RED RIVER FISH KILLS

Update on an Unsolved Mystery

Brendan Furneaux

Oklahoma Clean Lakes and Watersheds Association
22nd Annual Conference
April 18, 2013

OKLAHOMA
DEPARTMENT OF ENVIRONMENTAL QUALITY
…for a clean, attractive, prosperous Oklahoma

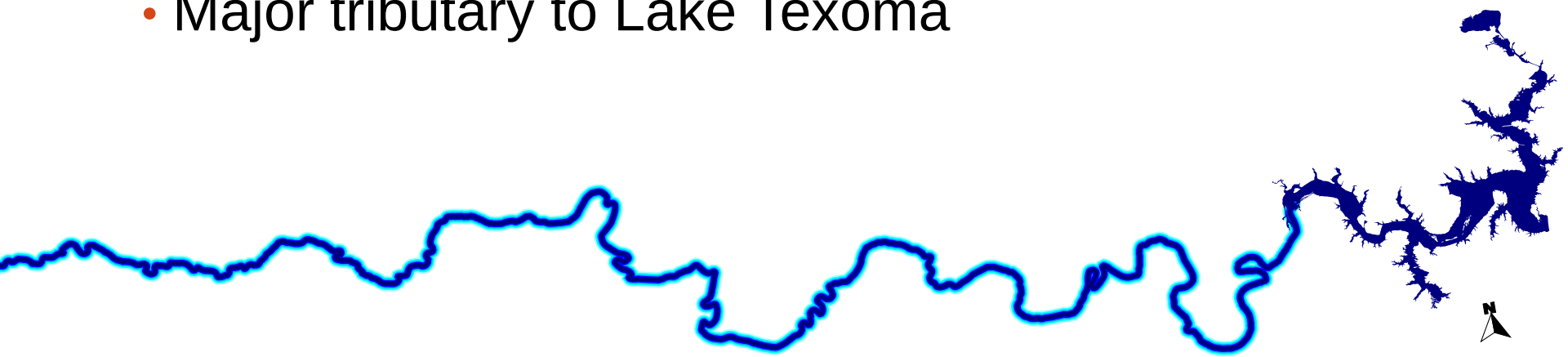
Overview

- Background
- Timeline
- Analysis
  - Geomorphology
  - Chemistry
- Conclusions

BACKGROUND

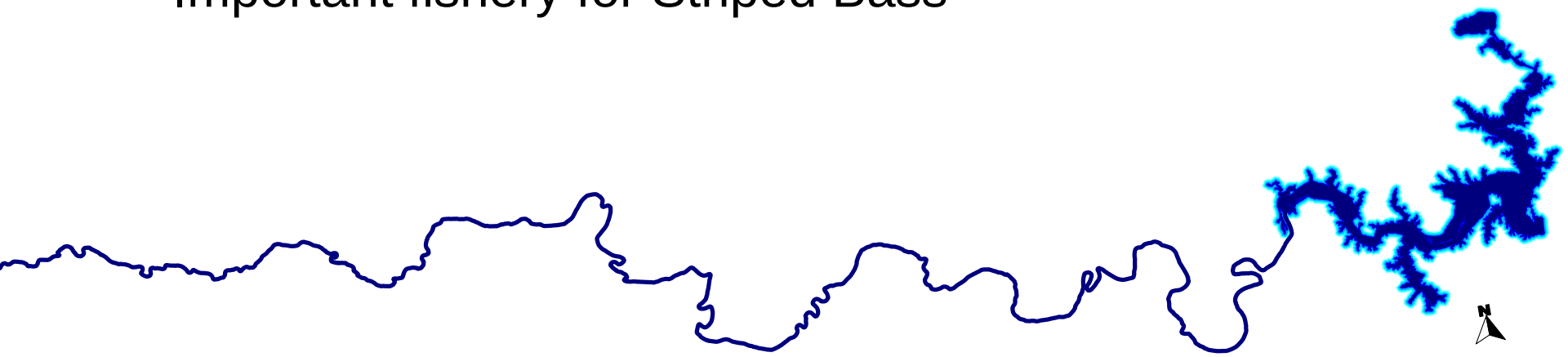
Background

- Red River
  - Flows west to east over salt plains
  - High conductivity for “fresh” water
    - 2,000 - 10,000+ µS/cm
  - Borders Oklahoma, Texas and tribal lands
    - Jurisdiction is complicated
  - Major tributary to Lake Texoma



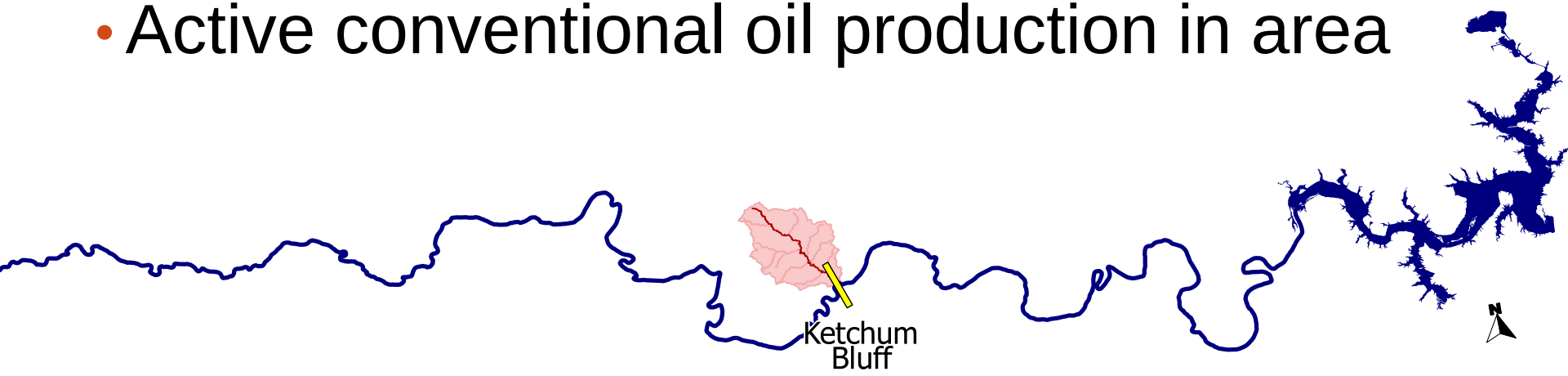
Background

- Lake Texoma
  - Built in 1944 by USACE
  - Major reservoir used for flood control, water supply, hydroelectric power, regulation of Red River flows, navigation improvement, and recreation
  - Provides 450,000 acre feet of water supply and storage
  - Important fishery for Striped Bass



Ketchum Bluff

- Outcrop on north (Oklahoma) bank of Red River
- 6-8 ft. deep pool
- Red Creek confluence at downstream end of pool
- Active conventional oil production in area

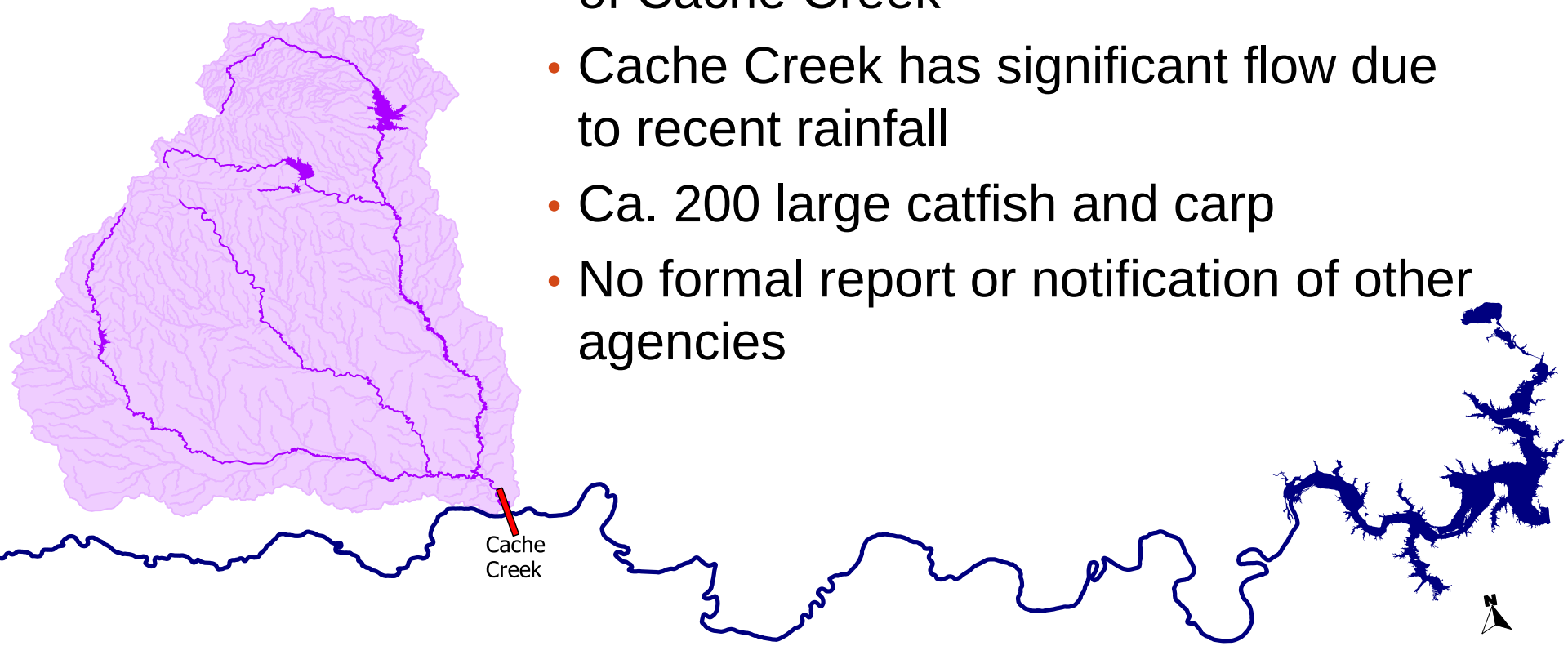


Ketchum Bluff

TIMELINE

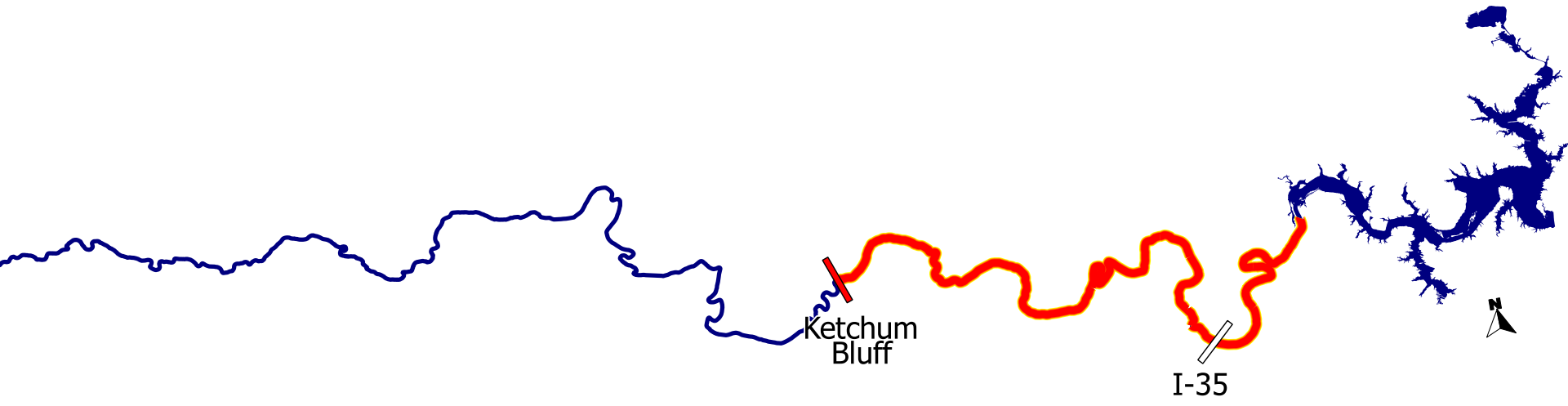
Timeline of Kill – 2011

- April 28th
  - ODWC responds to fish kill at mouth of Cache Creek
  - Cache Creek has significant flow due to recent rainfall
  - Ca. 200 large catfish and carp
  - No formal report or notification of other agencies



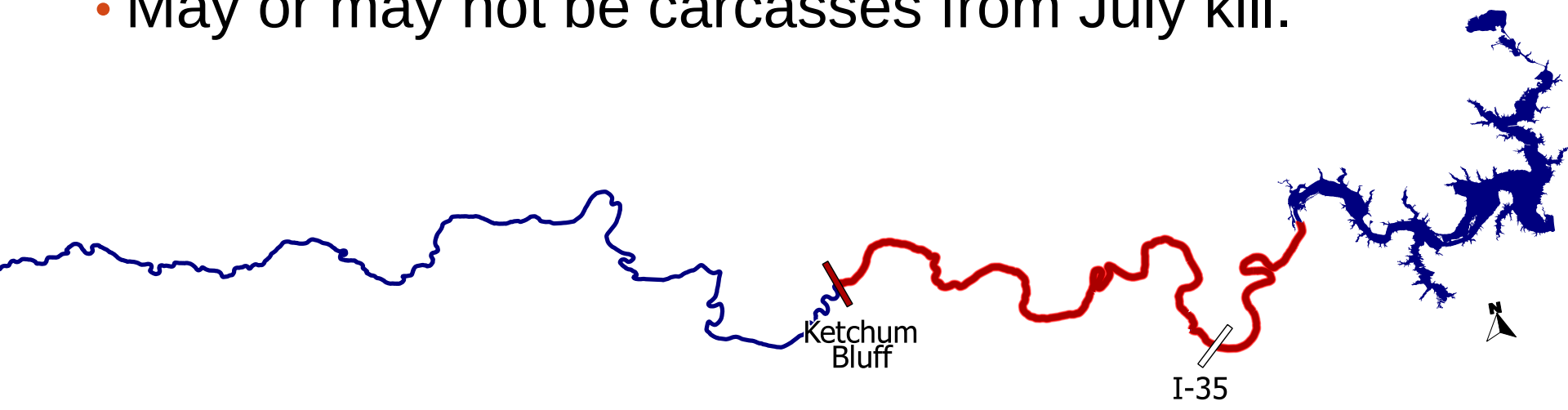
Timeline of Kill – 2011

- July 1st-15th
  - Fish kill stretching from Ketchum Bluff to near Lake Texoma
  - 1500+ large fish, mostly catfish and buffalo
  - Small fish unaffected
  - Downstream progress 8-10 miles per day



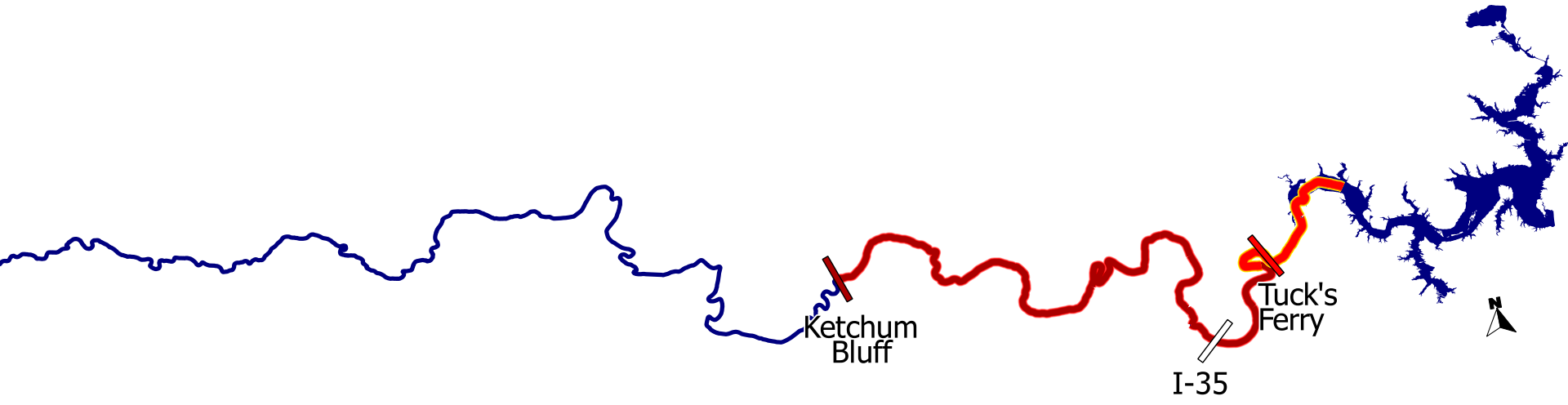
Timeline of Kill – 2011

- August 9th
  - Unconfirmed report of additional dead fish at Ketchum Bluff
- August 22nd
  - EPA sampling team observes ca. 50 dead fish in affected area.
- May or may not be carcasses from July kill.



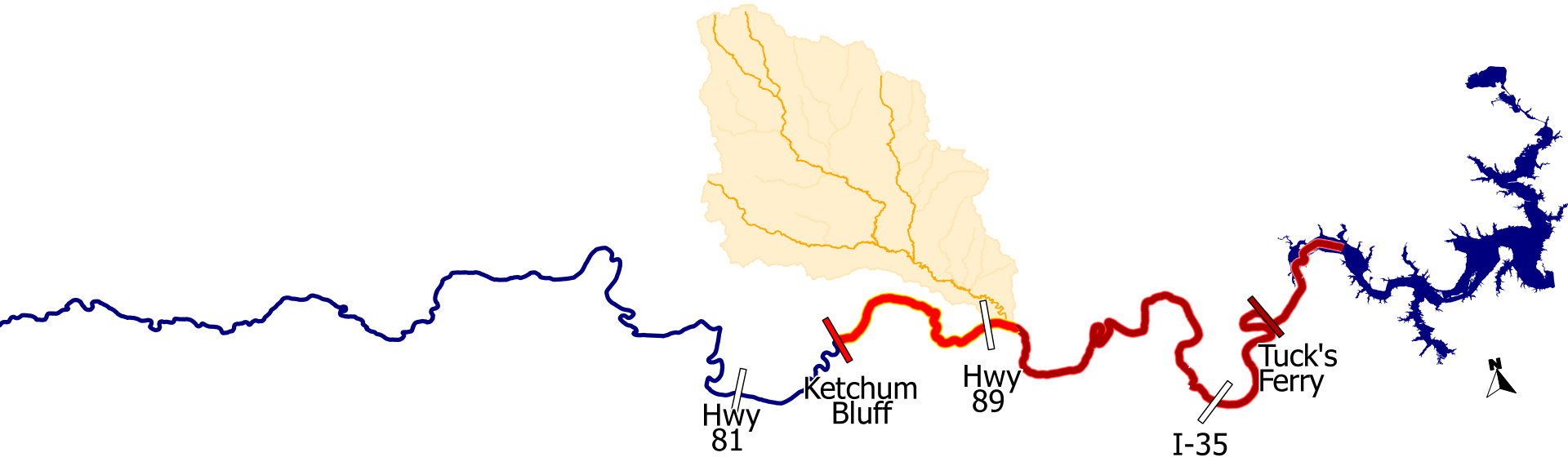
Timeline of Kill – 2011

- September 10th-14th
  - Fish kill between Tuck's Ferry and open water of Lake Texoma
  - 1300+ large fish, mostly catfish and buffalo
  - Near downstream endpoint of July kill



Timeline of Kill – 2012

- June 12th
  - Fish kill between Ketchum Bluff and Mud Creek
  - 500+ large fish
  - Mud Creek has substantial flow due to recent rain



Response

- Multiagency response
- Water, sediment, and fish sampling during kills
- Water and sediment sampling August 2011
- Fish impact study November 2011
- Baseline water and sediment study February 2012
- Red Creek characterization July-December 2012
- Gas sampling in Red Creek & Ketchum Bluff December 2012

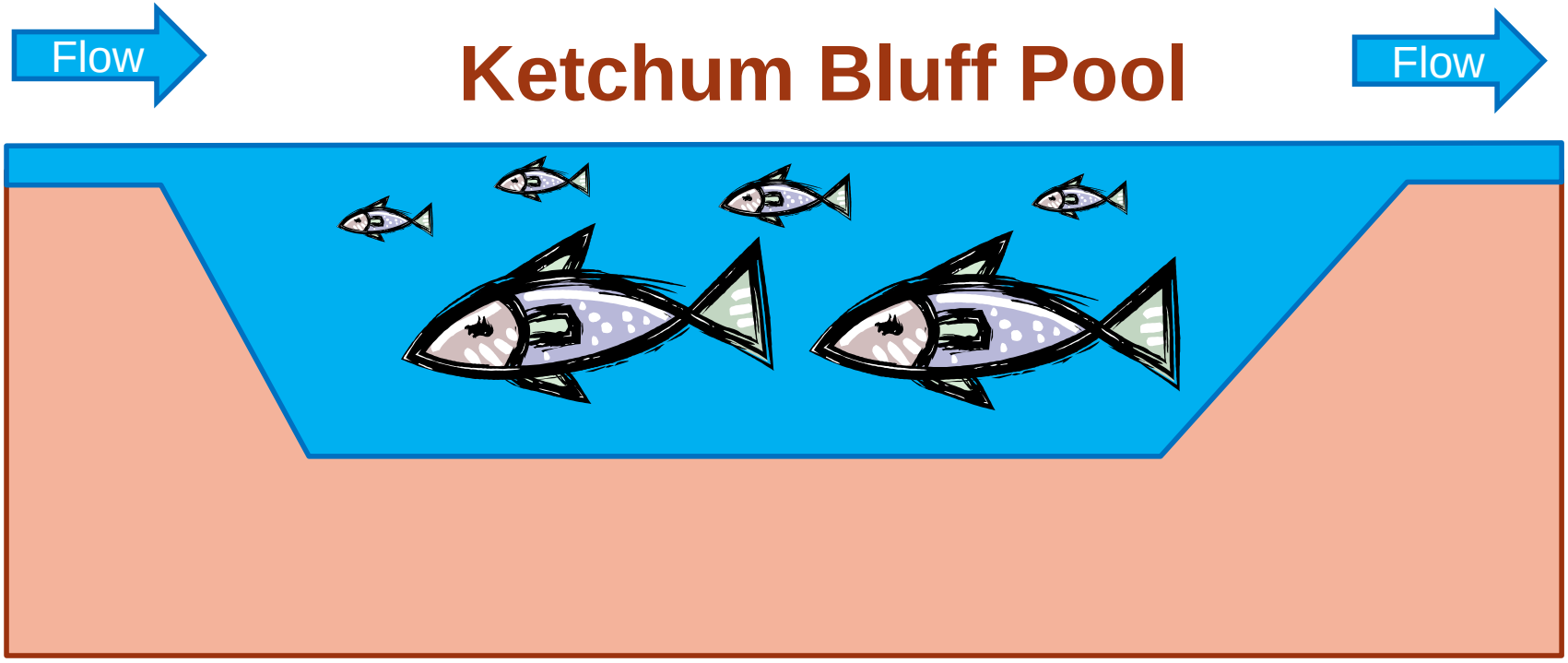
ANALYSIS: GEOMORPHOLOGY

Pattern

- Large fish
  - Mostly larger than 20”
  - Not gar
  - Not turtles, frogs, birds, etc.
- More toxic to large fish?
  - Lethal to minnow fry within 48 hours
- Low flow in main stream of Red River (<100 cfs)
- Affected fish at upstream end of pools
  - Looking for clean water?
- Dead fish at downstream end of pools

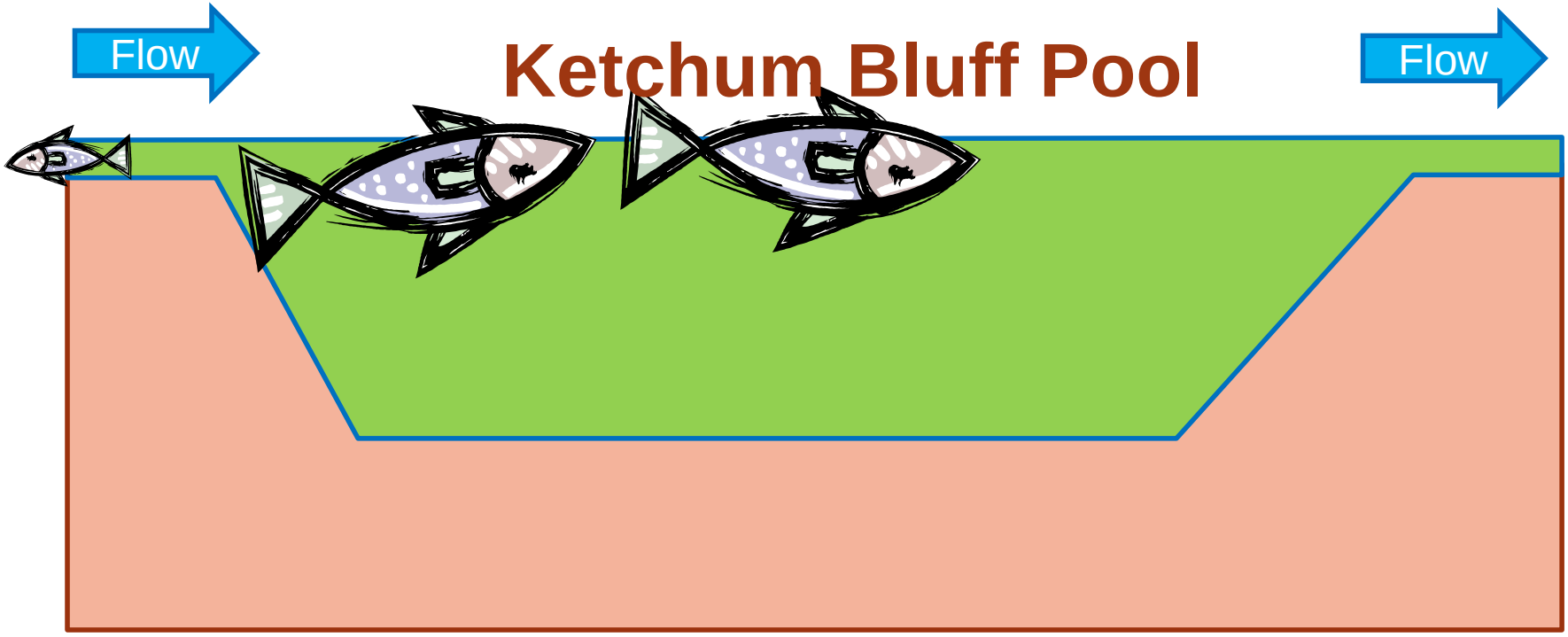
Geomorphology Hypothesis

- During low flow, riffles may be only inches deep
- Big fish are constrained
- Small fish can move between pools



Geomorphology Hypothesis

- Toxic event - Fish try to escape upstream
- Smaller fish escape (water upstream of kill zone is safe)
- Large fish are trapped and die



ANALYSIS: CHEMISTRY

Pattern

- Toxic “plug,” or “Kill zone”
  - Flows downstream 8-10 mi/day
  - Fish don’t die upstream
- Kills end in dilution
  - River enters lake
  - Tributary enters river
- Gills are red, no hemorrhaging
- Necropsied fish have liver damage

Not the Problem

- Dissolved Oxygen
  - Gills of dead fish are not pale
  - Predawn DO > 5 mg/L
- Pesticides
- TPH
- Golden algae
  - Low numbers present
  - No gill hemorrhaging
- Toxic cyanobacteria

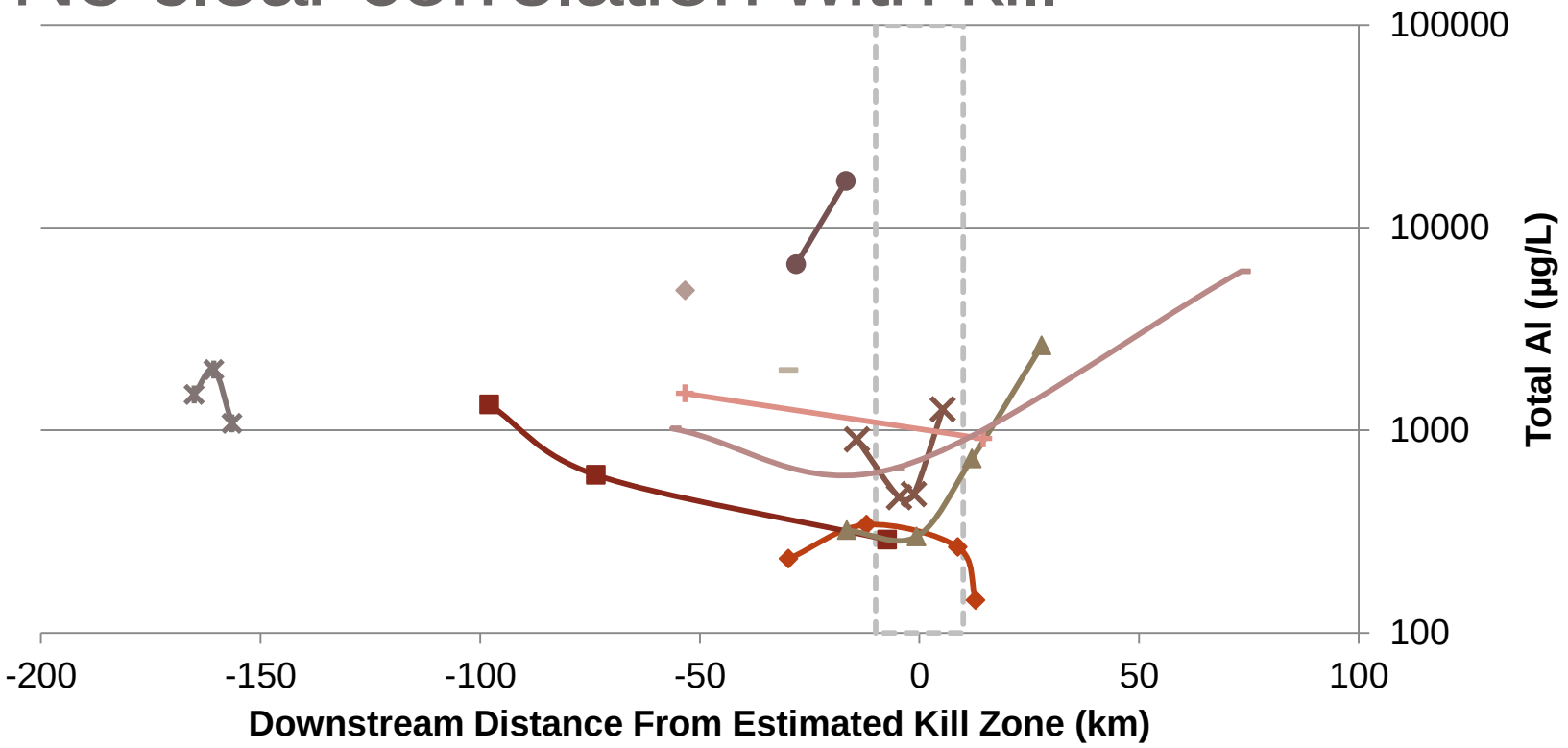
Maybe the problem

- Metals
- Red Creek
- Gas bubbles
- Gel formation
- “Mycotoxin”

Metals

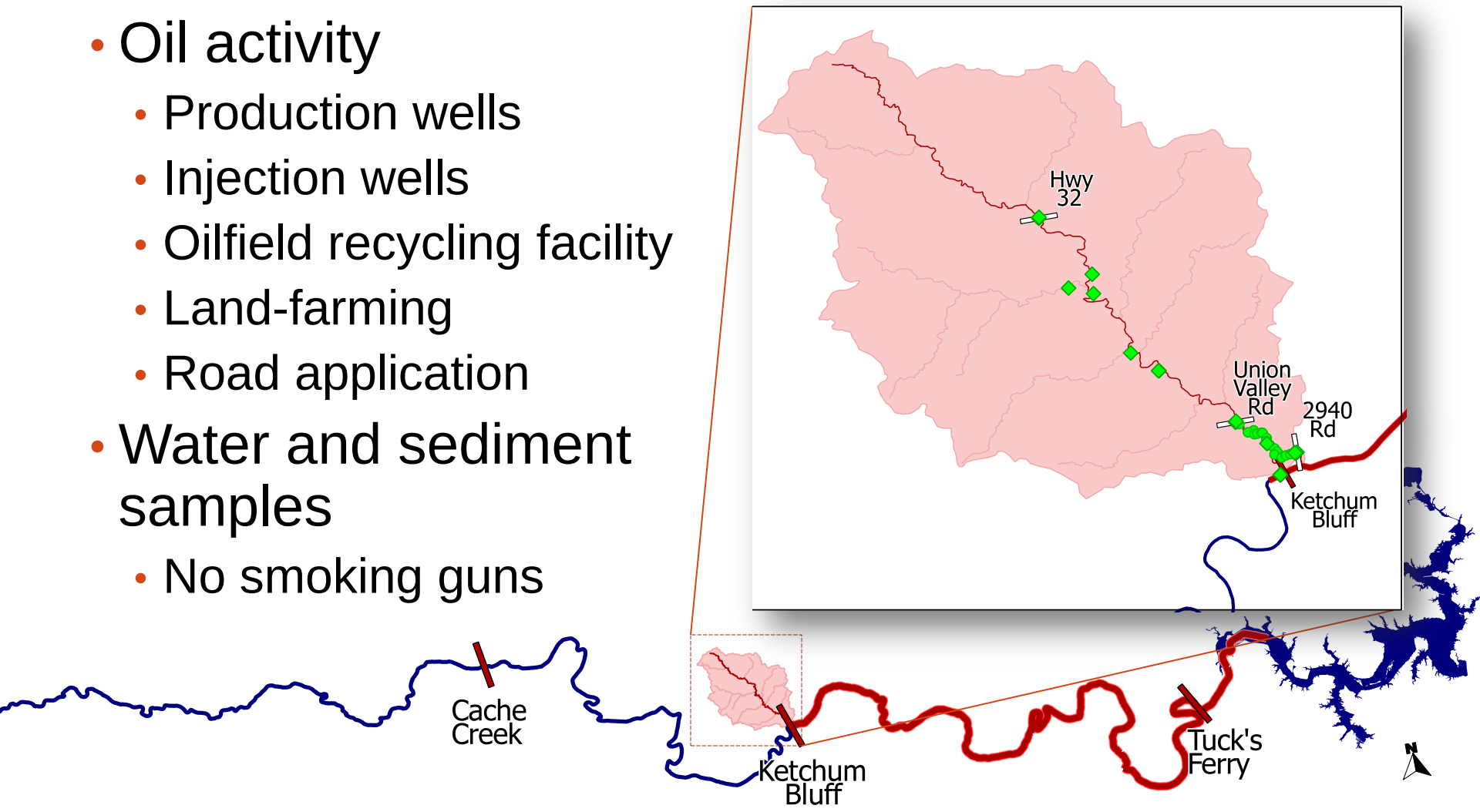
- OGS suggests metals, particularly Al, were high during 2011 kill event
  - Al can kill fish
  - Acute NAWQC for Al exceeded
- But-
  - Red River high in total and dissolved minerals
  - Only total metals analyzed in 2011
  - Clay contains Al
  - Al within historical range

Aluminum profile:
No clear correlation with kill



Red Creek Watershed

- Oil activity
  - Production wells
  - Injection wells
  - Oilfield recycling facility
  - Land-farming
  - Road application
- Water and sediment samples
  - No smoking guns



Geomorphology: Tributaries

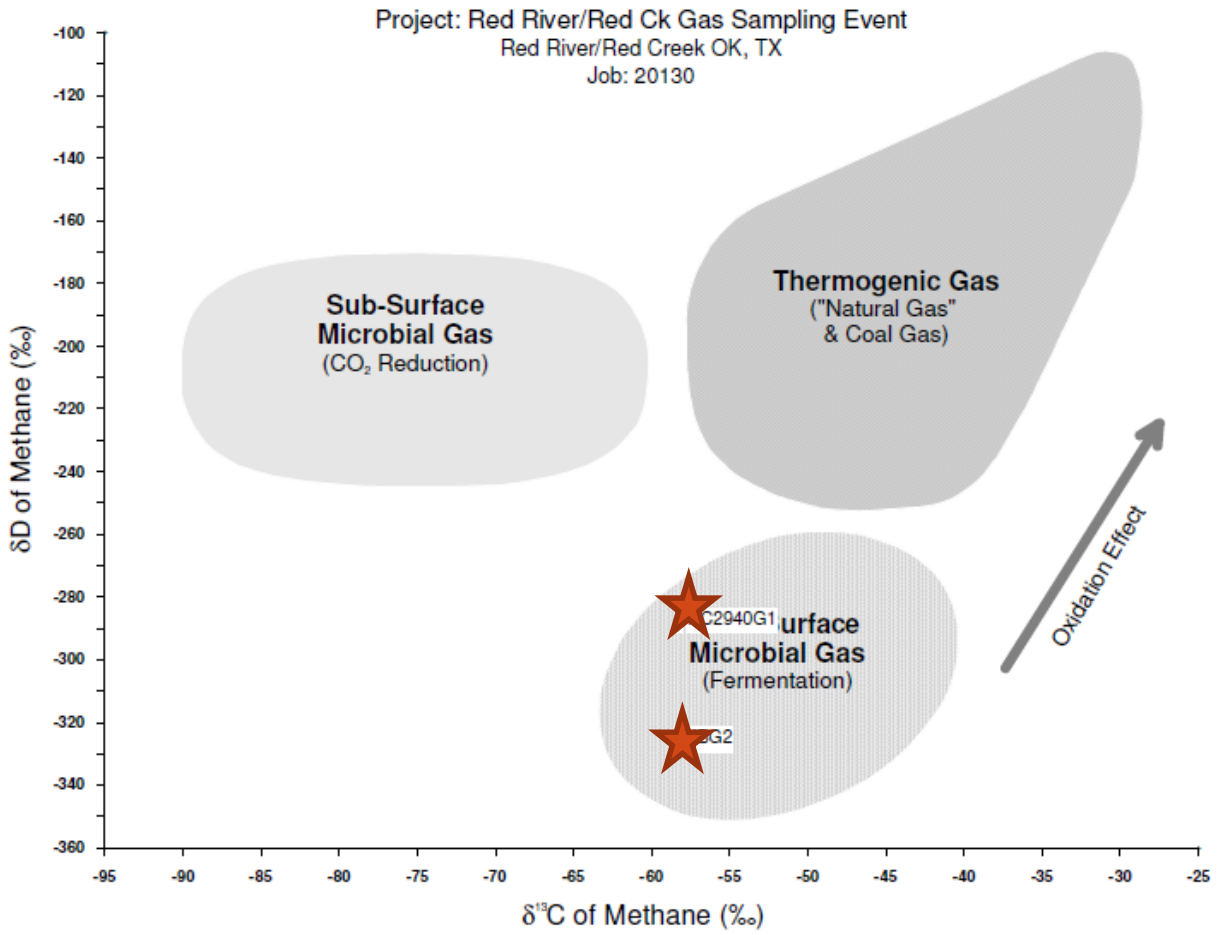
- Some local creeks have no base flow
  - Red Creek, Beaver Creek, Mud Creek
- Upper reaches are frequently dry
- Lower reaches are slough-like
  - ”Backwards” flow when river rises
  - Water quality in lower reaches more indicative of Red River than tributary watershed
  - Slough area flushed out after rain

Gas Bubbling

- Observed at Ketchum Bluff starting in August 2011
- Also observed in lower Red Creek
- Sometimes vigorous
- Captured bubbles are flammable
- Related to Oil & Gas?

Gas Bubbling

- Lab Results – Biogenic Methane



Gel Formation

- Gel produced during SVOC test in ODEQ lab
  - Basification to pH 12 and heat
  - Interferes with test
- Seems to be correlated with kills
  - Positive during months of kills
  - No gel during baseline study in Feb 2012
  - Positive in lower Red Creek and upper Lake Texoma
  - Negative in Beaver Creek, Cow Creek, Texas tributary
  - Negative upstream of Ketchum Bluff

Gel Formation

- Lab analysis of gel by EPA NEIC
  - $Mg(OH)_2$, NaCl
  - Also CO_3, Na, Ca, S, Si
  - No organics detected (limit 100 ppm)
- Seems harmless?

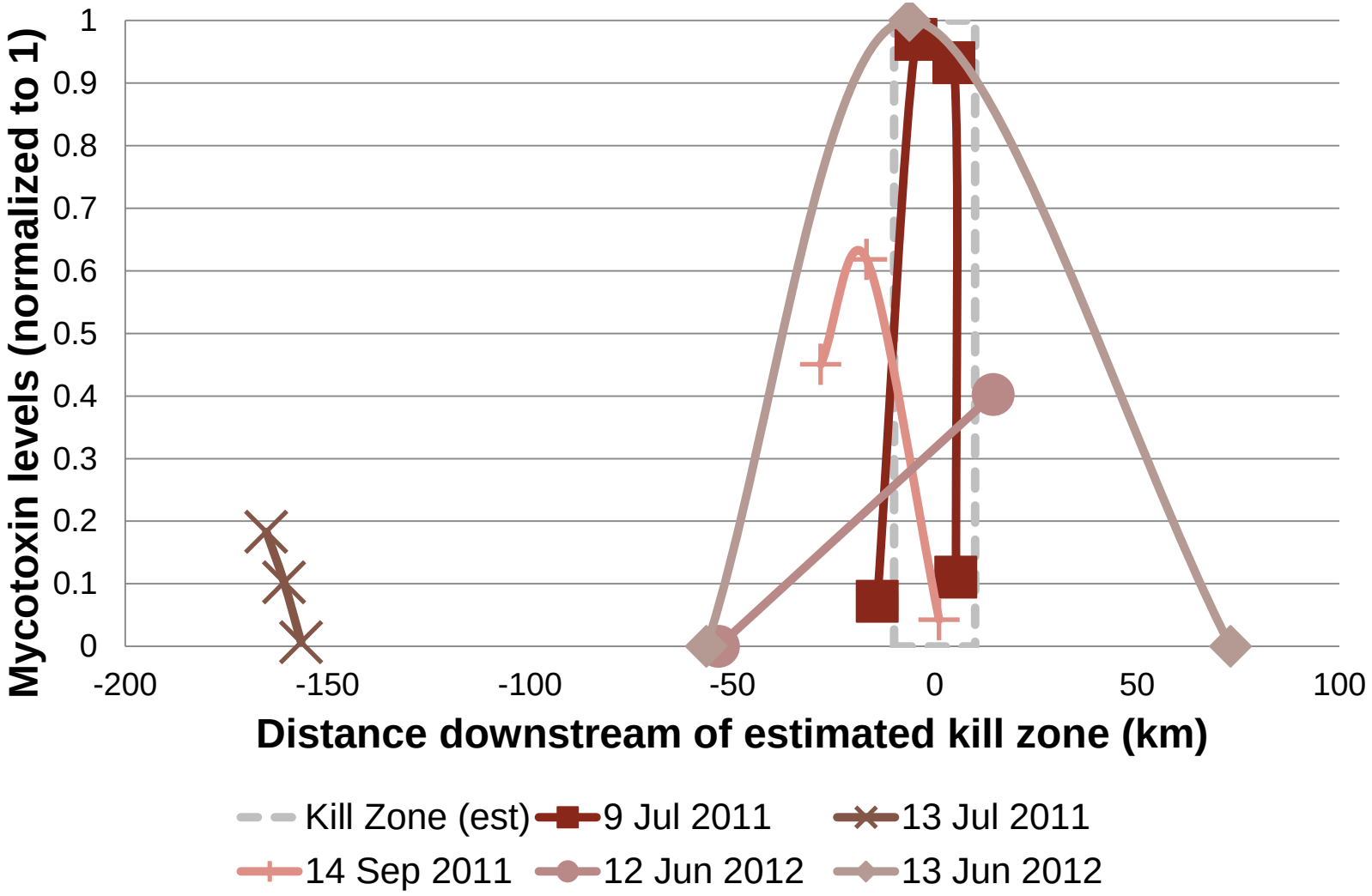
Photo of gel formed in ODEQ lab

“Mycotoxin”

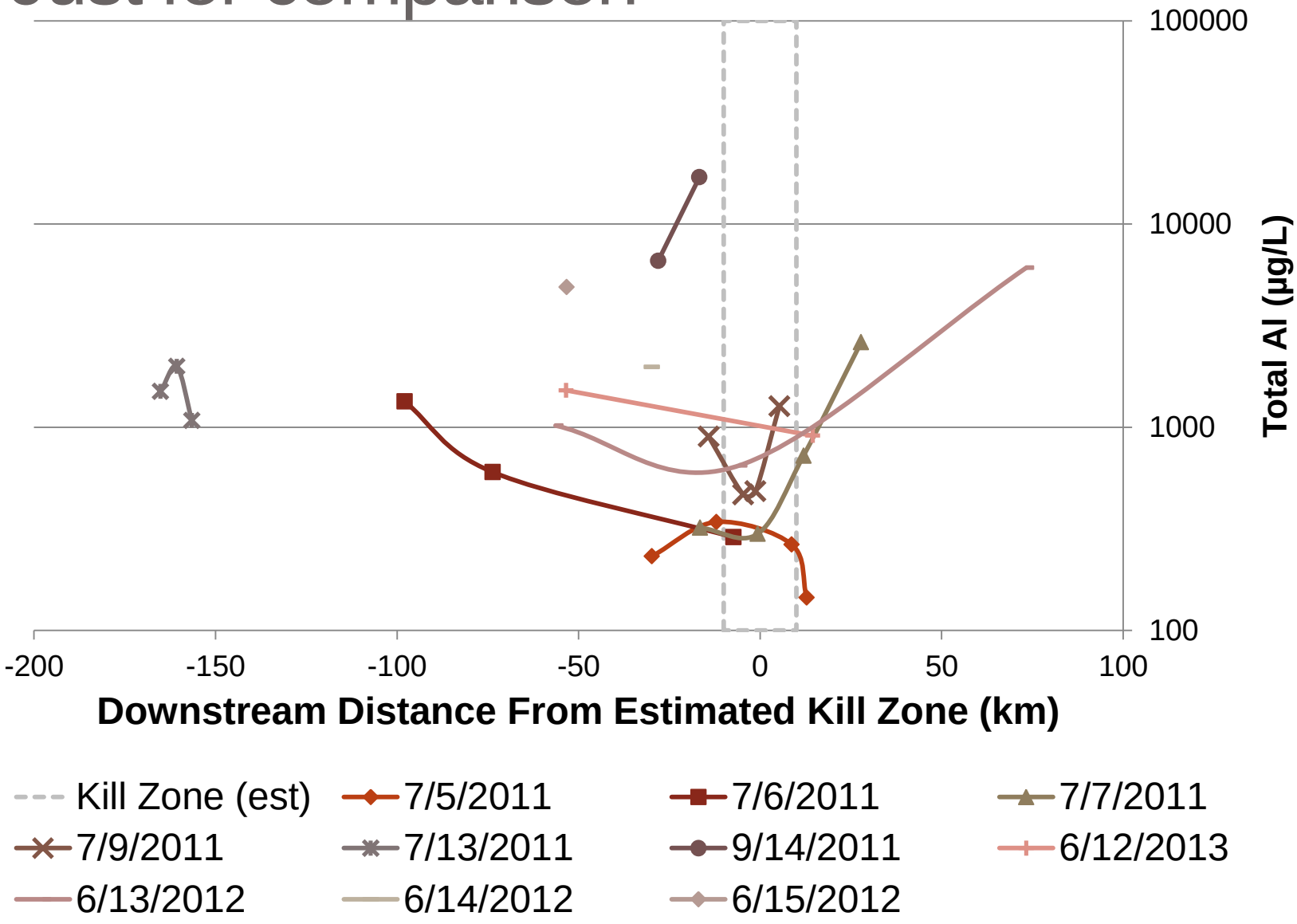
- Found by EPA ORD Las Vegas during investigation of gel
  - Detected with LC-MS
- 4 similar organic compounds
- Tentative ID– “mycotoxin” (ergot alkaloid)
  - Ergot grows on infected wheat, rye, etc.
  - Also produced by other fungi
- Derivatives used as pharmaceuticals
  - Migraine medication
  - Stimulate uterine contractions
  - Control postnatal bleeding
  - LSD
- Other MS experts disagree with ID

Ergot on Wheat
http://pnw-ag.wsu.edu/smallgrains/Ergot.html

“Mycotoxin” profile: Peaks are evident in kill zone



Aluminum profile:
Just for comparison



CONCLUSIONS

What we think we know

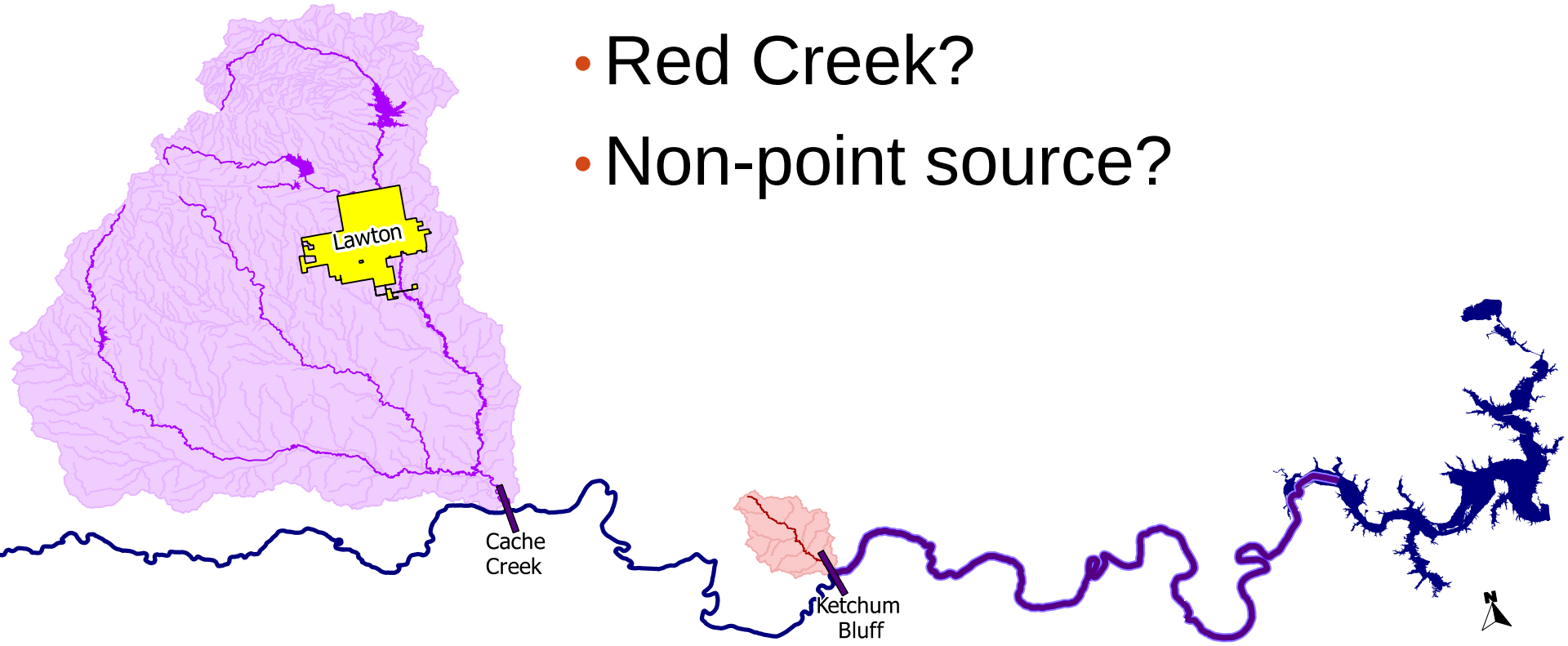
- Large-fish mortality due to geomorphology
  - Kills expected in deeper pools during low flow conditions
- Causative agent released in short-duration pulse(s)
- Causative agent is ”mycotoxin” detected at EPA-ORD

What we still don't know

- What is the "mycotoxin?"
  - Ergot alkaloid?
  - Microorganism?
  - Anthropogenic chemical?
- Is the gel just incidental?
  - Summer heat
  - Low flow
  - High Mg

What we still don't know

- Where is the source?
  - Cache Creek?
  - Red Creek?
  - Non-point source?



What we still don't know

- Why did two kills start at Ketchum Bluff?
  - Near source?
  - Agent stored in lower Red Creek?
  - Geomorphology?

What we still don't know

- Why did the Sept. 2011 kill start where July 2011 kill ended?
  - No more fish left to kill upstream?
  - Agent settled to bottom and resuspended?
- How many source events?
  - Repeated release?
  - Settling/resuspension?
  - Storage in sloughs?
  - Encystment?

What we still don’t know

- Why don’t gar die in kills?
  - Large, but skinny enough to pass riffles?
  - Air-breathing?
  - Resistant to toxin?

What we still don’t know

- Will there be a 2013 kill?

Acknowledgements

- ODEQ
  - Ferrella March
  - Brian Maggott
  - Chris Armstrong
  - Scott Thompson
  - Jay Wright
  - Land Protection Division
- ODWC
  - Phillip Cottrill
  - Matt Mauck
  - Larry Cofer
- EPA
  - Adam Adams
  - Tammy Jones-Lepp
- OCC
  - Tim Baker
  - Shawn Coslett
- TPWD
  - Jennifer Bronson
  - Greg Southard

Questions?