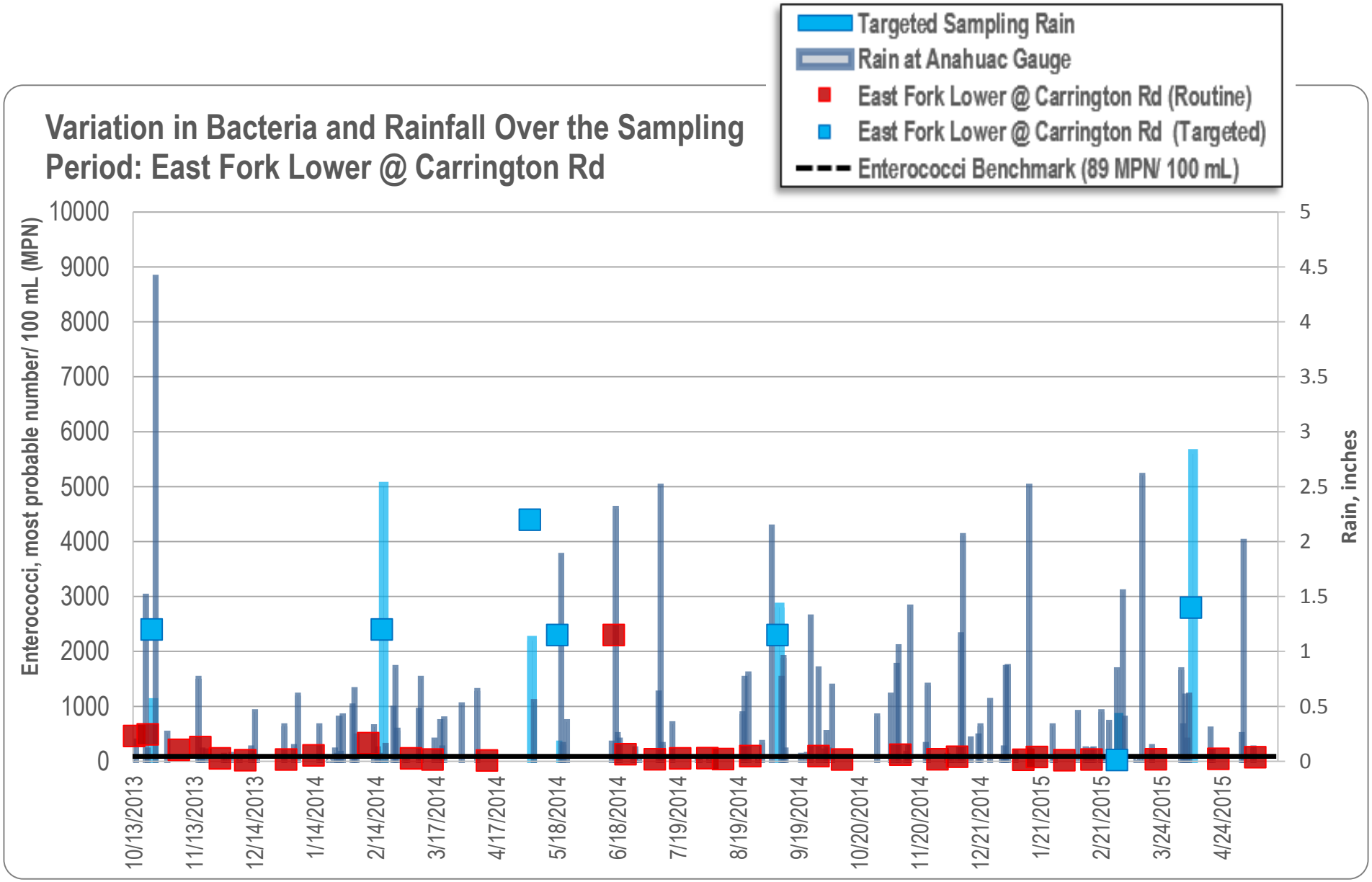
DOUBLE BAYOU WATERSHED PARTNERSHIP

Variation in Bacteria Over the Sampling Period: East Fork Lower @ Carrington Rd

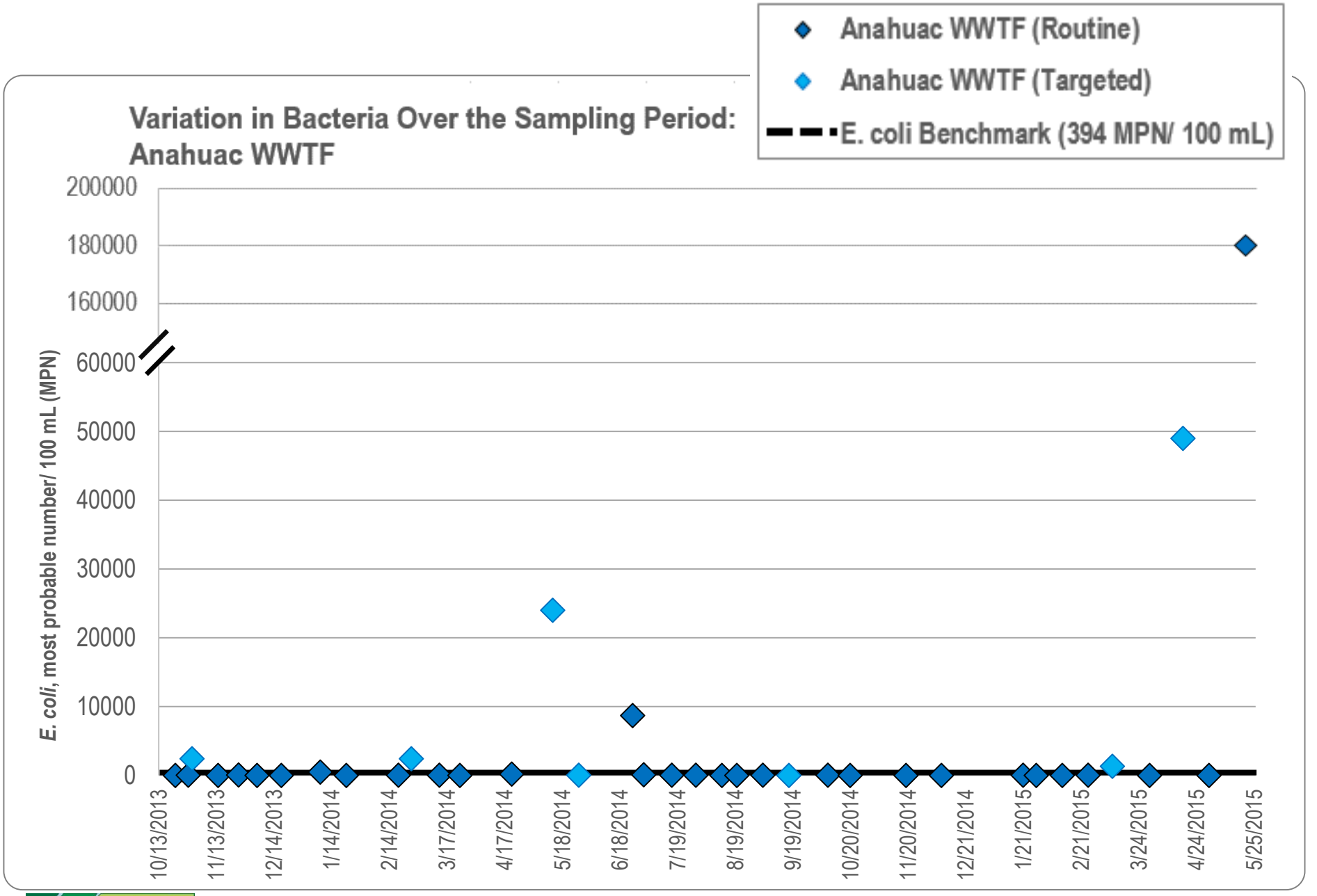


DOUBLE BAYOU WATERSHED PARTNERSHIP

Variation in Bacteria and Rainfall Over the Sampling Period: East Fork Lower @ Carrington Rd

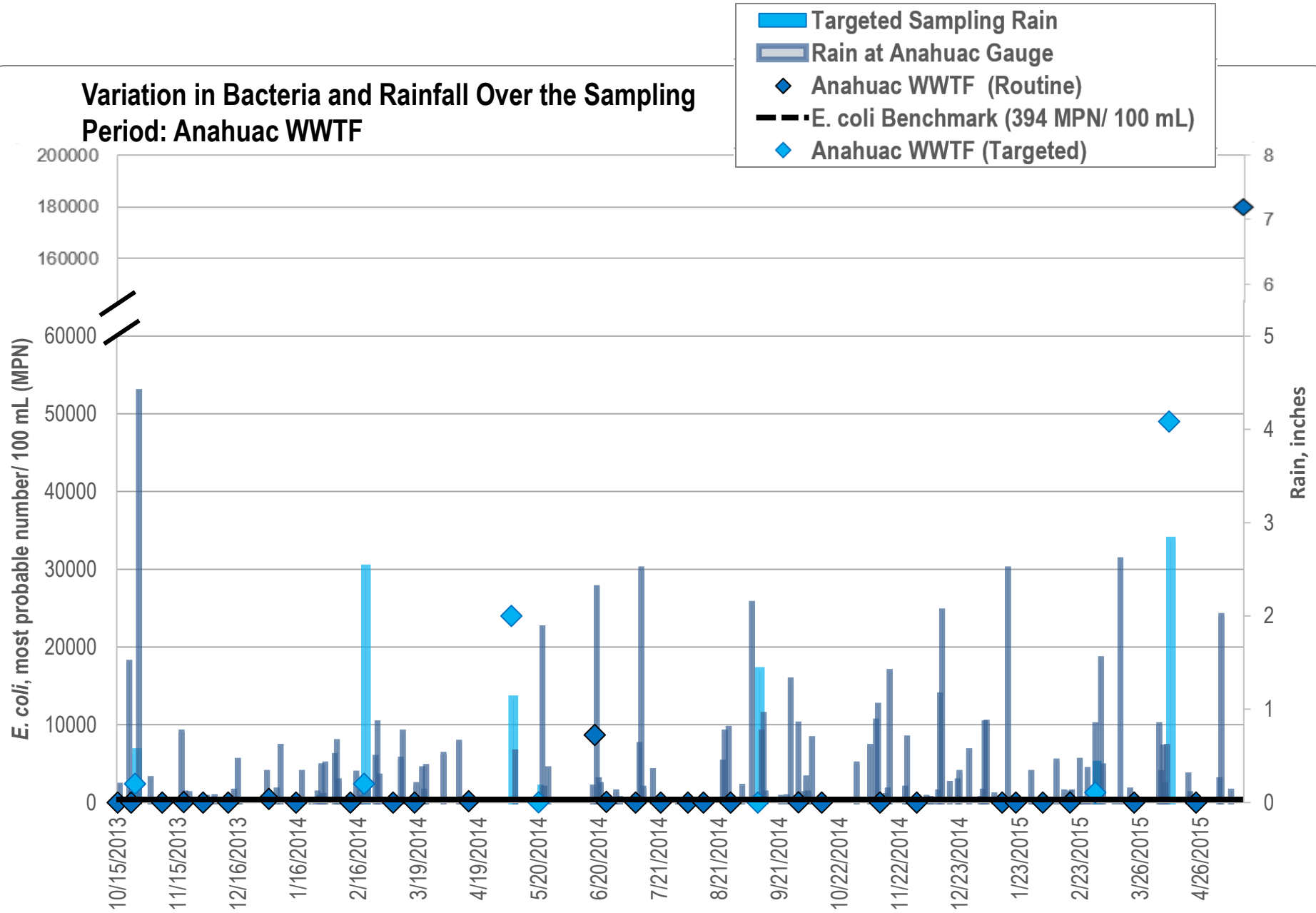


DOUBLE BAYOU WATERSHED PARTNERSHIP



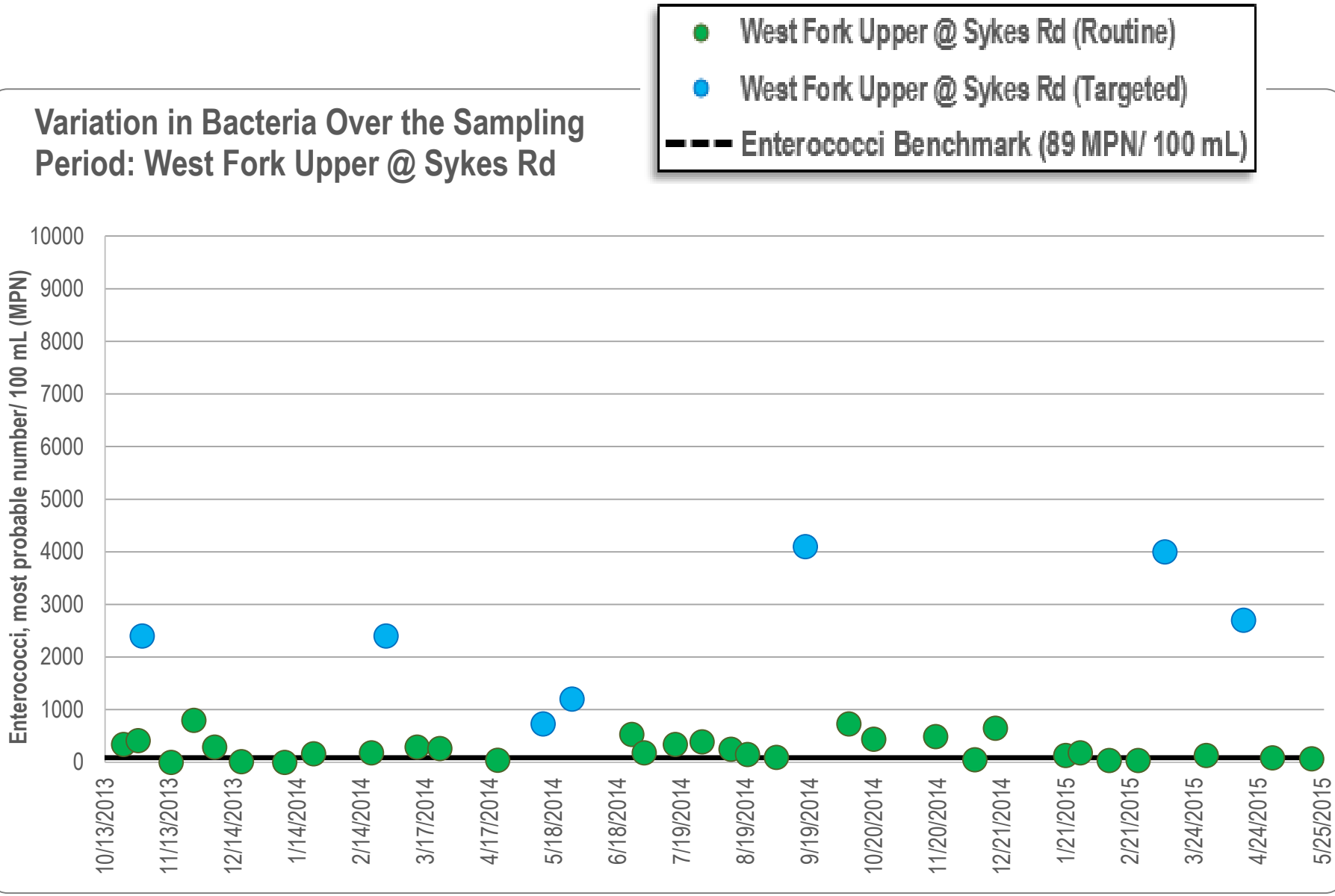
DOUBLE BAYOU WATERSHED PARTNERSHIP

Variation in Bacteria and Rainfall Over the Sampling Period: Anahuac WWTF



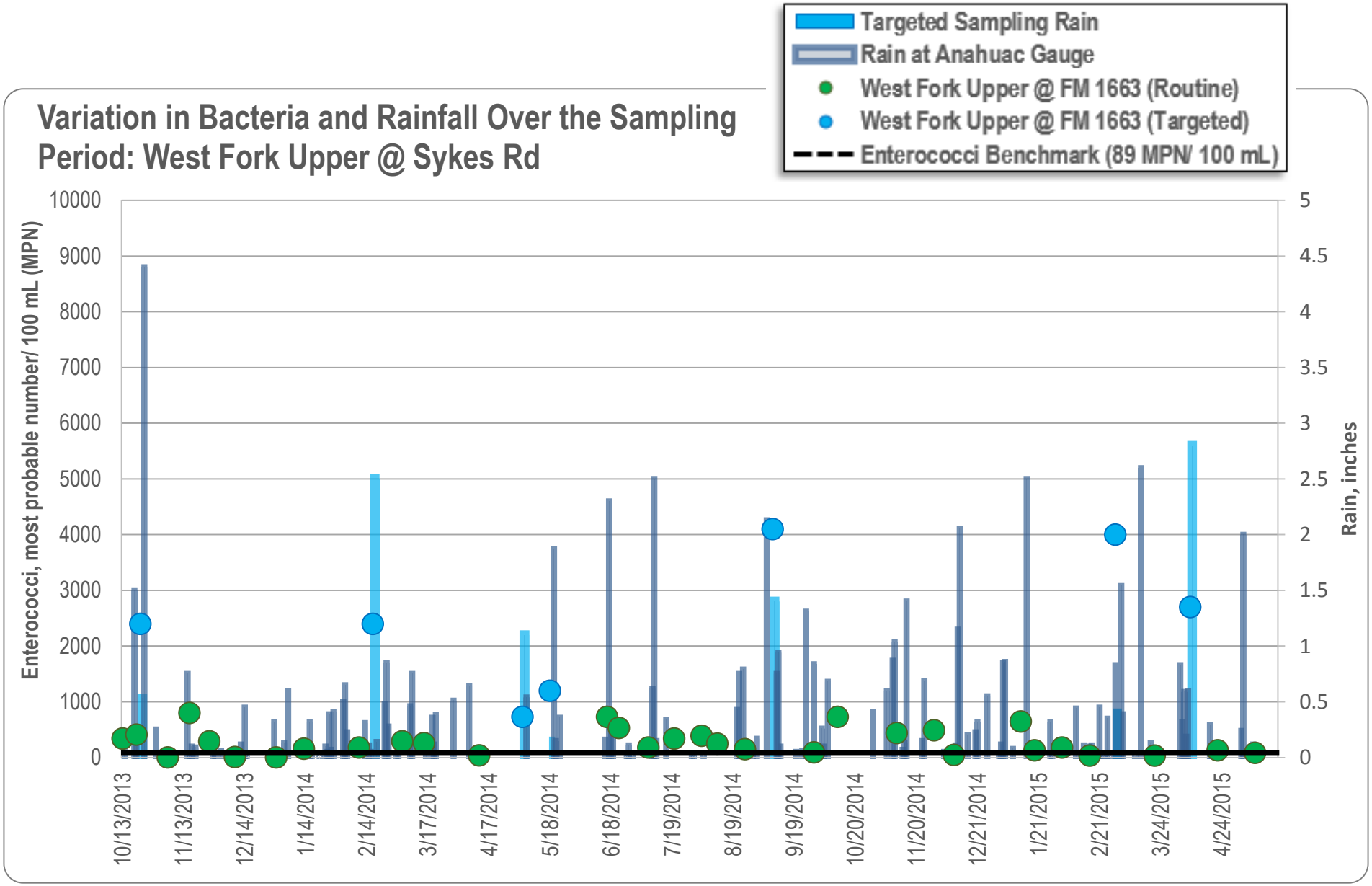
DOUBLE BAYOU WATERSHED PARTNERSHIP

Variation in Bacteria Over the Sampling Period: West Fork Upper @ Sykes Rd

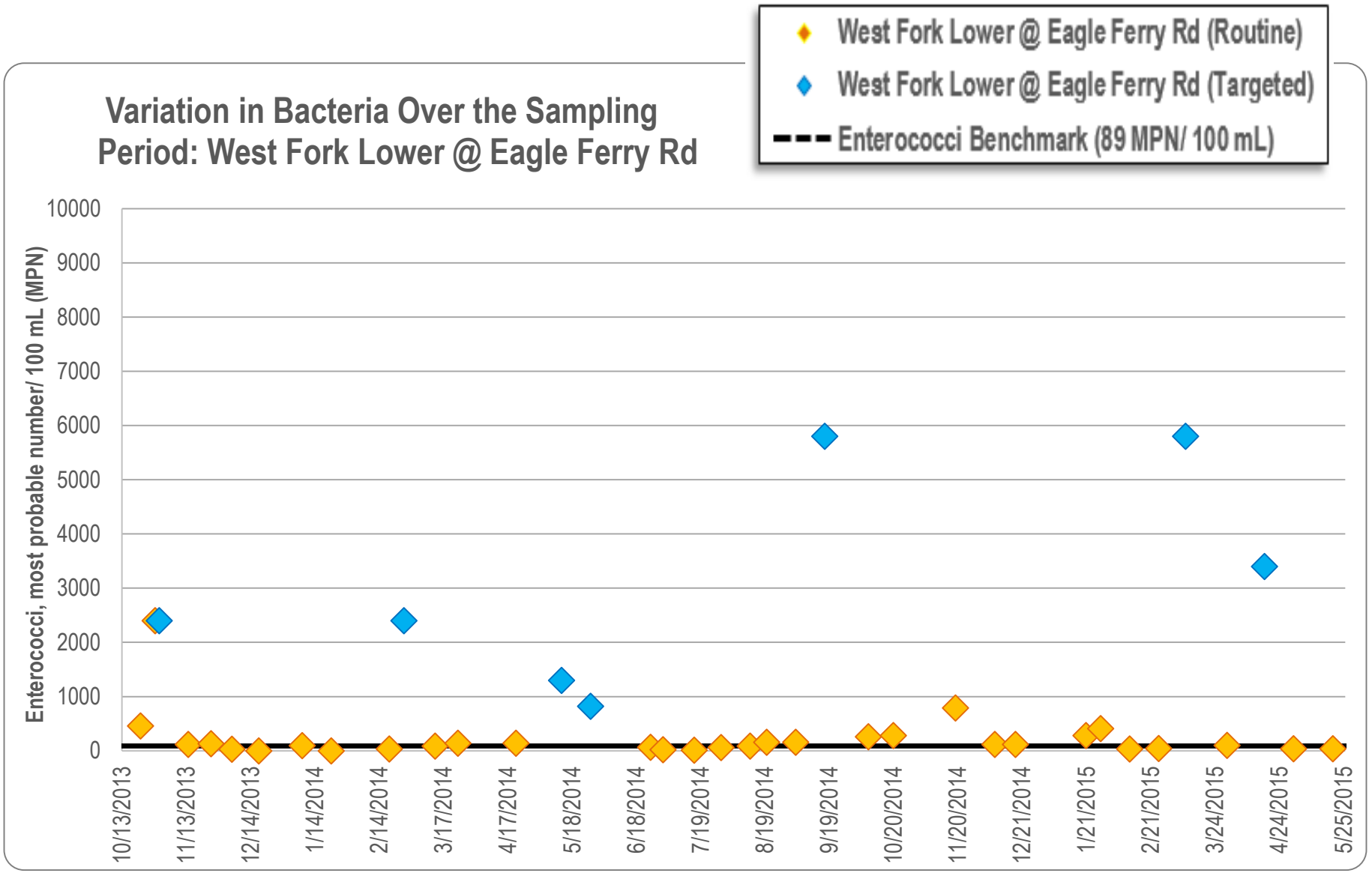


DOUBLE BAYOU WATERSHED PARTNERSHIP

Variation in Bacteria and Rainfall Over the Sampling Period: West Fork Upper @ Sykes Rd

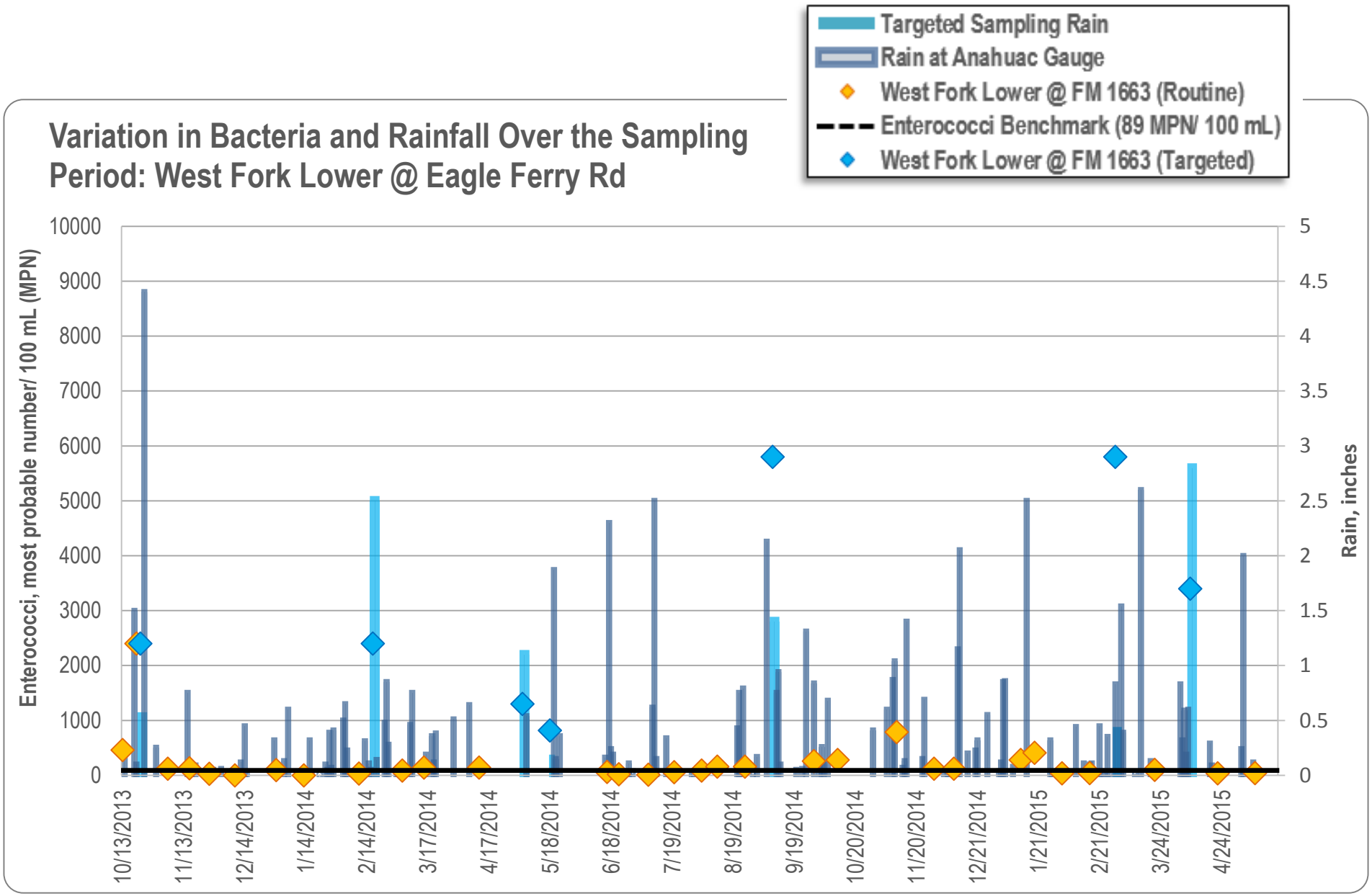


DOUBLE BAYOU WATERSHED PARTNERSHIP



DOUBLE BAYOU WATERSHED PARTNERSHIP

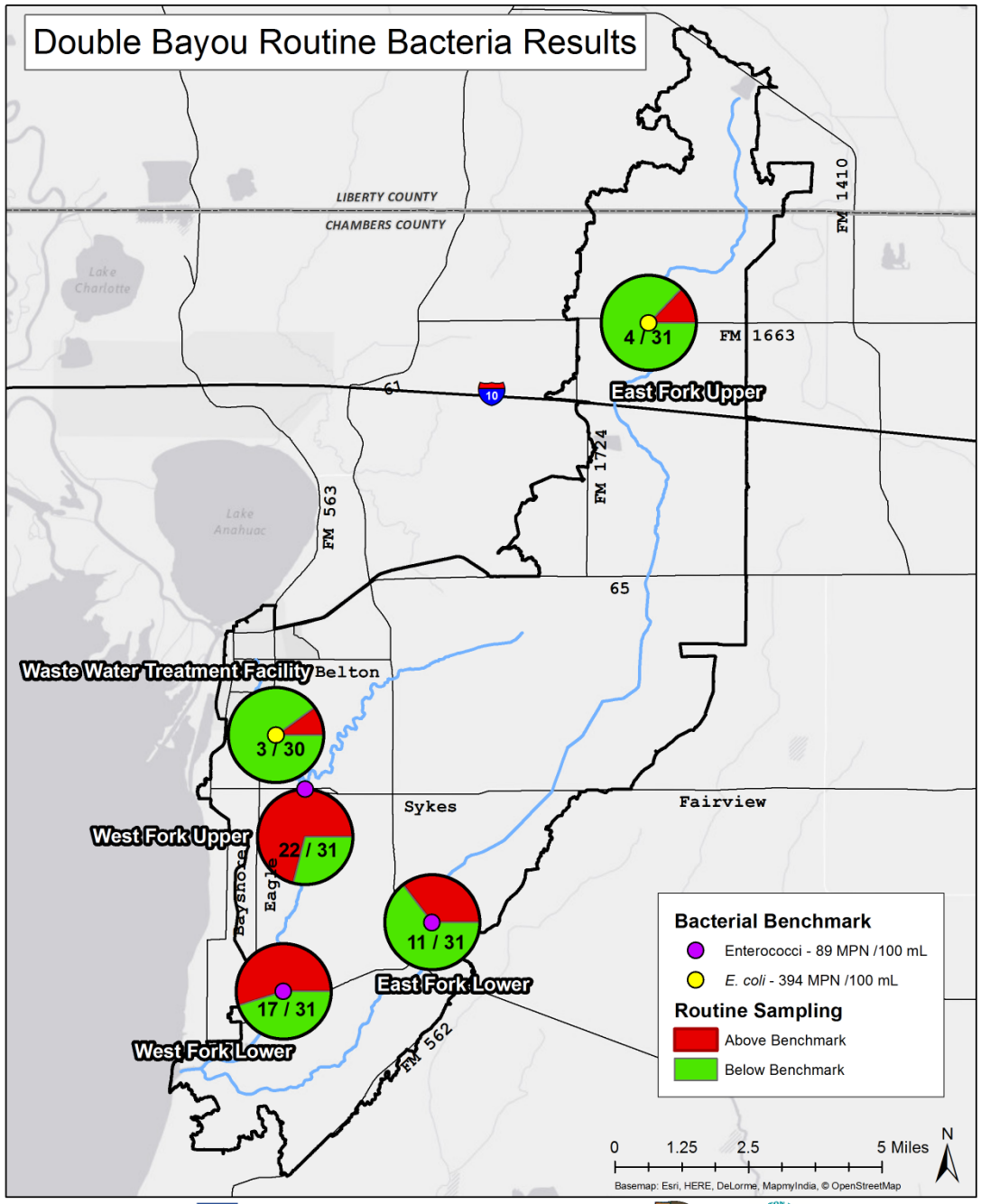
Variation in Bacteria and Rainfall Over the Sampling Period: West Fork Lower @ Eagle Ferry Rd



DOUBLE BAYOU WATERSHED PARTNERSHIP

Variation in Bacteria by Sampling Station

- Routine Sampling 10/22/13-5/20/15
- Represents 17 total sampling events (# of samples = 17 per station)

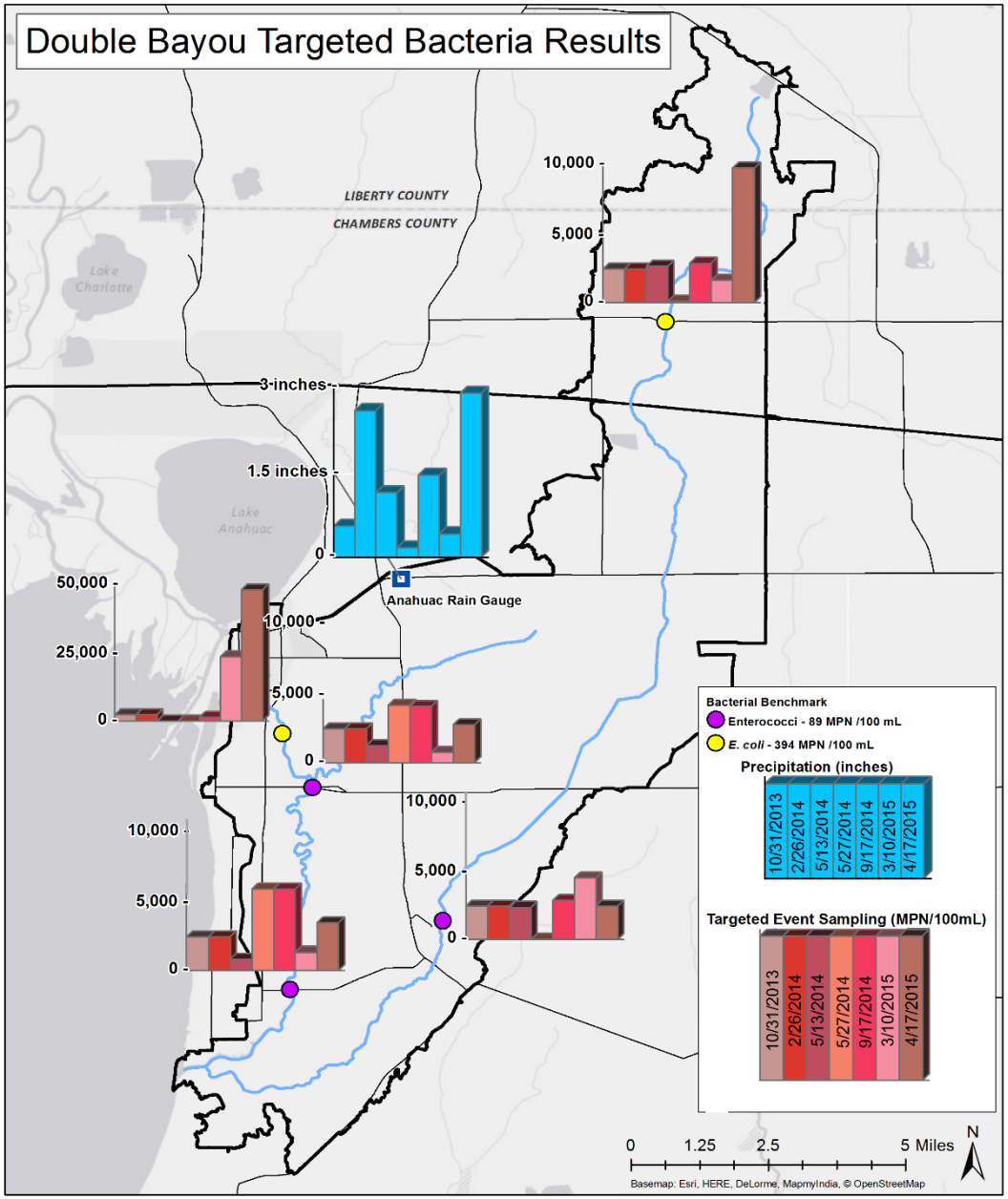


DOUBLE BAYOU WATERSHED PARTNERSHIP

HARC TCEQ Shead Conservation Solutions TSSWCB USGS science for a changing world

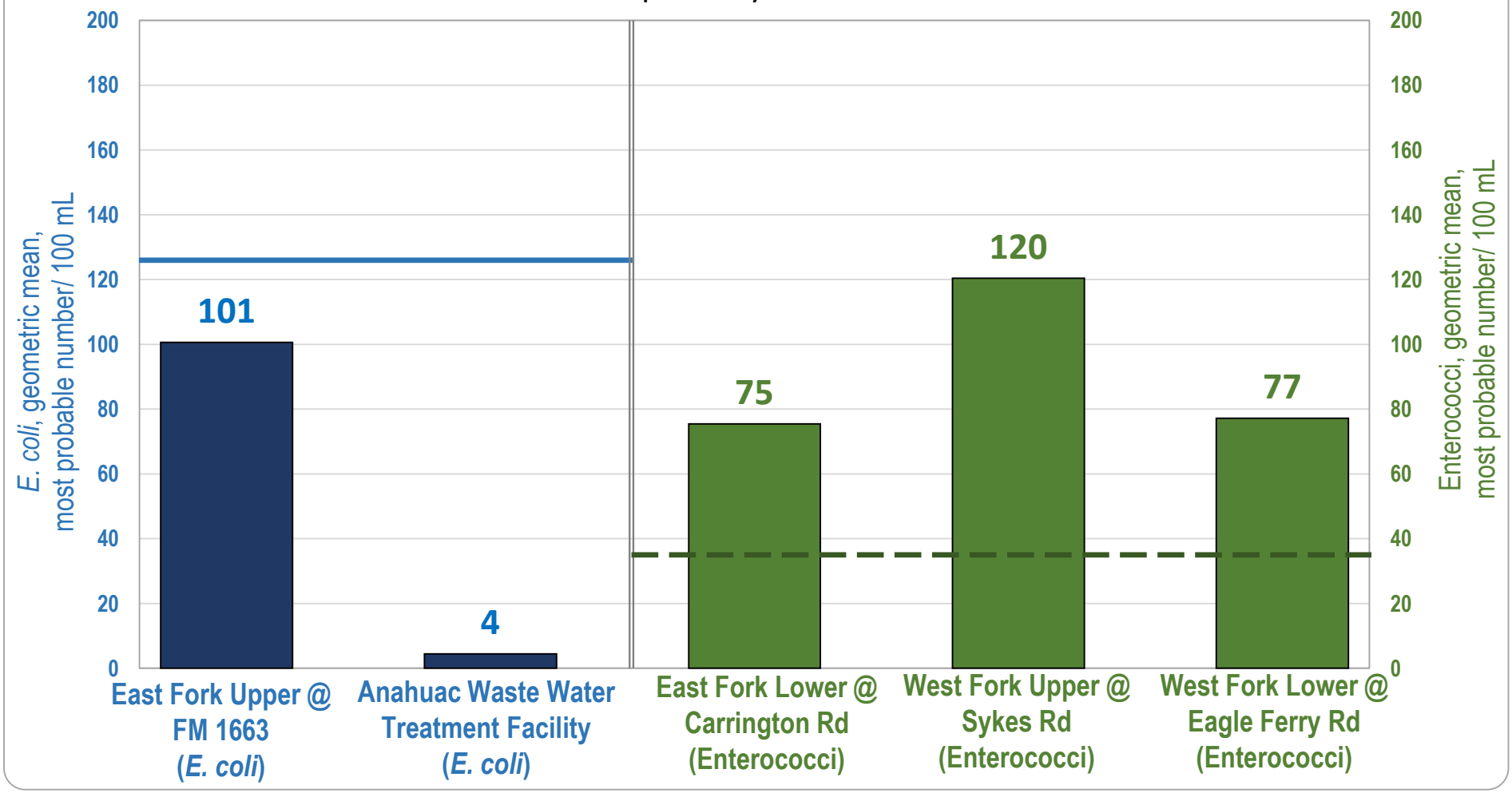
Variation in Bacteria by Sampling Station

- Targeted Rain Event Sampling
- Represents 7 total sampling events (# of samples = 7 per station)



Double Bayou Bacteria Geometric Mean

*Geometric means includes routine samples only



DOUBLE BAYOU WATERSHED PARTNERSHIP

BACTERIA

- Initial Sampling Results indicates:
  - Geomean Criteria (State) – 3 of 5 stations (excluding WWTF and EFU) have high dry weather geomeans; all of those three exceed the criteria
  - Grab Samples
    - Routine
      - WFU, WFL, EFL – high percent exceedance
    - Targeted
      - All – high percent exceedance
  - Targeted Rain Event showed higher numbers, also showed importance of not just precipitation event but also days since last rain event
  - Variation in bacteria - Fall (Sept-Nov) had the greatest percent of exceedances in routine sampling

DOUBLE BAYOU WATERSHED PARTNERSHIP

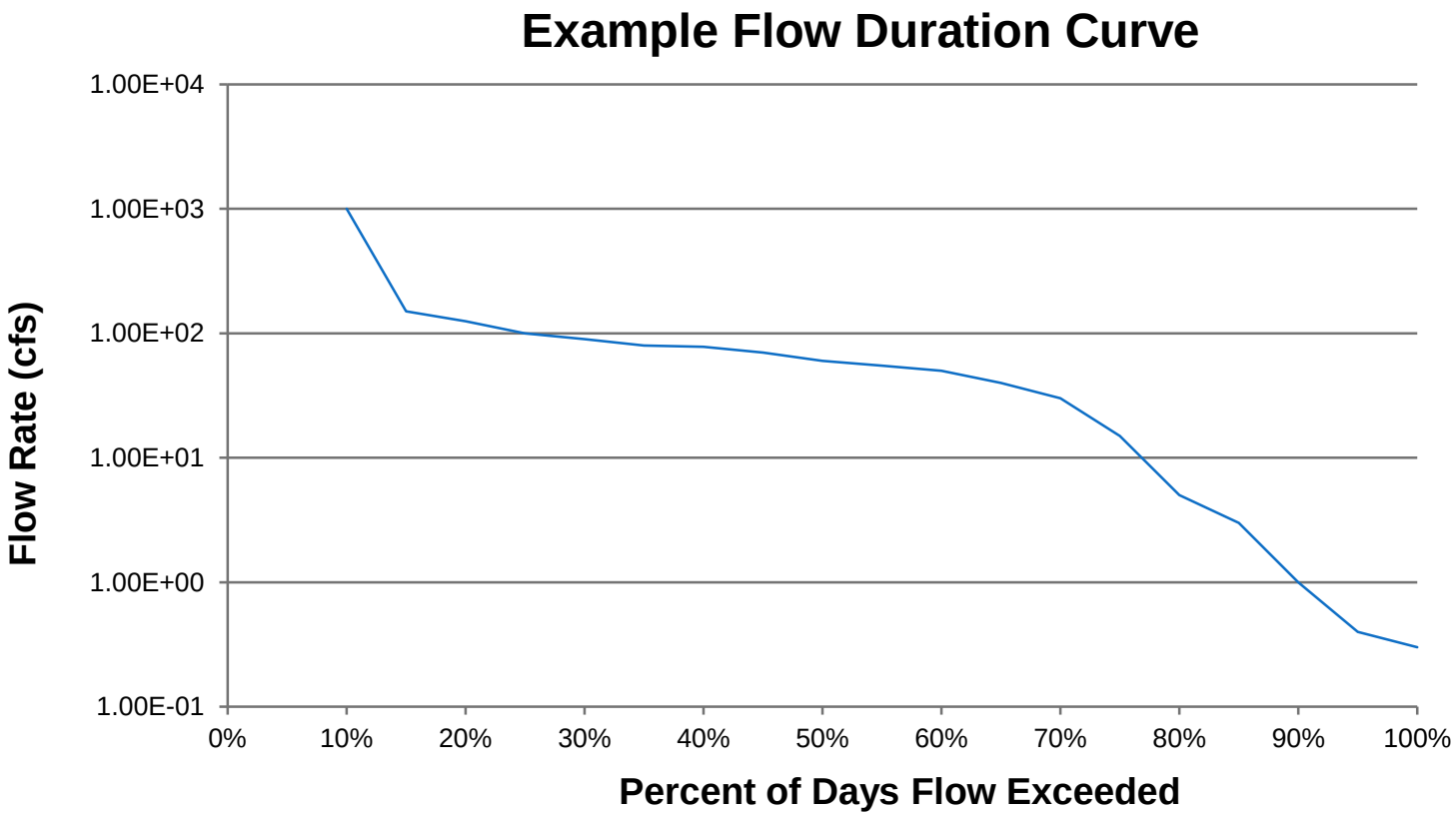
Load Duration Curves

- Aid in determining pollutant loadings under different flow conditions
- Traditionally, LDCs are developed for non-tidal stations due to the way the flow is represented and visualized in the LDC.
- East Fork Upper is only station in our watershed that is not classified by TCEQ as tidal
- No continuous stream flow gages on East Fork; however, stream flow data samples were measured each time a bacteria grab samples was collected
- Following discussion will focus on LDC development for East Fork Upper sampling station and load reduction goals associated with the upper watershed
- Future discussion will focus on lower part of the watershed, tidal mixing, and associated load reduction goals

DOUBLE BAYOU WATERSHED PARTNERSHIP

LOAD DURATION CURVES

- Development of a LDC
  - 1st step: Flow Duration Curve
    - Flow data are sorted and ranked from highest flow to lowest flow and then used to develop a graph of flow volume versus frequency

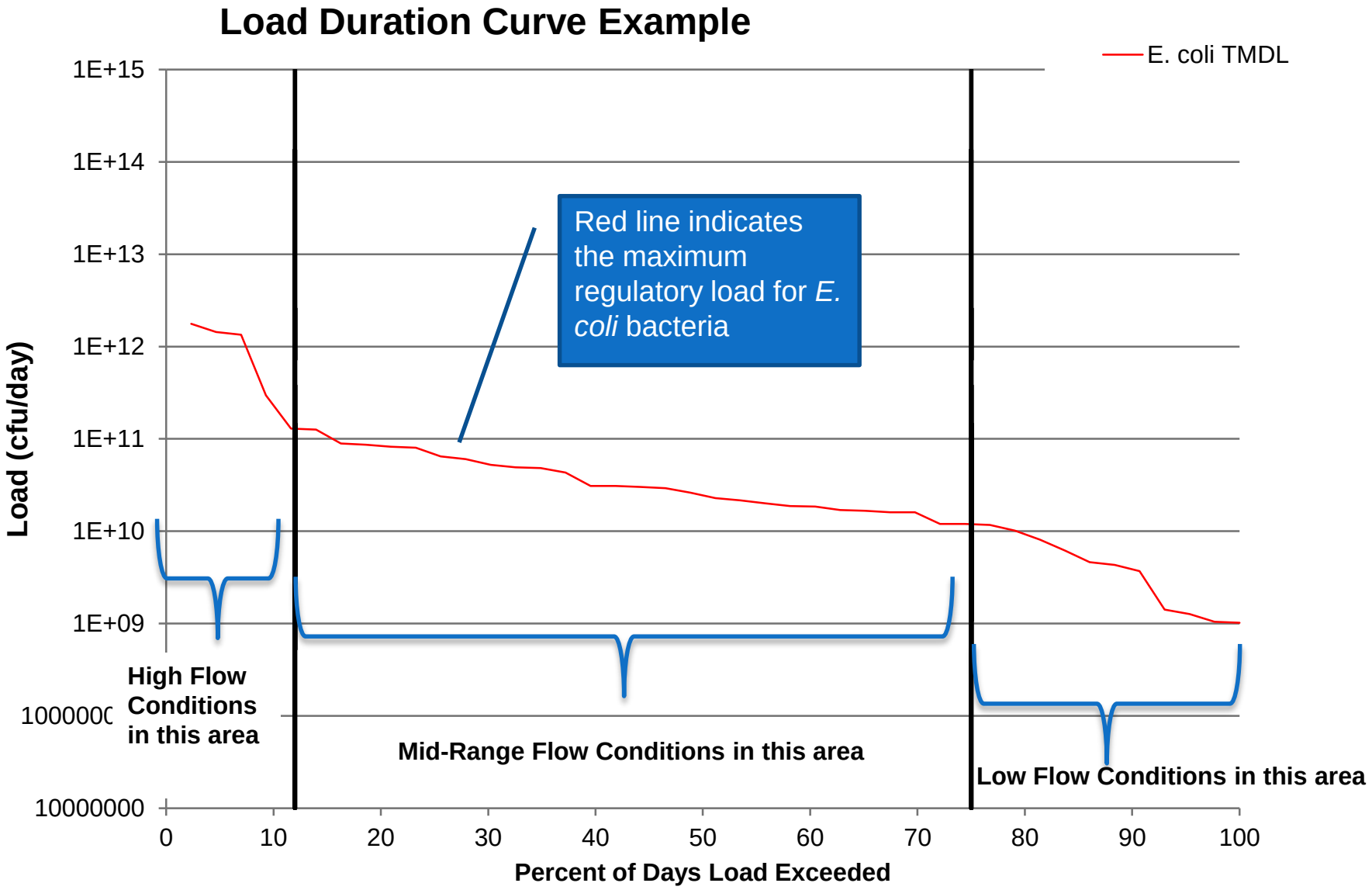


DOUBLE BAYOU WATERSHED PARTNERSHIP

LOAD DURATION CURVES

- Incorporate the concentration of the water quality standard for the pollutant in question (in Double Bayou's case, bacteria) to produce the Load Duration Curve (LDC).
- The "load" is expressed as amount of pollutant per unit time – i.e., bacteria in cfu/day.
- Resulting curve reflects the maximum load a stream can carry across the regime of flow conditions (low flow, medium flow, high flow) without exceeding the water quality standard.
- Different flow regimes are identified in the LDC as areas where the slope of the curve changes significantly – indicating a significant change in flow.

LOAD DURATION CURVES



Different flow regimes are identified in the LDC as areas where the slope of the curve changes significantly – indicating a significant change in flow.

LOAD DURATION CURVES

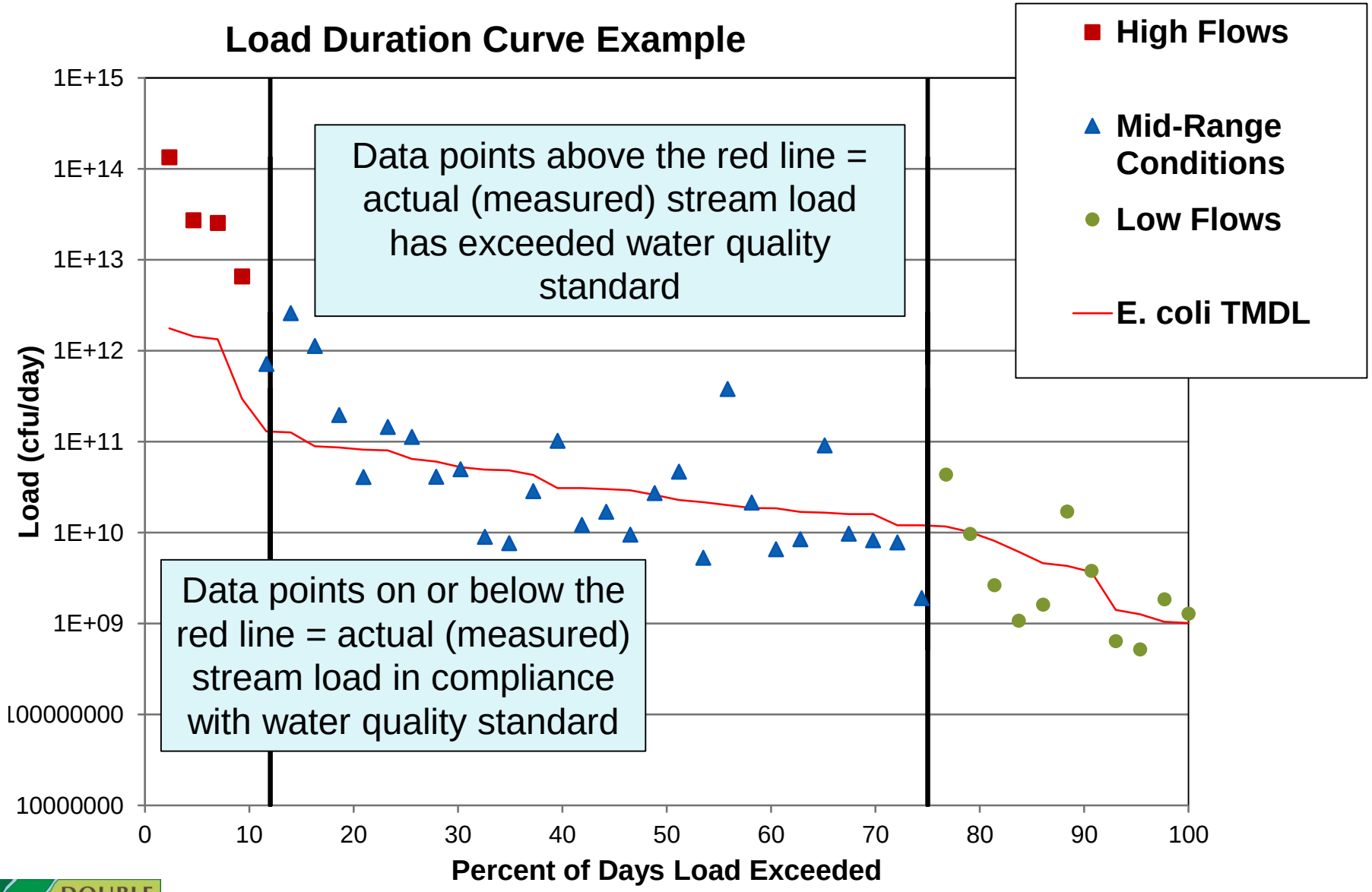
- Monitored data is then plotted on the curve to show the **frequency** and **scale** of exceedances
- In the example:
  - Red squares: data collected in high flow conditions
  - Blue triangles: data collected in mid-range flow conditions
  - Green circles: data collected in low flow conditions
- When the monitored data points are above the red line indicating maximum regulatory load, the actual (measured) stream load has exceeded the water quality standard.
- Monitored data points on or below the red line indicate the actual (measured) stream load is in compliance with the water quality standard.

LOAD DURATION CURVES

- Flow regime pollutant concentrations can be useful for evaluating potential point or nonpoint sources
- Primarily high flows exceedances → nonpoint sources
  - High flows usually linked to higher rainfall events; surface runoff which can carry pollutants to the stream
- Primarily low flows exceedances → point sources
  - Low flows usually linked to no runoff entering the stream and primarily direct discharges contributing

DOUBLE BAYOU WATERSHED PARTNERSHIP

LOAD DURATION CURVES



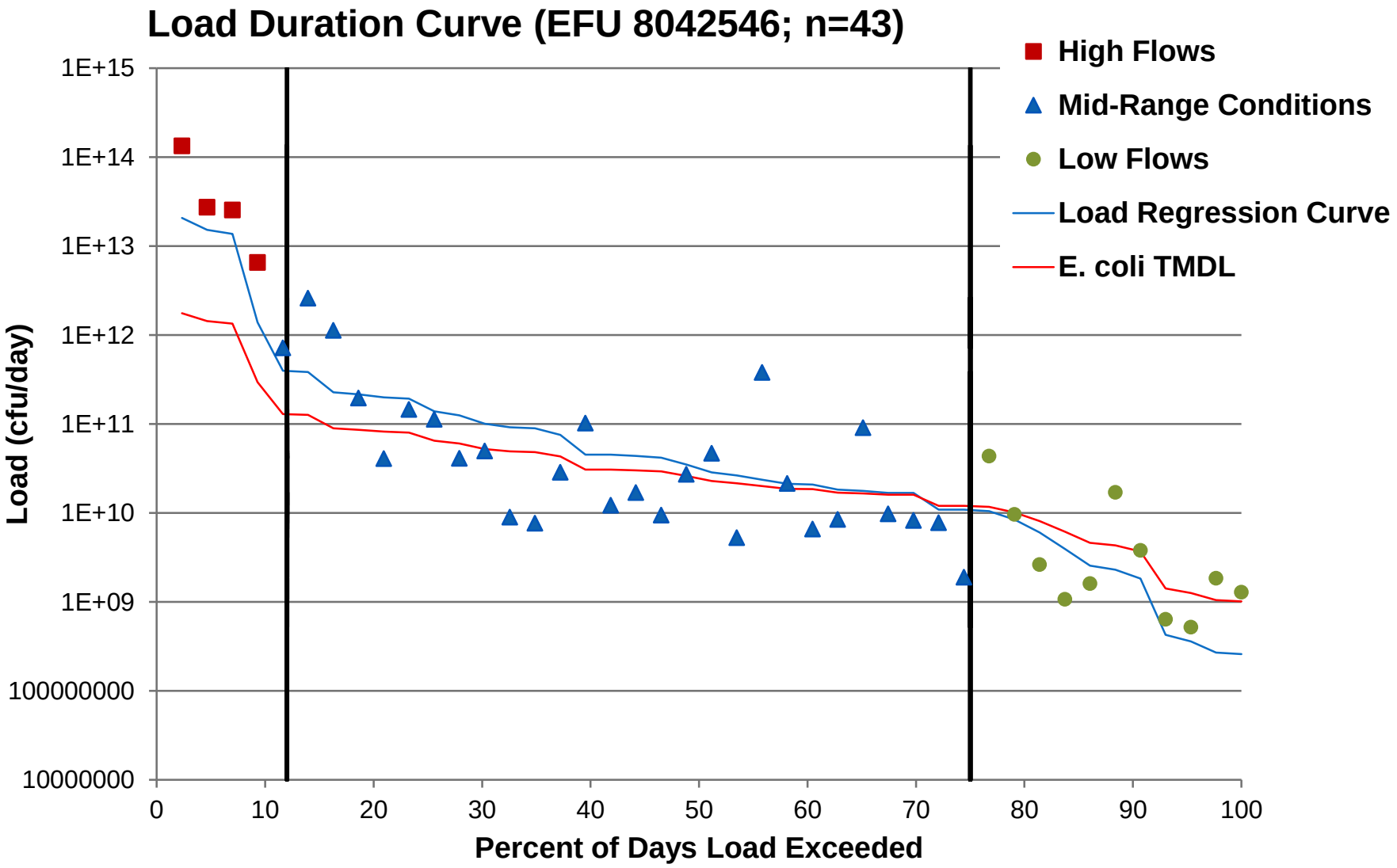
DOUBLE BAYOU WATERSHED PARTNERSHIP

LOAD DURATION CURVES

- Regression analysis is conducted using the monitored samples to calculate a “line of best fit” (it will be shown as a blue line).
- Blue line on or **below** the red TMDL line → monitoring data at that flow condition are in compliance with the water quality standard
- Blue line **above** the red TMDL line → monitoring data at that flow condition are not in compliance with the water quality standard
- Load Reduction Goals
  - Regression analysis → estimated percent reduction needed to achieve pollutant loads

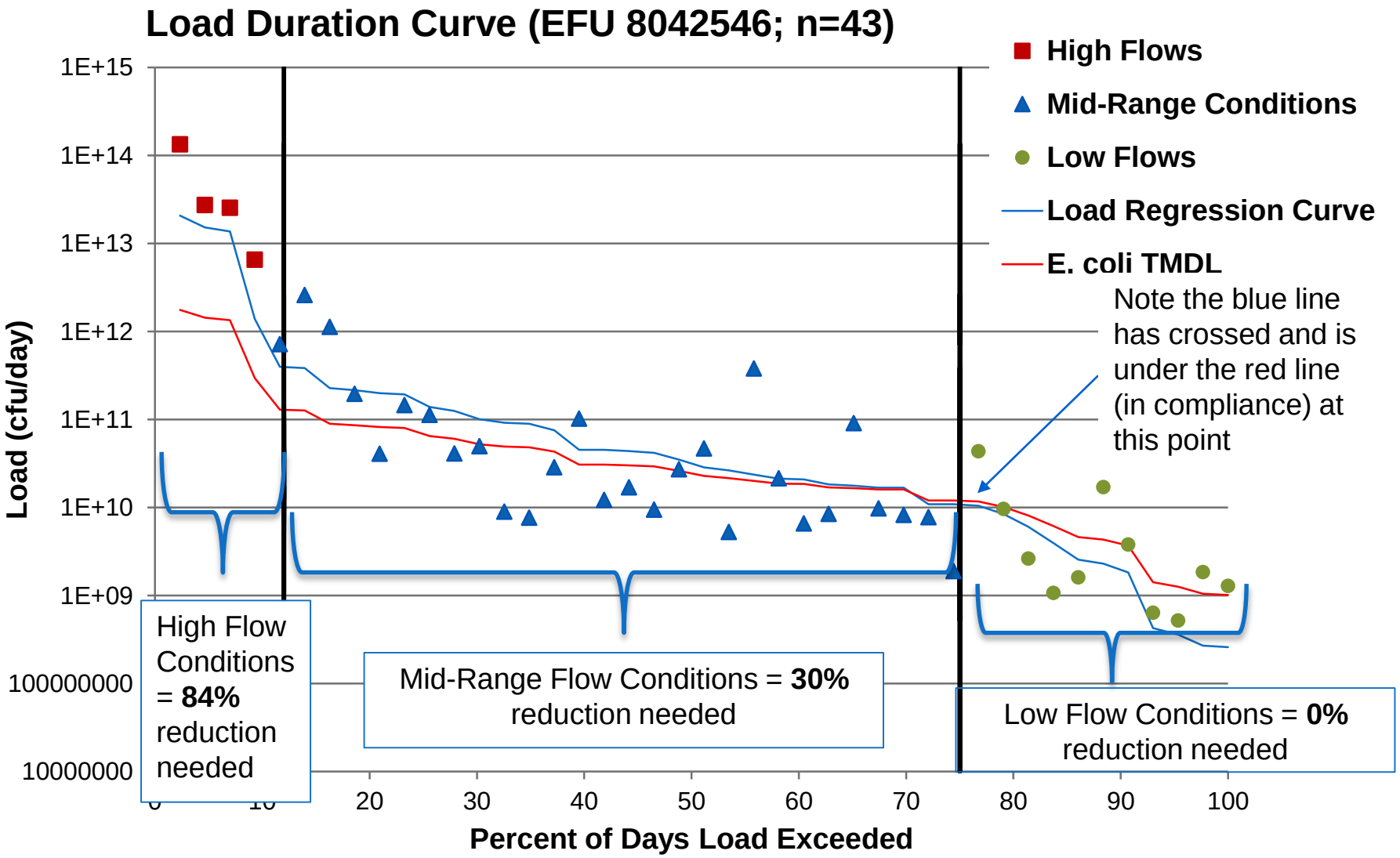
DOUBLE BAYOU WATERSHED PARTNERSHIP

LOAD DURATION CURVES



Blue line **above** the red TMDL line → monitoring data at that flow condition are not in compliance with the water quality standard

LDC – Estimate of Pollutant Loads



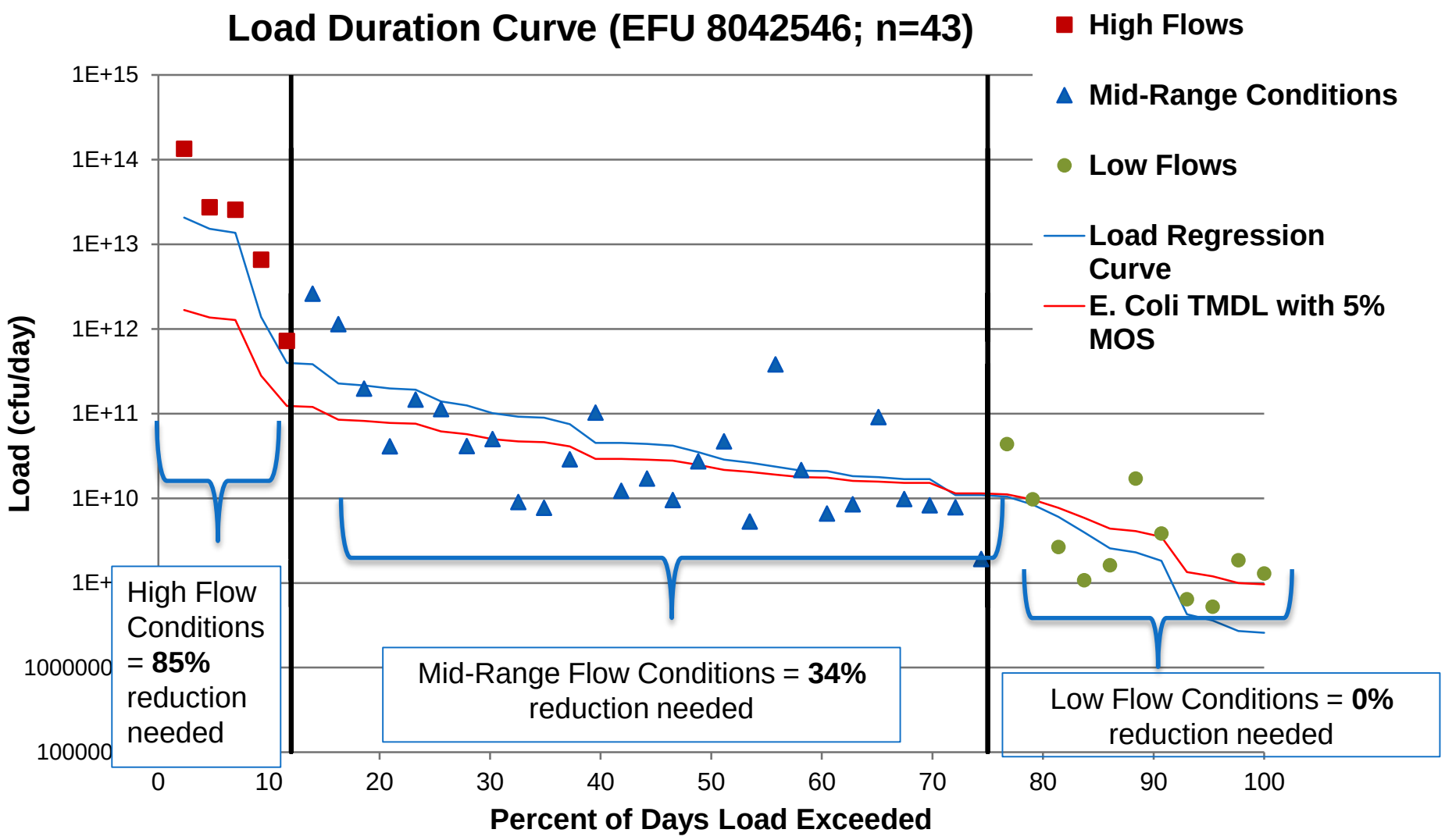
Regression analysis → estimated percent reduction needed to achieve pollutant loads

Load Duration Curves – Margin of Safety (MOS)

- A margin of safety (MOS) can be applied to the pollutant concentrations to account for variations in loading from potential sources, stream flow, management measures, etc.
  - Gives you more of a buffer for error if things go wrong
  - Gives the plan the capacity to plan for bigger loads
- Input on MOS:
  - TCEQ regulatory standard for *E. coli* - 126 cfu/100 mL
  - Options for more conservative thresholds for reduction goals
    - 5% MOS - 120 cfu/100 mL
    - 10% MOS - 113 cfu/100 mL

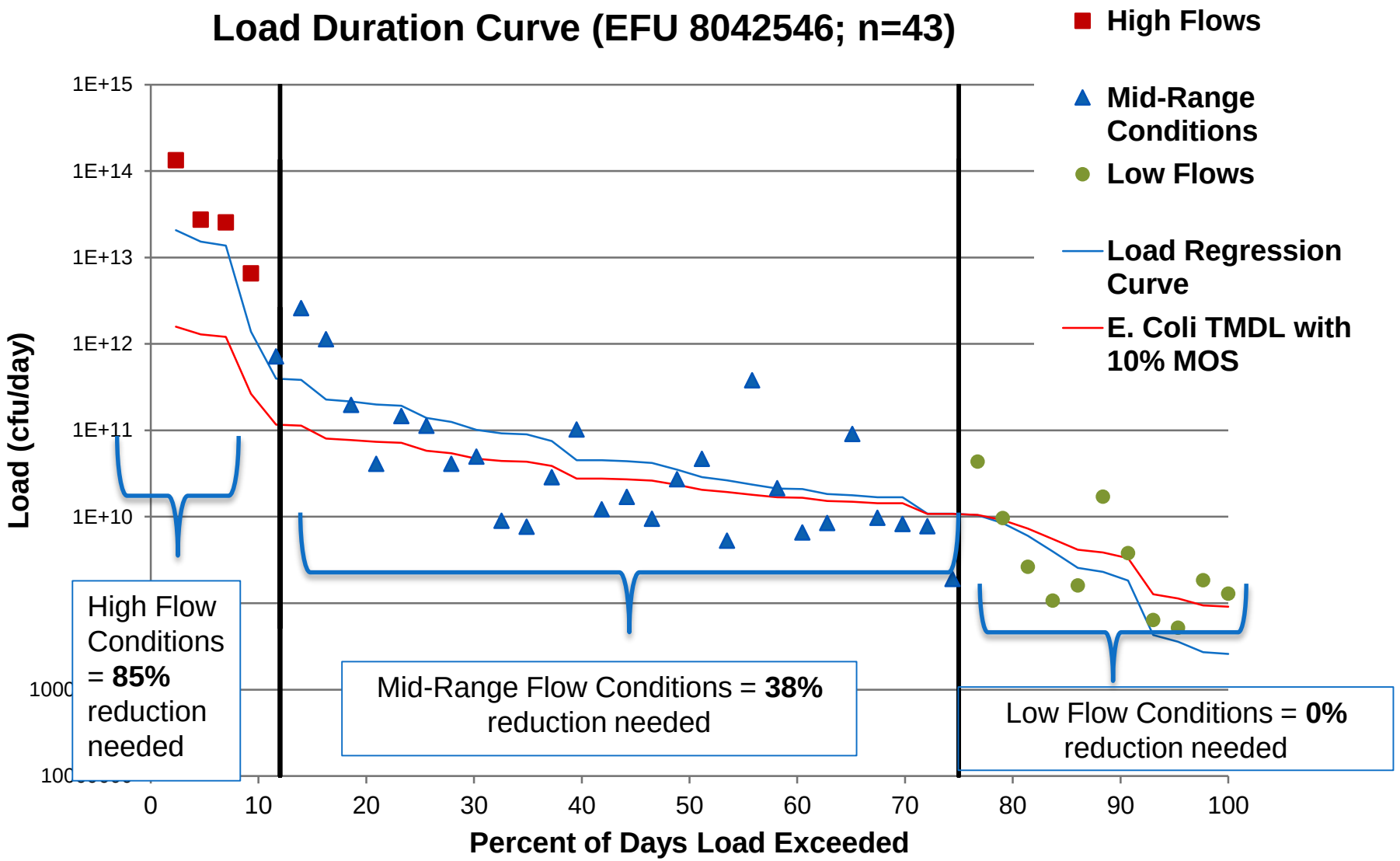
DOUBLE BAYOU WATERSHED PARTNERSHIP

LDC – 5% MOS Estimate of Pollutant Loads



DOUBLE BAYOU WATERSHED PARTNERSHIP

LDC – 10% MOS Estimate of Pollutant Loads



DOUBLE BAYOU WATERSHED PARTNERSHIP

LOAD REDUCTION GOAL

- Plan generally for “mid-range” flow conditions
- MOS can be applied to the pollutant concentrations to account for variations in loading from potential sources, stream flow, management measures, etc.
- Input on MOS:
- No MOS – 126 cfu/100mL
  - Mid-range flow conditions **30%** reduction goal
- 5% MOS - 120 cfu/100 mL
  - Mid-range flow conditions **34%** reduction goal
- 10% MOS - 113 cfu/100 mL
  - Mid-range flow conditions **38%** reduction goal

DOUBLE BAYOU WATERSHED PARTNERSHIP

Next Steps

- Work Recommended Percent Load Reduction into WPP
- Discussion on Tidal Mixing and load reduction for lower portion of watershed

QUESTIONS


DOUBLE
BAYOU
WATERSHED
PARTNERSHIP


Soil
Water
TSSWCB
Texas State Soil and Water Conservation Board


Shead Conservation
Solutions


USGS
science for a changing world


HARC

BACKUP SLIDES

Aquatic Cycle: Dissolved Oxygen and Nutrients

- Nutrient Inputs (nitrogen and phosphorus)
- Bacteria and plants (i.e. phytoplankton) consume the nutrients
- Chlorophyll-a can be an indicator of how much photosynthesis is going on in a system
- Excess nutrients can increase both bacteria growth and plant growth (which leads to increased chlorophyll-a and decreased DO)

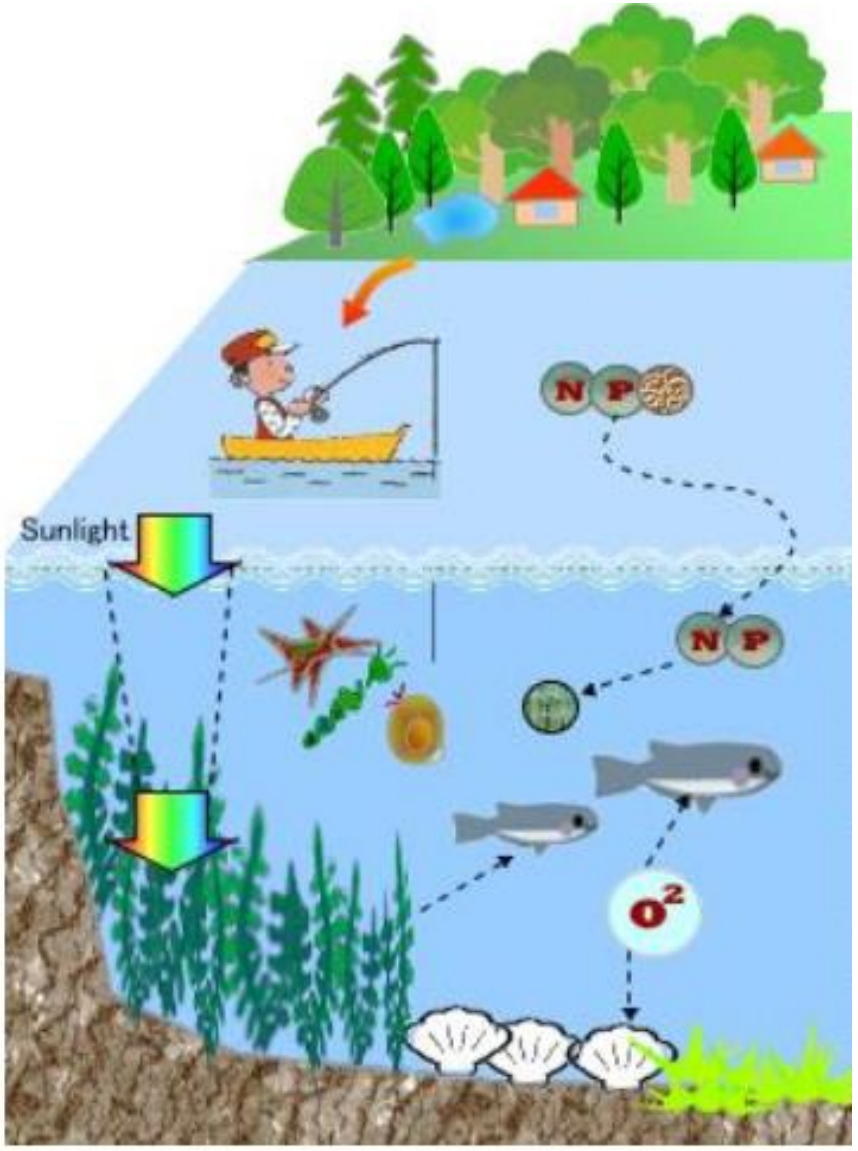


Image from Eutrophication: NPEC/CEARAC

DOUBLE BAYOU WATERSHED PARTNERSHIP

Dissolved Oxygen

- **Designated Use: Aquatic Life**
- **Low Dissolved Oxygen levels can indicate an excessive demand on the oxygen in the system.**

< 0.5 mg/L *Anoxic* – *Oxygen dependent animals die*
< 3 mg/L *Hypoxic* - *Most aquatic organisms cannot survive*
4-5 mg/L *Aquatic organisms become stressed*
> 6 mg/L *Optimal for many aquatic organisms*

DOUBLE BAYOU WATERSHED PARTNERSHIP

Dissolved Oxygen

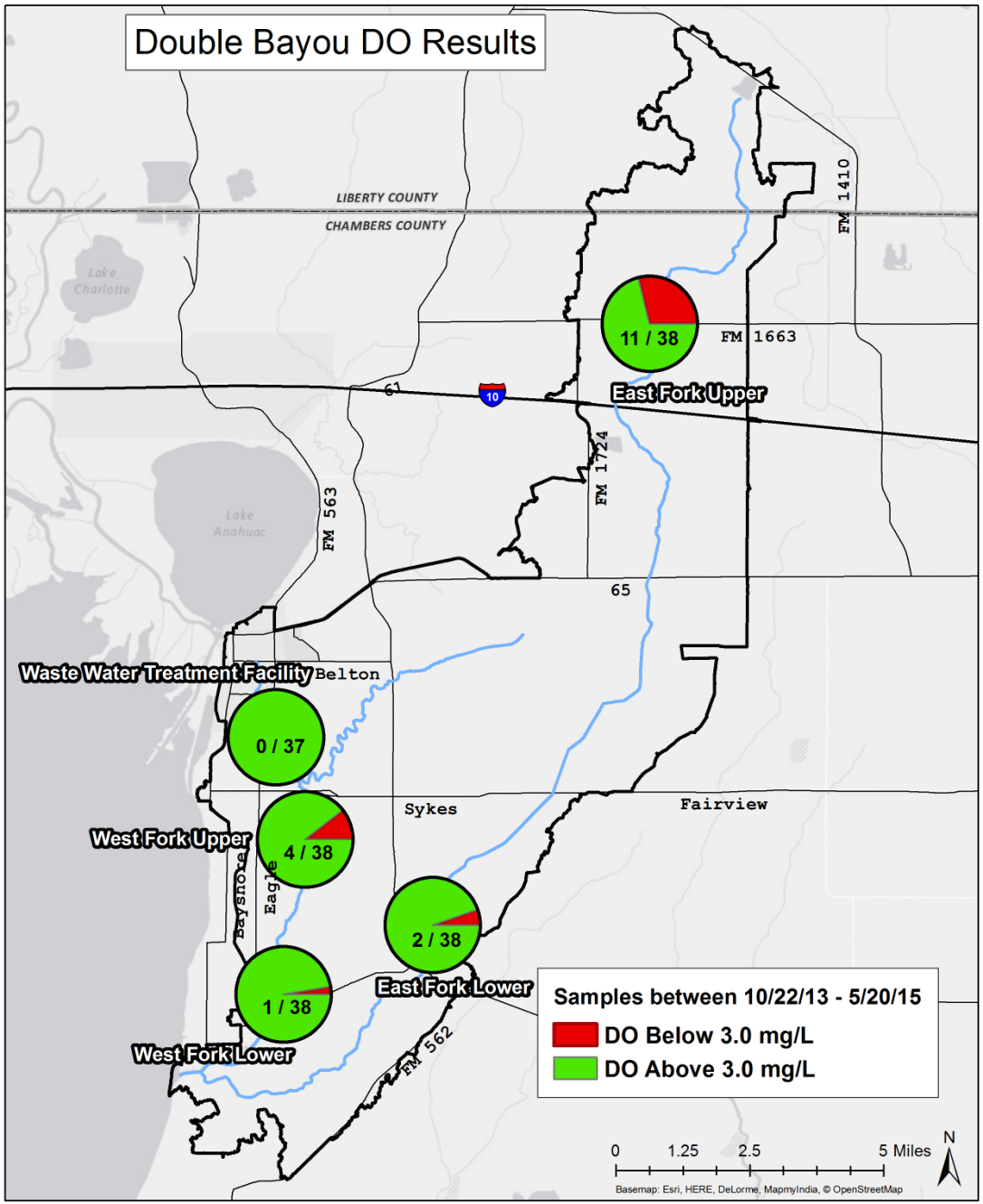
- **Time dependent**
  - **Plants don't produce oxygen during the night - but oxygen is still being used then for respiration, so dissolved oxygen (DO) concentrations will be the lowest in a water body in the morning.**
- **Temperature dependent**
  - **The colder the water, the greater capacity it has to hold oxygen.**

DOUBLE BAYOU WATERSHED PARTNERSHIP

Dissolved Oxygen

- **Salinity dependent**
  - **As salinity in water increases, its ability to hold DO decreases.**
  - **But DO decreases more as temperature goes up regardless of salinity.**
- **Event dependent**
  - **DO can go up right after a rainfall because fresh rain water, which is high in DO, is flushed into the system.**
  - **After a lag period, the DO may go down because of increased bacteria in the runoff leading to increased decomposition.**

DOUBLE BAYOU WATERSHED PARTNERSHIP

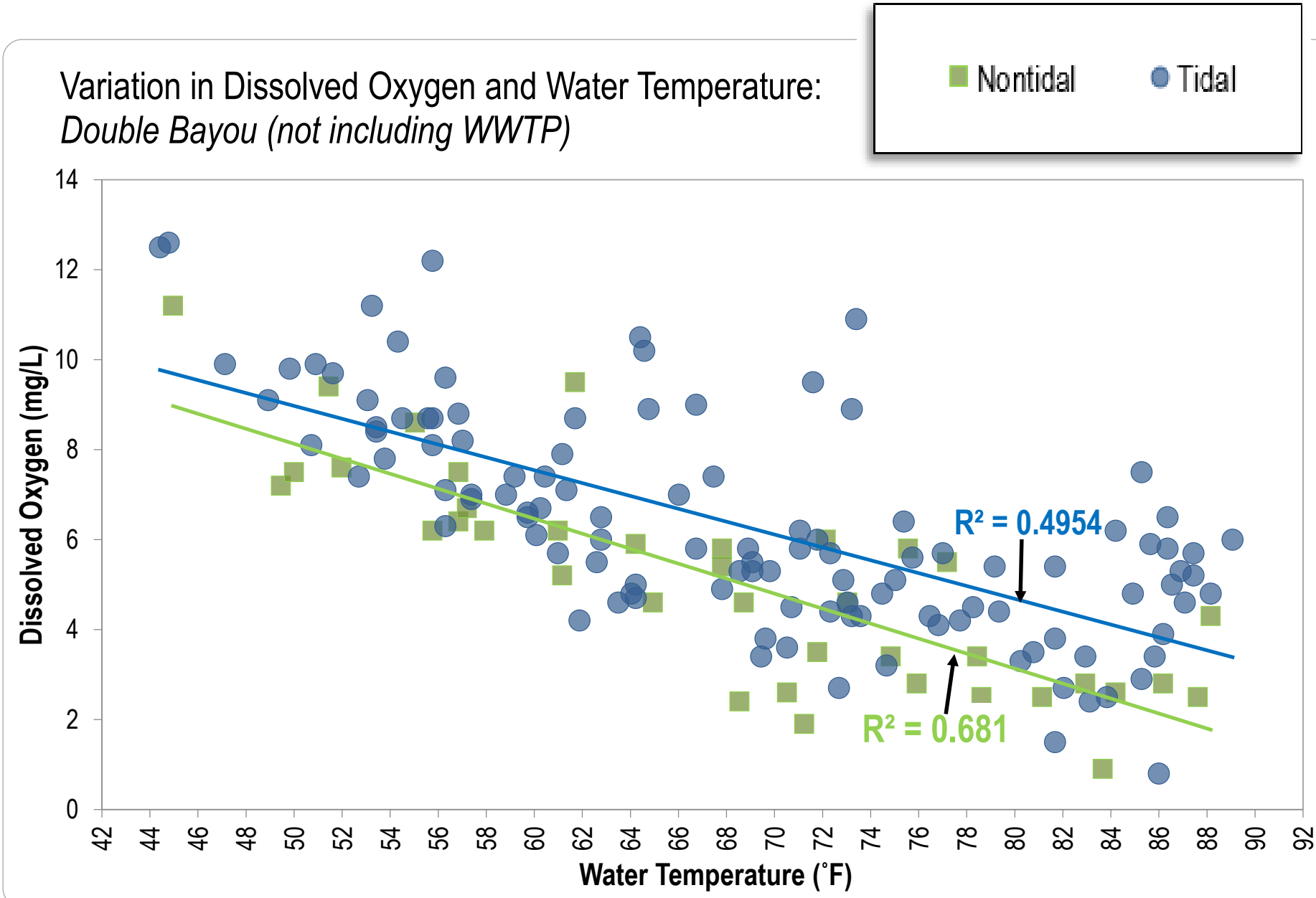


DOUBLE BAYOU WATERSHED PARTNERSHIP

HARC TCEQ Shead Conservation Solutions TSSWCB USGS science for a changing world

Dissolved Oxygen – Grab Samples

Variation in Dissolved Oxygen and Water Temperature:
Double Bayou (not including WWTP)



Dissolved Oxygen – Grab Samples

- **Seasonal Table (does not include WWTP)**
  - **Highest % below Screening Levels in Summer**

Dissolved Oxygen	Number of Routine Samples	Routine Samples Below Benchmark	Percent Below Benchmark (Routine)	Number of Targeted Rain Event Samples	Targeted Rain Event Samples Below Benchmark	Percent Below Benchmark (Targeted)
Fall Total (Sept.- Nov.)	32	6	**19%**	8	3	**38%**
Winter Total (Dec. - Feb.)	44	0	**0%**	4	0	**0%**
Spring Total (Mar. - May)	24	4	**17%**	16	0	**0%**
Summer Total (June - Aug.)	24	5	**21%**	0	0	**0%**

DOUBLE BAYOU WATERSHED PARTNERSHIP

Variation in Bacteria over Season – Samples from 10/22/13 – 5/20/15

Fall (September- November)				
Station	# of Routine Samples	Routine Samples Exceedance	# of Targeted Samples	Targeted Samples Exceedance
WWTP (ENT)	8	1	2	1
WWTP (*E. coli*)	8	0	2	1
EFU (E. coli)	7	1	2	1
EFL (ENT)	8	7	2	1
WFU (ENT)	8	7	2	2
WFL (ENT)	8	8	2	2
Total	47	24	12	8
Percent Above Benchmark		51%		67%

Winter (December - February)				
Station	# of Routine Samples	Routine Samples Exceedance	# of Targeted Samples	Targeted Samples Exceedance
WWTP (ENT)	10	0	1	1
WWTP (*E. coli*)	10	1	1	1
EFU (E. coli)	11	1	1	1
EFL (ENT)	11	2	1	1
WFU (ENT)	11	6	1	1
WFL (ENT)	11	5	1	1
Total	64	15	6	6
Percent Above Benchmark		23%		100%

Spring (March - May)				
Station	# of Routine Samples	Routine Samples Exceedance	# of Targeted Samples	Targeted Samples Exceedance
WWTP (ENT)	7	2	4	3
WWTP (*E. coli*)	7	2	4	2
EFU (E. coli)	6	0	4	4
EFL (ENT)	6	0	4	4
WFU (ENT)	7	4	4	4
WFL (ENT)	5	3	4	4
Total	38	11	24	21
Percent Above Benchmark		29%		88%

Summer (June - August)				
Station	# of Routine Samples	Routine Samples Exceedance	# of Targeted Samples	Targeted Samples Exceedance
WWTP (ENT)	6	1	0	0
WWTP (*E. coli*)	6	1	0	0
EFU (E. coli)	6	1	0	0
EFL (ENT)	6	2	0	0
WFU (ENT)	6	6	0	0
WFL (ENT)	6	1	0	0
Total	36	12	0	0
Percent Above Benchmark		33%		

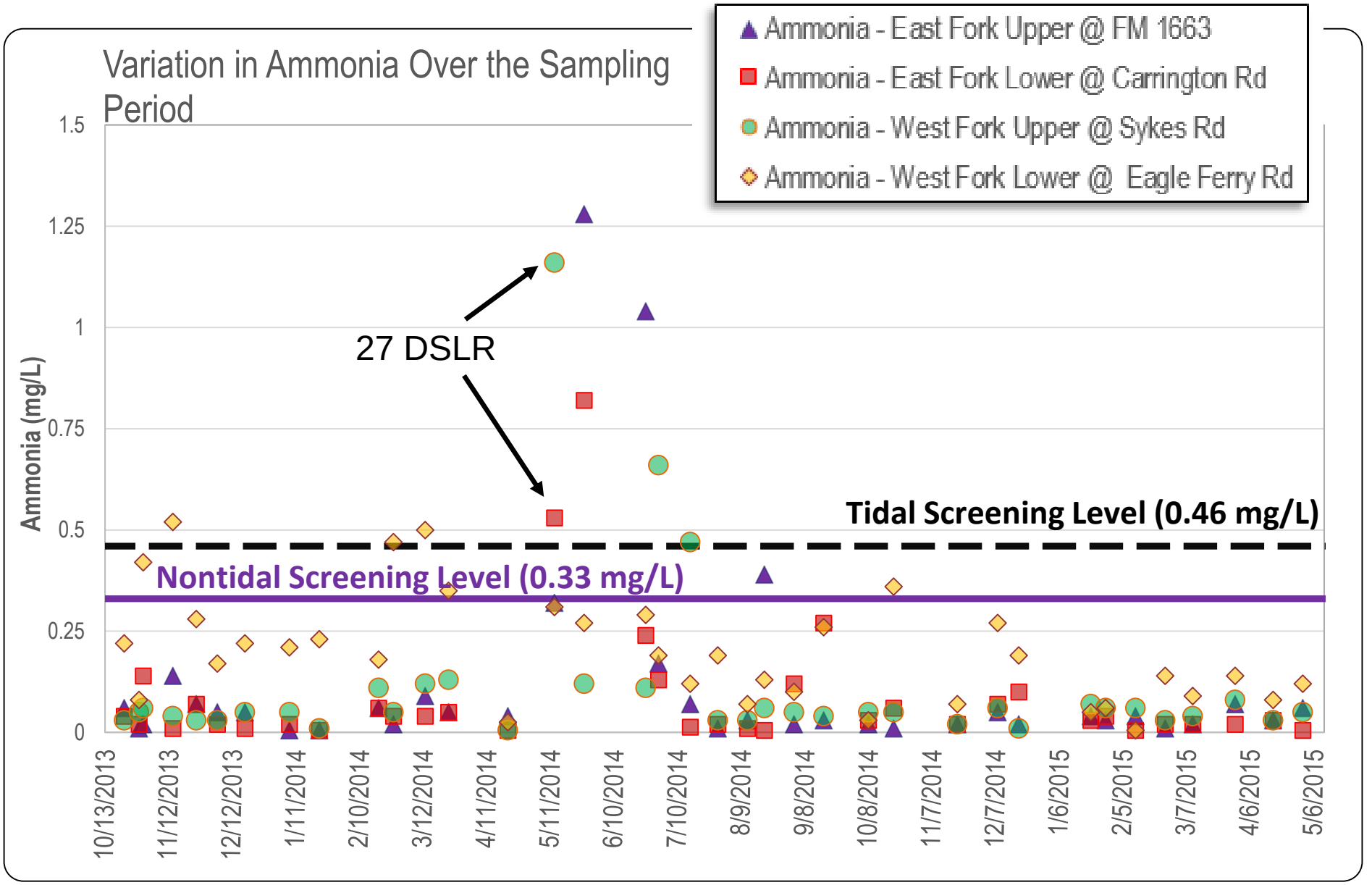
East Fork Upper: *E .coli* Benchmark (394 MPN /100 mL)
Anahuac WWTP, West Fork Stations and East Fork Lower: Enterococci Benchmark (89 MPN/100 mL)

CHLOROPHYLL-A & NUTRIENTS

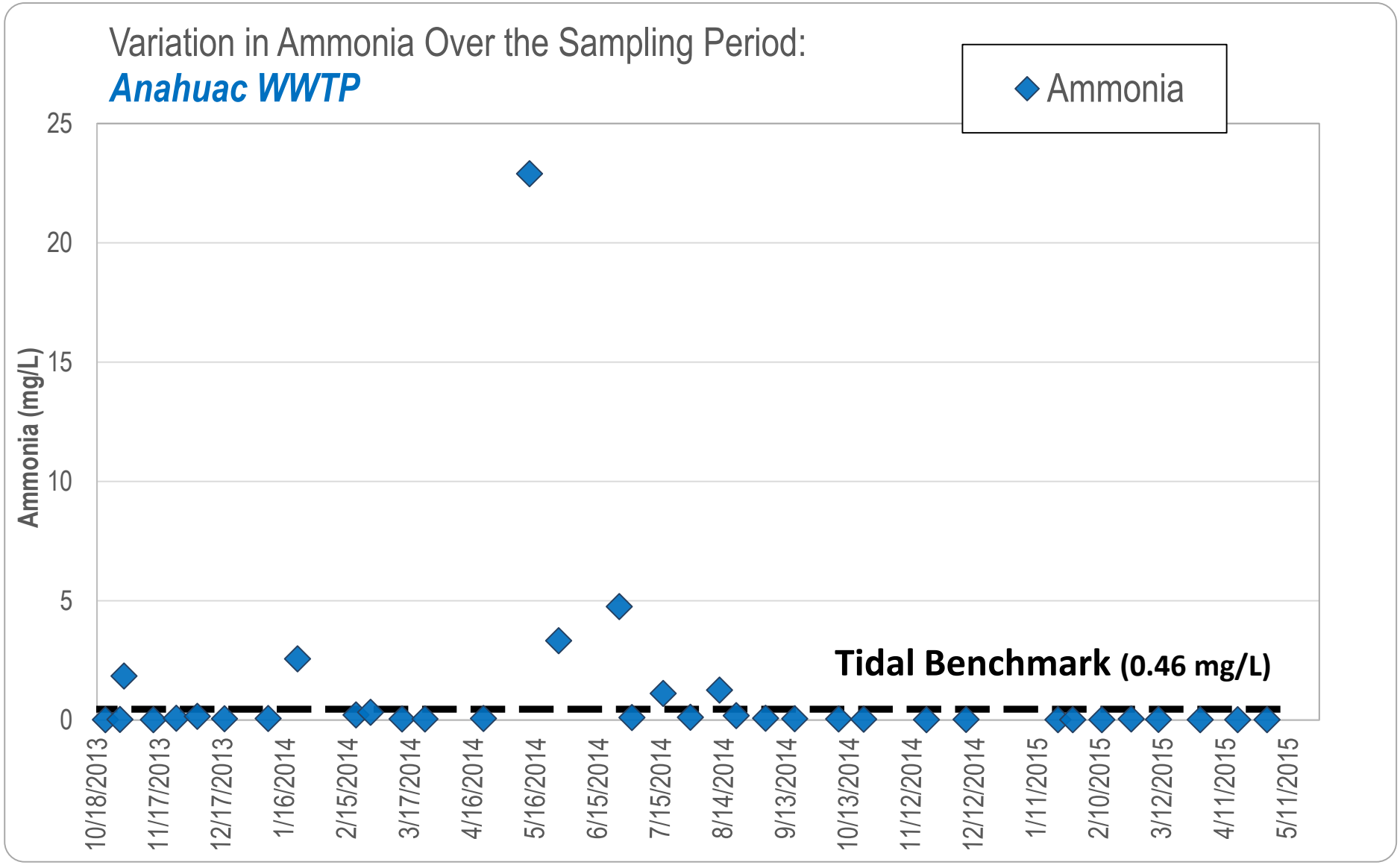
- **Indicator of phytoplankton abundance and biomass in coastal and estuarine waters**
- **Chlorophyll-a is a green pigment found in plants that absorbs sunlight and converts it to sugar during photosynthesis using nutrients such as phosphorus and nitrogen**
- **High levels often indicate poor water quality and low levels often suggest good conditions BUT it is the overall cycle that is important**
  - **Temporal and spatial variation**
  - **Long-term persistence of elevated levels that can be problematic**
- **Grab samples (results include both routine and targeted rain event)**

DOUBLE BAYOU WATERSHED PARTNERSHIP

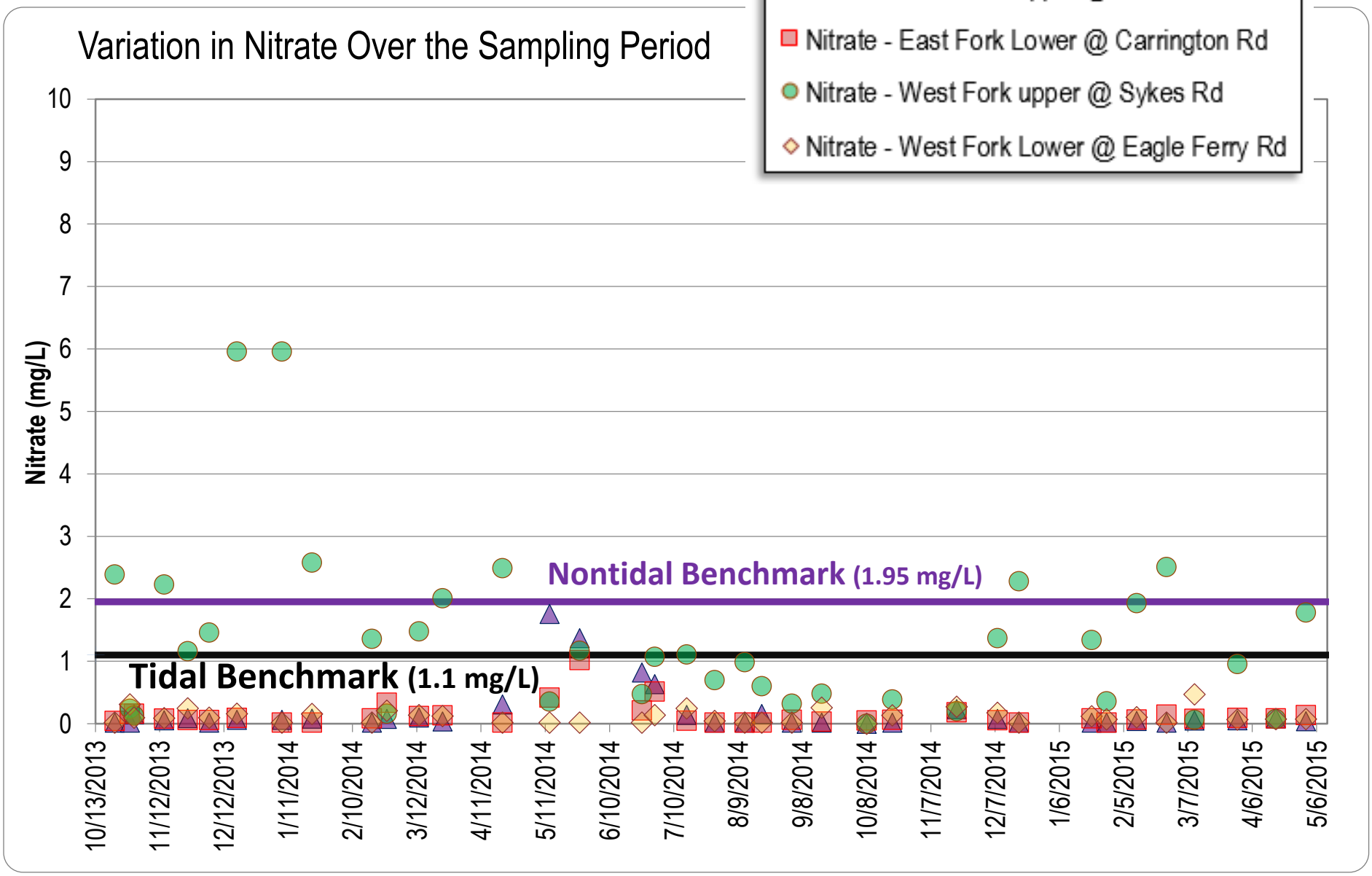
Chlorophyll-a and nutrients: Ammonia



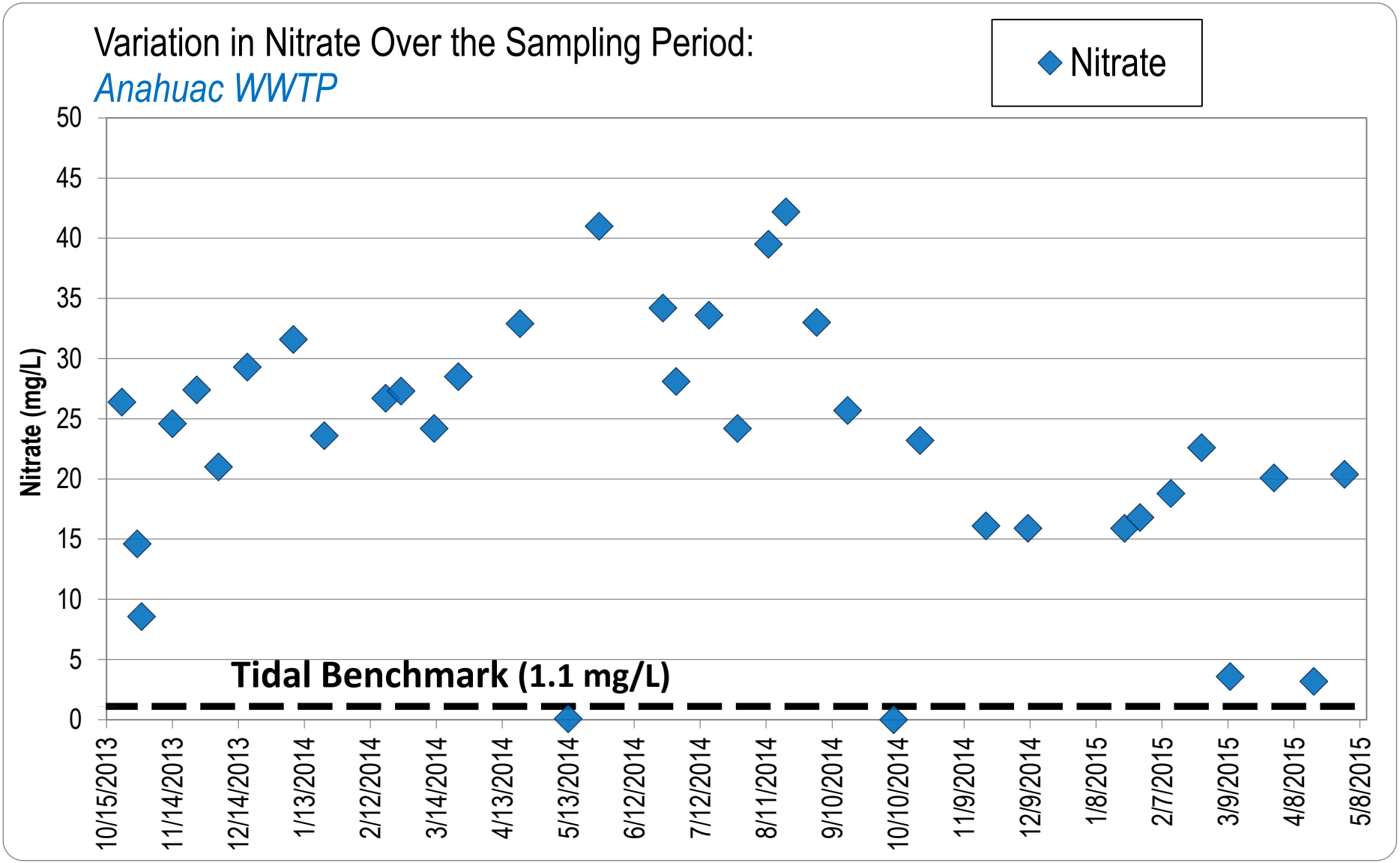
CHLOROPHYLL-A AND NUTRIENTS: AMMONIA



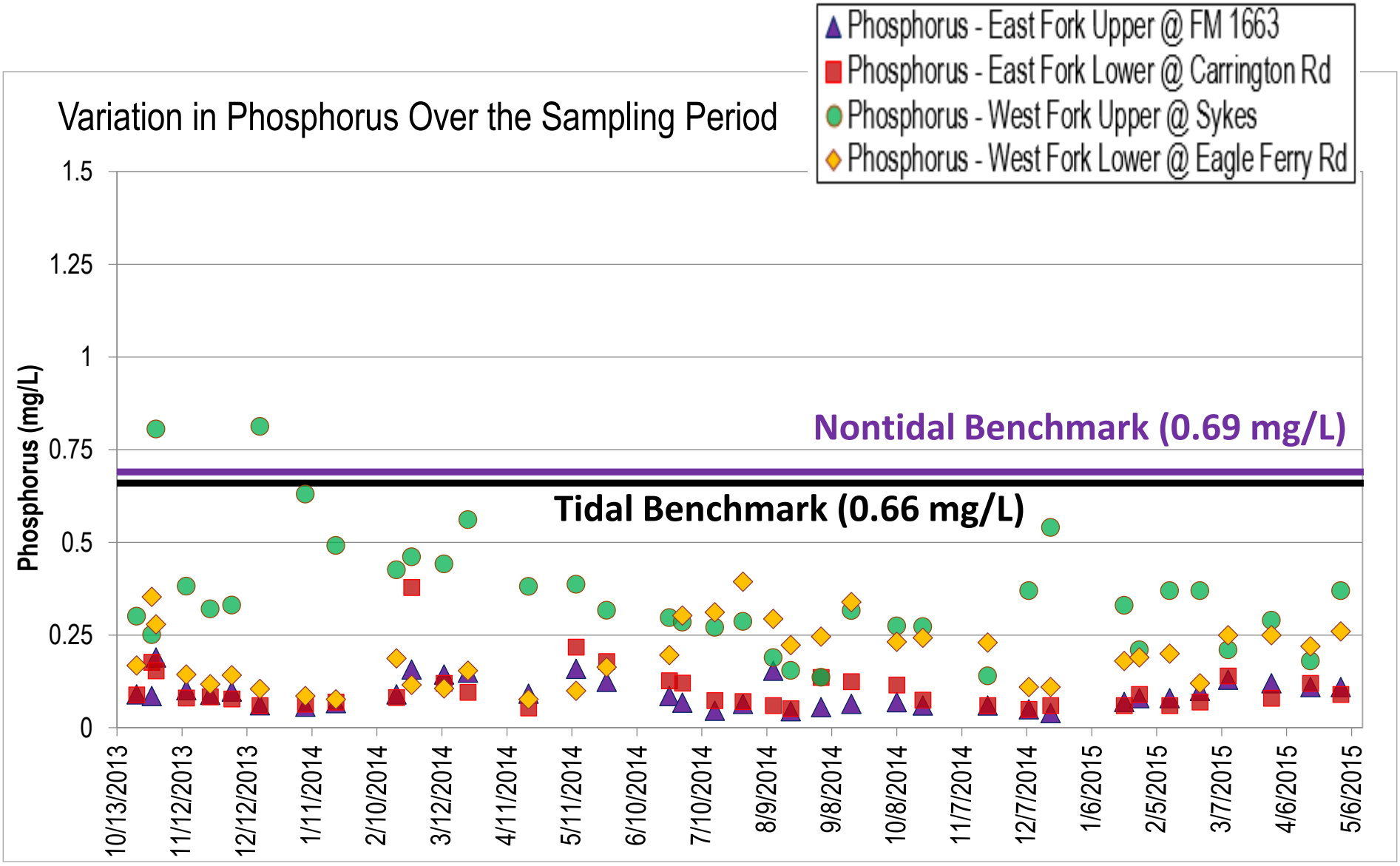
Chlorophyll-a and nutrients: Nitrate



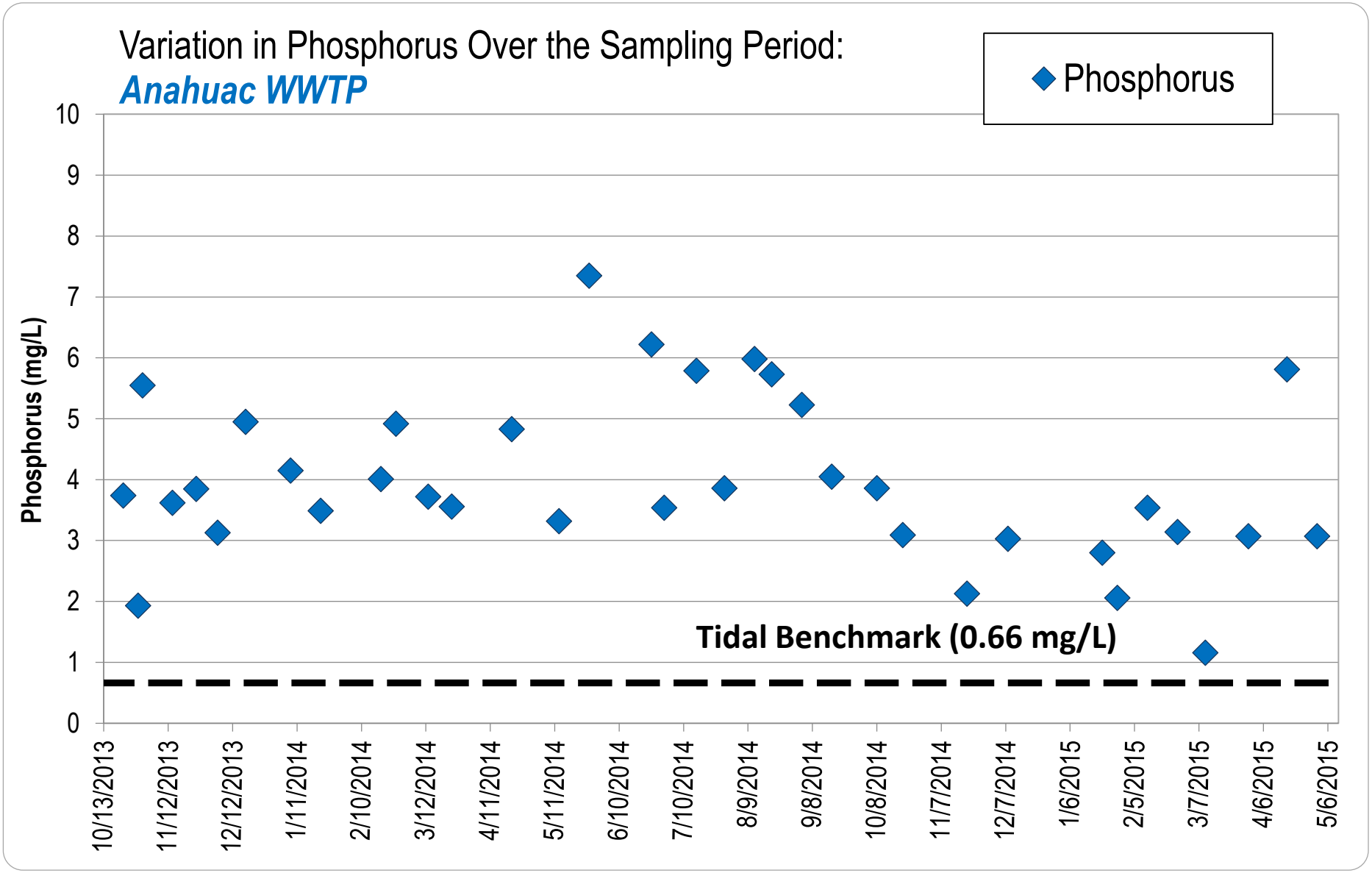
Chlorophyll-a and nutrients: Nitrate



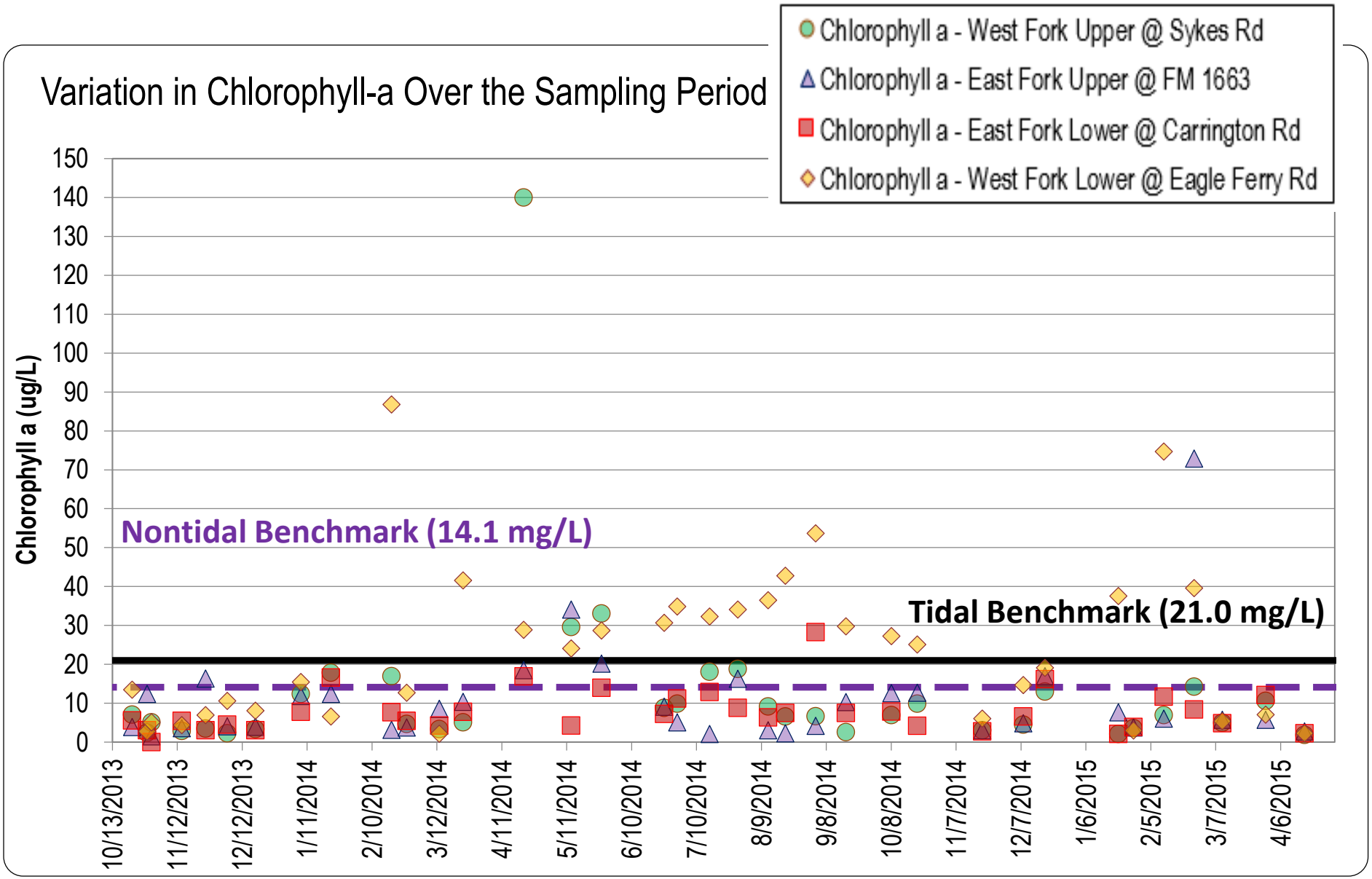
Chlorophyll-a and nutrients: Phosphorus



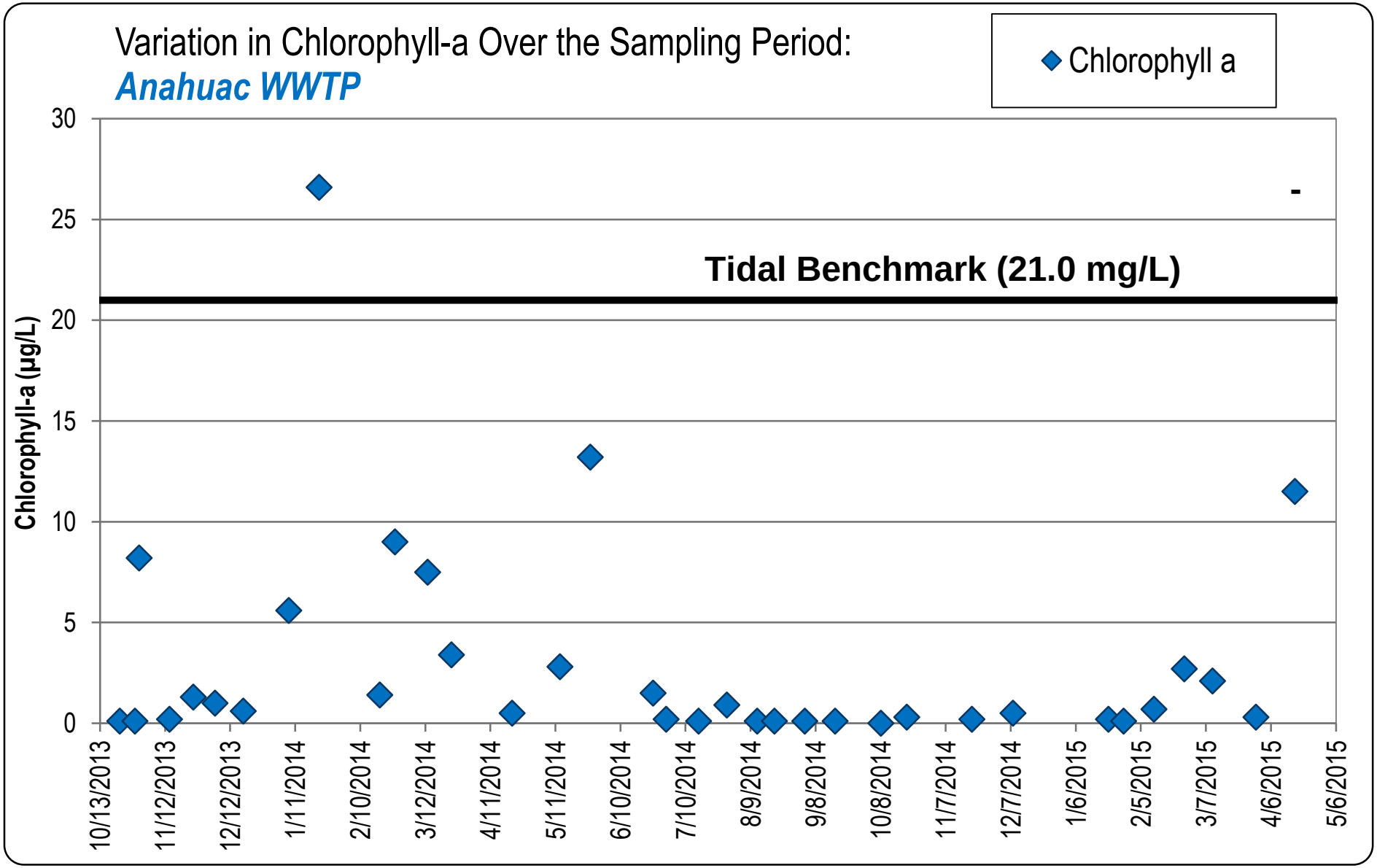
Chlorophyll-a and nutrients: Phosphorus



CHLOROPHYLL-A AND NUTRIENTS: CHLOROPHYLL-A

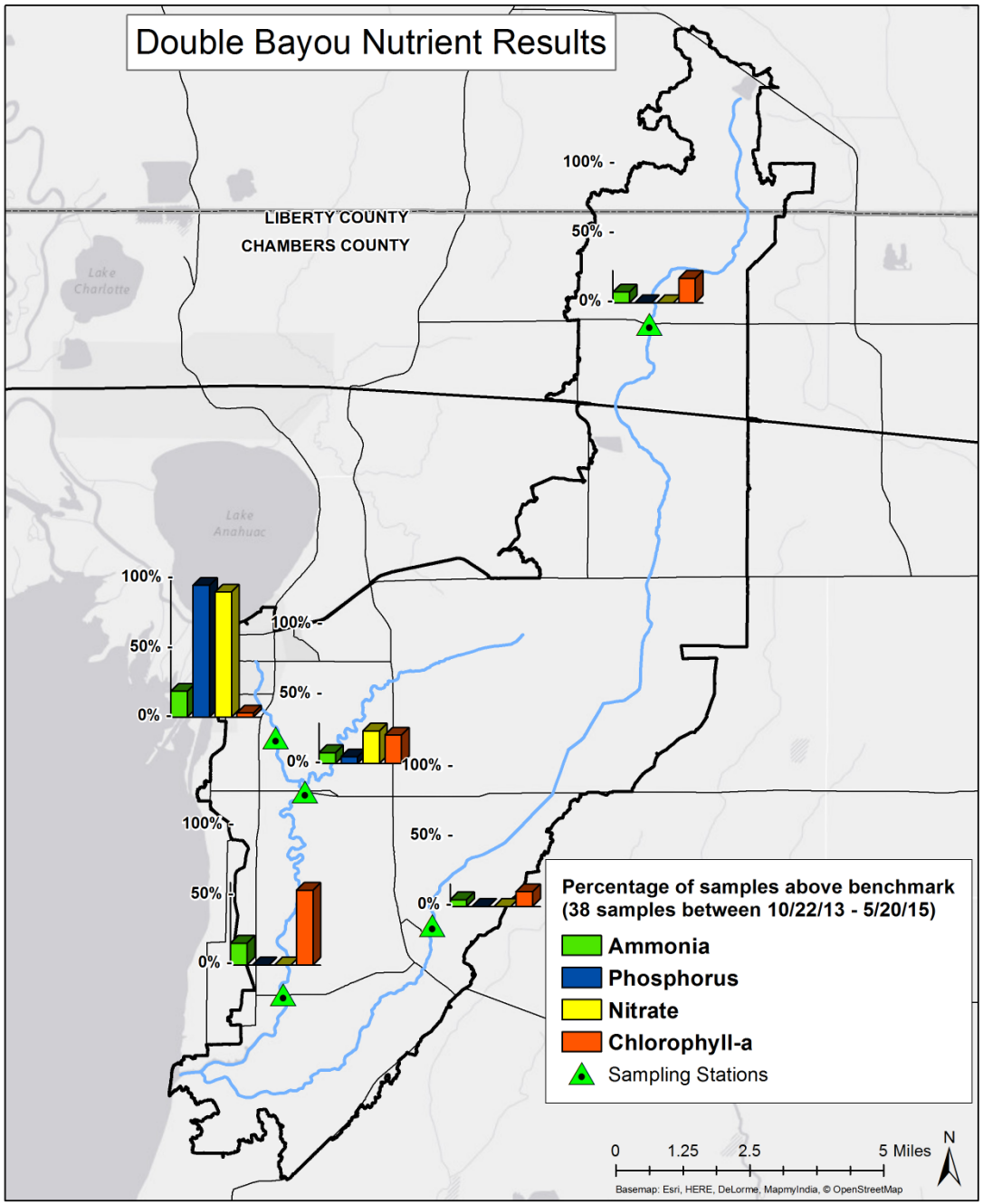


CHLOROPHYLL-A AND NUTRIENTS: CHLOROPHYLL-A



CHLOROPHYLL-A AND NUTRIENTS

- **Routine and Targeted Sampling**
- **Represents 37-38 total sampling events (# of samples = 37-38 per station)**
- **Height of column reflects percentage of samples above benchmark**



DOUBLE BAYOU WATERSHED PARTNERSHIP

HARC TCEQ Shead Conservation Solutions TSSWCB USGS science for a changing world

CHLOROPHYLL- A AND NUTRIENTS

- By Station
  - Overall exceedances low by station except
    - Ammonia at all stations with large Days Since Last Rain Event
    - Nitrate at West Fork Upper
    - Chlorophyll a at West Fork Lower
    - Phosphorus, Nitrate and Ammonia at WWTP
- For BMP Consideration
  - Sources of nitrates include wastewater treatment plants, runoff from fertilized lawns and cropland, failing on-site septic systems, runoff from animal manure storage areas

DOUBLE BAYOU WATERSHED PARTNERSHIP