SOVEREIGN CONSULTING INC.
AN ENVIRONMENTAL SERVICES FIRM

DIAMOND ENGINEERING ASSOCIATES

Case Study: 20 Years of ARD Mitigation after a Bactericide Application

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Geophysical Mapping and Subsurface Injection for Treatment of Post-Reclamation Acid Drainage

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Paper presented at the 1997 National Meeting of the American Society for Surface Mining and Reclamation (ASSMR)

Austin, Texas, May 10-15, 1997

See: www.asmr.us

Outline

- Introduction to the ARD Tetrahedron/First Principles of ARD Suppression
- 1995 Bactericide Injection Event Summary
- 19 Years of Data
- Some Ideas of Why the Effects Linger

A Medical Analogue

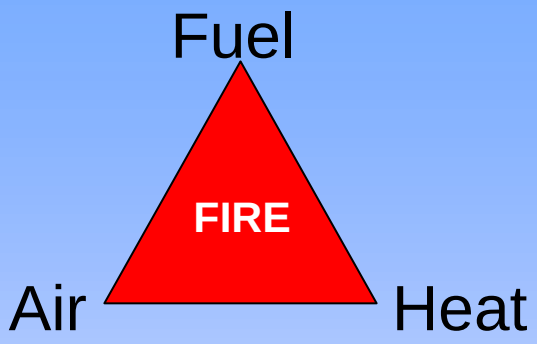
ARD is a global **bacterial infection**.

There are plenty of geo-antibiotics available but the current situation might be a lack of education. We've know about this for over 25 years.

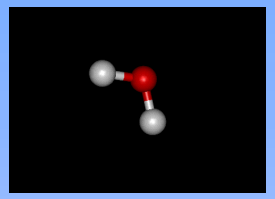
What's needed is a mining-analogue to an I-V drip of tetracycline and/or oral antibiotics.

And then there's the question: Do we need to **Vaccinate** or **Medicate** and what do these concepts mean?

Acid Rock Drainage Tetrahedron

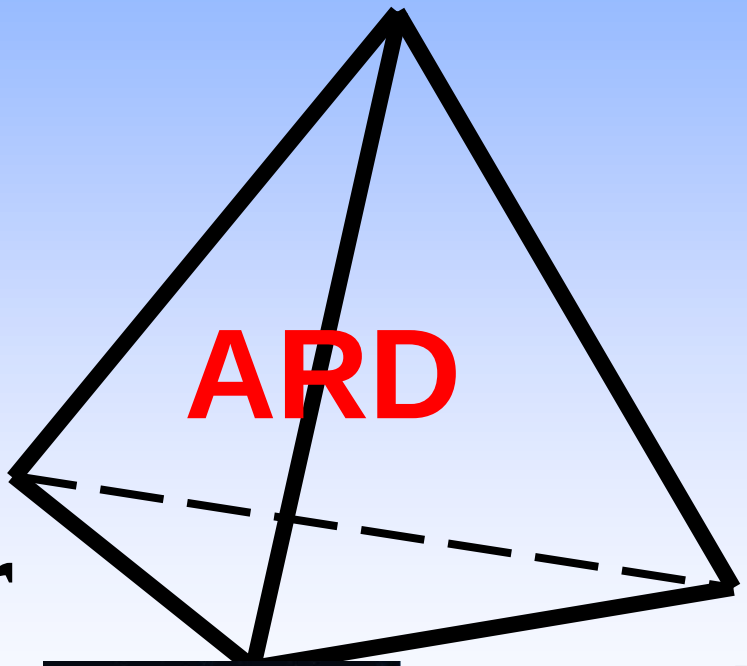


Water



Oxidizer

(Air, Fe^{+3})



Bacteria

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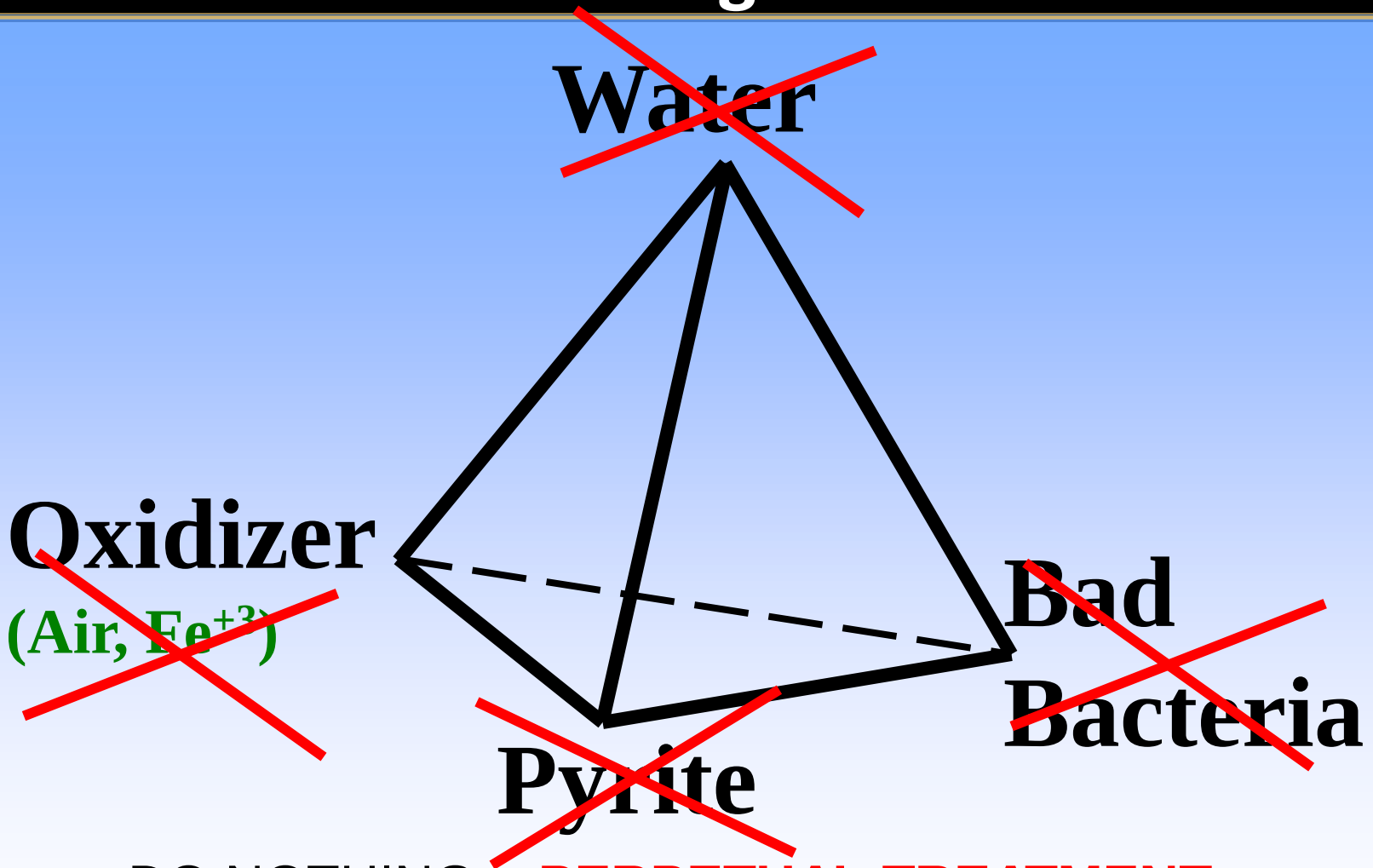
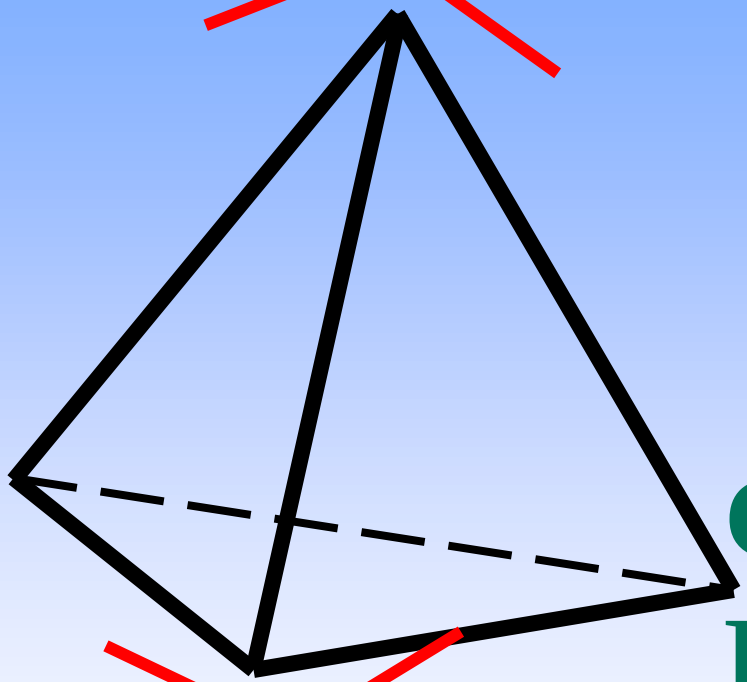


DO NOTHING = **PERPETUAL TREATMENT**

DO SOMETHING (anything) = **PATHWAY TO WALK-AWAY**

Acid Rock Drainage Tetrahedron



"PROBIOTIC"
PATHWAY TO WALK-AWAY

ARD Prevention Concept is Not New

"Control of acid generation for prolonged periods greatly enhances reclamation efforts and can reduce reclamation costs by reducing the amount of topsoil needed to establish vegetation. Three natural processes resulting from strong vegetative cover for three years or more can break the acid production cycle. These processes are:

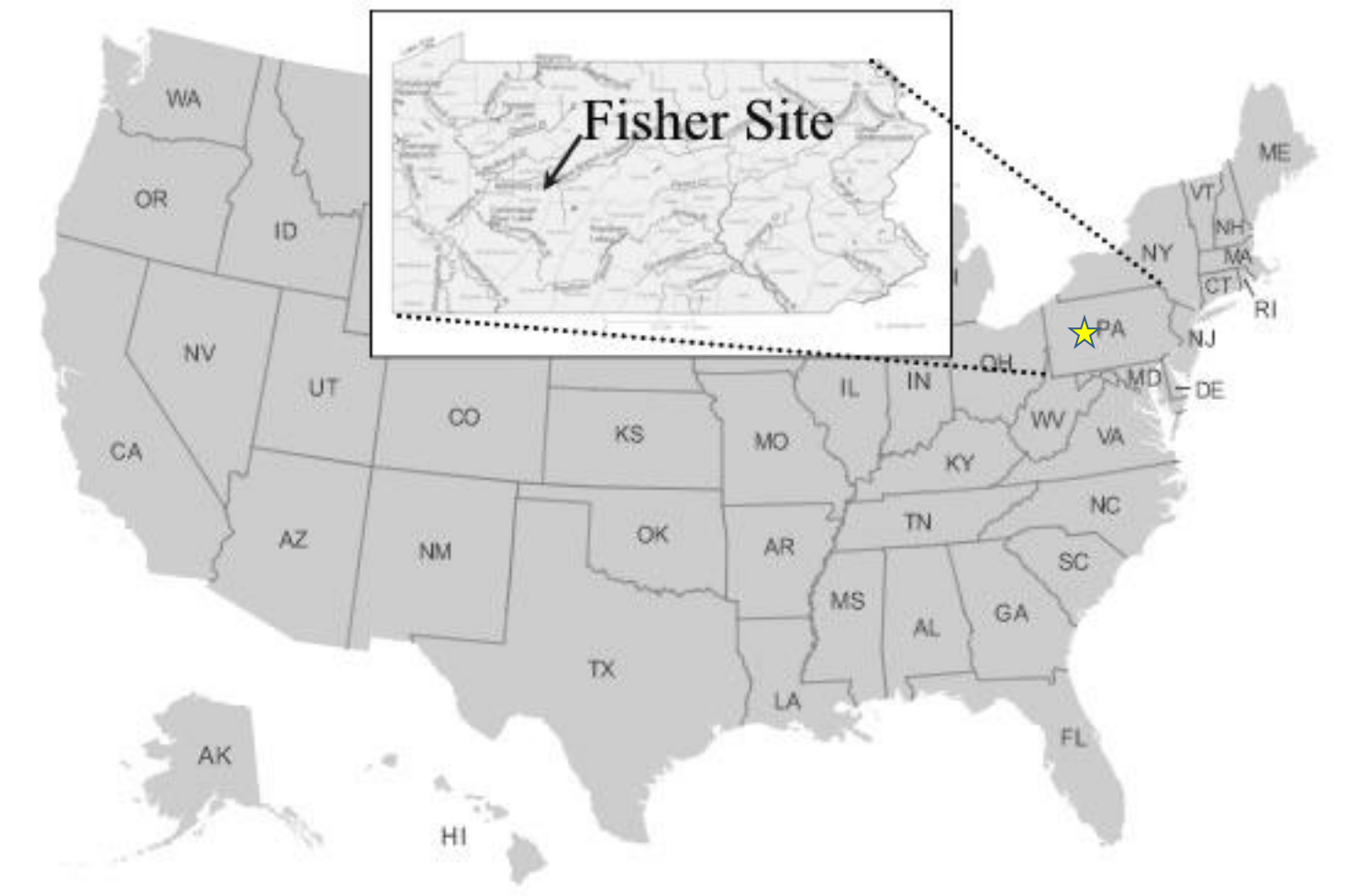
1. A healthy root system that competes for both oxygen and moisture with acid-producing bacteria;

2. Populations of beneficial heterotrophic soil bacteria and fungi that are reestablished, resulting in the formation of organic acids that are inhibitory to *T. ferrooxidans* (Tuttle et al. 1977); and

3. The action of plant root respiration and heterotrophic bacteria increase CO_2 levels in the spoil, resulting in an unfavorable microenvironment for growth of *T. ferrooxidans."*

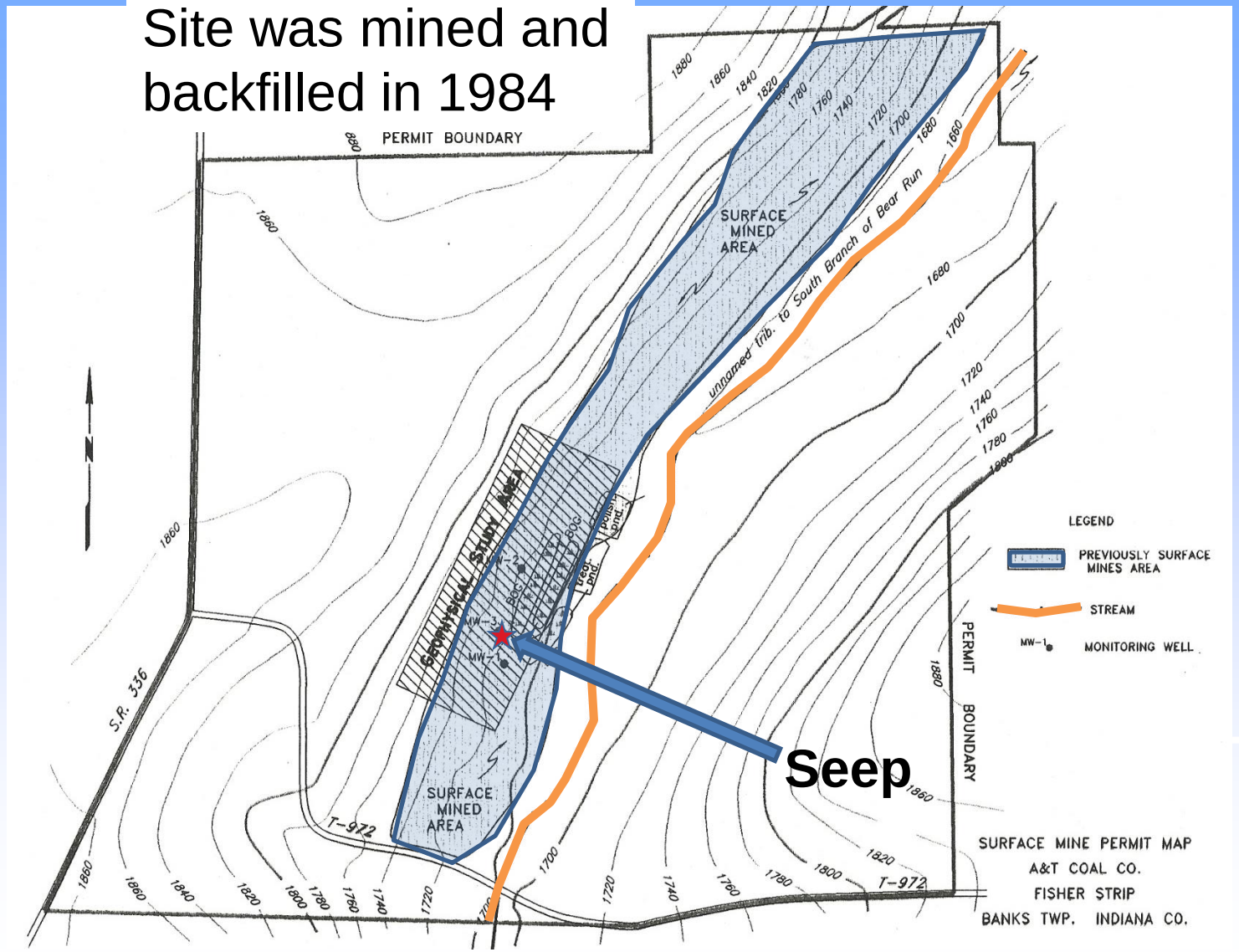
Sobek, A. A., D.A. Benedetti, & V. Rastogi. 1990.

Fisher Site Location

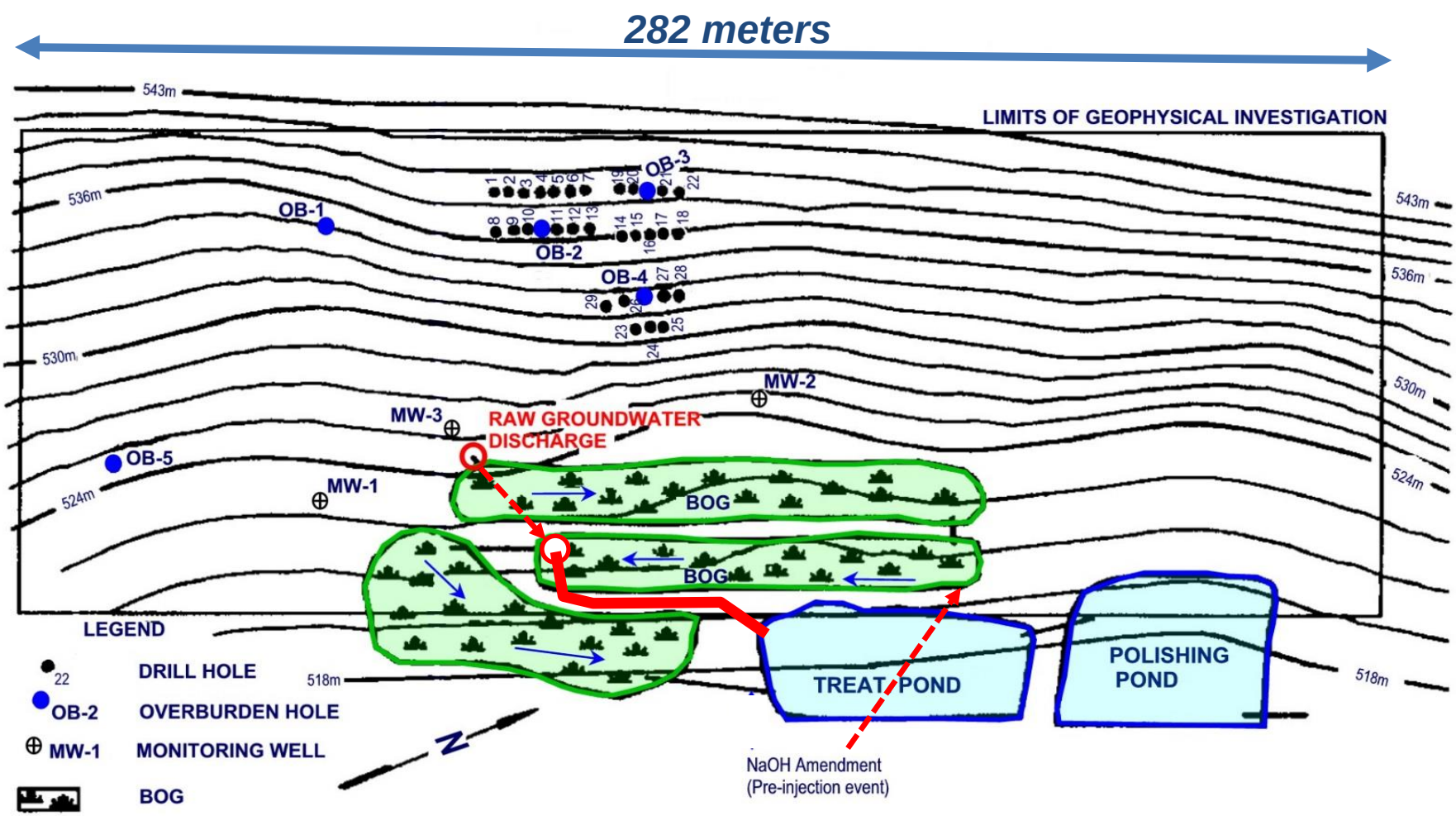


Fisher Site Location

Site was mined and backfilled in 1984

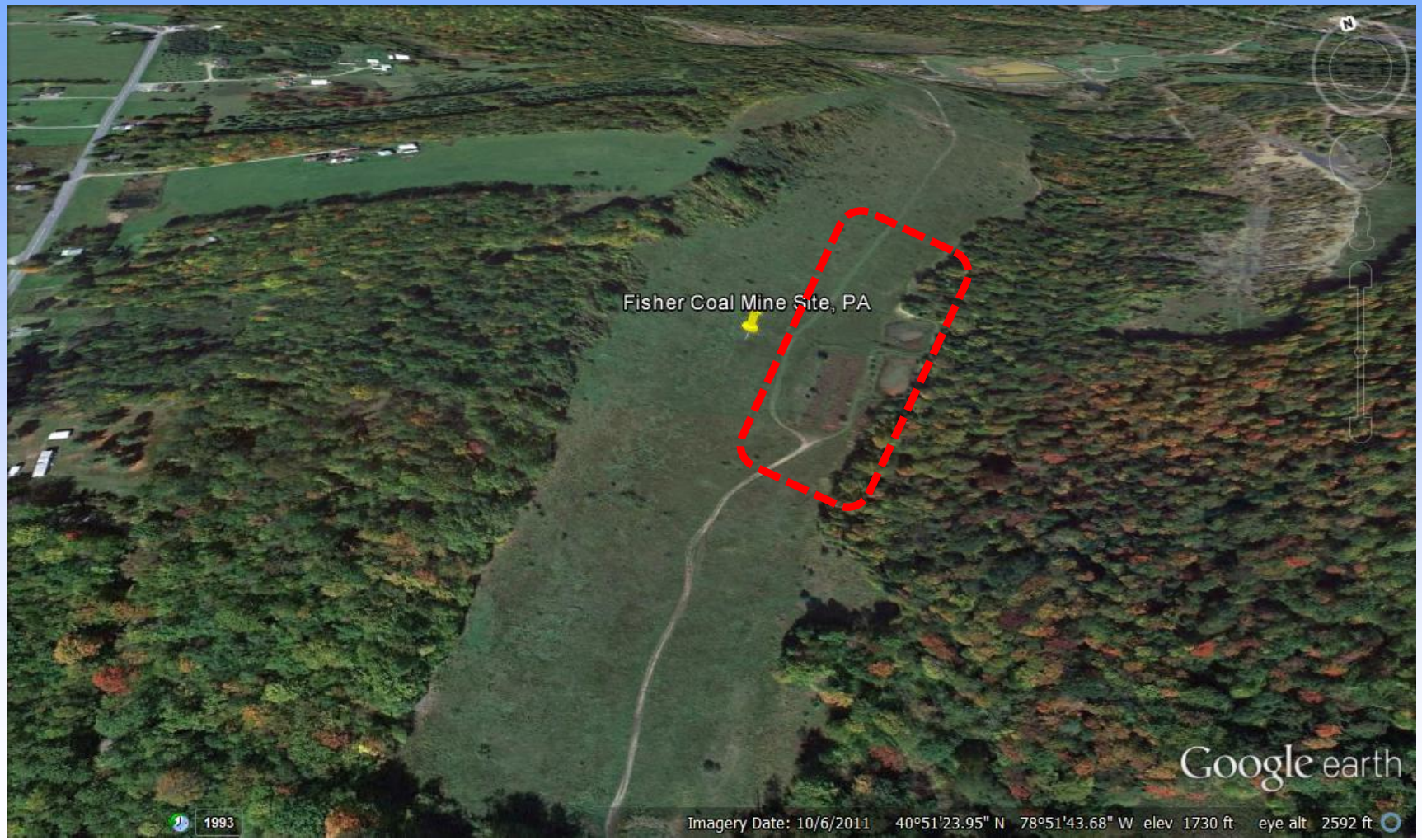


Fisher Site Location



Site Imagery (2011)

Fisher Coal Mine, PA – 65 NW of Pittsburgh, PA

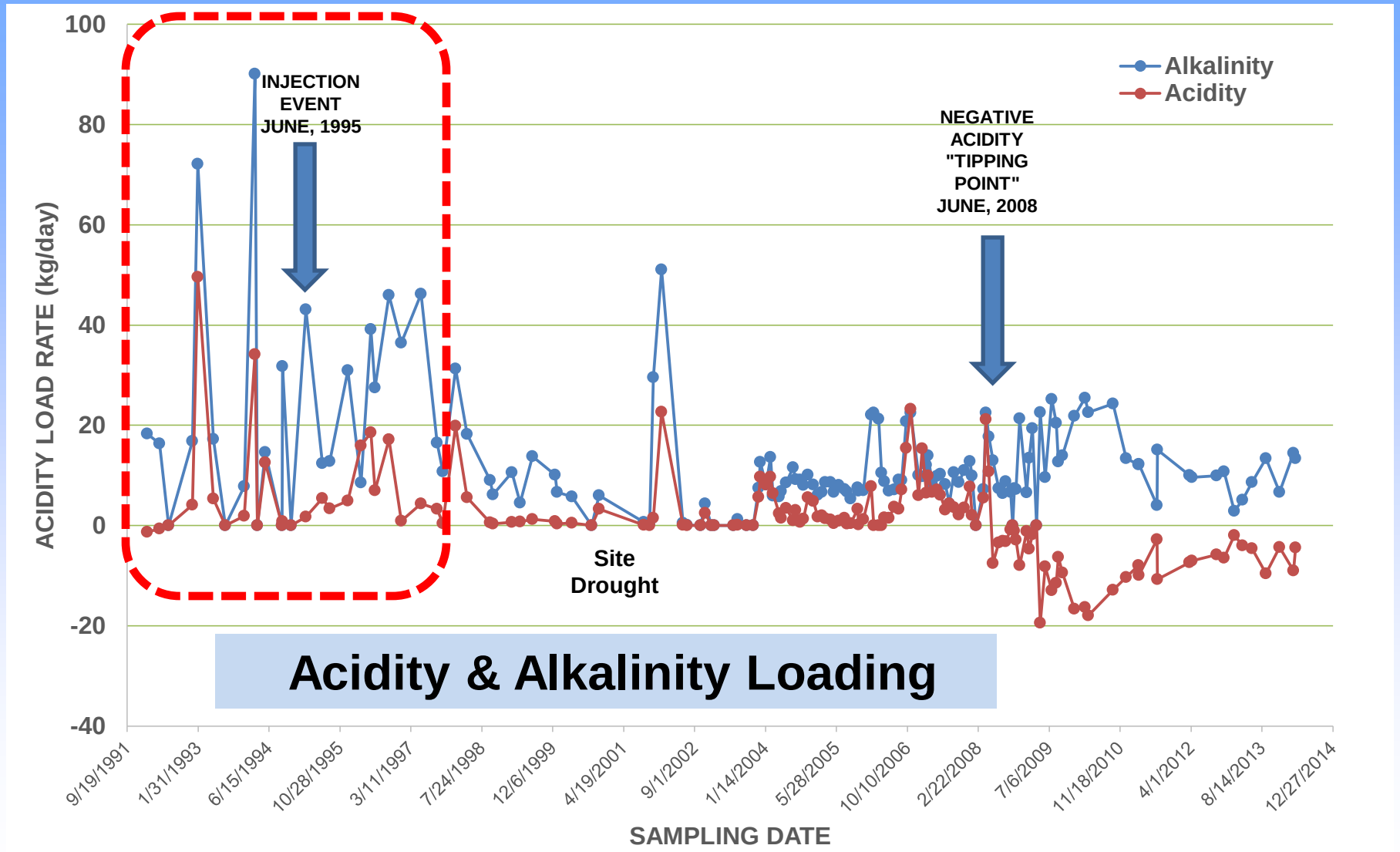


Site Imagery (2003 & 2011)

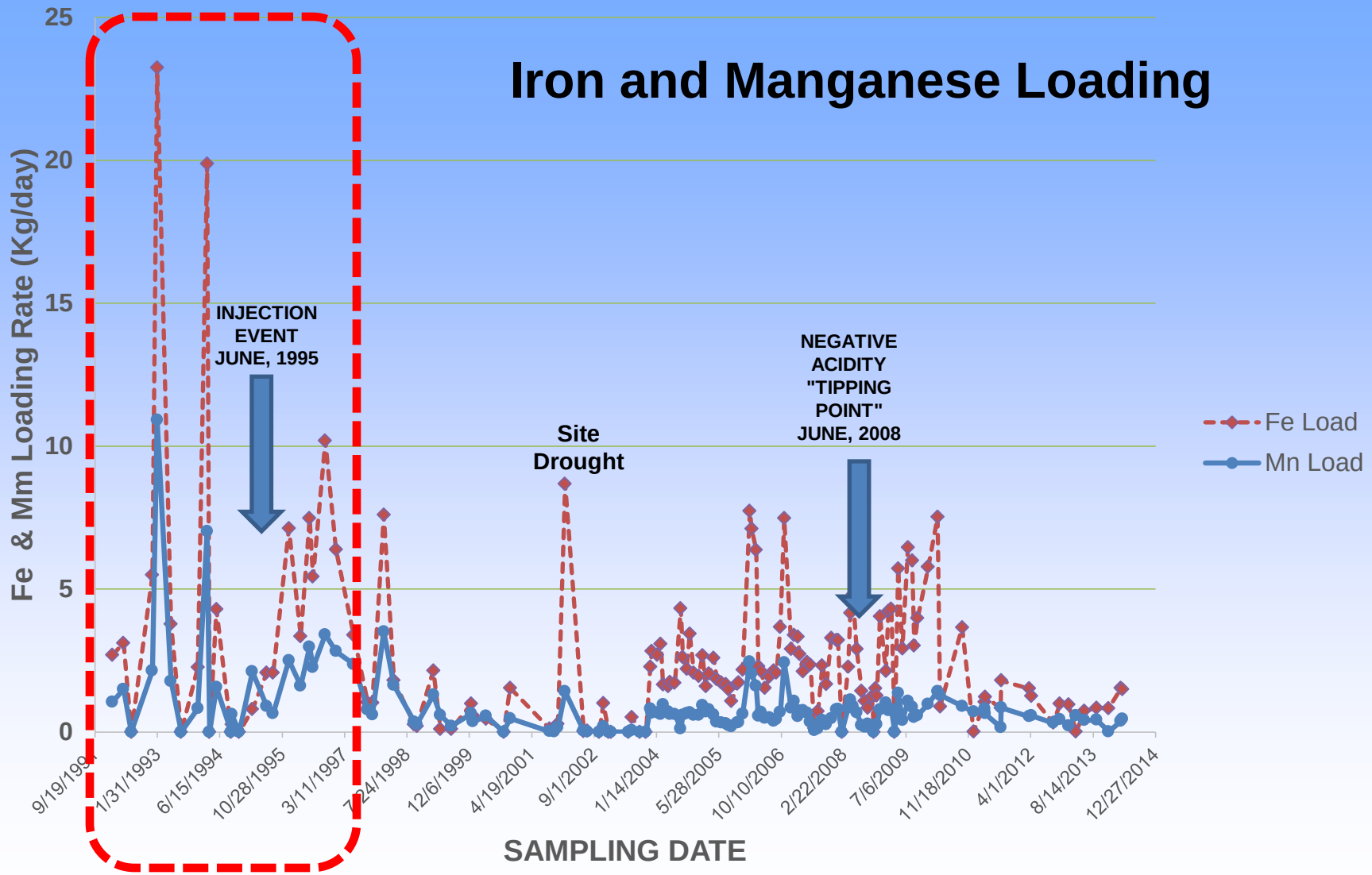
1995 Injection Event

- Geophysics targets three ARD–generating zones; seep pH was 5.5; iron 17 mg/L and higher
- Passive treatment alone could not meet discharge limits
- Multiple injection boreholes on a tight spacing
- Injection of 20% NaOH solution simultaneously into 12 shallow (3 m deep) boreholes with packers
- Injection of 2% sodium lauryl sulfate bactericide
- Cost of reagents: $8,400
- Seepage continues to be net alkaline 19 years later, bond release is imminent

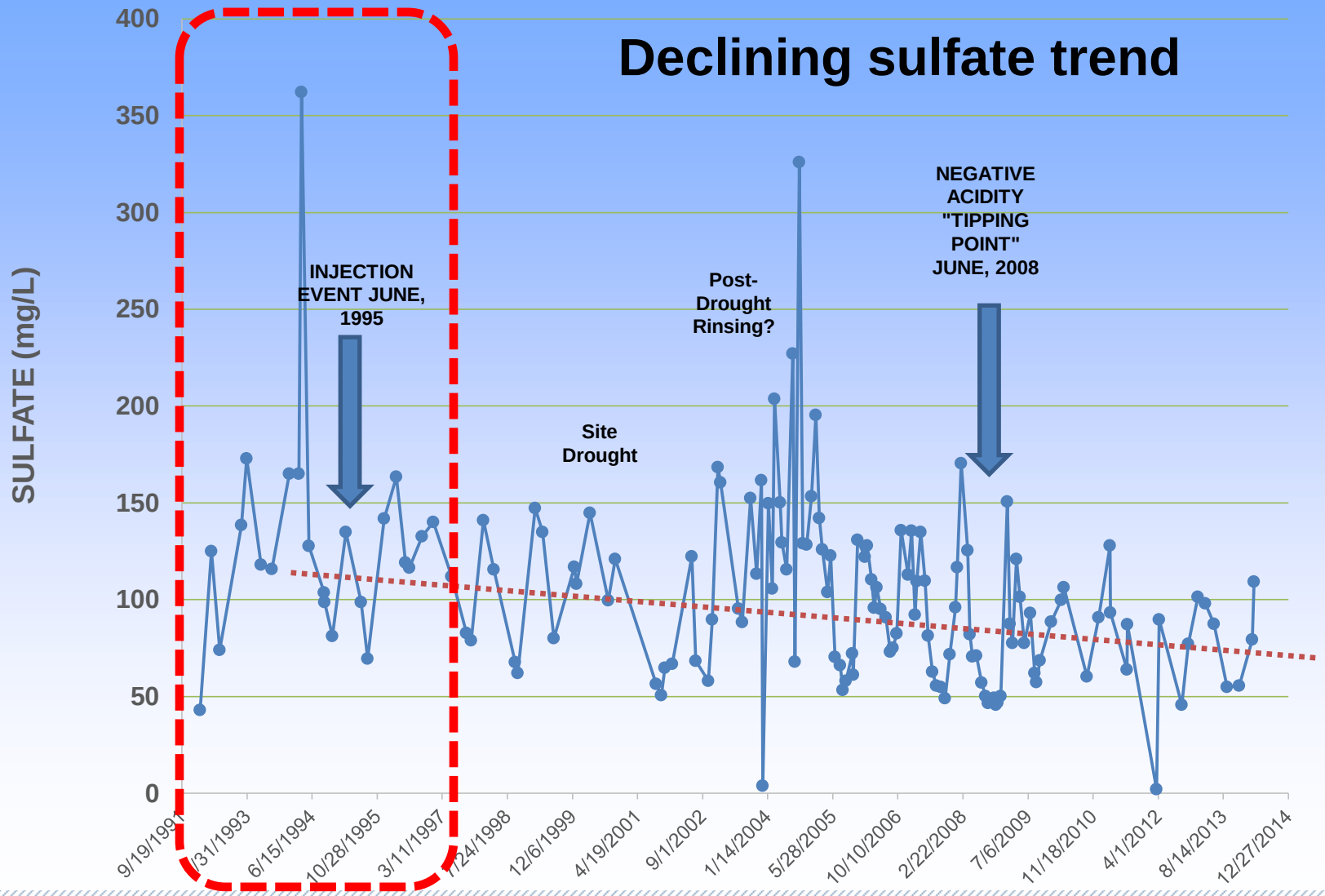
Performance Data (1 of 3)



Performance Data (2 of 3)



Performance Data (3 of 3)



Why Does It Still Work – 20 Years Later?

1) The initial "flooding" injection of caustic neutralized the residual acidity in the mine waste so that the subsequent application of bactericide was "protected" from chemical attack;
2) The bactericide solution (2% sodium lauryl sulfate) would have followed the preferential pathways established during the stage 1 injection of caustic to inhibit the activity of the acidophilic community; and
3) The well-established revegetated surface of the site provided a steady supply of bacteria inhibiting organic acids (and continues to do so) which appears to have suppressed the "reinfection" of the site that would have otherwise occurred.

Theory: if organic matter had been added to the backfill during mining, steps 1 & 2 would have been unnecessary.

19 Years of Hindsight

20 Years of Hindsight

1) Geophysical investigation was very successful in identifying ARD “hot spots”.
2) Agronomic amendments could have helped to mature the site vegetation faster and the groundwater improvements might have been observed sooner.
3) The initial conditions were not the worst ARD chemistry compared to some other sites, but the improvements appear to be sustainable.

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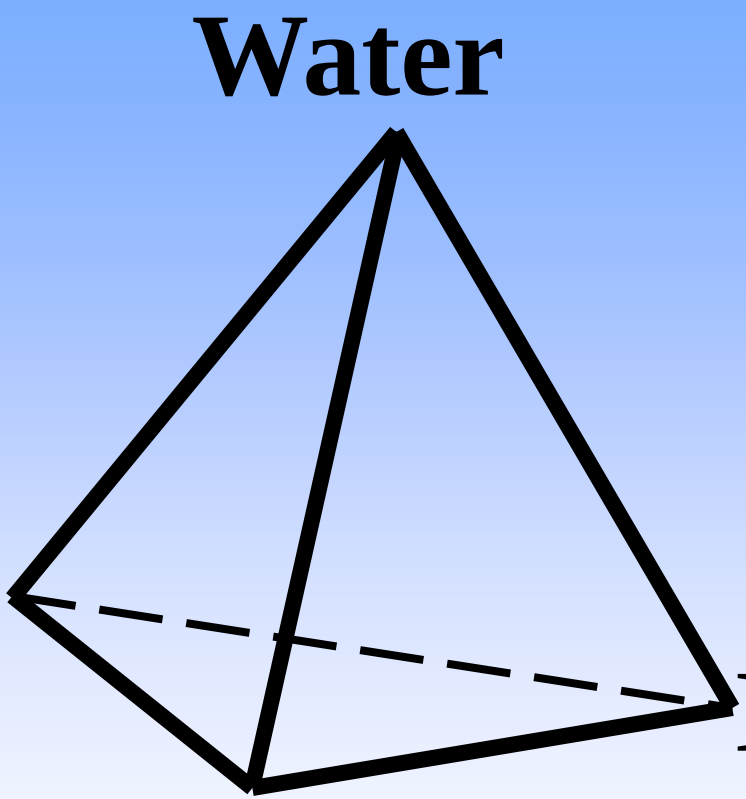

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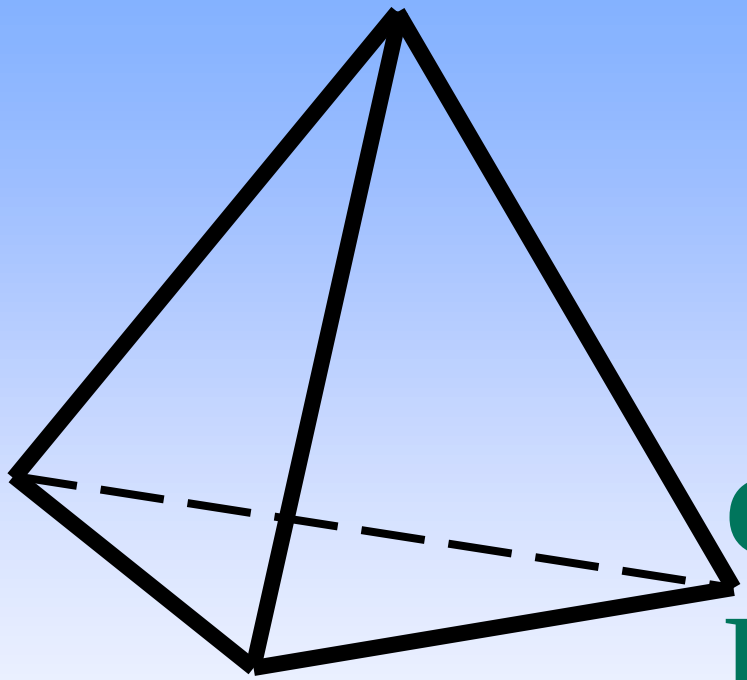

"PROBIOTIC"
PATHWAY TO WALK-AWAY

Thank You

DO SOMETHING (anything) as a first step on the

PATHWAY TO WALK-AWAY

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