Chemical Constituents in Water and Sediment from Grand Lake O' the Cherokees, Oklahoma, Downstream from the Tri-State Lead-Zinc Mining District

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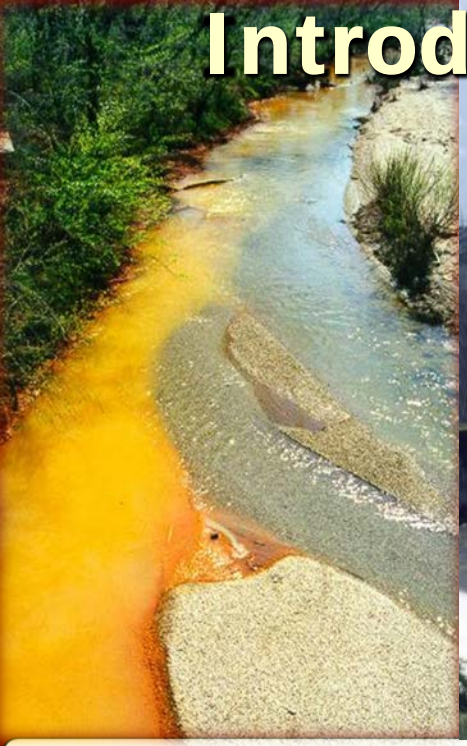
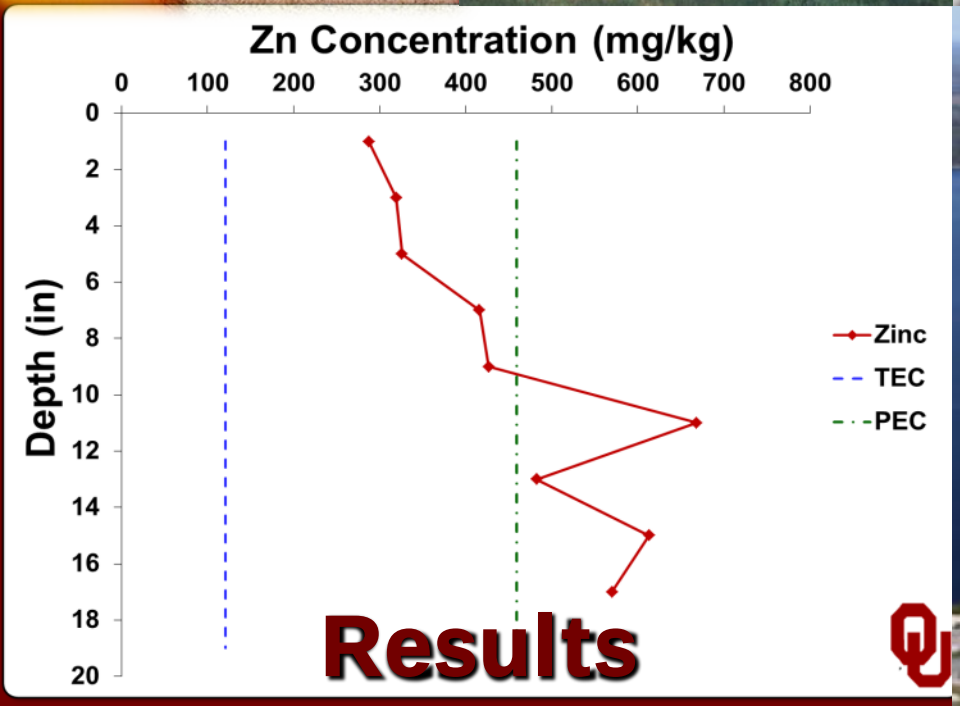
School of Civil Engineering and Environmental Science
The University of Oklahoma, Norman, OK

Introduction

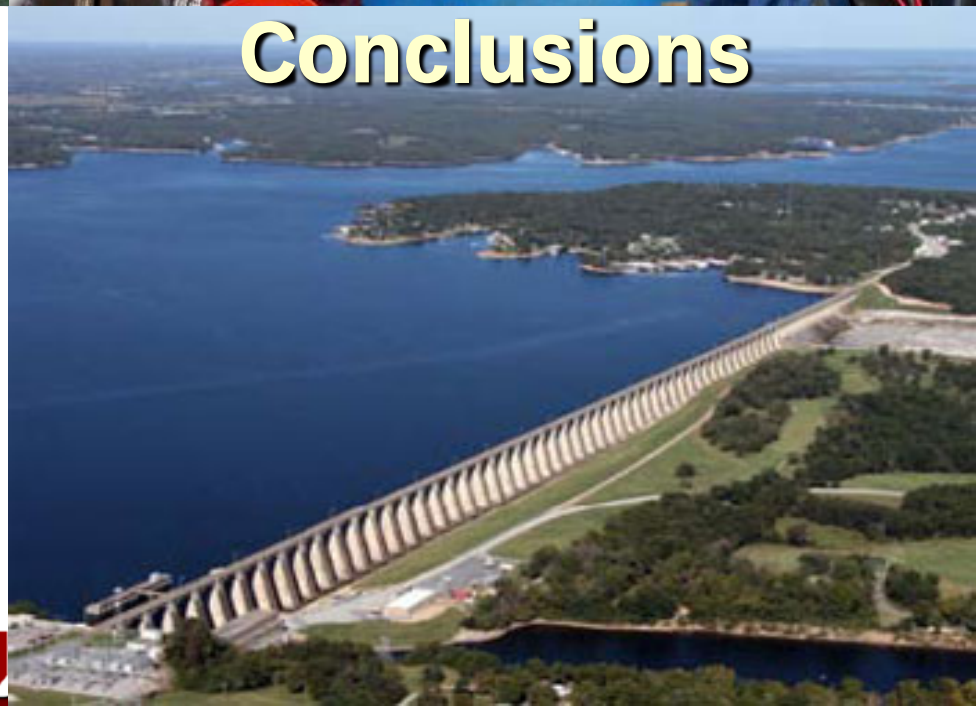


Methods

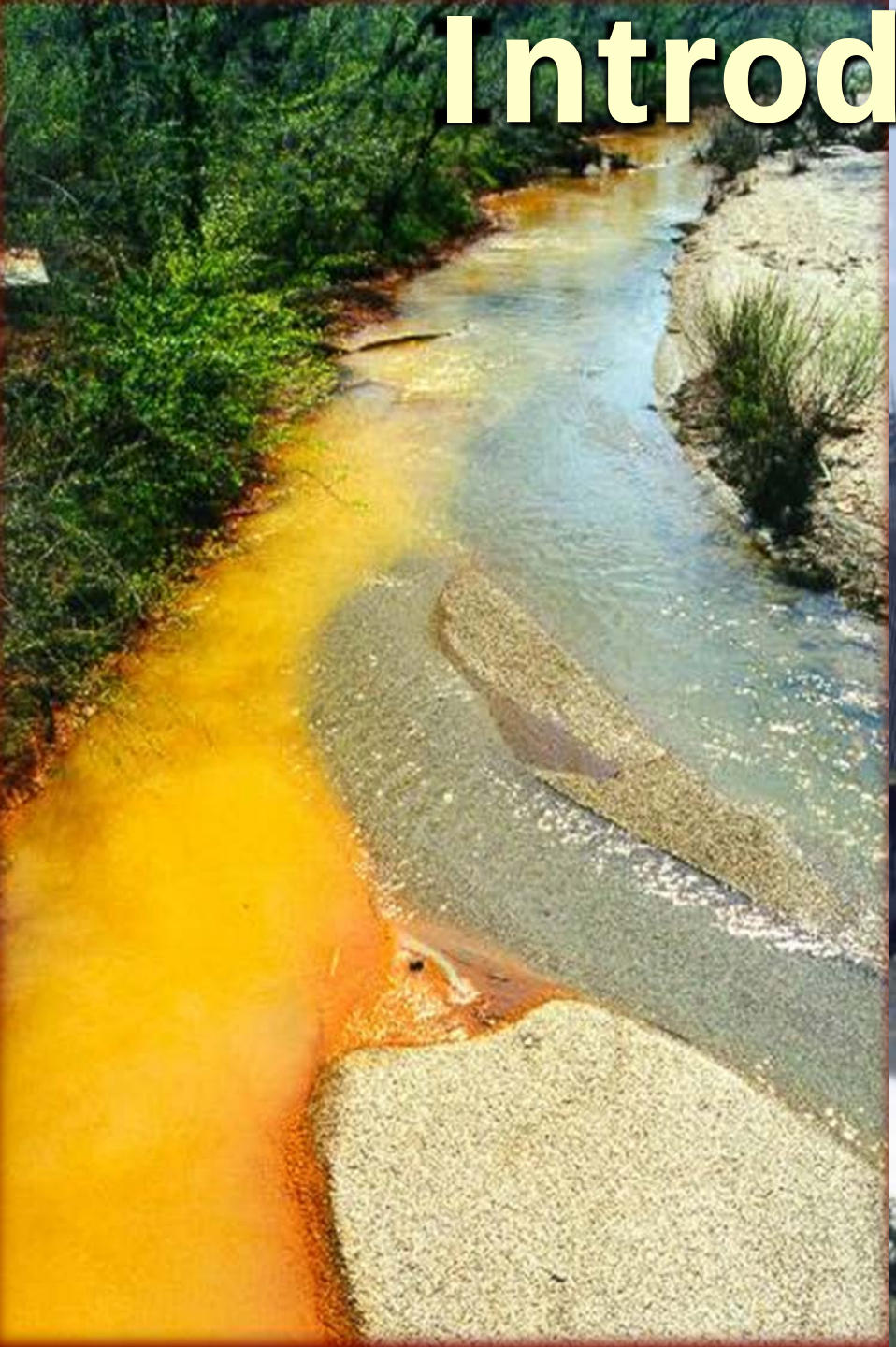


Results

Conclusions



Introduction



Capstone Experience

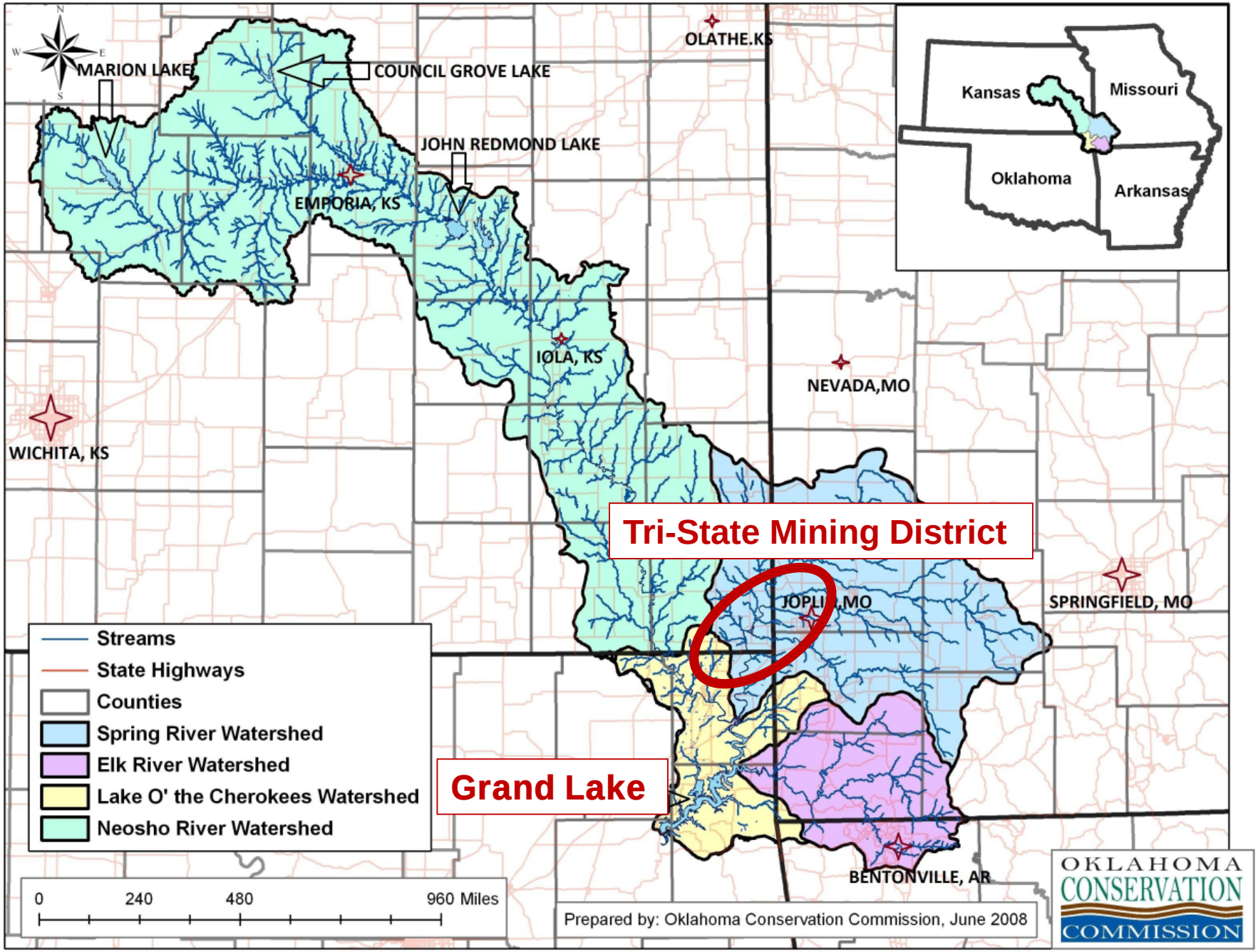
- Senior Environmental Scientists and Engineers
- Comprehensive analysis of an open-ended, real-world problem
- Work directly with clients and stakeholders

2010/2012 Capstone Projects

- Outgrowth of long-term cooperative efforts
- Focus on reservoir sediment contamination
- Historic mining impacts
- Management implications

Grand River Dam Authority
ECOSYSTEMS & EDUCATION CENTER
PARTNERS IN CONSERVATION AND RESTORATION
GRDA Grand River Dam Authority

Grand Lake Watershed

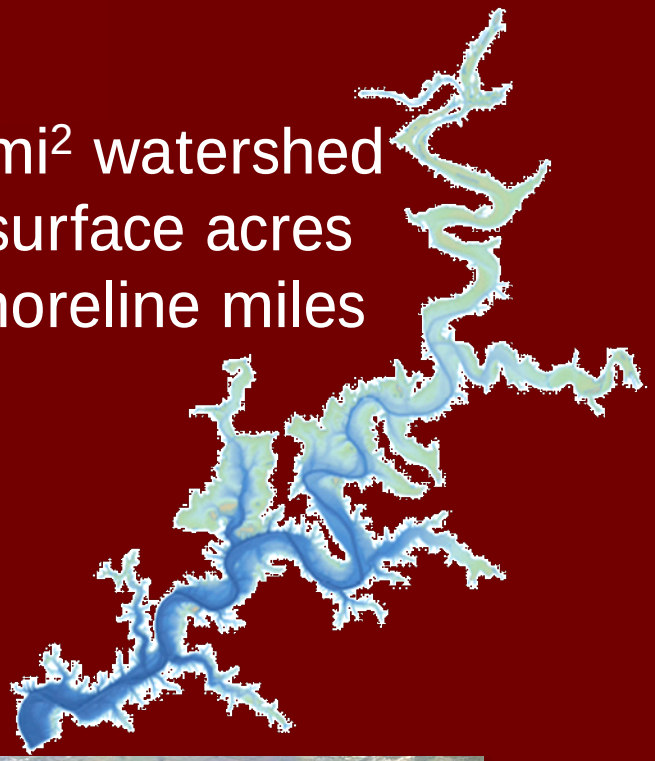


Grand Lake O' the Cherokees

- Third largest reservoir in Oklahoma

- Beneficial uses
  - Hydroelectric power
  - Flood control
  - Water supply
  - Recreation
  - Fish and wildlife propagation

- Operated by GRDA



- 10,298 mi^2 watershed
- 46,500 surface acres
- 1,300 shoreline miles

- Pensacola Dam (1940)
- Largest multiple arch dam

Grand Lake O' the Cherokees

- Premier recreation destination
- Near shore development
  - Boat docks
  - Sediment dredging

One weekend
$26 million economic impact

Tri-State Mining District

- 1200 mi^2 mined ~1838-1970
- Mississippian sulfides
  - Galena (PbS)
  - Sphalerite (ZnS)
- Four USEPA CERCLA Sites

Project Scope

- Lake shore development often requires sediment dredging
- GRDA Shoreline Management Plan
  - Total metals concentrations compared to MacDonald et al. (2000) Sediment Quality Guidelines
- Examine sediment metal concentrations

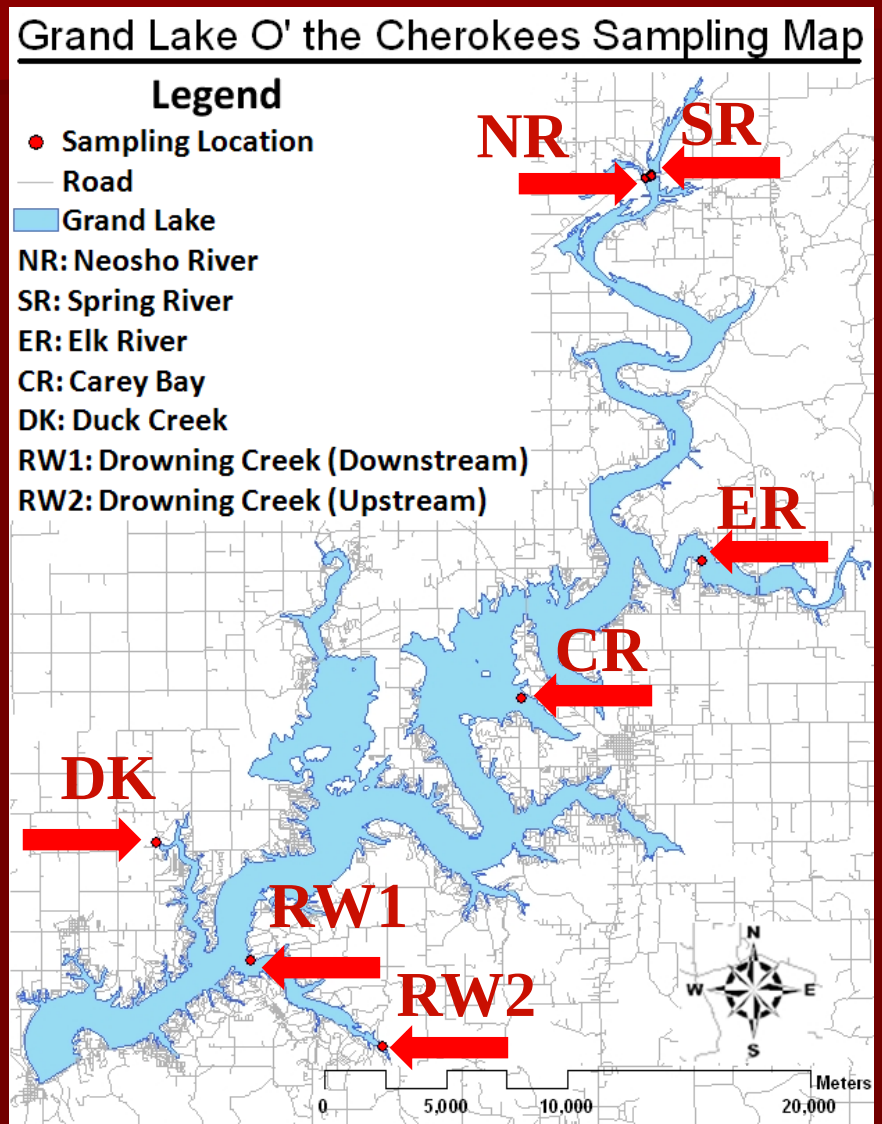
Project Objectives

- Assess the potential impacts from sediment dredging
- Focus primarily on metals associated with the TSMD
- 2010: Initial lake-wide survey
- 2012: Targeted work in two coves

Methods

Sampling Locations

2010



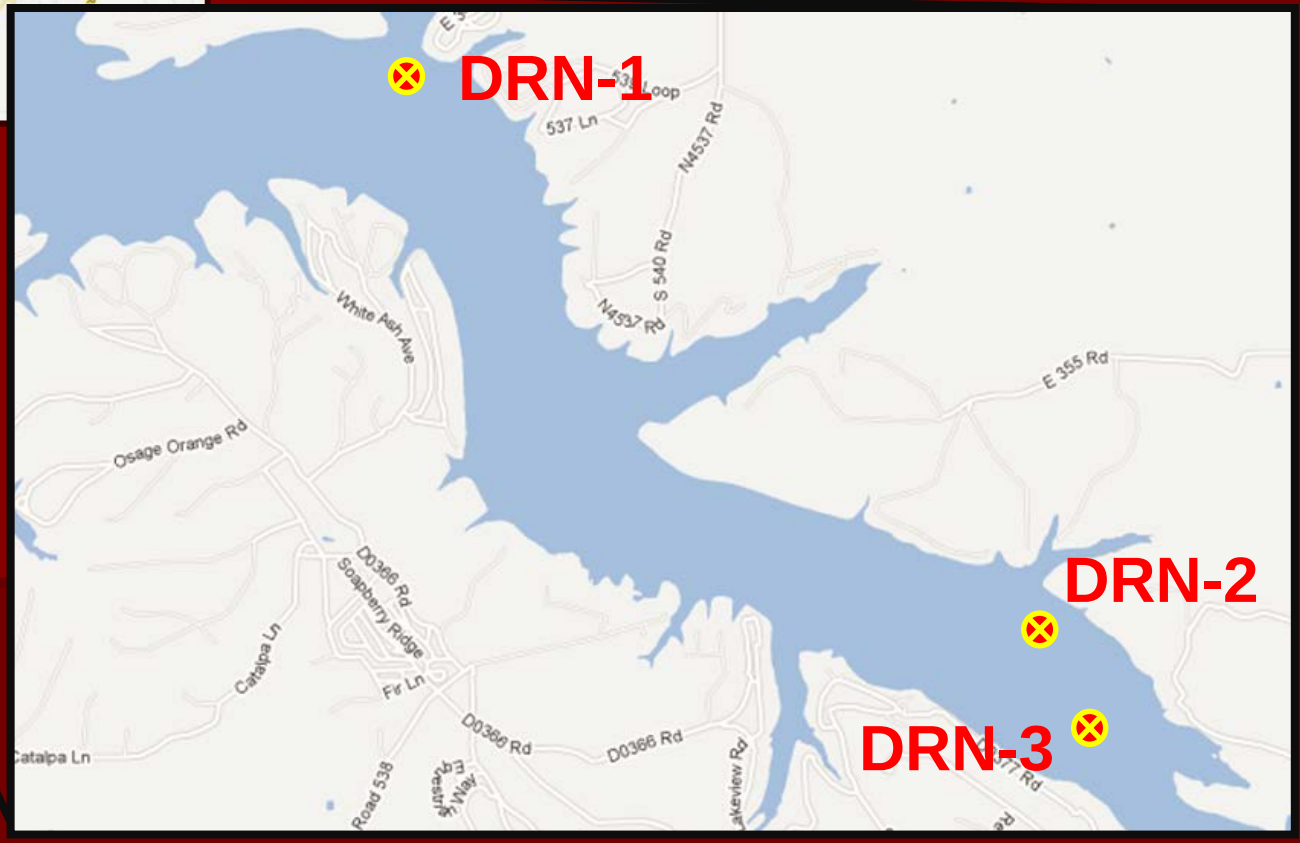
2012


Afton
Copeland
Cayuga
Bernice
Grove
Grove Municipal Airport
Grand Lake Rgnl
South Grand Lake Regional Airport
Cleora
Dennis
Ketchum
Grand Lake Towne
Zena
Disney
Langley


DCK-2
DCK-1
DCK-5
DCK-6
DCK-3
DCK-7
DCK-4

Duck Creek

Drowning Creek



Water – 1 m above sediment

	2010	2012
In situ physical parameters	X	X
Total metals*	X	X
Dissolved metals*	X	
Alkalinity	X	X
Hardness	X	
Nitrate	X	X
Nitrite		X
Ammonia		X
Phosphate	X	X
Turbidity	X	X

*Al, As, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Zn

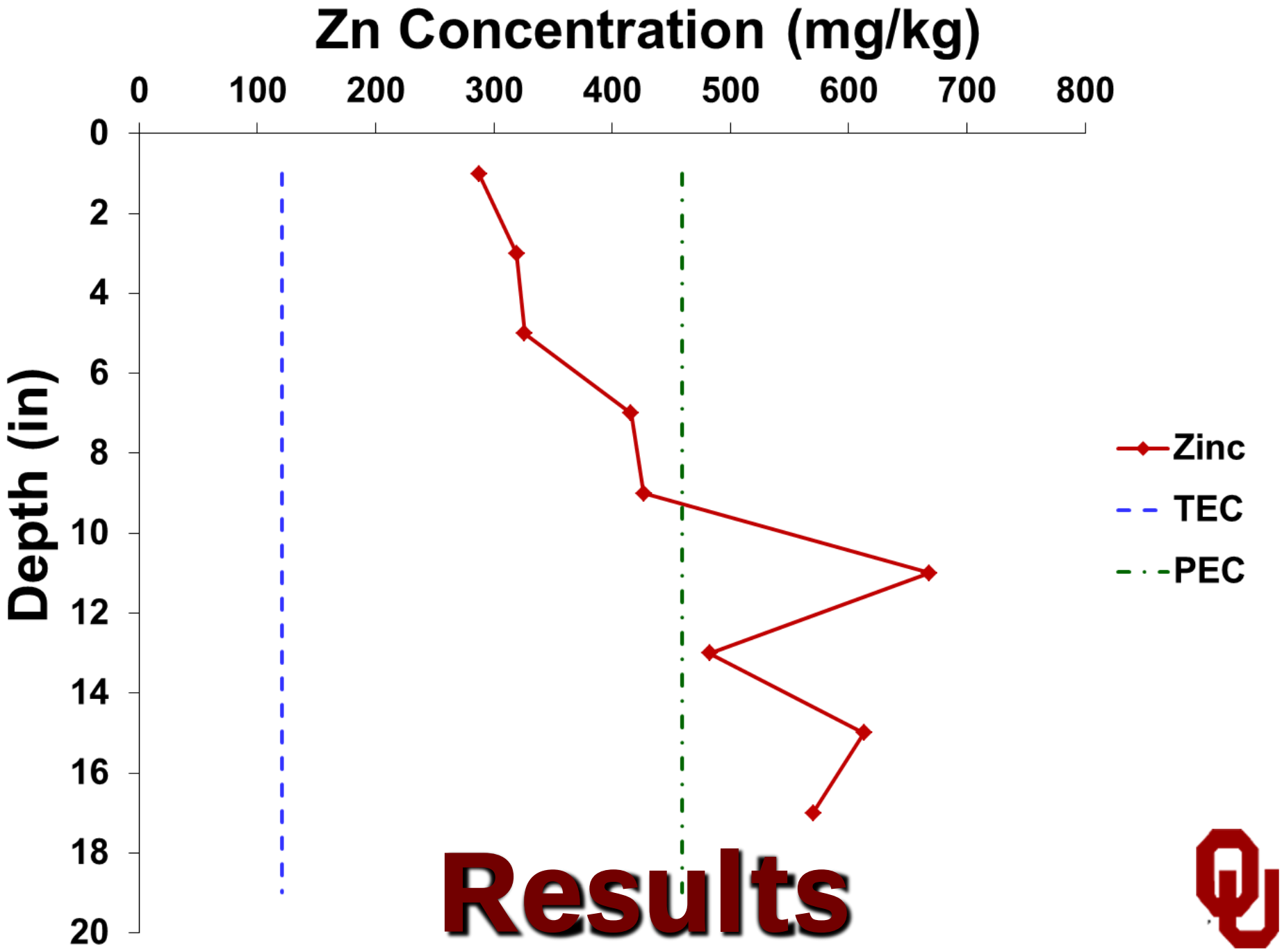
Sediment

- 2” diameter gravity corer
- Incremented 2” sections
- TCLP samples re-composited

	2010	2012
Moisture content	X	X
Organic matter	X	X
Total metals	X	X
TCLP Metals	X	
Total mercury		X


OK 7967 EA


MERCURY


Zn Concentration (mg/kg)
0
100
200
300
400
500
600
700
800
Depth (in)
0
2
4
6
8
10
12
14
16
18
20
Zinc
TEC
PEC

Results

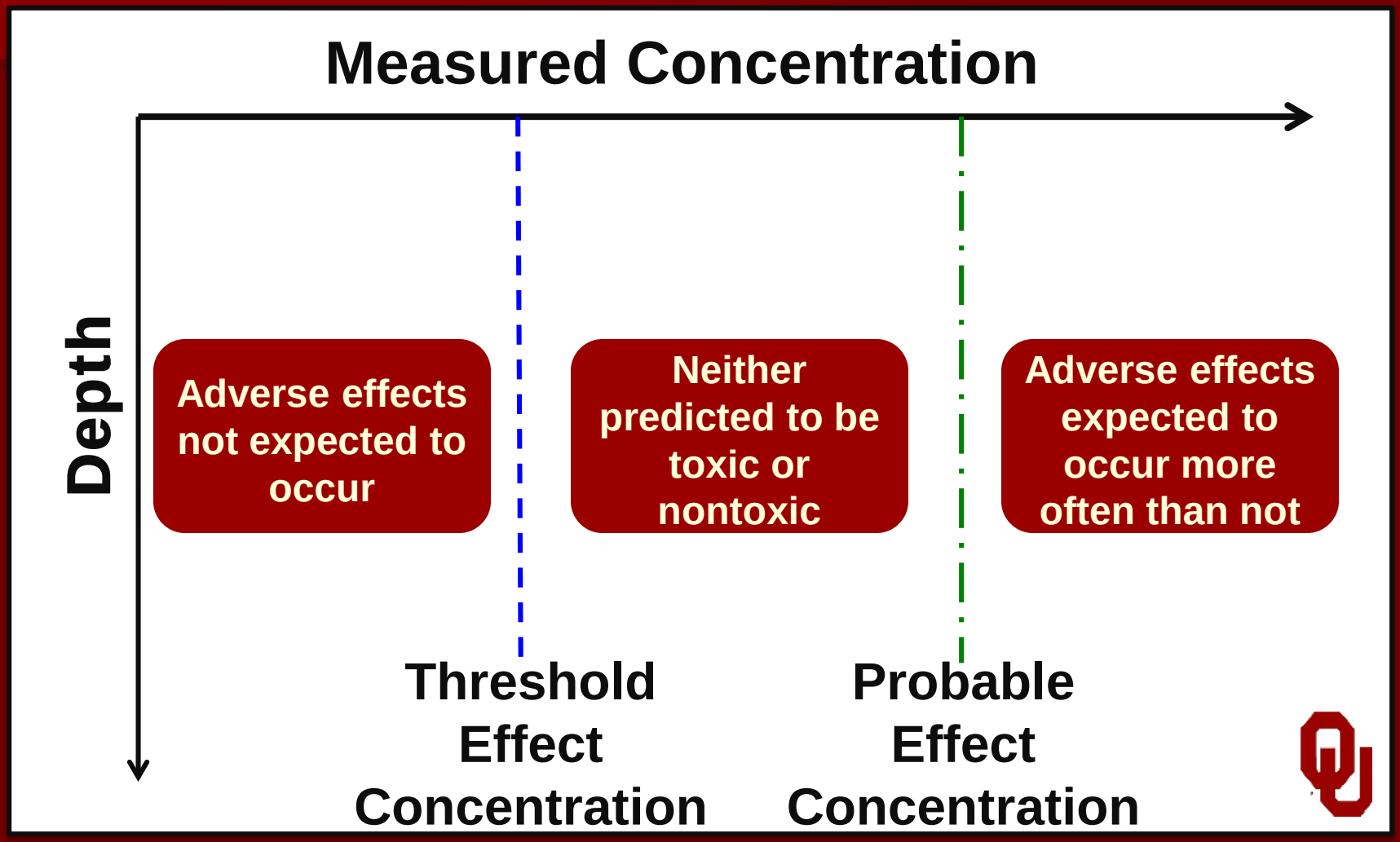
Water Quality Results

- 2010 data
  - Turbidity > lake criteria in 2 of 7 samples
  - Nutrients < in-lake criteria
  - Metals < acute and chronic criteria in all samples
- 2012 data
  - Phosphate > in-lake criteria in all samples
  - Ammonia and nitrate < in-lake criteria
  - Cd > chronic criteria at DCK-1

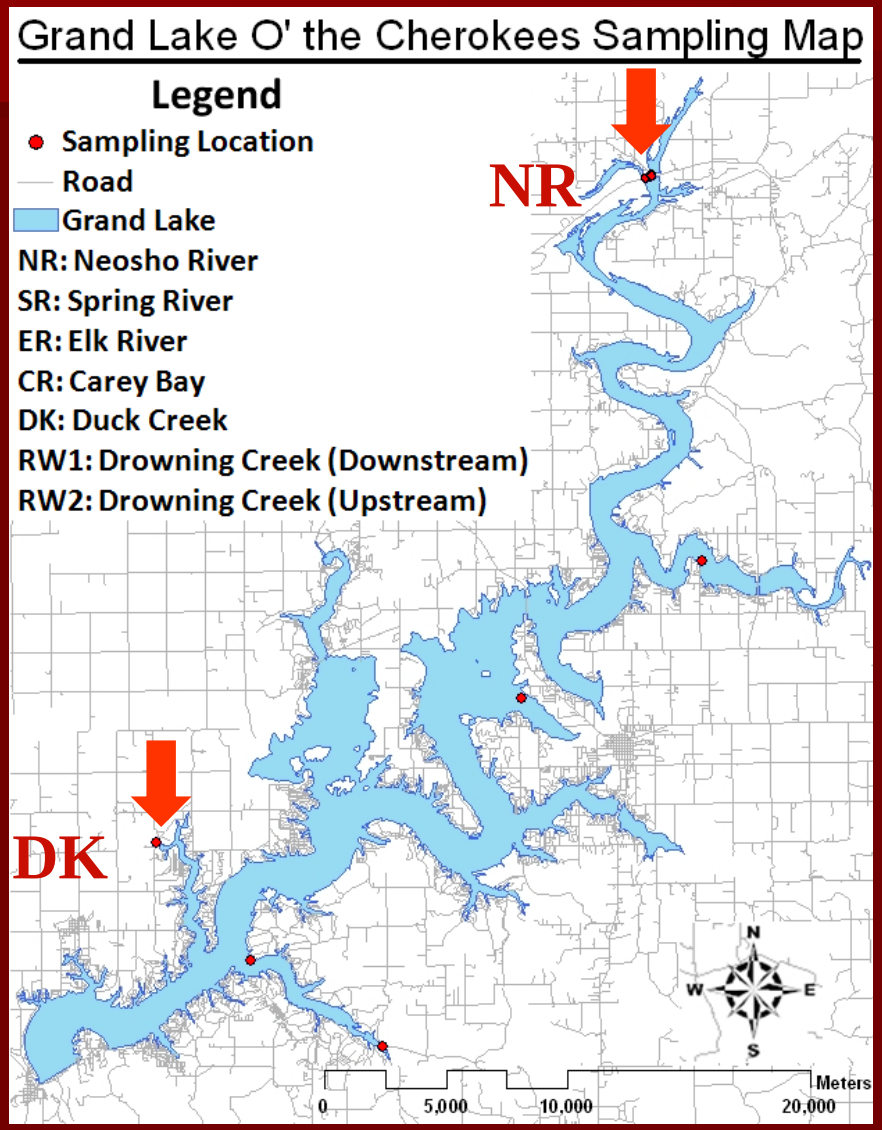
Sediment TCLP Metals

- No RCRA guideline for Zn
- As, Cd, Cr, and Pb have RCRA guidelines
- None exceeded TCLP criteria

Sediment Quality Guidelines

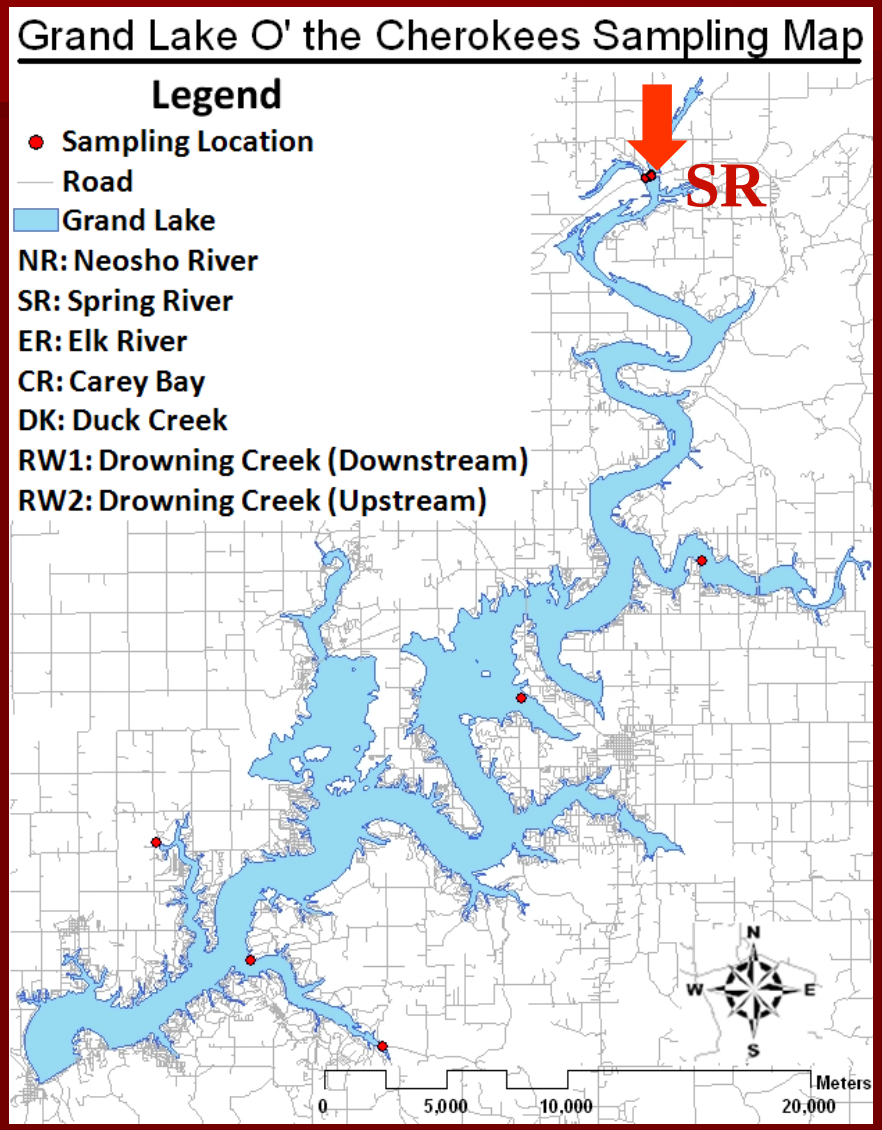


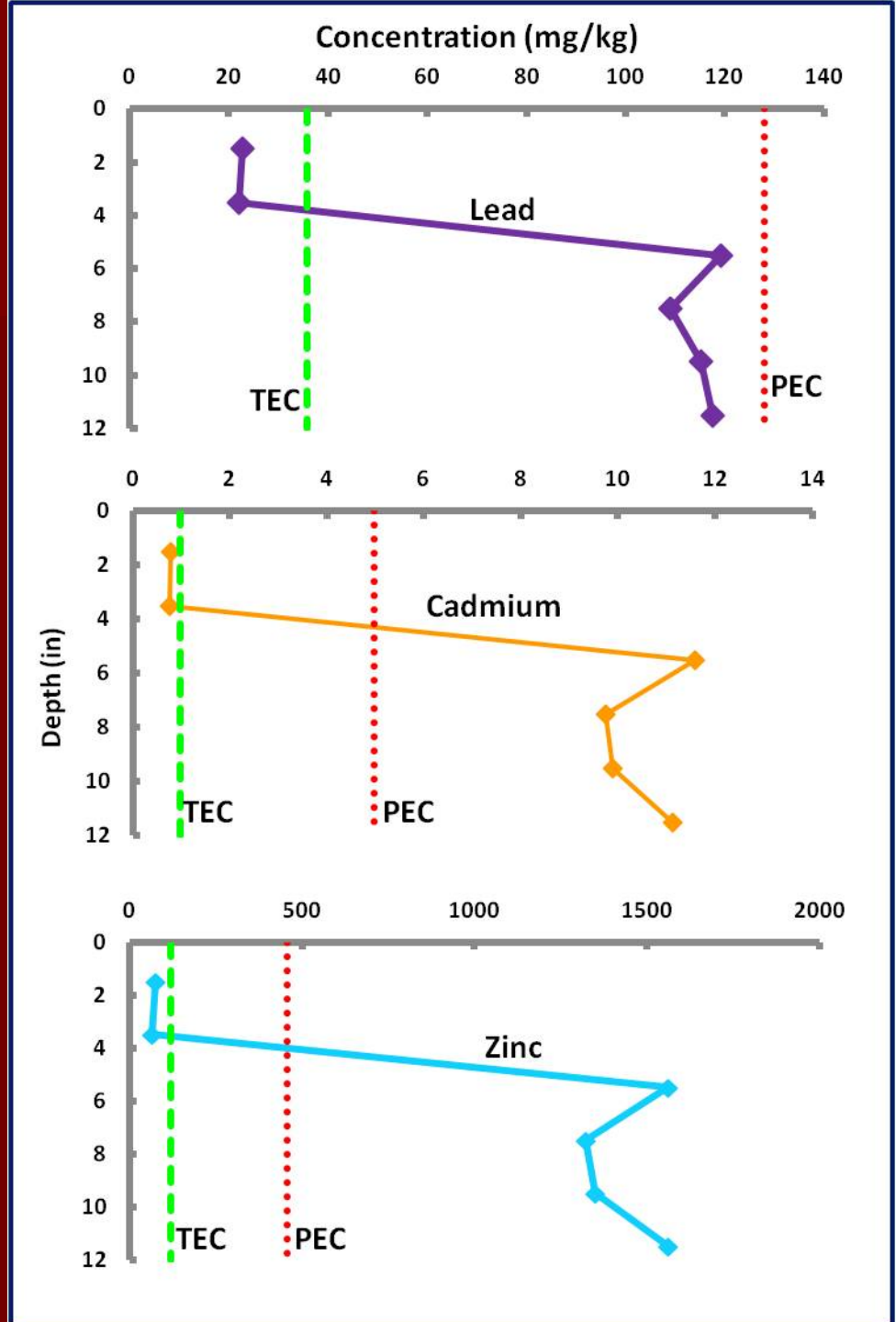
Neosho River and Duck Creek



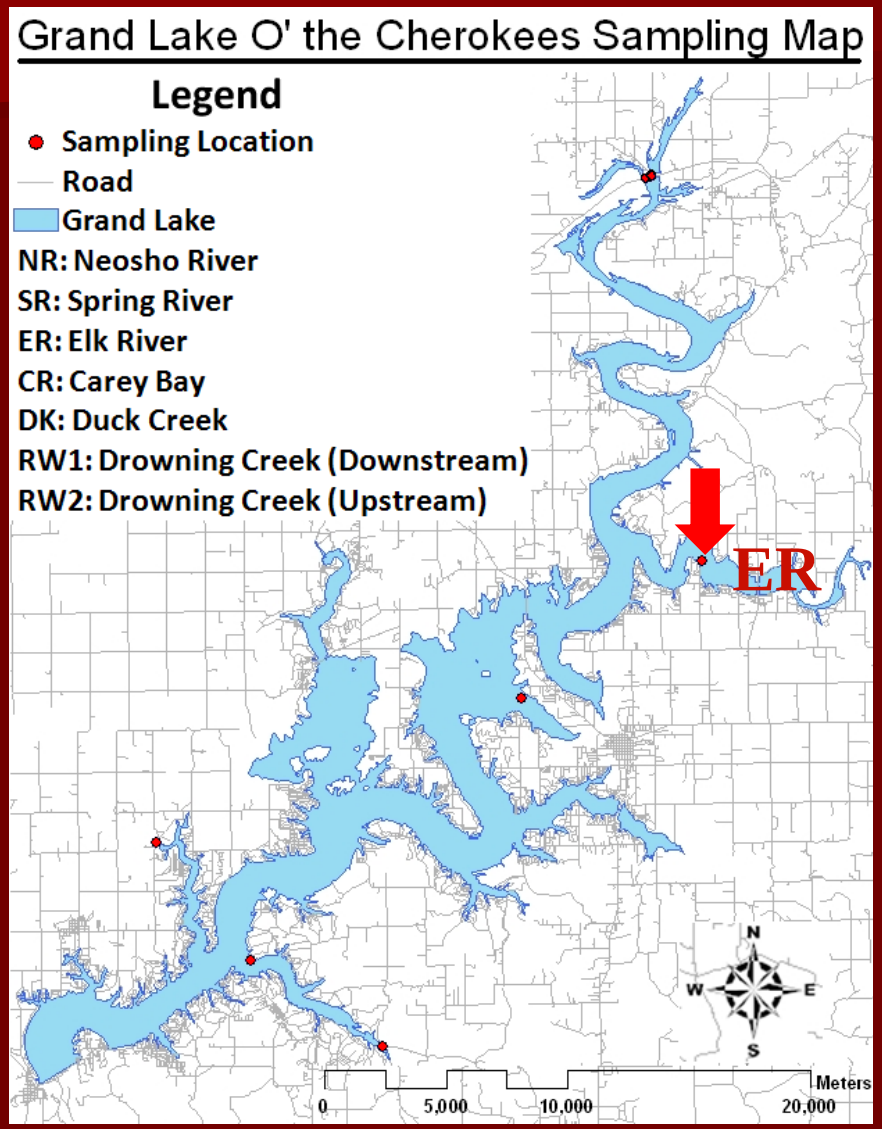
- Neosho River and Duck Creek < TEC for Pb, Cd, and Zn

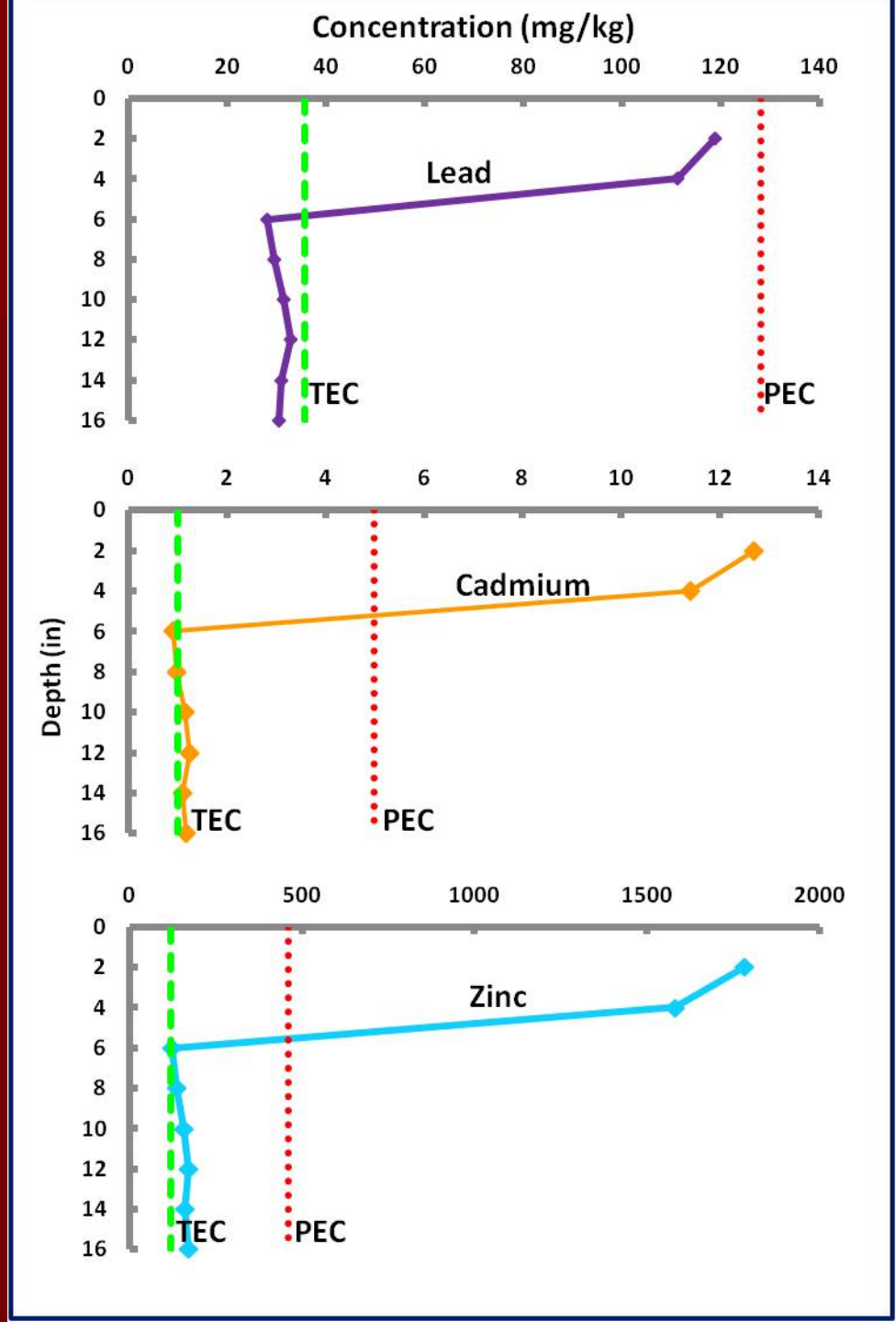
Spring River



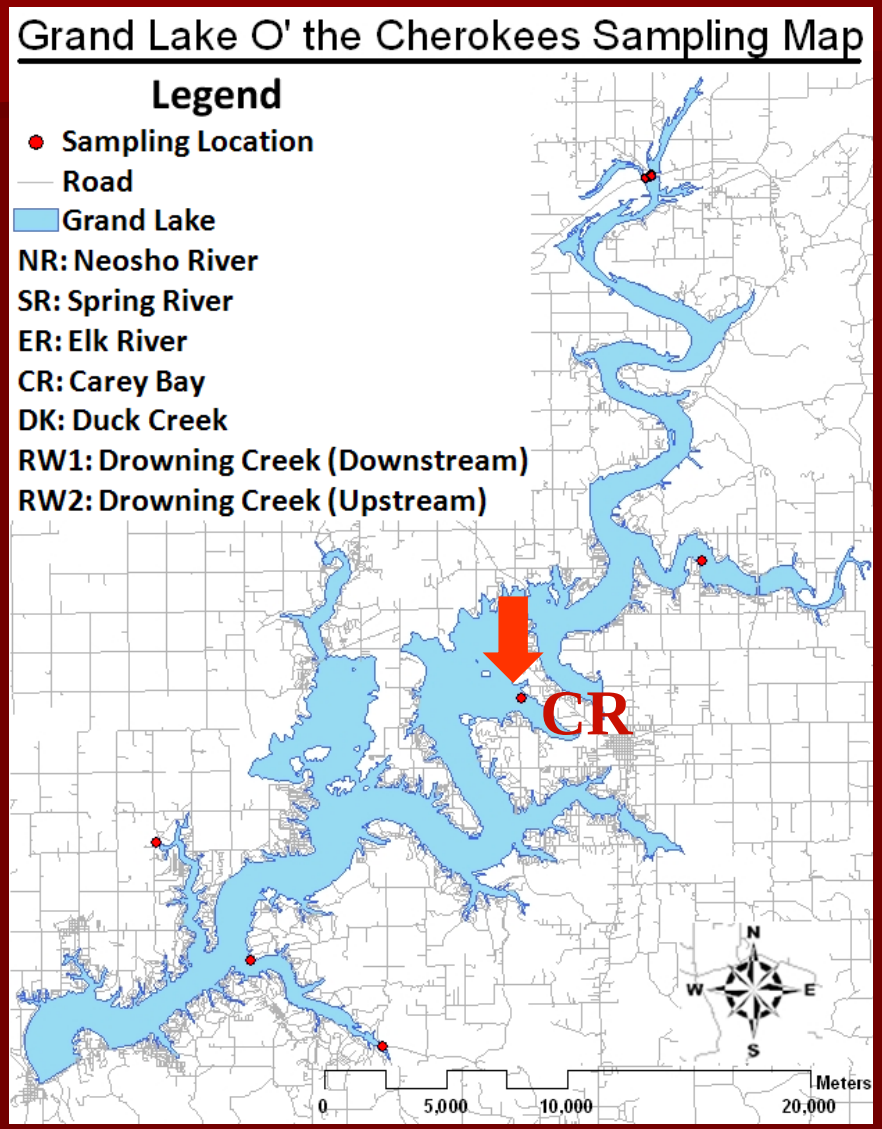


Elk River


Grand Lake O' the Cherokees Sampling Map
Legend
Sampling Location
Road
Grand Lake
NR: Neosho River
SR: Spring River
ER: Elk River
CR: Carey Bay
DK: Duck Creek
RW1: Drowning Creek (Downstream)
RW2: Drowning Creek (Upstream)
ER
N
W
E
S
0
5,000
10,000
20,000
Meters


Concentration (mg/kg)
Depth (in)
Lead
TEC
PEC
Cadmium
TEC
PEC
Zinc
TEC
PEC

Carey Bay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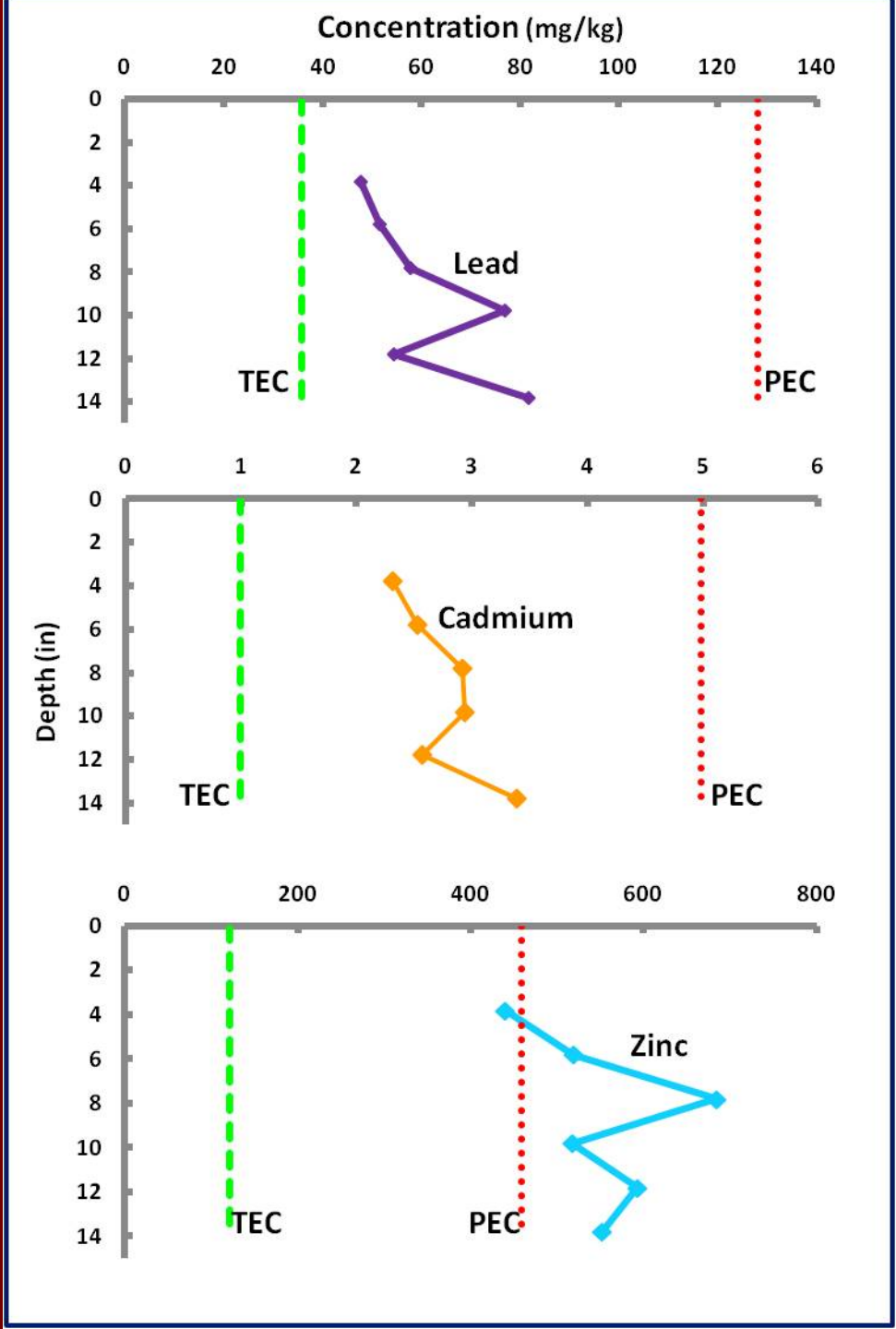
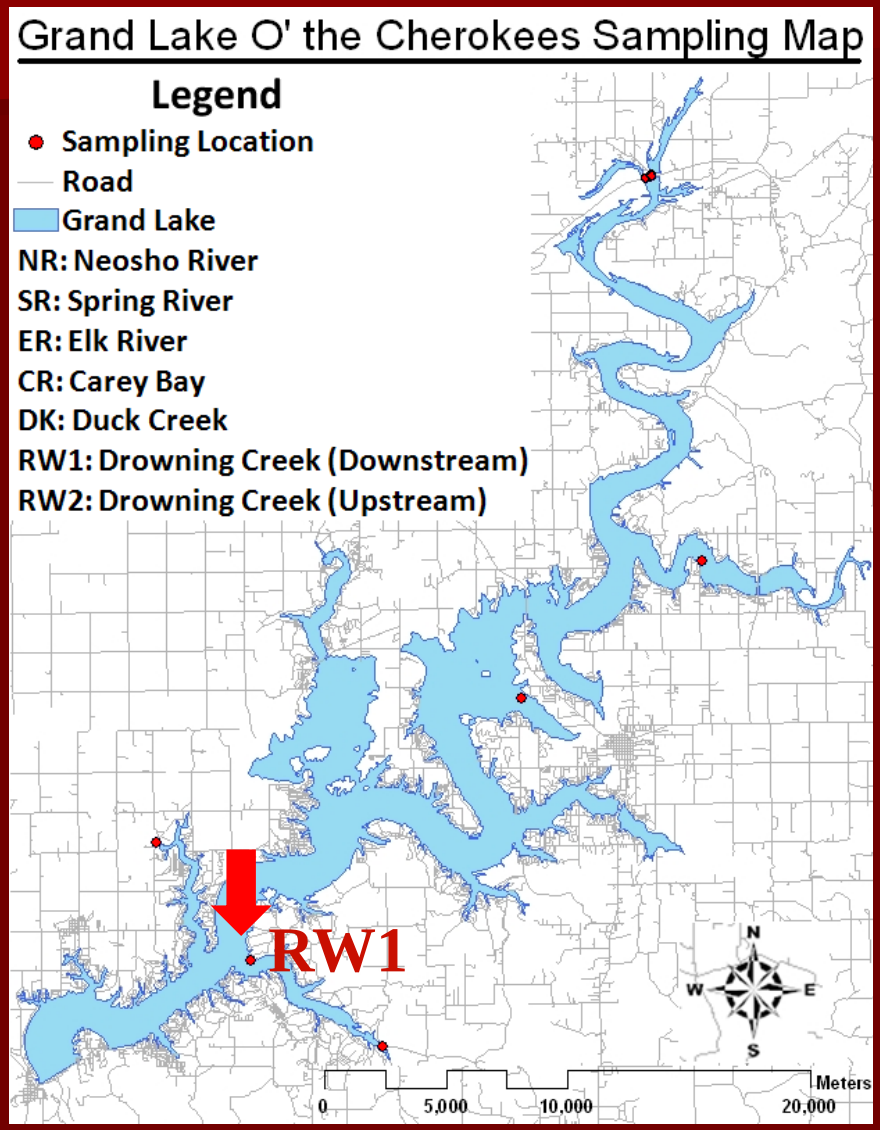
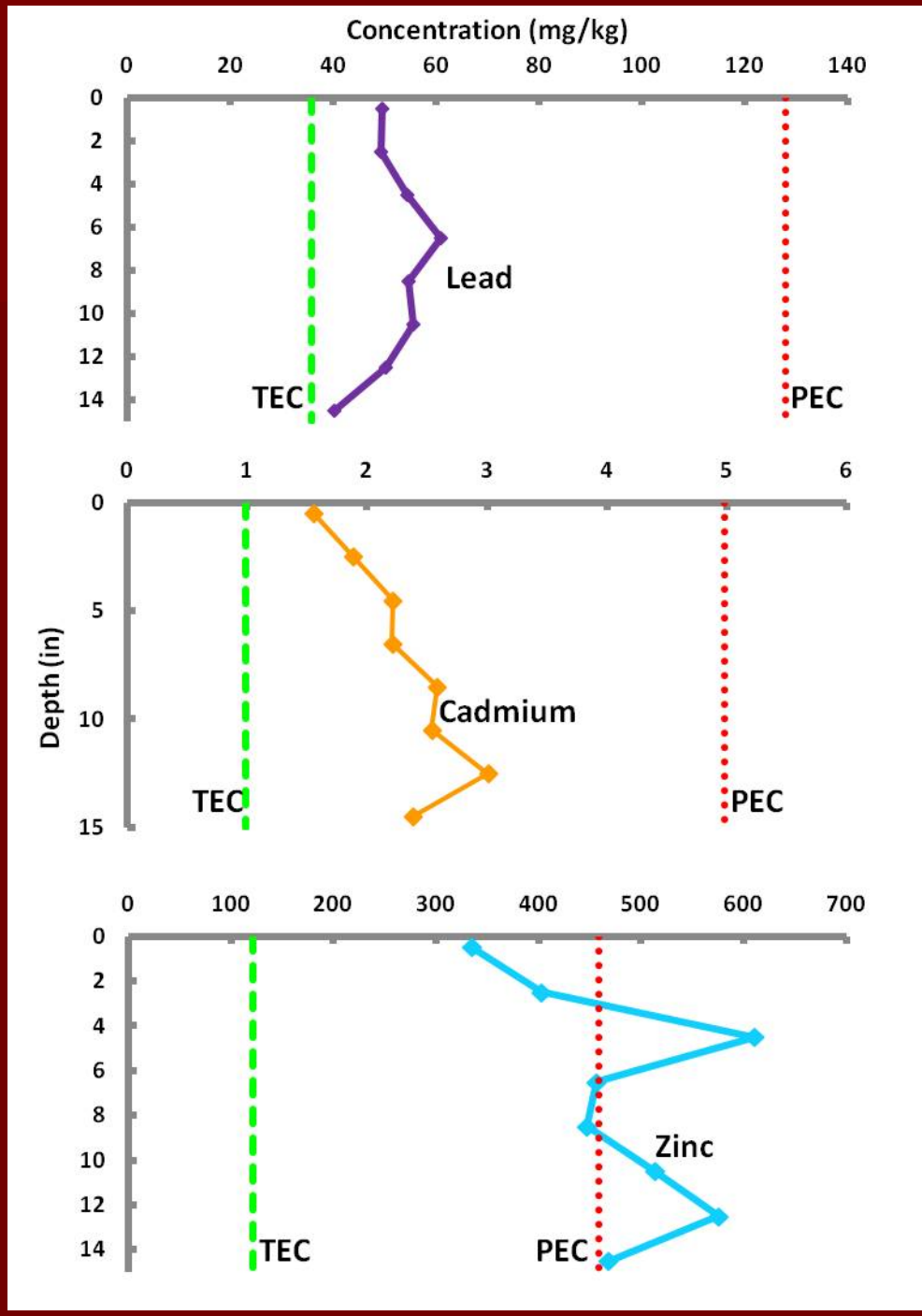
DK: Duck Creek
RW1: Drowning Creek (Downstream)
RW2: Drowning Creek (Upstream)
CR
N
W
E
S
0
5,000
10,000
20,000
Meters

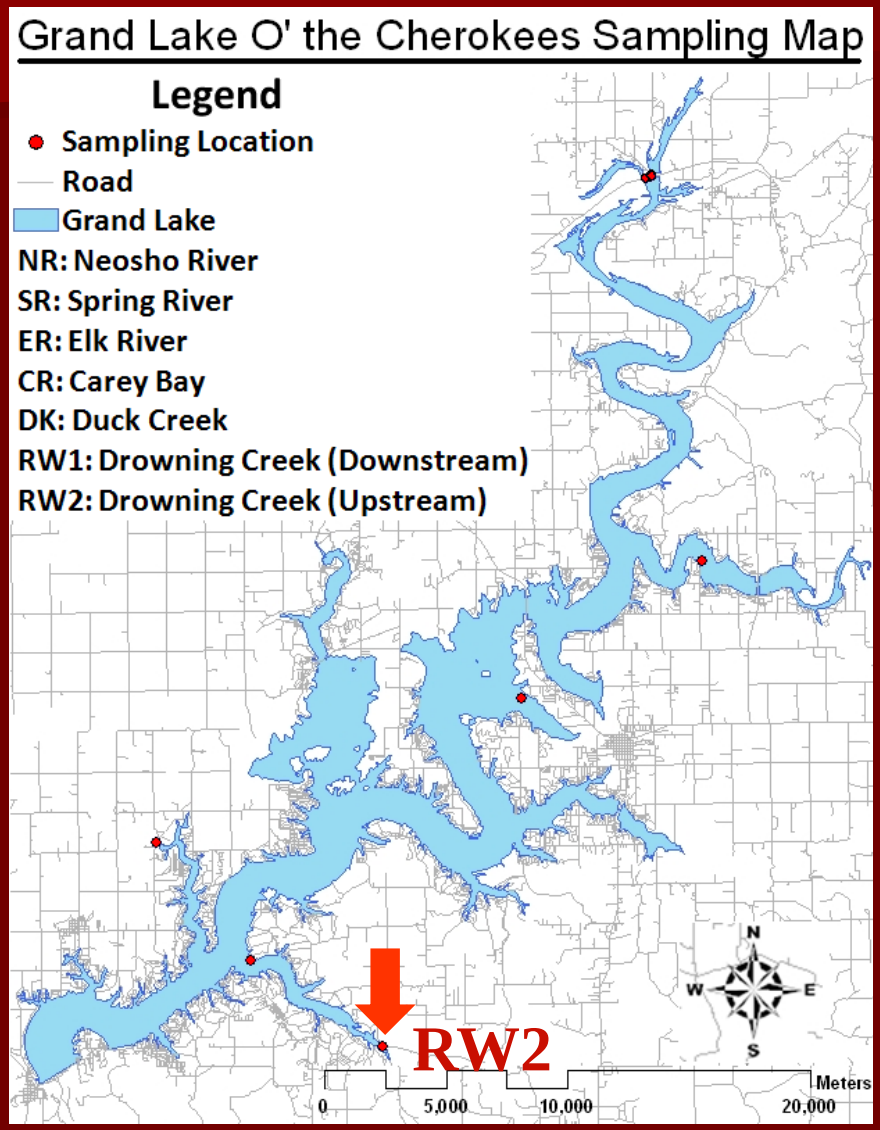

Concentration (mg/kg)
Depth (in)
Lead
TEC
PEC
Cadmium
TEC
PEC
Zinc
TEC
PEC

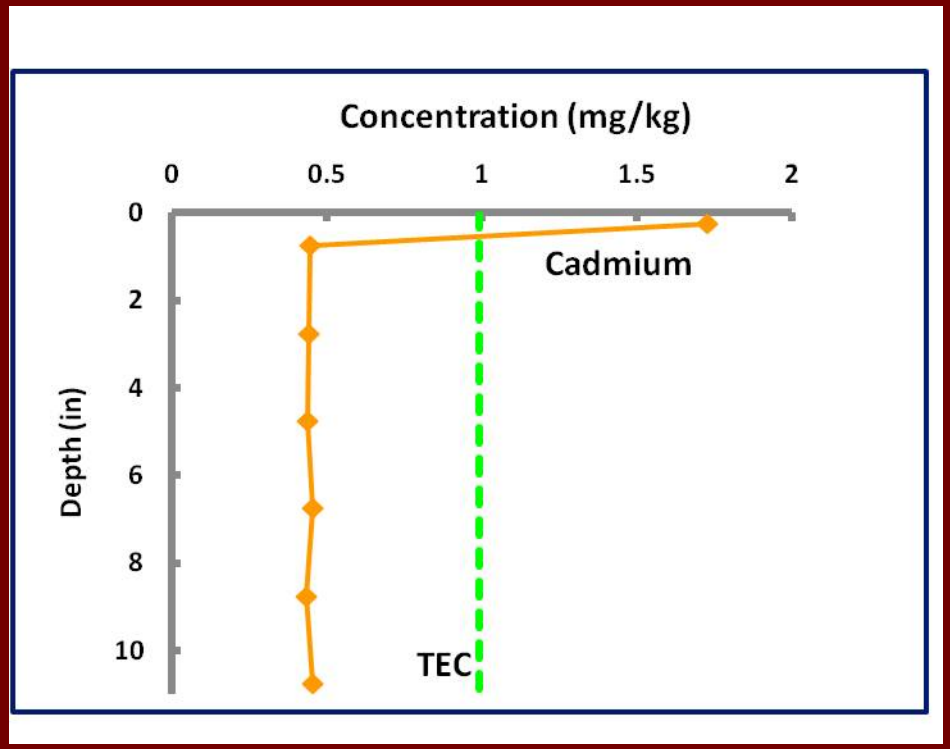
Drowning - Downstream



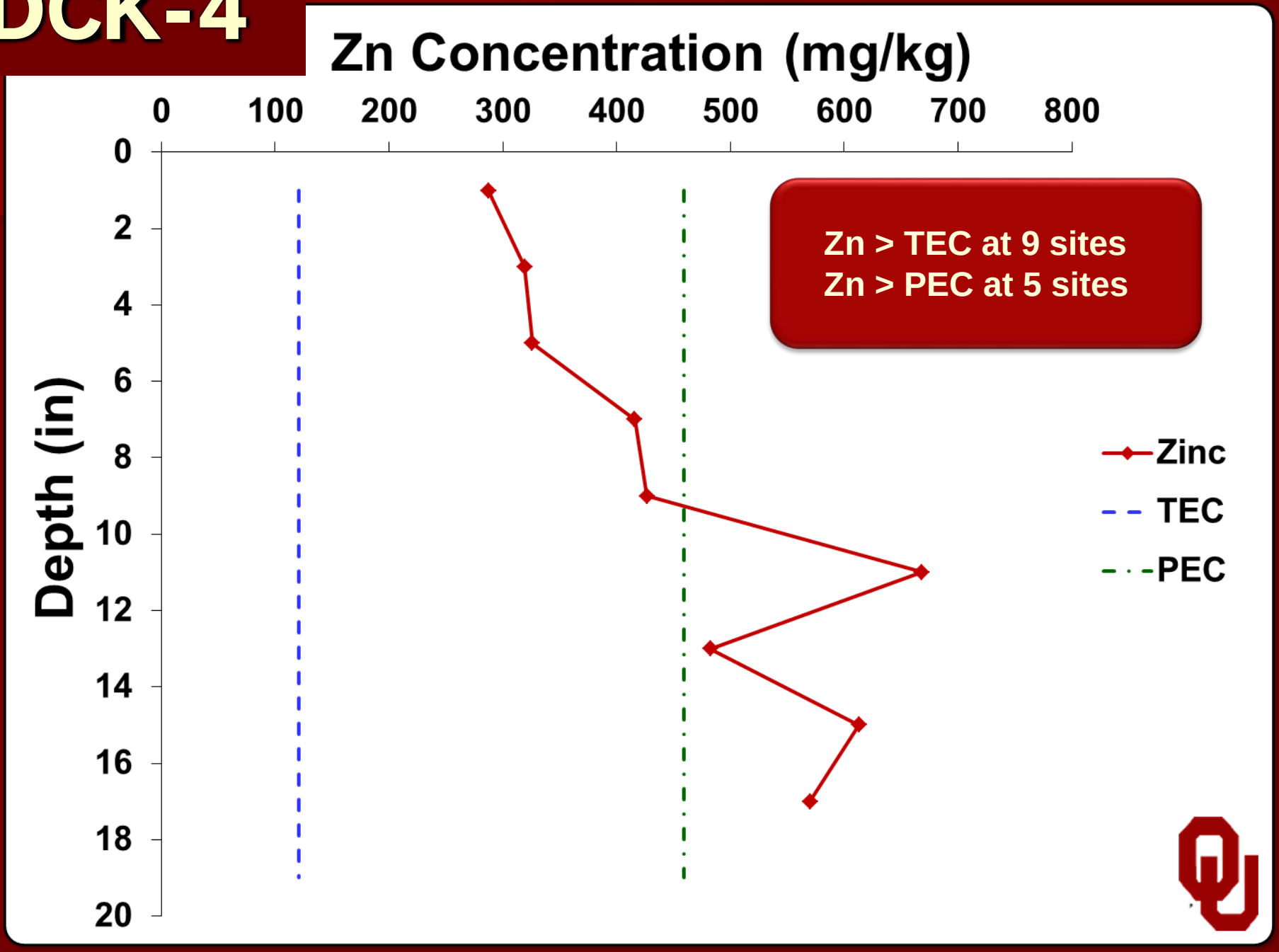


Drowning - Upstream

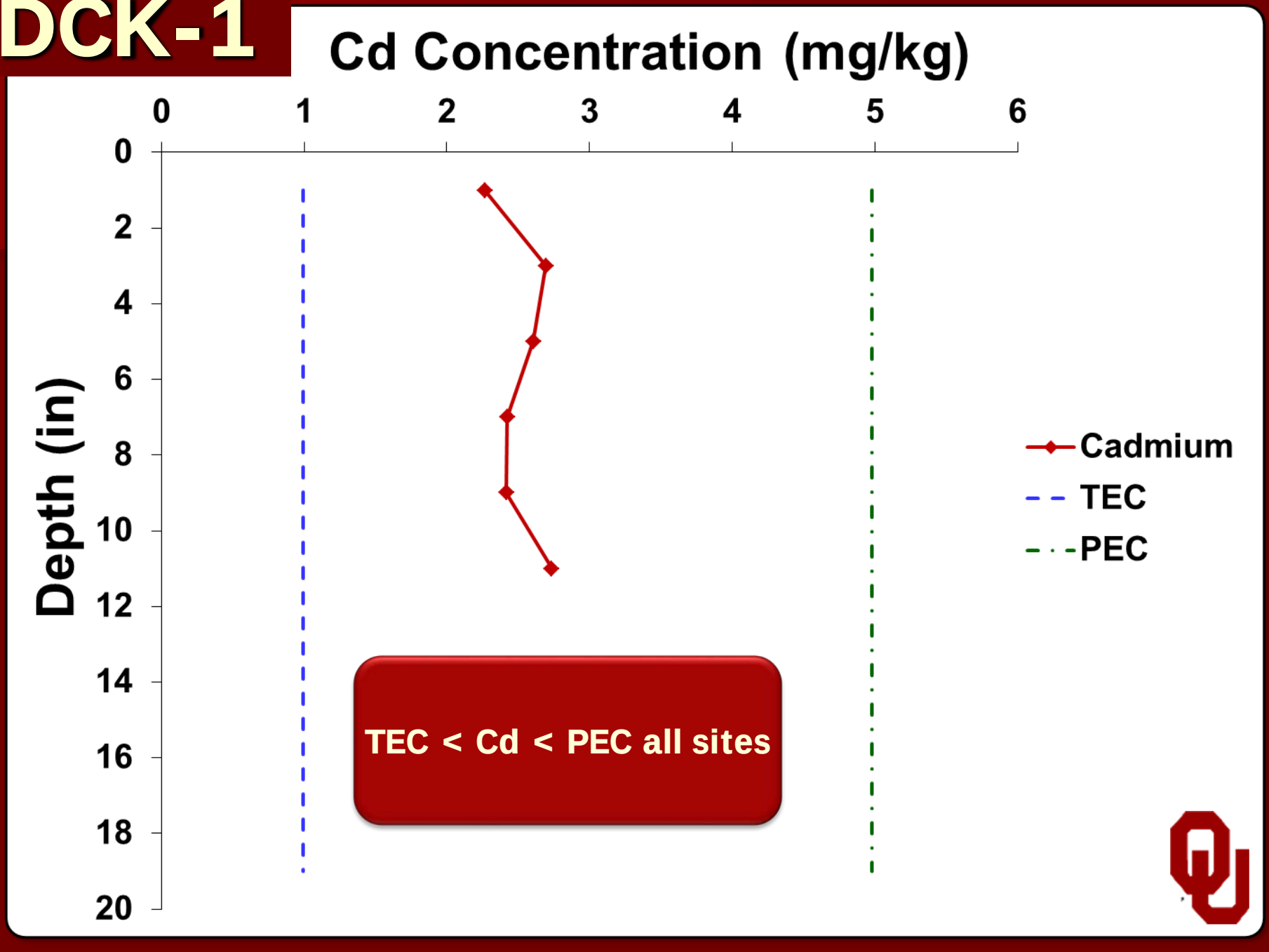




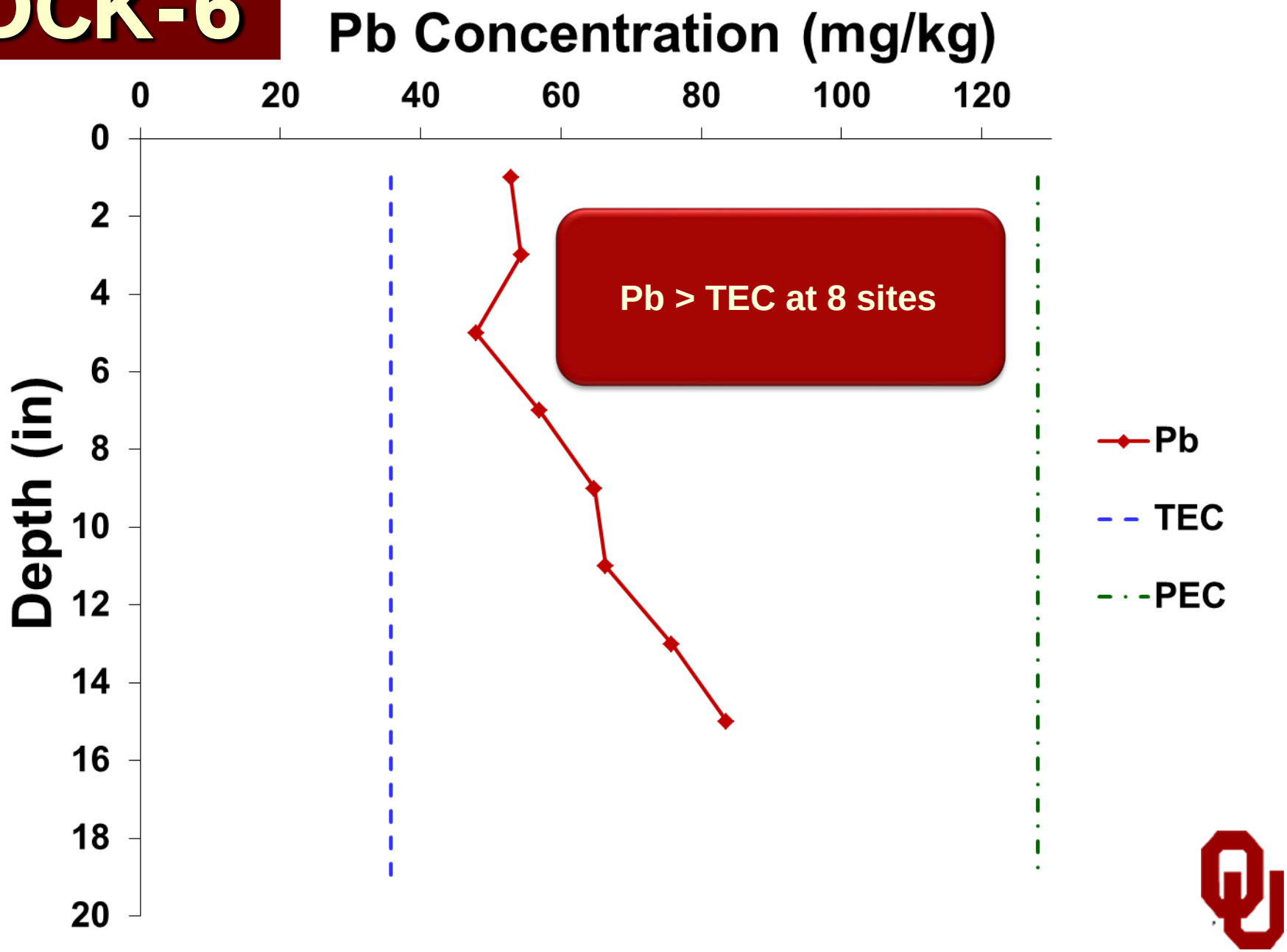
DCK-4

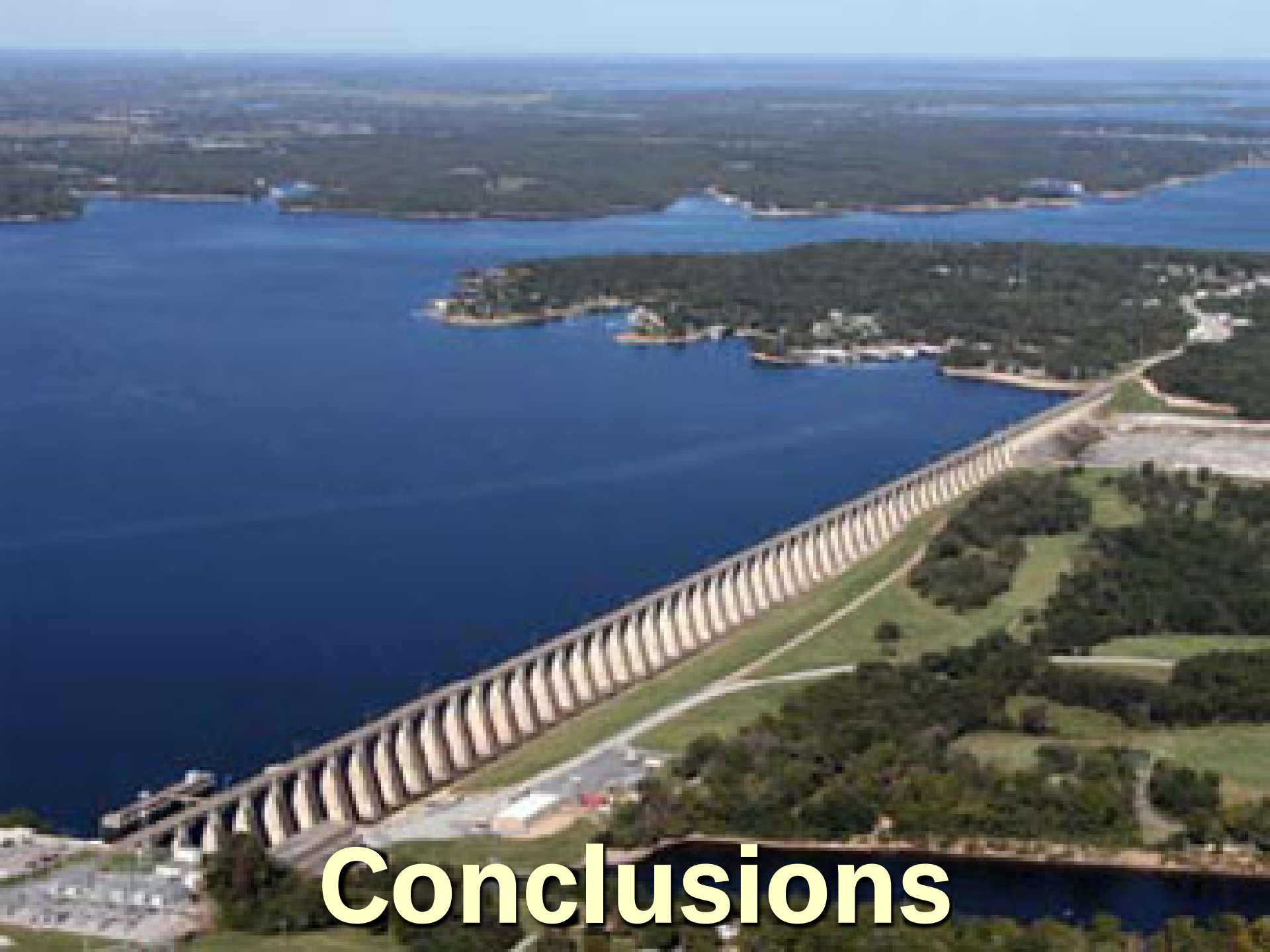

Zn Concentration (mg/kg)
0
100
200
300
400
500
600
700
800
Depth (in)
0
2
4
6
8
10
12
14
16
18
20
Zn > TEC at 9 sites
Zn > PEC at 5 sites
Zinc
TEC
PEC

DCK-1


Cd Concentration (mg/kg)
0
1
2
3
4
5
6
Depth (in)
0
2
4
6
8
10
12
14
16
18
20
Cadmium
TEC
PEC
TEC < Cd < PEC all sites

DCK-6


Pb Concentration (mg/kg)
0
20
40
60
80
100
120
Depth (in)
0
2
4
6
8
10
12
14
16
18
20
Pb > TEC at 8 sites
Pb
TEC
PEC



Conclusions

Conclusions – Water and TCLP

- Lake water quality
  - Turbidity and phosphorus exceed applicable criteria
  - Cd > chronic criteria in one sample
- Sediment TCLP metals
  - Metals < regulatory criteria
  - Not considered hazardous waste

Conclusions – Total Metals

- 2010 TEC
  - Drowning – Upstream exceeded TEC for Cd
  - 71 % of sites exceeded TEC
- 2010 PEC
  - Four sites exceeded Cd, Pb or Zn criteria
    - Spring River, SR
    - Elk River, ER
    - Carey Bay, CR
    - Drowning - Downstream, RW 1
  - 57 % of sites exceed PEC

Conclusions – Total Metals

- 2012 data focus on dredging/development in coves
- Shoreline Management Plan dictates further action if [M+] > TEC

	% Exceedance
Zn	95
Cd	100
Pb	82
Cu	8
Ni	58

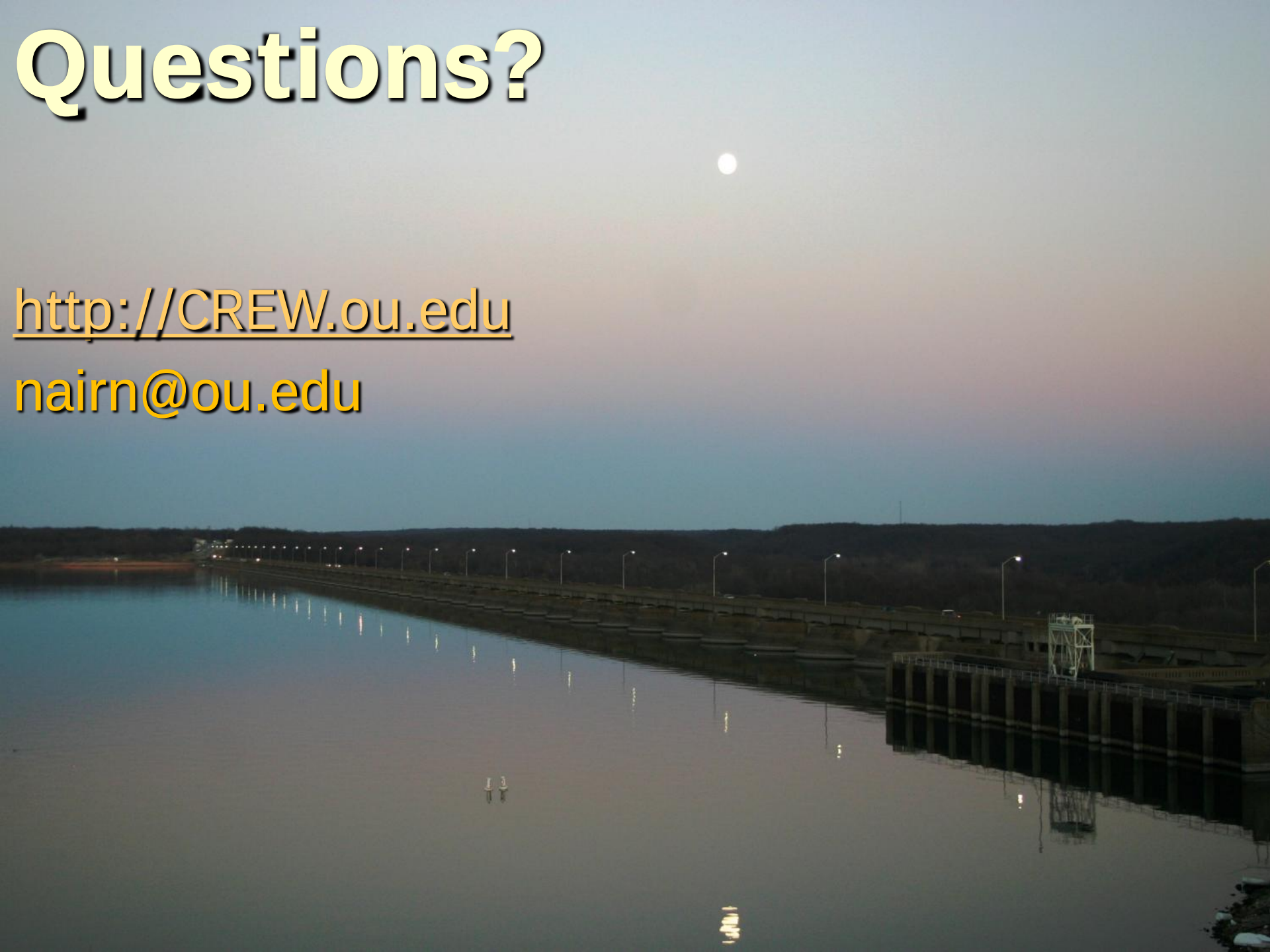
Recommendations

- Further sediment research needed
  - Sample more coves
  - Collect more cores
  - Complete particle size analyses
  - Age date cores
  - Assess native soils
- Disposal plans must be considered prior to dredging

Acknowledgements

- Jacklyn Jaggars
- Roger Simmons
- Darrell E. Townsend II
- Michael Willhoite
- Sam Ziara
- Lake Patrol Officers
- GRDA EEC

Questions?



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