North Central Texas Water Quality Project
Richland-Chambers Reservoir Watershed Protection Plan

Stakeholder Meeting
Waxahachie, Texas

AGENDA

Tuesday, April 25, 2017

9:30 Refreshments and Sign-in

10:00 Welcome and Introductions
Clint Wolfe, Program Manager Texas A&M AgriLife Research

10:10 Recap Last Meeting and Watershed Protection Plan Development Activities
Clint Wolfe, Program Manager Texas A&M AgriLife Research

10:20 Water Quality in the Richland-Chambers Watershed
Mark Ernst, Environmental Manager, Tarrant Regional Water District

10:40 Setting Water Quality Goals
Tina Hendon, Tarrant Regional Water District

11:00 BREAK

11:10 Use of Water Quality Models and Review of Preliminary Results
Essayas Kaba and Dr. Srinivasan, Texas A&M Spatial Sciences Lab

11:30 MS4 Stormwater Permitting and Renewal of Small MS4 General Permit
Hanne Nielsen and Lindsay Garza TCEQ Stormwater & Permitting Staff

12:00 LUNCH

12:45 2017 National Water Quality Initiative and the Chambers Creek Partnership
Kyle Wright, Natural Resource Manager,, USDA Natural Resources Conservation Service

1:05 Overview of Wastewater Study
Darrel Andrews, Tarrant Regional Water District

1:20 Overview of Economics Analyses
Darrel Andrews, Tarrant Regional Water District

1:35 BREAK

1:45 Steering Committee and Draft Guidelines
Clint Wolfe, Program Manager Texas A&M AgriLife Research

2:15 Discussion
- Timeline and Next Steps in WPP Development
- Time and Objectives for Next Meeting, May 24th

2:45 ADJOURN

Richland-Chambers Watershed Partnership

Stakeholder Meeting
April 25, 2017

Welcome and Introductions

CLINT WOLFE, TEXAS A&M AGRILIFE RESEARCH

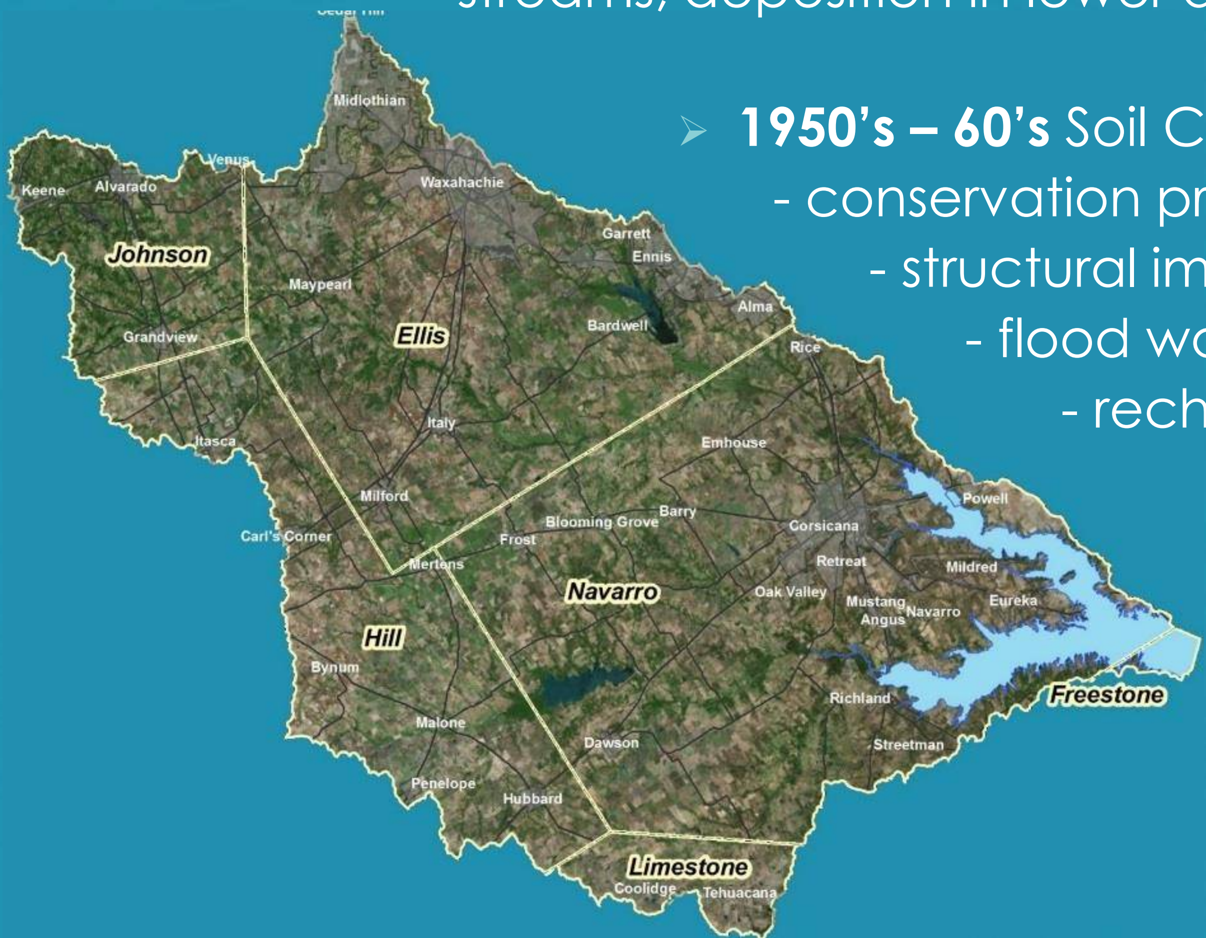
Recap of Previous Meeting

CLINT WOLFE, TEXAS A&M AGRILIFE RESEARCH

Richland-Chambers Watershed

Watershed History

- **1800's** Intensive agriculture results in erosion of land and streams, deposition in lower areas.



- **1950's – 60's** Soil Conservation Service
  - conservation practices,
  - structural improvements,
  - flood water dams (PL-566), and
  - rechannelized some streams.

- **1980's** Richland-Chambers Reservoir was built

Richland-Chambers Watershed

Watershed History

Today

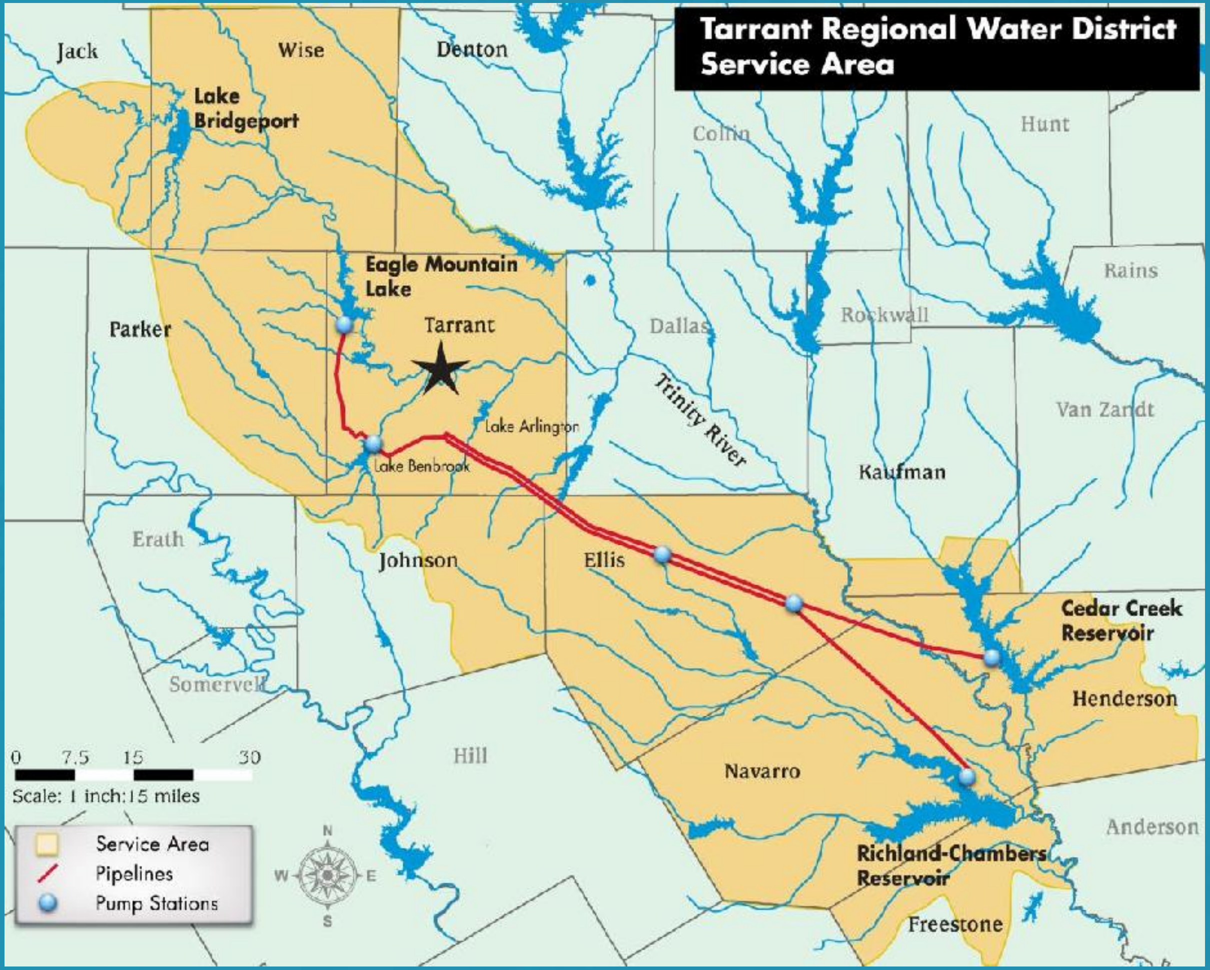
- Improved technologies and agricultural management practices.
- New pressures include land use changes and urban development.
- Landscape and stream erosion still persists in the watershed.

Richland-Chambers Watershed

Watershed History

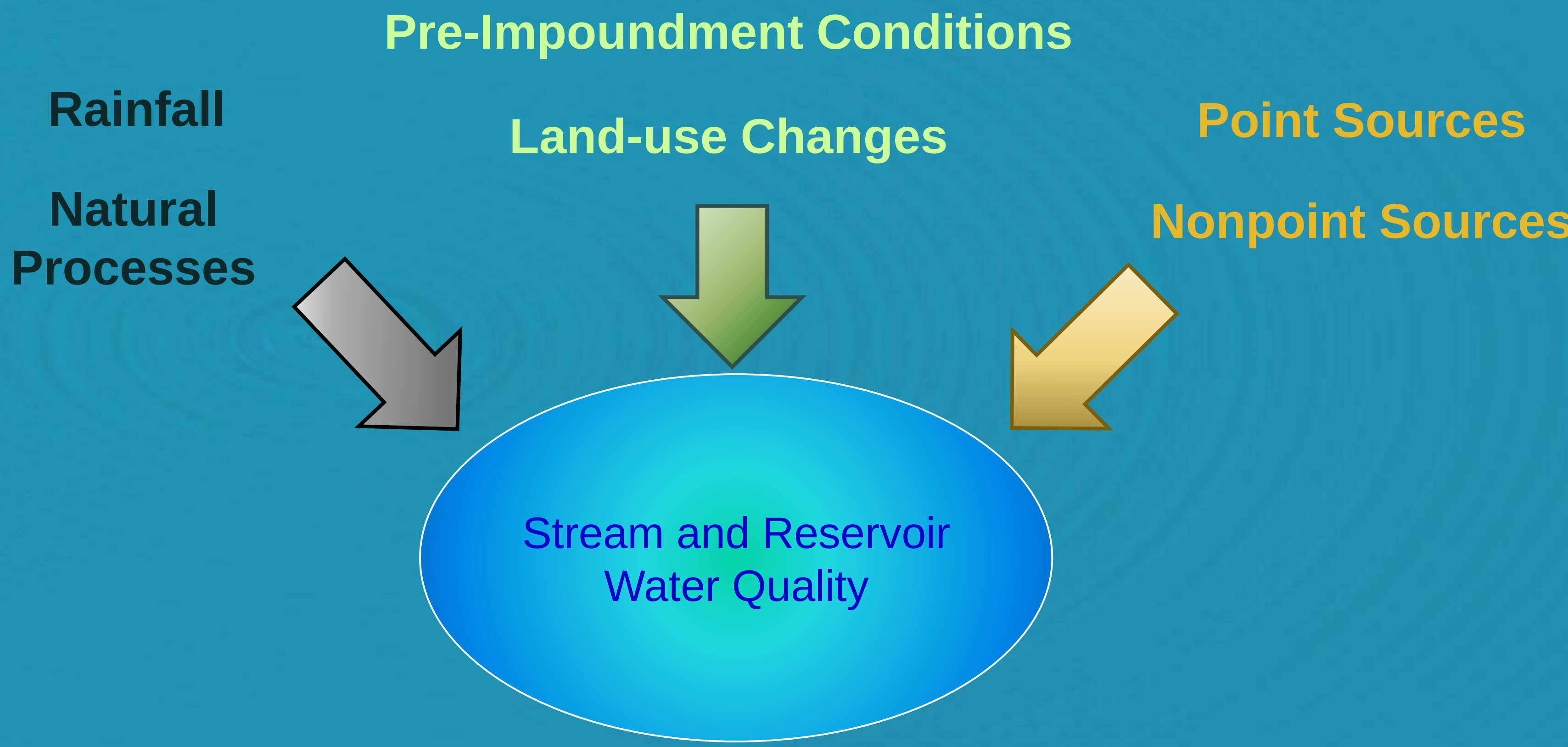
Today

- Richland-Chambers reservoir supplies almost half the drinking water for over 2 million people.



Watersheds 101

Watershed Effects on Water Quality

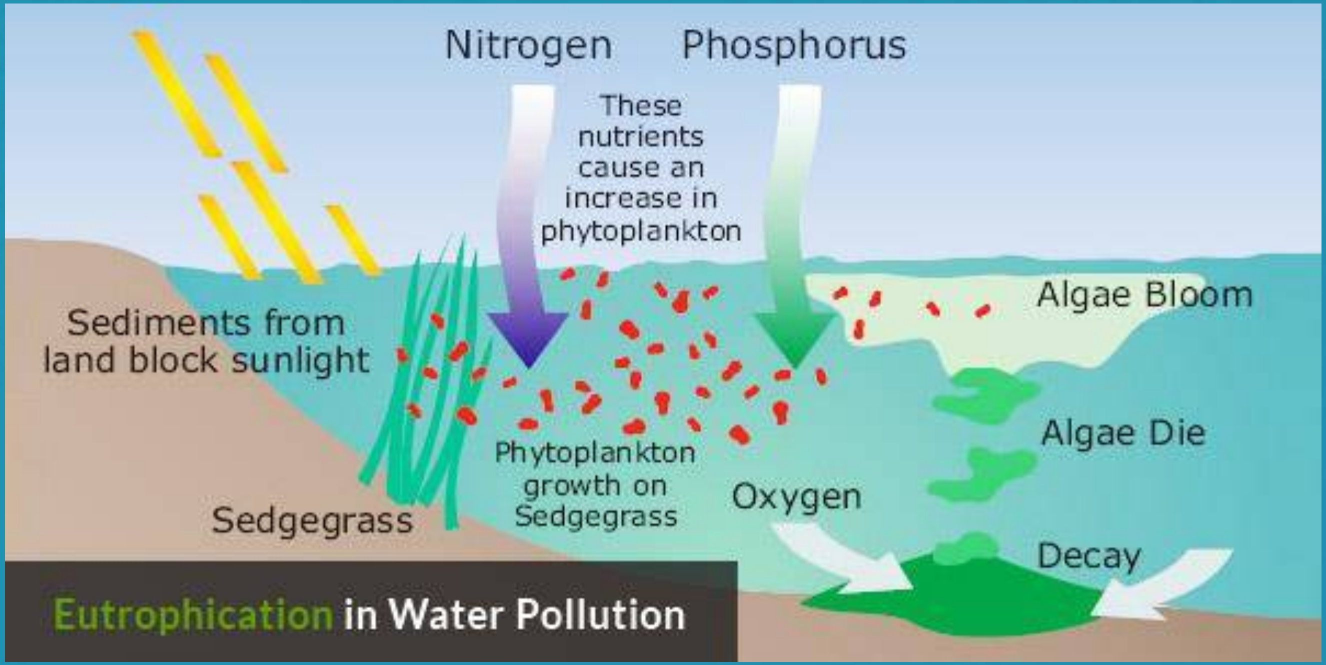


Watersheds 101

Eutrophication

- Excessive nutrient inputs - Nitrogen or Phosphorus
- Promotes excessive plant growth and decay

- Causes water quality problems
  - Algae blooms
  - Taste & odor problems
  - Low dissolved oxygen



Watersheds 101

Human Impacts to Water Quality

Point Source Pollution

from a clearly defined, fixed point such as a pipe, ditch, channel, sewer or tunnel

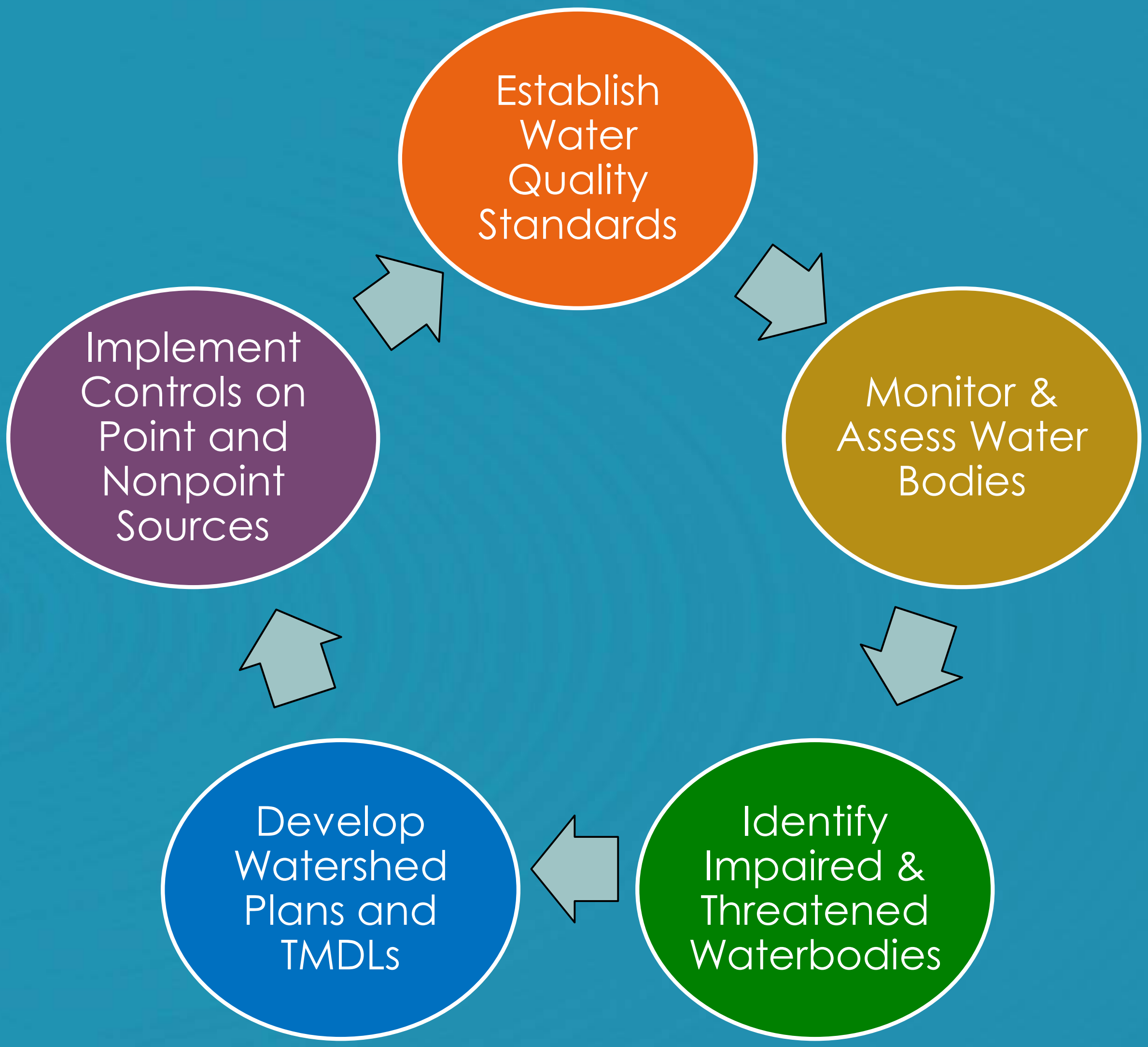
Non-Point Source Pollution

from many different places across the landscape, most of which cannot be readily identified.

Water Quality Management

Clean Water Act

- Federal regulatory process to protect water quality
- Programs delegated to state - TCEQ



Water Quality Issues

TCEQ Assessment Report

TCEQ Water Quality Status

Concern

Impaired

From: TCEQ 2014 Integrated Report

Options for Improving WQ

Total Maximum Daily Load - TMDL

- Allocates load between nonpoint sources and point sources
- Single parameter per segment/water body
- Regulatory, must be approved by EPA

Watershed Protection Plan

- Voluntary
- Addresses complex issues
- Includes multiple jurisdictions
- Addresses multiple sources

9 Elements of a WPP

A. Identify problem & sources
B. Reductions needed to reach goals
C. Identify measures needed to achieve reductions
D. Assistance needed
E. Education & outreach plan
F. Schedule
G. Milestones
H. Criteria for measuring progress
I. Monitoring Plan

WPP Development Activities

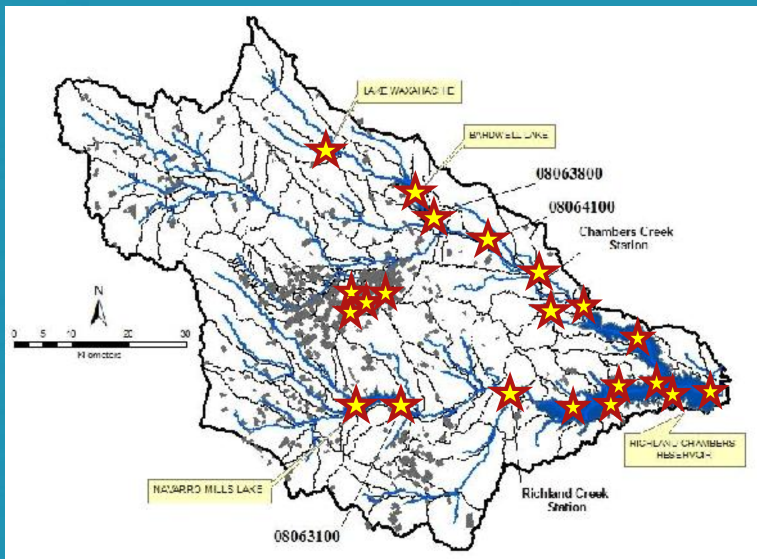
		Elements of a WPP Document								
		A	B	C	D	E	F	G	H	I
Planning process	*1. Build Partnerships*									
	2. Characterize Watershed	**X**								
	3. Goals and Solutions		**X**	**X**						
	4. Implementation Program				**X**	**X**	**X**	**X**	**X**	**X**
	5. Implement the Plan									
	6. Measure Progress & Make Adjustments									

1. Building Partnerships

Stakeholder Groups

- Balanced representation from various sectors
- Manageable size for decision-making purposes
- All stakeholders provide input
- Contribute ideas to WPP development and implementation
- Implement practices and activities in the WPP in order to accomplish the goals of the WPP

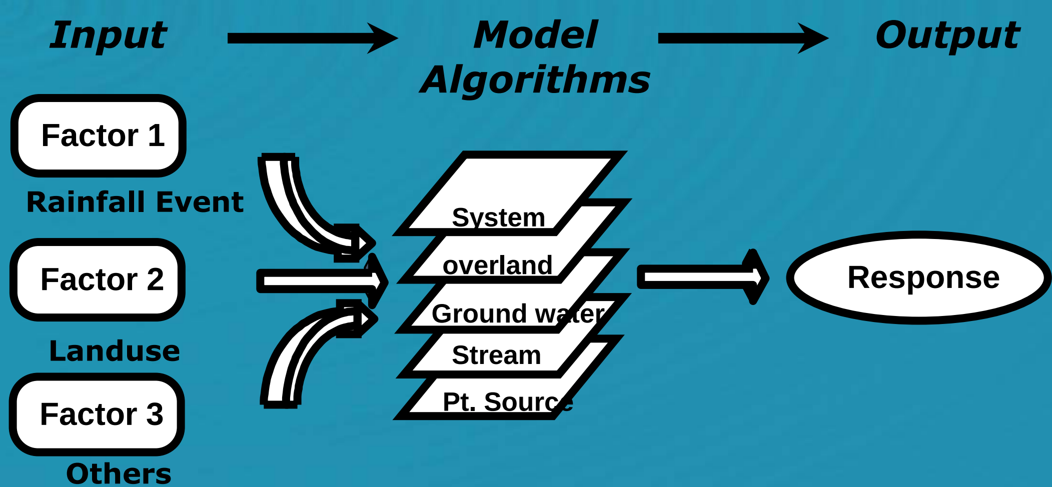
2. Characterizing Watershed



Sampling Programs

- TCEQ
- TRWD

Modeling and Analysis



3. Identifying Goals and Solutions

Begin discussion of Goals today

Workshop on Best Management Practices in May

4. Develop Implementation Plan

Over next few months…

- Identify technical & financial assistance needed
- Develop education & outreach plan
- Schedule
- Milestones
- Criteria for measuring progress
- Monitoring Plan

RICHLAND-CHAMBERS WPP

April 2017

Mark R. Ernst
TRWD

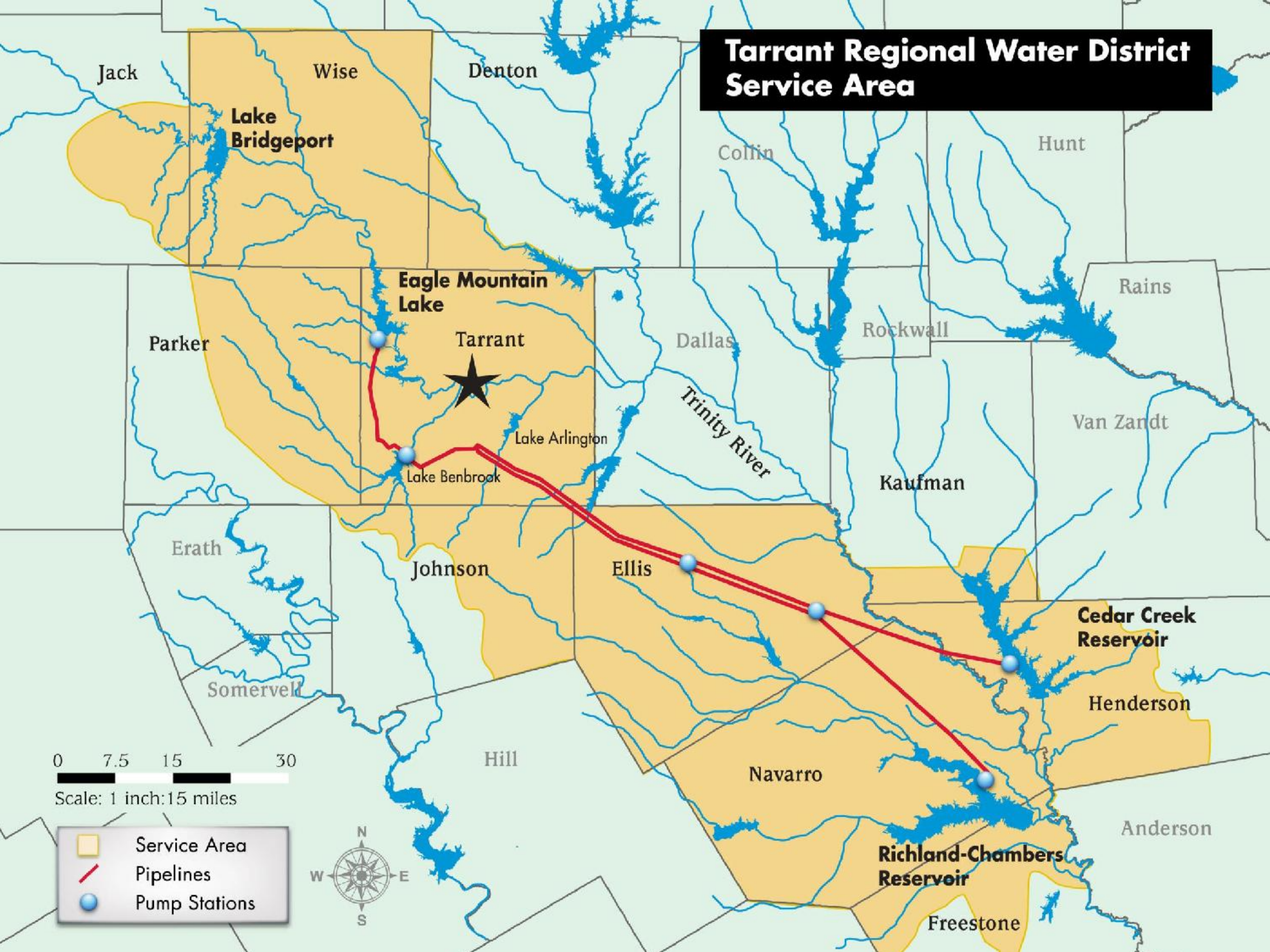
RICHLAND-CHAMBERS WPP

Status of Richland-Chambers reservoir water quality compared to other reservoirs in the area

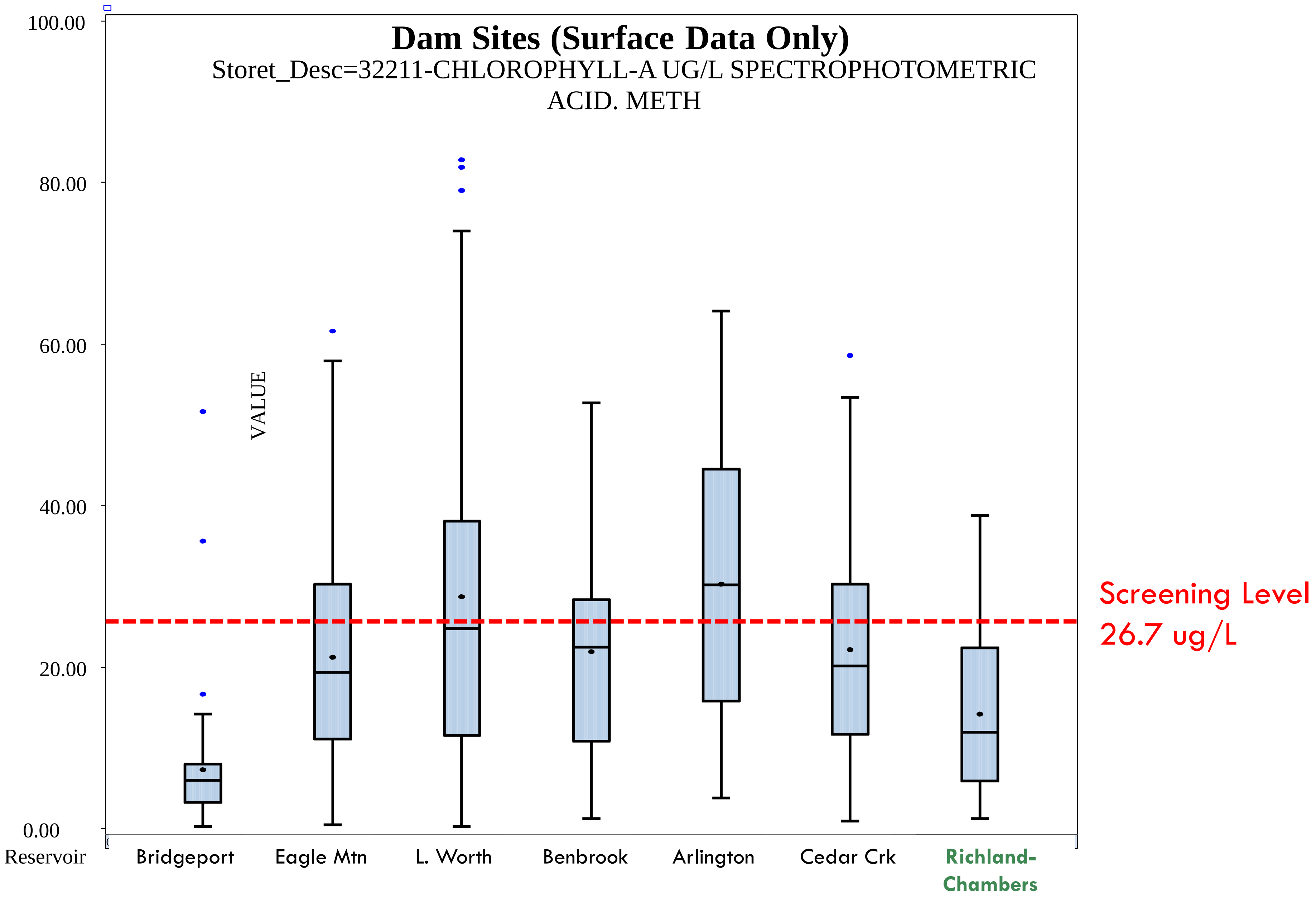
Variation of water quality within Richland Chambers Reservoir

Water quality of the two main tributaries

Contemplate where should we focus our assessment or measure of success.

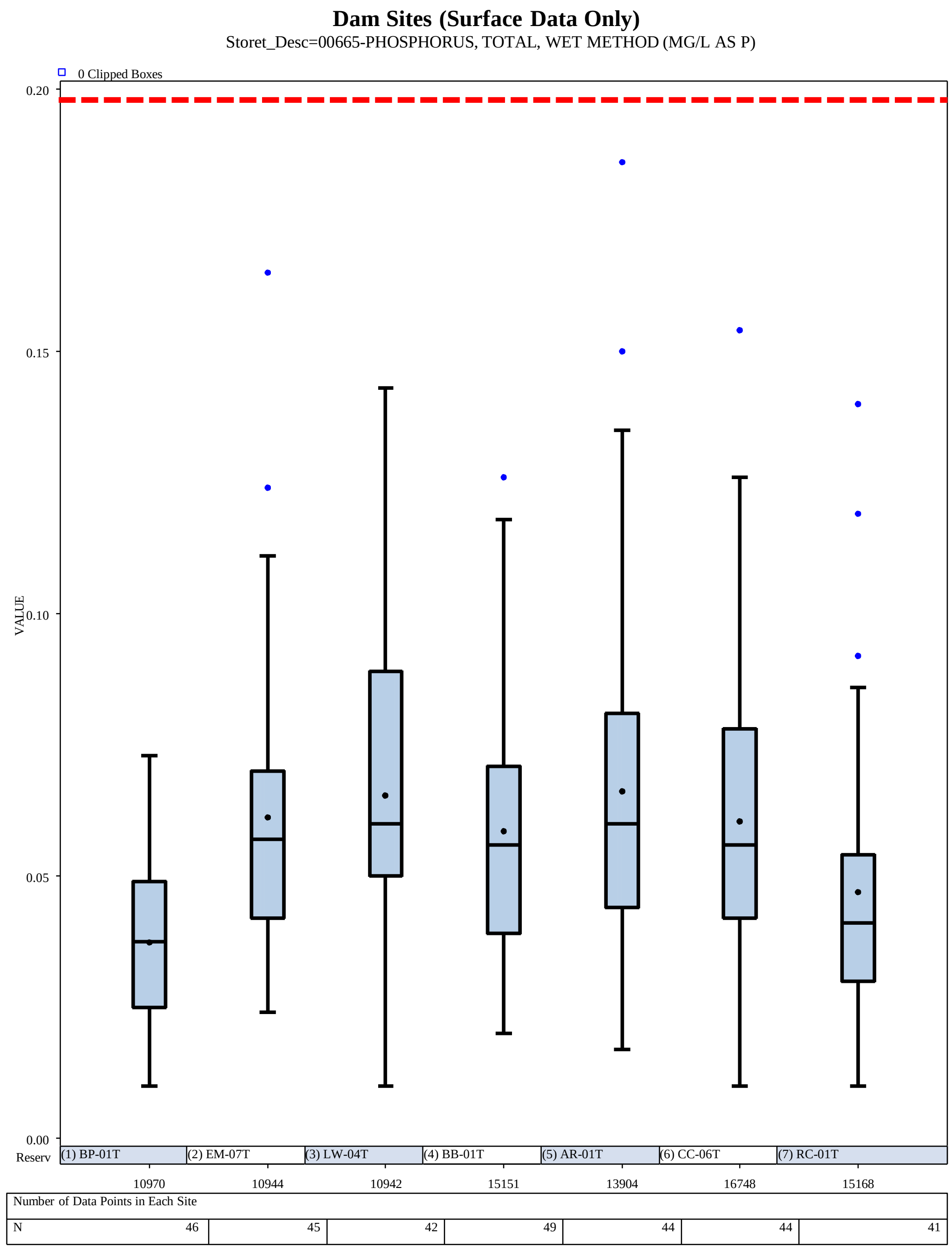

Tarrant Regional Water District
Service Area
Jack
Wise
Denton
Lake
Bridgeport
Collin
Hunt
Eagle Mountain
Lake
Rains
Parker
Tarrant
Dallas
Rockwall
Trinity River
Van Zandt
Lake Arlington
Lake Benbrook
Kaufman
Erath
Johnson
Ellis
Cedar Creek
Reservoir
Somervell
Henderson
Hill
Navarro
0 7.5 15 30
Scale: 1 inch:15 miles
Anderson
Service Area
Pipelines
Pump Stations
N
W
E
S
Richland-Chambers
Reservoir
Freestone

HOW DOES RICHLAND-CHAMBERS WATER QUALITY COMPARE TO OTHER RESERVOIRS?



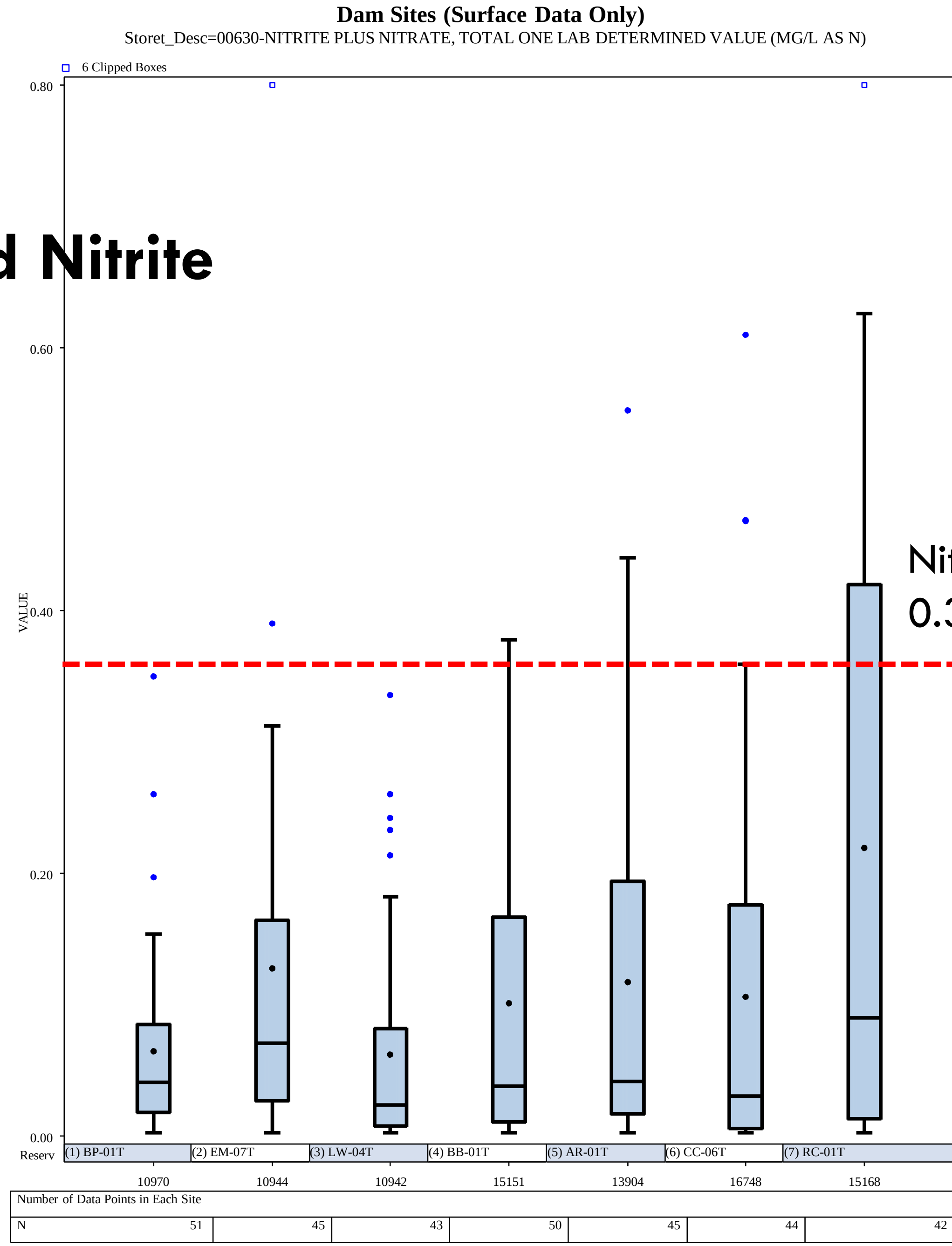
Dam Sites (Surface Data Only)
Storet_Desc=32211-CHLOROPHYLL-A UG/L SPECTROPHOTOMETRIC ACID. METH
100.00
80.00
60.00
40.00
20.00
0.00
VALUE
Reservoir
Bridgeport
Eagle Mtn
L. Worth
Benbrook
Arlington
Cedar Crk
Richland-Chambers
Screening Level
26.7 ug/L

Total Phosphorus



TP Screening Level
0.2 mg/L

Nitrate and Nitrite

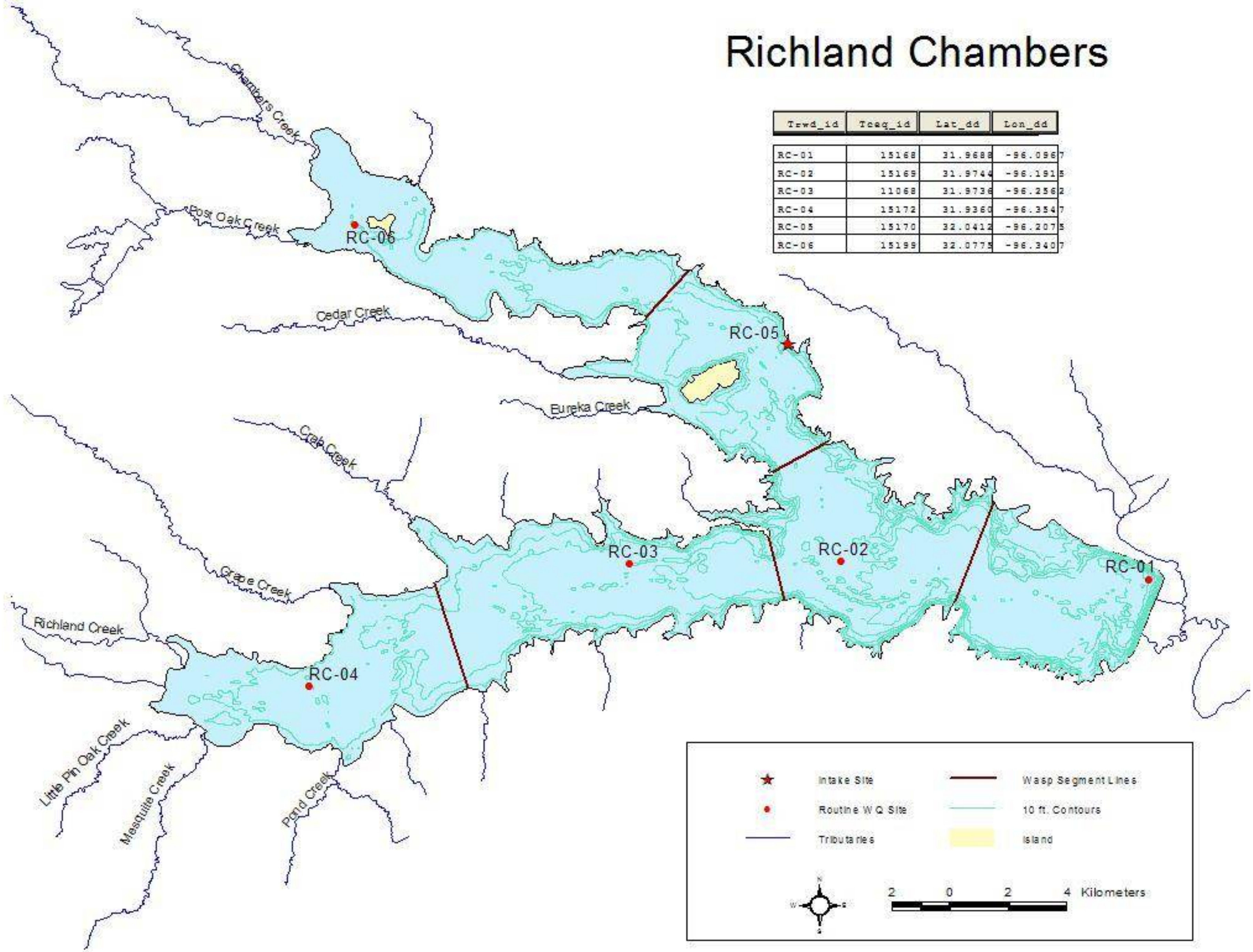


Nitrate Screening level

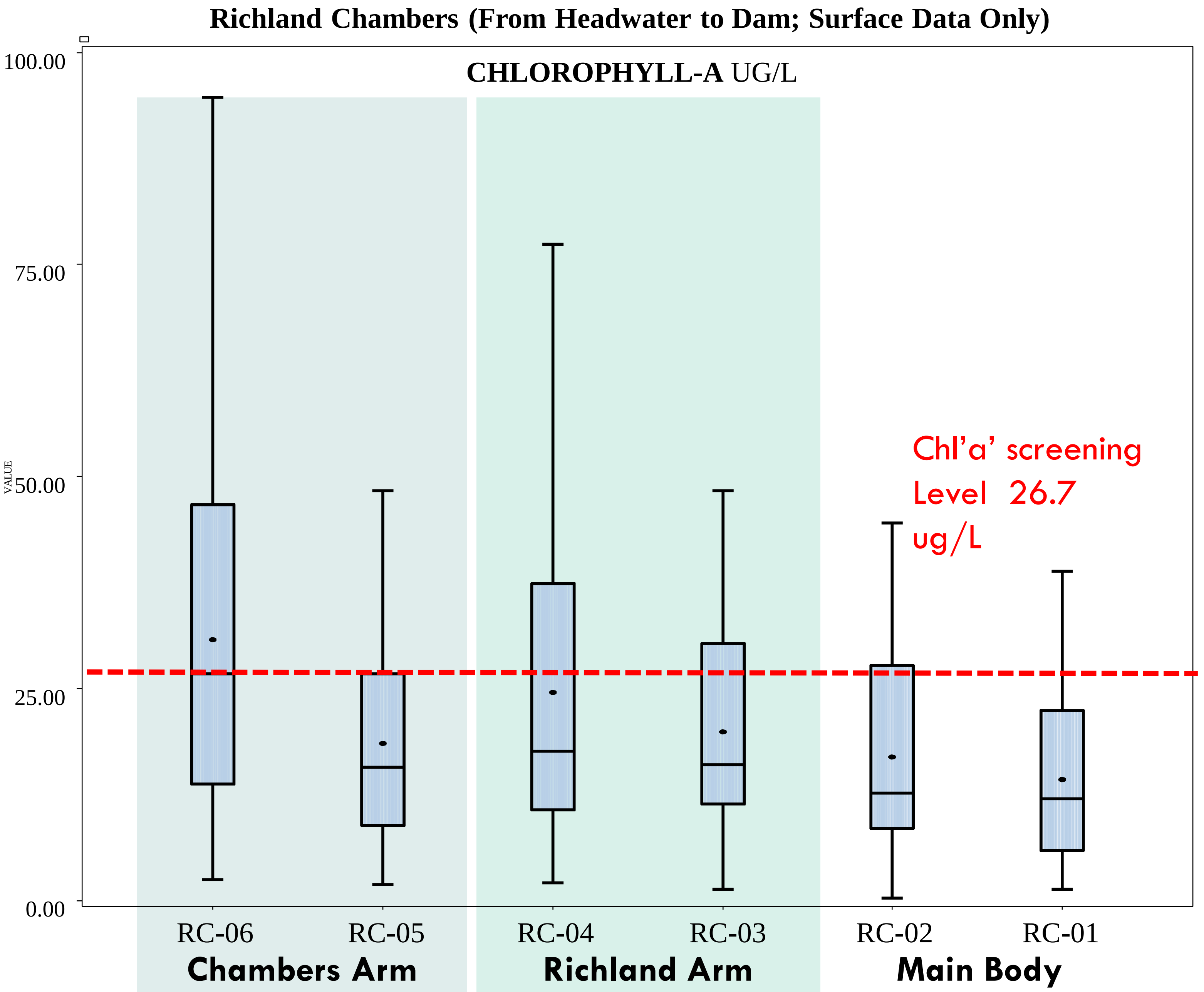
0.37 mg/L

Longitudinal Gradients in Richland Chambers Reservoir

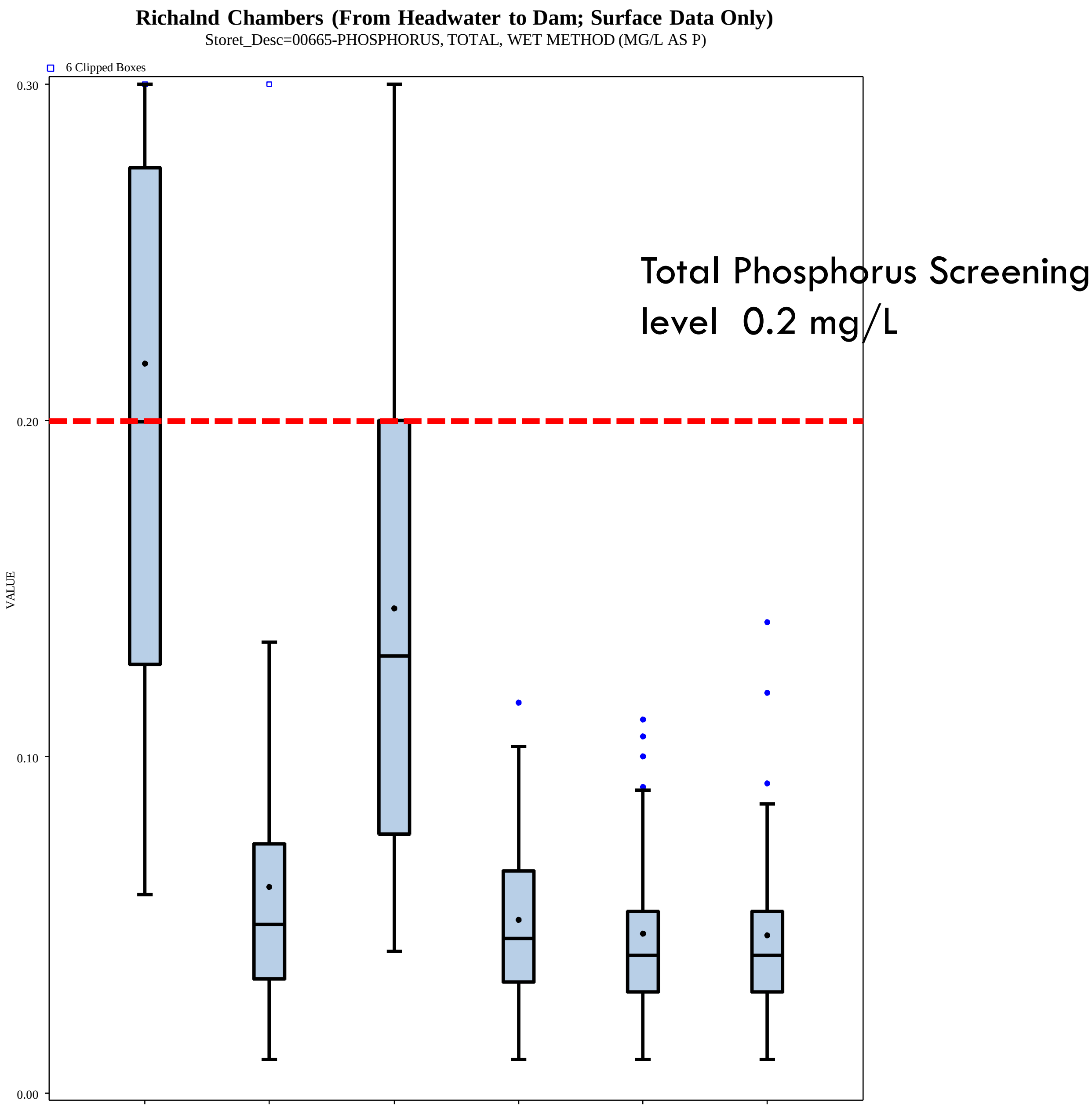
Richland Chambers



Trwd_id	Tceq_id	Lat_dd	Lon_dd
RC-01	15168	31.9688	-96.0967
RC-02	15169	31.9744	-96.1915
RC-03	11068	31.9736	-96.2562
RC-04	15172	31.9360	-96.3547
RC-05	15170	32.0412	-96.2075
RC-06	15199	32.0775	-96.3407

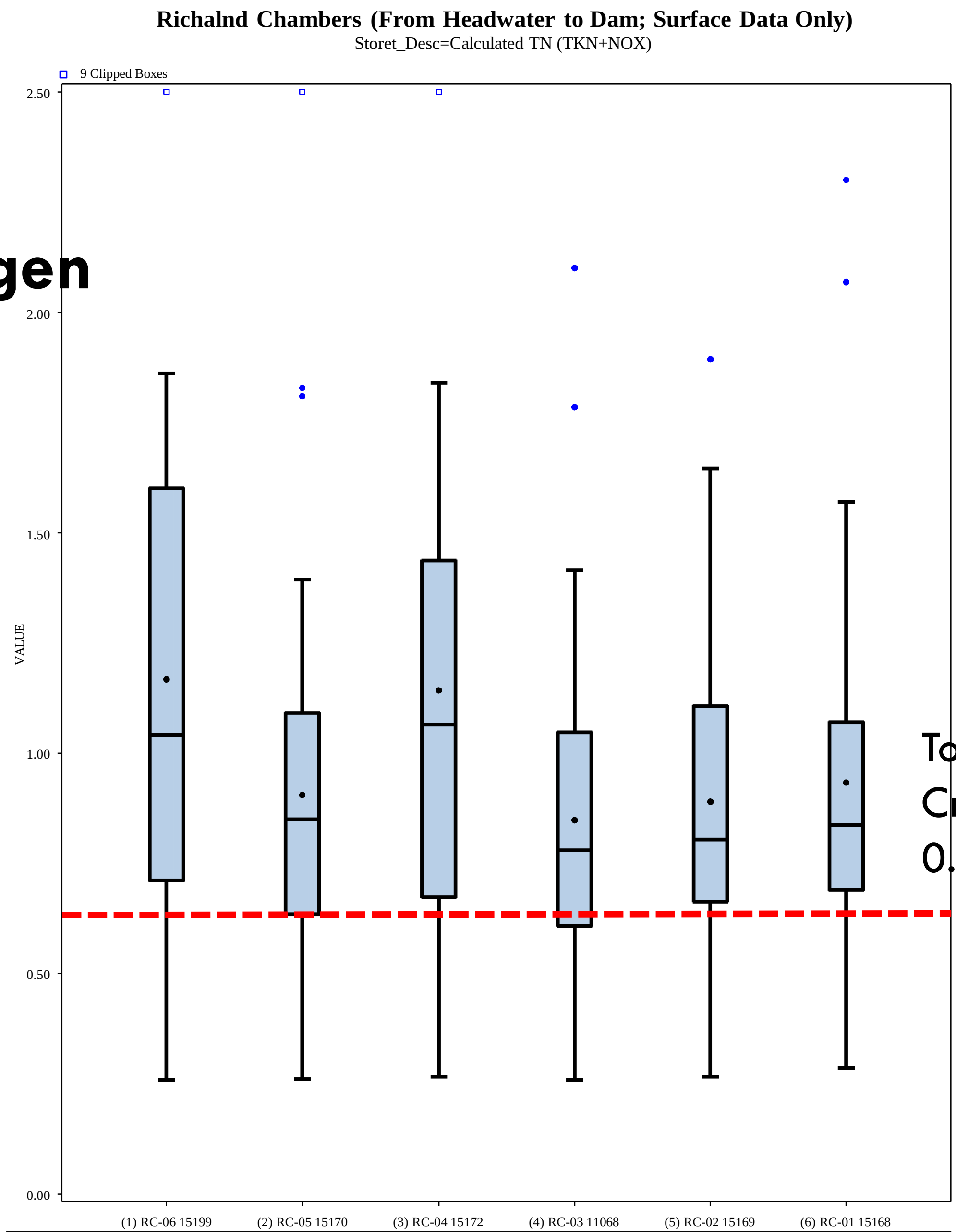

Richland Chambers (From Headwater to Dam; Surface Data Only)
CHLOROPHYLL-A UG/L
VALUE
100.00
75.00
50.00
25.00
0.00
Chl'a' screening
Level 26.7
ug/L
RC-06
RC-05
RC-04
RC-03
RC-02
RC-01
Chambers Arm
Richland Arm
Main Body

Total Phosphorus



Number of Data in Each Site						
N	36	44	26	42	43	41

Total Nitrogen

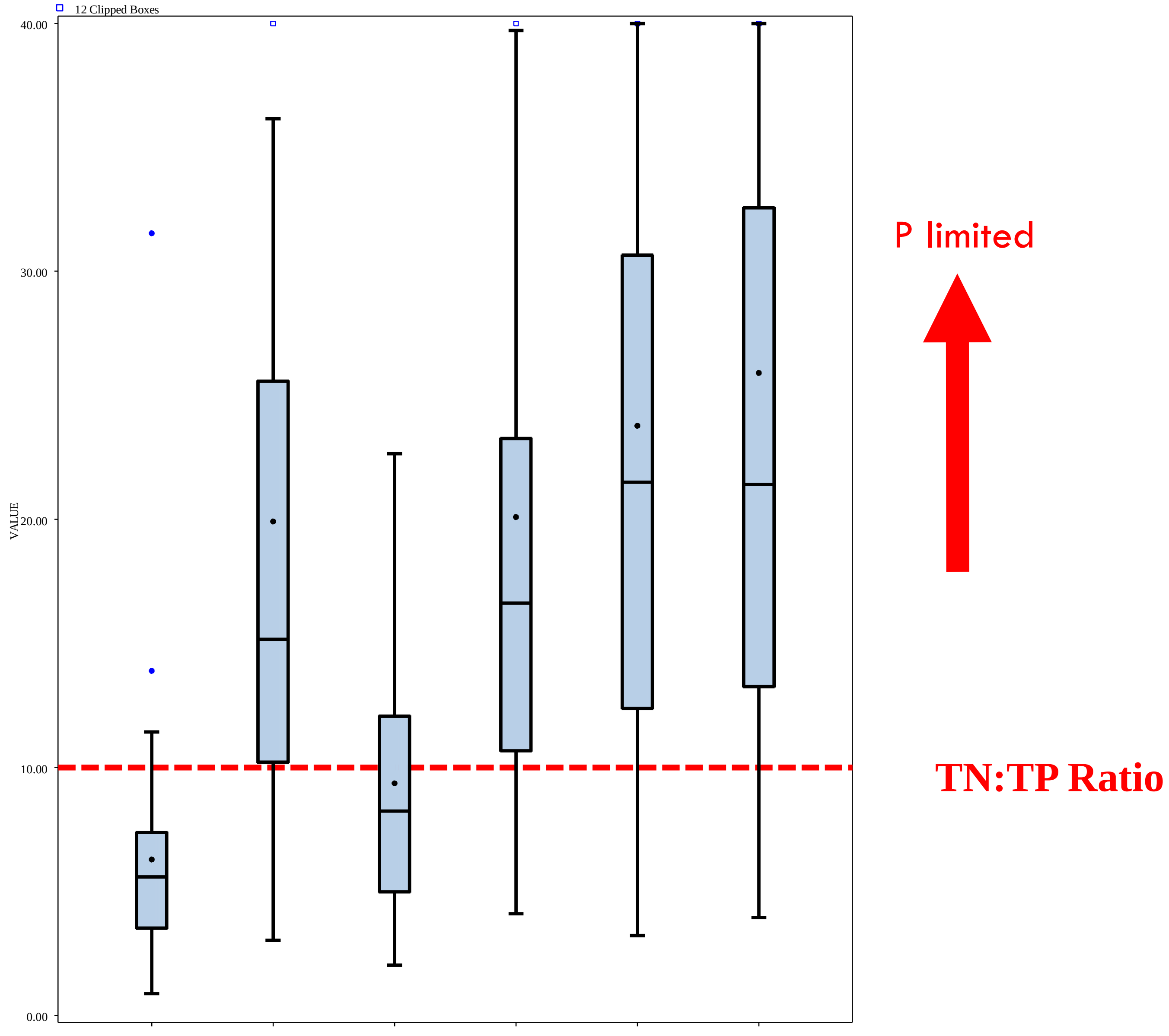


Number of Data in Each Site						
N	35	44	26	41	43	41

Total Nitrogen Proposed Criteria
0.58 mg/L

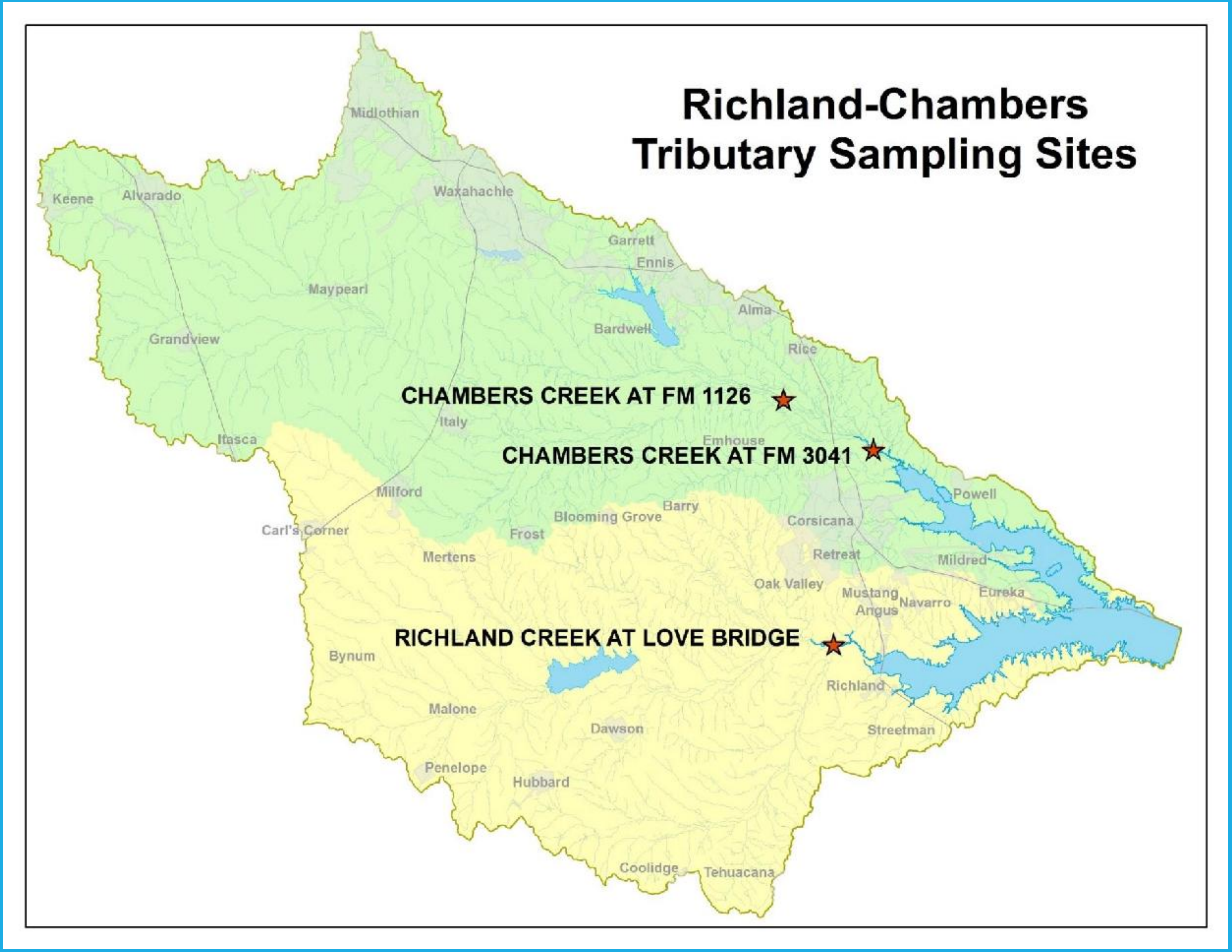
Richalnd Chambers (From Headwater to Dam; Surface Data Only)

Storet_Desc=TN/TP



Number of Data in Each Site						
N	35	44	26	41	43	41

What are the Main Tributaries Like?



CHALLENGES WITH ANALYZING TRIBUTARY DATA

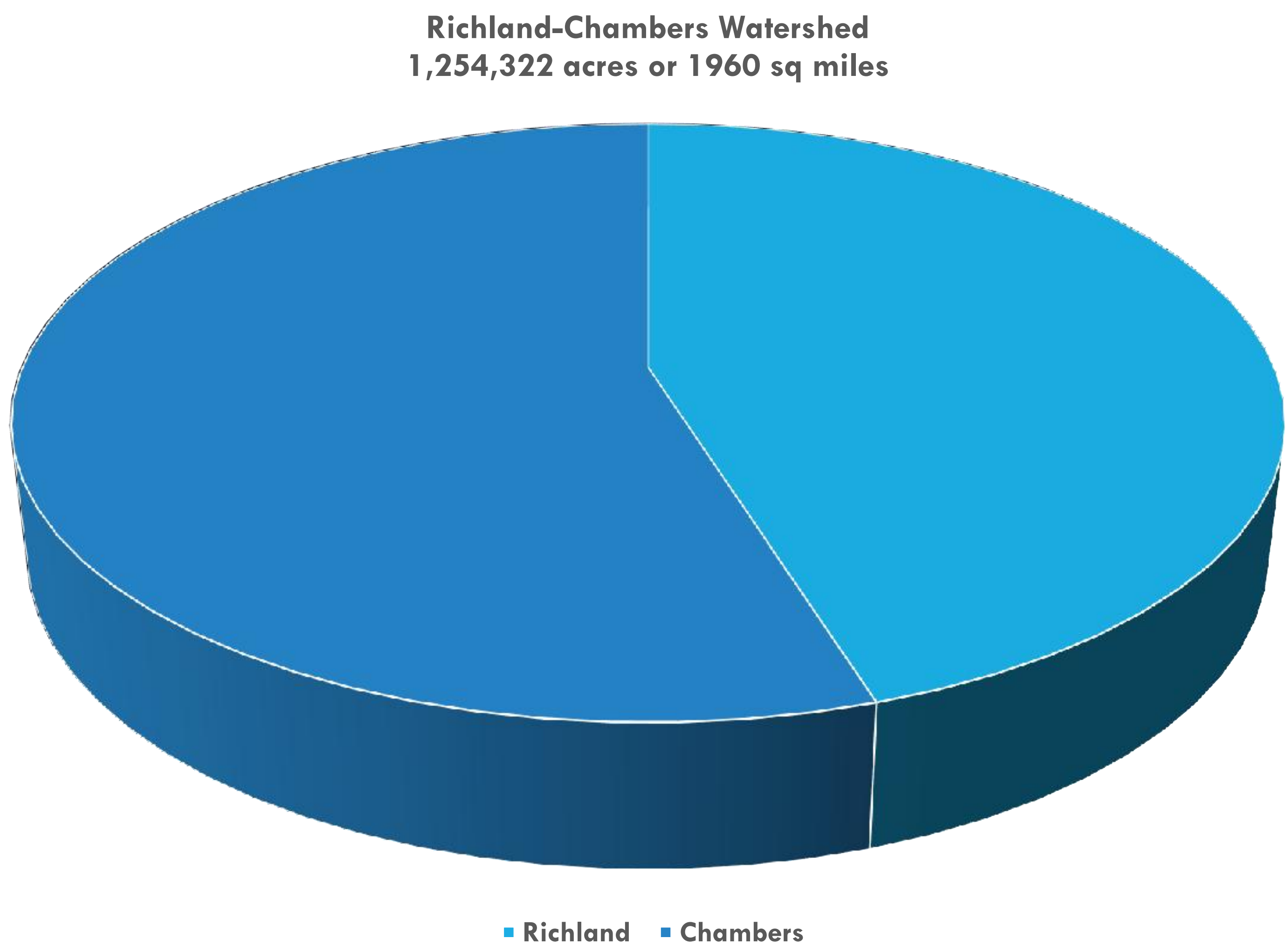
Change in sampling strategy: Storm vs routine

Reservoir release vs watershed runoff

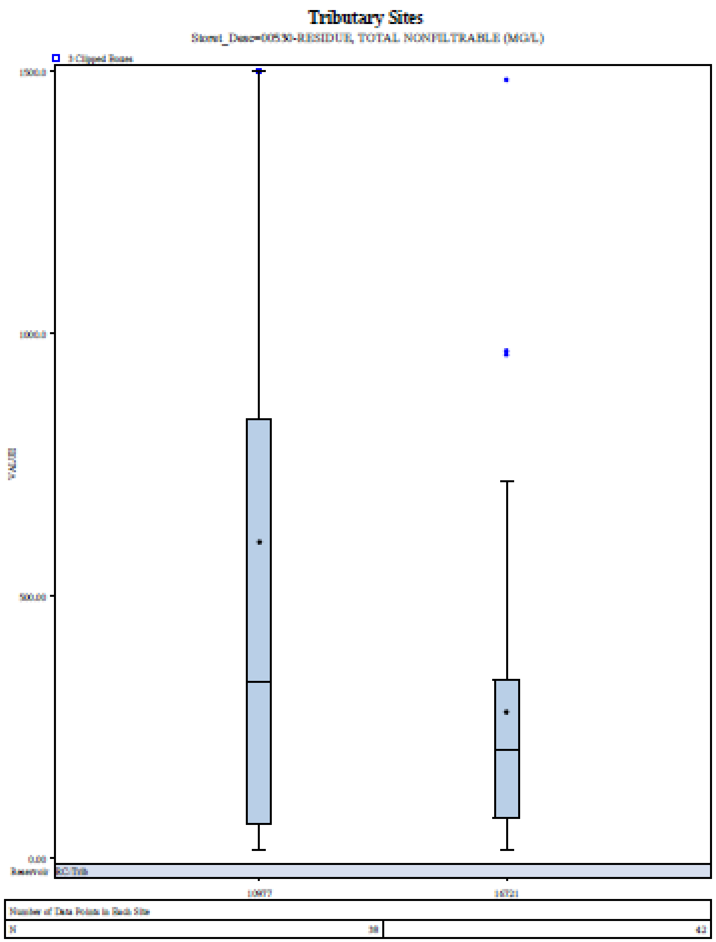
Seasonality

Long term dataset with drought and floods

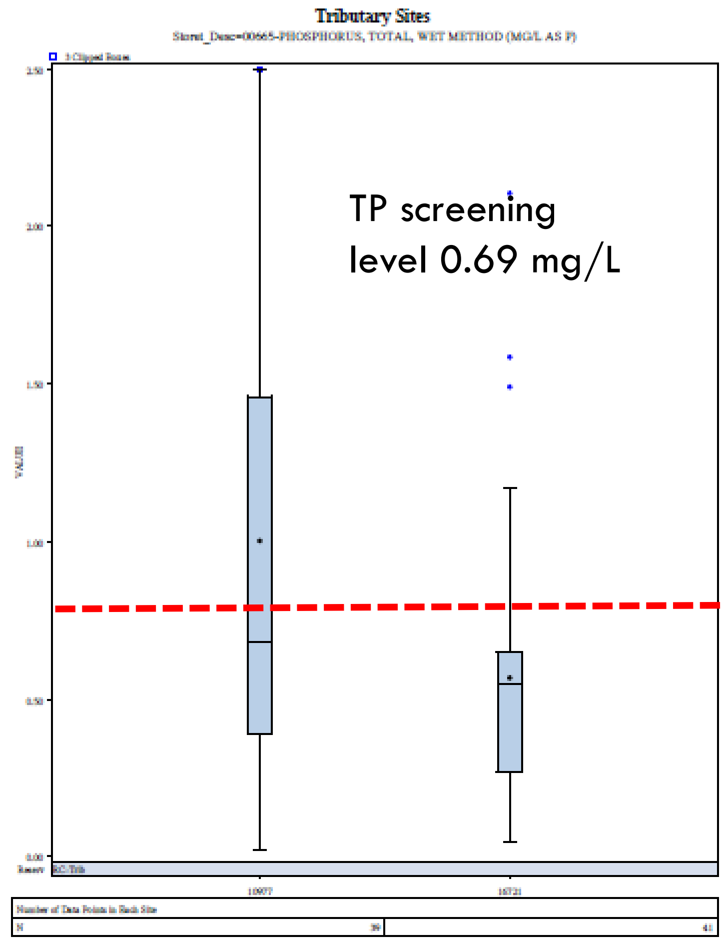
Lab changes


Richland-Chambers Watershed
1,254,322 acres or 1960 sq miles
Richland
Chambers

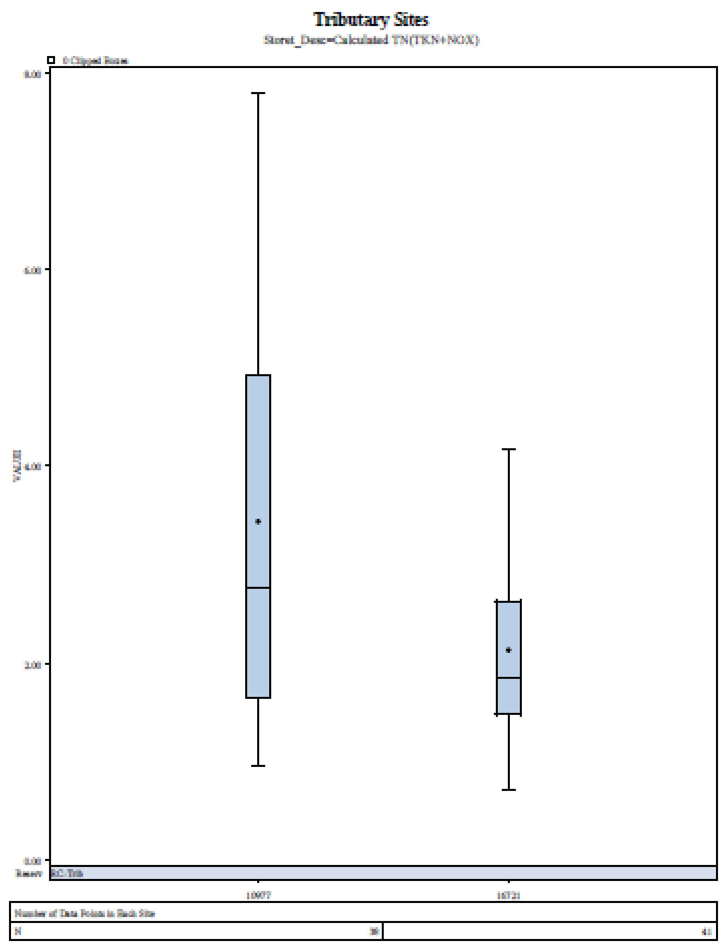
TSS


Tributary Sites
Storet_Desc=00530-RESIDUE, TOTAL NONFILTRABLE (MG/L)

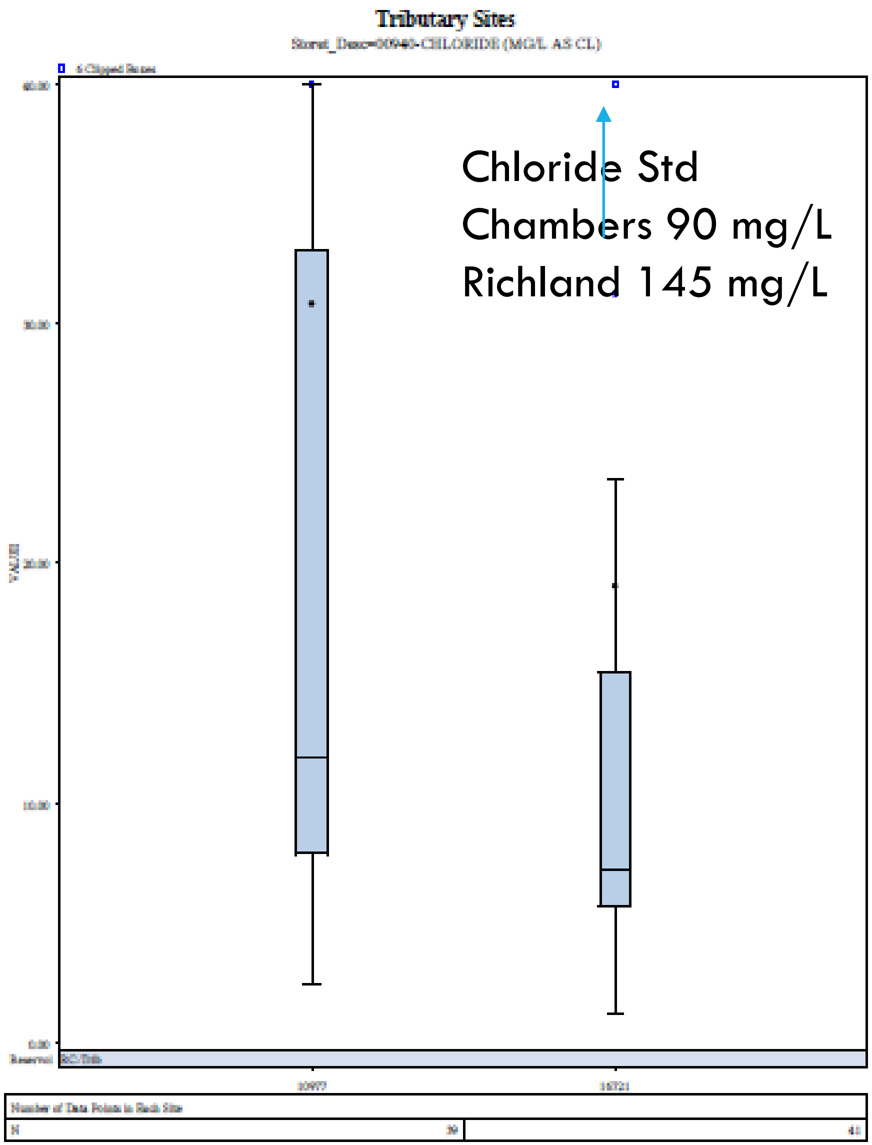
TP


Tributary Sites
Storet_Desc=00665-PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)
TP screening level 0.69 mg/L

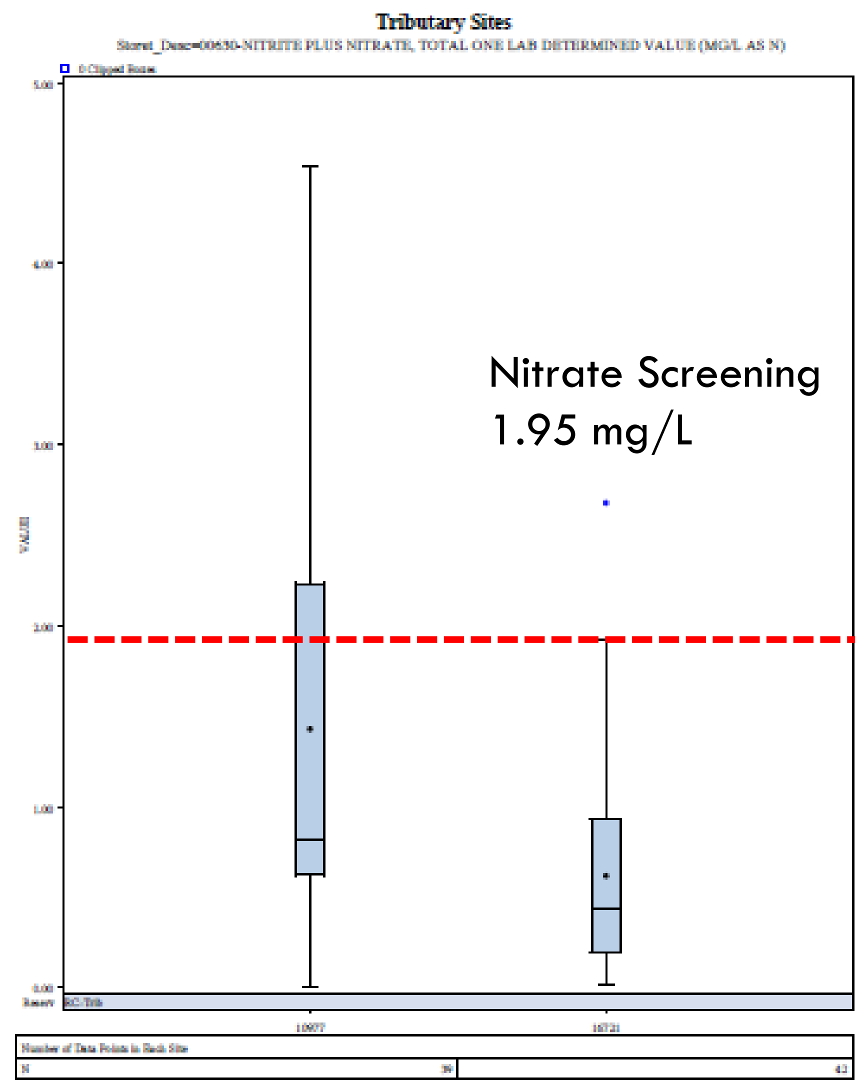
Total Nitrogen



Chloride



Nitrite + Nitrate



10-Year Tributary Trend Analysis 2007-2016
Only Statistically Significant Results

Site	Parameter	Median	Slope	P-value
Chambers	Flow (cfs)	1303	-1.5	.0048
Chambers	NOX (mg/L)	.82	.0004	.0382
Chambers	TP (mg/L)	.68	-.0003	.0053
Chambers	TOC (mg/l)	8.0	-.0016	.0208
Richland	Flow (cfs)	1038	-2.44	.0039
Richland	TP (mg/L)	.55	-.0001	.0357

Chambers Trib site moved from FM 3041 to FM 1126 in 2012.
Sampling program also went more routine
at that time.

CONCLUSIONS

Water Quality of Richland-Chambers Reservoir is quite good. 2nd in our system.

Definite longitudinal gradients from the headwater to the dam

Reservoir shows to be P limited in the main pool

Chambers Creek carries more water, sediment, salts and nutrients.

Where do we assess success?

TOOL TO ASSESS THE P LOADING OF THE RESERVOIR

Procedures to Implement the Texas Surface Water Quality Standards

Prepared by
Water Quality Division

RG-194
June 2010

$$P = \frac{L}{Vs + z/\mathcal{T}}$$

Where: P is the Lake Phosphorus concentration (mg/l)

L annual areal Phosphorus loading rate (load/median area, g/m^2-yr)

V_s is the apparent settling velocity or calibration coefficient (m/yr)

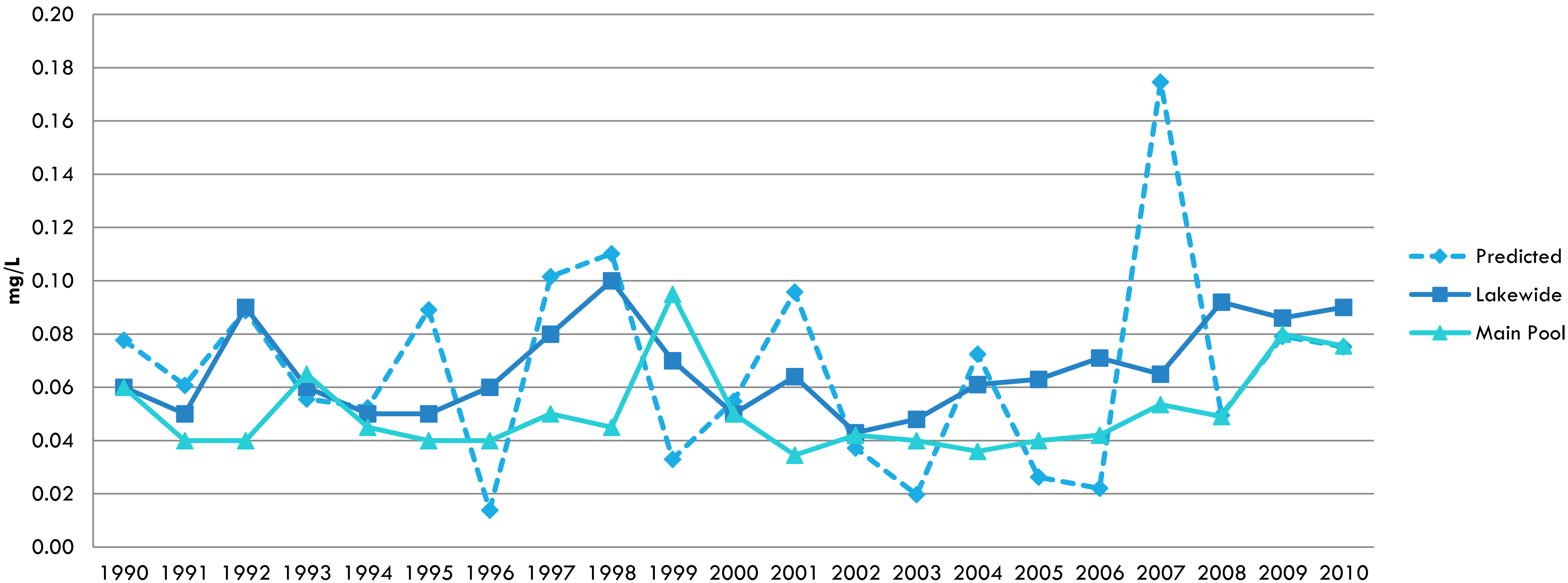
z is the median depth (m)

$\mathcal{T}$ is the hydraulic detention time (median volume/ total outflow, yr)

Reckhow, K.H. 1979. Empirical Lake Models for Phosphorus: Development, Applications, Limitations and Uncertainty.

In Perspectives on Lake Ecosystem Modeling. Ann Arbor Science

Richland-Chambers Reservoir TP Concentrations



Equation 7: $\ln(Chl\ a, \mu g/L) = 0.9312 \ln(TP, mg/L) + 5.14$

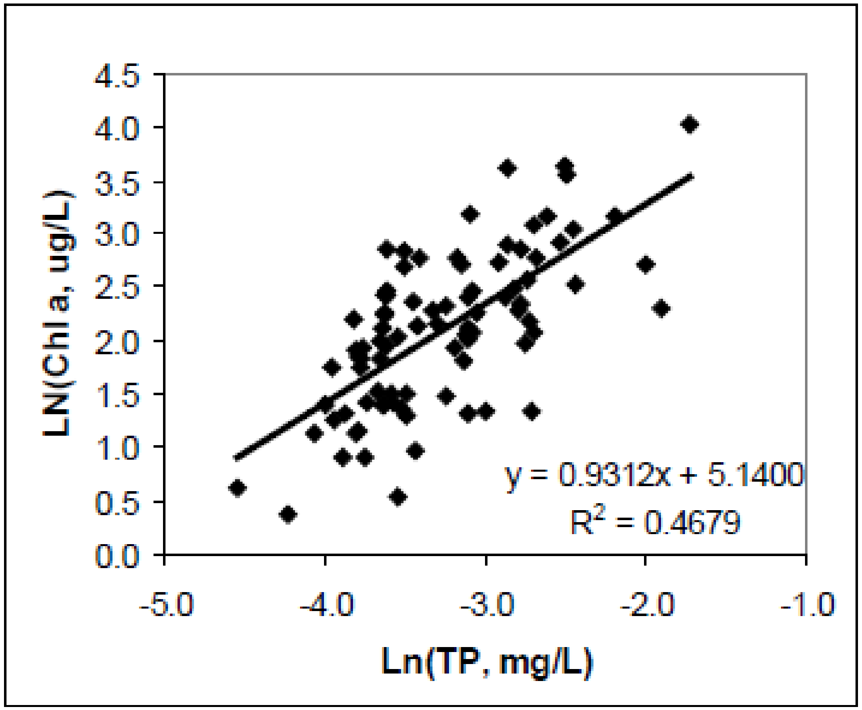
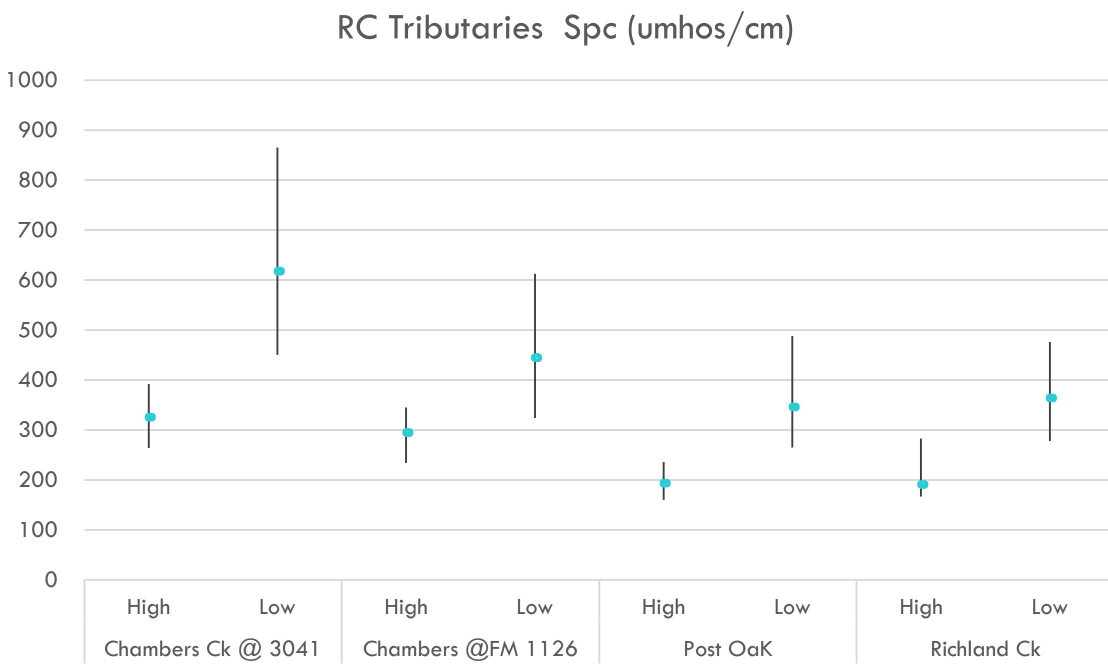
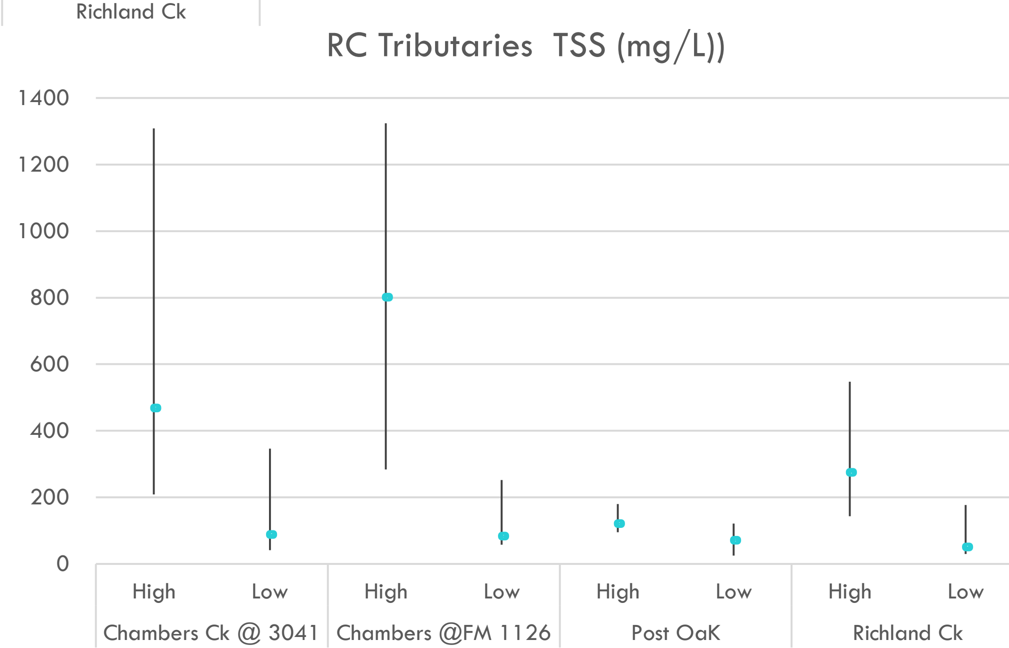


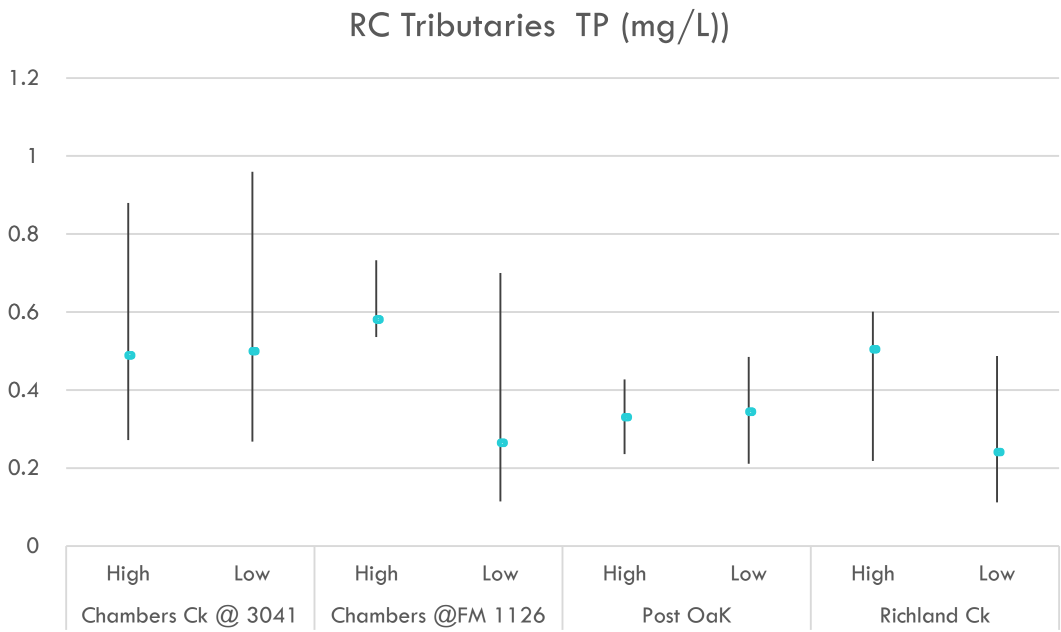
Figure 2. Relationship of mean chlorophyll *a* concentration to mean total phosphorous concentration in reservoirs.

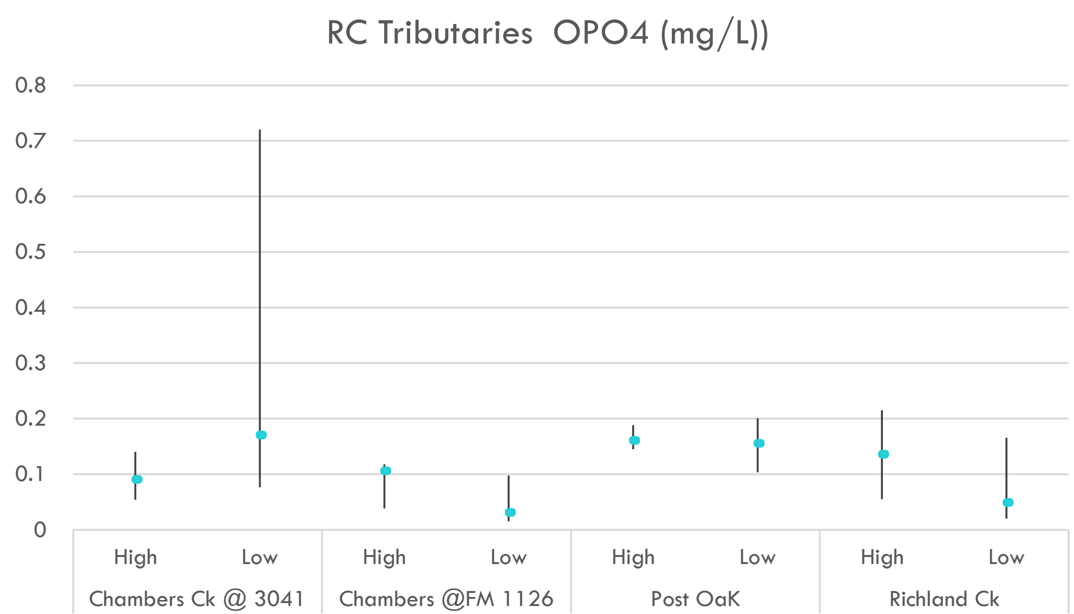
Source: TCEQ Implementation Procedures 2010

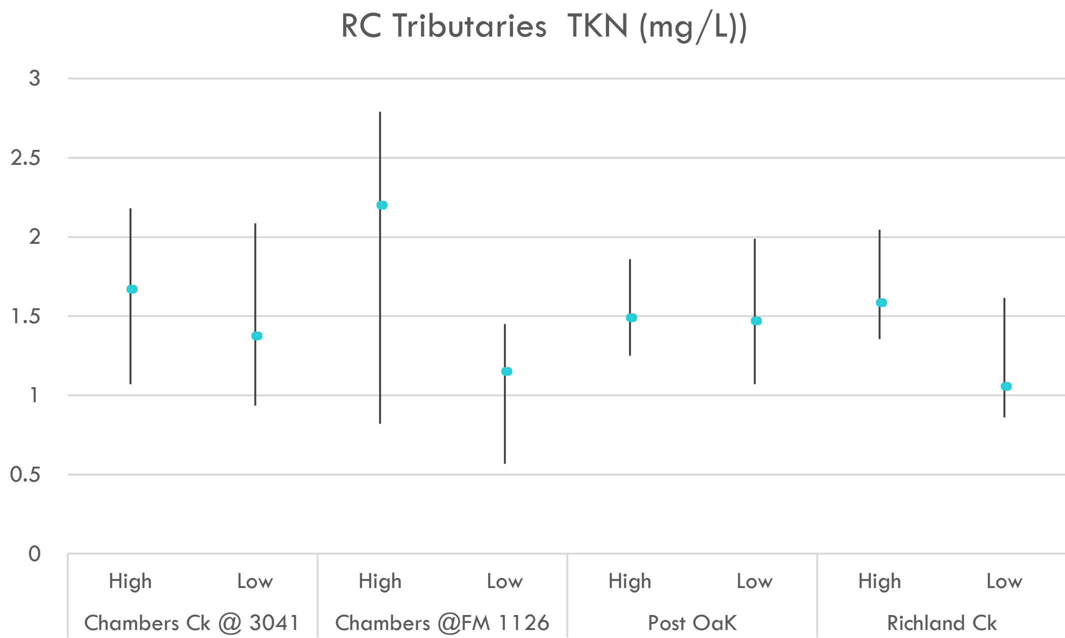
Median and Percentiles for Main Tributaries to Richland-Chambers Reservoir 1990 to present

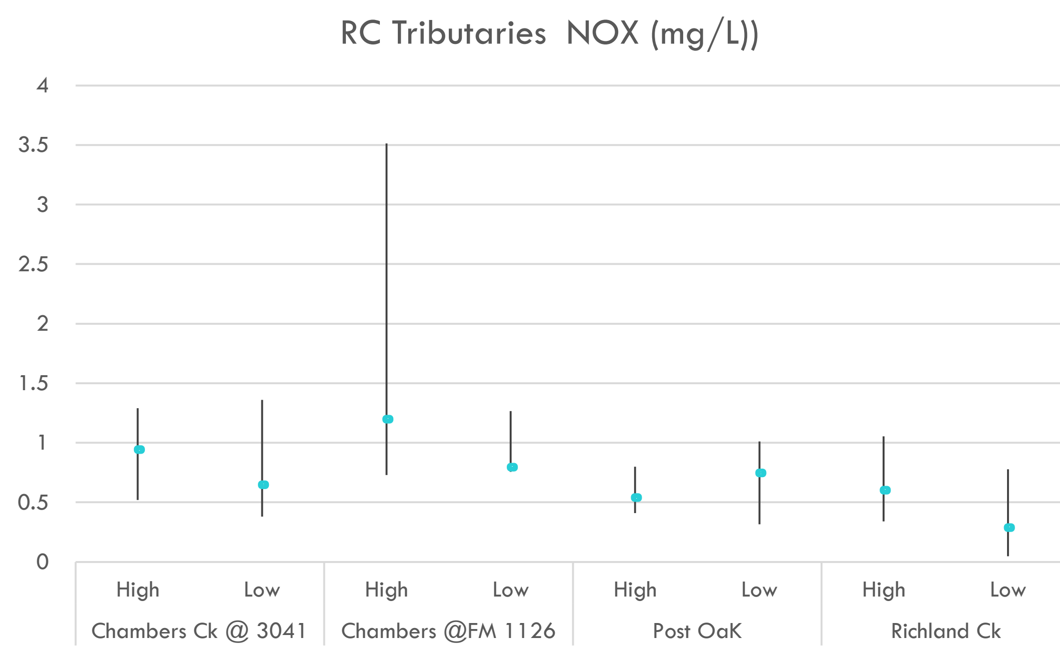





RC Tributaries TP (mg/L))
1.2
1
0.8
0.6
0.4
0.2
0
High
Low
High
Low
High
Low
High
Low
Chambers Ck @ 3041
Chambers @FM 1126
Post OaK
Richland Ck


RC Tributaries OPO4 (mg/L))
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
High
Low
High
Low
High
Low
High
Low
Chambers Ck @ 3041
Chambers @FM 1126
Post OaK
Richland Ck


RC Tributaries TKN (mg/L))
3
2.5
2
1.5
1
0.5
0
High
Low
High
Low
High
Low
High
Low
Chambers Ck @ 3041
Chambers @FM 1126
Post OaK
Richland Ck


RC Tributaries NOX (mg/L))
4
3.5
3
2.5
2
1.5
1
0.5
0
High
Low
High
Low
High
Low
High
Low
Chambers Ck @ 3041
Chambers @FM 1126
Post OaK
Richland Ck

Richland-Chambers Watershed Partnership

Stakeholder Meeting
September 20-21, 2016

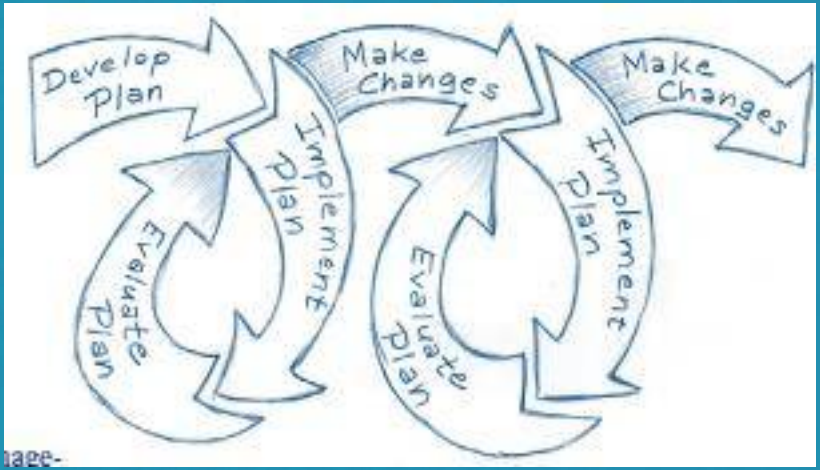
Setting Goals

TINA HENDON, TRWD

Watershed Protection Plans

Steps to Effective Watershed Management

1. Build partnerships
2. Characterize your watershed
3. Establish goals & identify solutions
4. Develop an implementation program
5. Implement your plan
6. Measure progress & make adjustments

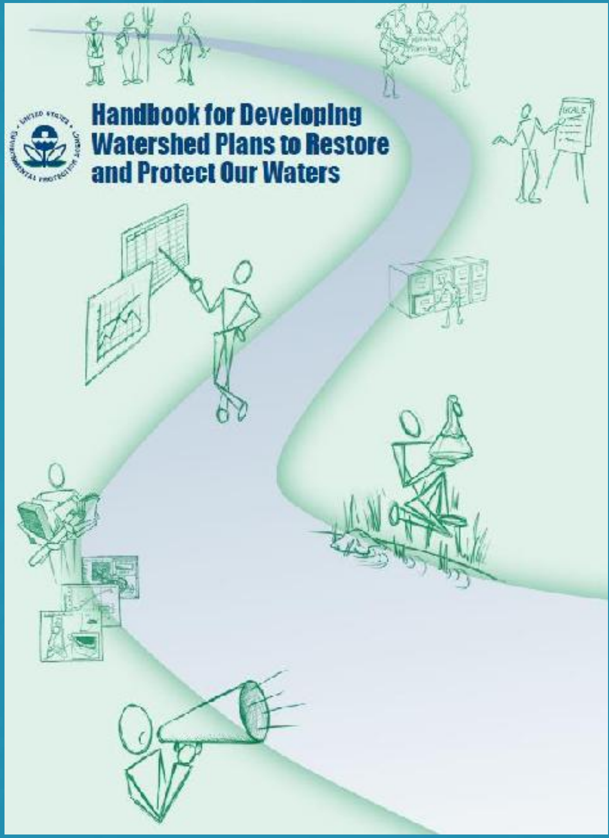


The outcomes of this process are documented or referenced in a watershed plan.

Watershed Protection Plans

Nine Elements of a Successful Watershed Plan

A. Identify problem & sources
B. Reductions needed to reach goals
C. Identify measures needed to achieve reductions
D. Assistance needed
E. Education & outreach plan
F. Schedule
G. Milestones
H. Criteria for measuring progress
I. Monitoring Plan



		"Nine Elements"								
		A	B	C	D	E	F	G	H	I
Planning process	Build Partnerships									
	Characterize Watershed	X								
	Goals and Solutions		X	X						
	Implementation Program				X	X	X	X	X	X
	Implement the Plan									
	Measure Progress & Make Adjustments									

Developing Goals

Where do we start?

- What’s the problem? Why are we here?
- You’re here because you’re interested in some facet of the project.
  - Natural Environment
  - Regulatory Environment
  - Economic Environment
  - Or maybe just curious or skeptical

Developing Goals

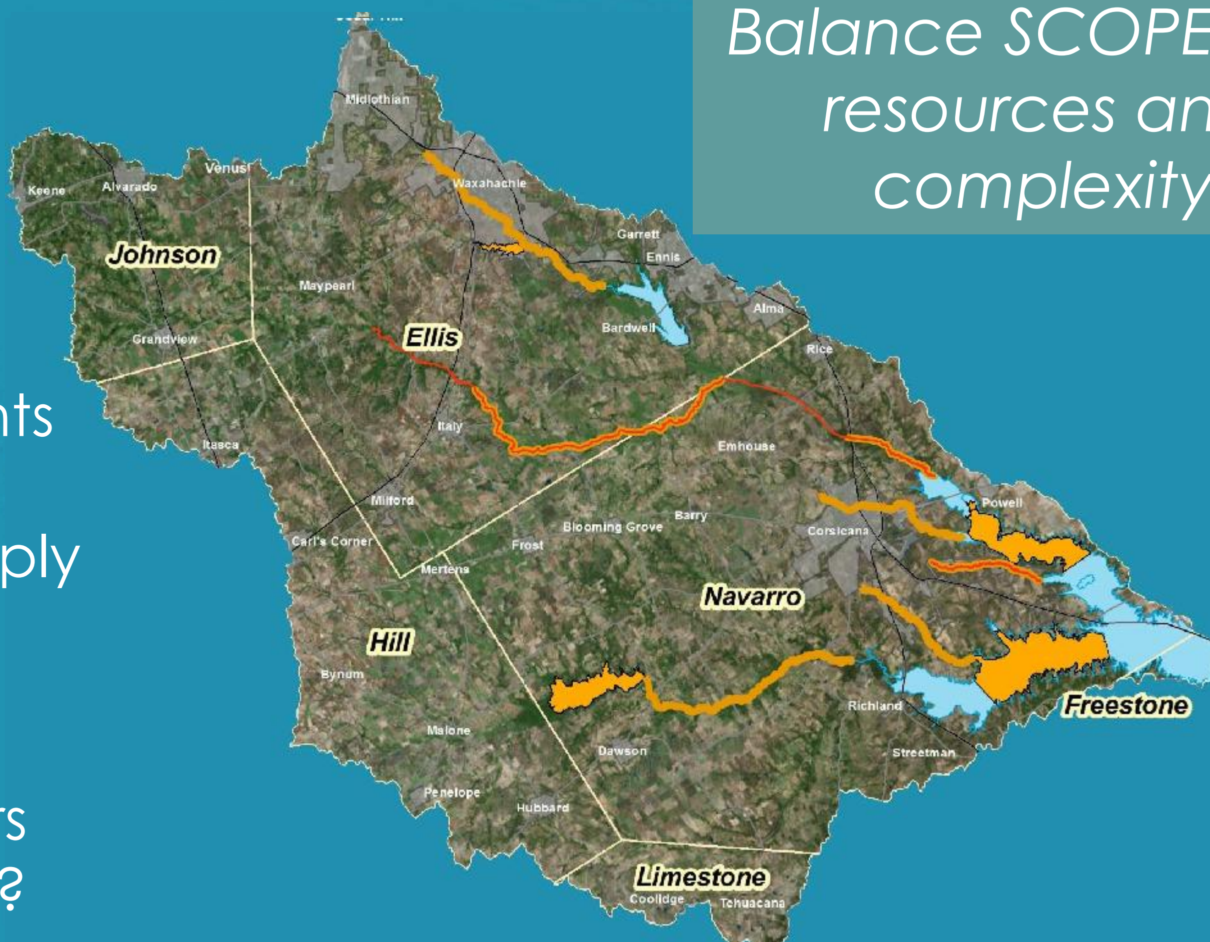
SCOPE *sets the boundaries of the project.*

Where?
- Streams
- Lake
- Both

What?
- Impairments
- Concerns
- Water Supply

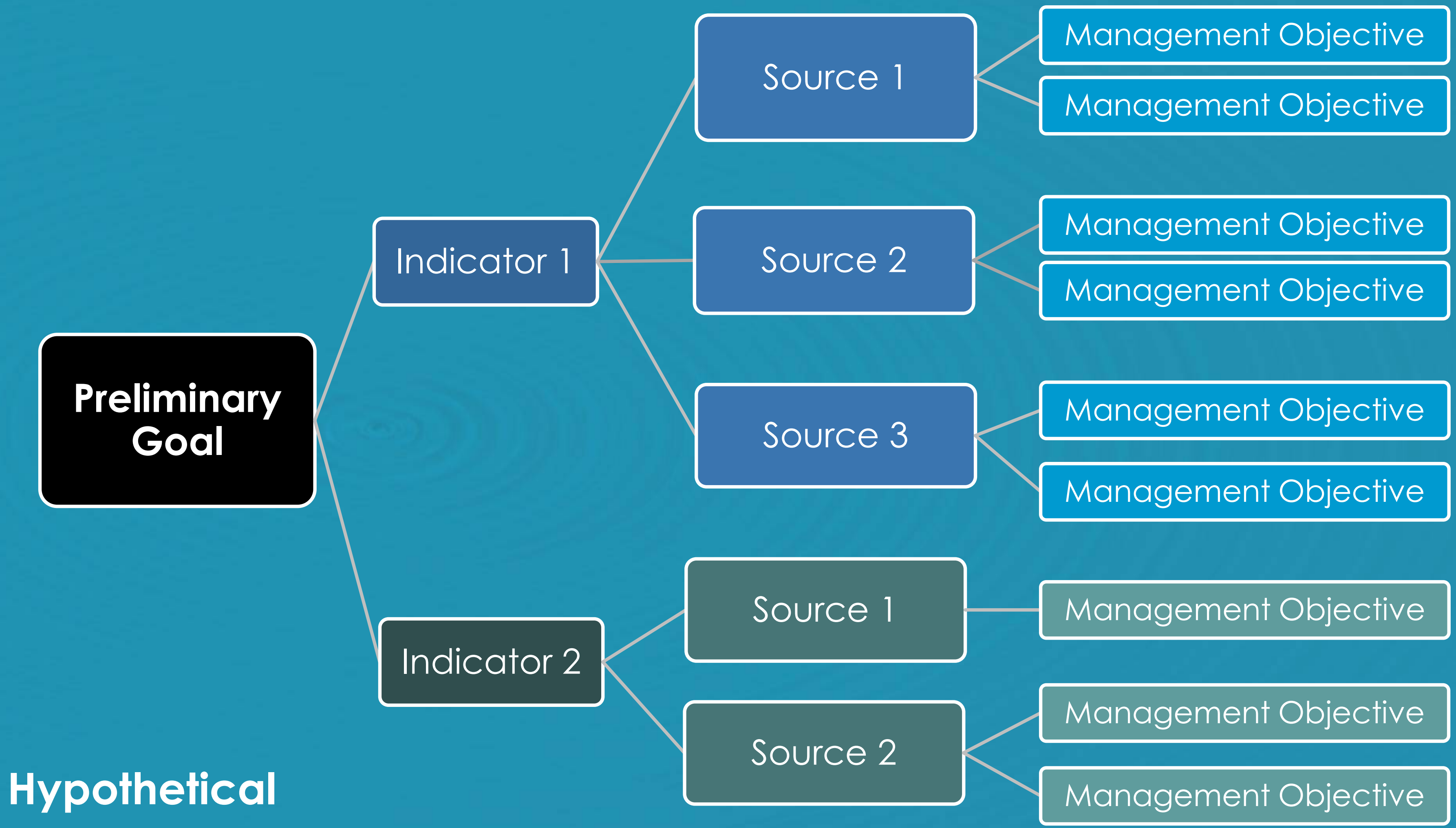
When?
- 5 years
- 10 years
- Longer?

Balance SCOPE with resources and complexity



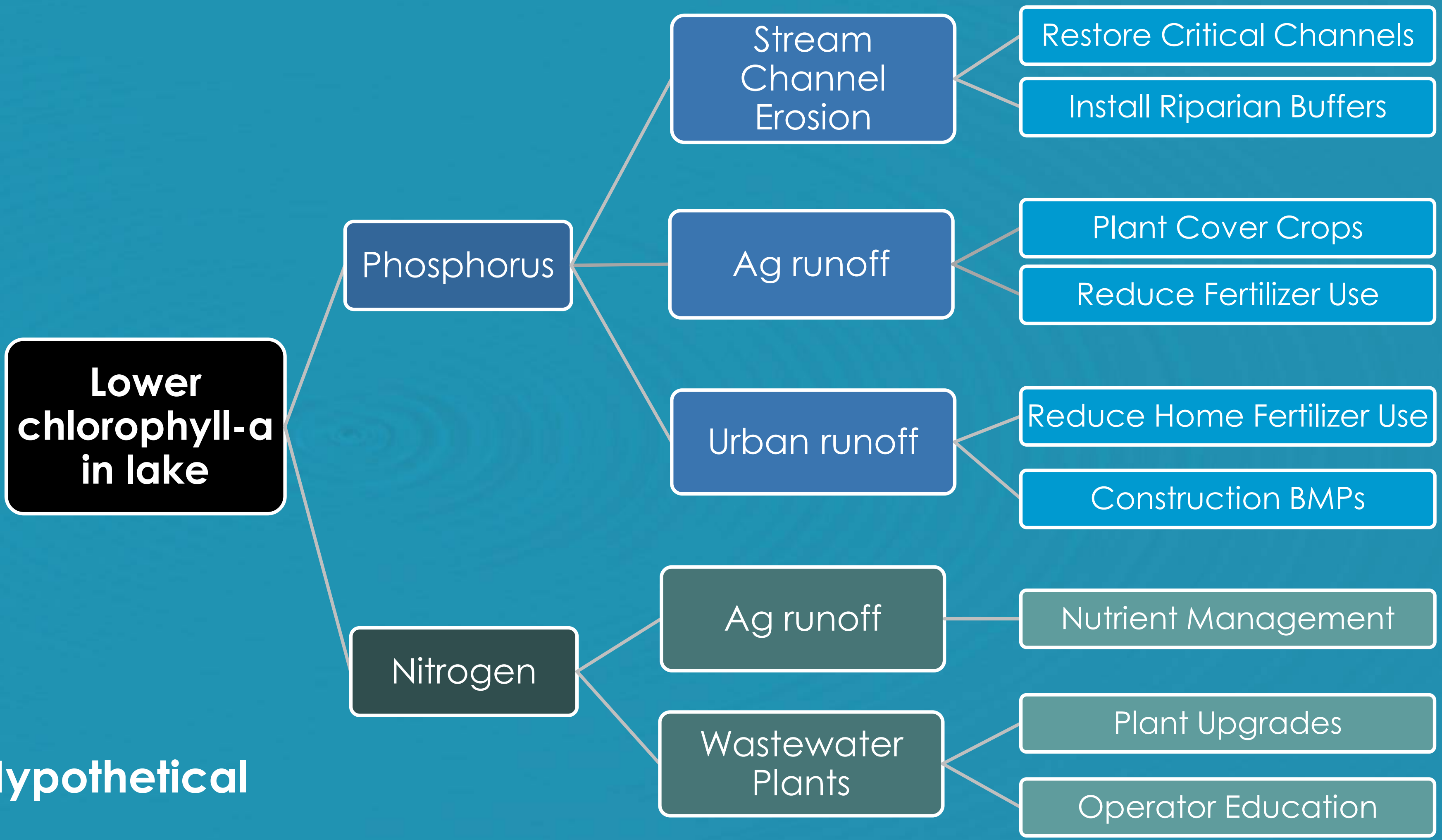
Developing Goals

Translating Goals into Management Objectives



Developing Goals

Translating Goals into Management Objectives



Hypothetical

Developing Goals

Managing Objectives to Measure Success

- Restore Critical Channels
- Install Riparian Buffers
- Plant Cover Crops
- Reduce Home Fertilizer Use
- Reduce Fertilizer Use
- Construction BMPs
- Nutrient Management
- Operator Education
- WWTP Plant Upgrades

Each management objective is

- quantified,
- assigned to a target area,
- scheduled,
- tracked, and
- evaluated at predetermined intervals.

Developing Goals

Where to focus?

- The watershed boundary defines an interconnected and interdependent system.
- What happens anywhere in a watershed affects downstream water bodies.
- Policy and guidance indicate that WPPs should be developed to address all identified water quality problems in a watershed.

Developing Goals

What issues to address?

- Impairments have to be addressed with a TMDL within 13 years of listing
- Concerns "less urgent" but may signal impending or future problems.

Water Body	N	DO	Chl-a	Cl
Chambers Creek			CS	Imp
Waxahachie Creek	CS			
Lake Waxahachie			CS	
Cedar Creek		Imp		
Post Oak Creek		CS		
Richland Creek		CS	CS	
Navarro Mills Lake		CS		
Grape Creek		CN		
Richland-Chambers Lake			**CS**	

- Other issues such as water supply and drinking water quality are not yet identified by TCEQ.

Restoration vs Protection?

Developing Goals

Considerations:

- TCEQ reports that
  - several impairments and concerns are not supported by sufficient water quality data.
  - Some impairments and concerns have been carried forward from previous reports without new supporting data.

Questions:

- Are these impairments and concerns still a problem?
- Are new data needed to consider these for goals?

Developing Goals

How long will all this take?

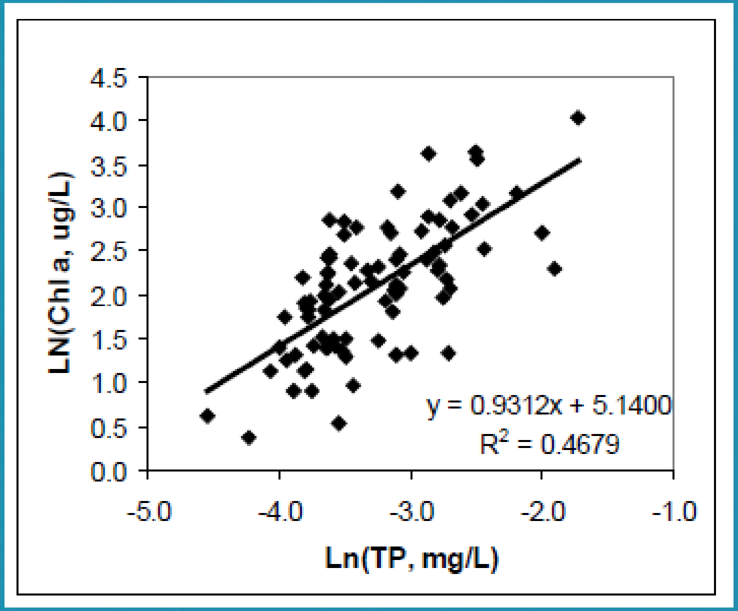
- WPPs are generally written for10 year periods.
- If project lasts longer, WPP is updated and the time needed to meet goals can be reassessed.
- More complex issues may take longer, while more straightforward issues may be resolved early in the project.

Developing Goals

Generally speaking…

- The combined issues of
  - elevated nutrients
  - Elevated chlorophyll-a,
  - low dissolved oxygen

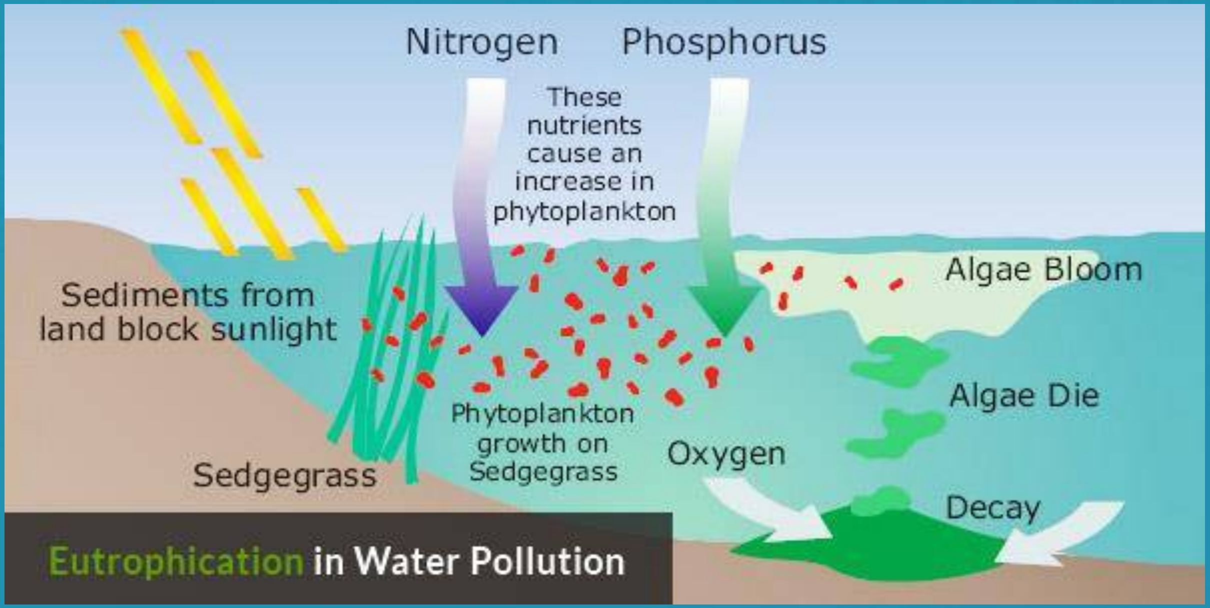
Point strongly to eutrophication related to phosphorus loading from the watershed.



Developing Goals

Review of Eutrophication

- Runoff of nutrients - typically nitrogen or phosphorus
- Promotes excessive plant growth and decay
- Causes water quality problems
  - Algae blooms
  - Taste & odor problems
  - Low dissolved oxygen



Developing Goals

Preliminary goals may include

- Addressing eutrophication problems in streams and the lake by reducing nutrient contributions from the watershed - likely phosphorus.
- Addressing lake sedimentation by reducing stormwater runoff and erosion in the watershed.

*Confirmation of concerns and impairments with insufficient data should take place before stakeholders invest in management measures to address them.

Questions?

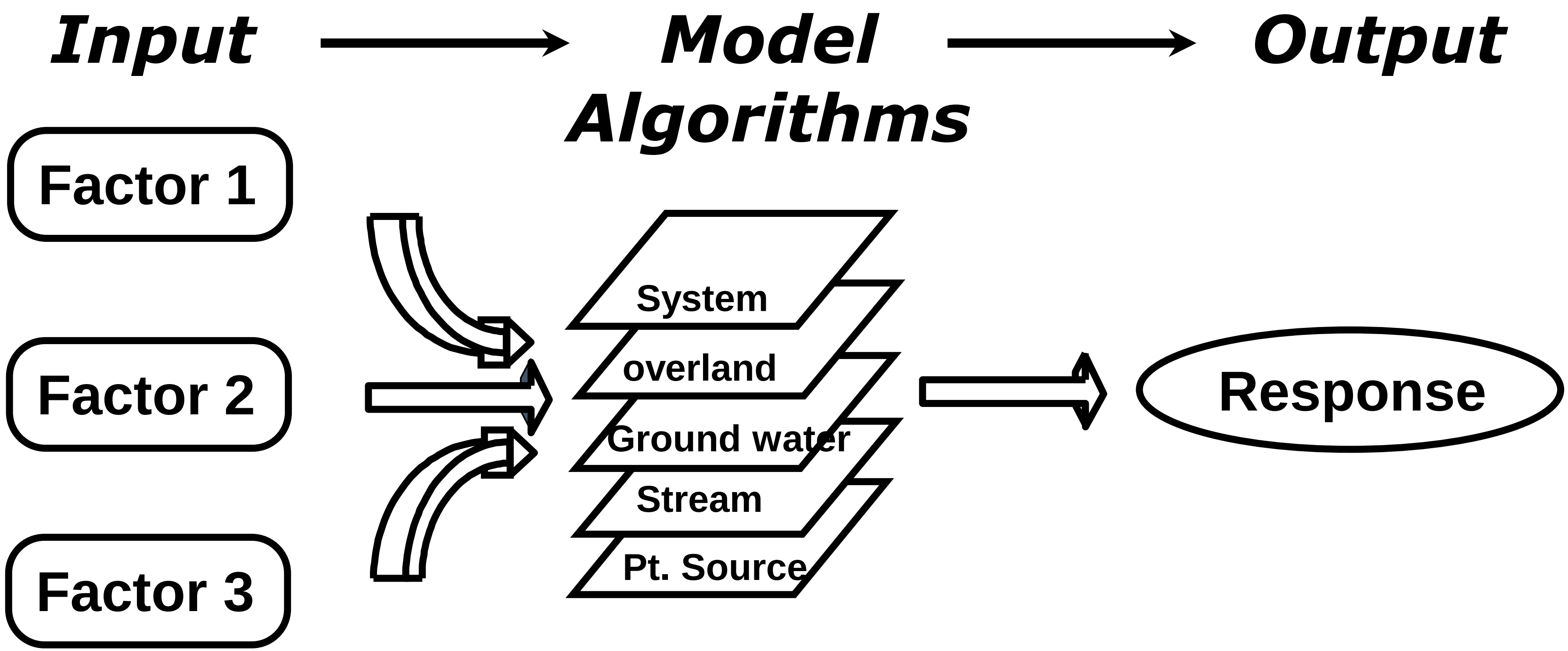
Water Body	**N**	**DO**	**Chl-a**	**Chloride**
Chambers Creek			CS	Imp
Waxahachie Creek	CS			
Lake Waxahachie			CS	
Cedar Creek		Imp		
Post Oak Creek		CS		
Richland Creek		CS	CS	
Navarro Mills Lake		CS		
Grape Creek		CN		
Richland-Chambers Lake			**CS**	

Watershed Model
Richland-Chambers Watershed

Stakeholders meeting
Waxahachie
(April 25, 2017)

R. Srinivasan
Essayas Ayana
Ecosystem Science and Management
Texas A&M University

Nuts and Bolts of a Model



Source: Quantify pollutant load: State of Michigan (Es-nps-quantifying-pollutant-loads_195909_7.ppt)

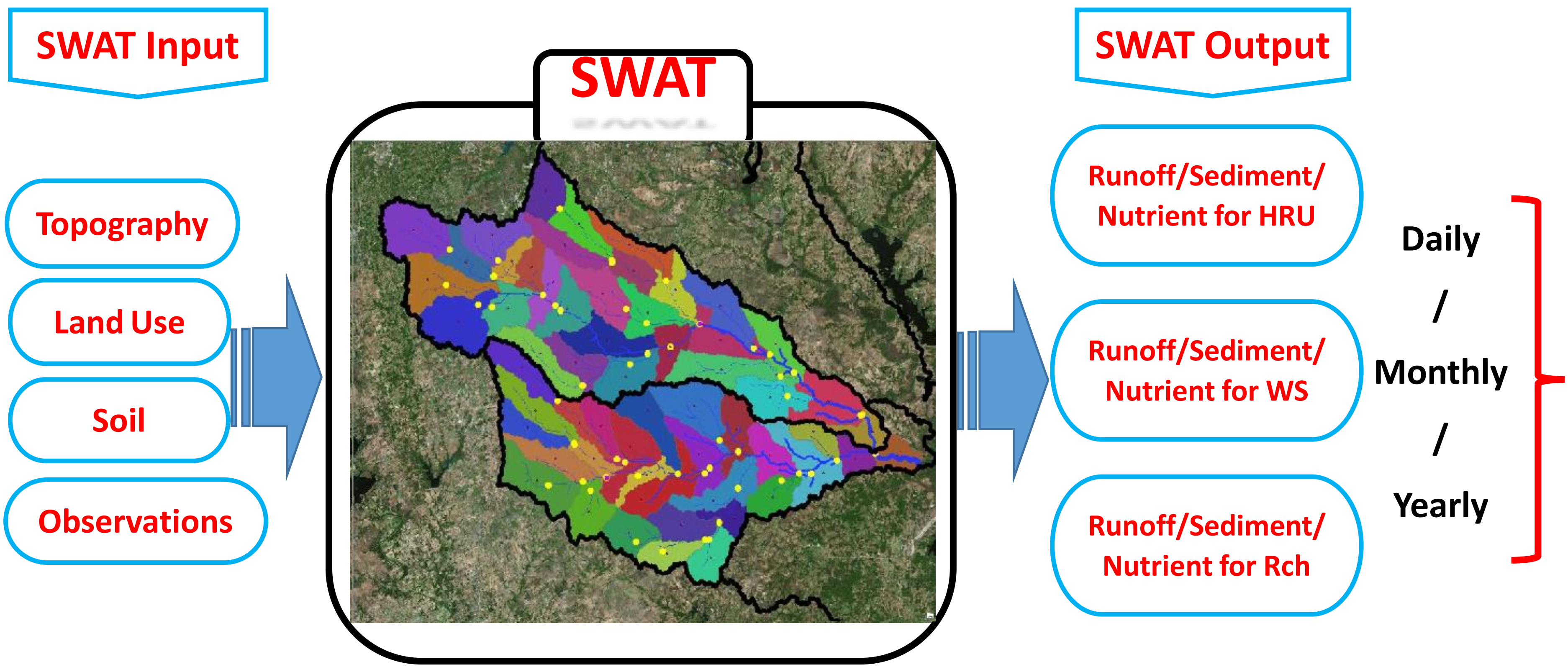
What our model do:

- Take spatial and non-spatial input

- apply set of equations or techniques to analyze
    - ***Rainfall/runoff***
    - ***Erosion and sediment transport***
    - ***Pollutant loading***
    - ***Stream transport***
    - ***Impact of Management practices***

SWAT in a Nutshell

- A river basin model used to predict
  - impact of land management practices on
    - Water/sediment/agricultural chemical yields

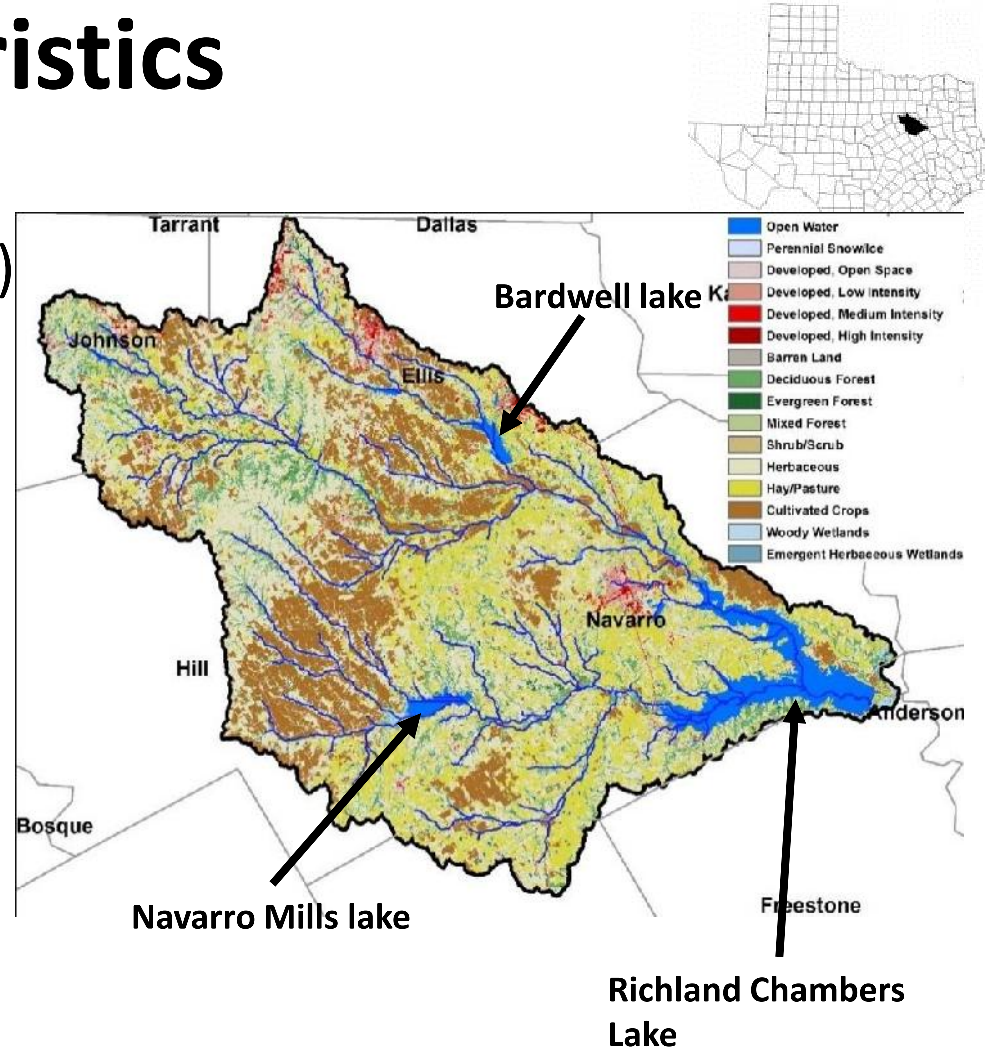


World_Imagery - Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Watershed characteristics

- Richland-Chambers Watershed
  - Area 5700 sq.km (2200 sq.mile)
  - Two HUC 8 /58 HUC 12 watersheds

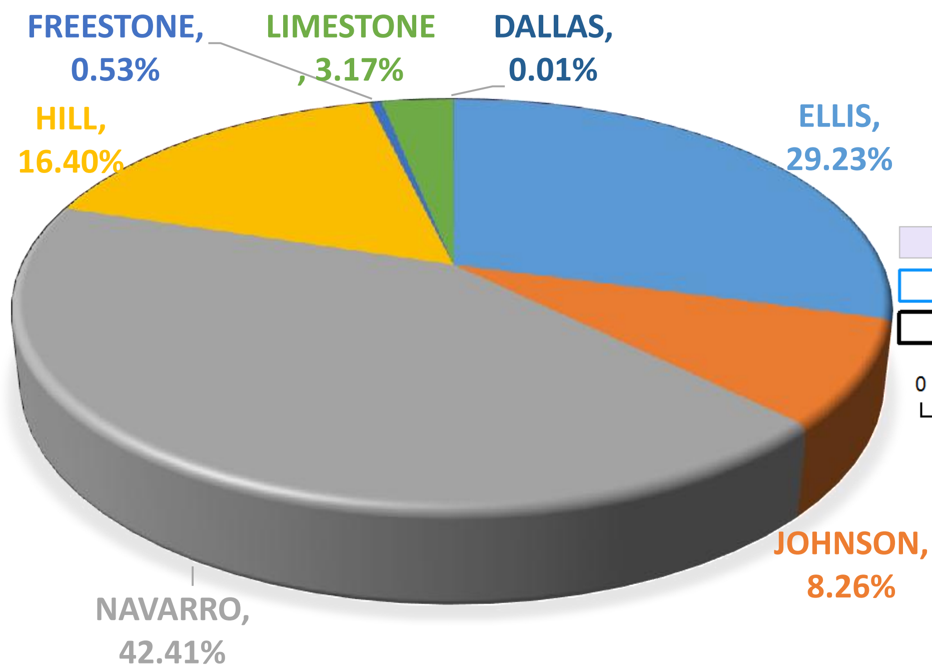
Agriculture	96222	19%
Forest	56390	11%
Water	29113	6%
Builtup	35872	7%
Range-Grasses	154222	30%
Pasture	121564	24%
Range-Brush	2689	1%

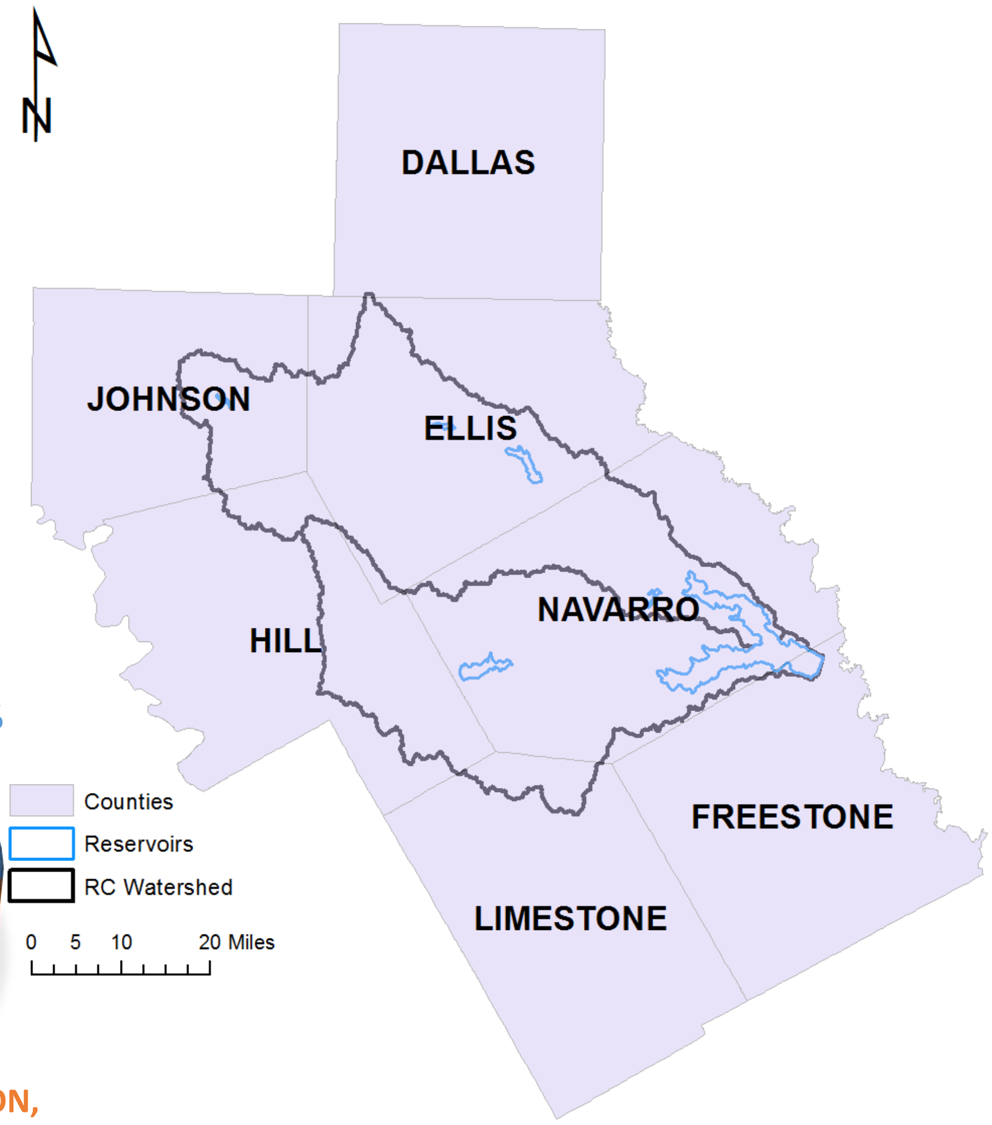


- Several BMPs implemented by USDA-NRCS to improve water quality

Counties in watershed

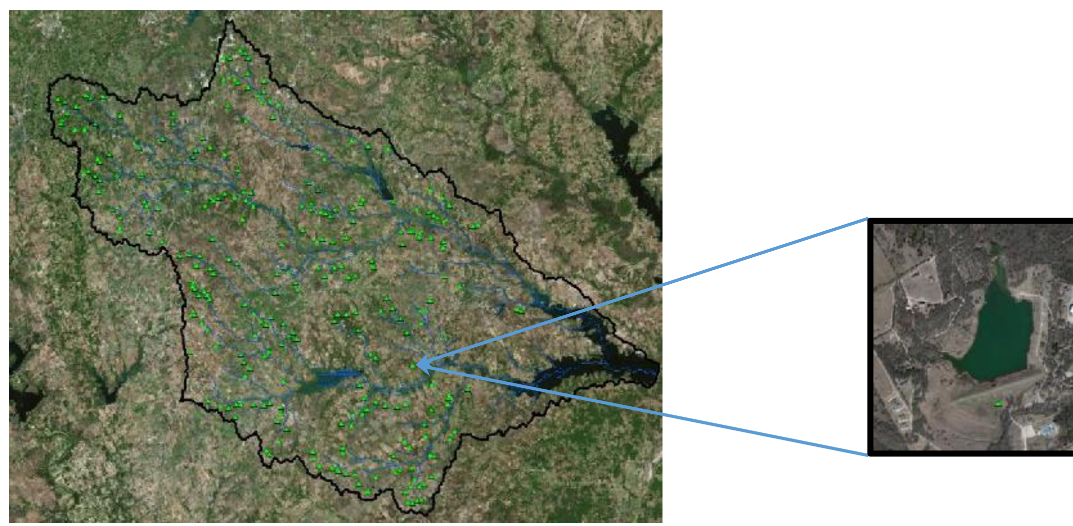
- Counties and their area proportion of watershed





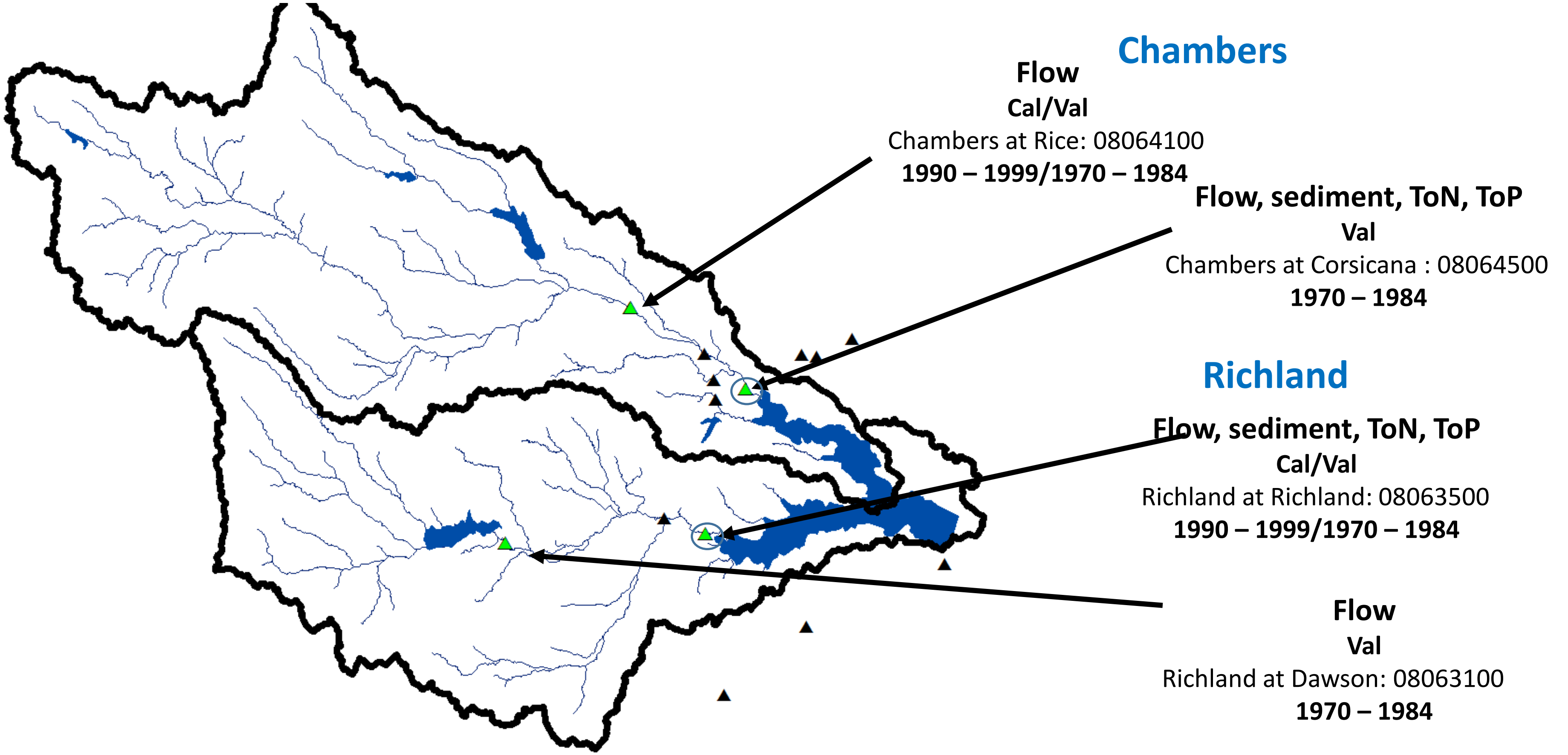
Data requirement

- Watershed characterization
    - USGS predefined Sub-watersheds and streams
- Land use land cover
    - USGS-NLCD and USDA-NASS combined
- Soils
    - NCRS-SSURGO soils
- Ponds and reservoirs
    - USDA-NRCS
        - Surface area
        - Volume

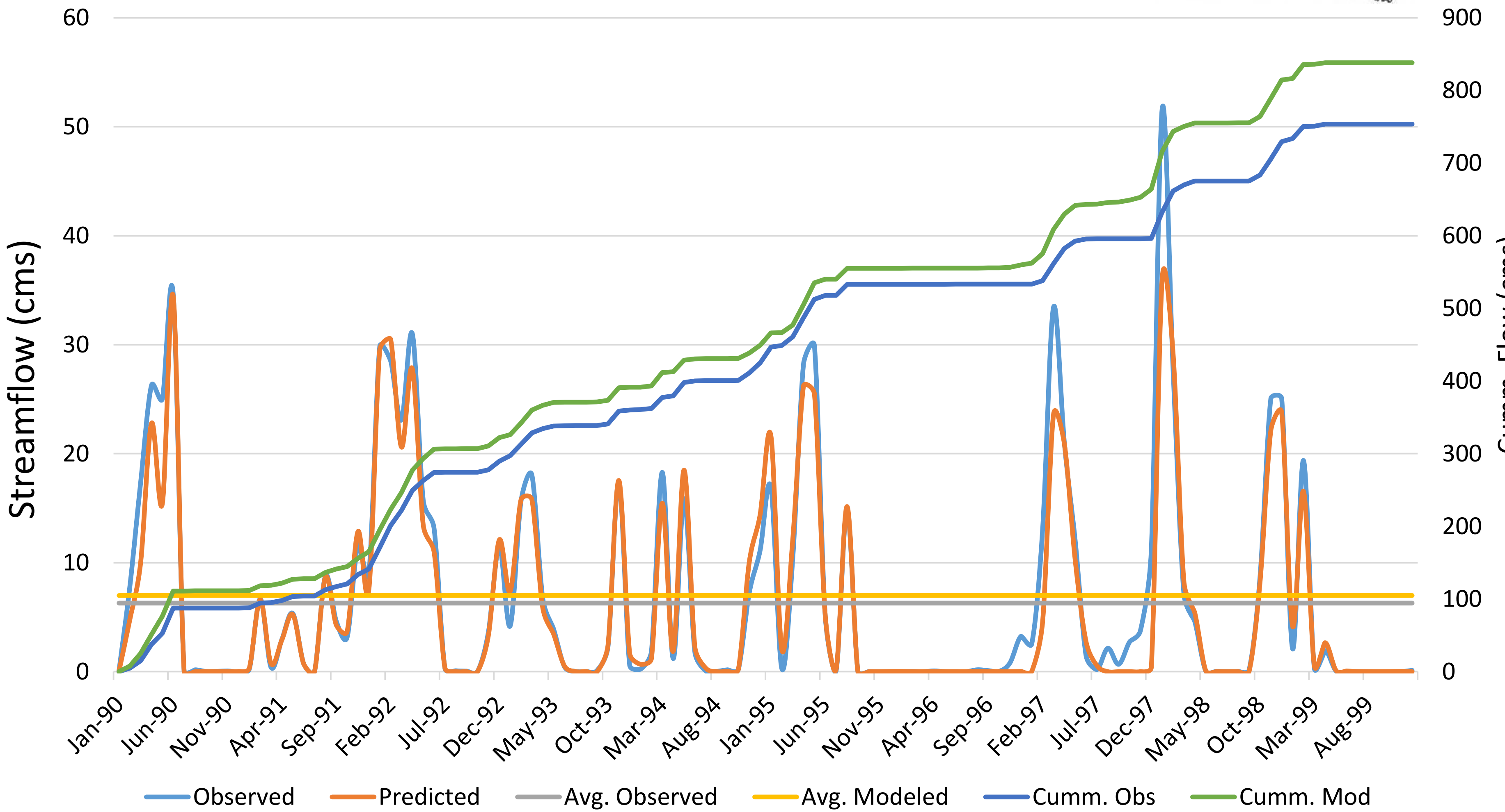


Model evaluation

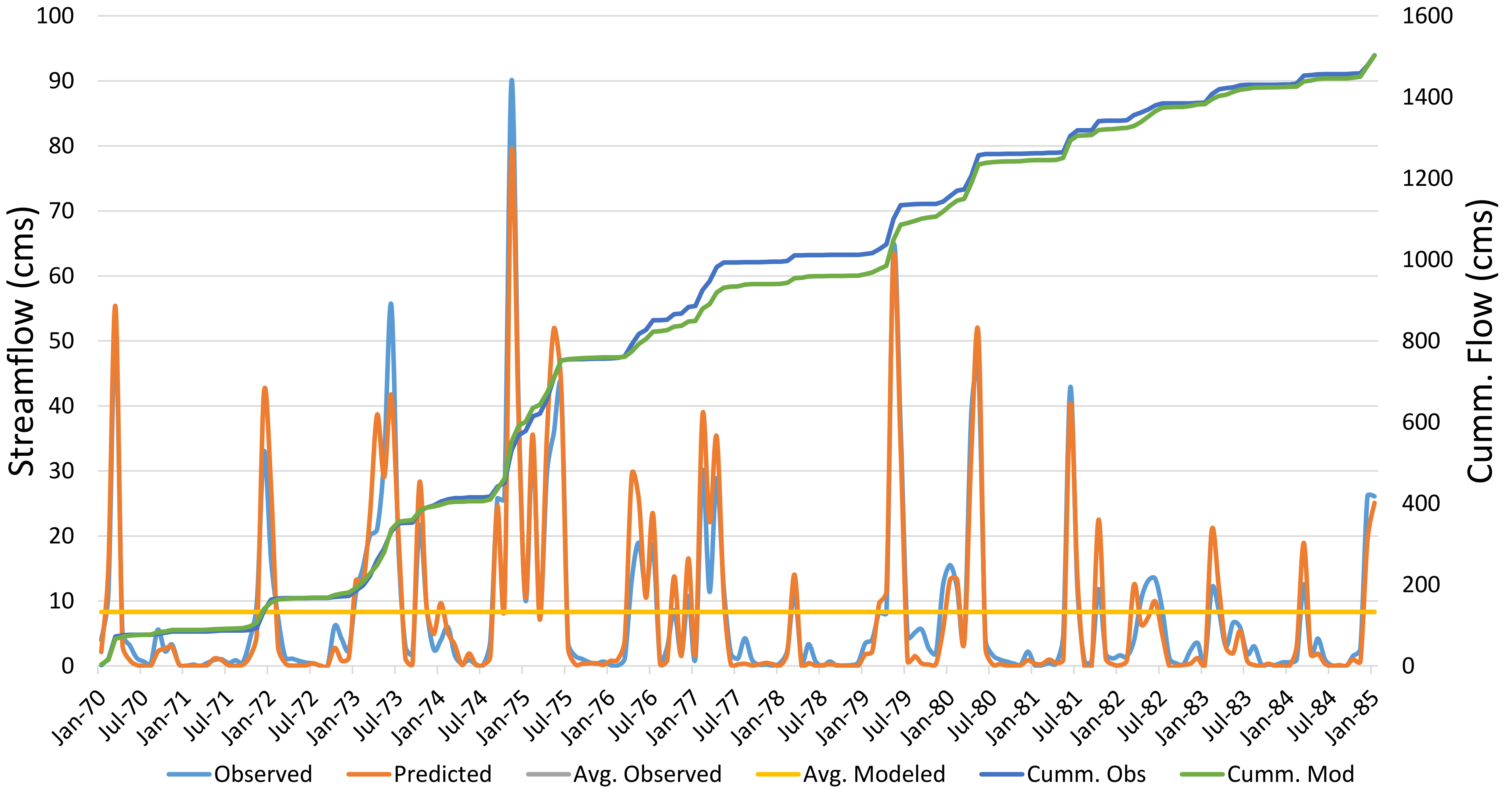
- A model verification step
  - How good is the model to represent a process on interest in our watershed?
  - Can the model be used to tell about the future?



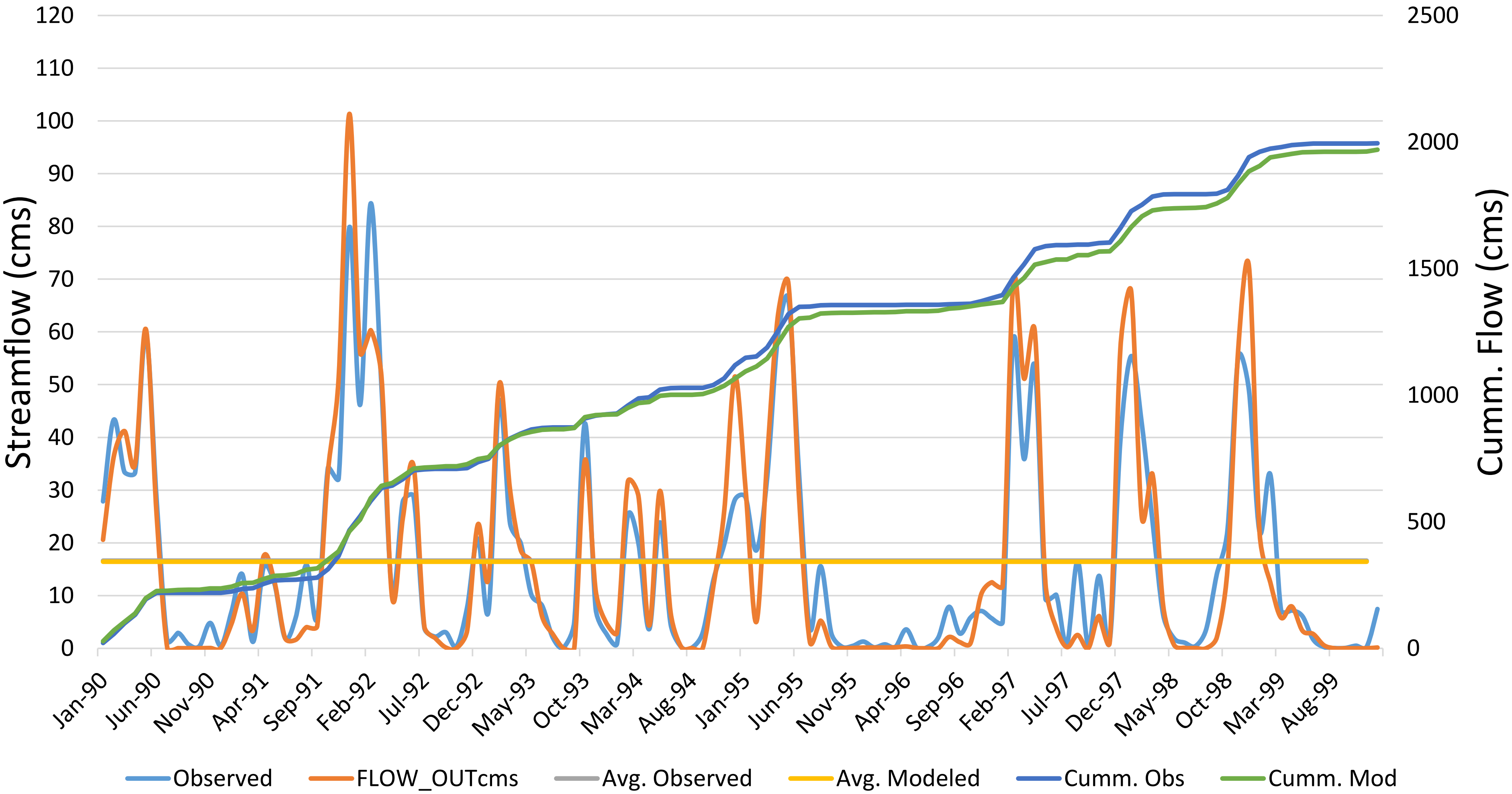
Results - Flow



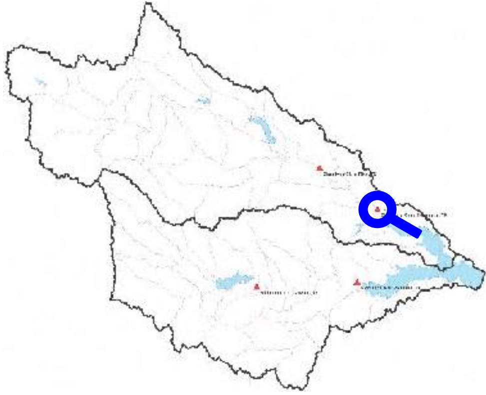
Results - Flow

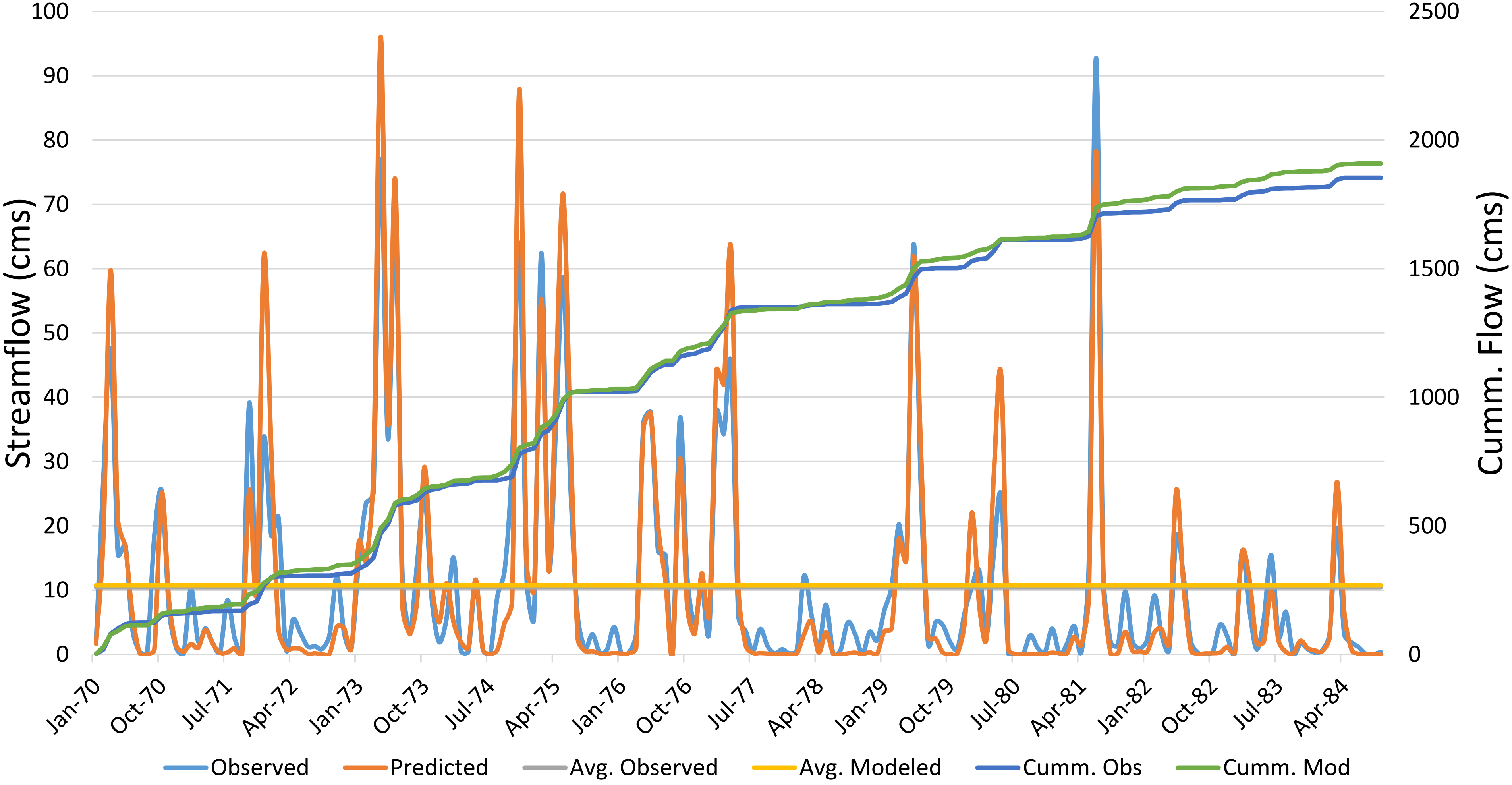


Results - Flow

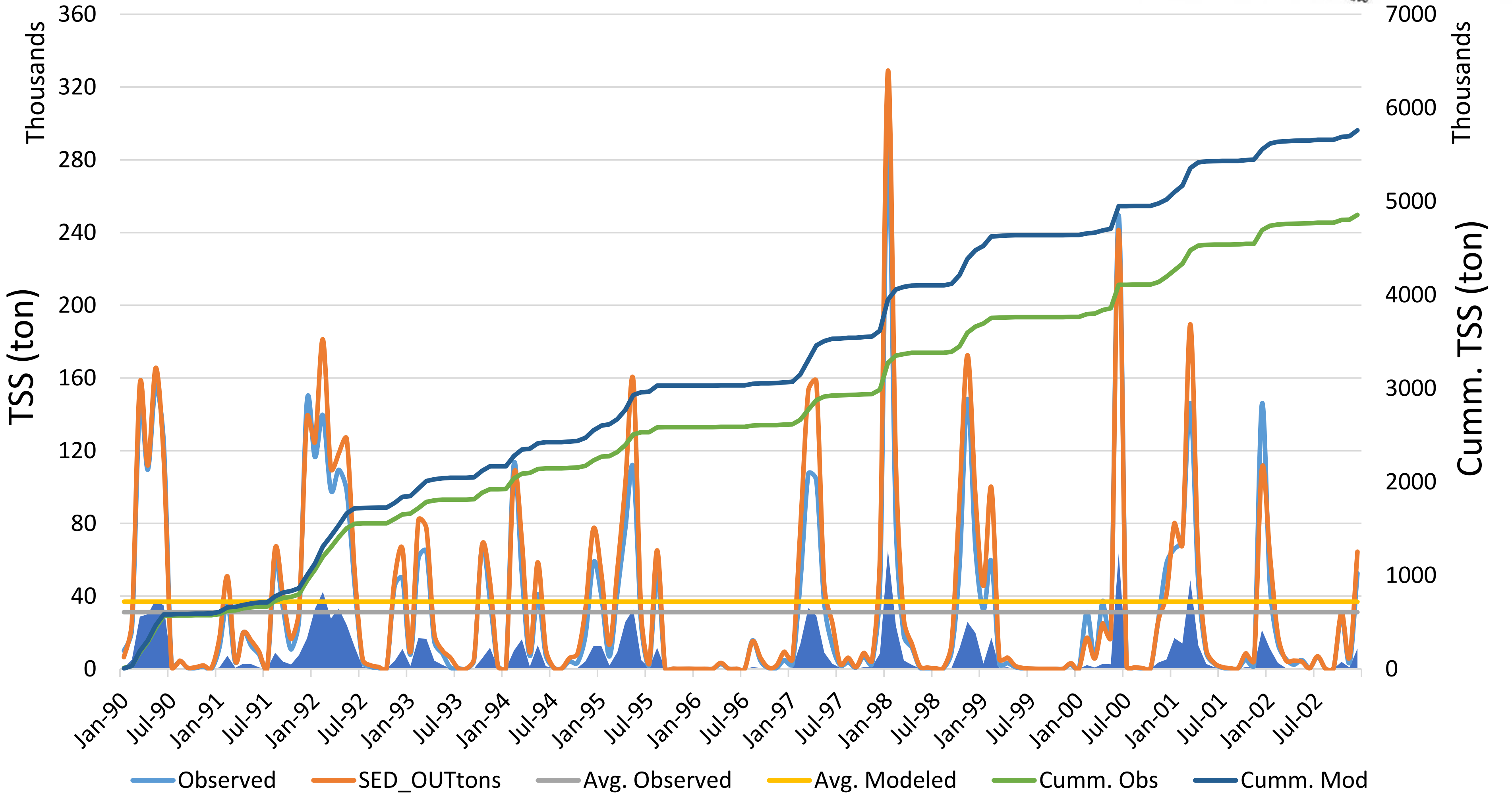


Results - Flow



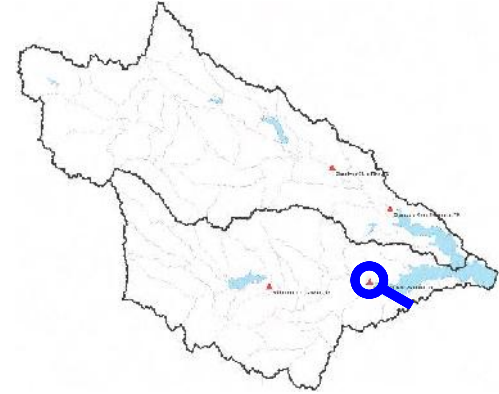


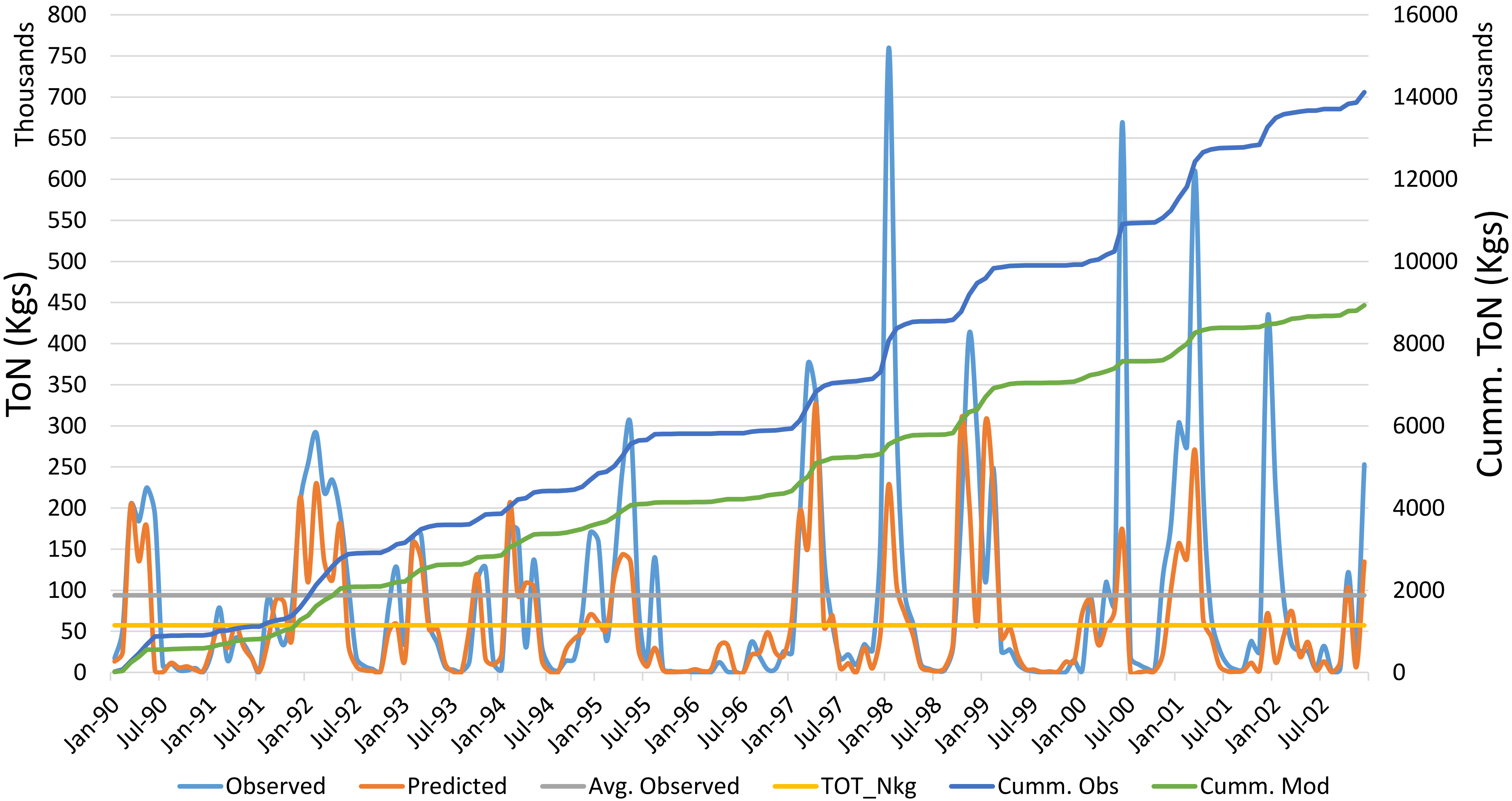
Results - TSS



Thousands
TSS (ton)
360
320
280
240
200
160
120
80
40
0
7000
6000
5000
4000
3000
2000
1000
0
Thousands
Cumm. TSS (ton)
Jan-90
Jul-90
Jan-91
Jul-91
Jan-92
Jul-92
Jan-93
Jul-93
Jan-94
Jul-94
Jan-95
Jul-95
Jan-96
Jul-96
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Observed
SED_OUTtons
Avg. Observed
Avg. Modeled
Cumm. Obs
Cumm. Mod

Results - ToN




Thousands
ToN (Kgs)
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
Thousands
Cumm. ToN (Kgs)
16000
14000
12000
10000
8000
6000
4000
2000
0
Jan-90
Jul-90
Jan-91
Jul-91
Jan-92
Jul-92
Jan-93
Jul-93
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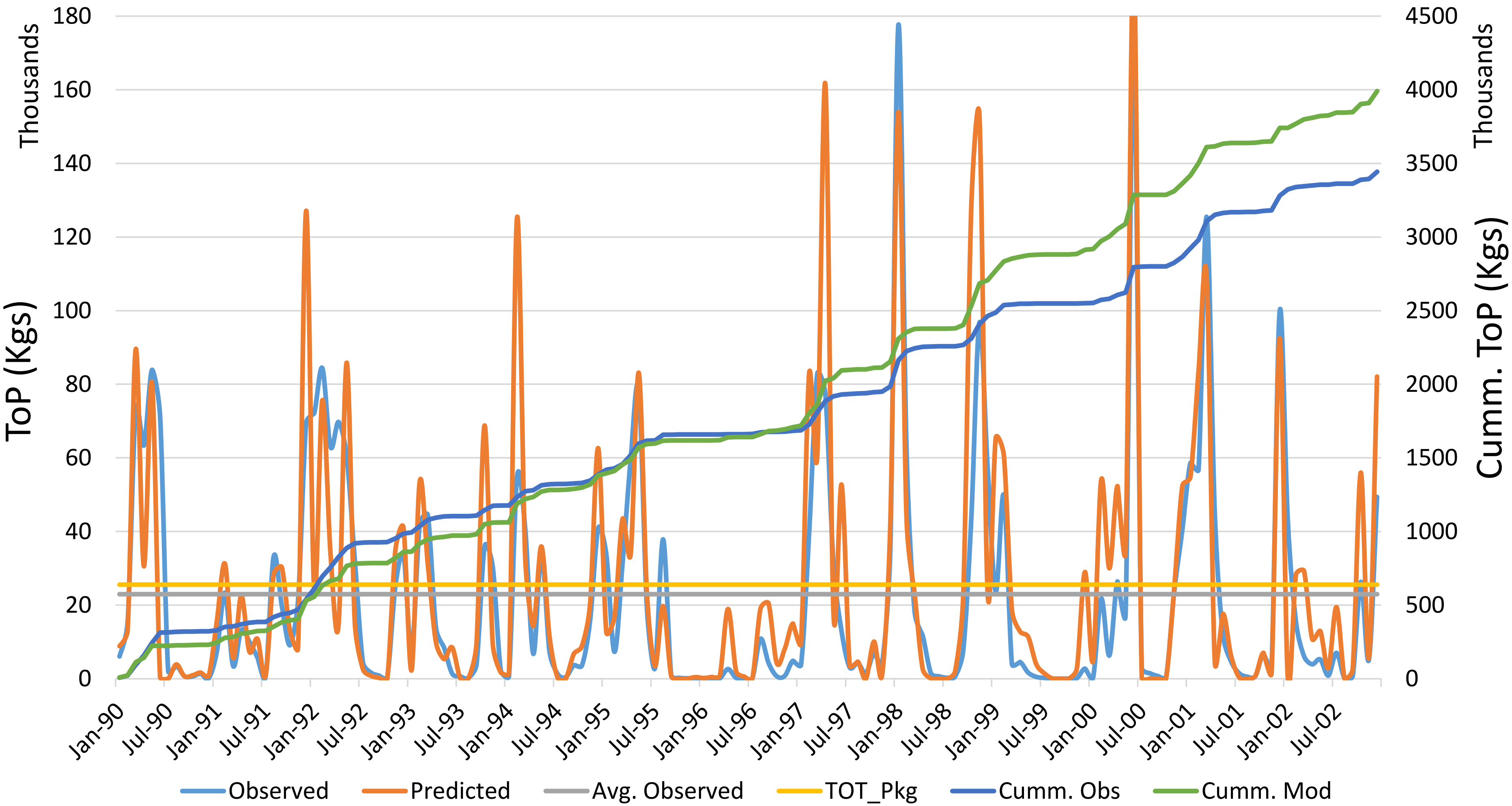
Jan-95
Jul-95
Jan-96
Jul-96
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Observed
Predicted
Avg. Observed
TOT_Nkg
Cumm. Obs
Cumm. Mod

Results - ToP



Thousands
ToP (Kgs)
0
20
40
60
80
100
120
140
160
180
Thousands
Cumm. ToP (Kgs)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Jan-90
Jul-90
Jan-91
Jul-91
Jan-92
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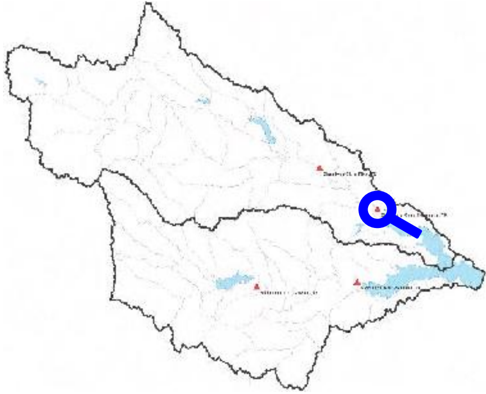
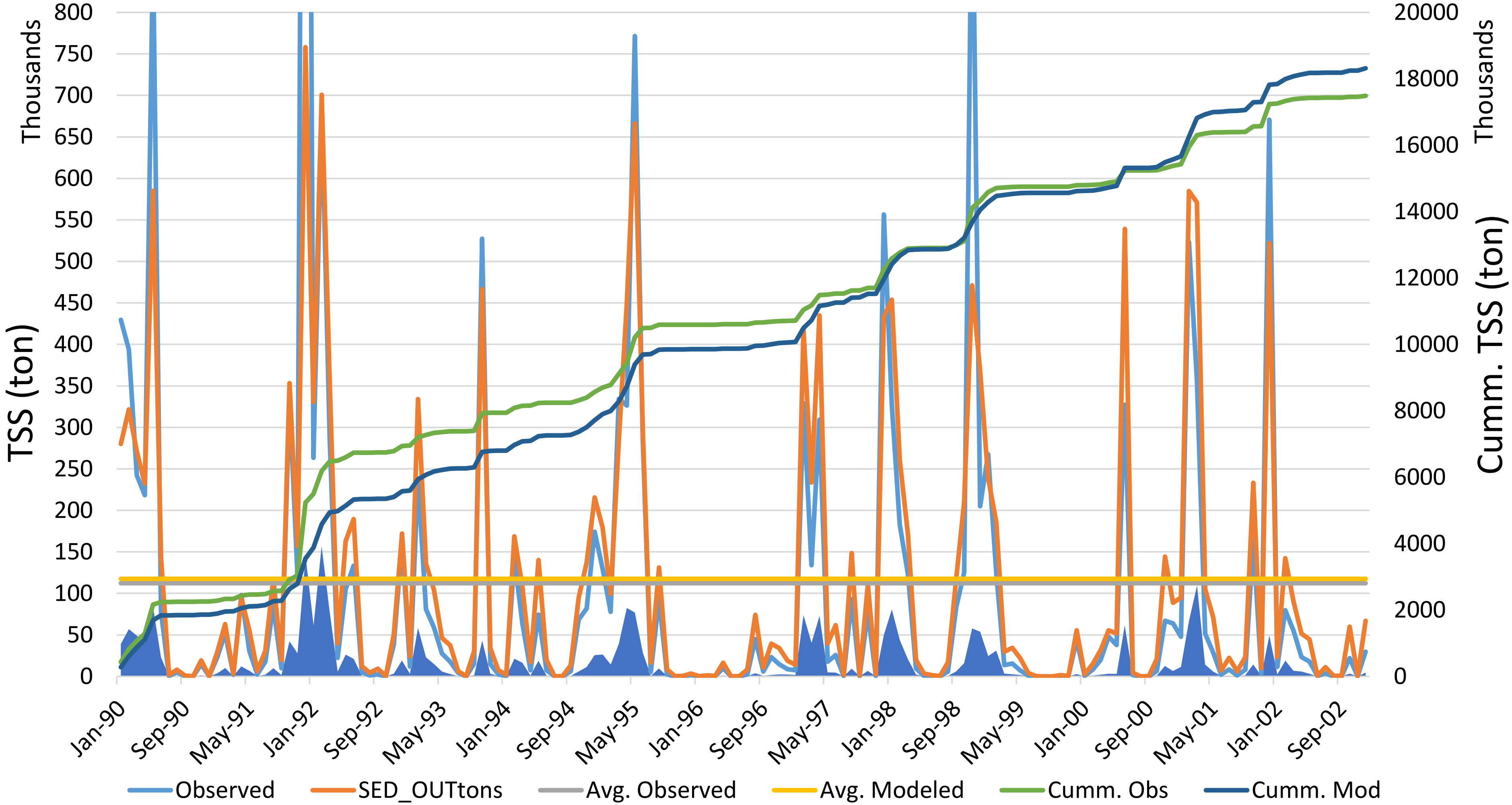
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Observed
Predicted
Avg. Observed
TOT_Pkg
Cumm. Obs
Cumm. Mod

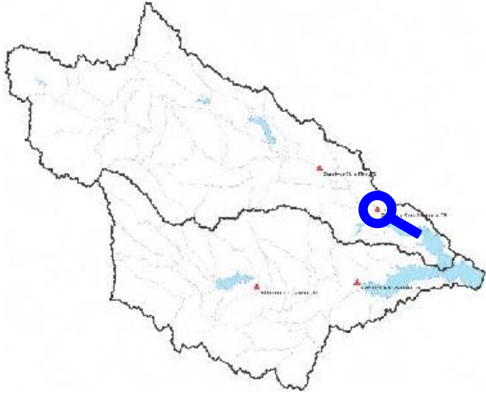
Results - TSS

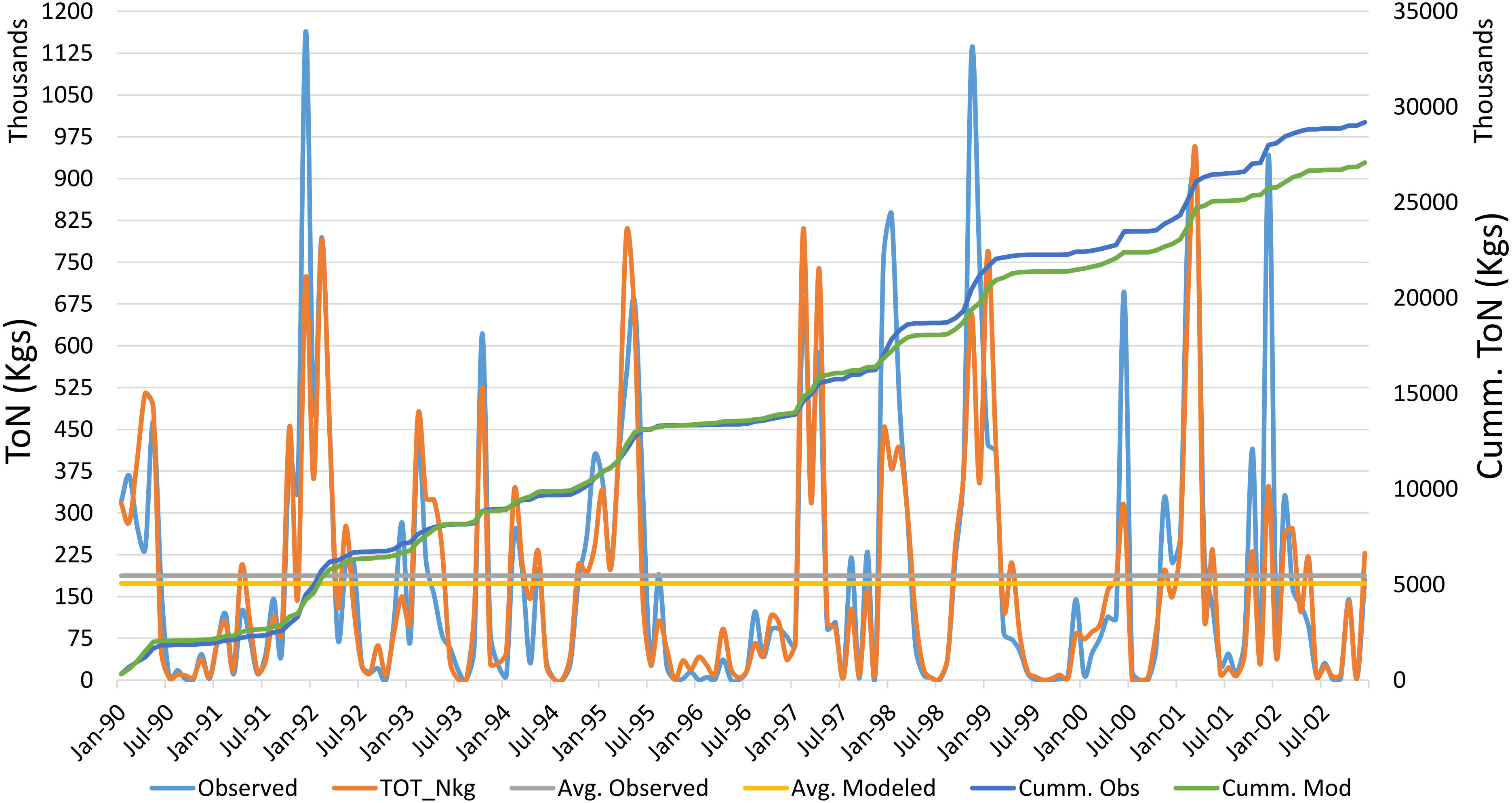




Thousands
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
TSS (ton)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Thousands
Cumm. TSS (ton)
Jan-90
Sep-90
May-91
Jan-92
Sep-92
May-93
Jan-94
Sep-94
May-95
Jan-96
Sep-96
May-97
Jan-98
Sep-98
May-99
Jan-00
Sep-00
May-01
Jan-02
Sep-02
Observed
SED_OUTtons
Avg. Observed
Avg. Modeled
Cumm. Obs
Cumm. Mod

Results - ToN





Thousands
ToN (Kgs)
1200
1125
1050
975
900
825
750
675
600
525
450
375
300
225
150
75
0
Thousands
Cumm. ToN (Kgs)
35000
30000
25000
20000
15000
10000
5000
0
Jan-90
Jul-90
Jan-91
Jul-91
Jan-92
Jul-92
Jan-93
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Jul-94
Jan-95
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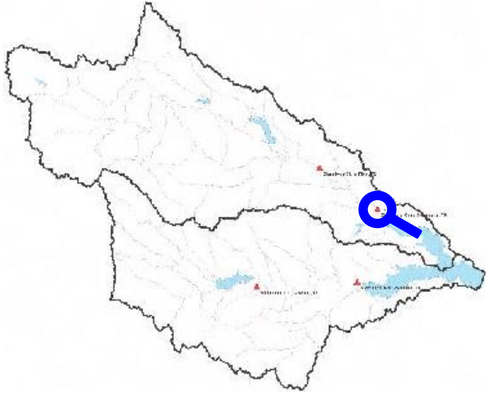
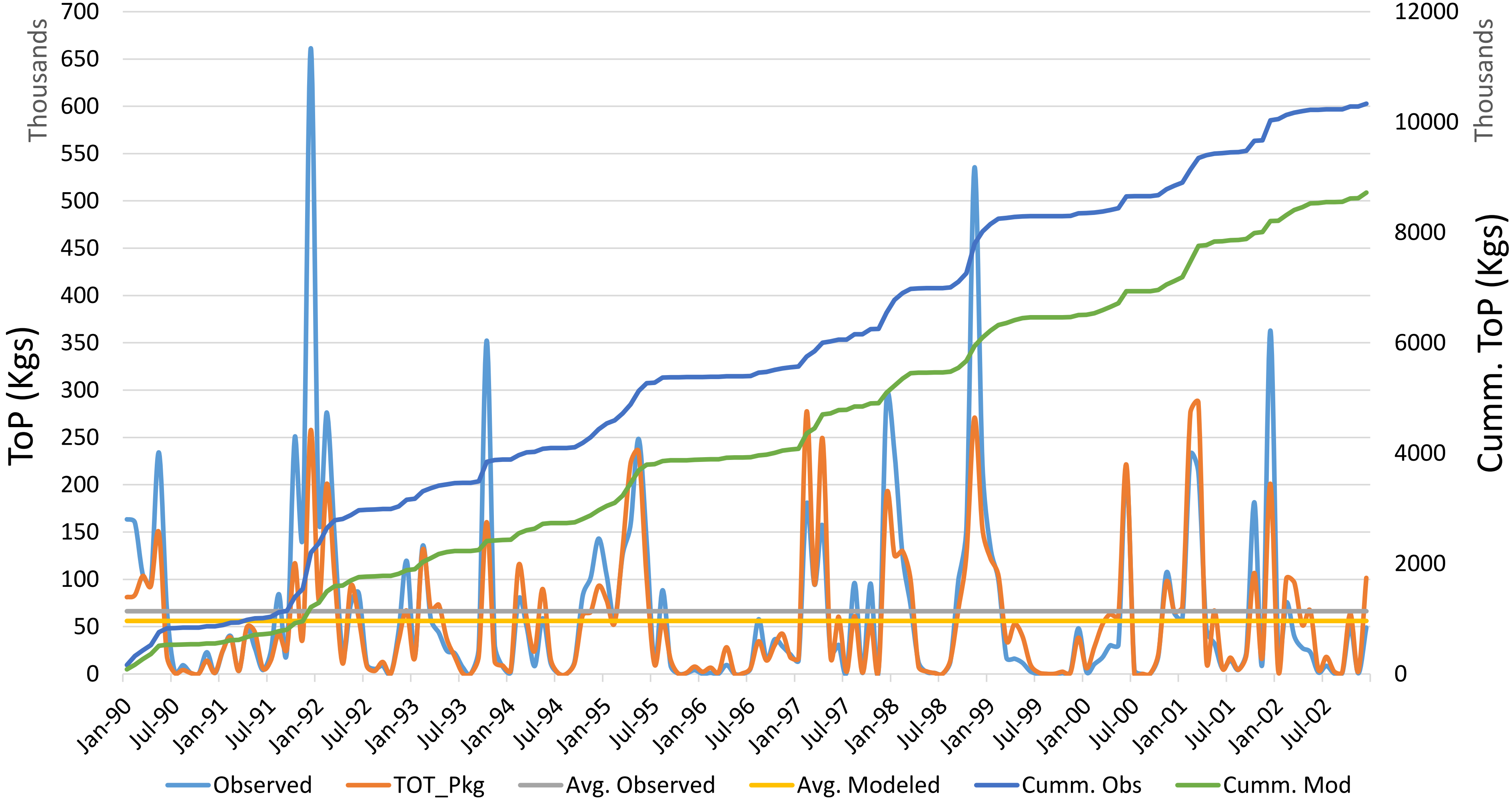
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Observed
TOT_Nkg
Avg. Observed
Avg. Modeled
Cumm. Obs
Cumm. Mod

Results - ToP




Thousands
ToP (Kgs)
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
12000
10000
8000
6000
4000
2000
0
Thousands
Cumm. ToP (Kgs)
Jan-90
Jul-90
Jan-91
Jul-91
Jan-92
Jul-92
Jan-93
Jul-93
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Jan-95
Jul-95
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Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Observed
TOT_Pkg
Avg. Observed
Avg. Modeled
Cumm. Obs
Cumm. Mod

- **Sediment results**

Richland @ 3510 -–– Just above RC reservoir							
Monthly Output	Average		Standard Deviation		Statistics		
	Measured	Simulated	Measured	Simulated	R^2	PBIAS (%)	**NSE**
Sediment (tons)	31135	36925	48221	54770	0.96	-18	**0.92**

Chambers @ 4500 – Just above RC reservoir							
Monthly Output	Average		Standard Deviation		Statistics		
	Measured	Simulated	Measured	Simulated	R^2	PBIAS (%)	**NSE**
Sediment (tons)	112078	117407	242295	166701	0.72	-5	**0.69**

- **Nutrient results**

Richland 3510 – Just above RC reservoir							
Monthly Output	Average		Standard Deviation		Statistics		
	Measured	Simulated	Measured	Simulated	R^2	PBIAS (%)	**NSE**
Total Nitrogen (Kgs)	90498	57276	127912	70656	0.55	37	**0.45**
Total Phosphorus (Kgs)	22078	25589	31335	36450	0.69	-15	**0.57**

Chambers 4500 – Just above RC reservoir							
Monthly Output	Average		Standard Deviation		Statistics		
	Measured	Simulated	Measured	Simulated	R^2	PBIAS (%)	**NSE**
Total Nitrogen (Kgs)	187212	173647	243321	204445	0.85	7	**0.76**
Total Phosphorus (Kgs)	66232	55904	97565	67322	0.72	16	**0.68**

What does this mean?

- Total sediment brought to RC reservoir since operation started (to 2015)

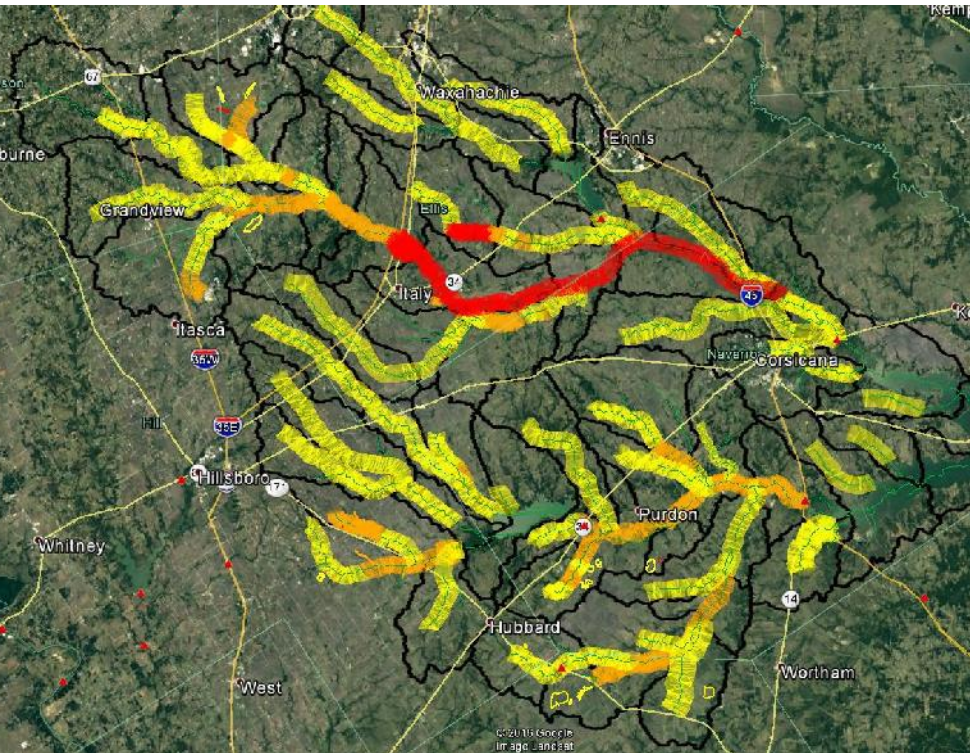
	Sediment (tons)	ToN (Kg)	ToP (kg)
Total Richland	24,229,057	46,829,282	25,999,163
Annual rate	835,485	1,614,803	896,523
Yield tons/ha	**0.08**	**0.15**	**0.09**
Total Chambers	37,615,985	70,551,410	27,464,142
Annual rate	1,297,103	2,432,808	947,040
Yield tons/ha	**0.14**	**0.26**	**0.10**
Grand Total	61,845,042	117,380,692	53,463,305
Aggregated Annual rate	**2,132,588**	**4,047,610**	**1,843,562**
Aggregated yield t/ha	**0.11**	**0.21**	**0.09**

- RGA estimated (Baylor Univ.) total sediment mass of 43,330,910 tons (i.e. **1,455,890 tons/yr**)

Comparison with RGA

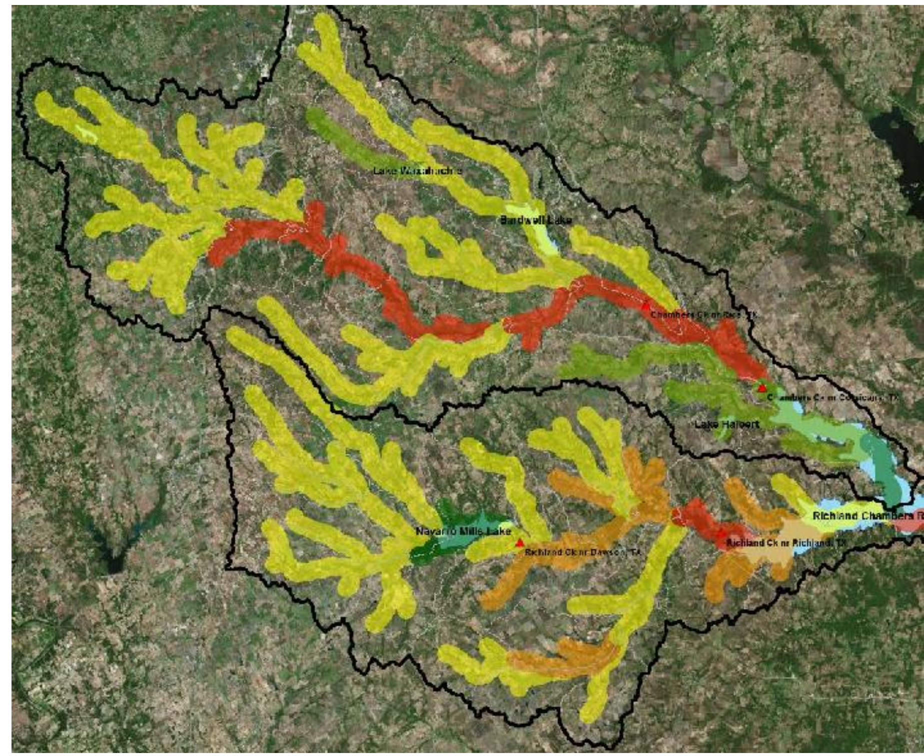
- Severity of channel erosion

RGA (Baylor University)



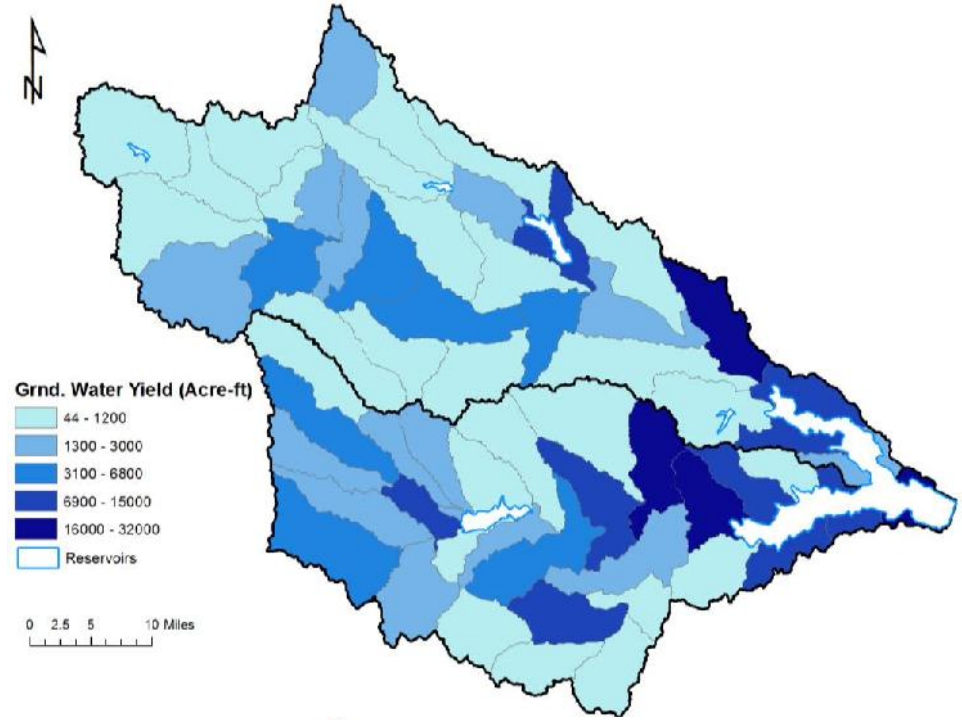
slight *moderate* *severe*

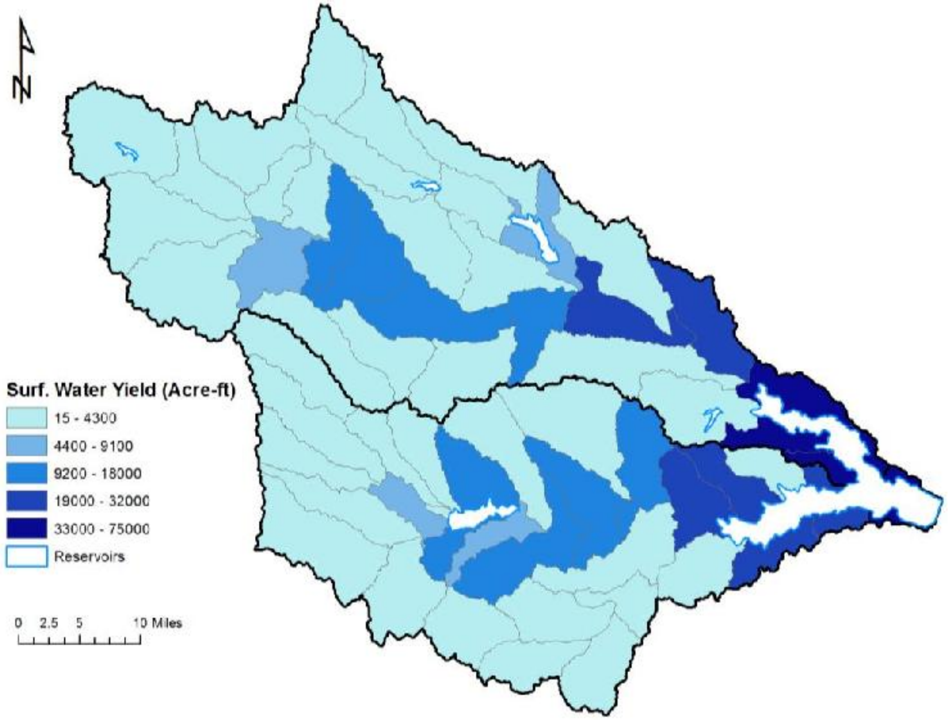
SWAT Sediment Delivery Ratio

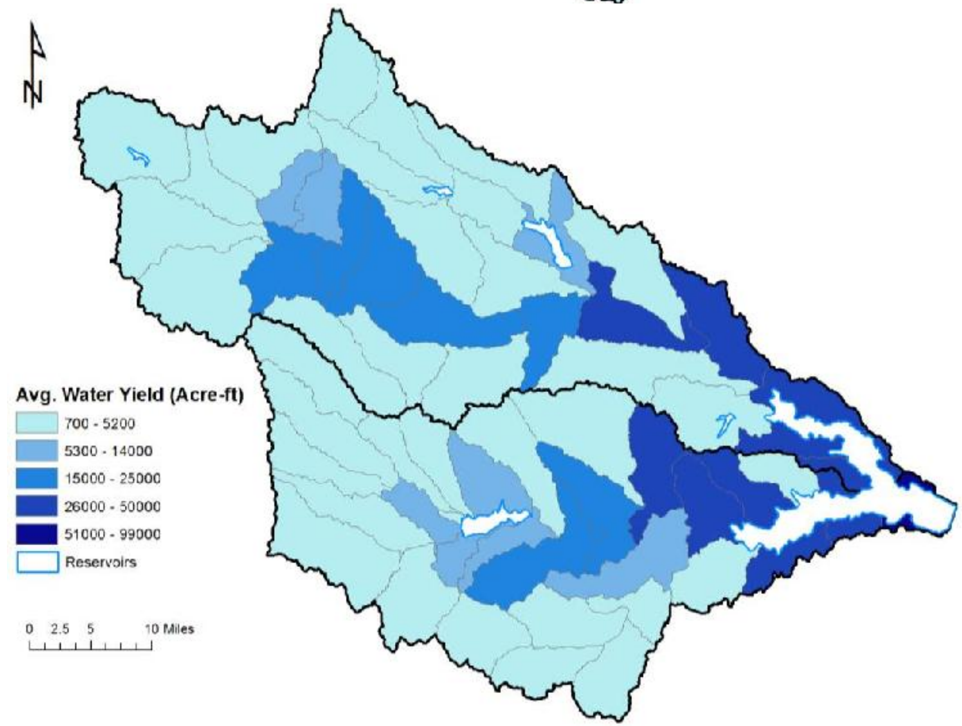


<100% *≈100%* *>100%*

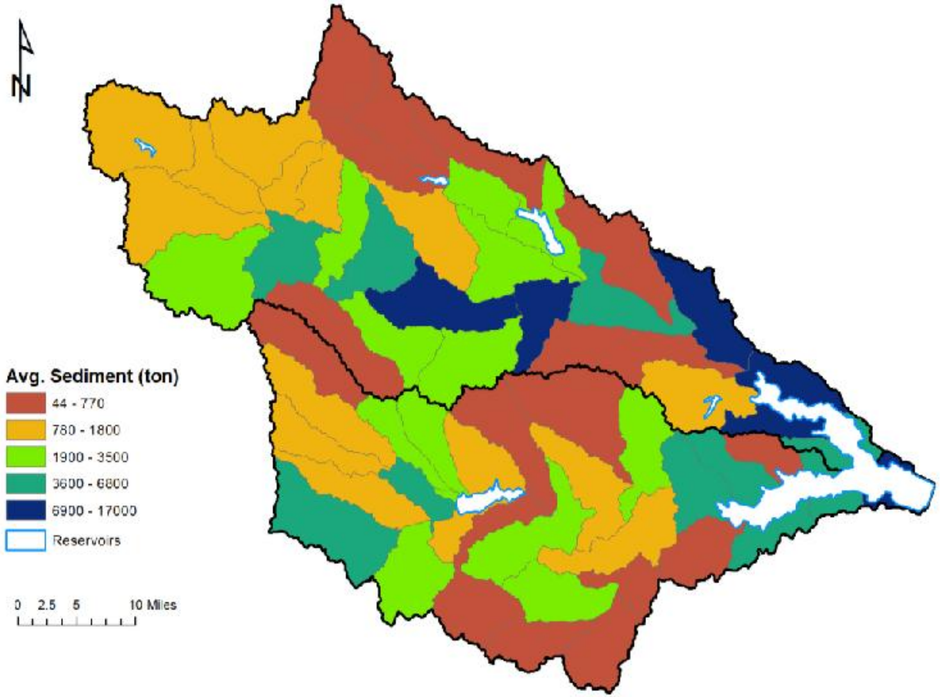
Average water yield (1987-2015)

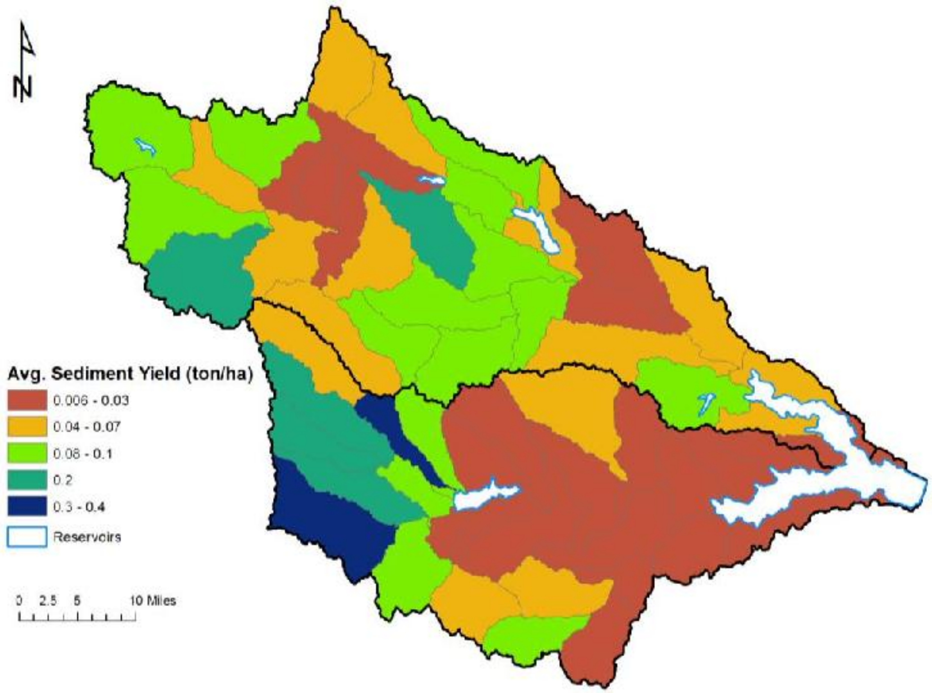






Average sediment yield (1987-2015)

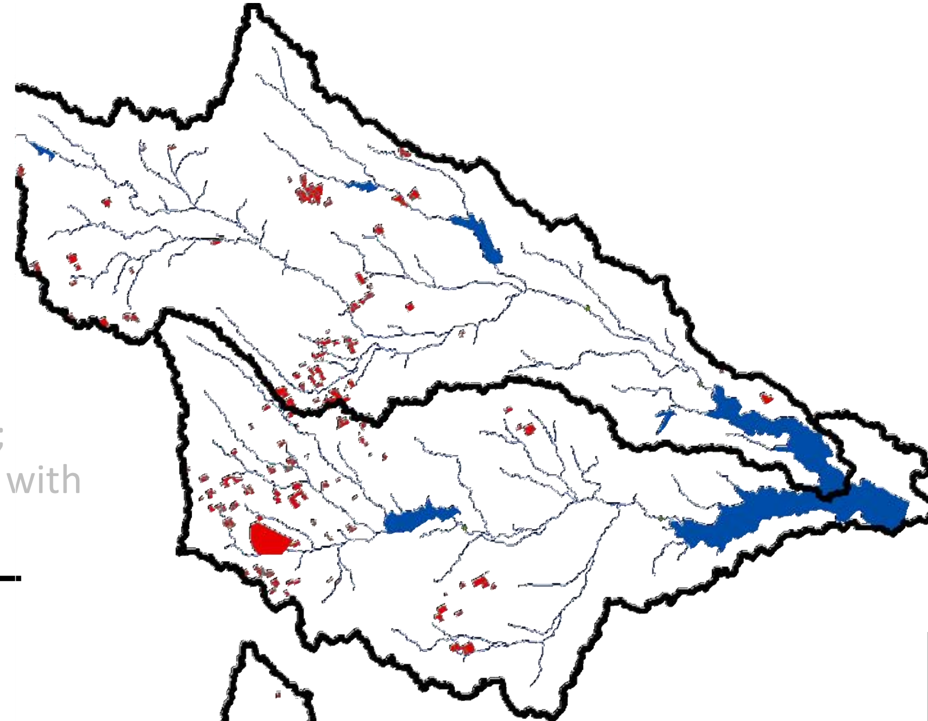


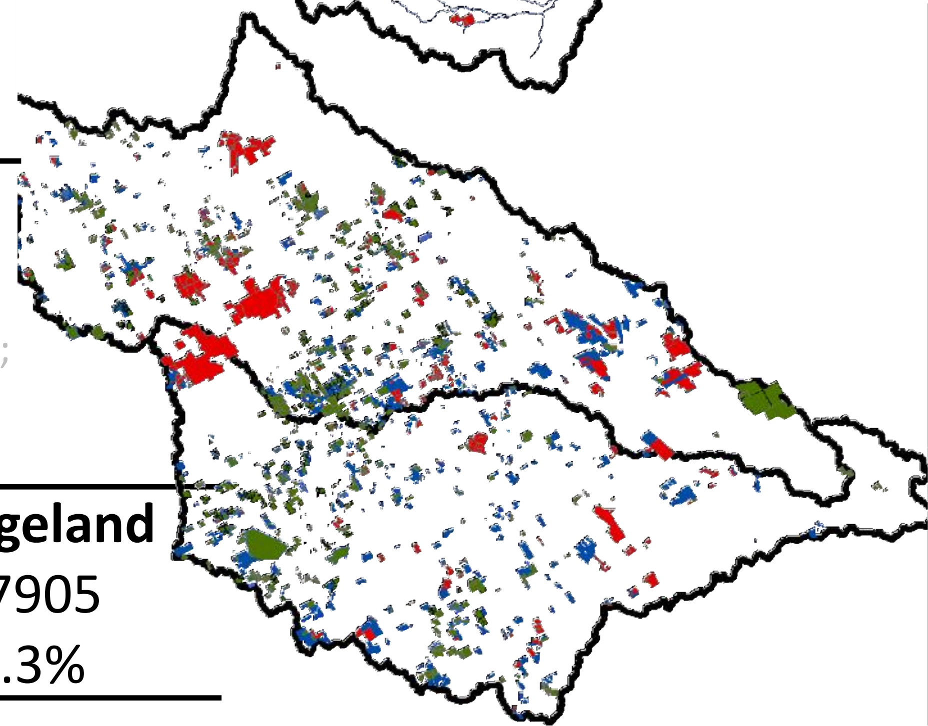


Next steps Accounting for BMPs
(2003 onwards)

- Total BMPs applied on 20% of watershed
- Structural BMPs (in ha)
  - Contour Farming; filter strips; Grassed Waterways; Terraces; Terraces with Contour Farming; Terraces with Grassed waterways

	Area	%
Total watershed	507792	
Total BMPs applied	6767	1%



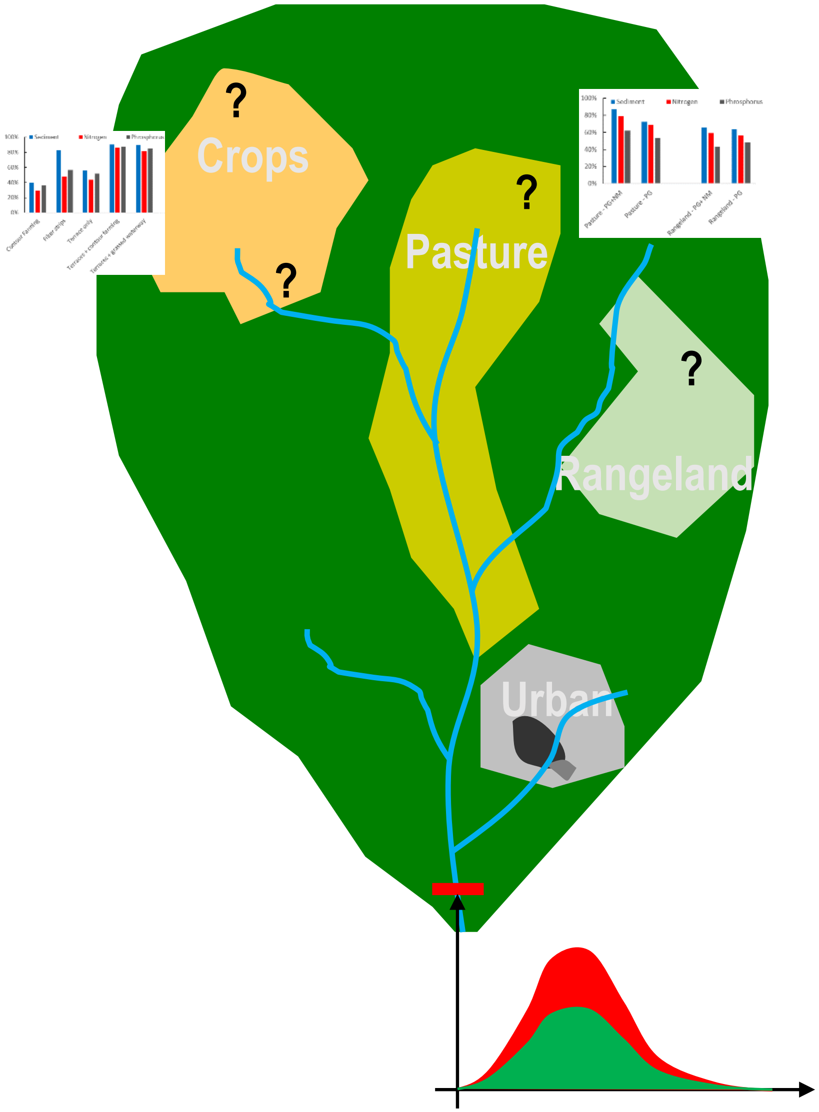


- Non Structural BMPs
  - Residue Management; Conservation crop rotation; Nutrient management; Prescribed grazing; Brush management; Integrated pest management

	Cropland	Pasture	Rangeland
BMP applied	43107	24228	27905
% Watershed	8%	4.6%	5.3%

Next steps

- Incorporate BMPs to calibrated model
- Run model and evaluate
    - ***Reduction (if any) in***
        - ***sediment***
        - ***Nutrient***
- Identify
    - location and
    - type of BMPs with for effectiveness



Thanks

Texas Pollutant Discharge Elimination System (TPDES) Permitting
Municipal Separate Storm Sewer Systems (MS4s)

Richland-Chambers Reservoir Watershed Protection Plan

April 25, 2017

Hanne Lehman Nielsen

Lindsay Garza

Stormwater & Pretreatment Team

Water Quality Division

TCEQ

Municipal Separate Storm Sewer Systems (MS4)

An MS4 is a publicly owned or operated stormwater drainage system designed to collect and convey stormwater

Which MS4s are Regulated?

- Medium and Large MS4s (“Phase I”)
  - Individual TPDES Permits
- Small MS4s in Urbanized Areas (Phase II”)
  - TCEQ Small MS4 General Permit – TXR040000
- Combined Phase I and Phase II MS4s
  - Individual MS4 Permit for Texas Department of Transportation – WQ0005011000

Phase II MS4 General Permit, TXR04000

- Regulates stormwater discharges from publicly owned or operated "Small" MS4s located in urbanized areas (UAs)
- Population based on the 2000 and 2010 U.S.Censuses
- Renewed December 13, 2013 – 5 year permit term

	General Permit 2007 Authorizations Issued	General Permit 2013 Applications Received
NOIs	406	539
Waivers	66	78
Total	472	617

**12 have not renewed yet*

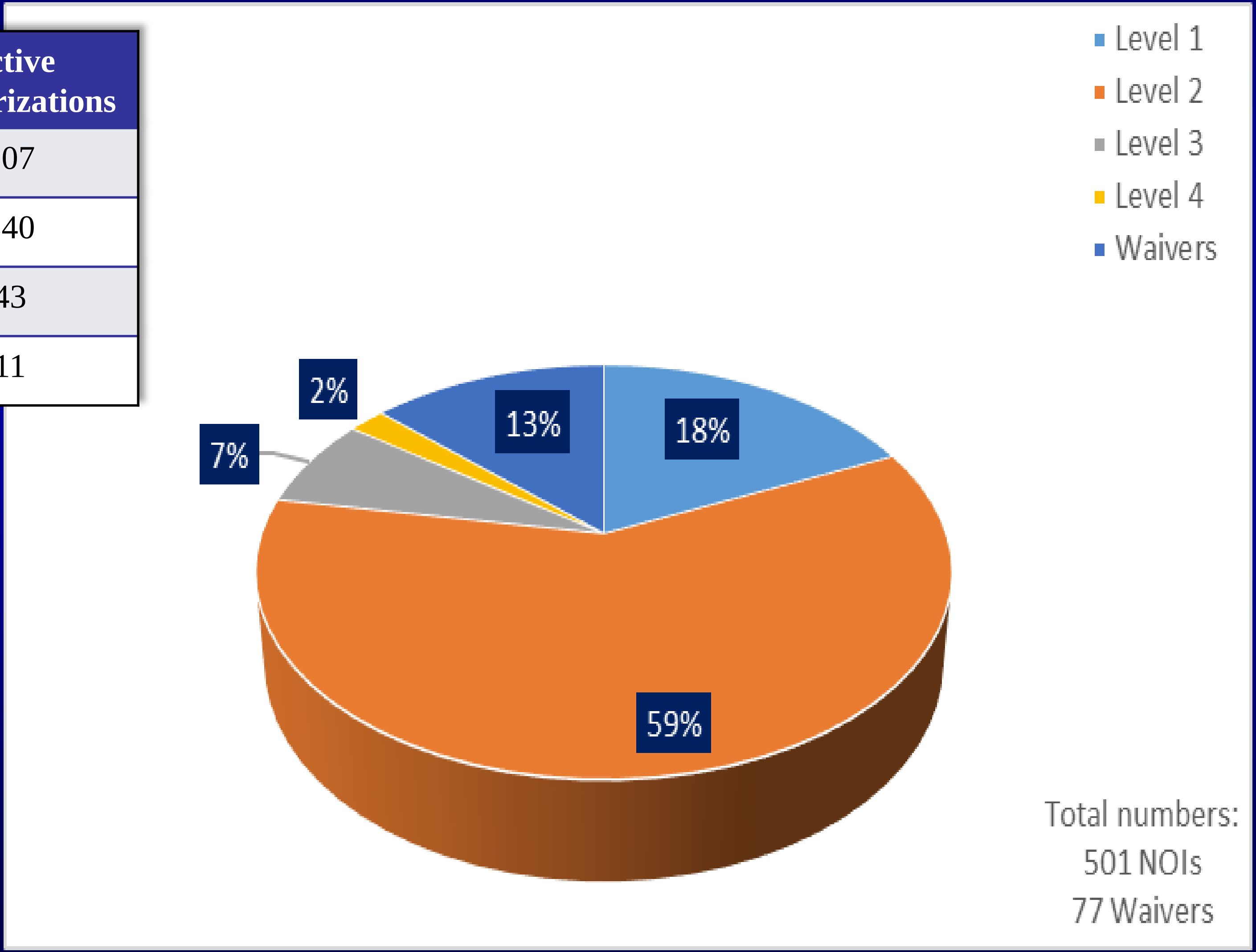
Phase II MS4 General Permit

- Tiered Permitting Approach - based on population in the UA
  - Level 1 - Up to 10,000
  - Level 2 - 10,000 to 40,000
    - includes non-traditional MS4s
  - Level 3 - 40,000 to 100,000
  - Level 4 - More than 100,000
- Waiver option for population less than 1,000

**Based on the 2000 and 2010 U.S.Censuses*

Phase II MS4s
Active Authorizations

Level	Active Authorizations
1	107
2	340
3	43
4	11



Requirements of Phase II MS4s

- Develop and Implement a Stormwater Management Program (SWMP)
  - Develop an implementation schedule
  - Implement in yearly intervals over the five year permit term
  - Must be fully implemented at the end of the five year permit term
- Coalitions
  - Develop, implement, and share same SWMP
  - Usually share a boundary or watershed
  - Each MS4 is responsible for its own compliance
  - Agreements with clear delineation of responsibilities

Requirements of Phase II MS4s

- Contents of a SWMP
  - Six Minimum Control Measures (MCMs)
    - Operators must address to reduce pollutants from the MS4 to the Maximum Extent Practicable (MEP)
  - List of best management practices (BMPs)
  - Measurable goals
    - Including frequency, month, and year
  - Schedule for implementation

Requirements of Phase II MS4s

- Minimum Control Measures (MCMs)
  1. Public Education, Outreach, and Involvement
  2. Illicit Discharge Detection and Elimination
  3. Construction Site Stormwater Runoff Control
  4. Post-Construction Stormwater Management in New Development and Redevelopment
  5. Pollution Prevention and Good Housekeeping for Municipal Operations
  6. Industrial Stormwater Sources (*Level 4 only*)
  7. *Optional* MCM for Construction done by the Permittee (MS4)

- Additional requirements for discharges into impaired waterbodies

Impaired Water Bodies

- Additional Permit Requirements
  - Category 5 - CWA 303(d) for stream segment, no TMDL
  - Category 4 - Not on CWA 303(d), *with* watershed TMDL

Texas Integrated Report Index of Water Quality Impairments

2012 Texas Integrated Report Index of Water Quality Impairments

SegID: 0806A **Fosdic Lake (unclassified water body)**
From Fosdic Lake Dam to the reservoir headwaters in Oakland Lake Park in Tarrant County

Parameter(s)		*Category*	*Carryforward*
PCBs in edible tissue			
0806A_01	Entire lake	4a	Yes

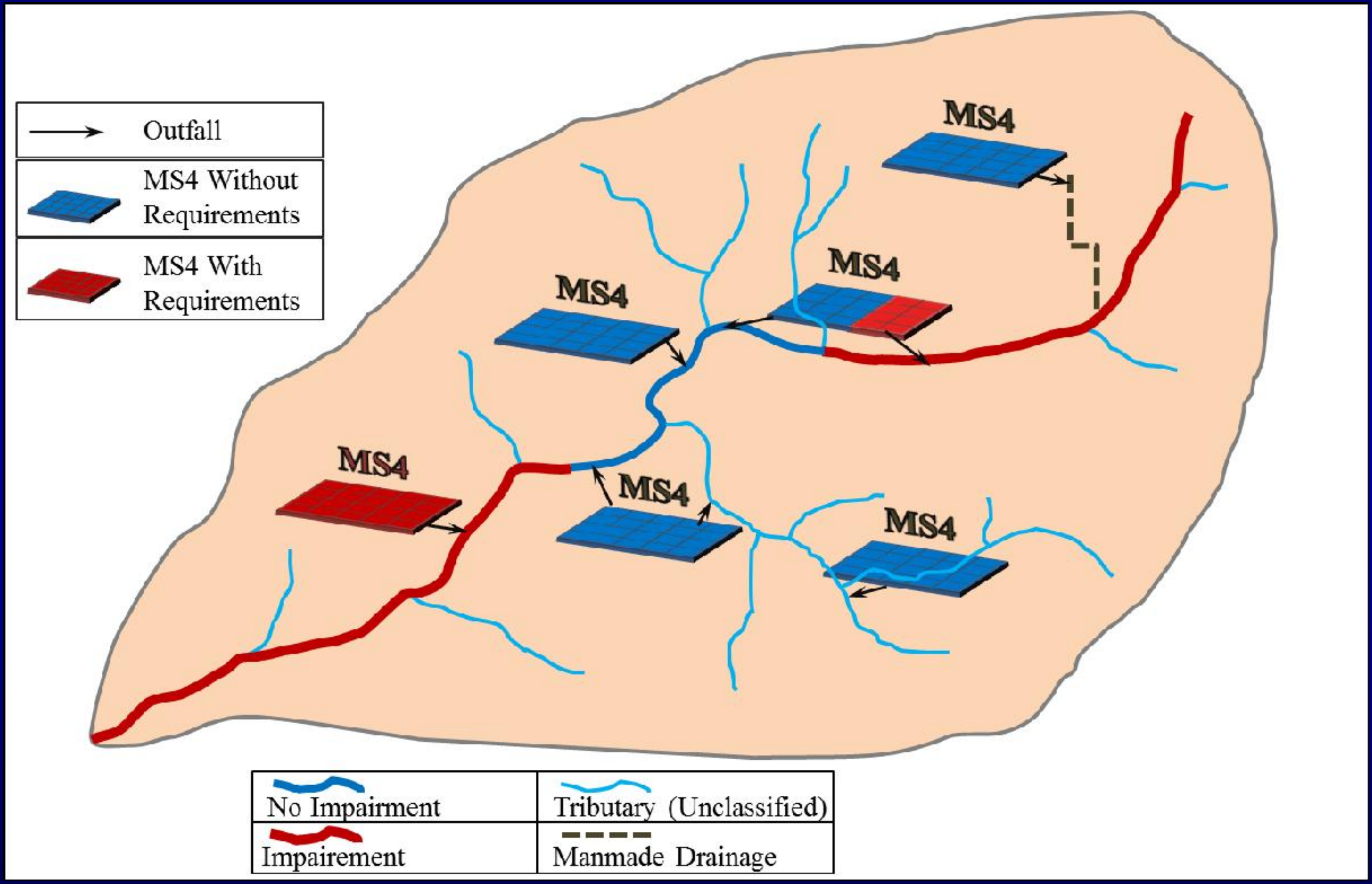
SegID: 0806B **Echo Lake (unclassified water body)**
From Echo Lake Dam to the reservoirs headwaters in Tarrant County

Parameter(s)		*Category*	*Carryforward*
PCBs in edible tissue			
0806B_01	Entire lake	4a	Yes

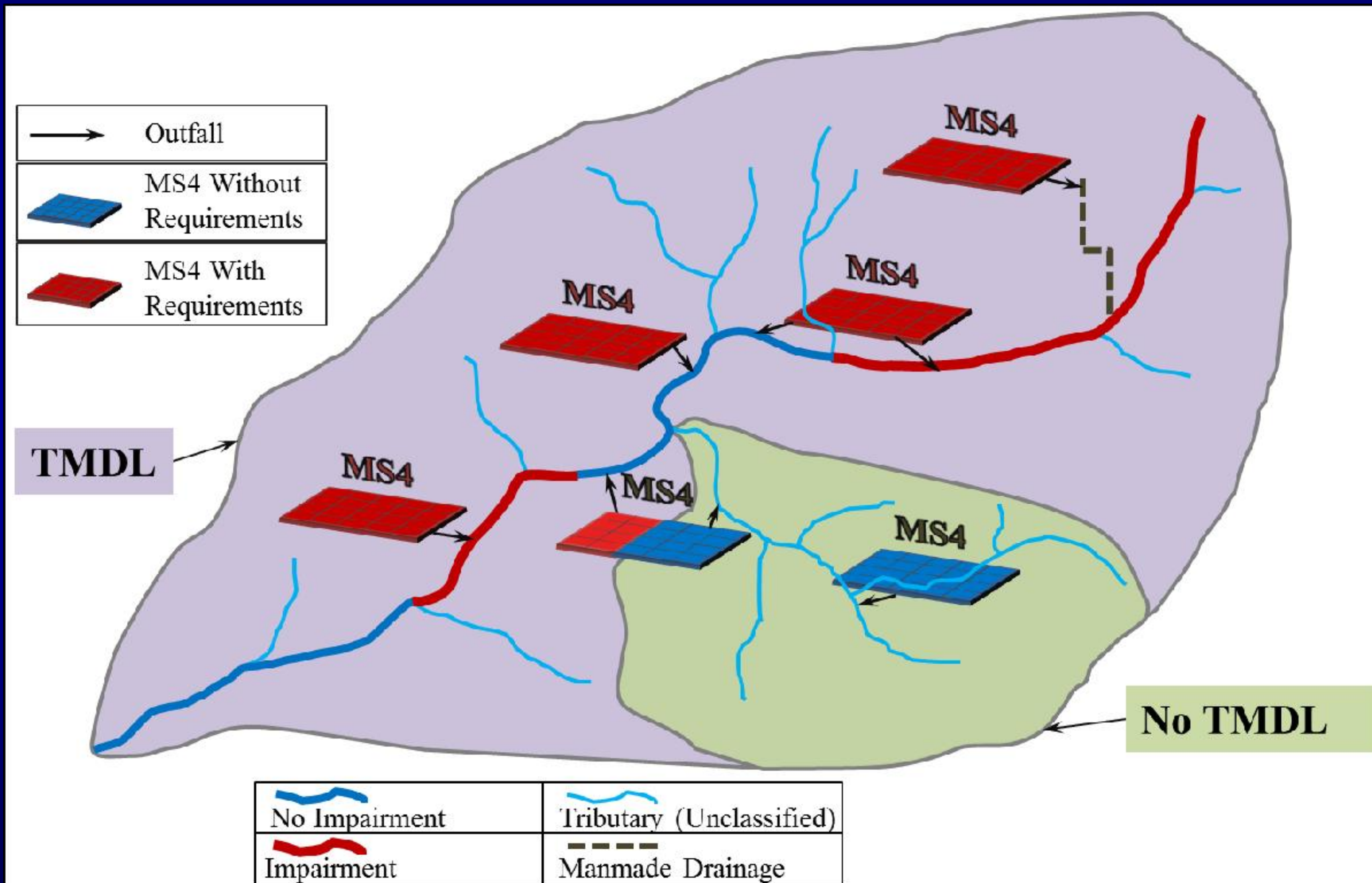
SegID: 0806E **Sycamore Creek (unclassified water body)**
Five mile stretch of Sycamore Creek running upstream from confluence with the W. Fork of Trinity River to confluence with Echo Lake Tributary in Fort Worth.

Parameter(s)		*Category*	*Carryforward*
bacteria			
0806E_01	Five mile stretch of Sycamore Creek running upstream from confluence with the W. Fork of Trinity River to confluence with Echo Lake Tributary in Fort Worth	5b	No

Discharges to Impaired Waterbodies without a TMDL



Discharges to Impaired Waterbodies with a TMDL



Requirements of Phase II MS4s

- Annual Report
  - Due 90 days after *reporting* year
  - Flexibility selecting reporting year
    - Fiscal year, calendar year, or permit year
  - Reporting year cannot change during the permit term
  - Use Annual Report Template (Form 20561)

New NPDES Rules – Phase II MS4 Remand Rule
40 CFR §§122.33 and 122.34

- Phase II MS4 Remand Rule – Published in Fed. Reg. December 9, 2016 with an effective date of Jan. 9, 2017

- The regulations are revised to ensure that:
  - States determine the adequacy of BMPs and permit requirements
  - States provide public notice and opportunity for the public to request a public hearing

New NPDES Rules – Phase II MS4 Remand Rule
40 CFR §§122.33 and 122.34

- Procedural rule – no substantive changes are made to the Phase II MS4 requirements
- Includes two options for states to administer their Phase II MS4 programs
  - Option 1: Comprehensive general permit approach
    - The general permit needs to include all requirements necessary to meet the MS4 permit standard "to reduce pollutants to the maximum extent practicable" (MEP).
  - Option 2: Two-step General Permit
    - The general permit includes some requirements for all MS4s
    - The state established additional requirements and BMPs for individual MS4s (this is in the SWMPs).

New NPDES Rules – Phase II MS4 Remand Rule *40 CFR §§122.33 and 122.34*

- All permits must be written with terms that are "clear, specific, and measurable"

- The general permits need to use "mandatory" terms and cannot use terms such as:
  - as practicable, should, encouraged, etc.
  - *if feasible*, cannot be used unless it is defined

- The permit language needs to be worded in a manner that will help assess compliance and track whether measurable goals have been met by the MS4.

- EPA published examples of provisions from general permits across the country

  https://www.epa.gov/npdes/stormwater-discharges-municipal-sources#resources

New NPDES Rules – Phase II MS4 Remand Rule
40 CFR §§122.33 and 122.34

Clear

- Certainty in specific actions and requirements
- Avoid words such as “if practicable”, “as necessary”, “should”

Specific

- Provide level of detail in requirements that portray level of effort(s) needed from MS4 to comply

Measurable

- Requirement needs to be articulated in a manner to assess compliance in a straightforward way

New Federal Rules – Electronic Reporting Rule
40 CFR Part 127

- Electronic Reporting Rule – effective Dec. 21, 2015
  - Requires electronic submittal of applications and reports
    - Phase 1 of Rule: DMRs submitted electronically by Dec. 21, 2016
    - Phase 2 of Rule: General permit applications (NOIs) and MS4 reports need to be submitted electronically by Dec. 21, 2020

- Waiver option is available from eReporting (permanent and temporary)
    - Religious beliefs
    - No internet access
    - Training needed

Small MS4 General Permit, TXR04000
2018 Renewal

- Internal TCEQ input – Feb. 2017
- Stakeholder Meeting – March 21, 2017
  - Comment period ended – April 4, 2017
- Development of draft permit – April/June 2017
- EPA Review – Fall of 2017
- Public comment period – Spring of 2018

Proposed Changes to Existing Permit
Consistency with other TPDES General Permits

- Definitions
  - Define “Infeasible” - not technologically possible or not economically practicable and achievable in light of best industry practices
  - Update “Construction Activity”, “Waters of U.S.” and “Impaired Water Bodies”
- MCM 7 – Construction Activities where the MS4 is the Site Operator
  - Lower benchmark value for TSS to 50 mg/L from 100 mg/L
  - Analysis must be done by NELAP certified laboratories

Proposed Changes to Existing Permit
Consistency with Federal Rules

- Add language to comply with Electronic Reporting Rule
  - EPA will develop tools to accept applications and reports from small MS4s
- Add language to comply with Phase II MS4 Remand Rule
  - Modify permit language to be <u>clear</u>, <u>specific</u> and <u>measurable</u>

Proposed Changes to Existing Permit
Examples of clear, specific, and measurable

- MCM 1. Public Education, Outreach, and Involvement

  If feasible, ~~consider using~~ use public input (for example, the opportunity for public comment, or public meetings) in the implementation of the program

- MCM 2. IDDE

  Inspections – The permittee shall conduct inspections ~~as determined appropriate~~, in response to complaints, and shall conduct follow-up inspections ~~as needed~~ to ensure that corrective measures have been implemented by the responsible party.

<u>The permittee shall develop written procedures describing the basis for conducting inspections in response to complaints</u>

Proposed Changes to Existing Permit
For all MS4s

- Clarify that annexation of land resulting in a level change due to change in population will require a Notice of Change

- Impaired water bodies and TMDL Requirements
  - Clarify terms – benchmarks, decorative ponds, pet waste

- New requirement to annual check if a water body within the MS4s permitted area has been added to the latest Integrated Report of Surface Water Quality.

- New requirement to annually review the SWMP

Proposed Changes to Existing Permit
For Level 4 MS4s only

- New requirement to publish the annual report and SWMP on MS4 website, if MS4 has one
- Add a program to control the discharge of floatables into the MS4
- Add a program to evaluate new and existing flood management projects for their water quality impact

Phase I MS4s

- Medium and Large MS4s
  - Municipal population 100,000+ (1990 U.S.Census)
  - Includes public entities in the UA
    - Transportation authorities, universities, counties, districts, etc.
  - Universe: 22 individual TPDES permits
    - Includes 50 permittees due to coalitions

**No new permits issued*

Requirements of Phase I MS4s

- Develop a SWMP to address MCMs in permits
  - Public Education and Outreach/Public Involvement and Participation
  - Pollution Prevention/Good Housekeeping for Municipal Operations
  - MS4 Maintenance Activities
  - Illicit Discharge Detection and Elimination
  - Construction Site Runoff
  - Post-Construction Control Measures
  - Industrial & High Risk Runoff

Requirements of Phase I MS4s

- Monitoring Requirement Options
  1. Representative Storm Events
  2. Representative Rapid Bioassessment or
  3. Watershed Monitoring
     - Regional Wet Weather Characterization Program

Requirements of Phase I MS4s

- Monitoring of Floatables
  - Often required in two locations at a frequency two times per year
  - Report the amount collected

- Submit Annual Reports
  - TCEQ reviews and provides feedback

TPDES Stormwater Program Contacts

- Water Quality Division
  - Stormwater & Pretreatment Team

- Rebecca L. Villalba, Team Leader
  - Lindsay Garza, Work Leader
  - Hanne Lehman Nielsen
  - Dan Siebeneicher
  - Gordon Cooper
  - Kent Trede
  - Jessica Alcoser

- Austin Office: (512) 239-4671

Contact Information

- Small Business and Local Government Assistance (SBLGA)
  (800) 447-2827
  TexasenviroHelp@tceq.texas.gov
  http://www.tceq.texas.gov/assistance

- Permitting Information (Technical)
  (512) 239-4671
  swgp@tceq.texas.gov
  https://www.tceq.texas.gov/permitting/stormwater

Overview
National Water Quality Initiative (NWQI)
Chambers Creek
2017

Richland-Chambers Watershed Protection Plan Meeting
Waxahachie, Texas
April 2017

Background of the NWQI

- **The National Water Quality Initiative (NWQI) was launched in 2012 by USDA's Natural Resources Conservation Service (NRCS) in collaboration with the Environmental Protection Agency and state water quality agencies.**

- **The NWQI is utilized to accelerate the implementation of conservation practices in a concentrated area in an effort to improve water quality while maintaining agricultural productivity.**

Helping People Help the Land

- NRCS will work with landowners to develop conservation plans implementing practices such as nutrient management, cover crops, conservation cropping systems, filter strips, terraces and buffers.

- The Environmental Quality Incentives Program (EQIP) funds this assistance, and in some cases, is leveraged by funds from local and state partners.

What are the Benefits of NWQI

Water quality-related conservation practices enhance agricultural profitability through reduced input and enhanced soil health, which results in

- **Higher soil organic matter**
- **Increased infiltration**
- **Increased water-holding capacity**
- **Improved nutrient cycling.**

What are the Benefits of NWQI

Well-managed farms and ranches limit pollution from runoff, produce food and fiber, sustain rural economies and provide food security to the nation.

Communities benefit by having clean waterways, safer drinking water and healthy habitat for fish and wildlife.

Highlights 2012 through 2016

- Landowners were encouraged to implement practices that improve water quality.
- These practices included Prescribed Grazing, Cover Crops, Forage and Biomass Planting, Residue Management, Reduced Till, No Till and many others.
- These practices help landowners to protect and care for their land and soil in ways that improve the quality of the water that drains from their lands into creeks and streams.

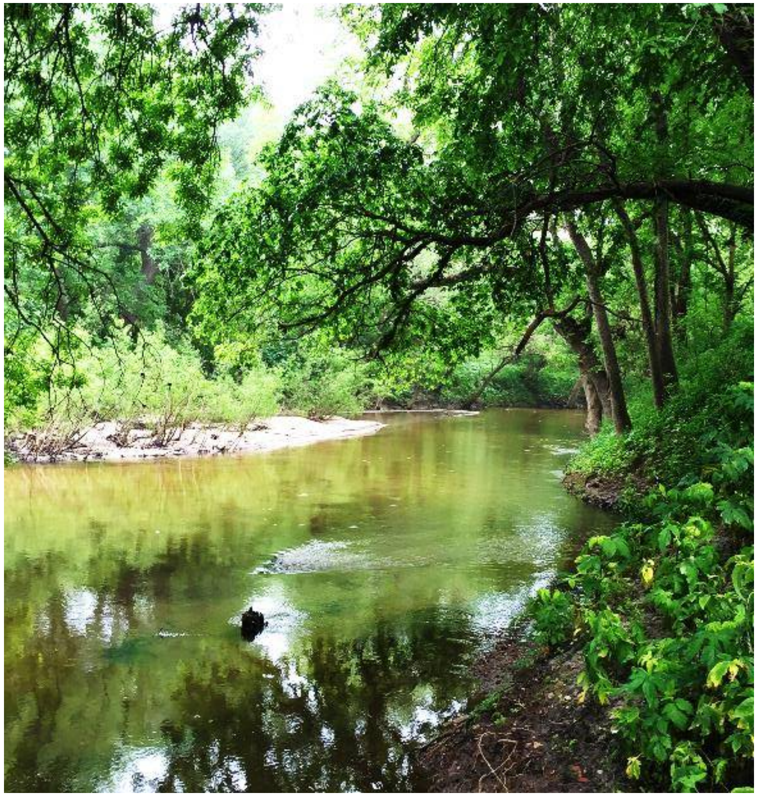
The landowner response was exceptional and over the past 5 years the NRCS has funded over 120 contracts with over 100 individual landowners and land managers.
The following chart lists practices that were applied.

Conservation Practices and "ACT"
Avoid, Control and Trap

- The NWQI emphasizes a "systems approach" to address priority natural resource concerns.
- A cornerstone of this approach is to encourage producers to implement a system of practices that address the concept for Avoiding, Controlling, or Trapping pollutants, or "ACT."

Avoid

Avoidance helps manage nutrients and sediment source control from agricultural lands, including animal production facilities.



Practices such as ***Nutrient Management***, ***Cover Crop***, and ***Conservation Crop Rotation*** help producers avoid pollution by reducing the amount of nutrients available in runoff or leaching into water bodies and watersheds.

Practices such as cover crops and crop rotation help take up nutrients to avoid potential runoff and pollution. Crop rotations that include differing crops, such as legumes, can limit amounts of commercial nutrients applied.

Control

Choose practices that will help with controlling erosion and runoff.

Specific practices such as ***No-till/Strip/Till/Direct Seed***, ***Mulch Tillage***, and ***Ridge Till*** are foundation practices to recommend to producers.

Practices such as ***Cover Crop*** will also do double duty by helping with Avoidance as well as Controlling.

Other facilitating practices, such as ***Terraces*** or ***Stripcropping***, help control erosion and may manage runoff to reduce nutrients loading.

Trap

The last line of defense against potential pollutants is to trap them.

Practices such as ***Contour Buffers***, ***Filter Strips***, ***Riparian Buffers*** and the suite of ***wetland practices to create, enhance, and/or restore wetlands*** all serve to trap and uptake nutrients before entering water bodies.

USDA United States Department of Agriculture

Core Practices	Code	Avoiding	Controlling	Trapping
Waste Storage Facility	313	X	X	
Composting Facility	317	X	X	
Conservation Cover	327	X		X
Conservation Crop Rotation	328	X		
Residue and Tillage Management, No Till/Strip Till/Direct Seed	329		X	X
Cover Crop	340	X		X
Critical Area Planting	342		X	X
Residue Management, Seasonal	344		X	X
Residue and Tillage Management, Mulch Till	345		X	X
Field Border	386		X	X
Riparian Herbaceous Cover	390			X
Riparian Forest Buffer	391			X
Filter Strip	393		X	X
Stream Habitat Improvement and Management	395	X		
Grade Stabilization Structure	410		X	X
Grassed Waterway	412		X	
Irrigation Pipeline	430		X	
Irrigation Reservoir	436		X	
Irrigation Water Management	449		X	
Access Control	472	X		
Livestock Pipeline	516	X		
Prescribed Grazing	528	X		
Range Planting	550			X
Heavy Use Area Protection	561	X		
Animal Trails and Walkways	575		X	
Nutrient Management	590	X		
Terrace	600		X	
Vegetative Barrier	601			X
Tree/Shrub Establishment	612	X		X
Waste Treatment	629		X	
Waste Transfer	634	X		
Water and Sediment Control Basin	638		X	X

United States Department of Agriculture

Supporting Practices	Code	Avoiding	Controlling	Trapping
Agrichemical Handling Facility	309	X		
Alley Cropping	311		X	X
Brush Management	314	X	X	
Herbaceous Weed Control	315	X		
Sediment Basin	350		X	
Diversion	362		X	
Roofs and Covers	367	X	X	
Pond	378			X
Windbreak/Shelterbelt Establishment	380		X	X
Silvopasture Establishment	381	X		
Fence	382	X		
Woody Residue Treatment	384	X		
Hedgerow Planting	422	X		X
Irrigation Pipeline	430		X	
Irrigation System, Micro-Irrigation	441	X		
Irrigation System, Sprinkler	442	X		
Precision Land Forming	462			X
Lined Waterway or Outlet	468		X	
Mulching	484		X	X
Forage and Biomass Planting	512	X		X
Livestock Pipeline	516	X	X	
Pond Sealing	521A	X	X	X
Pumping Plant	533	X		
Range Planting	550			X
Row Arrangement	557	X		
Roof Runoff Structure	558	X		
Access Road	560	X		
Spring Development	574	X		
Stream Crossing	578	X		
Stripcropping	585		X	
Structure for Water Control	587		X	X
Integrated Pest Management	595	X		
Herbaceous Wind Barriers	603		X	
Watering Facility	614	X		
Underground Outlet	620		X	
Solid/Liquid Waste Separation Facility	632		X	
Water Harvesting Catchment	636	X	X	
Restoration and Management of Declining Habitats	643	X		
Wetland Wildlife Habitat Management	644		X	
Windbreak/Shelterbelt Renovation	650		X	X
Wetland Restoration	657		X	
Wetland Enhancement	659		X	
Upland Wildlife Habitat Management	645	X		

Promising Results

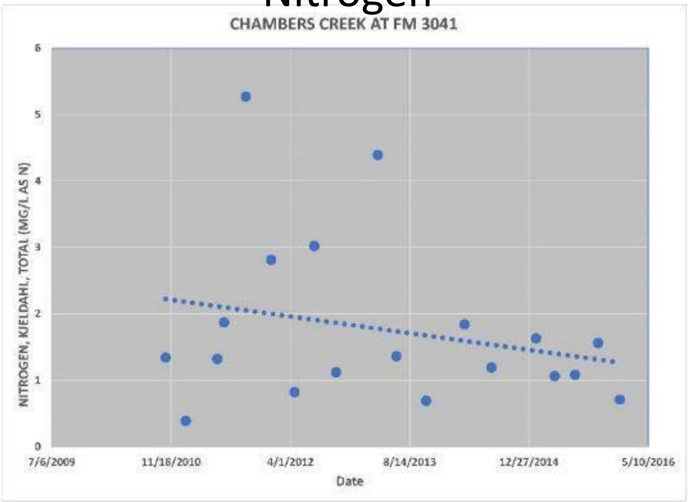
Improving water quality by addressing Non-Point Source pollution through voluntary programs is a long term process with improvements often not realized for decades or longer.

However, after five years of intensive outreach, targeted conservation planning, significant financial assistance and exceptional partnership efforts, the water quality is improving.

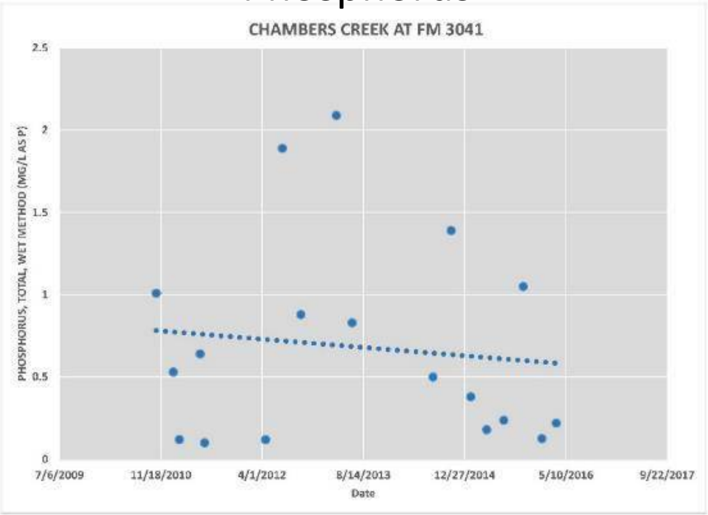
United States Department of Agriculture

- When the data is graphed and a trend line applied the results indicate a trend towards improvements in Nitrogen, Phosphorus, Dissolved Oxygen, Chlorophyll and Bacteria.

Nitrogen



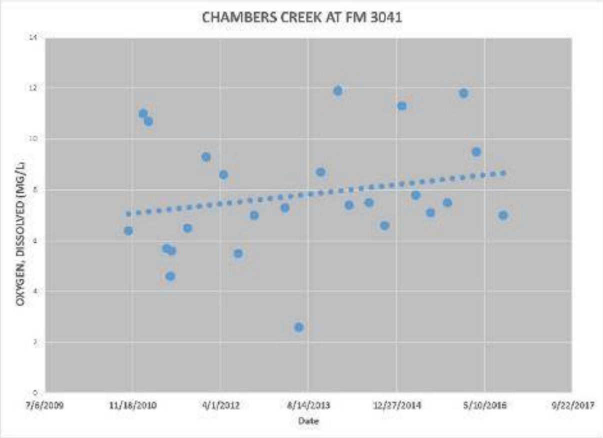
Phosphorus



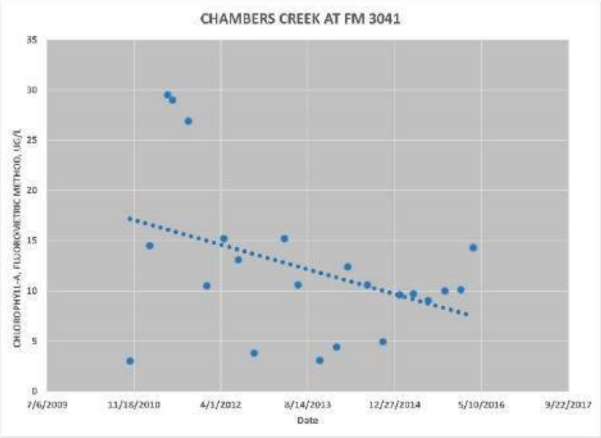
USDA

United States Department of Agriculture

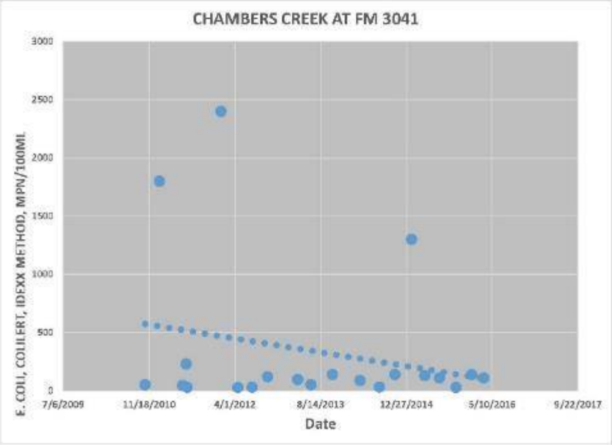
Dissolved Oxygen



Chlorophyll a



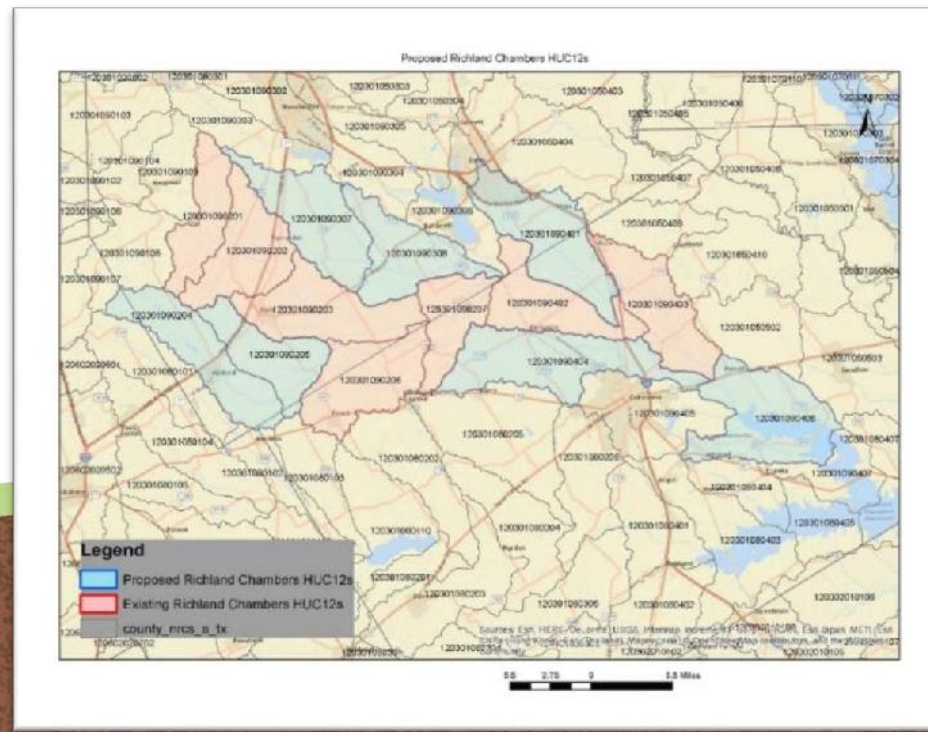
Bacteria



What’s New for 2017

Expand the program by offering NWQI funding in seven HUC12 watersheds immediately adjacent to the areas we have been treating.

Suspend initiative funding on the highly successful, original designated area. Continue to fund additional work in the previous watershed through other EQIP funding channels.

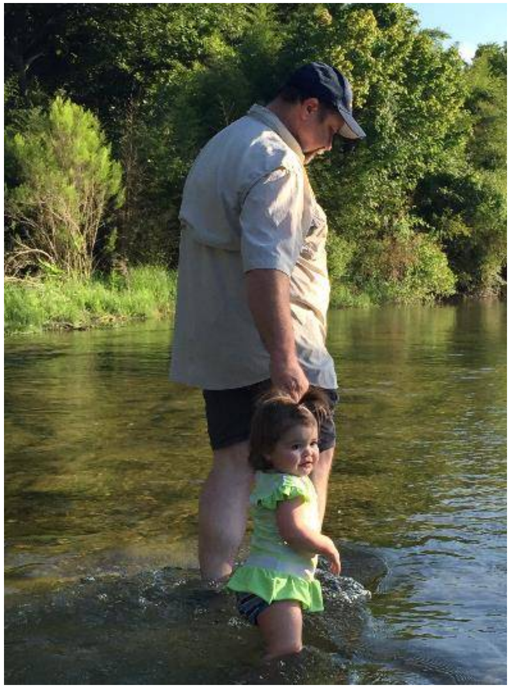


Partnerships

Tarrant Regional Water District
Texas State Soil and Water Conservation Board
Texas Commission on Environmental Quality
Environmental Protection Agency
Navarro Soil and Water Conservation District
Ellis-Prairie Soil and Water Conservation District
and other private sector partners.

NRCS will continue to coordinate with local, state and federal agencies, conservation districts, nongovernmental organizations and others to implement this initiative

USDA
United States Department of Agriculture



Questions?

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USDA Natural Resources Conservation Service
101 S. Main, Temple, TX 76501
(254)742-9865   Kyle.wright@tx.usda.gov

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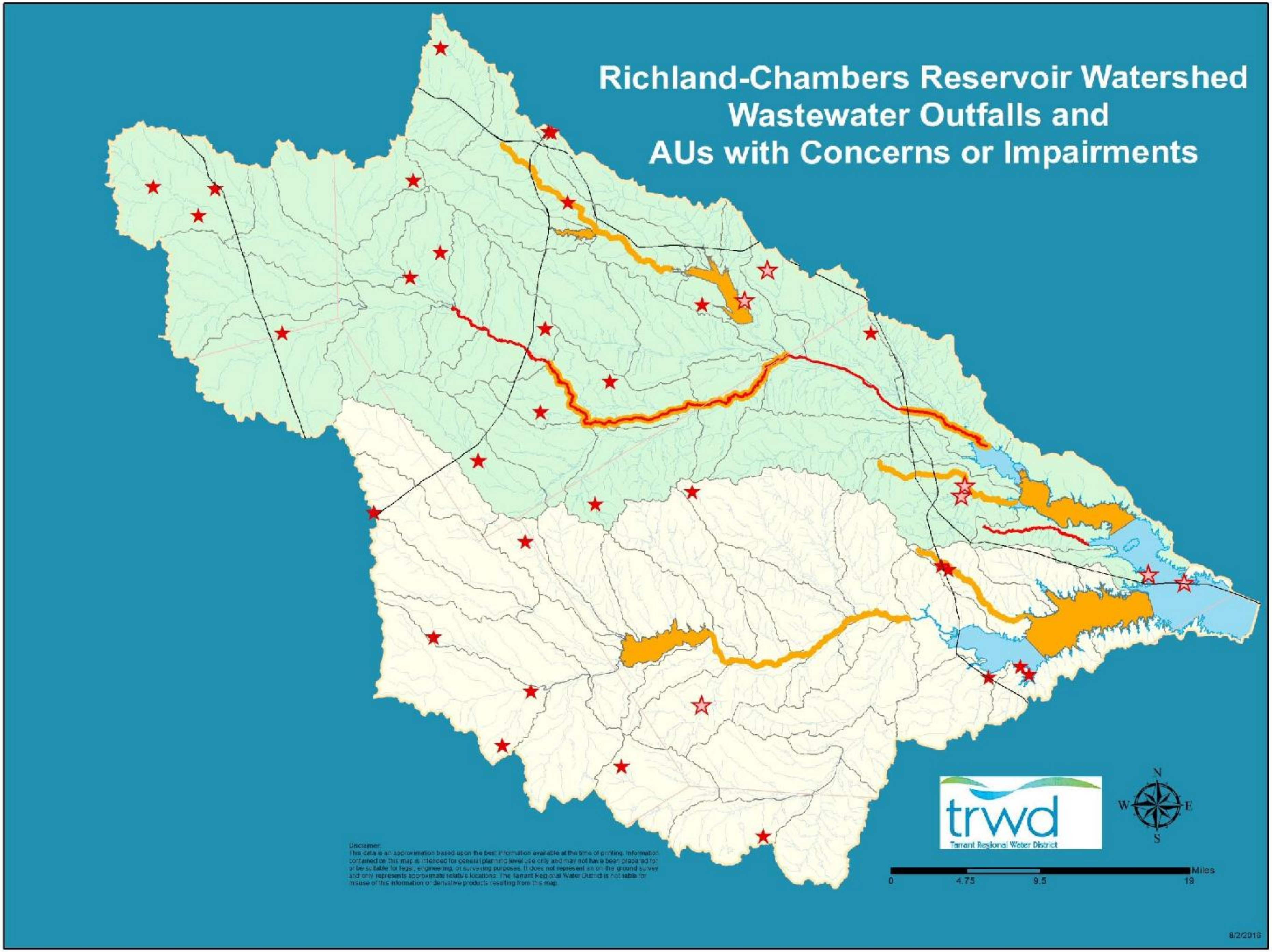
Richland-Chambers Watershed Point Source Evaluation

ROBERT ADAMS PE – ALAN PLUMMER ASSOCIATES

Richland-Chambers Reservoir

Point Source Evaluation



Richland-Chambers Reservoir Watershed
Wastewater Outfalls and
AUs with Concerns or Impairments
Disclaimer:
This data is an approximation based upon the best information available at the time of printing. Information contained on this map is intended for general planning level use only and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. It does not represent an on the ground survey and only represents approximate relative locations. The Tarrant Regional Water District is not liable for misuse of this information or derivative products resulting from this map.
trwd
Tarrant Regional Water District
N
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9.5
19
8/2/2018

Point Source Evaluation
Data Gathering

- Site Data
  - Lat/lon of discharge point.
  - Receiving stream and segment
  - Flow – average flow (mgd)

Point Source Evaluation
Data Gathering

- Water Quality Data
  - Stream Health
    - Biochemical oxygen demand (BOD-mg/L)
    - Carbonaceous BOD (CBOD-mg/L)
    - Total Suspended Solids (TSS) in mg/L
    - Minimum dissolved oxygen (DO) in mg/L
  - Nutrients
    - Ammonia nitrogen (NH_3-N) in mg/L
    - Total phosphorus (TP) in mg/L

Point Source Evaluation
Load Assessment

- Assess current load, permit limits, and annual variability
  - Permit Limits vs. Actual Discharges
  - Site specific data will be used if available

Point Source Evaluation
BMP Assessment

Practices are available for maintaining and improving water quality

Cost considerations

Point Source Evaluation
Next steps

Data gathering – letters to permittees

Phase I and Phase II

6 month study

Richland-Chambers Watershed Economic Analysis of BMPs

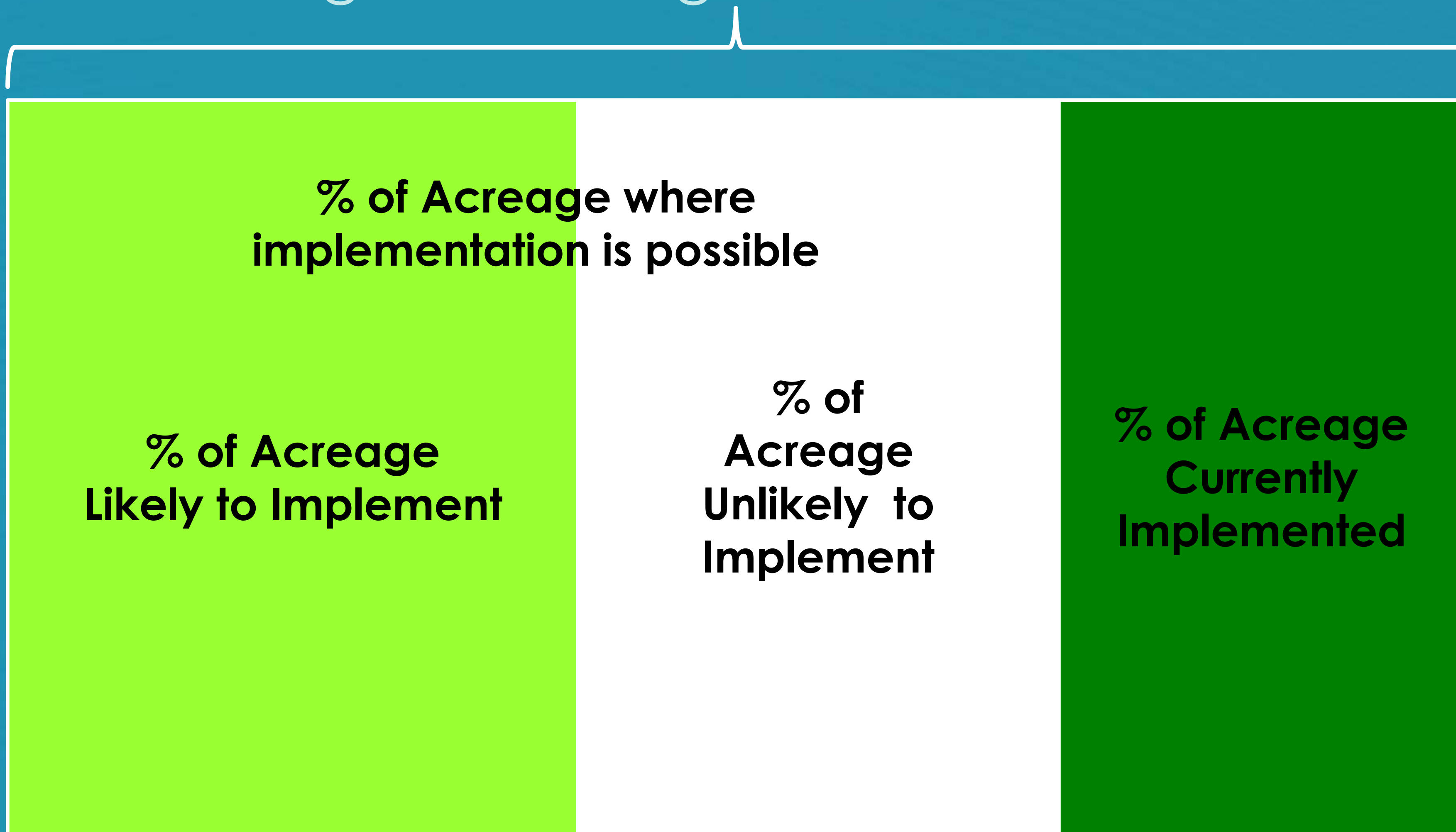
DR JASON JOHNSON – TEXAS A&M UNIVERSITY AND AGRILIFE EXTENSION

Economic Study of BMPs
Identification of Relevant BMPs

Economic Study of BMPs
Identification of Relevant Solutions

- Historic Use of Effective BMPs in Watershed
- Estimation of Current, Potential and Most Likely Adoption Rates
- Creation of Budgets for Individual BMPs
- Ranking of BMPs - least cost for load reduction
- Identification of suite of BMPs to reach project goal
- Establish Cost Estimates for Least Cost Solution

Total Eligible Acreage for an Individual BMP



Initial Estimates – Ranking of BMPs

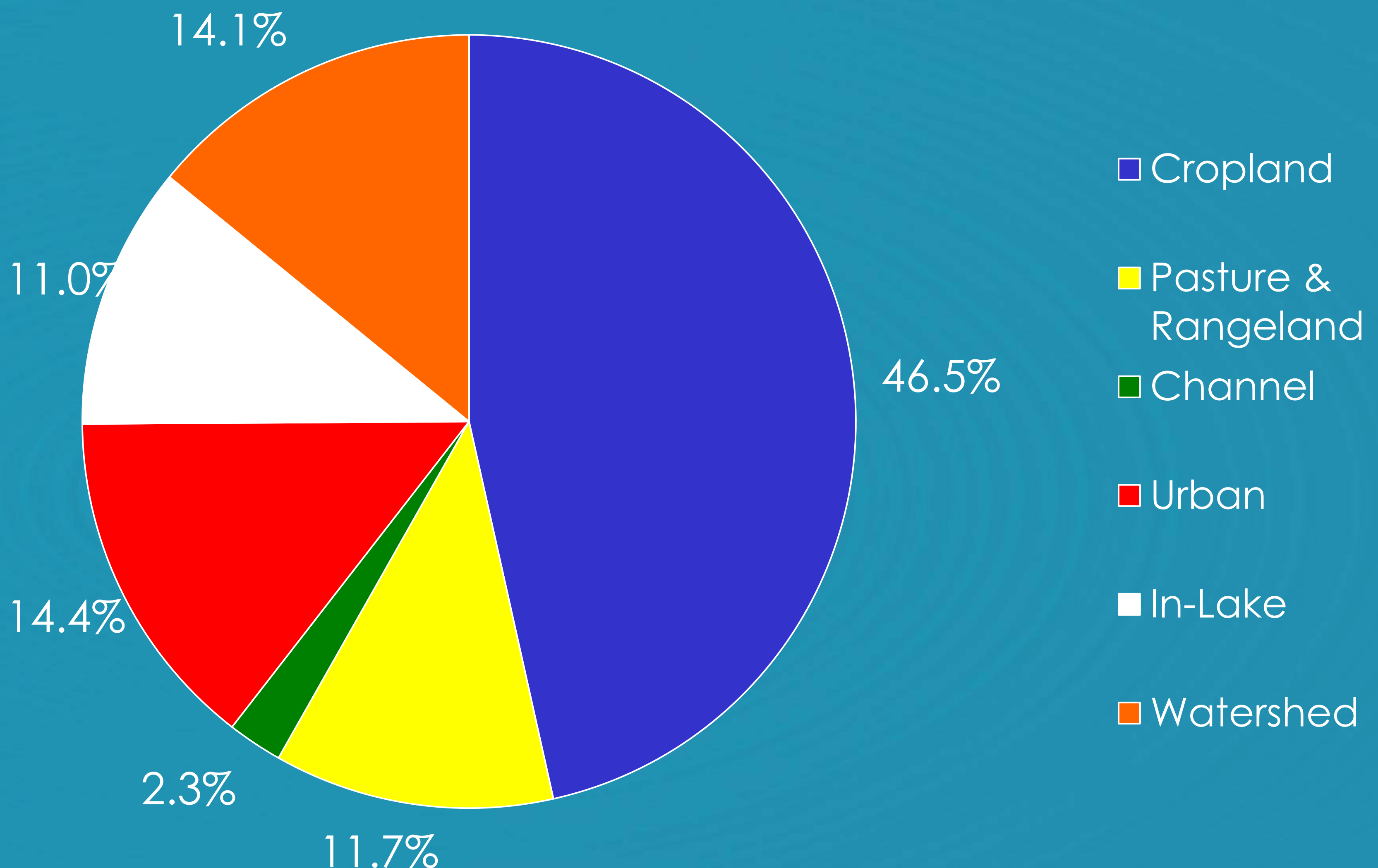
BMP Description	Annual $ per kg. of P reduced
Establish Filter Strips	$6.39
Establish Grassed Waterways	$9.65
Grade Stabilization – gully plugs	$14.92
Herbicide Application – Riparian Corridor	$15.37
Required Urban Nutrient Mgt.	$27.06
Terracing	$53.39
Conversion of Cropland to Grass/Hay	$55.31
…	…
Critical Pasture Planting – shaping	$1,005.37
WWTP – Level I to Level III	$1,153.13
Riparian Buffer Strips – Med. Erosion Areas	$1,431.70

CEDAR CREEK: Cost-Effective BMP Strategy P Reduction Target

BMP	Cumulative P Reduction (%)
Filter Strips	14.2%
Grade Stabilization Structures	16.1%
Critical Pasture Planting	17.1%
Terracing Cropland	21.3%
WWTP Level II	25.9%
Conversion of Cropland to Pasture	31.7%
Prescribed Grazing	33.1%
2,000 ft. Fertilizer Buffer Around Lake	34.6%

EAGLE MOUNTAIN ANALYSIS

Contributions of Cost-Efficient BMP Categories – 29.9% Reduction in P



Economic Study of BMPs
Next Steps

Data Gathering – May 24 Workshop
- BMP historical review and input
- Economic information development

Next Meeting

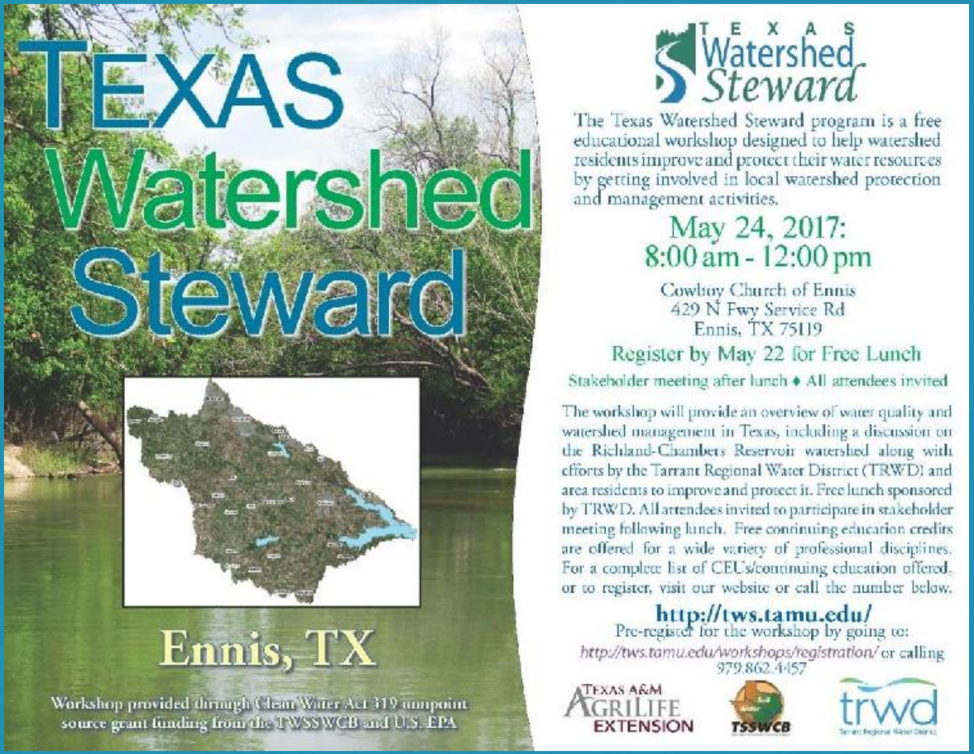
May 24, 2017
Ennis Cowboy Church

8:00 Texas Watershed Steward Workshop

12:00 Lunch

1:00 Stakeholder Meeting and BMP Workshop

Register at:
http://tws.tamu.edu



Next Meeting

Texas Watershed Steward Workshop CEUs

2 NM CEUs for Nutrient Management Specialists

3 TDA CEUs for pesticide license holders

4 TCEQ for: Landscape Irrigators, On-site Sewage Facility Installers, Public Water System Operators, and Wastewater System Operators

4 TFMA CECs for Certified Floodplain Managers

4 AICP CM hours for Certified Planners

4 ASLA CEPHs for Certified Landscape Architects

4 CCA CEUs in Soil & Water Management

4 TBPE CEPs for Professional Engineers

4 Credits applicable to Professional Geoscientists.

4 SBEC CPEs FOR Science Educators

Next Meeting

BMP Workshop

Agricultural/Rural

Urban

Education/Outreach