Cooperative Mine Land Reclamation Operations & Comprehensive Managed Watershed Planning

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OBJECTIVE:
Showcase large-scale, long-term success

- Reclamation involved both mining industry and government
- Conducted over a long time in a mutually beneficial manner
- Several projects, scopes, permitted actions
- Similar motivation

Open vs. Closed Systems – what's the difference?

Scientifically…….

Open System

- ENERGY and MATTER can be exchanged (variable) with the physical surroundings
- Physical input can change with time
- Input boundaries are continually open and variable

Closed System

- ENERGY can be exchanged (variable) with the physical surroundings, but MATTER cannot (fixed)
- Physical mass is constant through time
- Distinct boundaries are completely closed

Reality Check:

Multi-dimensional overlapping systems

- Crooked Creek Watershed in Indiana County PA
- Extensive Historical Coal Mining Features
- Ongoing Mined Land Reclamation Operations
- Active coal mining operations
- Non-mining – farming, municipal

Programmatic Challenges of Open Systems:

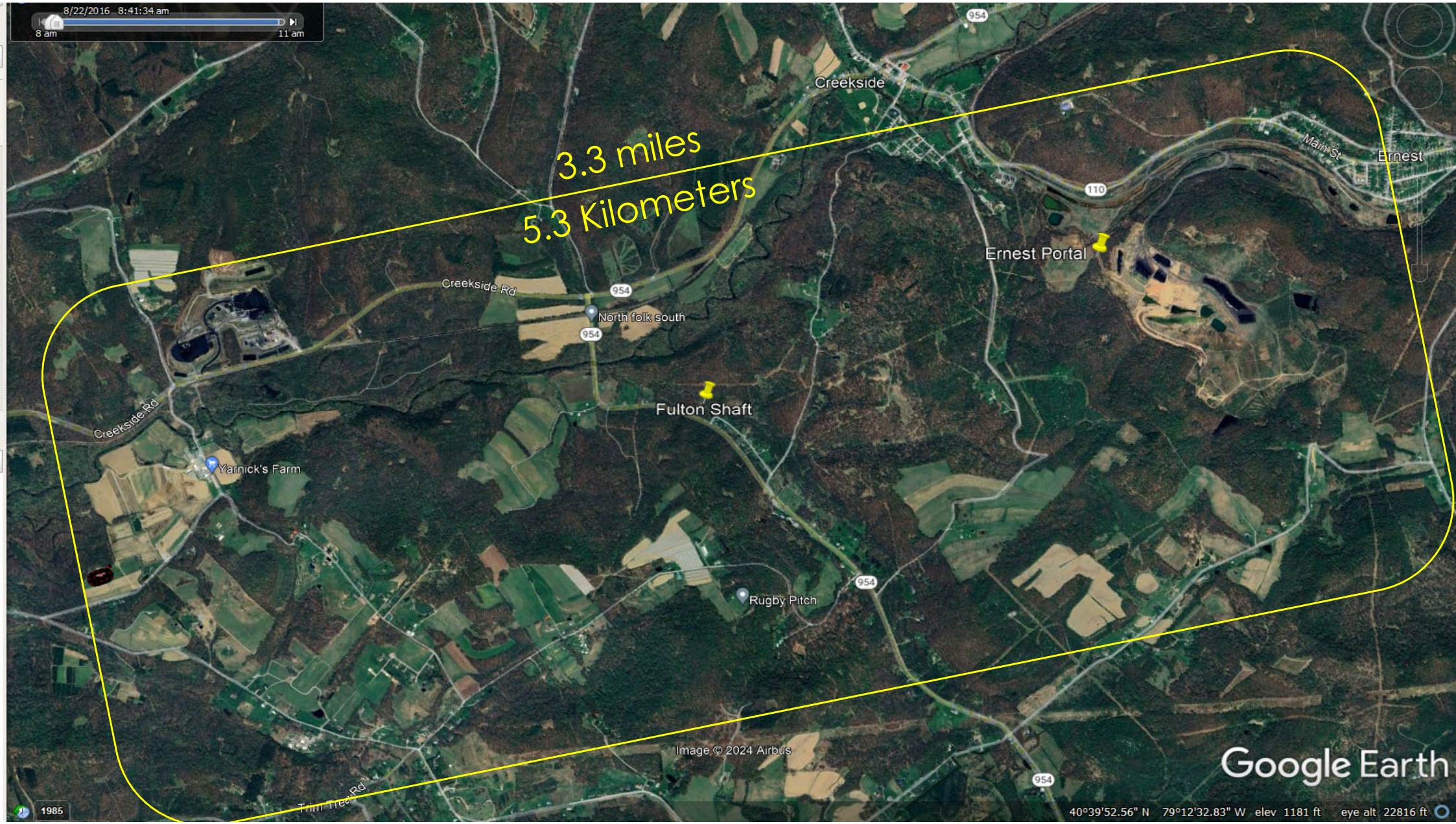
A Question of Provenance & Influence

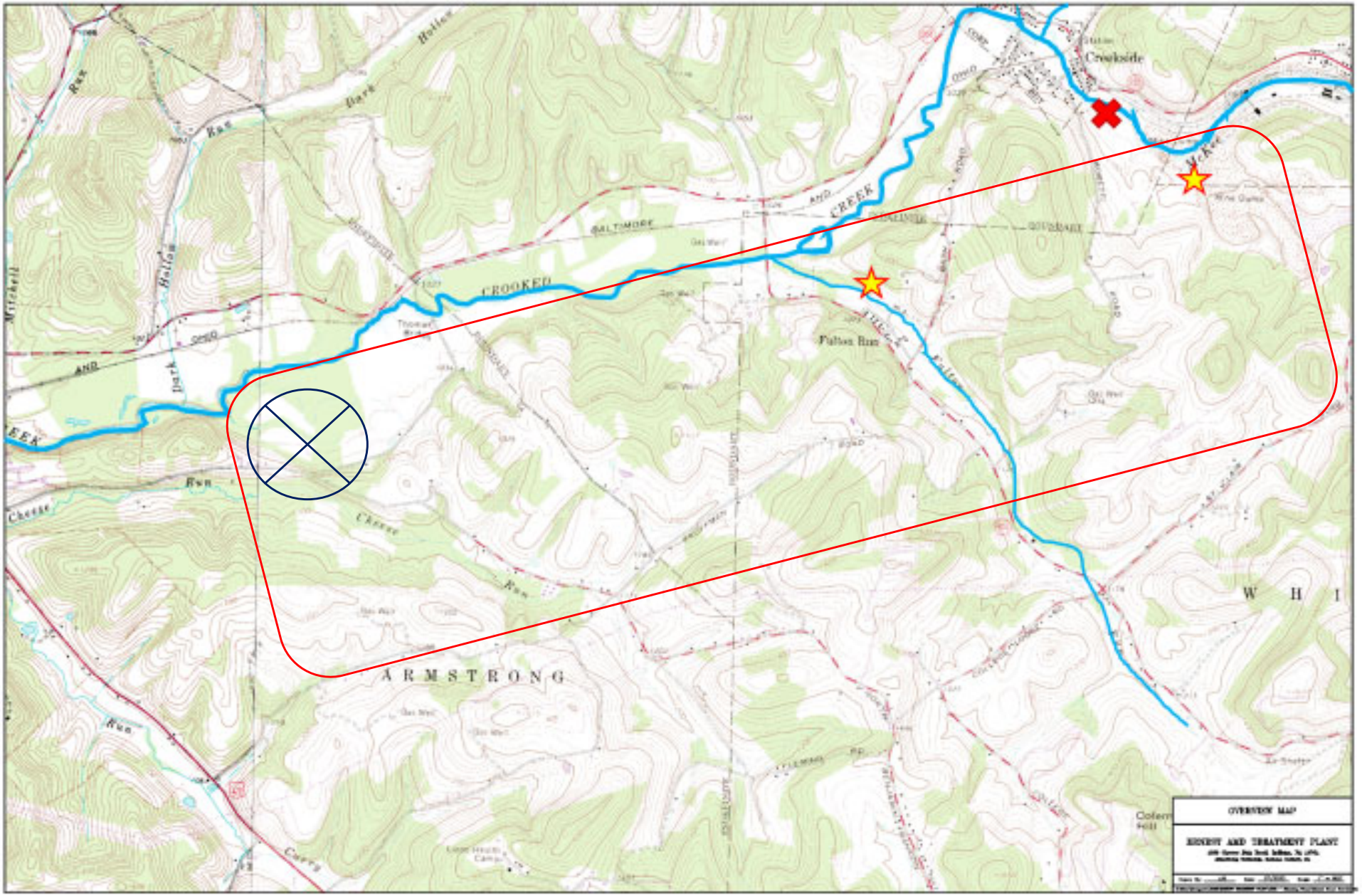
Reclamation Context: It matters where & when

- Funding Eligibility
- Responsible Entities
- Scope of Work and Influence

The Cooperative Crux

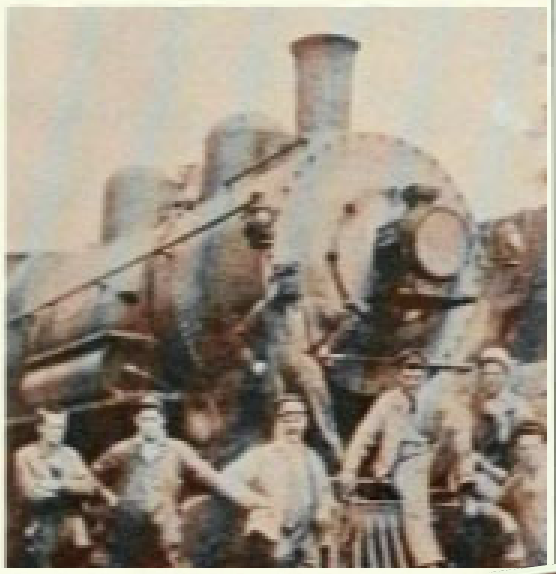
- Design For Versatility & Partner With Talent
  - *"Cast A Wide Net And Get Good Help"*
- Characterize Open System Dynamics
  - Track and Interpret Change Through Time
- Identify Effective Partners
- Cooperate to Creatively Achieve Goals


8/22/2016 8:41:34 am
8 am
11 am
3.3 miles
5.3 Kilometers
Creekside
954
Main St
Ernest
110
Ernest Portal
Creekside Rd
954
North folk south
954
Fulton Shaft
Creekside Rd
Yarnick's Farm
Rugby Pitch
954
Image © 2024 Airbus
954
Google Earth
1985
40°39'52.56" N 79°12'32.83" W elev 1181 ft eye alt 22816 ft


Crooked
Fulton Run
ARMSTRONG
W H I
OVERVIEW MAP

Ernest PA
Extensive Historical Mining 1902-1965

Indiana Branch Local at Creekside, Pennsylvania, circa 1909 (Paul Pietrak)



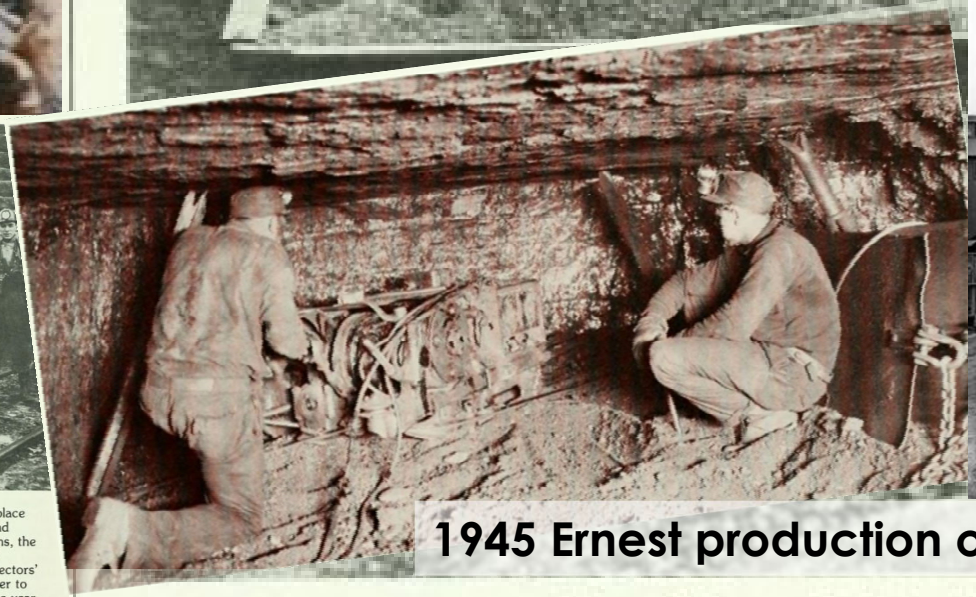
1925 Miner's wages - $20/week pre-deduction

- Eventual apex 1,200 miners
- 7 days a week, multi-shift

Flame safety lamp of the 1930's. Modern versions of this lamp are still used today in mines to test for explosive gases and insufficient oxygen.

R&P mine rescue team at Ernest, circa 1930. Pictured left to right are William Northover, Chuck Bush, Duane Jones, Pete Gottardi, "Timer" Gearhart, Willard "Nook" McQuown, Ralph Chapman, and Pat Loughney.

difficult and dangerous, and inevitable clashes took place between Company and employees. But memories and records reveal that in the hey-day of the mining towns, the R&PC&I and its labor force enjoyed long periods of harmony. As early as July 2, 1908, at a Board of Directors' meeting, R&PC&I executives authorized the treasurer to "set aside out of the earnings of the Company for the year



278 Coke Ovens built by R&P

1945 Ernest production over 1 Million Tons of Coal

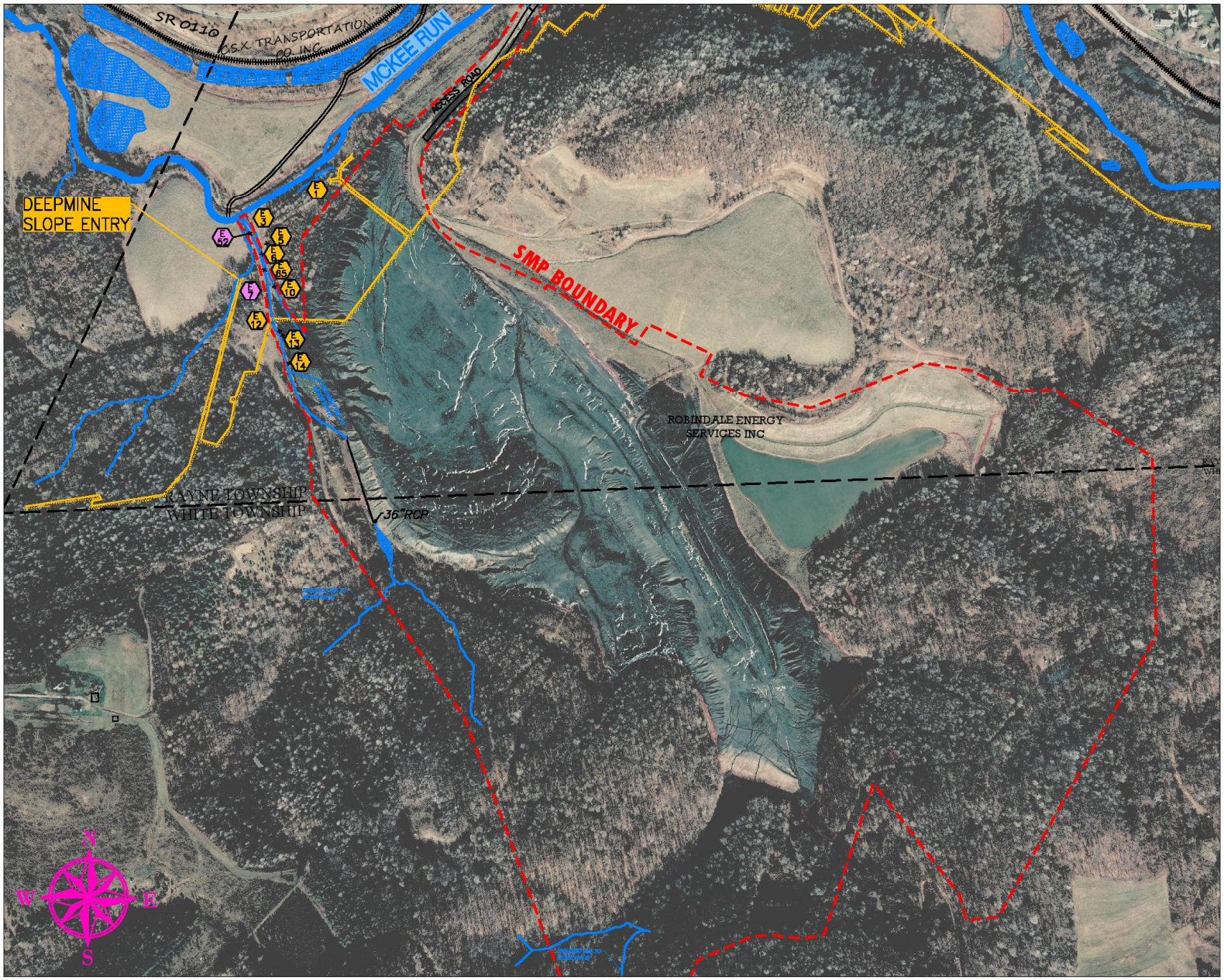
Crooked Creek Watershed
Open System Components

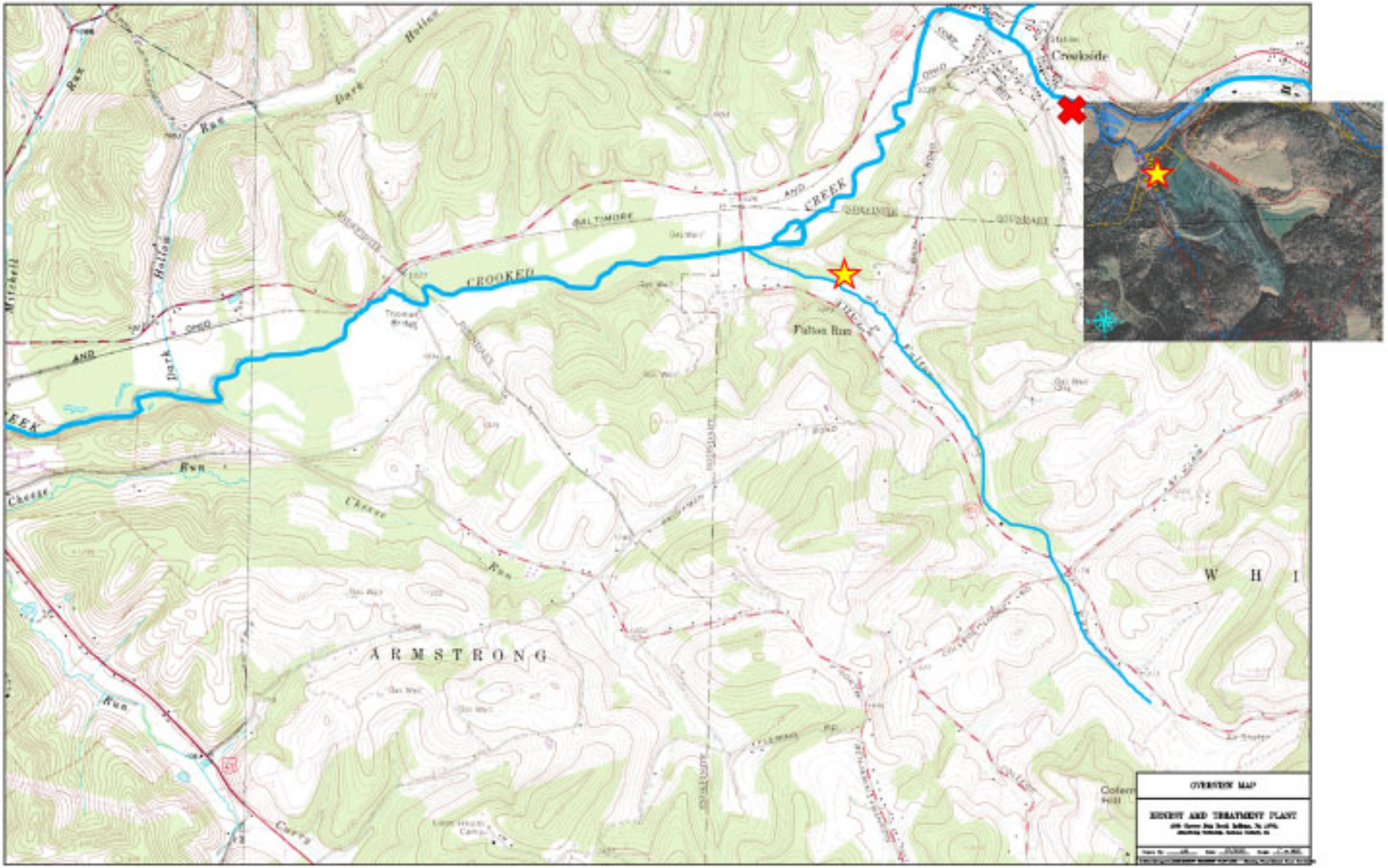
- **Primary Contaminant Sources**
  - Surface: Ernest Refuse Pile
    - Precipitation Infiltration
    - Blocked and Buried Tributaries
  - Underground: Ernest No 2 & 3 Mine Complex Pool
    - Geological Structure Controlling Connectivity
    - Shallow cover conditions
    - 2 Pressure Relief Discharges
- Seasonal Precipitation Fluctuations & baseflow
- Active Mining Variables
- Reclamation Developments
- Established Water Quality Targets

Primary Contaminant Source Area
Surface: ERNEST REFUSE PILE

- 94 acres (38 ha) of accumulated coal refuse
- high BTU's, low sulfur concentrations
- Estimated volume = 11.4 million cubic yards (MCY) (8.6M m^3)

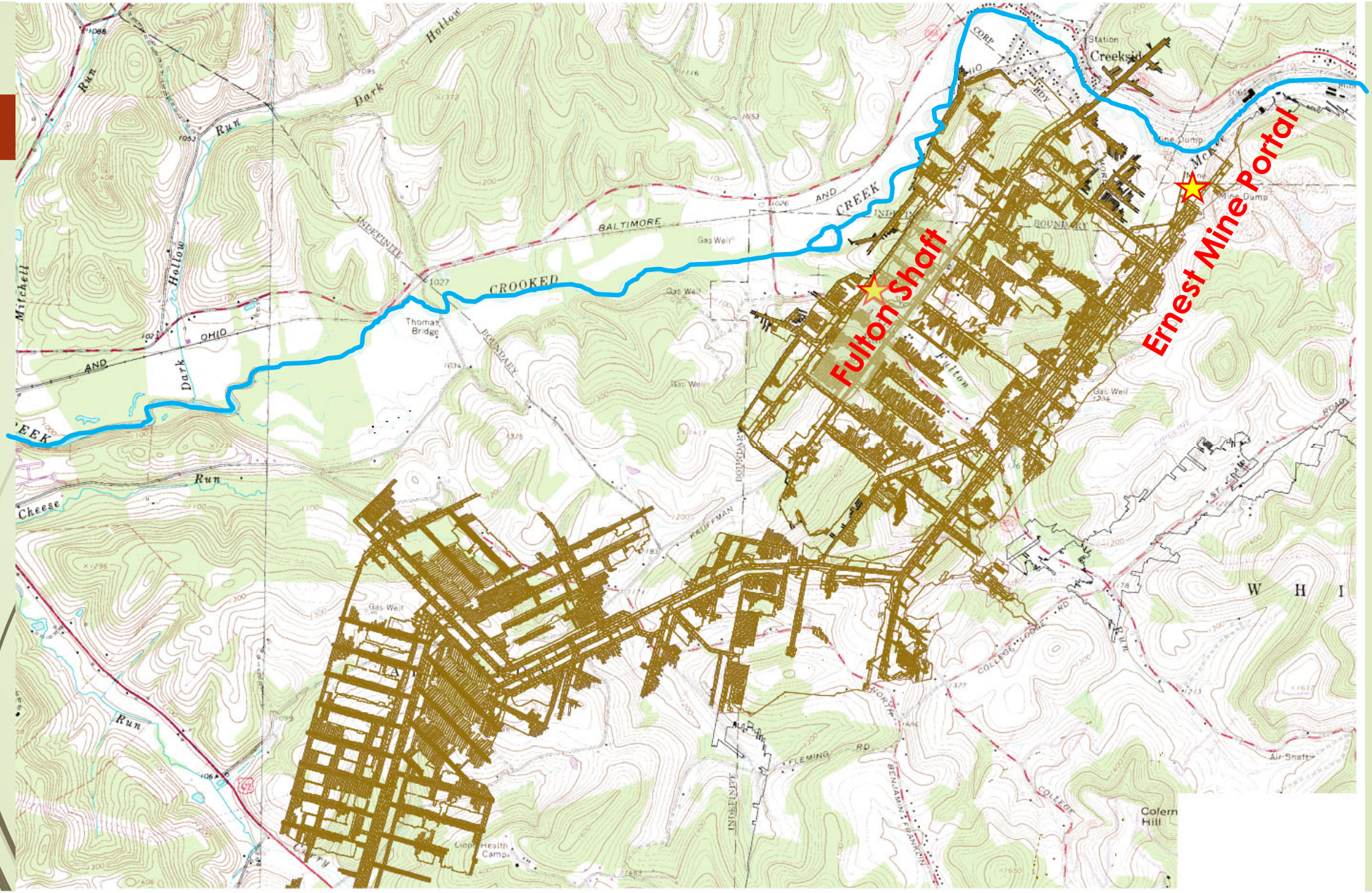
  (~94 acres at avg 100' (33 m) depth)
- Pronounced valley fill, interrupting surface drainage topography, unlined, uncontrolled E&S
- Overlying & Up-dip of the easternmost Ernest 2 & 3 Mine workings, to the south of McKee Run


SR 0110
C.S.X. TRANSPORTATION CO. INC.
MCKEE RUN
ACCESS ROAD
DEEPMINE
SLOPE ENTRY
SMP BOUNDARY
ROBINDALE ENERGY
SERVICES INC
RAYNE TOWNSHIP
WHITE TOWNSHIP
36"RCP
N
W
E
S


Crookside
CROOKED
CREEK
Fulton Run
Cheese
Run
ARMSTRONG
W H I
OVERVIEW MAP
RESERVE AND TREATMENT PLANT

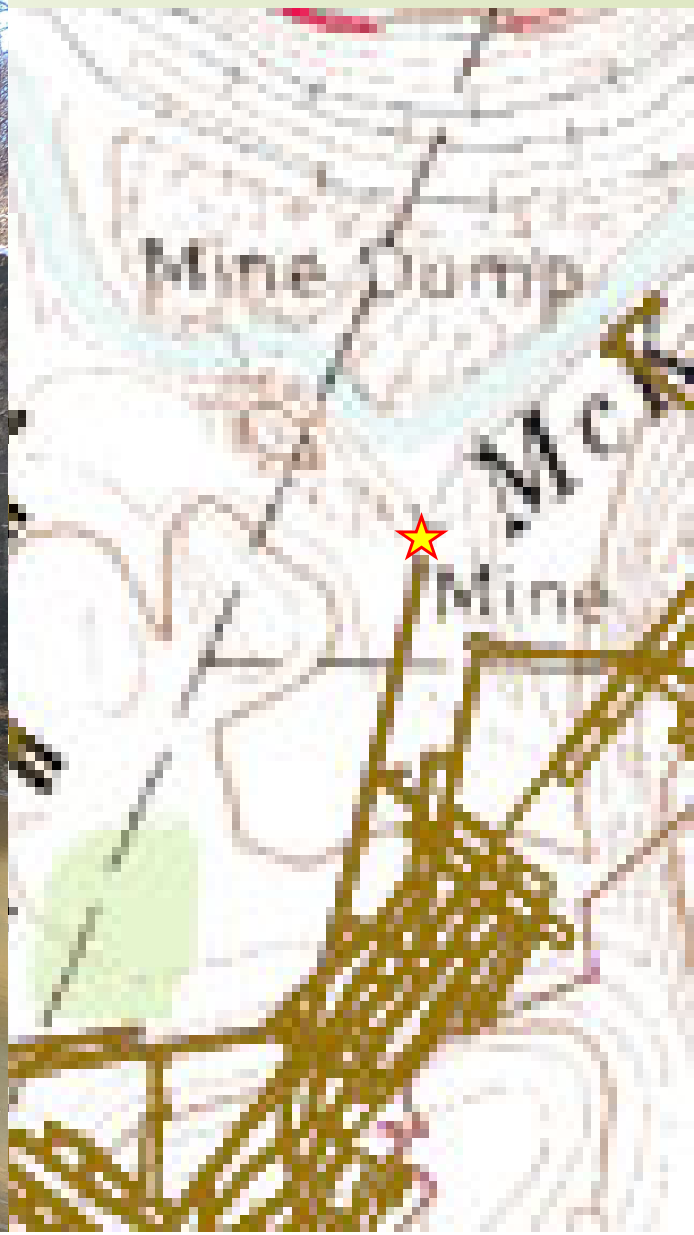
Primary Contaminant Source Area Underground: ERNEST NO. 2 & 3 MINE POOL

- Mine Pool Area: 2,469 acres (999 ha)
  (~18% total workings of 21mi^2 [54.4 Km^2)
- Drainage Area: 5,462 acres (2,210 ha)
- Mine Pool Volume: 1,528,270,000 gallons (100%)
- Mine Pool Area Hydrogeologically connected:
  508 acres containing 314,791,000 gallons (20.6%)
- Underlying and directly down-dip of the Ernest Refuse Pile, with less than 100' cover


Fulton Shaft
Ernest Mine Portal
CROOKED
CREEK
BALTIMORE
AND
OHIO
Dark
Hollow
Run
Mitchell
Cheese
Thomas
Bridge
Creekside
Station
Gas Well
Mine Dump
Fulton
Kauffman
Fleming
Rd
College
Colern
Hill
Air Shaft
Camp
Health
Camp
W
H
I

The Ernest Mine Portal

- Upper Freeport coal Mine Complex drift entry, free-flowing
- Up-dip of and higher topo elevation than Fulton Shaft (10 feet, 3 m) distance 1.4 miles (2.25 km)
- Estimated flow ~630 gallons per minute (post 2018) = ~907,200 GPD ; ~331,055,000 MGY
- Loading Rate ~ 77,500 Lbs. per year of iron, aluminum, manganese (McKee Run)
- Post 2014 chemical shift change in loading rate: 89% net reduction in Fe, Al, Mn – induced by refuse removal
- March 2018 Flow shift reduced average flow rates by ~ 50%


Mine Dump
Mine

Ernest Mine Portal Chemistry

Pre-Reclamation Averages

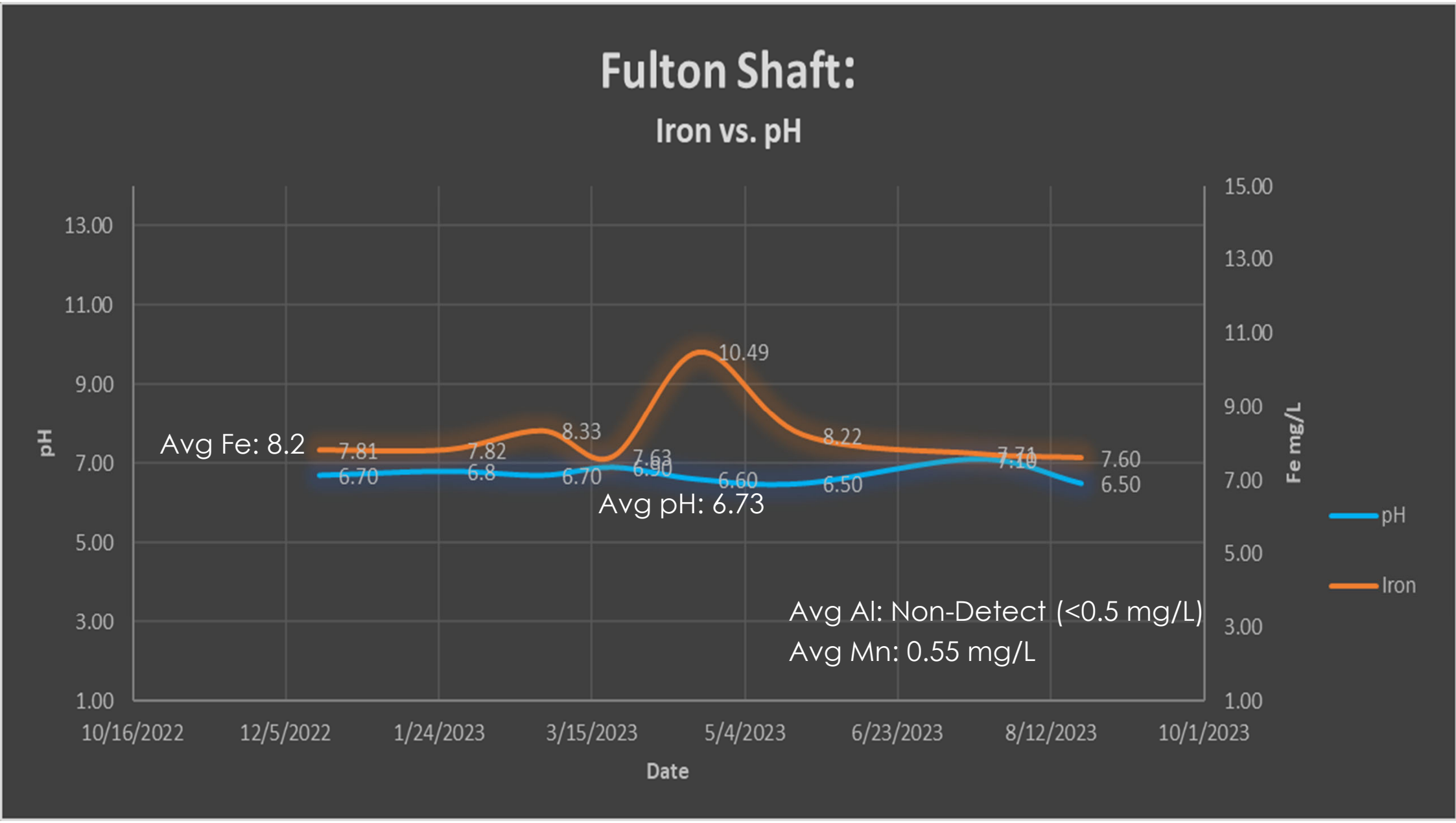
- pH = 4.6
- Iron (mg/L) = 83.6
- Aluminum (mg/L) = 26
- Manganese (mg/L) = 2.7
- Acidity (mg/L) = 306.2
- Sulfate (mg/L) = 751
- Total Suspended Solids (mg/L) = 45


Mine Dump
Mine

The Fulton Shaft

- Upper Freeport Mine complex; Shaft largely collapsed
- Down-dip of and topographically lower than Ernest Mine Portal (~10 feet) distance 1.4 miles (2.25 km)
- Estimated flow ~ 1150 gallons per minute (post 2018)

  = 1.65 MGD ; 604,440,000 MGY
- Loading rate ~ 47,300 lbs per year of iron, aluminum, manganese (Fulton Run to Crooked Creek)
- Post 2018 loading rate: ~ 18% reduction in Fe, Al, Mn induced by flow displacement event
- March 2018 flow shift event increased average flow rate to 215%* (529 gpm to 1143 gpm)


Fulton Shaft:
Iron vs. pH
Avg Fe: 8.2
Avg pH: 6.73
Avg Al: Non-Detect (<0.5 mg/L)
Avg Mn: 0.55 mg/L
pH
Fe mg/L
Date
Iron
13.00
11.00
9.00
7.00
5.00
3.00
1.00
15.00
10/16/2022
12/5/2022
1/24/2023
3/15/2023
5/4/2023
6/23/2023
8/12/2023
10/1/2023
7.81
7.82
8.33
10.49
8.22
7.71
7.60
6.70
6.8
6.70
6.60
6.50
6.50

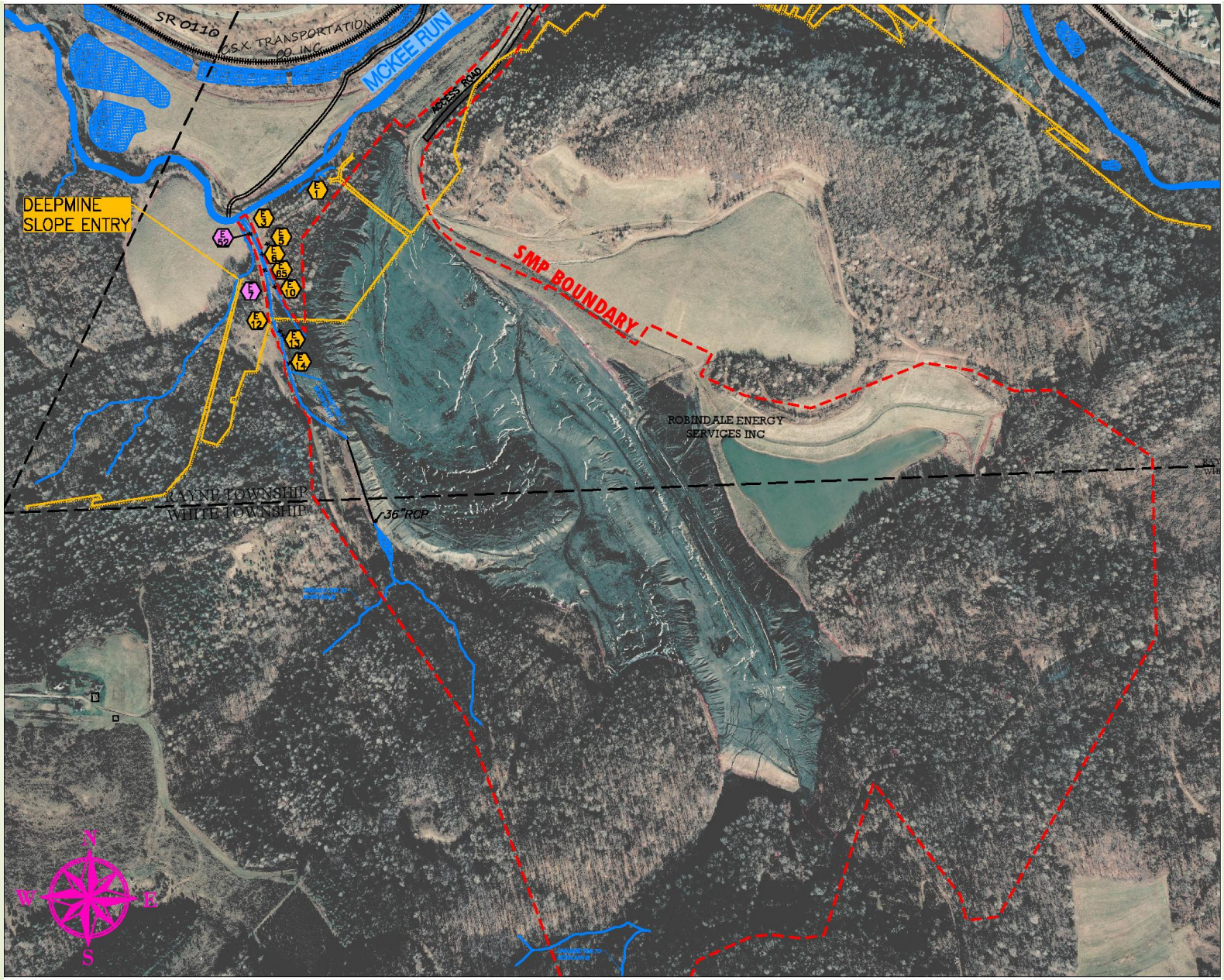
Cumulative Hydro Impacts

- Average Annual Loading
  - **Ernest Portal** Average Annual Loading: **77,412** lbs Fe, Al, Mn
  - **Fulton Shaft** Average Annual Loading: **47,292** lbs Fe, Al, Mn
- Combined total of **124,704** lbs/yr stream loading
- Combined Flow Estimate: **1,767** gallons per minute
  - = **106,020** gallons per hour
  - = **2,544,480** gallons per day
  - = **928,735,000** gallons per year
- Decades of significant receiving stream & habitat degradation (over **12.5 miles [20.1 km]** impacted)

Previous Abatement Attempt -1970's

- "Operation Scarlift" included the design/construction of an AMD treatment plant near the edge of McKee Run to the North of the Ernest Refuse Pile
- Ultimately failed in the relative short-term from sludge disposal recirculation problems controlled by geological structure
- Abandoned by PA DER and eventually repurposed as a brine water treatment plant for Oil &Gas Operations


CROOKED
CREEK
Run
Creek
Hill


SR 0110
C.S.X. TRANSPORTATION CO. INC.
MCKEE RUN
ACCESS ROAD
DEEPMINE
SLOPE ENTRY
SMP BOUNDARY
ROBINDALE ENERGY
SERVICES INC
RAYNE TOWNSHIP
WHITE TOWNSHIP
36"RCP
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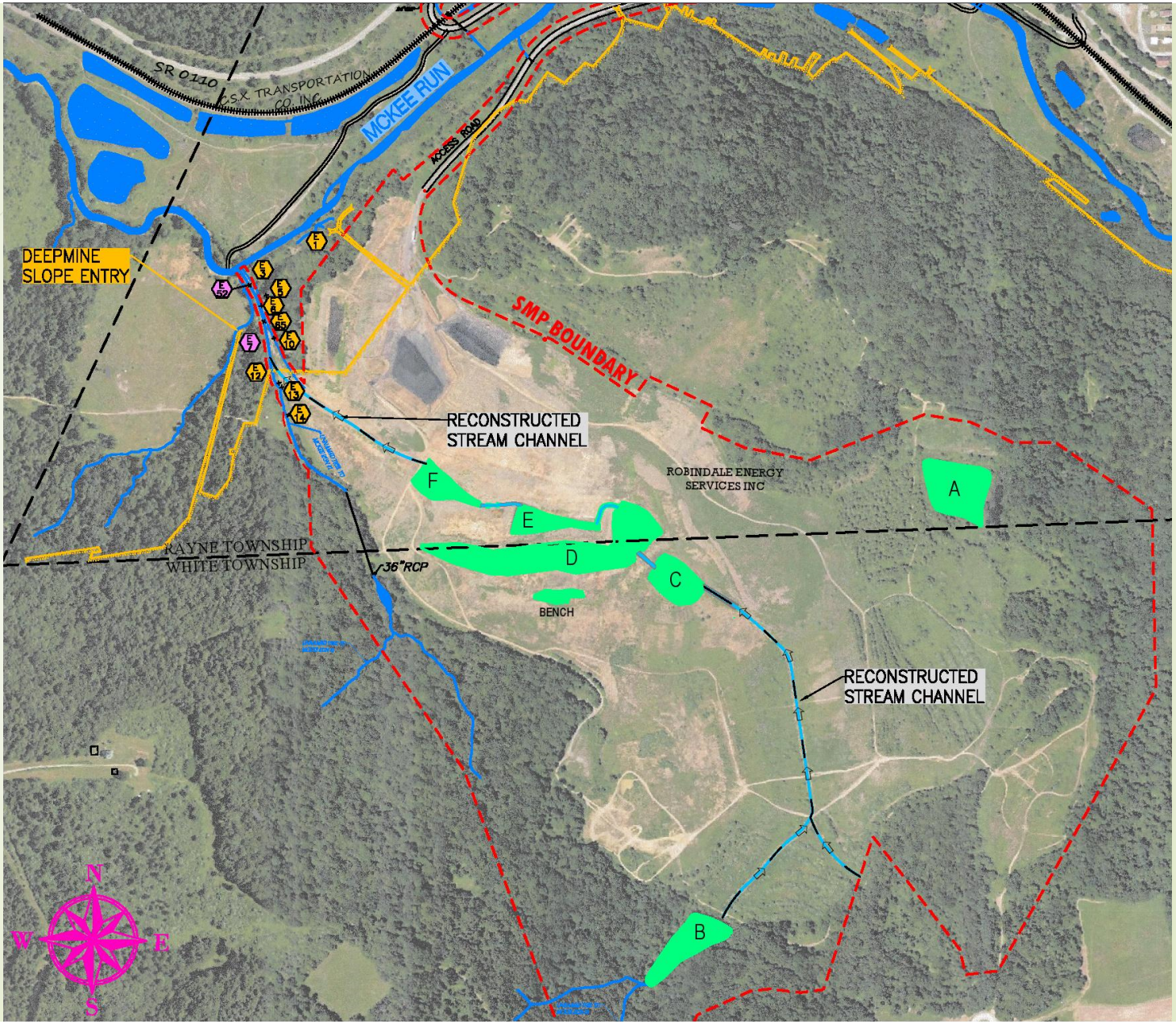
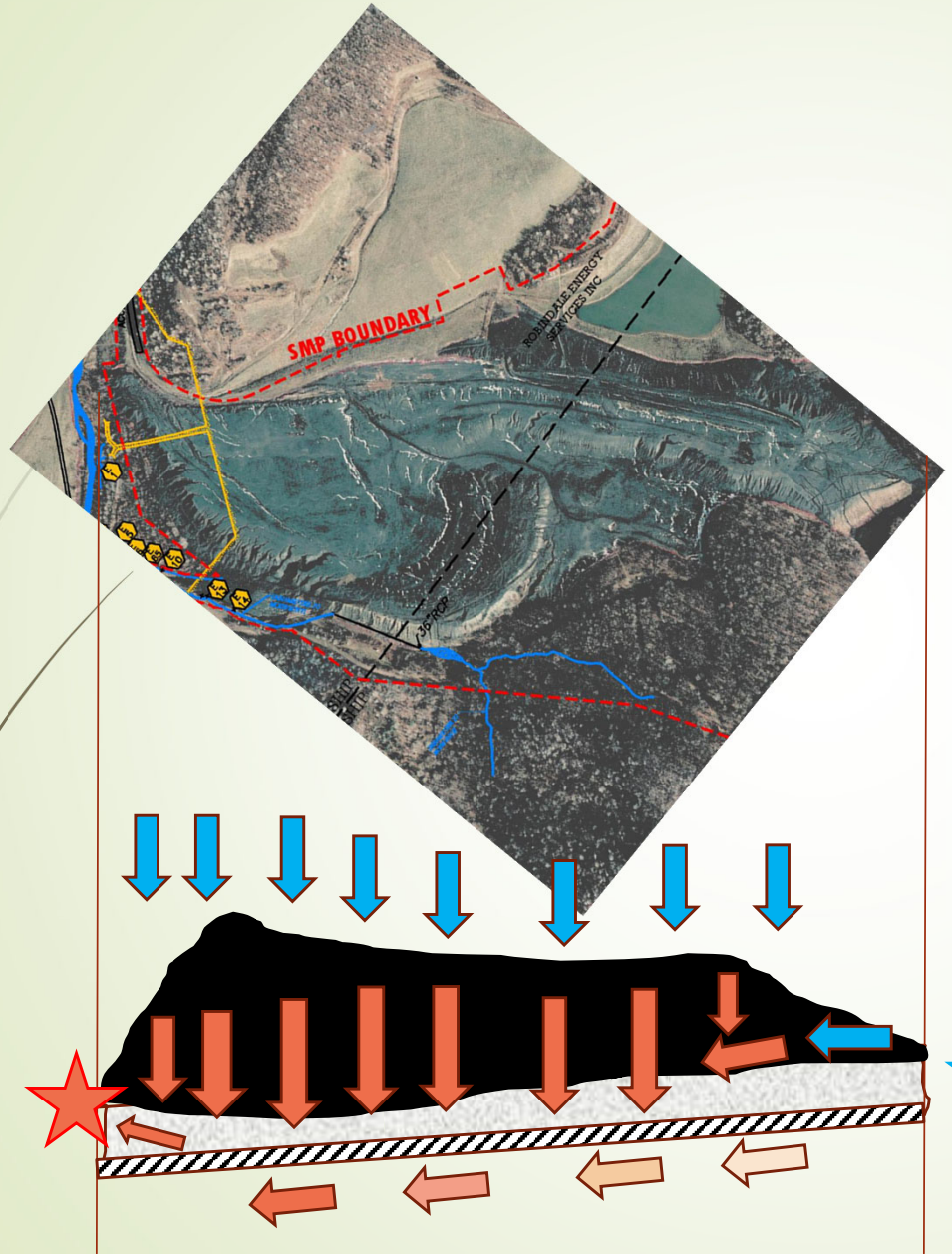
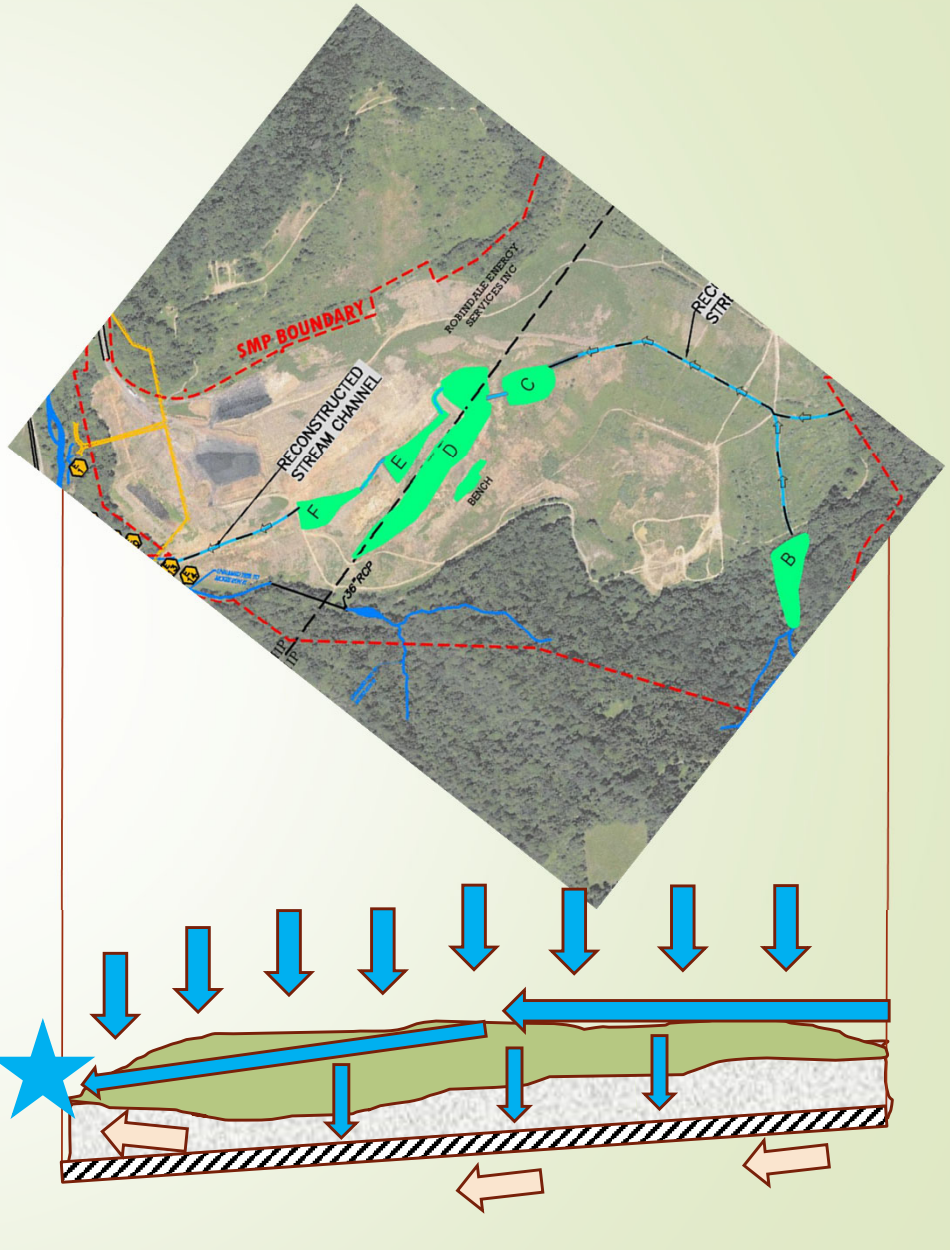

SR 0110
U.S.X. TRANSPORTATION CO INC
MCKEE RUN
ACCESS ROAD
DEEPMINE SLOPE ENTRY
SMP BOUNDARY
RECONSTRUCTED STREAM CHANNEL
ROBINDALE ENERGY SERVICES INC
A
F
E
D
C
B
BENCH
RAYNE TOWNSHIP
WHITE TOWNSHIP
36"RCP
RECONSTRUCTED STREAM CHANNEL
N
W
E
S


SMP BOUNDARY
ROSINDALE ENERGY SERVICES INC
36"RCP


SMP BOUNDARY
ROSINDALE ENERGY SERVICES INC
RECONSTRUCTED STREAM CHANNEL
C
D
E
F
BENCH
B
36"RCP

Refuse Pile Reclamation Results

- Permitted to remove 11.4 MCY of coal refuse material
- 85% volume (9.7 MCY) to be returned as alkaline ash backfill/regrade additive
- Virtual Elimination of Pollution Loading

	ACIDITY lbs/day	IRON lbs/day	MANG. lbs/day	ALUM. lbs/day
1995	13978.63	3435.06	28.76	960.34
03/02/23 - 02/28/24	23.71	0.08	0.37	2.91
% Loading Reduction	99.8%	100.0%	98.7%	99.7%

- Stream Reconstruction increased drainage flow by **577%**

(28.7 gpm to 165.6 gpm) – eliminating site material contact time

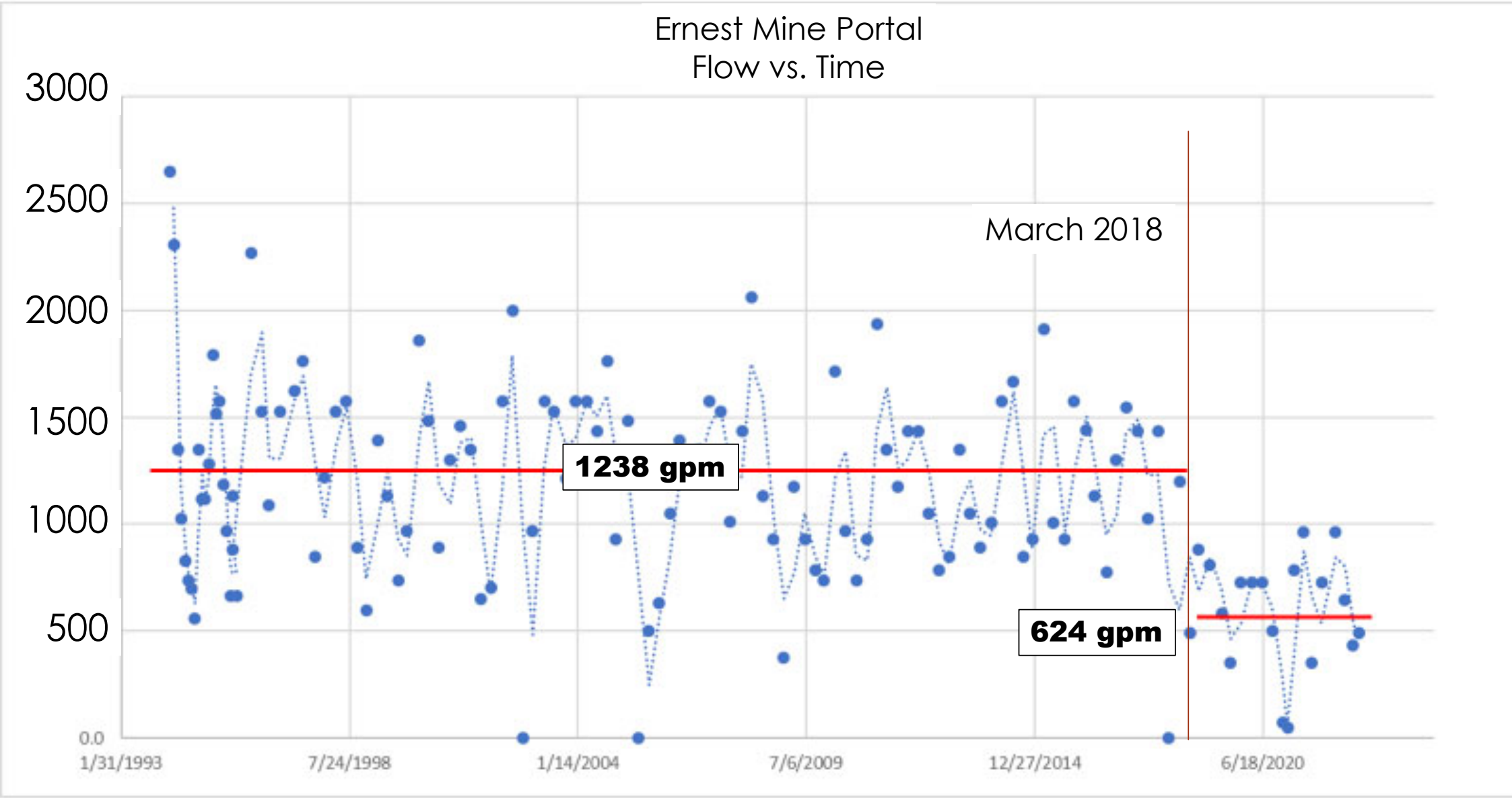
That's a flow increase of 71.9 MGY. ~22% of the pre-rec portal flow

Remaining surface infiltration contacts placed alkaline ash volumes

Open System Variable: Mine Pool Flow Displacement

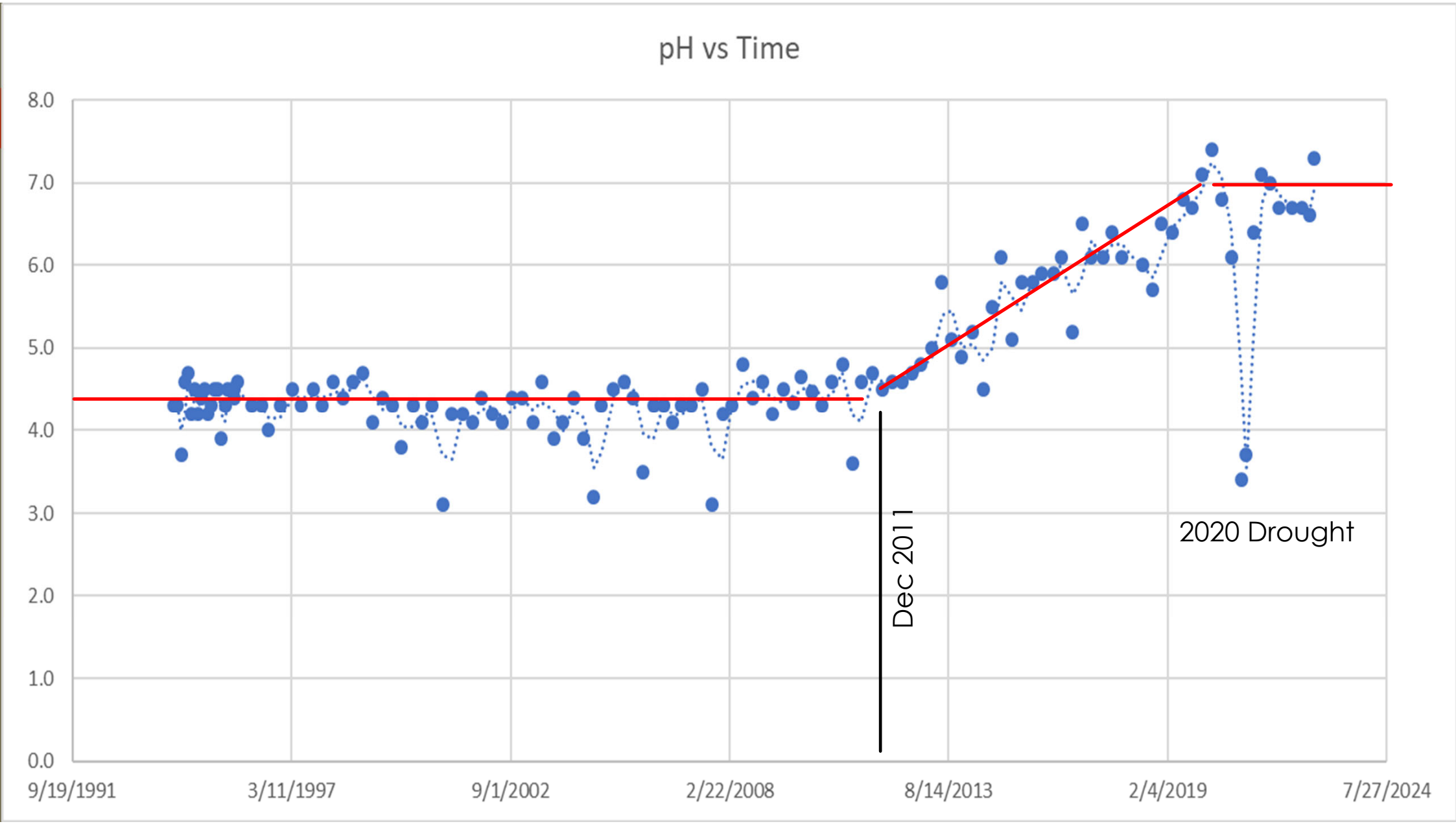
- **March 2018**
  - **Torrential downpour in mid-March overwhelmed the Erosion and Sedimentation structure capacity**
  - **Erosional scouring = sedimentation blockage of the Ernest Portal, backflow into mine workings**

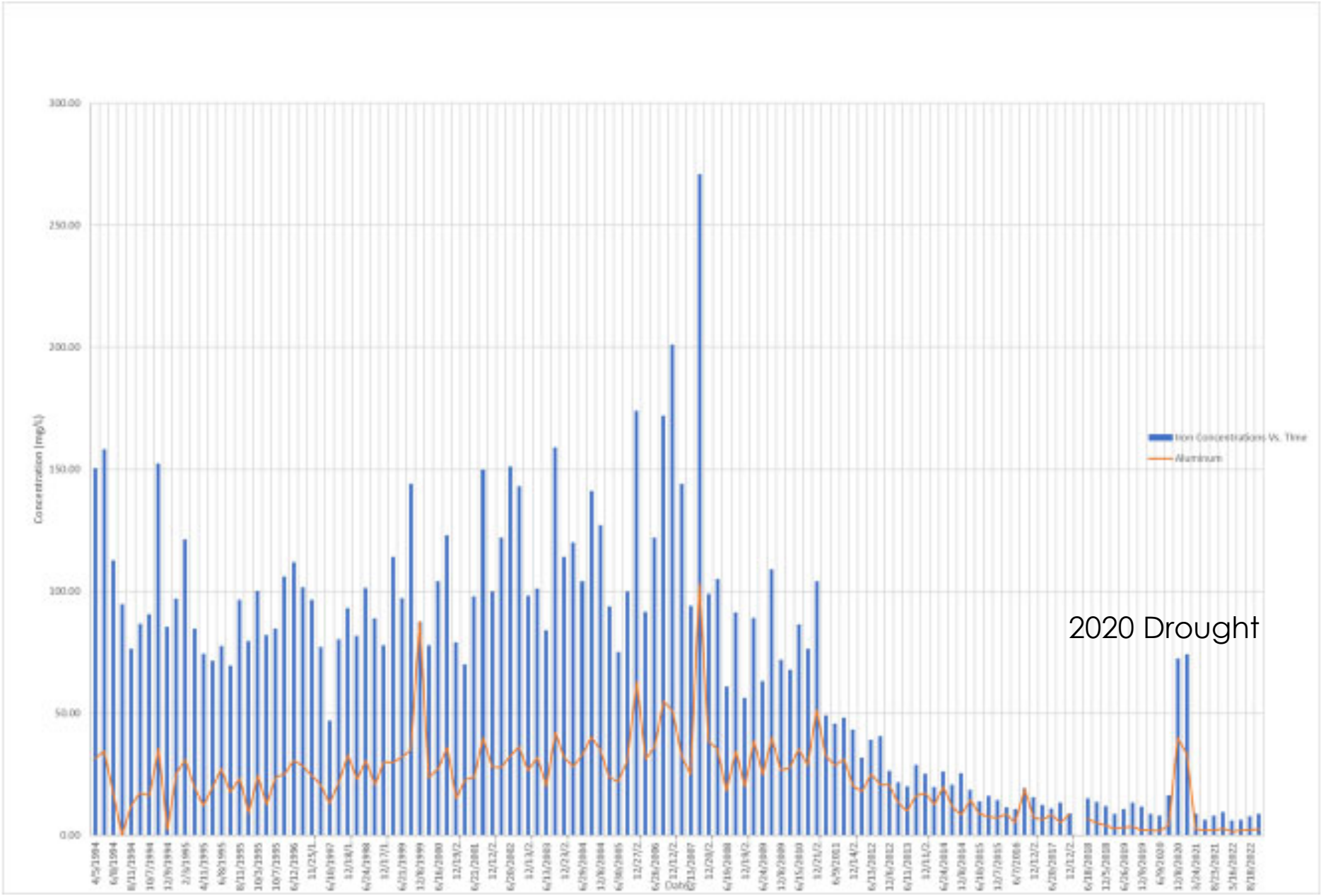
- Ernest Portal flow reduced by **50%**
- Fulton Run flow Increased to **~215%***

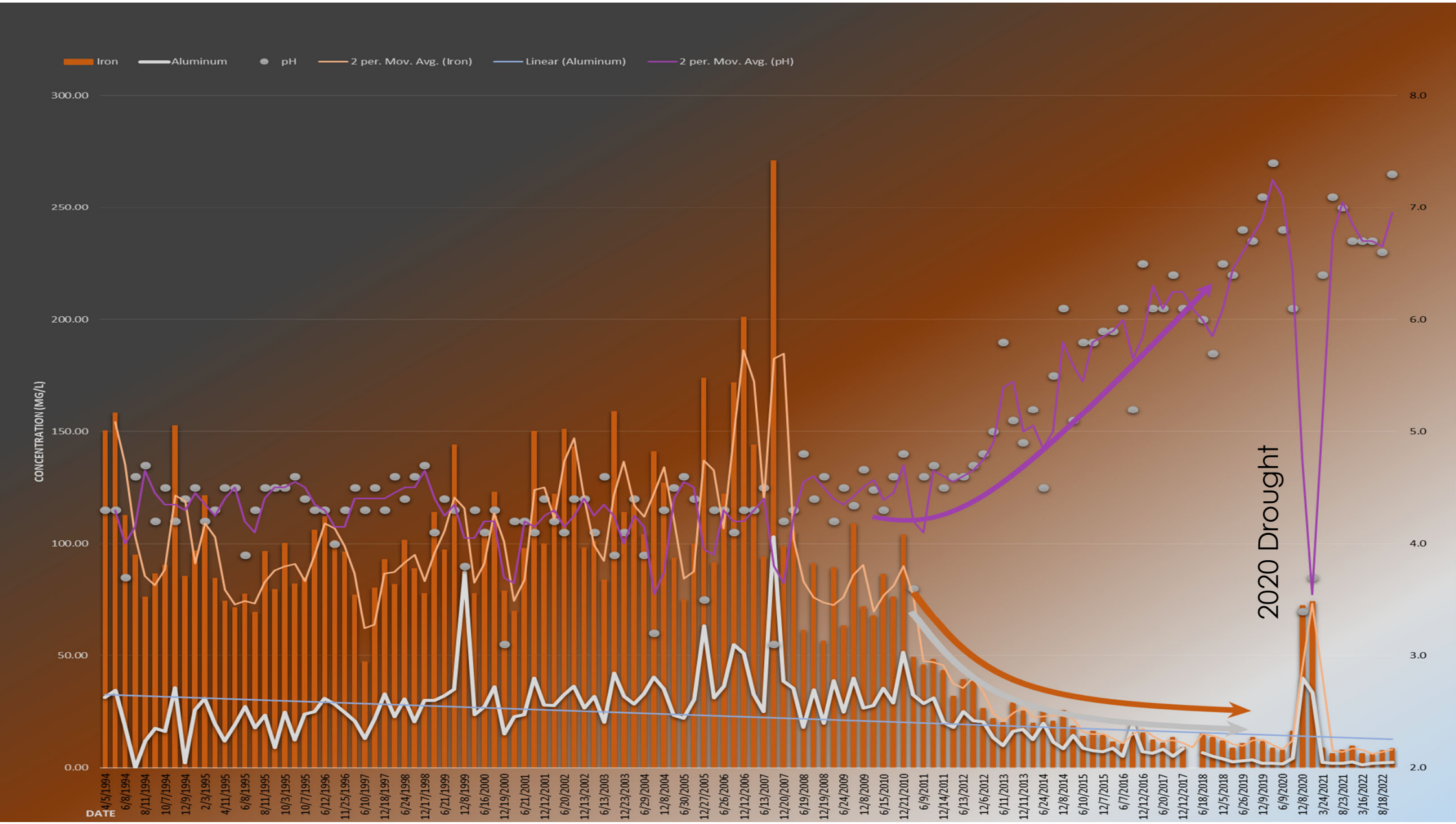

Ernest Mine Portal
Flow vs. Time
3000
2500
2000
1500
1000
500
0.0
March 2018
1238 gpm
624 gpm
1/31/1993
7/24/1998
1/14/2004
7/6/2009
12/27/2014
6/18/2020

Open System Variable: Mine Pool Compositional Change

- Dataset Review
  - Stable mine pool chemistry observed 1970's - 2011
  - By 2014 the baseline shifted out of seasonal extremes
- Significant improvement in pH, metals conc.
- Circa neutral pH values since 2019
- Metals concentrations fell off in 2011-2014
- Directly related to pH increase
- Interpreted as result of overlying refuse removal, ash placement and reconstructed stream channel


pH vs Time
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
9/19/1991
3/11/1997
9/1/2002
2/22/2008
8/14/2013
2/4/2019
7/27/2024
Dec 2011
2020 Drought


300.00
250.00
200.00
150.00
100.00
50.00
0.00
Concentration (mg/L)
Iron Concentrations Vs. Time
Aluminum
2020 Drought


Iron
Aluminum
pH
2 per. Mov. Avg. (Iron)
Linear (Aluminum)
2 per. Mov. Avg. (pH)
300.00
250.00
200.00
150.00
100.00
50.00
0.00
8.0
7.0
6.0
5.0
4.0
3.0
2.0
CONCENTRATION (MG/L)
DATE
2020 Drought
4/5/1994
6/8/1994
8/11/1994
10/7/1994
12/9/1994
2/3/1995
4/11/1995
6/8/1995
8/11/1995
10/3/1995
10/7/1995
6/12/1996
11/25/1996
6/10/1997
12/18/1997
6/24/1998
12/17/1998
6/21/1999
12/8/1999
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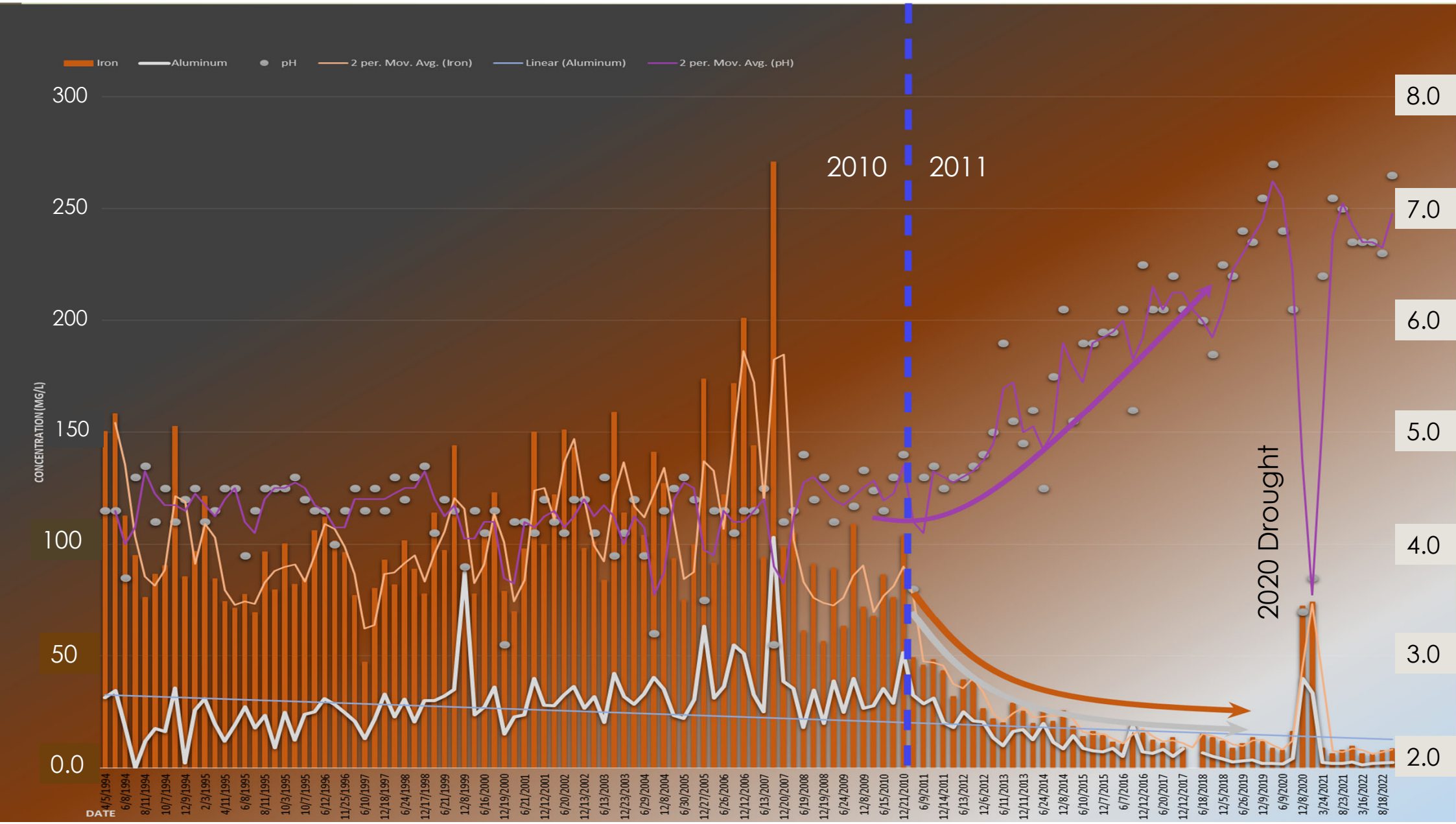
6/24/2014
12/8/2014
6/10/2015
12/7/2015
6/7/2016
12/12/2016
6/20/2017
12/12/2017
6/18/2018
12/5/2018
6/26/2019
12/9/2019
6/9/2020
12/8/2020
3/24/2021
8/23/2021
3/16/2022
8/18/2022

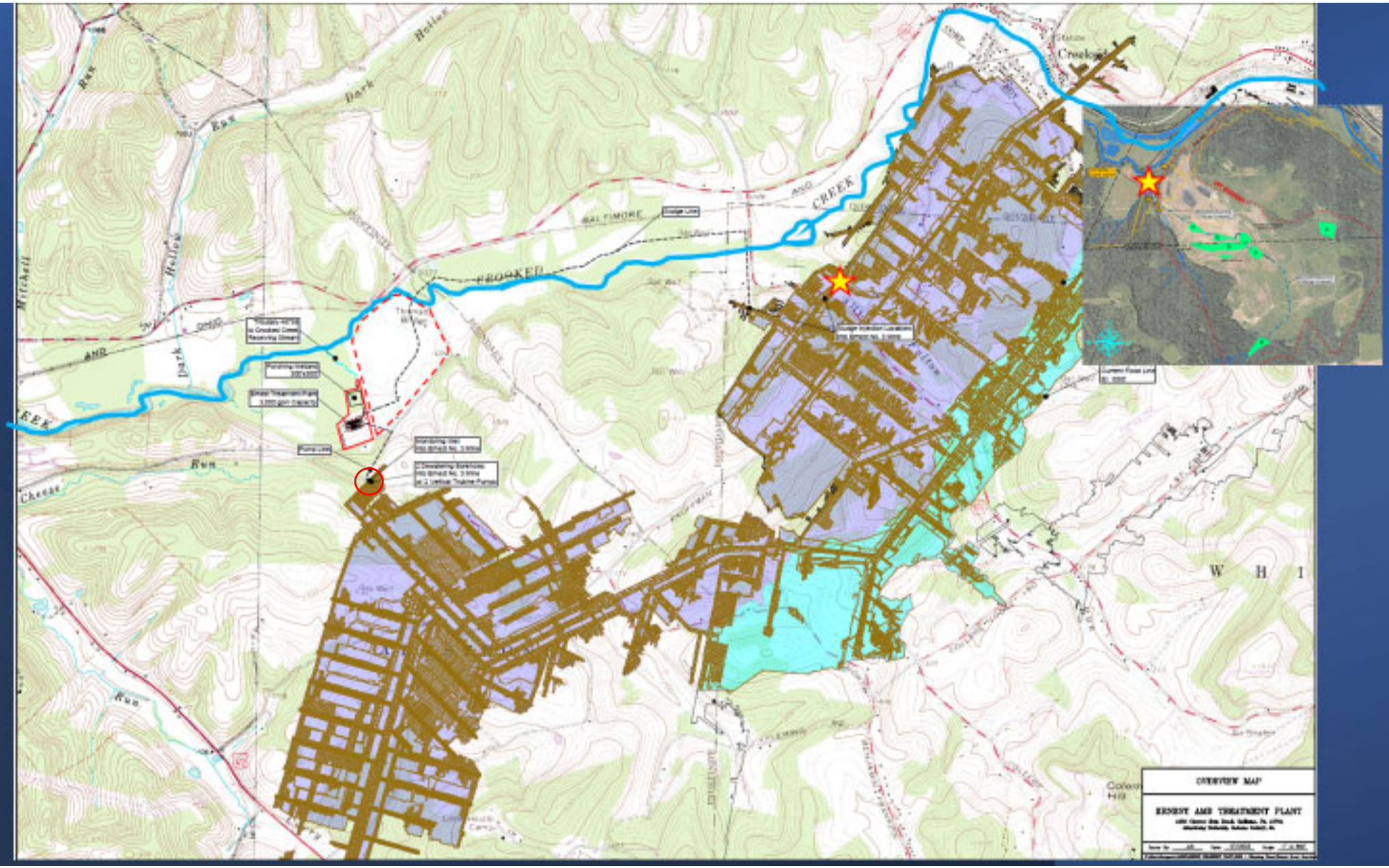

Iron
Aluminum
pH
2 per. Mov. Avg. (Iron)
Linear (Aluminum)
2 per. Mov. Avg. (pH)
300
250
200
150
100
50
0.0
CONCENTRATION (MG/L)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
2010
2011
2020 Drought
DATE

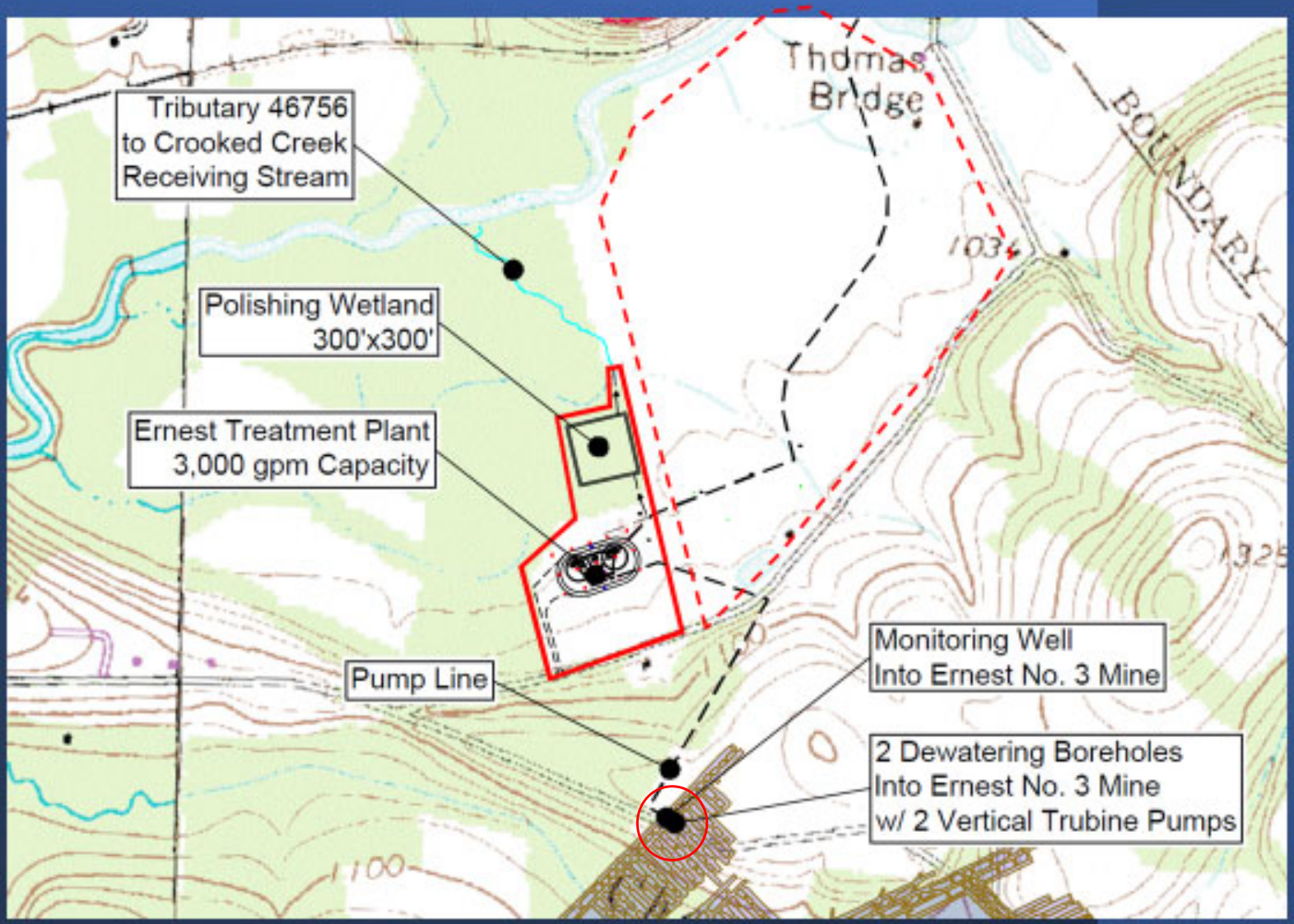
Concurrent AMD Treatment Planning

- Cost Differential Multiplier 2.9X more cost efficient
- 2008 Published Pollution Reduction goals –
  - 30% TSS Watershed Reduction - above & beyond (89% reduced from refuse removal)
  - Remaining 11% will be reduced by 70% (total 97+% loading induced by abandoned mining)

	ACIDITY lbs/day	IRON lbs/day	MANG. lbs/day	ALUM. lbs/day
1995	13978.63	3435.06	28.76	960.34
03/02/23 - 02/28/24	23.71	0.08	0.37	2.91
% Loading Reduction From 1995 to 2024	99.8%	100.0%	98.7%	99.7%

	FLOW gpm	ACIDITY mg/l	IRON mg/l	MANG. mg/l	ALUM. mg/l
1995	28.7	2810.83	282.24	10.22	309.71
03/02/23 - 03/20/24	165.6	12.80	1.61	0.35	0.58
% Concentration Reduction From 1995 to 2024		99.5%	99.4%	96.6%	99.8%


OVERVIEW MAP
REMEDY AMD TREATMENT PLANT


Tributary 46756
to Crooked Creek
Receiving Stream
Polishing Wetland
300'x300'
Ernest Treatment Plant
3,000 gpm Capacity
Pump Line
Monitoring Well
Into Ernest No. 3 Mine
2 Dewatering Boreholes
Into Ernest No. 3 Mine
w/ 2 Vertical Trubine Pumps
Thomas
Bridge
BOUNDARY
1034
1100
1100

Different Watershed

Similar Story

St. Michaels AMD Treatment System
Cambria County PA

- Treats up to 10,000 gpm
- Industry built
- Reduces loadings by 33 to 40 %
- Fe from 150+ mg/L to 1.5
- Jump started full watershed restoration
- End-of- mining strategy

Opportunity

Watershed Partners Get Their Wish

- BIL/IIJA
- $244M/yr
- Subrecipient Program
- Think /Act BIG
- Watershed scale restoration
- Partnering opportunities

10 Miles Downstream

Photo courtesy of Rich Beam, OSMRE

Recap:
Large-scale, Long-term Success!

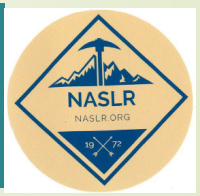
- Reclamation involved both Active Mining & Abandoned Reclamation Program entities
- Conducted over time to mutual, cumulative benefit
- Refuse Removal
  - Eliminated Surface Loading
  - Substantially Improved Mine Pool Chemistry
- Proposed Treatment System Project
  - Set to Eliminate Remaining Pollution Loading

Grateful Acknowledgement

"Cast A Wide Net and Get Good Help"

Earth Wise Consulting, LLC

https://cleanstreams.net/



“Many Thanks.”

QUESTION & ANSWER SESSION

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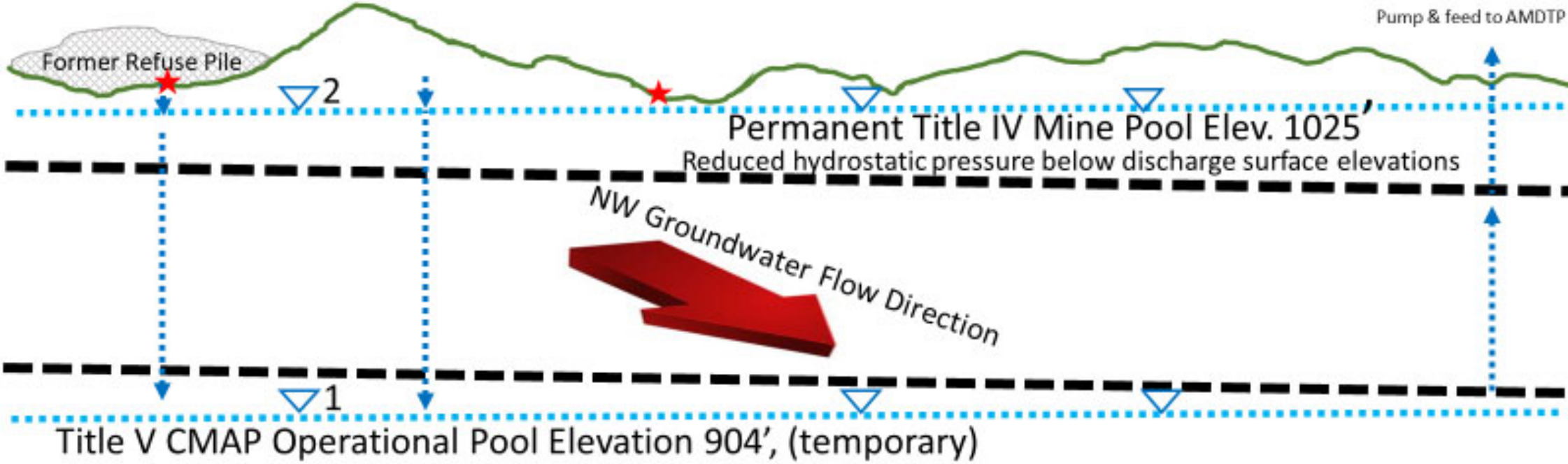
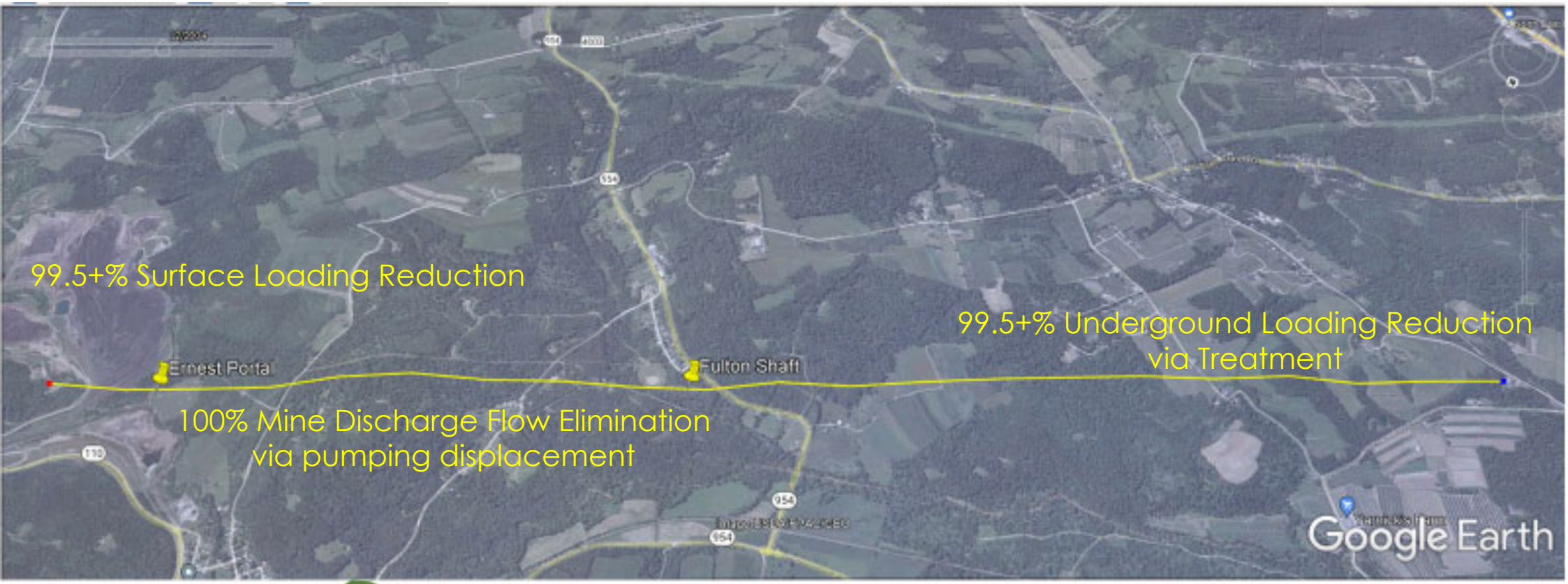
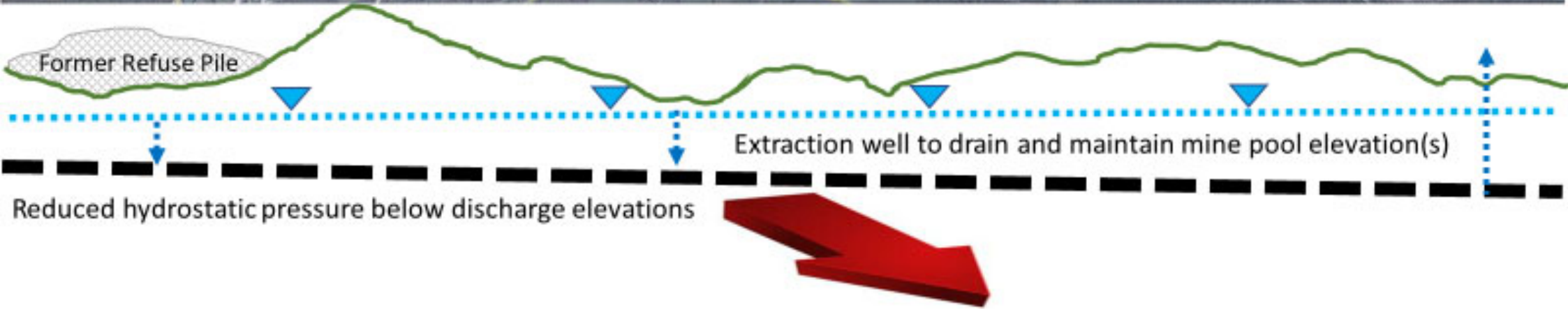
Todd Coleman, P.E.
Principal, Minetech Engineers
Branden Diehl
Principal, Earth Wise Consulting, LLC


Former Refuse Pile
Ernest Portal
Fulton Shaft
Extraction well to control mine pool elevation(s)
"T4" AMDTP site


Pump & feed to AMDTP
Former Refuse Pile
2
Permanent Title IV Mine Pool Elev. 1025'
Reduced hydrostatic pressure below discharge surface elevations
NW Groundwater Flow Direction
1
Title V CMAP Operational Pool Elevation 904', (temporary)


99.5+% Surface Loading Reduction
99.5+% Underground Loading Reduction
via Treatment
Ernest Porta
Fulton Shaft
100% Mine Discharge Flow Elimination
via pumping displacement
Google Earth


Former Refuse Pile
Extraction well to drain and maintain mine pool elevation(s)
Reduced hydrostatic pressure below discharge elevations