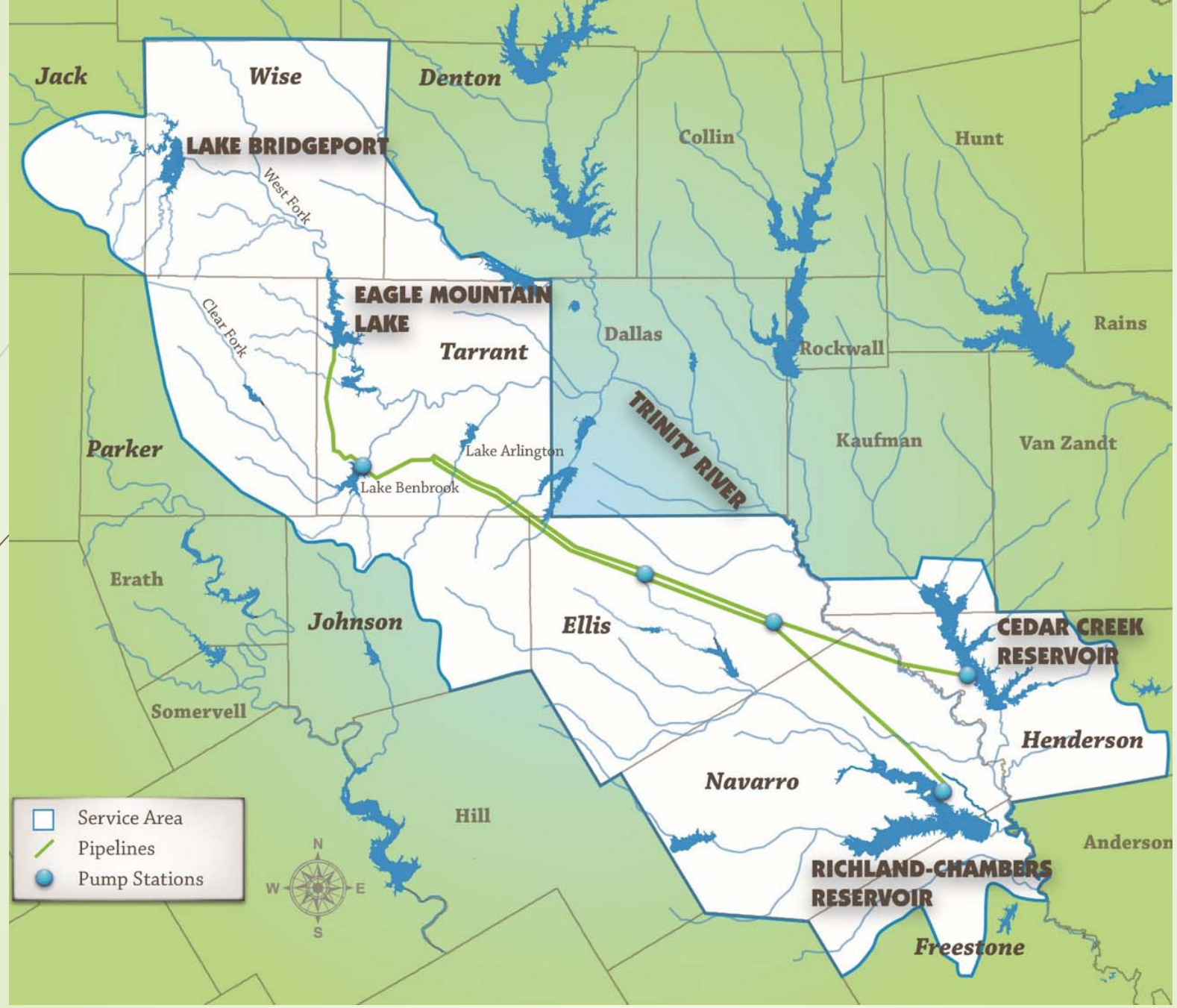
Seven Reservoirs, 12 years of Data, Lots of Stats and 6 Questions Answered

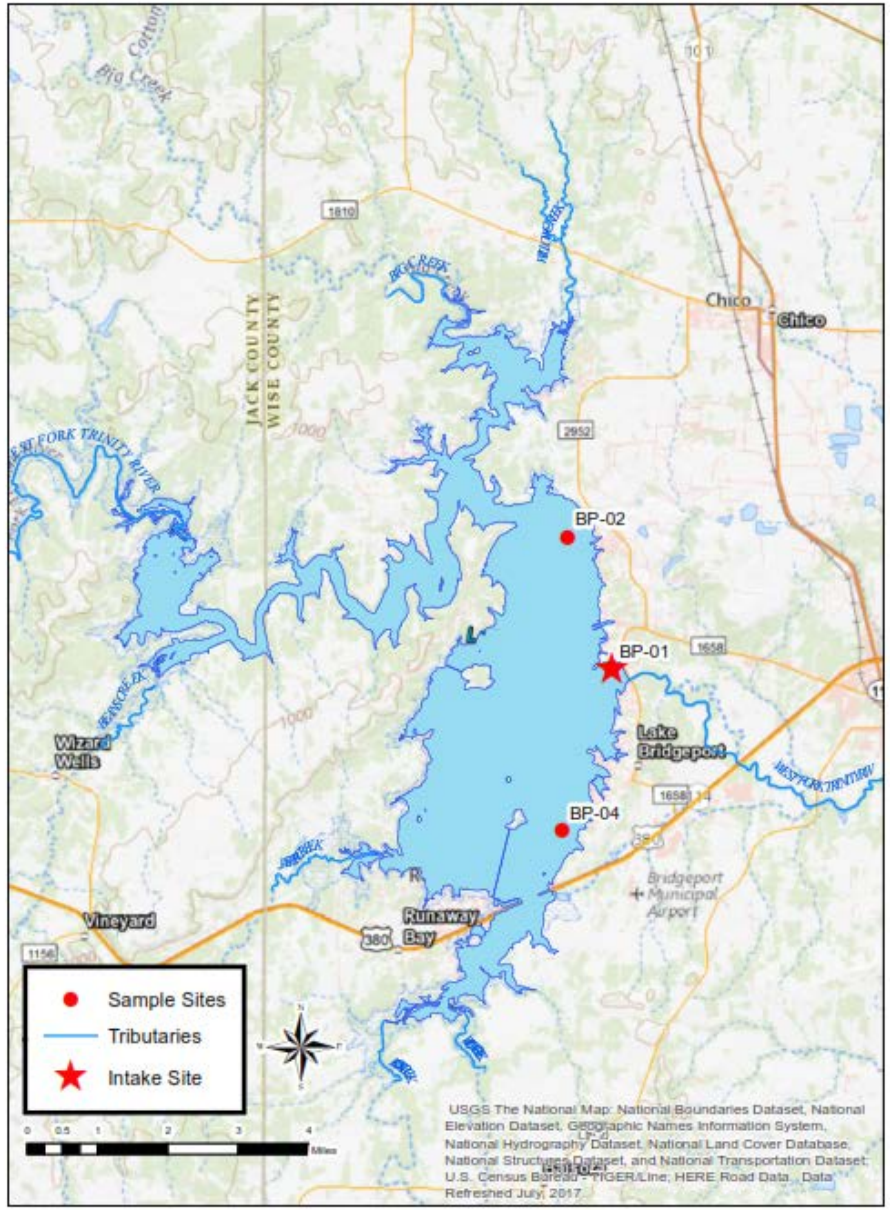
TCEQ Oct 2019 Meeting

Mark R Ernst

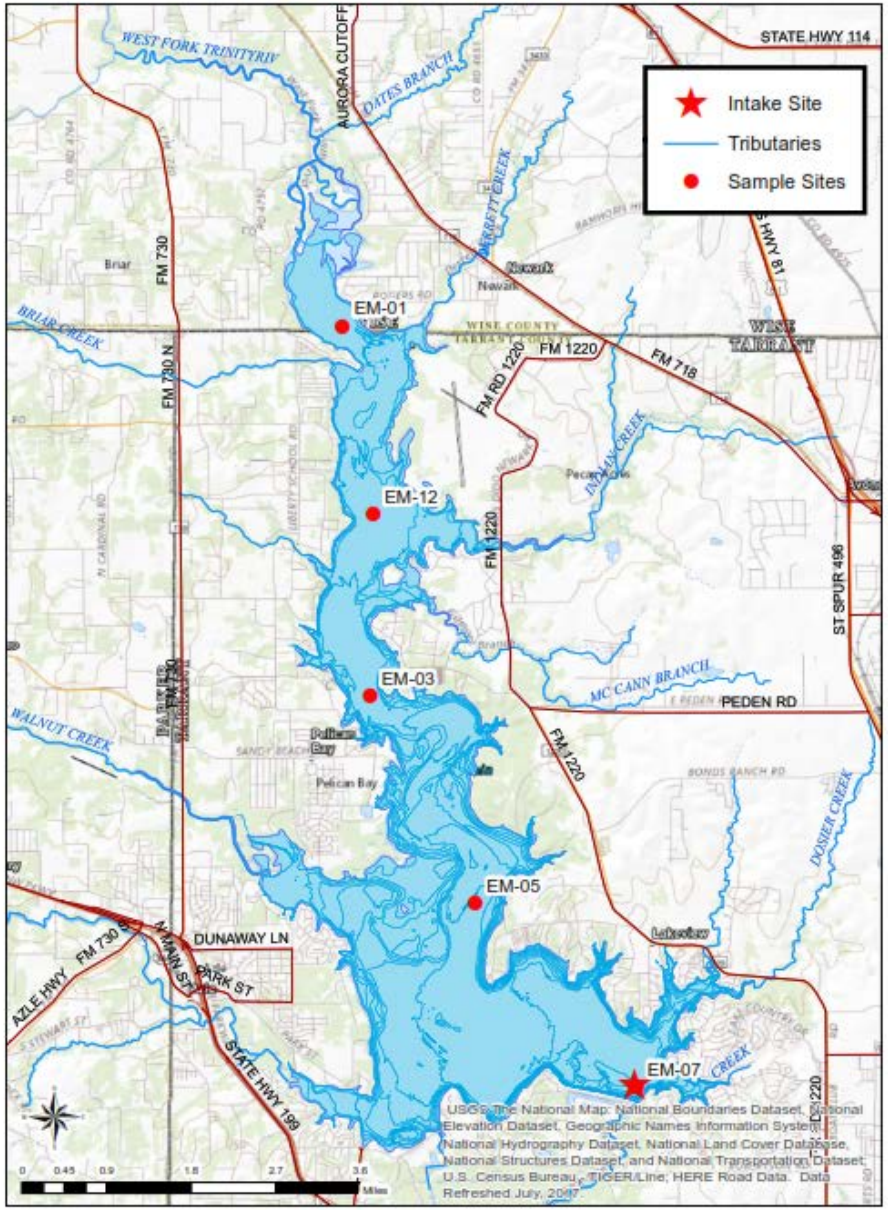
Tarrant Regional Water District


Jack
Wise
Denton
LAKE BRIDGEPORT
West Fork
Collin
Hunt
EAGLE MOUNTAIN LAKE
Clear Fork
Tarrant
Dallas
Rockwall
Rains
TRINITY RIVER
Parker
Lake Arlington
Lake Benbrook
Kaufman
Van Zandt
Erath
Johnson
Ellis
CEDAR CREEK RESERVOIR
Somervell
Henderson
Navarro
Hill
Anderson
RICHLAND-CHAMBERS RESERVOIR
Freestone
Service Area
Pipelines
Pump Stations
N
W
E
S

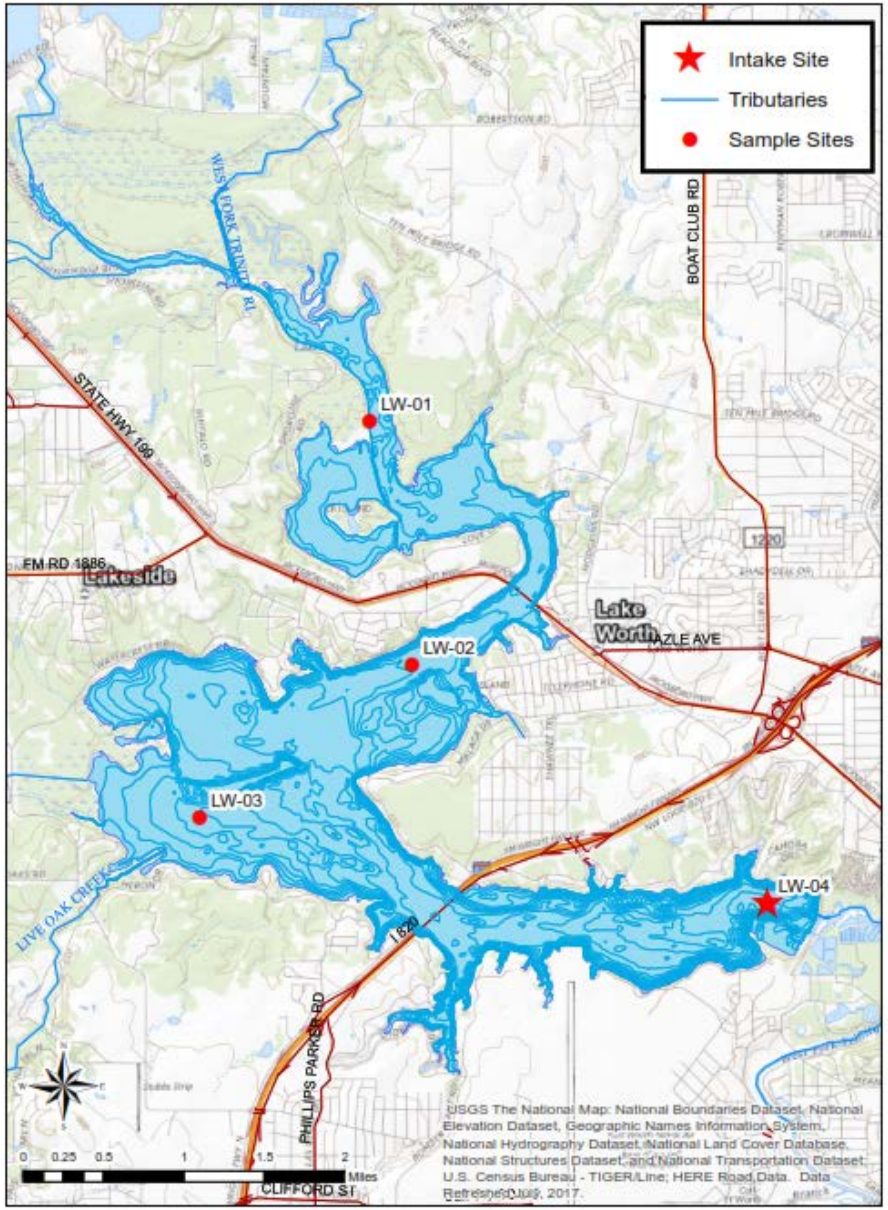
Bridgeport Lake



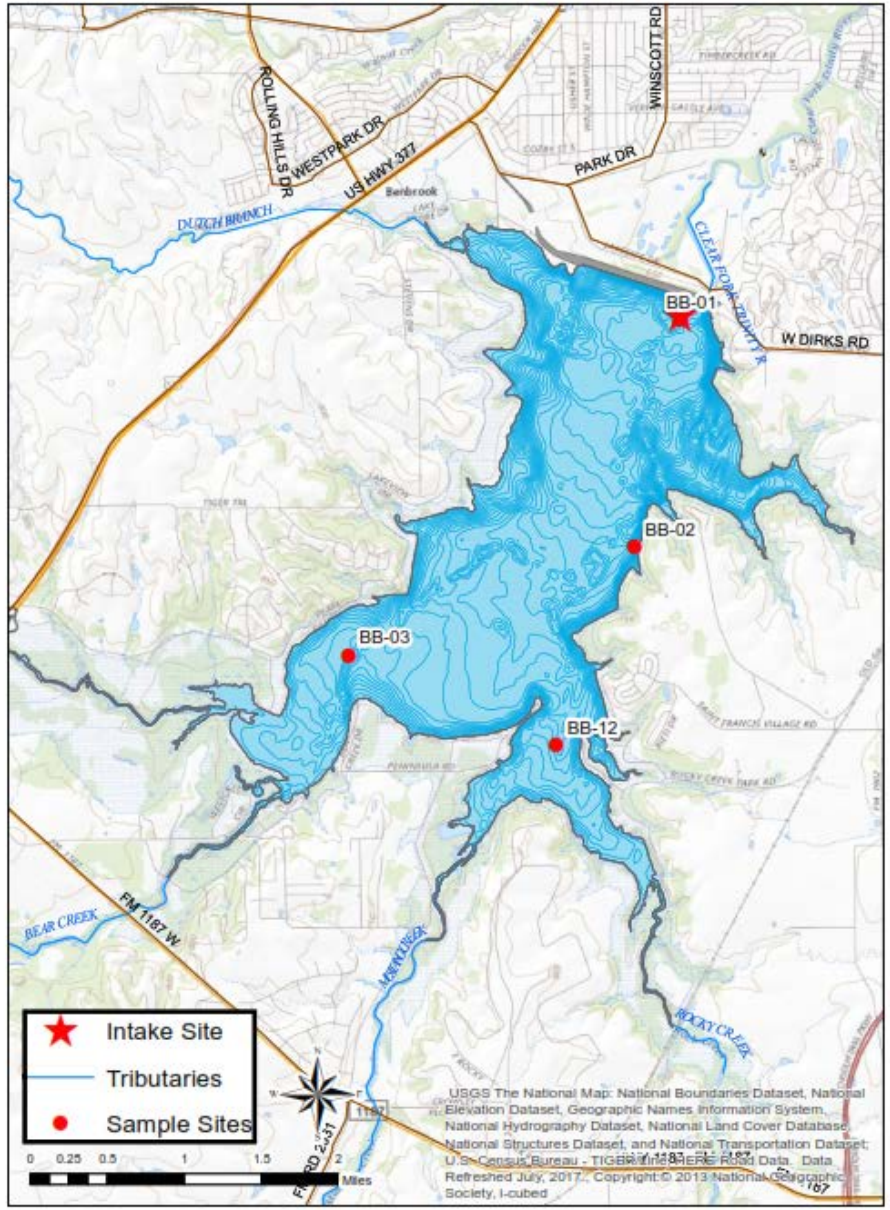
Eagle Mountain Lake



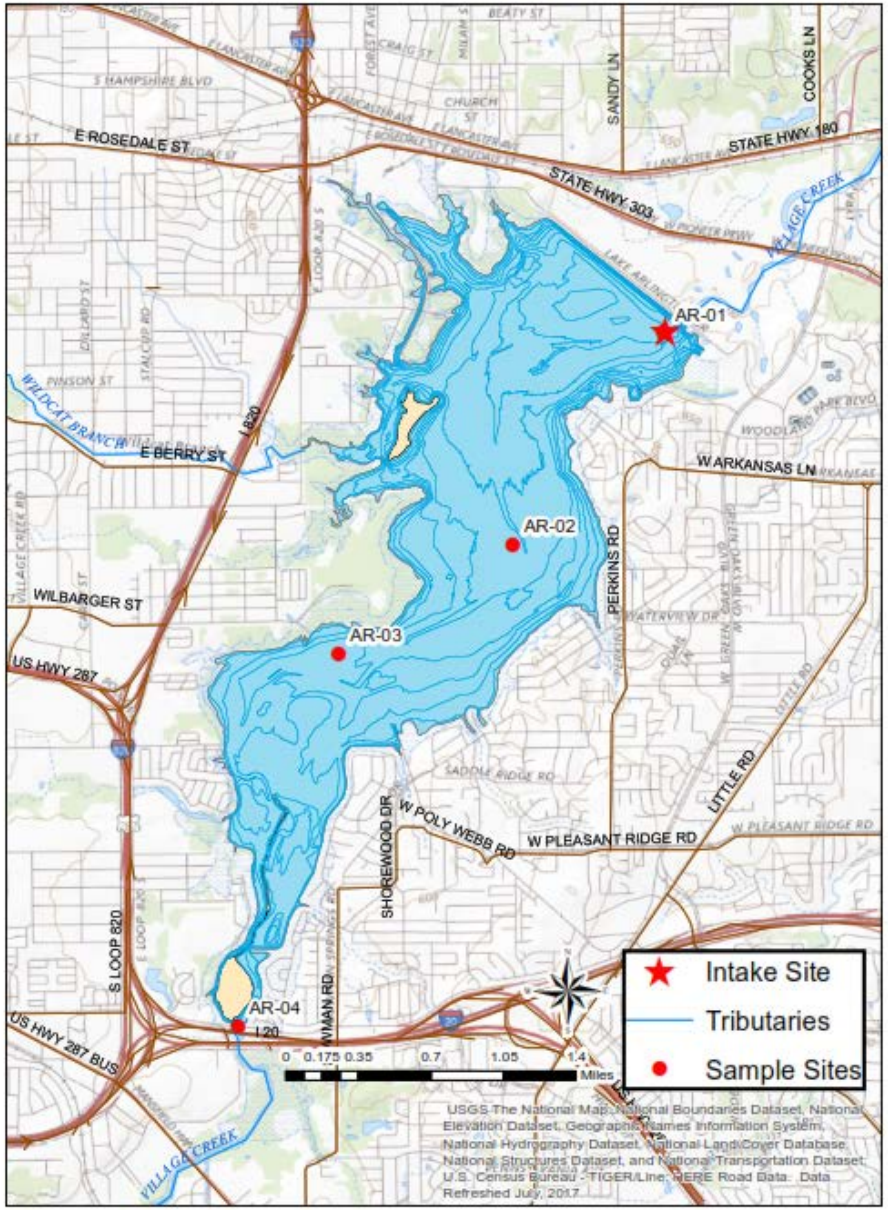
Lake Worth


Intake Site
Tributaries
Sample Sites
LW-01
LW-02
LW-03
LW-04
BOAT CLUB RD
STATE HWY 199
FM RD 1886
Lakeside
Lake Worth
AZLE AVE
1220
1820
PHILLIPS PARKER RD
CLIFFORD ST
LIVE OAK CREEK
WEST FORK TRINITY RI
0 0.25 0.5 1 1.5 2 Miles
USGS The National Map: National Boundaries Dataset, National Elevation Dataset, Geographic Names Information System, National Hydrography Dataset, National Land Cover Database, National Structures Dataset, and National Transportation Dataset; U.S. Census Bureau - TIGER/Line; HERE Road Data. Data Refreshed July, 2017.

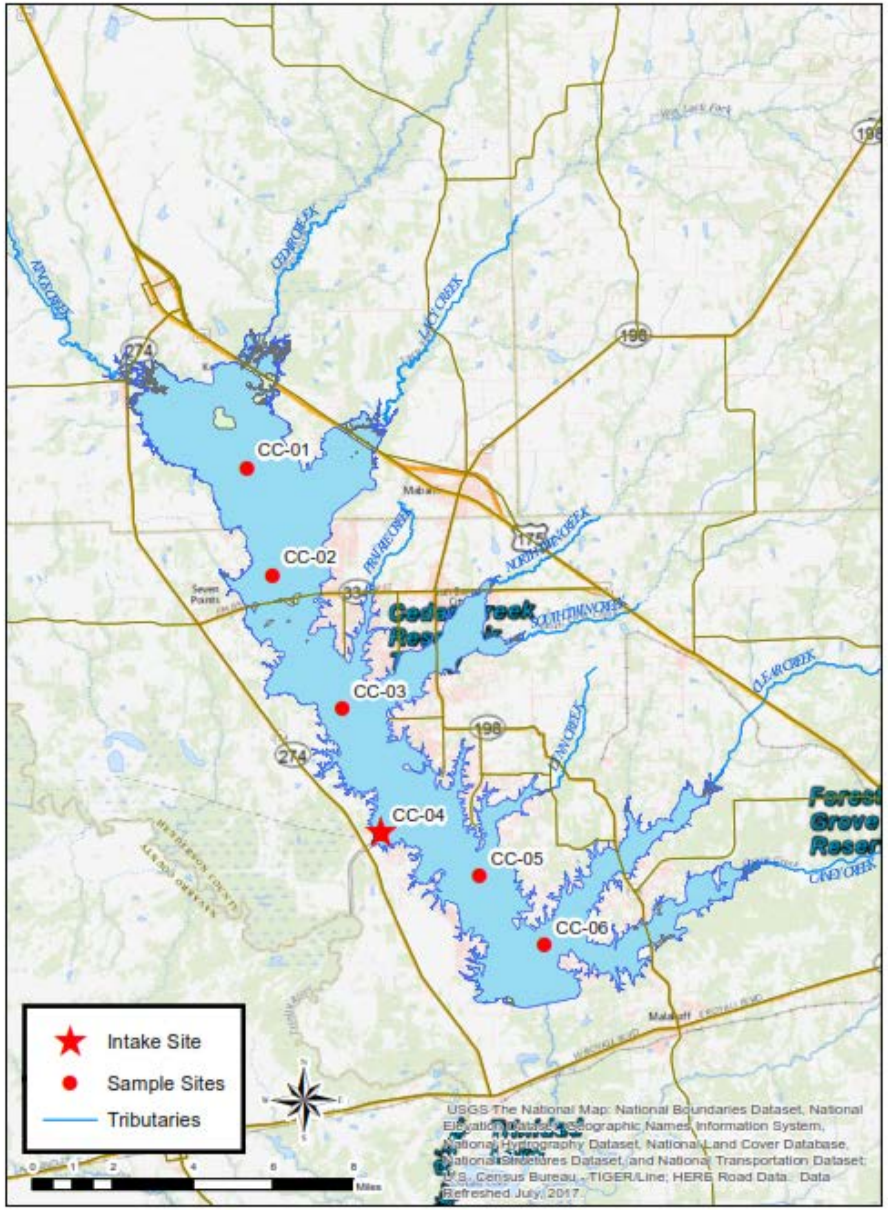
Lake Benbrook



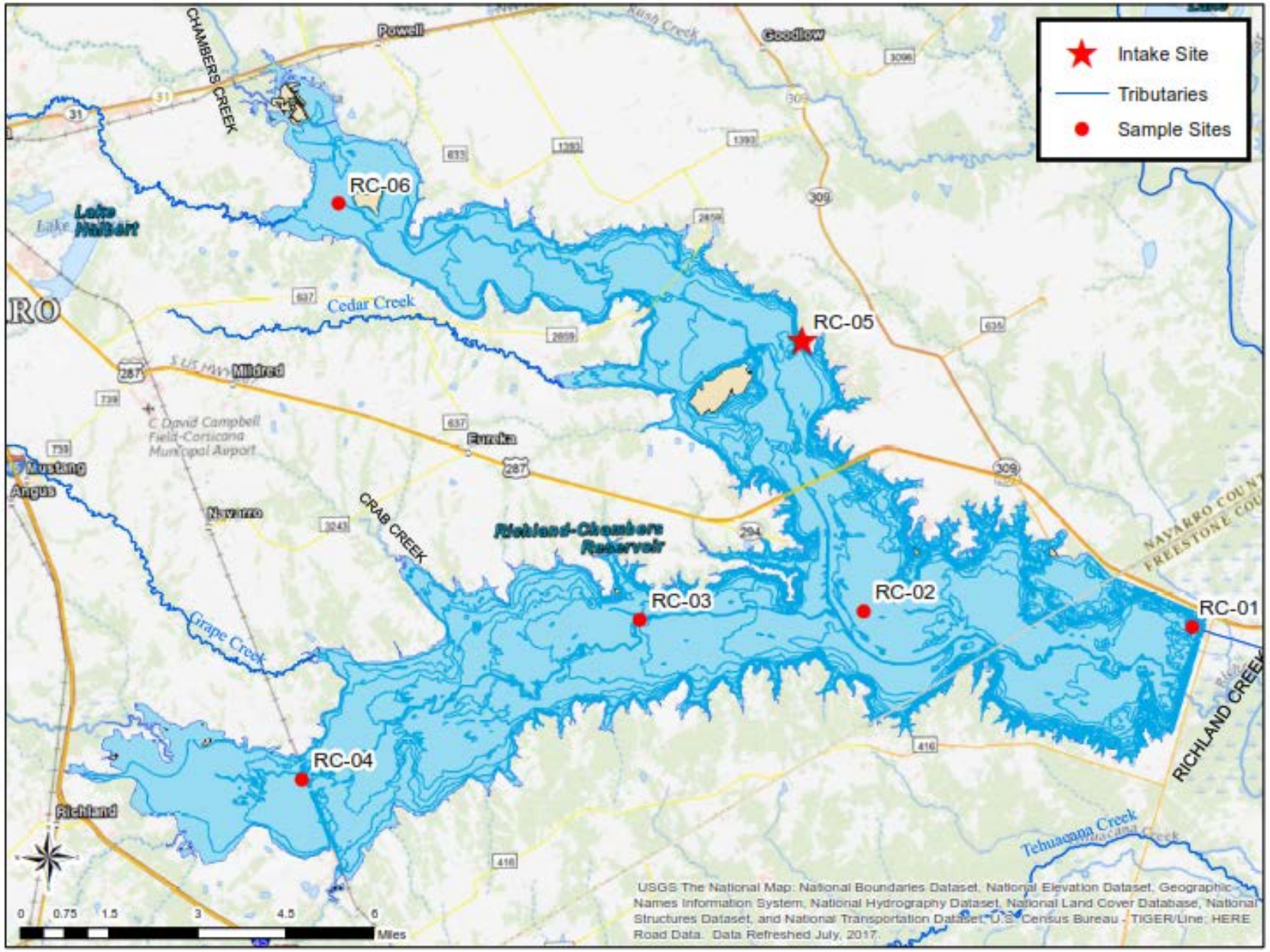
Lake Arlington



Cedar Creek Lake



Richland-Chambers Lake



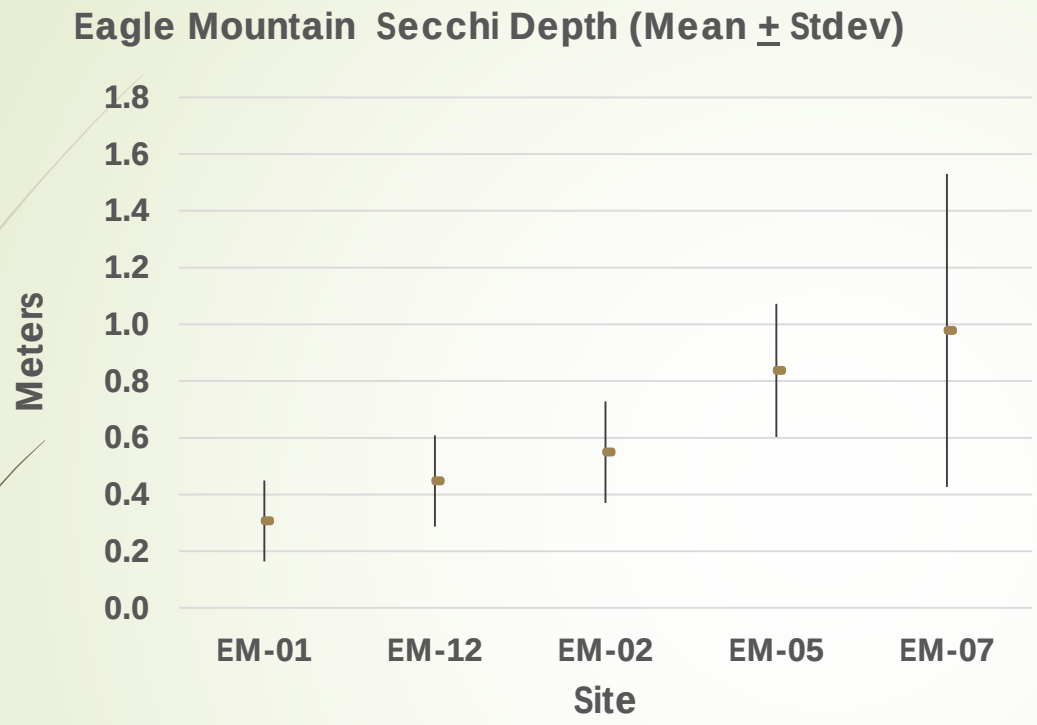
Statistical Testing

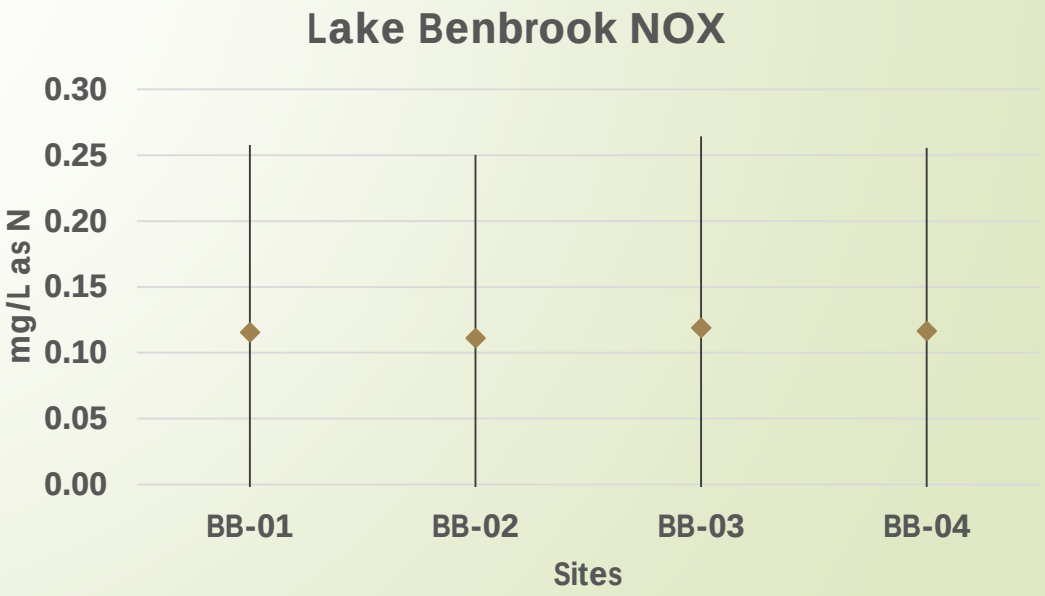
- H_o: there is no difference between the average concentrations of each reservoir intake
- Significantly Different: rejection of the null hypothesis “proving” the difference is not due to chance alone. P
- Probability associated with “proving” Used 0.05 or 0.01 P levels.
- Period of record 2007 to 2018, 12 years of data
- Averages tested with ANOVA and Duncan’s Multiple Range $P < 0.05$
- Trends tested with a linear regression $P<0.01$
- Parametric vs nonparametric statistics

Parameters for Each Analysis

	Longitudinal Difference	Seasonality Dam	Seasonality Intake	Time Trends	Interspecific Dam	Interspecific Intake
Secchi	X	X		X	X	
SPC	X	X	X	X	X	X
Alkalinity	X		X	X		X
TSS	X			X		
NOX	X	X	X	X	X	X
TKN	X	X		X	X	
TN	X	X		X	X	
TP	X	X		X	X	
TN:TP	X	X		X	X	
Chloride	X	X	X	X	X	X
Chla	X	X	X	X	X	X
TDS	X	X	X	X	X	X
E coli		X			X	
pH		X	X		X	X
TOC	X		X	X		X
DOC			X			X
Total Fe			X			X
Total Mn			X			X
Phyto			X			X

H_o: No longitudinal difference in 13 parameters

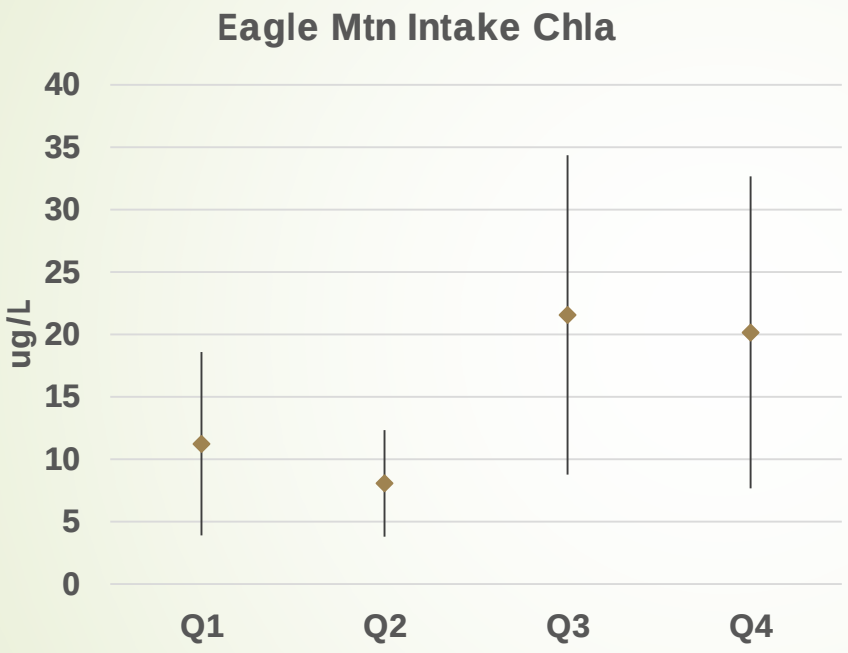


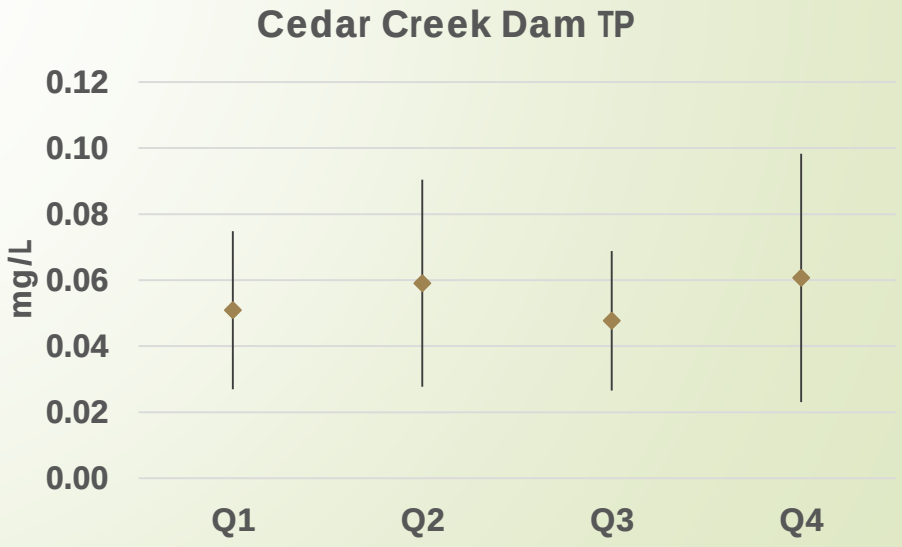


H_o: No longitudinal difference in 13 parameters

- 13 parameters * 7 reservoir = 91 ANOVA tests
- 39 of 91 (43%) showed significant longitudinal differences in concentration
- If BP excluded, 38 of 78 (49%)
- Most common parameters with sig longitudinal differences: Secchi increase, TSS and TP decrease, TN:TP Increase
- Parameters with the least longitudinal differences: Alkalinity never, TKN once (CC), NOX once (AR), TOC once (RC).

H_o: No seasonality at dam surface sites for 12 parameters





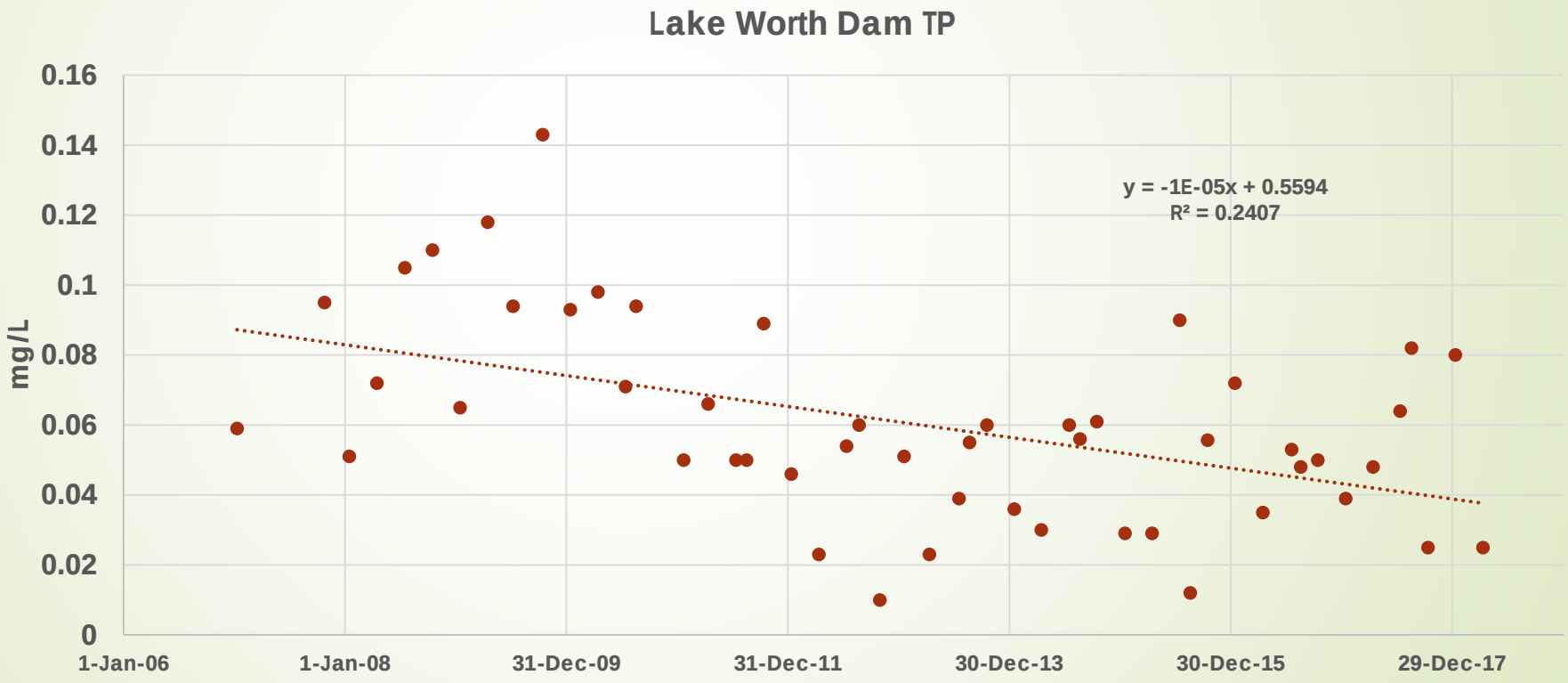
H_o: No seasonality at dam surface sites for 12 parameters

- 12 parmeters * 7 reservoirs = 84 ANOVA tests
- 30 of these (36%) had significant seasonal differences
- Spc, NOX, and Chla were most frequently different (5 of 7)
- Spc and NOX greatest in winter, Chla greatest in summer and fall
- Secchi and TDS seasonally sig different more often than not (4 of 7)
- AR and RC had the most seasonally sign parameters
- TKN, TP, Chloride and TN:TP ratio did not have any seasonally sign differences

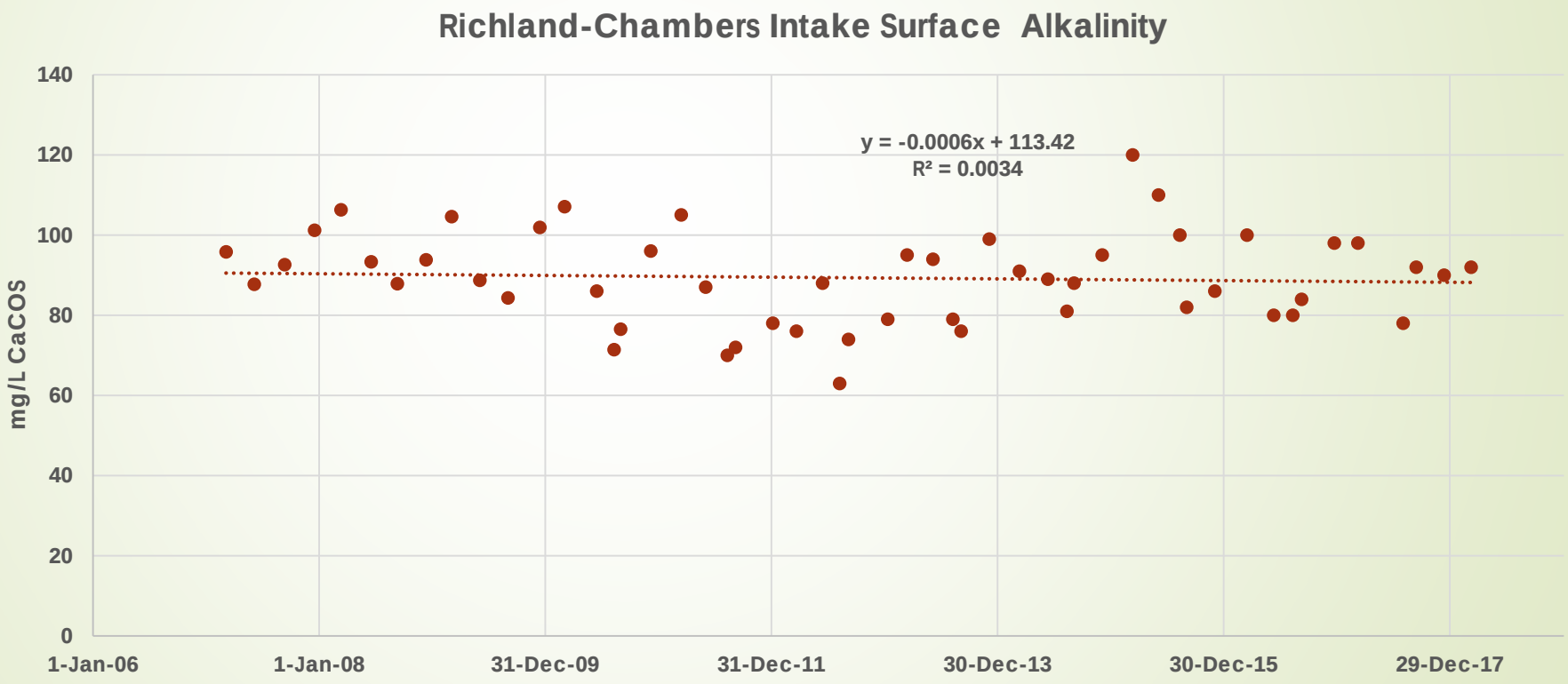
H_o: No seasonality of 12 parameters at 7 reservoir Intake sites

- 12 parameters * 7 reservoirs = 84 ANOVA tests
- 51% showed sign seasonal differences
- Iron was seasonally different in 7 reservoirs, All Q represented
- Chla was seasonally different in 6 of 7 reservoirs, summer and fall Q
- SPC, pH, Alkal, NOX , MN and TDS seasonally sig more often than not (4 of 7)
- NOX highest in winter months
- TOC and Chloride never showed seasonal differences
- DOC and Phytoplankton were only sig seasonally in one reservoir

H_o: There is no linear trend in water quality parameters over the 12 year period



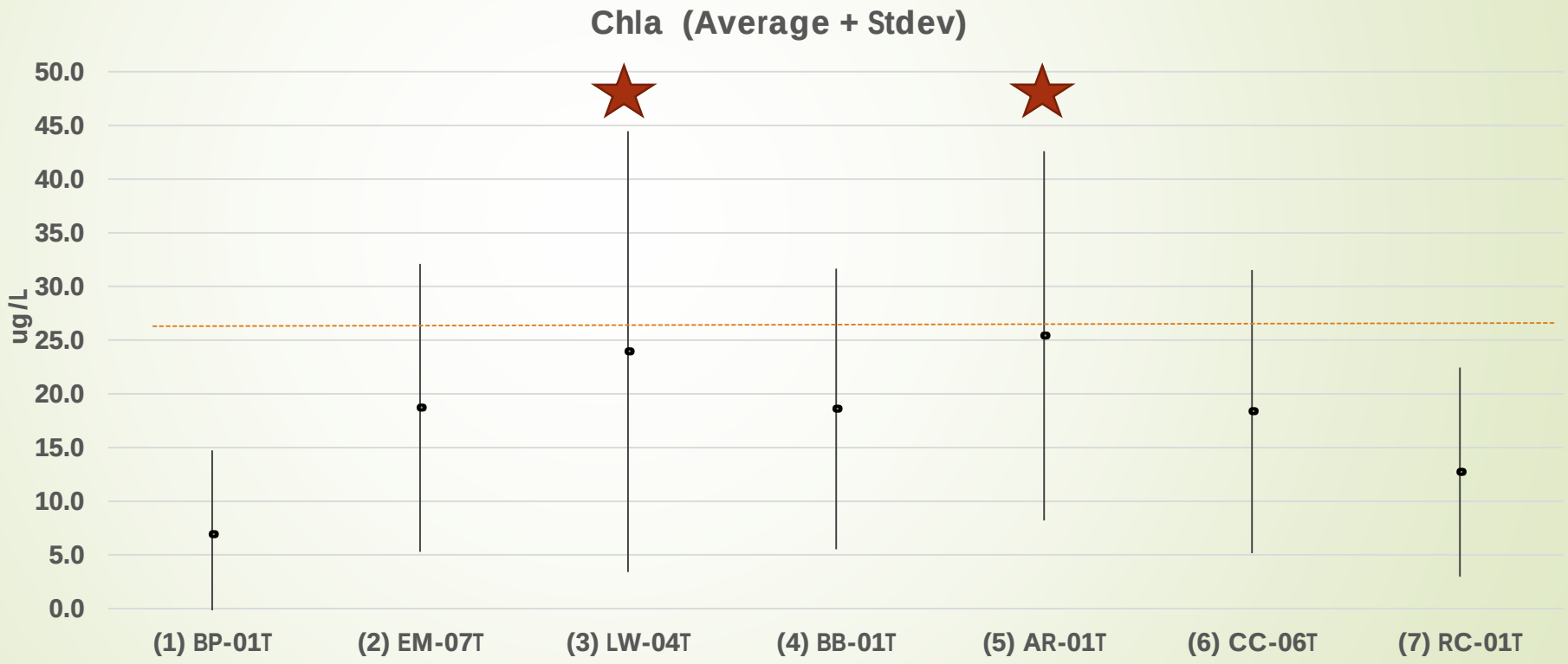
H_o: There is no linear trend in water quality parameters over the 12 year period



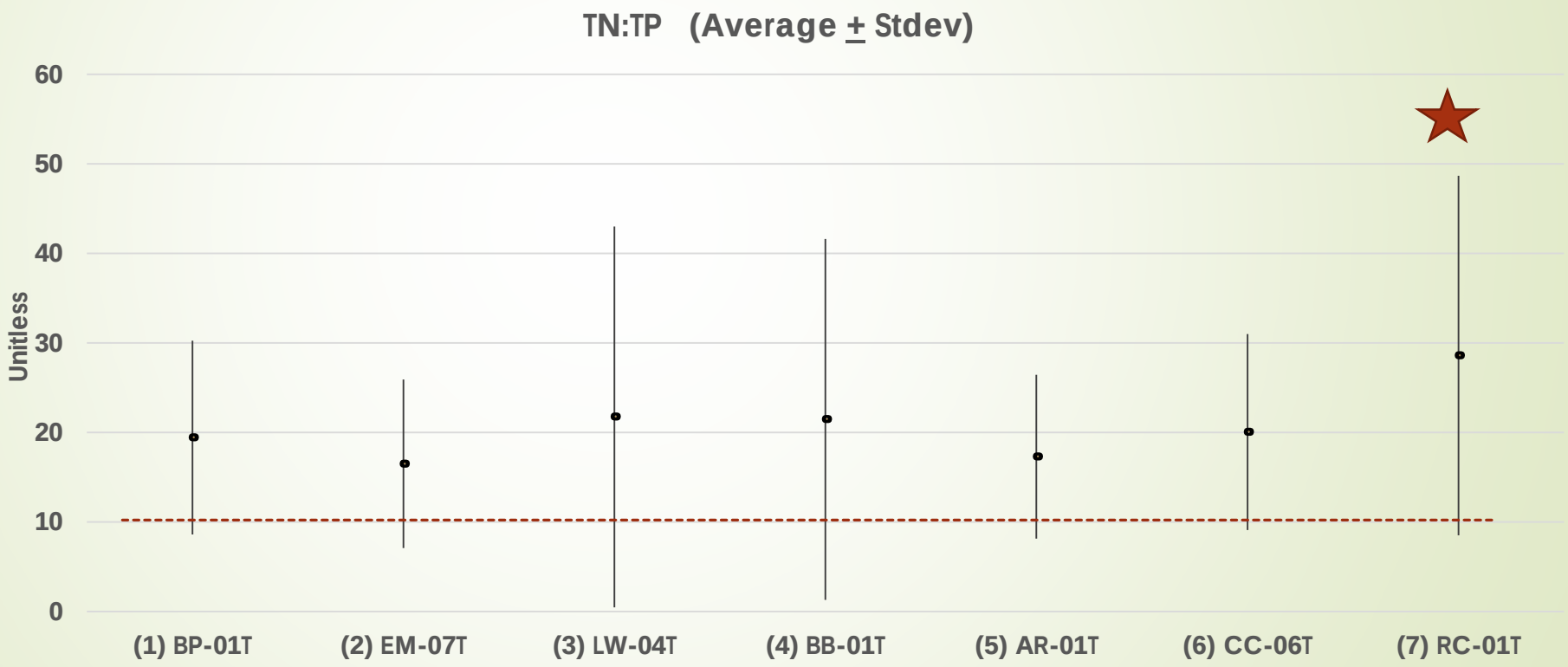
H_o: There is no linear trend in water quality parameters over the 12 year period

- 13 parameters at 32 sites (from 7 reservoirs) = 416 regressions
- 71 (17%) of the regressions had slopes sign different from zero ($p<0.01$)
- TP most commonly Sig with 18 of 32 showing negative slopes
- Chla was second most common sig trend with 12 of 32 showing negative slopes
- Spc and Chloride had 8 of 32 showing sig neg slopes
- TN:TP ratio had 8 of 32 showing sign positive slopes

H_o: No difference in surface reservoir dam sites for 12 parameters



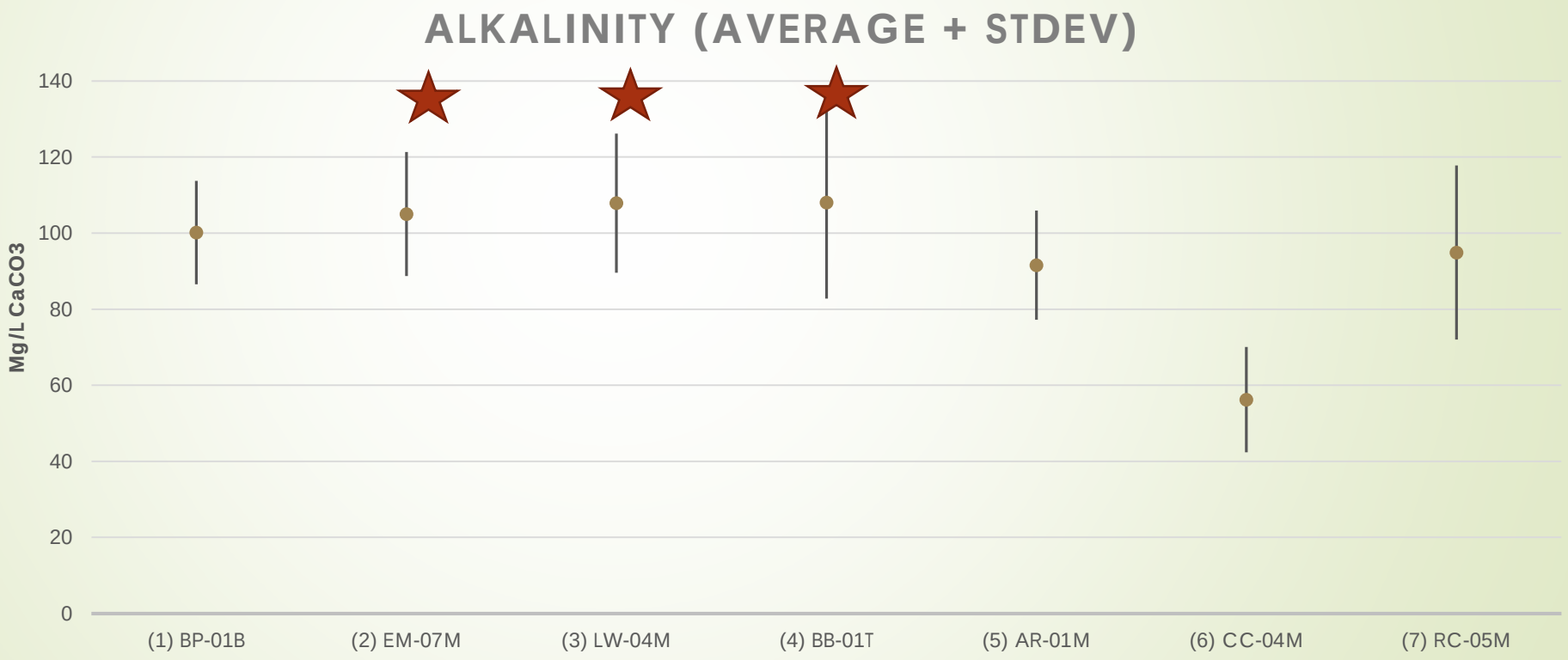
H_o: No difference in surface reservoir dam sites for 12 parameters



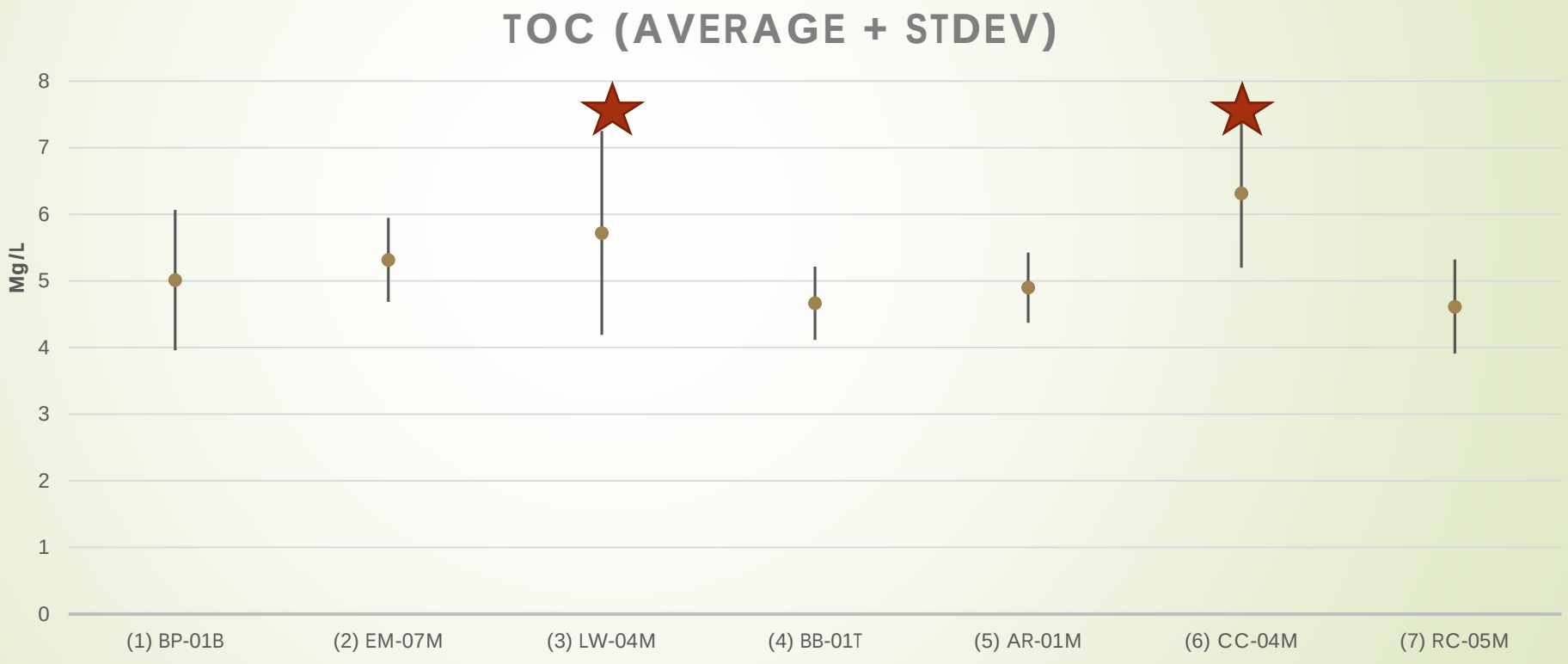
H_o: No difference in surface reservoir dam sites for 12 parameters

- 12 ANOVA tests
- 11 out of 12 parameters were sig different across the 7 reservoirs.
- Only E coli was not sign different
- In general the most eutrophic reservoirs are LW and AR

H_o: No difference in 7 reservoir intake sites for 12 parameters



H_o: No difference in 7 reservoir intake sites for 12 parameters



H_o: No difference in 7 reservoir intake sites for 12 parameters

- 12 ANOVA tests
- All 12 parameters were sign different
- LW (5) and CC (4) had the most sig high values (inverse for Alkalinity)
- LW and CC rank as the lowest supply water quality
- EM and BB rank the best water supply quality

Conclusions

- About half of the parameters tested showed longitudinal and seasonal differences
- Only 17% of the parameters trended over a 12 year period within a reservoir
- 96% of the parameters showed sig differences between reservoirs.

Few more Conclusions

- Room to reduce sampling of parameters that do not differ longitudinally and/or seasonally.
- Addition of a site at BP will help understand the reservoir
- General longitudinal and/or season patterns are great for reviewing a reservoir model.
- Lack of longitudinal variability of Alkalinity and TOC increases our dataset!
- SPC and TDS vary seasonally, they are not as conservative as chloride.

Additional Analyses

- Comparison of major tributaries to see if there are significant water quality differences and determine if there are relationships between flow and concentration.
- Expand POR, 25- 30 years
- Include testing water quality at difference depths, i.e. surface and bottom when stratified.
- Compare bottom water when stratified between reservoirs
- Refined data sets to equalize sample sizes of lab and field data, monthly vs quarterly sampling

Acknowledgement

- Trinity River Authority as our Clean Rivers Program leader
- Particularly Hong Wu and her expertise with SAS and attention to detail