What Decades of Irregular Monitoring Can Show for Two Mines Sites: Iron Mountain, CA and Questa, NM

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Charles Alpers, the Questa Gang, NMED, Molycorp, and RGC

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Iron Mountain Mining History

- **Largest Cu mine in State of California; also produced Au, Ag, Zn, and S (for the production of H_2SO_4 from FeS_2)**
- **In production from 1880's to 1962**
- **Brick Flat Open Pit and several underground mines**
- **Operated by Mountain Copper Co. (London) for 70 years**

Environmental History

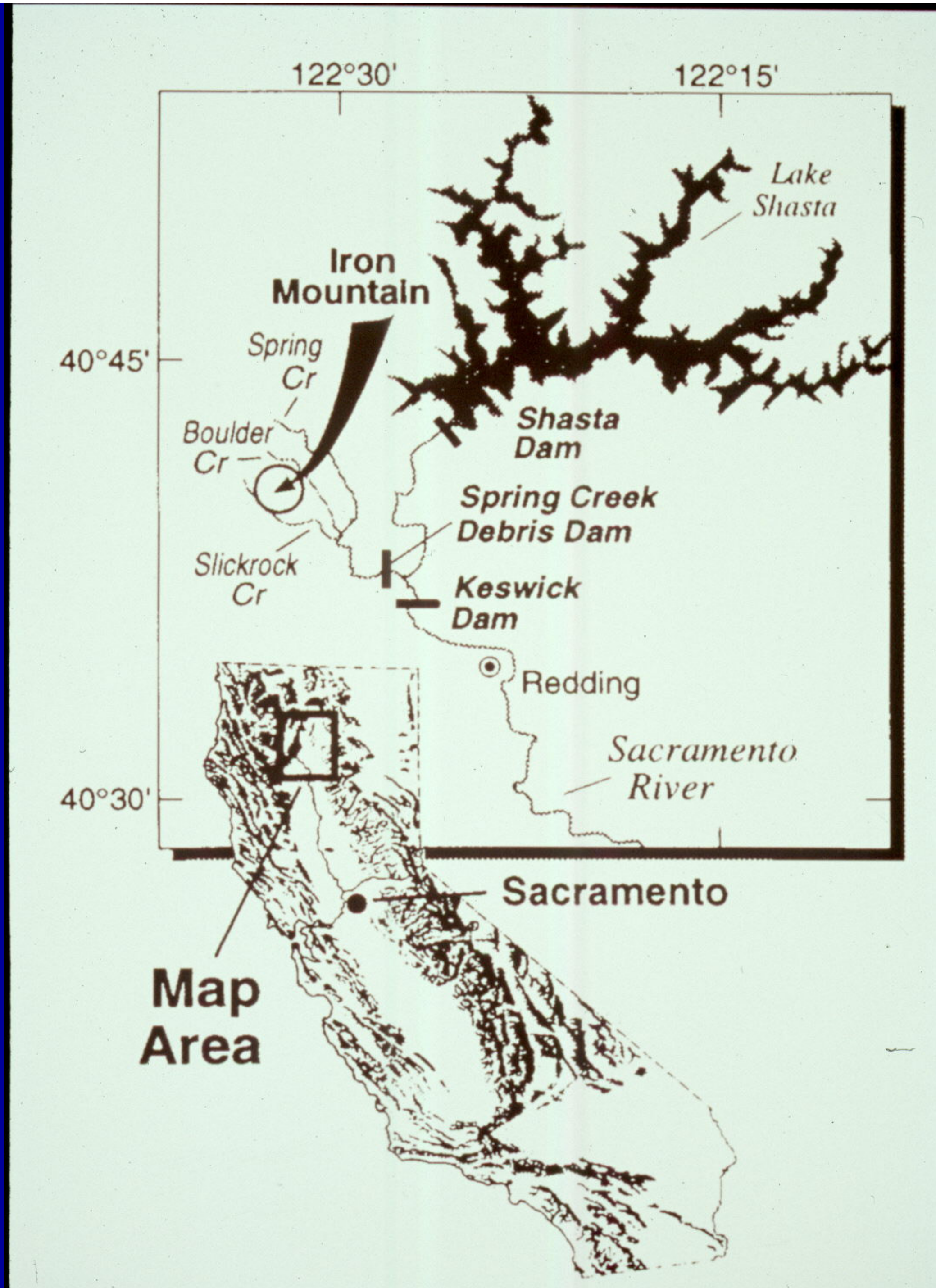
- **Largest mine waste discharger in CA; 730 kg/day of Cu, Zn, Cd discharged and 4,700 tons/yr of pyrite weathered**
- **Discharging metals into the Sacramento River, California's single most important river, for > 100 yrs.**
- **It would take > 2,500 years to complete the oxidation of the remaining pyrite**
- **Caused bitter legal battles for decades**

Environmental History

- 40 fish kills since 1940; as many as 100,000 anadramous fish killed in a single event
- Ranked 3rd worst Superfund site in the State of California since 1983
- Breaks all known records for low pH and highest metal and sulfate concentrations in the world

Environmental History

- 1901: Litigation against MCC by Forest Service
- 1901: USFWS note loss of fish
- 1940: USFWS investigates fish losses from acid mine drainage; leads to 1955 study by PA Acad. Sci.
- 1973-76: USGS investigates acid mine drainage
- 1983-present: USEPA begins Superfund RI/FS
- 1986-97: Four RODs issued for remediation
- 1991: After numerous negotiations, USEPA files lawsuit for cost recovery
- Oct. 19, 2000: Out-of-court settlement reached for a grand total of $862 million and remediation completed by 2026


122°30'
122°15'
Lake Shasta
Iron Mountain
Spring Cr
Boulder Cr
40°45'
Shasta Dam
Spring Creek Debris Dam
Slickrock Cr
Keswick Dam
Redding
Sacramento River
40°30'
Sacramento
Map Area

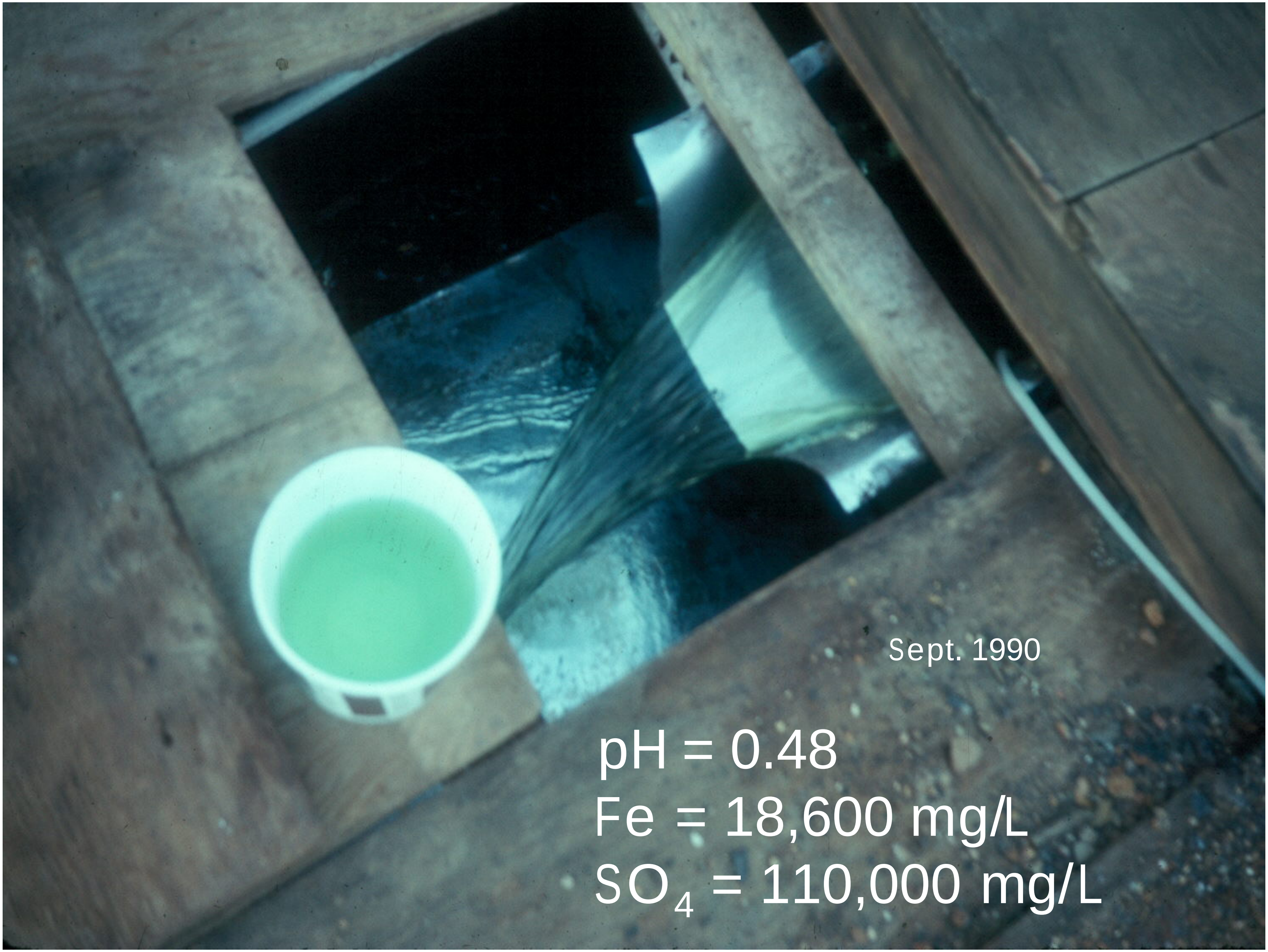
Town of Keswick
Power Plant
Debris
Spring Creek Arm
of Keswick Reservoir
Keswick Reservoir
on Sacramento River

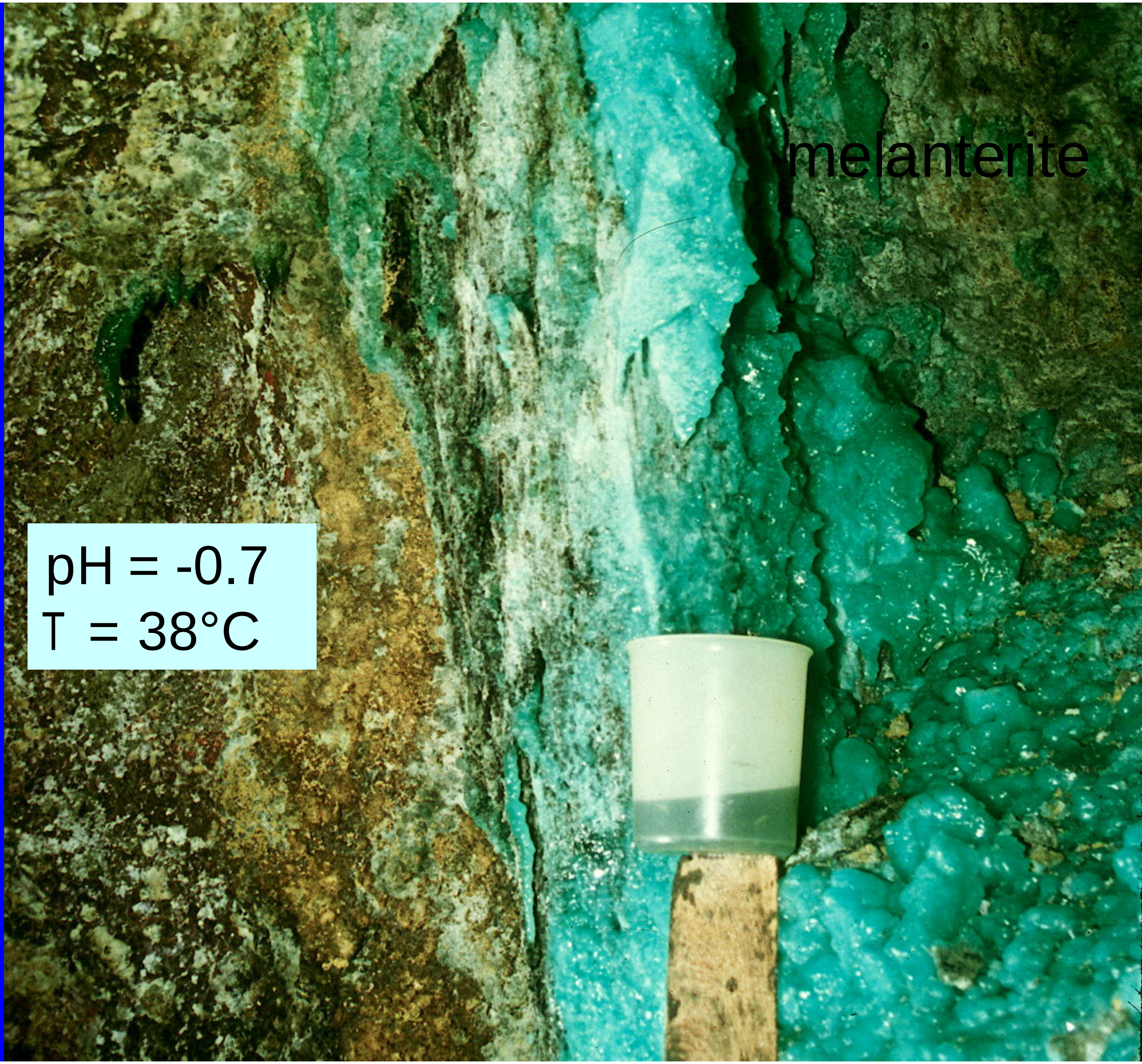
Spring Creek Debris Dam

Hydroelectric Power Plant ➜

Spring Creek Arm Of Keswick Reservoir ➜


Iron Mountain
Brick Flat Open Pit
Slickrock Canyon


Sept. 1990
pH = 0.48
Fe = 18,600 mg/L
SO_4 = 110,000 mg/L


melanterite
pH = -0.7
T = 38°C

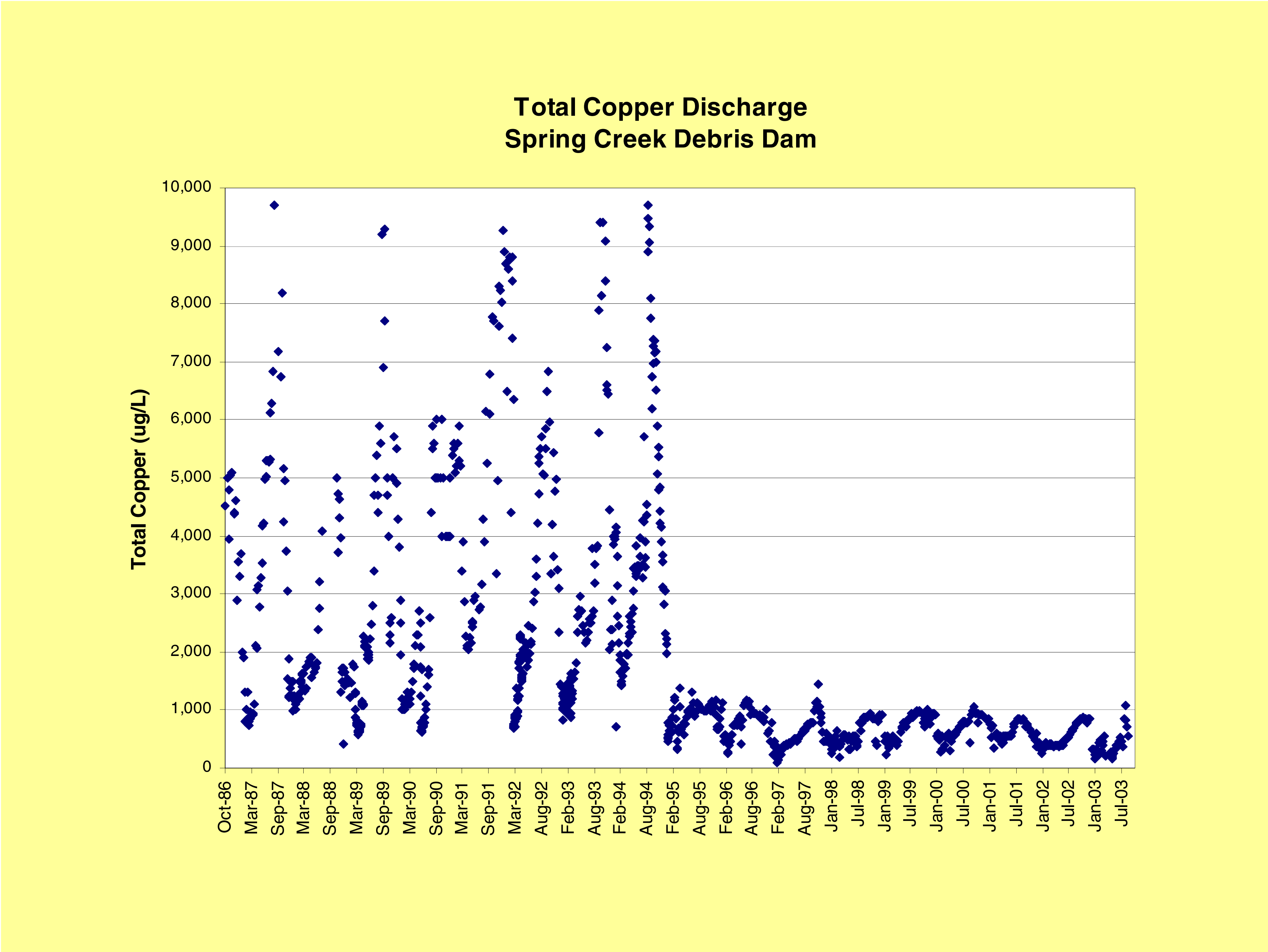
Environmental History:

Four RODs issued for remediation (1986-97)

- Tailings removal
- Surface-water diversions
- Lime neutralization treament

Overall Cu and Zn load reduction
= 80-90%


Minnesota Flats Wastewater Treatment Plant


Total Copper Discharge
Spring Creek Debris Dam
Total Copper (ug/L)
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Oct-86
Mar-87
Sep-87
Mar-88
Sep-88
Mar-89
Sep-89
Mar-90
Sep-90
Mar-91
Sep-91
Mar-92
Aug-92
Feb-93
Aug-93
Feb-94
Aug-94
Feb-95
Aug-95
Feb-96
Aug-96
Feb-97
Aug-97
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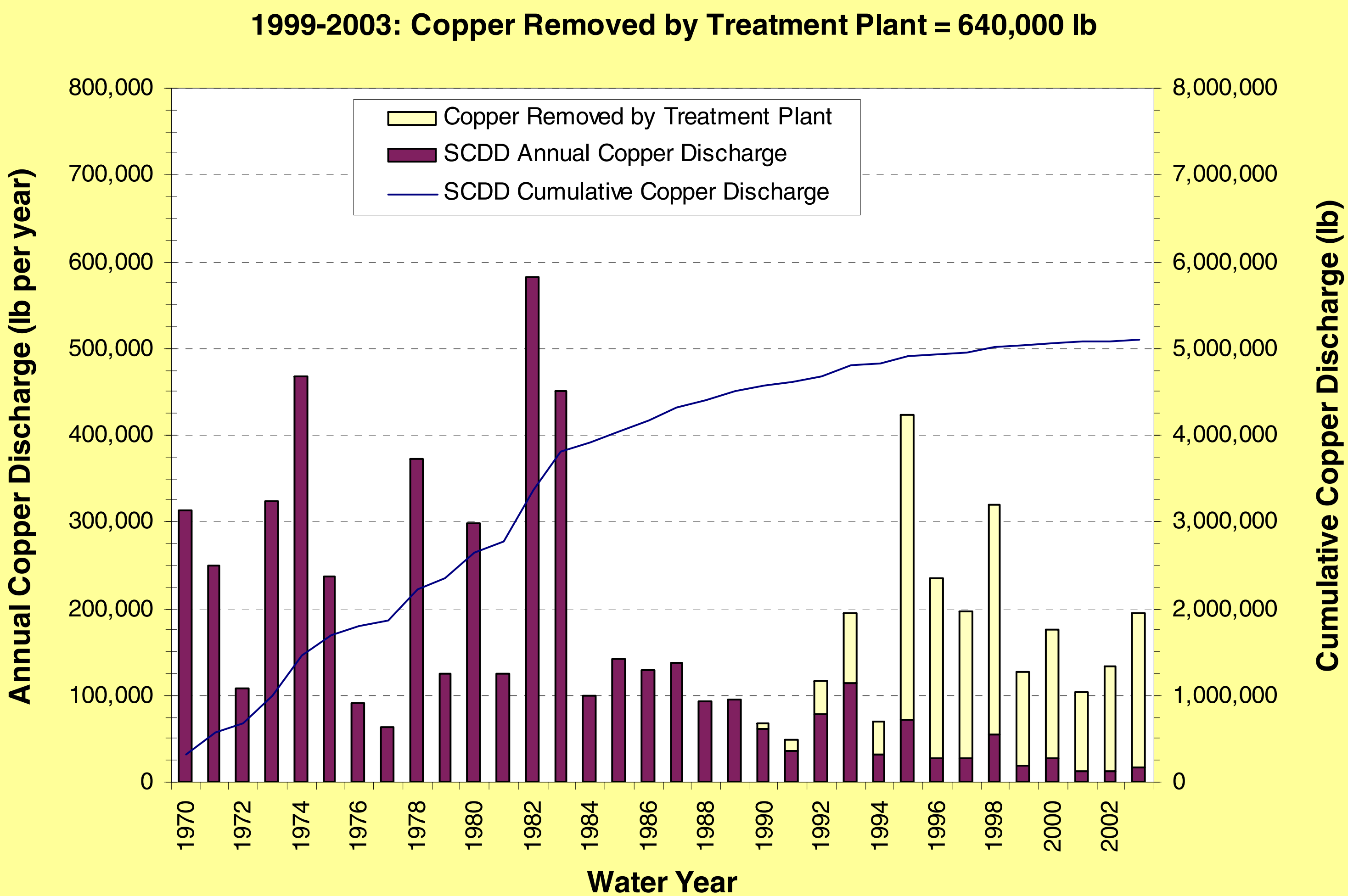
Jul-02
Jan-03
Jul-03



IMM COPPER DISCHARGE

IRON MOUNTAIN MINE

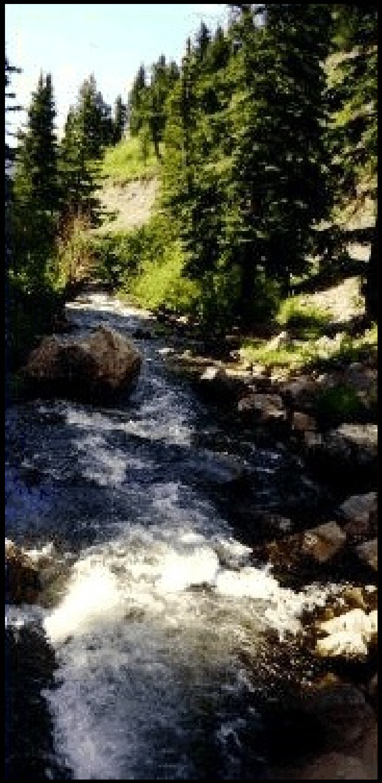
Present remediation phase:

Construction of Slickrock Creek dam to collect last major source of Cu and Zn loads for treatment

Total reduction of Cu and Zn expected to = 95%


Slickrock Creek Retention Dam

The Questa Baseline and Pre-Mining Ground-Water Quality Investigation



D. Kirk Nordstrom (leader)

Philip Verplanck (assistant leader)

Cheryl Naus (groundwater chief)

Geoff Plumlee (geology chief)

Briant Kimball (tracer chief)

Blaine McCleskey (chief chemist)

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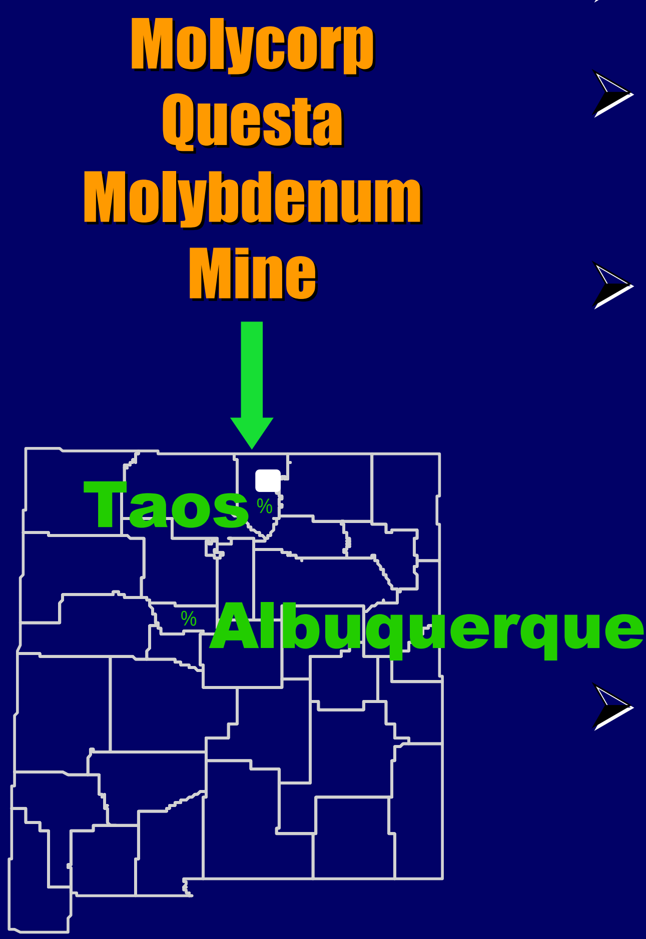
Ultimate driver for the study:

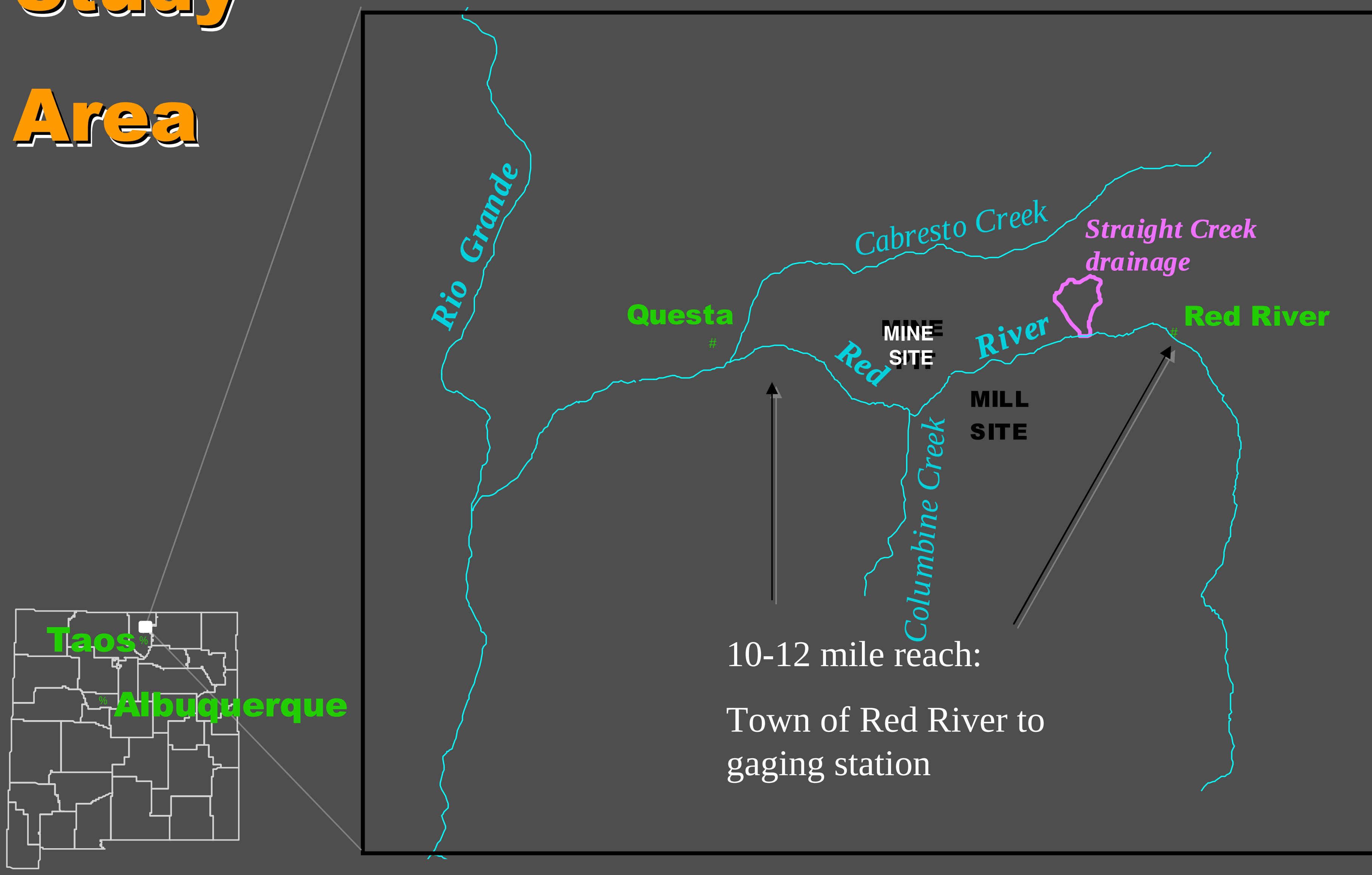
If it can be shown that the pre-mining ground-water quality was worse than the New Mexico standards, then those values can be adopted for the site-specific standards according to New Mexico law.

Overview

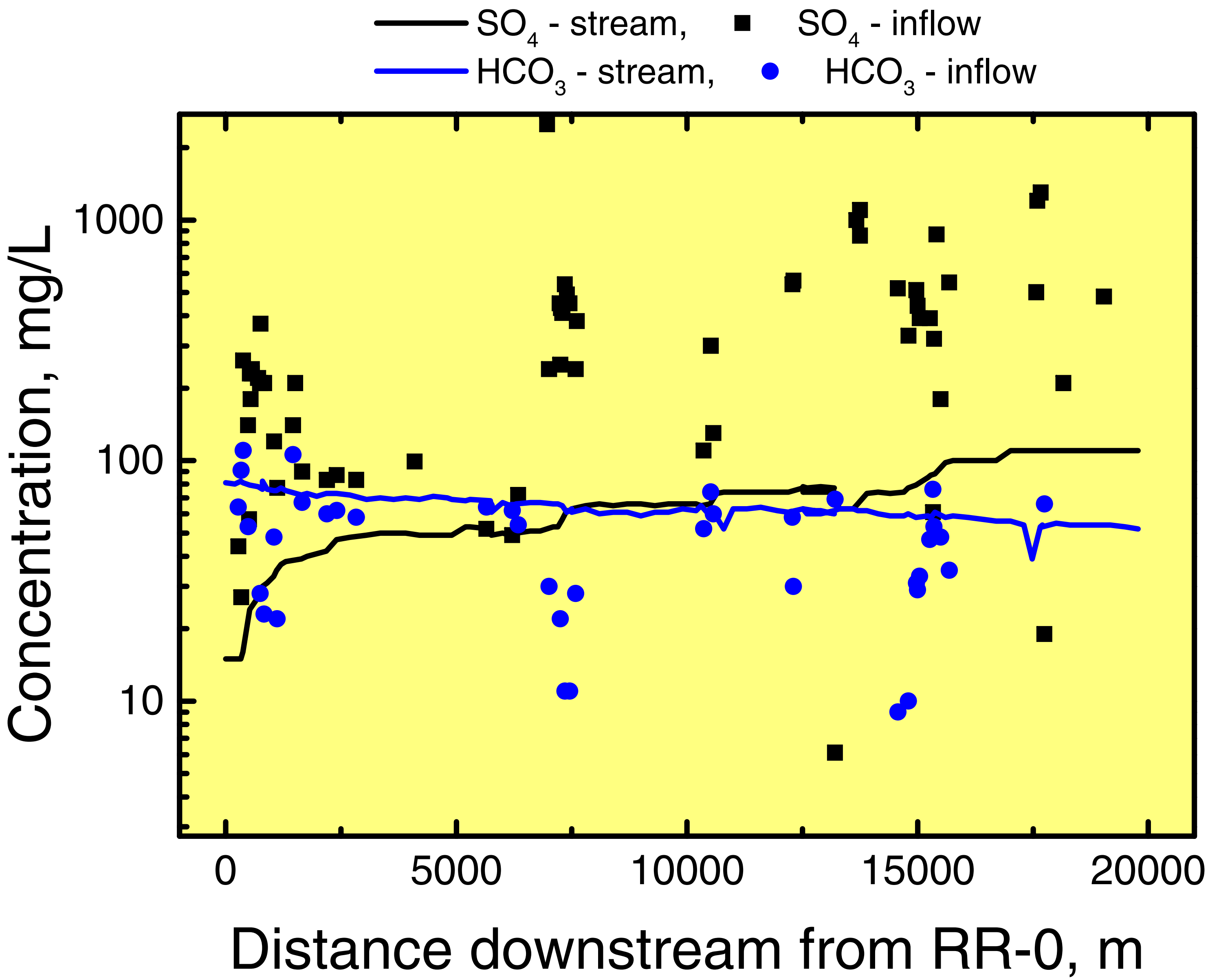


- Molycorp formed in 1919 after the discovery of molybdenite
- Underground and open pit mining
- Permit for closure requires GW quality must meet NM stds
- Natural weathering of mineralized and altered bedrock could result in concentrations of several water-quality constituents that may exceed water-quality standards
- The State of New Mexico regulations provide for limited site-specific alternative standards

Study Area


Rio Grande
Cabresto Creek
Straight Creek
drainage
Questa
MINE
SITE
Red
River
Red River
MILL
SITE
Columbine Creek
Taos
Albuquerque
10-12 mile reach:
Town of Red River to
gaging station


Questa
Open pit
Red River
Mill site



SO4 - stream,
SO4 - inflow
HCO3 - stream,
HCO3 - inflow
Concentration, mg/L
1000
100
10
0
5000
10000
15000
20000
Distance downstream from RR-0, m

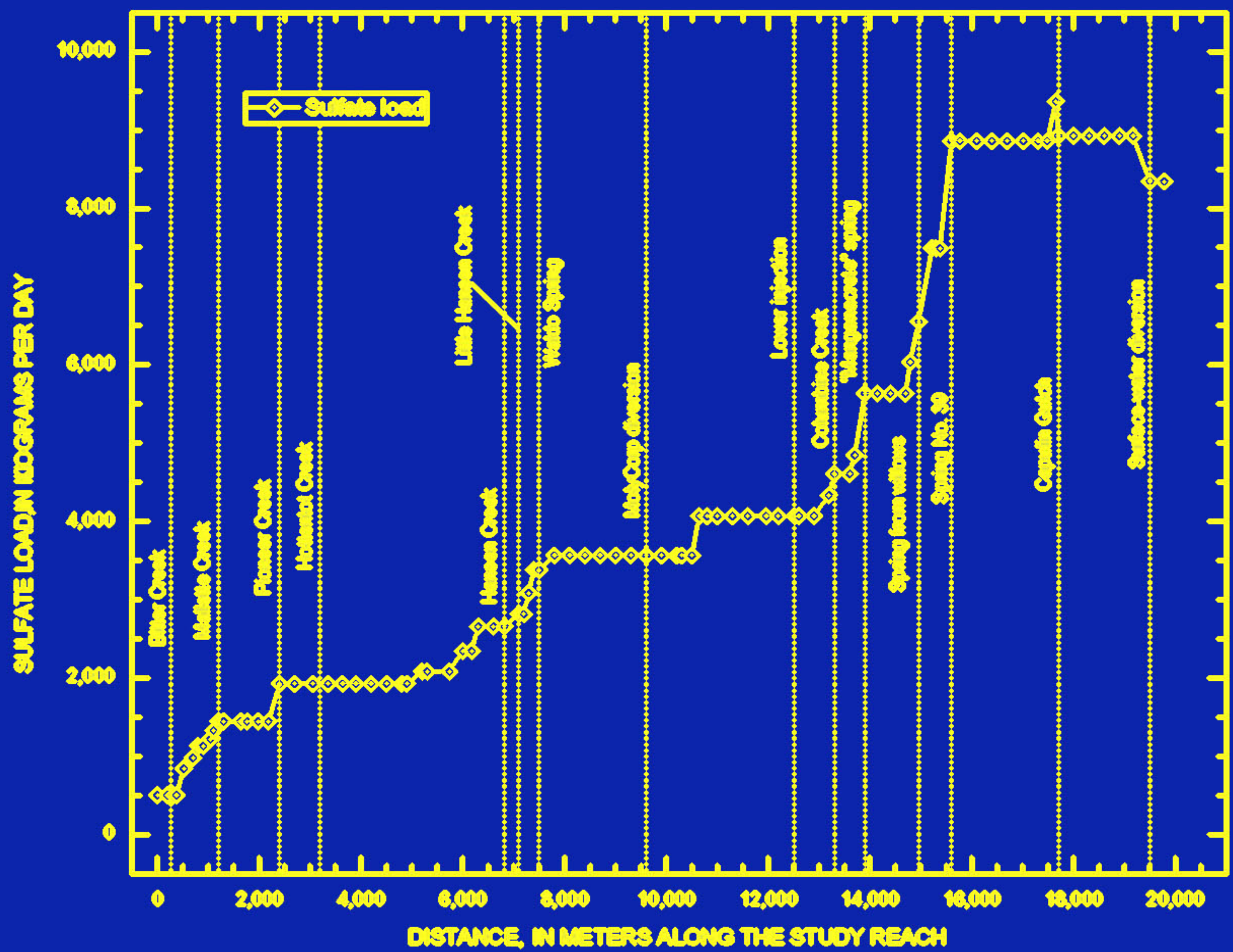
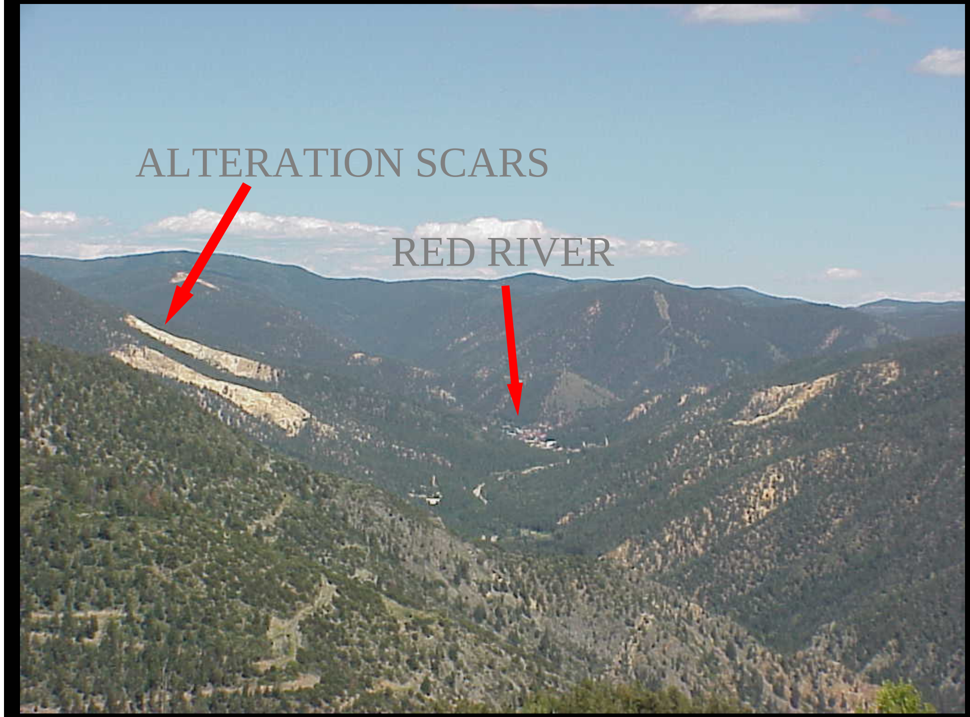
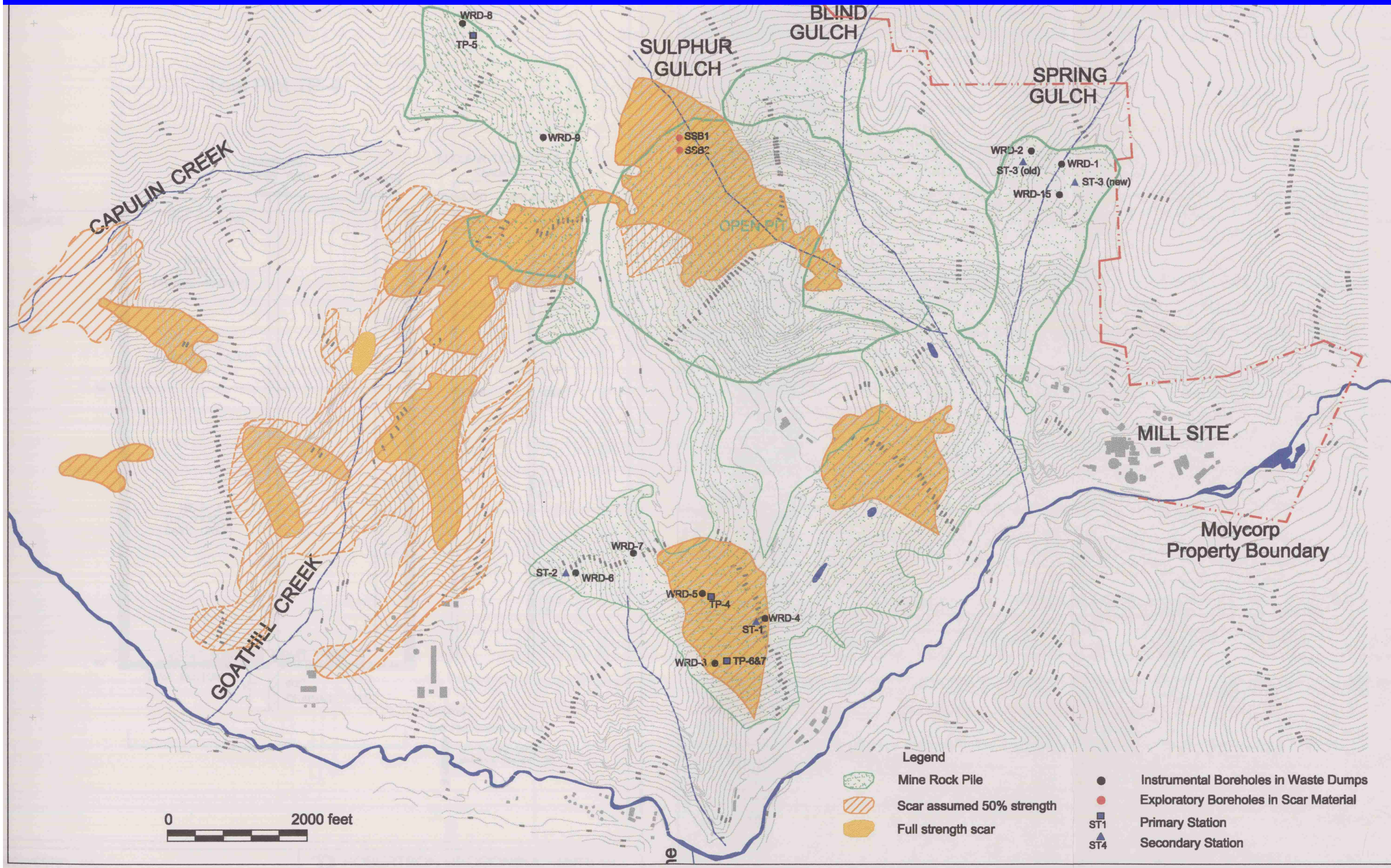


Figure 15. Variation of dissolved sulfate load with distance along study reach, Red River, New Mexico, August 2001

Scar Areas



Alteration & Scar Distribution



CLIENT:	MOLYCORP, INC.
PROJECT No:	052008/11
PROJECT:	QUESTA AS BUILT REPORT
LOCATION:	QUESTA MINE NEW MEXICO, USA

ROBERTSON GEOCONSULTANTS INC.
Consulting Geotechnical and Environmental Engineers

Location of Primary and Secondary Monitoring Stations

DATE:	DRAWN BY:	FIGURE:
Nov. 2000	JG	1

Ground-water chemistry

parameter	SC-1A	SC-1B
pH	3.63	6.61
SC	2,800	3,440
Ca	420	520
HCO_3	--	490
Mg	120	220
F	11	1.4
SO_4	2100	1900
Al	96	<0.05
Fe	30	2.7
Zn	7.6	0.68
SiO_2	100	25

Main weathering processes that account for ground-water composition

Pyrite oxidation
    sulfate up to thousands of mg/L
Gypsum dissolution
    calcium up 600 mg/L
Calcite dissolution
    bicarbonate up to 500 mg/L
Chlorite dissolution
    magnesium up to 400 mg/L
Fluorite dissolution
    fluoride up to 150 mg/L

40 years of irregular monitoring at the Red River gaging station, 1965–2003

- Downstream of the Questa mine
- Sulfate concentrations: 100–200 mg/L
- pH generally 6–7.5
- Water quality sensitive to any major changes caused by increased or decreased loading associated with mining contamination or remediation

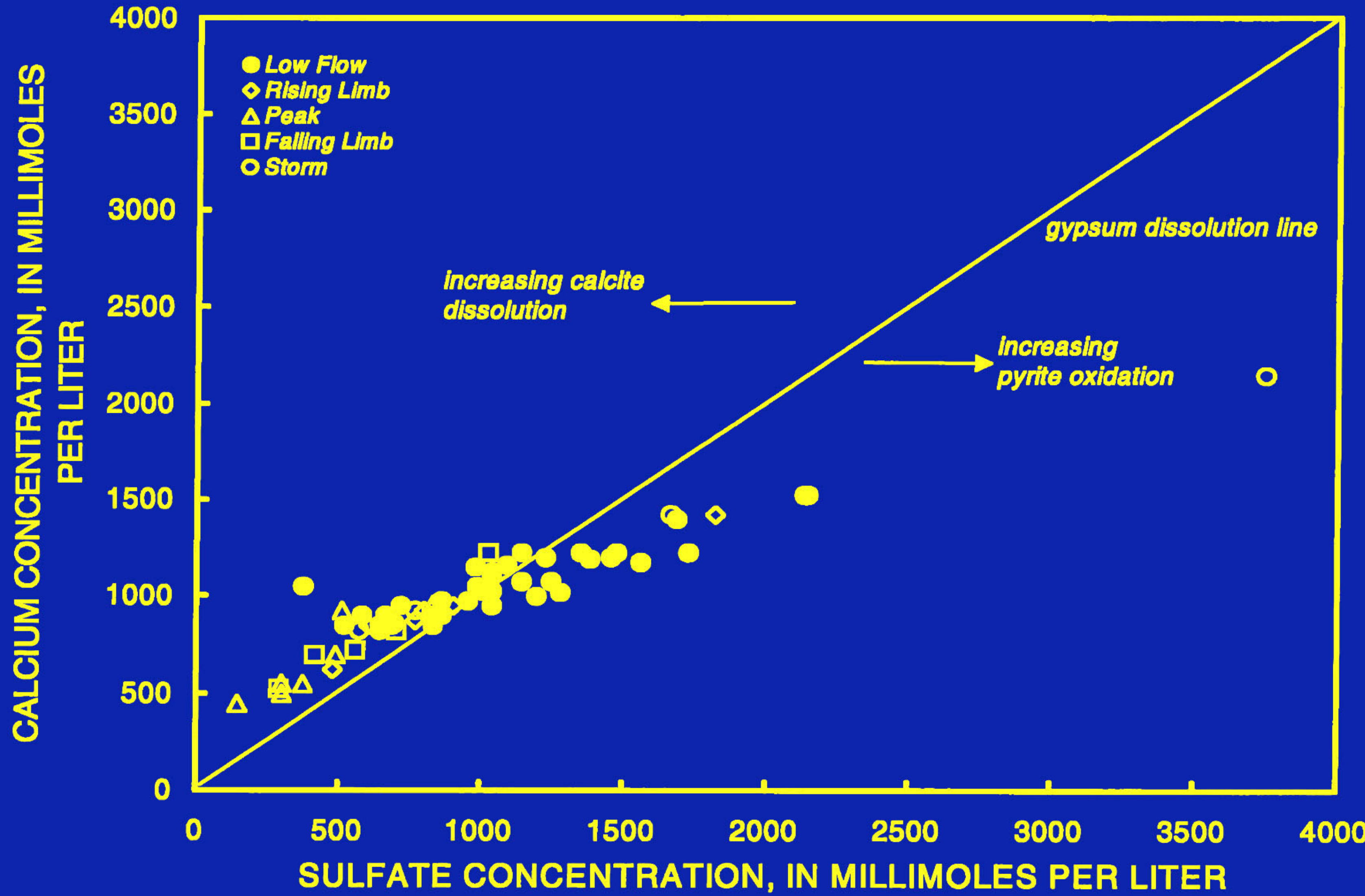


Figure 12. Graph showing calcium concentrations in relation to sulfate concentrations in the Red River at Questa Ranger Station and the gypsum congruent dissolution line.

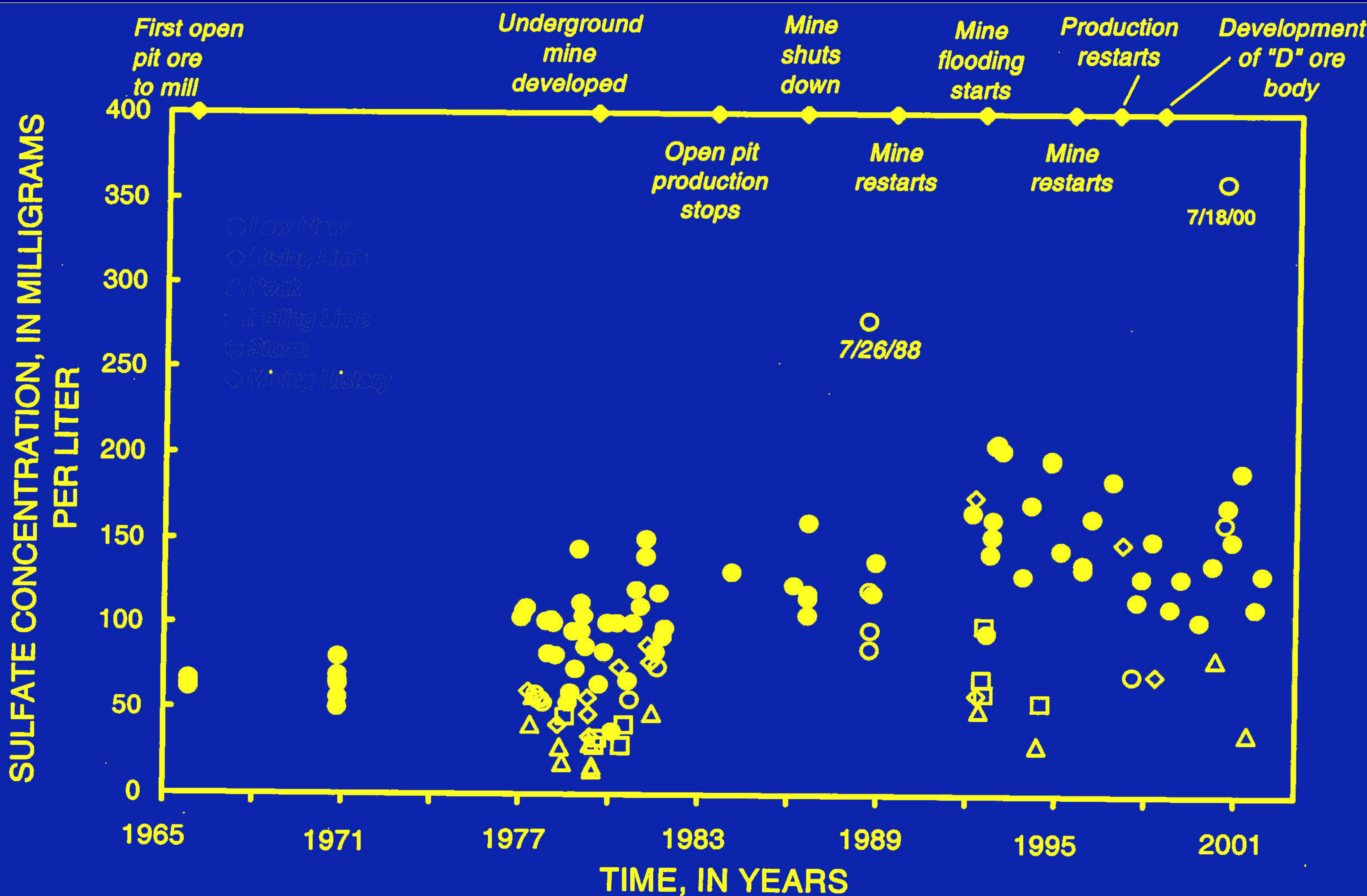


Figure 5. Graph showing sulfate concentrations in the Red River at the Questa Ranger Station from 1966 to 2001, and timing of mining history.

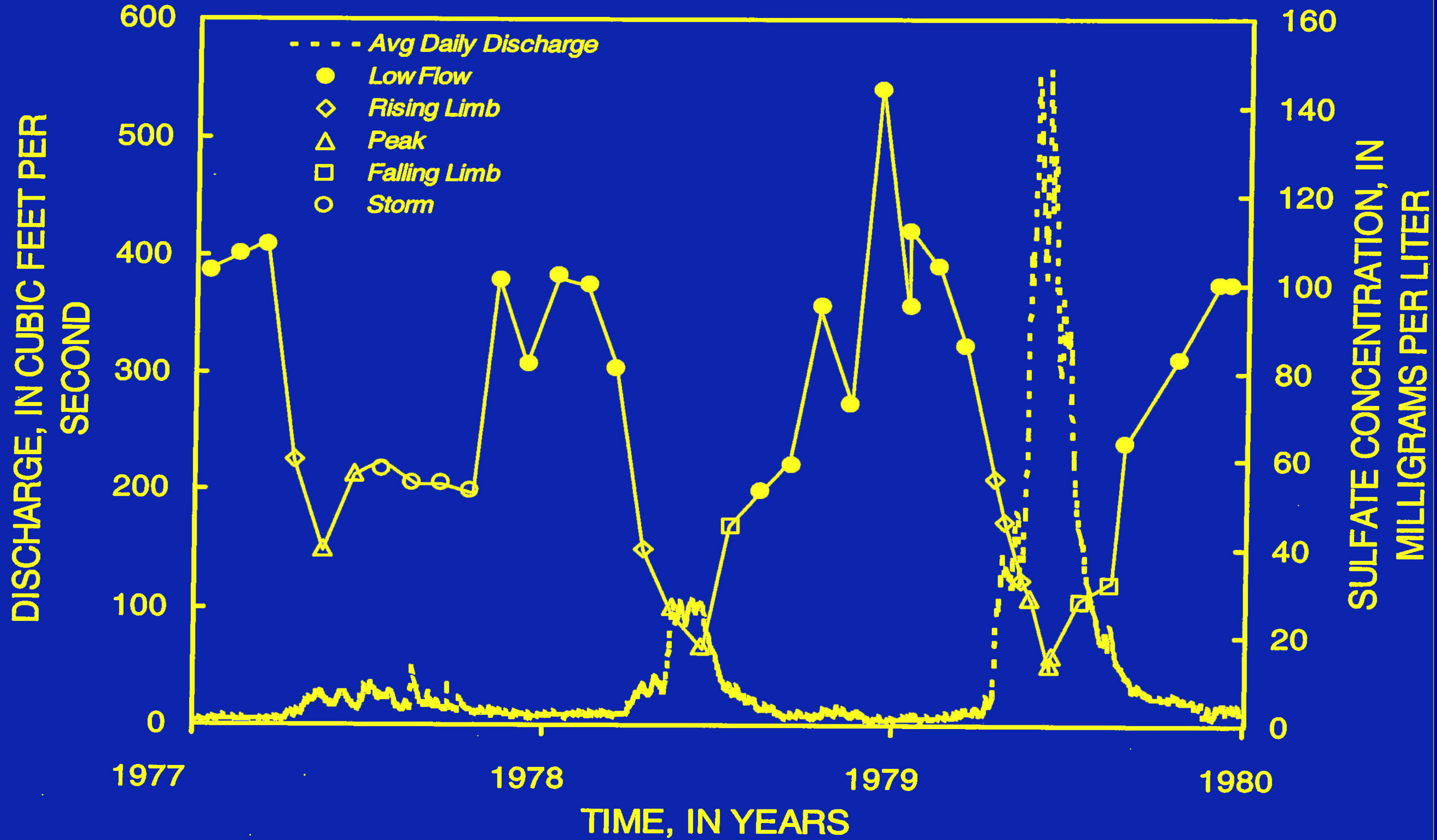


Figure 4. Graph showing sulfate concentrations and average daily discharge in the Red River at the Questa Ranger Station, from January 1977 to December 1979.

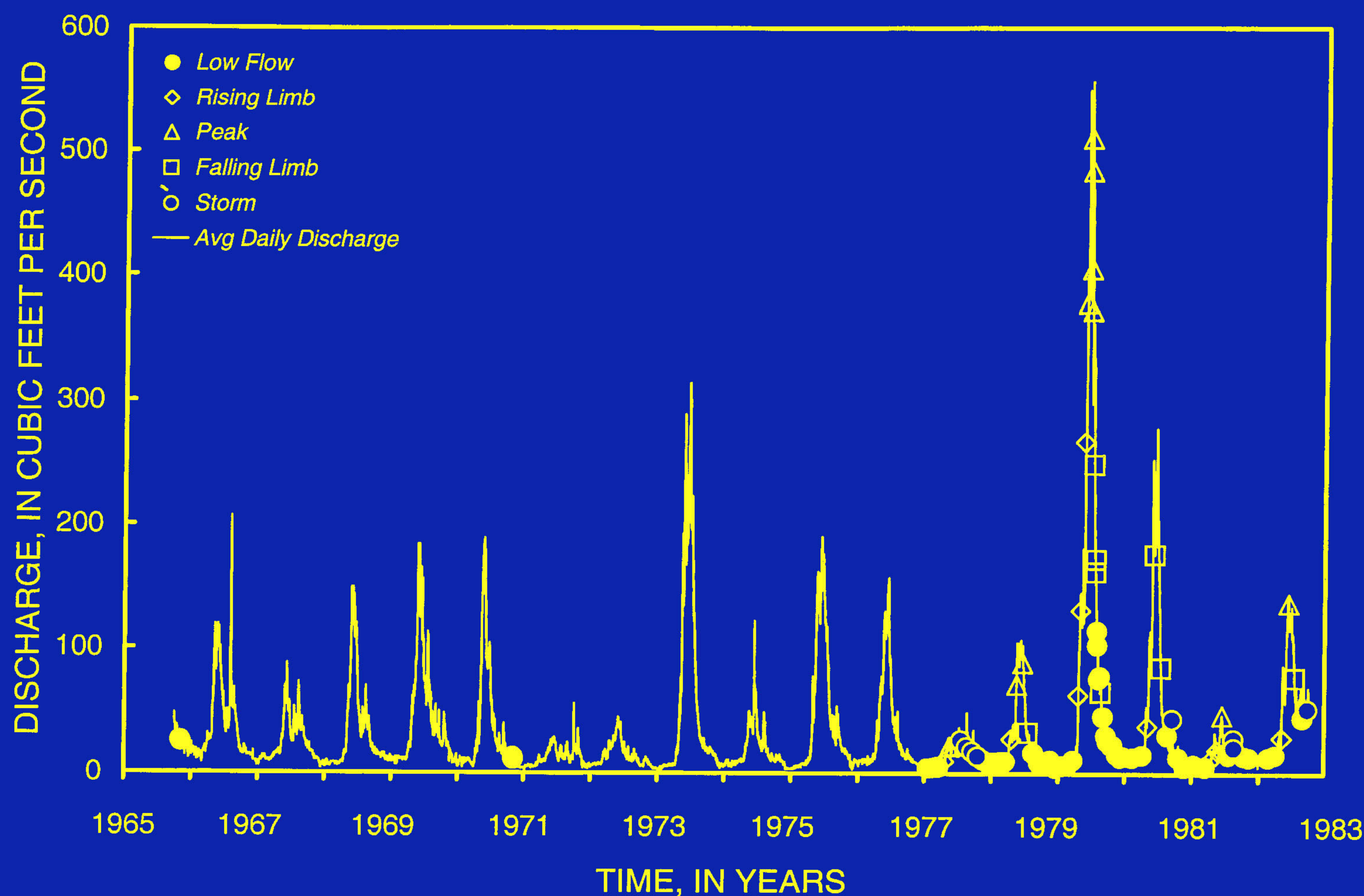


Figure 2. Graph showing average daily discharge and timing of surface water samples collected in the Red River at the Ranger Station in water years 1966 to 1982.

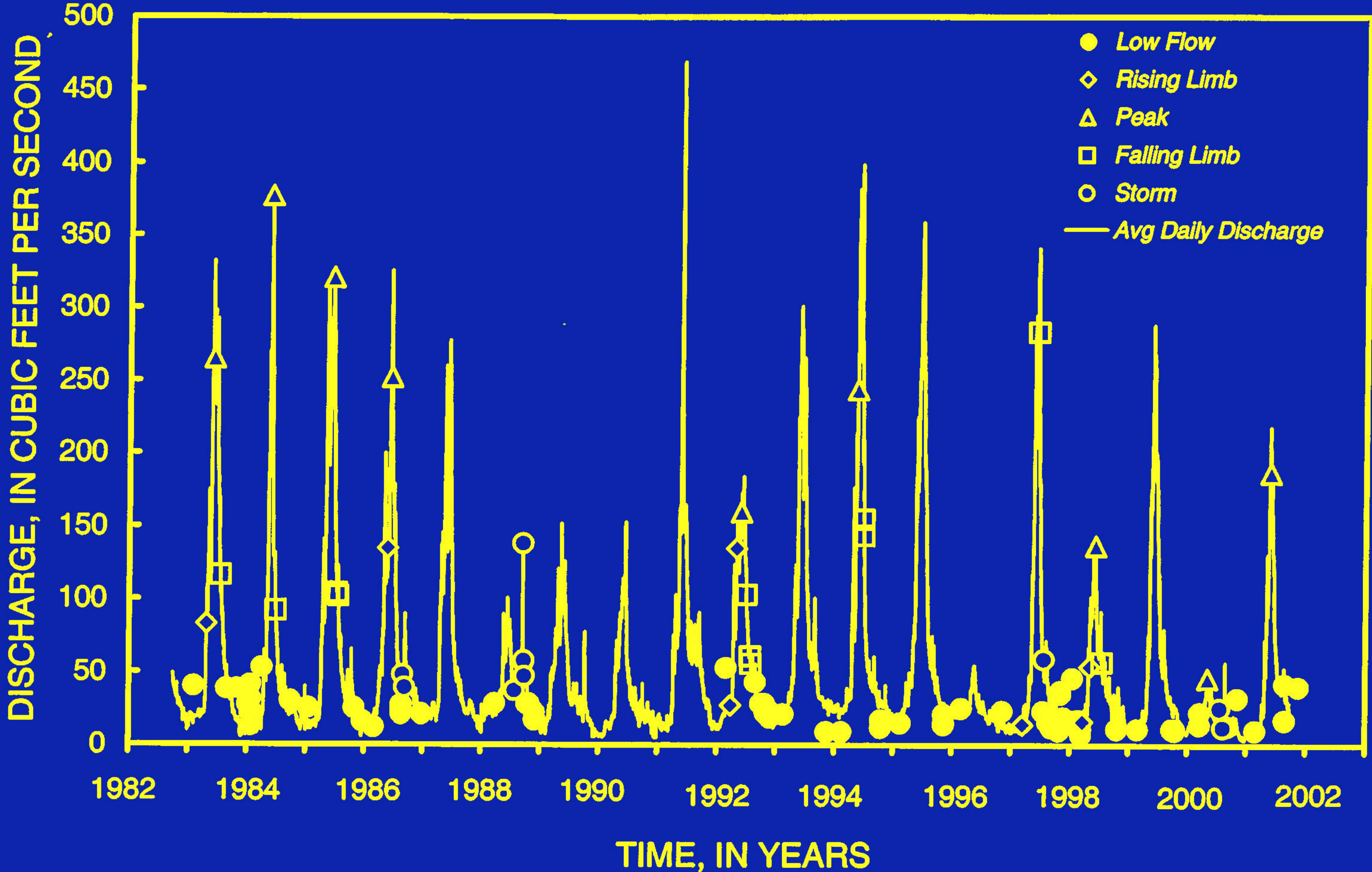
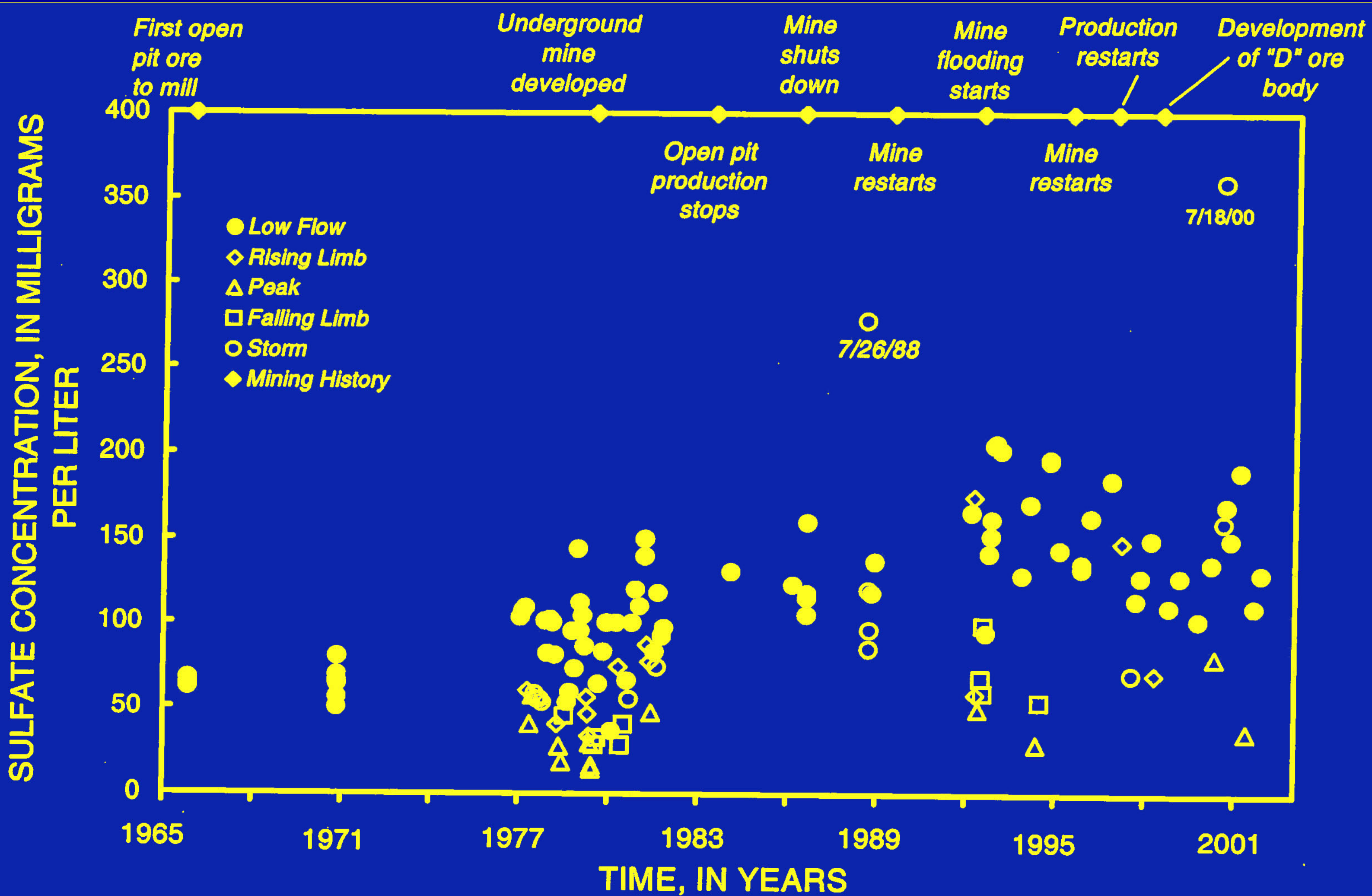


Figure 3. Graph showing average daily discharge and timing of surface water samples collected in the Red River at the Ranger Station in water years 1983 to 2001.



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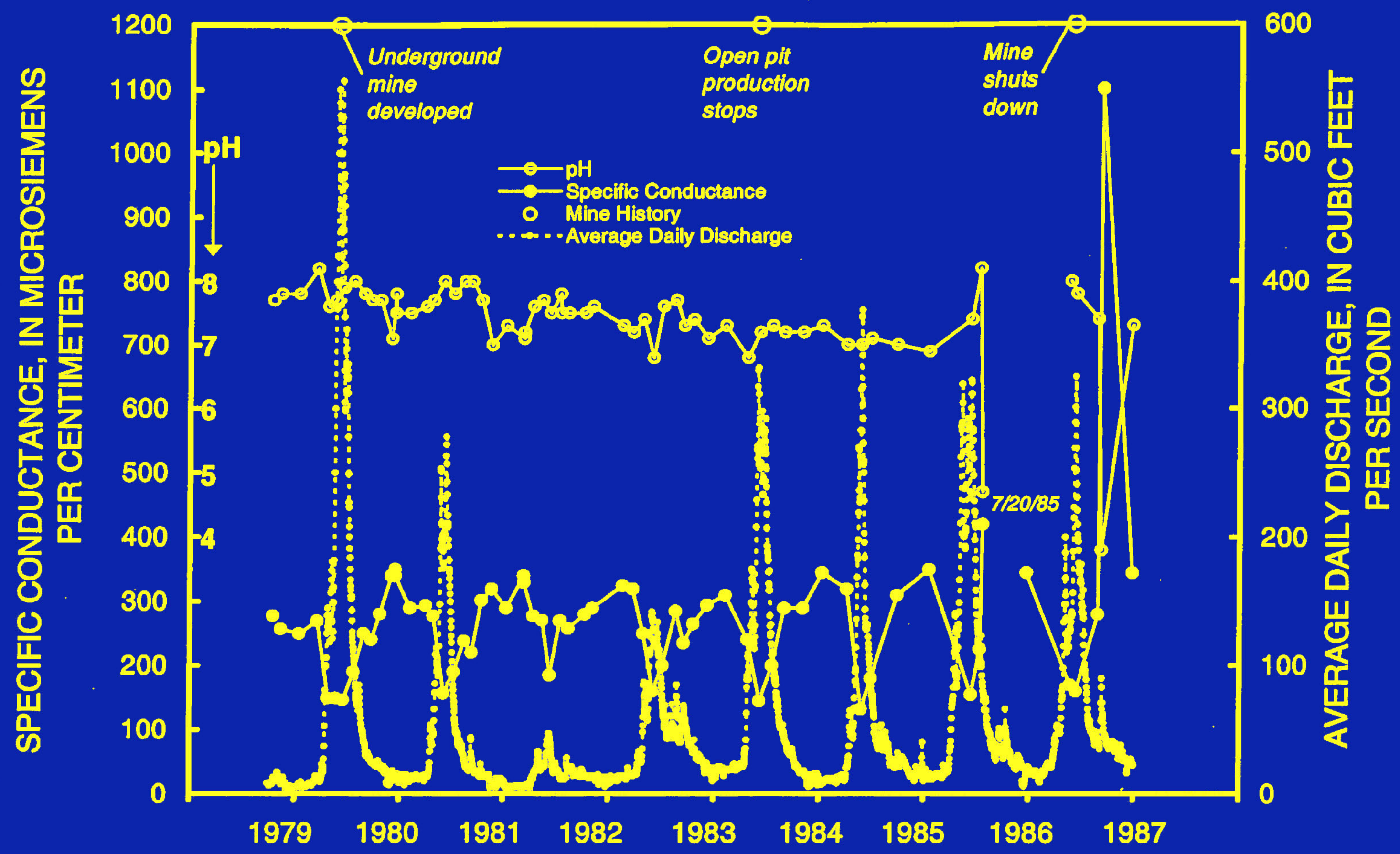

Figure 15. Graph showing specific conductance, pH, and average daily discharge in the Red River at Questa Ranger Station, from October 1978 to December 1986.

Remedial Activities:

- Stabilization of slumping waste piles
- Pumping out acid ground-water discharges into Red River along mine site
- Further site characterization

CONCLUSIONS:

- **Continuous monitoring is necessary to show effectiveness of remediation and to quantify that effectiveness**
- **For the IMM site, diversions, lime neutralization, and tailings removal has decreased Cu, Zn loads by 80-90%; further capture of SW flows could improve the reduction to 95%**
- **At the Questa site, loads are much lower and remediation by pumping out contaminated ground water should be effective but it will be difficult to quantify against a high variability in background**