Water Quality Impacts from Mining at the Tar Creek Superfund Site

Admiralty Collapse

Douthat Area Discharge

Tar Creek at Douthat

Ottawa County, Oklahoma

Presented By

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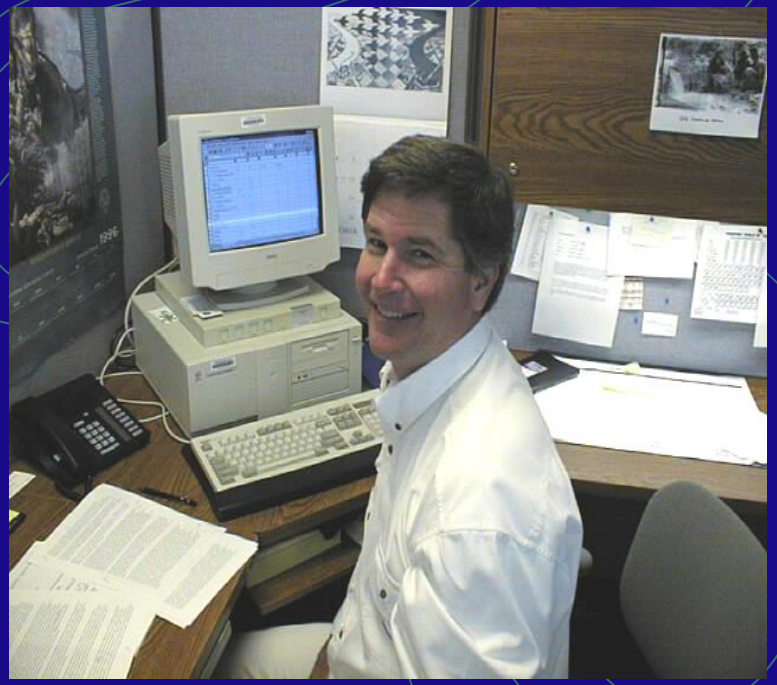


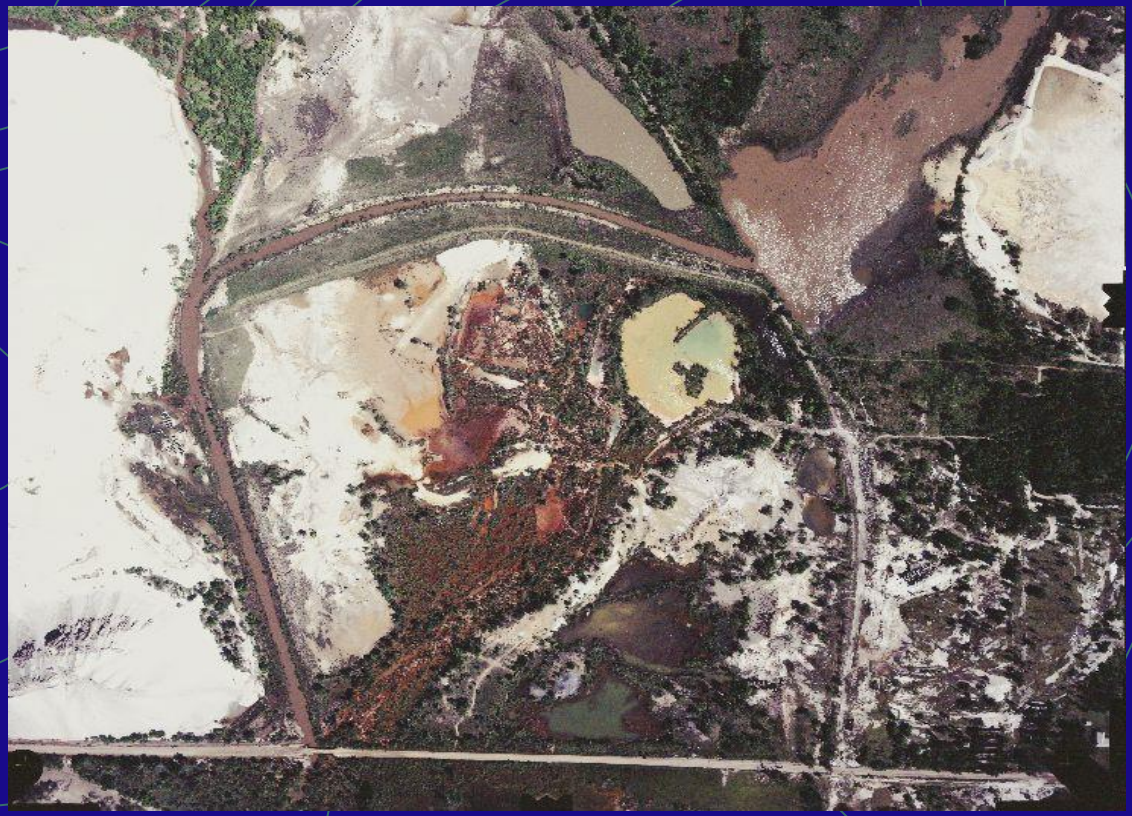
OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

June 17, 2014

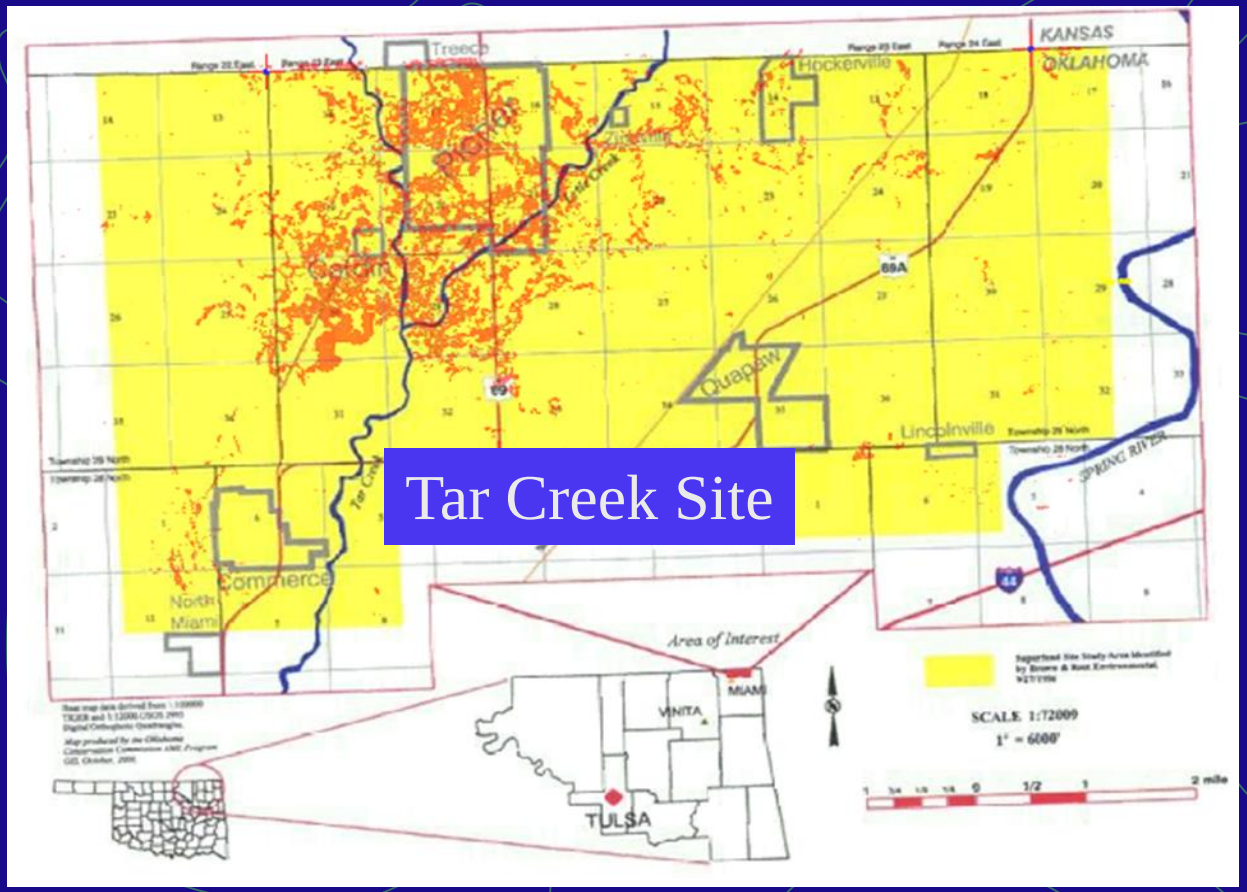
Major Topics

- Site
- Mine History
- Contaminant Sources
- Geology & Hydrology
- Receptors / Impacts
- Superfund Actions

Douthat Diversion



Tar Creek Superfund Site Location

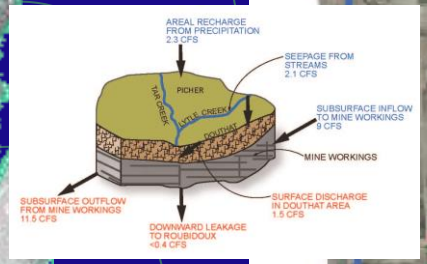


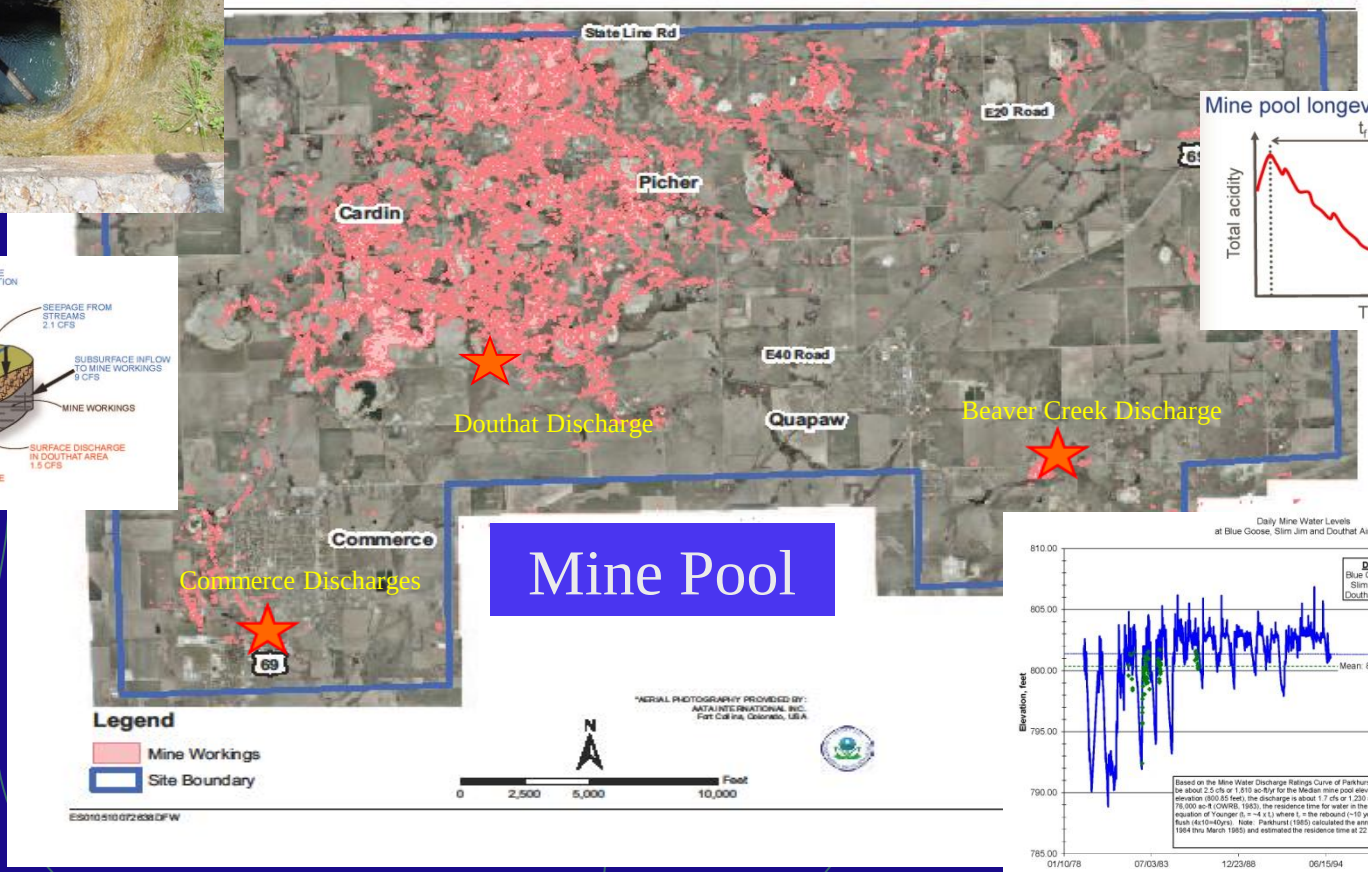
- 40 square miles in Northern Ottawa County, OK
- Picher, Cardin, Quapaw, Commerce, and North Miami

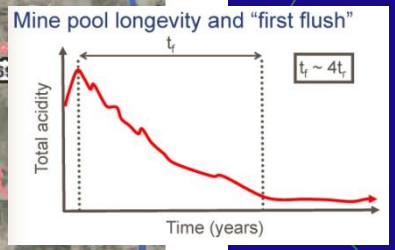
Mining Field History

Lead and Zinc Sulfide Ores
Room & Pillar Mining (1912–70)
(av. 15 ft. Ceilings; some > 100 ft.)
Milling (~140 mills in 1925)
120 million yd^3 of chat
1000s of acres of chat
Hundreds of open mine shafts
Subsidence
300 miles of tunnels (100 – 300 feet bgl; flooded)
Mine Pool (76,000K acre-ft)
Mine Drainage (began in 1980)

Picher Mine Pool



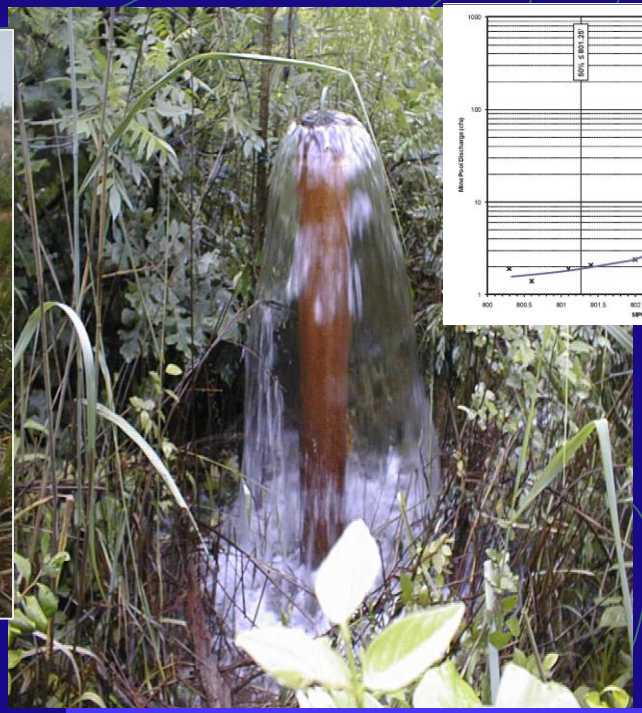


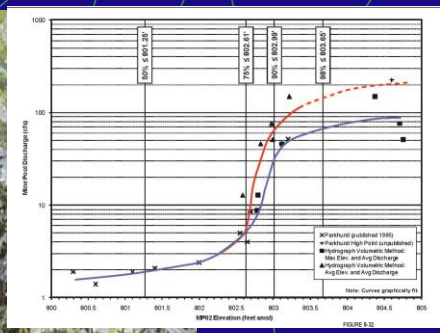


- 47K to 100K acre-ft (15 – 33 Billion Gallons);
- Circum Neutral pH (~6.4), High Sulfate, TDS, SC, Ca, Mg, Fe, Zn , Pb, Ni, Cd, As
- **40 – 100 years to flush :** Younger: 40 yrs ($t_f = 4t_r$); t_r = 10yrs (1970 – 1980)

Mine Water Discharges

Mayer Ranch Discharge





Artesian Flow of MW Douthat

- Began ~1980
- Metals (Fe, Zn, Pb, Ni, Cd, As)
- pH (~6.0), dropped to 3
- Toxic to aquatic organisms
- Precipitation of oxy-hydroxides
- Lower Metals Conc. over time

- Net Alkaline
- Q Varies with mine pool elevations

Discharge Water Quality

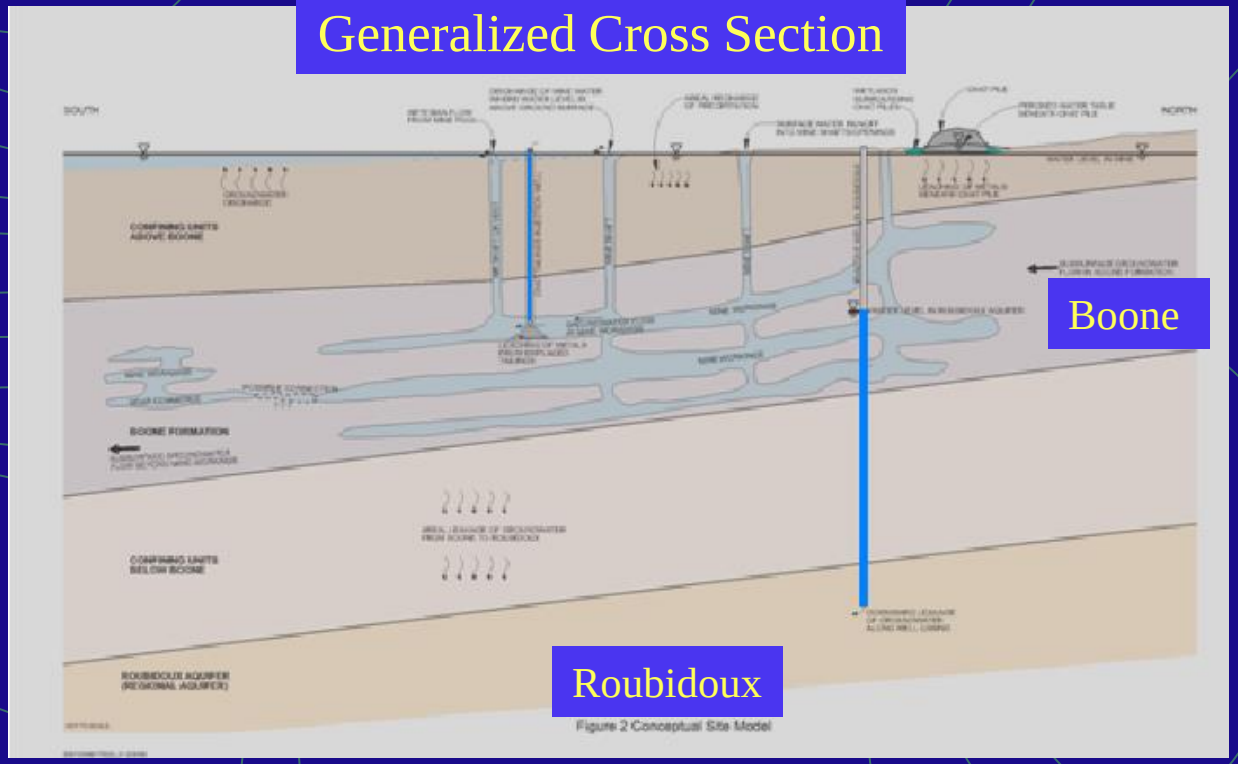
Parameter	Mayer Ranch PTS Design Influent	Representative Beaver Creek artesian discharge	Estimated Tar Creek artesian Discharge at Douthat
pH	5.95	6.62	6.2
Total alkalinity	393	185	100
Net alkalinity	29	90	
Fe	192	9.28	55.1
Zn	11	1.60	8.05
Ni	0.97	0.02	0.235
Cd	0.017	0.001	0.004
Pb	0.060	0.015	0.003
As	0.064	0.020	0.014
SO_4^{-2}	2239	244	1231
Discharge rate (LPM)	1000	95	8500

Chat – Another Source

- Leachate
- Chat Fines

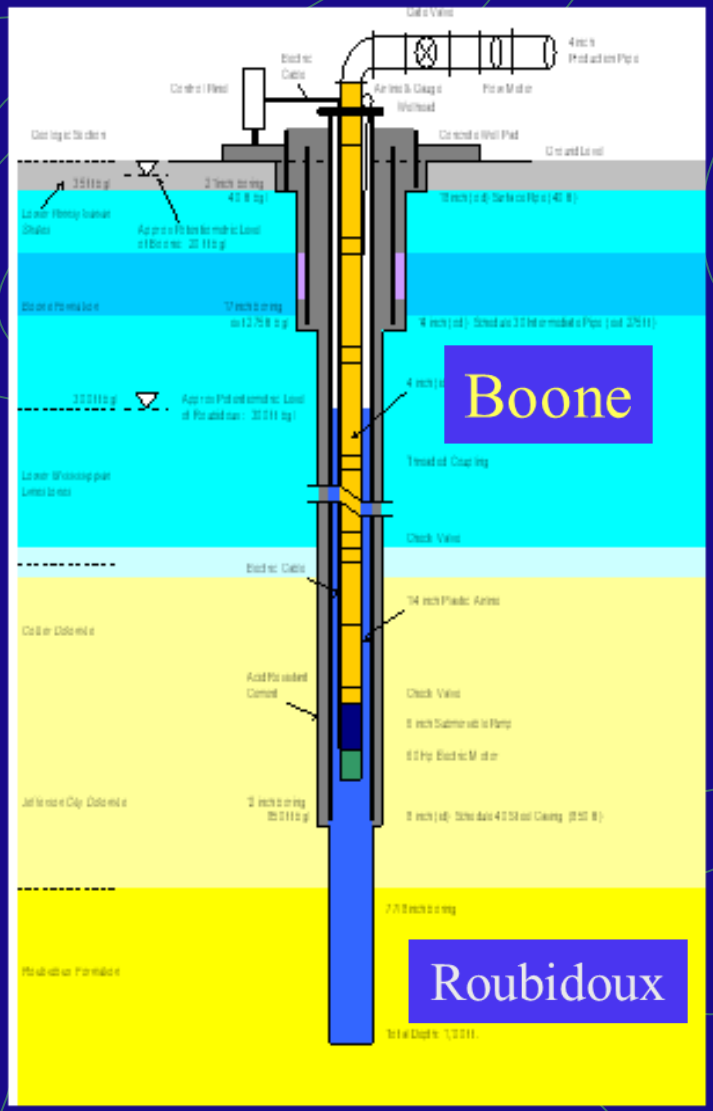
Boone & Roubidoux Aquifers

- **Boone WL:**
  - 800 ft elev. (~20 ft bgl)
- **Roubidoux WL:**
  - 550 ft elev. (~ 300 ft bgl)
- **Hydraulically Connected?**
  - 250 - 300 feet head difference (vertical gradient ~ 0.5)
    - Roubidoux used to be artesian at Miami in early1900s: 10 ft agl; now 400 ft bgl
  - **Low permeability of intervening rocks** (~700 feet thickness)
    - Geochem. rxns between MW & Roubidoux: Decreased Perm: (67-72%)
  - **Travel time estimates 15 to thousands of years**
  - **Abandoned wells may act as conduits (est. 5 MM gpyr from 1 well)**



Roubidoux Aquifer

- Primary Source of Drinking Water
- Underlies the Mine Pool
- Many Abandoned deep wells from mining



Roubidoux and Mine Water Concentrations

PARAMETER	MCLs	ROUBIDOUX	MINE WATER	MINE WATER	MINE WATER	BOONE
	(SMCLs)	1993	(1980)-Mean	(2002)-Max	(2009)-Mean	(2009-Mean)
Total Zinc (ug/l)	**5,000**	**8.8**	**108,000**	**56,300**	**15,286**	**1,504**
Total Iron(ug/l)	**300**	**61.5**	**110,000**	**27,400**	**38,760**	**19,825**
Sulfate (mg/l)	**250**	**25**	**1,950**	**1,590**	**1,180**	**1,045**
Aluminum (ug/l)	(500 – 200)	51.7	1,950	241	211	102
Total Manganese (ug/l)	50	4.3	3,370	1,700	1,040	2,578
Total Nickel (ug/l)	100	6.7	1,800	362	215	82.2
Total Lead (ug/l)	15	4.8	220	32.7	13.2	2.79
Total Cadmium (ug/l)	5	2	310	111	31.4	4.86
Total Copper (ug/l)	1,000	---	45	75.7	20.3	18.8
Total Arsenic (ug/l)	10	---	2.8	26	18.1	9.97
Dissolved Solids (mg/l)	500	290	3,410	2,660	1,860	1,949
Specific Conductance (uS/cm)	---	566	2,680	2,800	2,616	2,331
Hardness (mg/l $CaCO_3$)	---	142	1,800	1,700	1,191	1,029
Alkalinity (mg/l $CaCO_3$)	---	143	23	167	129	209.3
pH	---	7.9	6.4	5.7 (min)	6.53	6.71

Receptors / Impacts

- Roubidoux Aquifer
  - Wells with Inadequate casing depth or seal
- Streams
  - Metals > OWQS
- Sediments
  - Metals Precipitate into Sediments
  - Metals > TEC
- Aquatic Community

TC Task Force Environmental Health Effects Sub-Committee: “The sediments provide an effective long-term sink for metals and should effectively remove them from most biological Processes.”

Initial Superfund Actions (OU1)

Diversions & Diking
(to eliminate discharges)

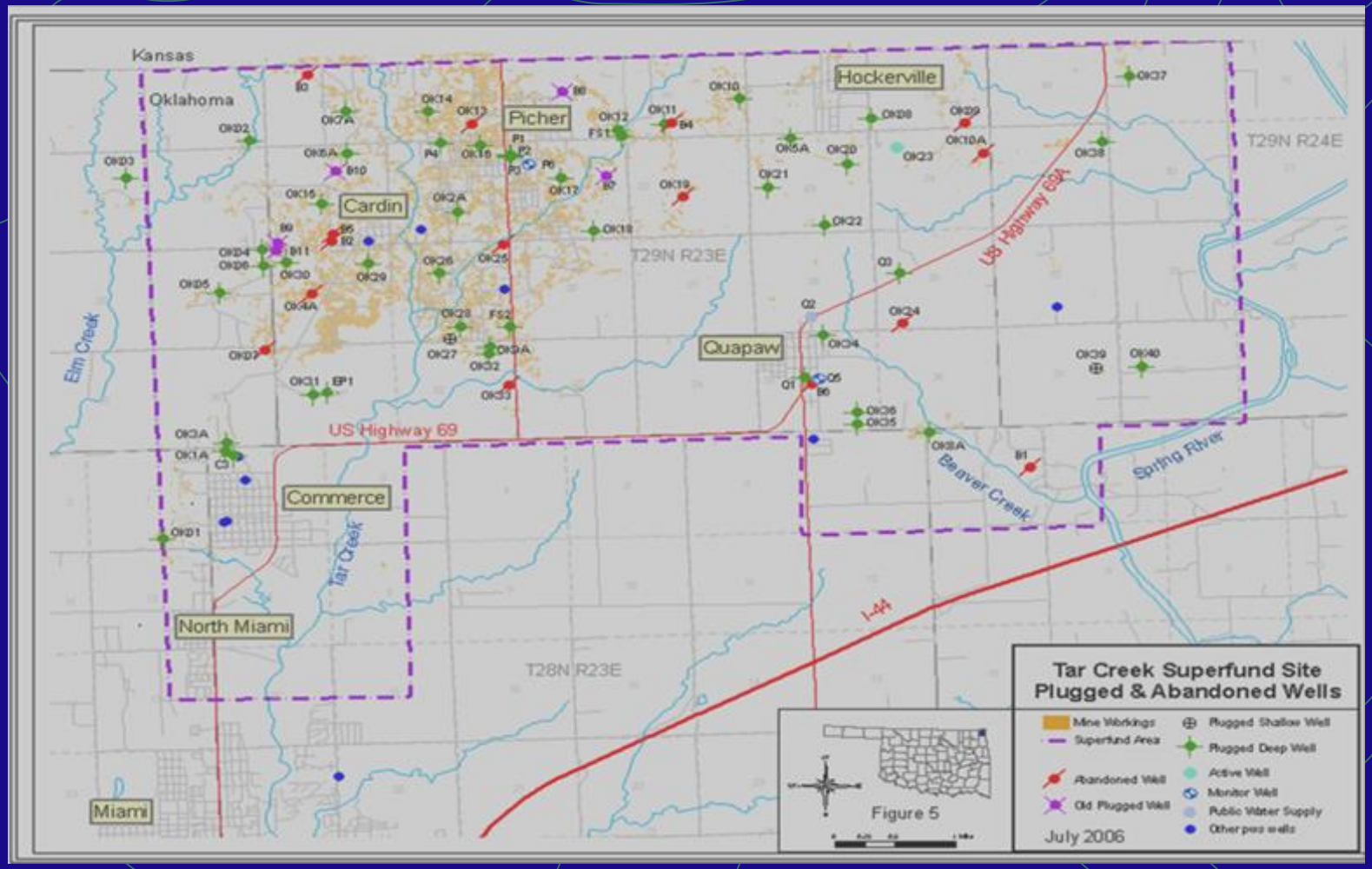
Muncie Collapse

Lytle Creek Diversion

Result:

Discharge rate Unchanged
Concentrations lower and Net Alkaline – Less metals loading
Fund Balancing Waiver, lowered Beneficial Uses due to
"irreversible man-made damages" – No additional Work

Initial Superfund Actions (OU1)



83 Abandoned deep Roubidoux wells located and plugged

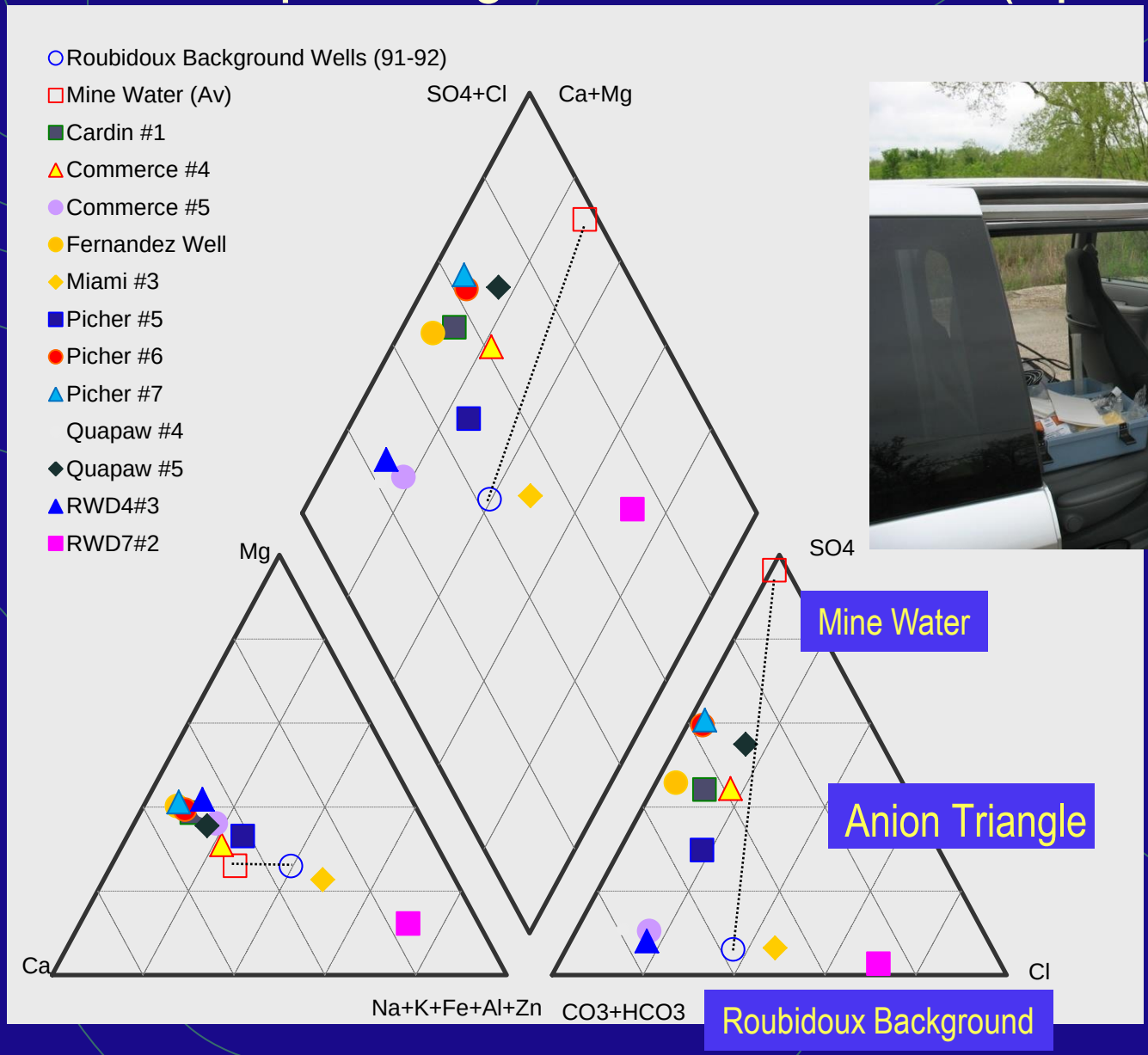
Conduct After Action Monitoring to determine the effectiveness of well plugging in protecting the Roubidoux

After Action Monitoring of Roubidoux

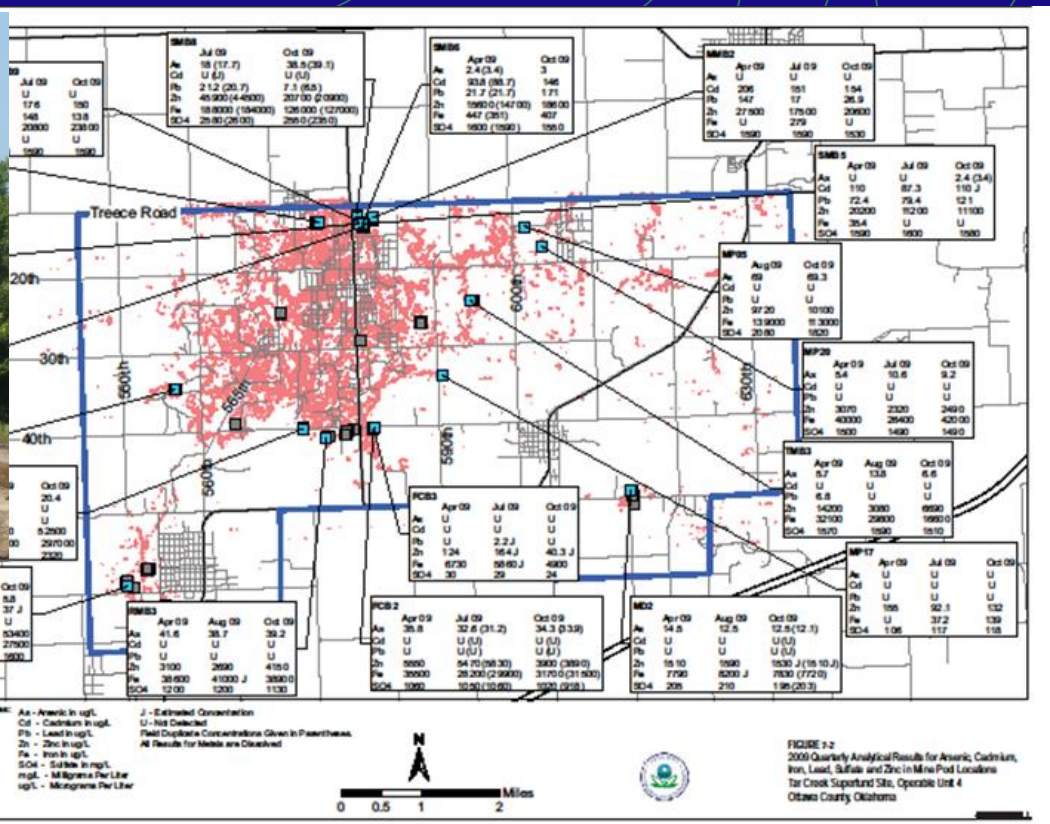
- **After Action Monitoring** (Assess effectiveness of remedy to protect Human Health)
  - Surface Water & Ground Water 1987 & 1989
  - Well Head Sampling: 1992-1993
  - Discrete Sampling: 1996 – 2002
  - Long Term Monitoring 2003-2014
- **Well-Head Sampling (Phase I)**
  - 21 wells (10 outside mining area)
  - 11 municipal wells within the mining area sampled once per month for 6 months and all 21 wells sampled one time only
  - Indicator parameters have aesthetic limits (SMCLs) not health based limits.
- **Discrete Sampling**
  - Packer Testing of 5 wells
  - 5 New Wells installed

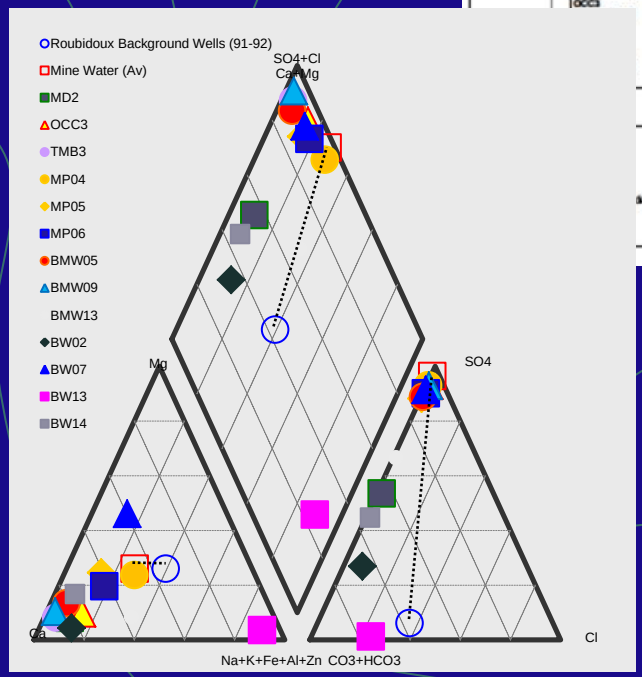
- **Roubidoux Background**
- **Indicator Parameters / Tolerance Limits**
  - Iron (Fe): 207 ug/l
  - Zinc (Zn): 43 ug/l
  - Sulfate (SO_4): 82 mg/l

Piper Diagram of LTM Wells (April 2010)



Operable Unit 4 Remedial Activities





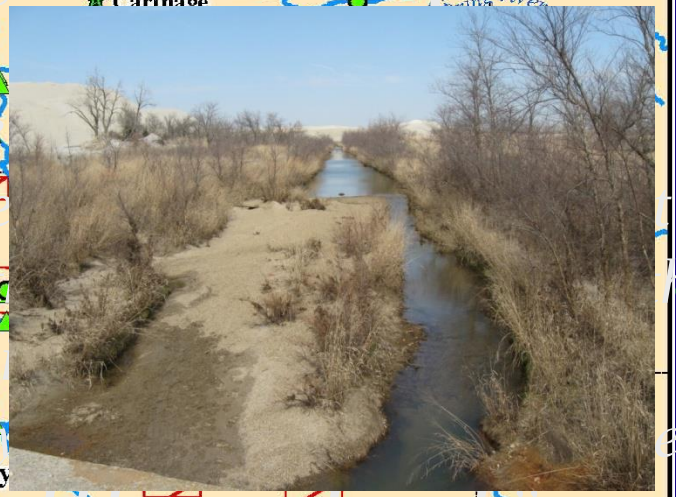
- Remediate Chat / Fill Subsidences
- Chat Fines injection
- Hydro Study & GW Model
- USGS Chat Leachate Study
- Remove Chat in Streams / Riparian areas
- Employ PTS ?

OK Plan – Mayer Ranch PTS

- Congressional Funding (2004)
- OU selected Mayer Ranch Site in Commerce
- Monitored & Conceptual Design Developed
- PTS Constructed in 2008 (Design Build)
- PTS Template for TC
- 5 ac
- 1000 L/min (265 gpm)
- Meets OWQS
- Low tolerant species returning
- $1.2 million

Mayer Ranch Passive Treatment System

OU5 - Sediments



Jasper County
MISSOURI

Carthage

Joplin

Picher

Commerce

Miami

Newton County
MISSOURI

Cow Creek
North Fork Spring River
Spring River
Center Creek
Turkey Creek
Short Creek
Empire Lake
Willow Creek
Fourmile Creek
Elm Creek
Spring River
Neosho River
Lost Creek

Legend

Zinc - 2007 data
- <2083 mg/kg DW
- 2083 - 2949 mg/kg DW
- 2949 mg/kg DW

Zinc - 2006 data
- <2083 mg/kg DW
- 2083 - 2949 mg/kg DW
- >2949 mg/kg DW

- Designated Waste Areas
- Cities
- Water
- Rivers
- Counties
- State Boundaries

N

Kilometers
0 2.5 5 10 15

KANSAS

MISSO

OKLAHOMA

ARK

Kilometers
0 45 90 180 270 360 450

SLERA OU5

Sediment Transport Modeling OU5

EPA to Close OU1?

5YR – PTS Feasible

Treat Discharges in OU5?

What's Next?

Parameter	MRPTS	RHMW-2	UT-P
Q (L/min)	**570** to **950**	NA	**354** ± 8.75
pH*	**5.95**	**5.47** ± 0.05	**6.01** ± 0.03
Tot. Alkalinity*	**393**	**255** ± 5.34	**311** ± 4.73
SO_4^{-2*}	**2239** ± 26	**2348** ± 80.9	**2040** ± 63.2
PO_4^{-3*}		**10.6** ± 0.66	**2.59** ± 0.37
Fe*	**177** ± 2.33	**207** ± 2.35	**138** ± 0.80
Zn*	**8.29** ± 0.078	**5.91** ± 0.08	**10.9** ± 0.36
Mn*	**1.51** ± 0.016	**1.73** ± 0.04	**5.34** ± 0.16
Ni*	**0.945** ± 0.015	**0.68** ± 0.01	**0.59** ± 0.01
Cd*	**0.016** ± 0.003	**0.019** ± 0.001	**0.037** ± 0.001
Pb*	**0.068** ± 0.003	**0.081** ± 0.002	**0.062** ± 0.002
As*	**0.063** ± 0.002	**0.086** ± 0.001	**0.040** ± 0.001

SE Commerce PTS

Funded

Design – Build

Parameter	Influent	Final effluent	Removal
Q (L/min)	570 to 950		
pH	5.95	7.02	
Alkalinity	393	205	
SO_4	2239 ± 26	2047 ± 72	
Fe	177 ± 2.33	0.57 ± 0.207	99.7
Zn	8.29 ± 0.078	0.096 ± 0.037	98.84
Mn	1.51 ± 0.016	1.38 ± 0.197	8.61
Ni	0.945 ± 0.015	0.035 ± 0.007	96.30
Cd	0.016 ± 0.002	BDL(0.00064)	96.0
Pb	0.068 ± 0.003	BDL(0.019)	72.06
As	0.063 ± 0.002	BDL (0.022)	65.08

Questions

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