LESSONS LEARNED FROM MINING-INFLUENCED WATERS STUDIES AT THE NEW MEXICO BUREAU OF GEOLOGY AND MINERAL RESOURCES

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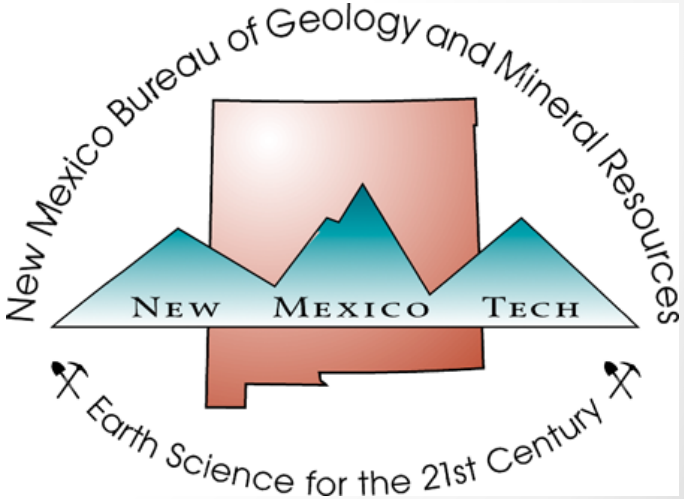


ACKNOWLEDGMENTS

- Numerous colleagues and students have assisted with studies presented in this paper and their help is appreciated
- Funding agencies over the years USGS, BOR, EPA, ACofE, Chevron

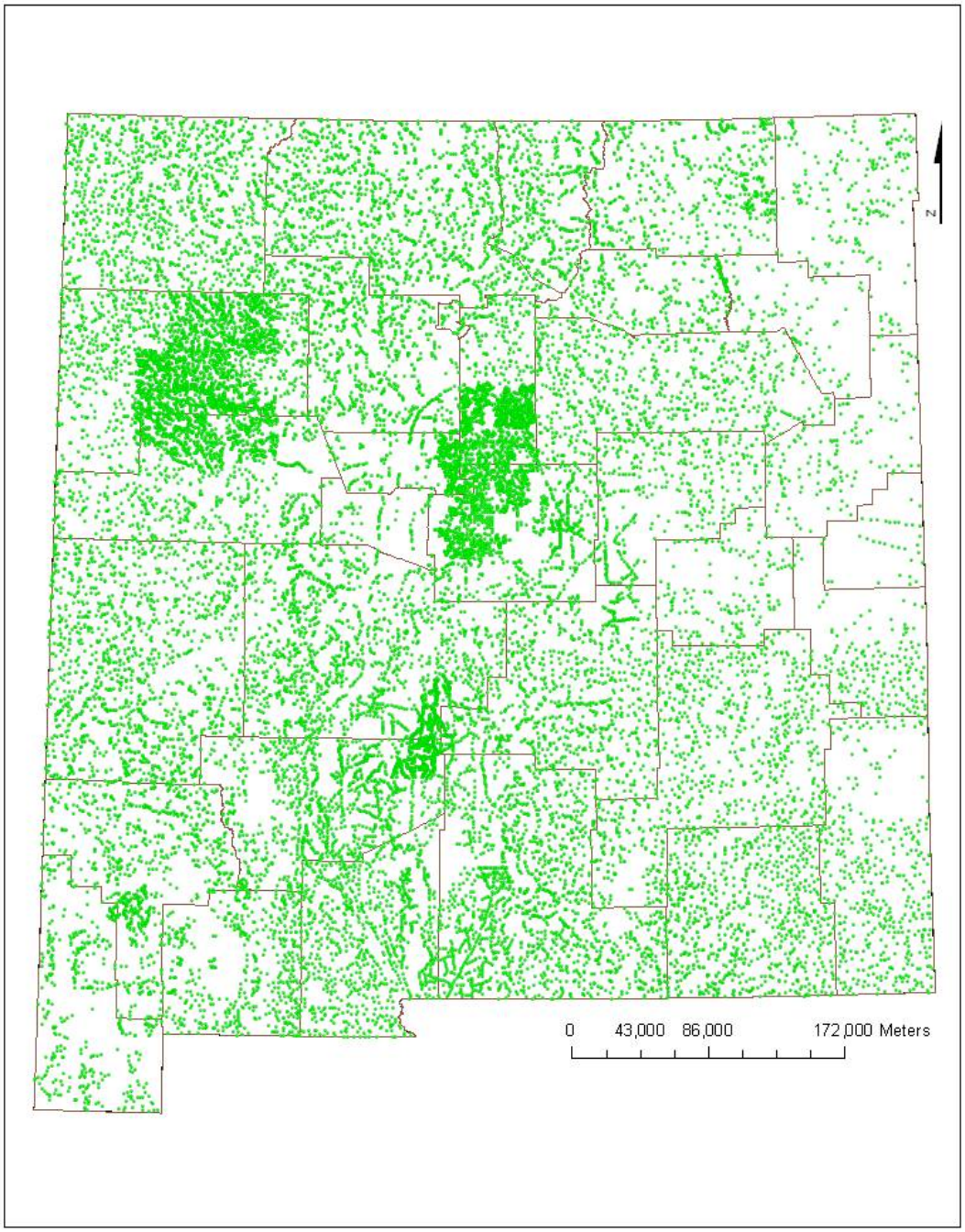
OUTLINE

- NURE data
- Uranium in the Española Basin, Santa Fe County
- Orogrande district, Otero County
- Terrero (Pecos) mine, Willow Creek district, San Miguel County
- Questa waste rock piles, Taos County
- Lessons learned

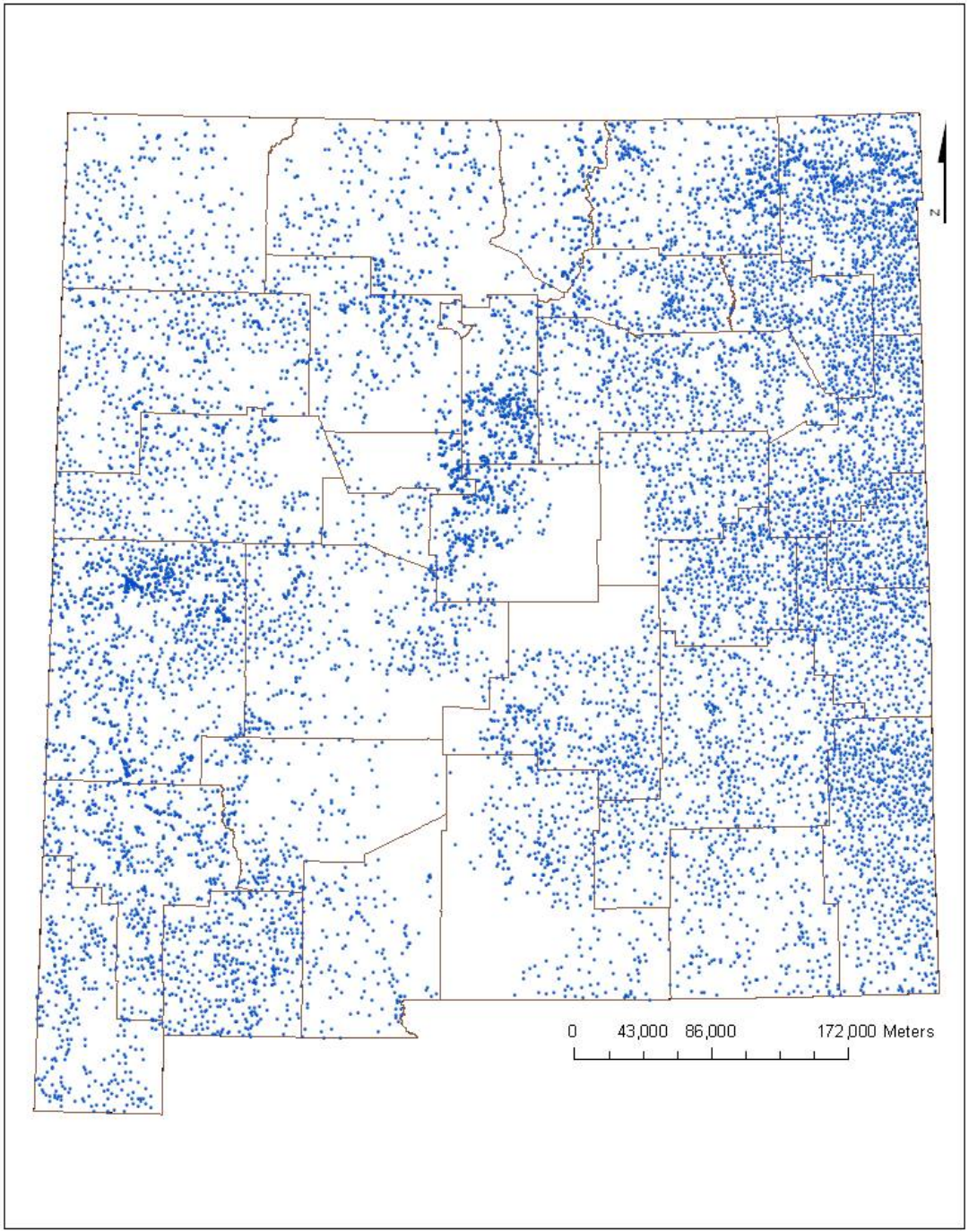
NURE DATA

NURE DATA

- National Uranium Resource Evaluation program during the 1970s
- >27,000 stream sediments samples
- >12,000 surface and well water samples
- Provides a first order of geochemical background conditions in New Mexico
- Part of the USGS National Geochemical Database http://mrdata.usgs.gov/geochem/doc/home.htm



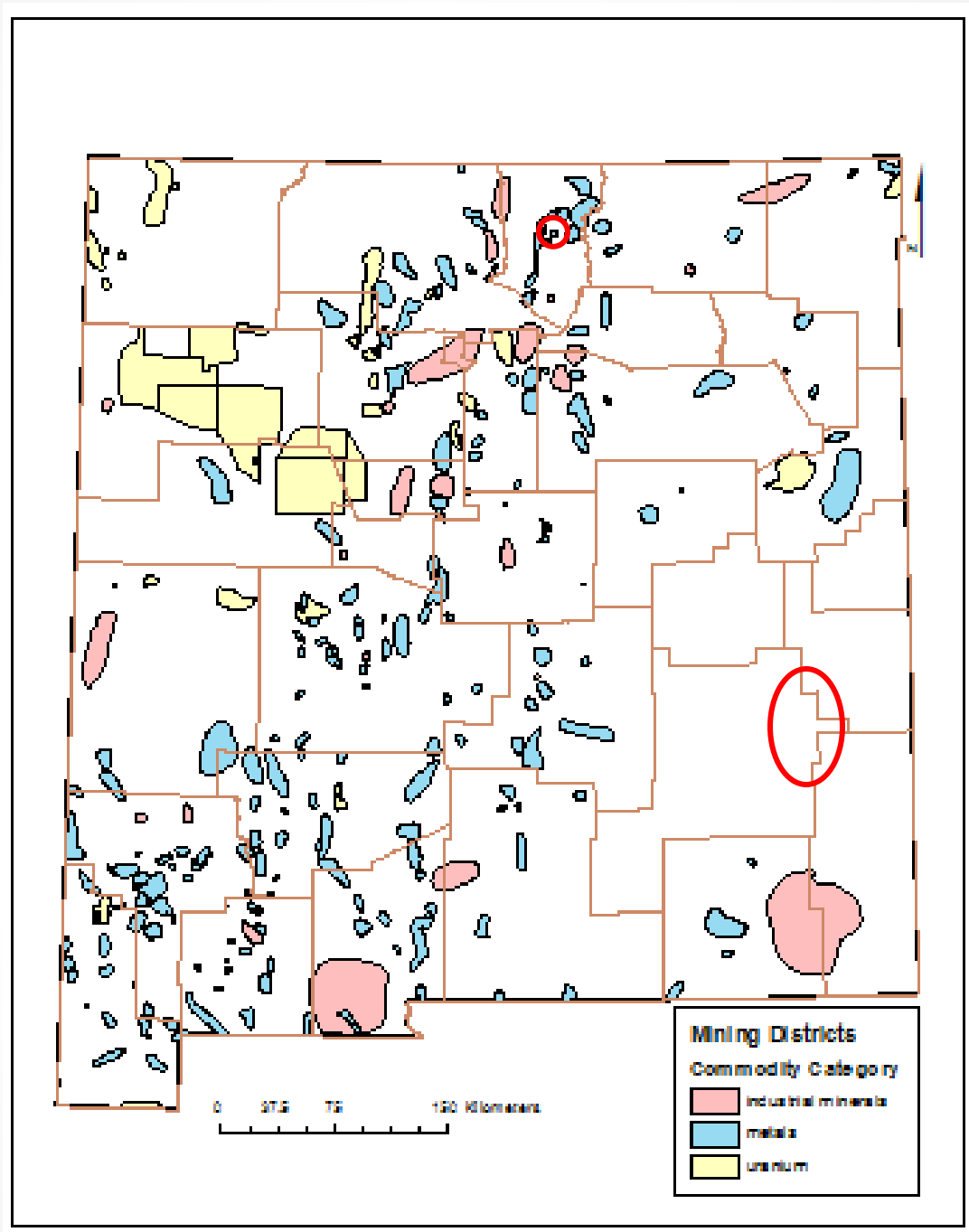
Distribution of NURE stream-sediment samples in New Mexico

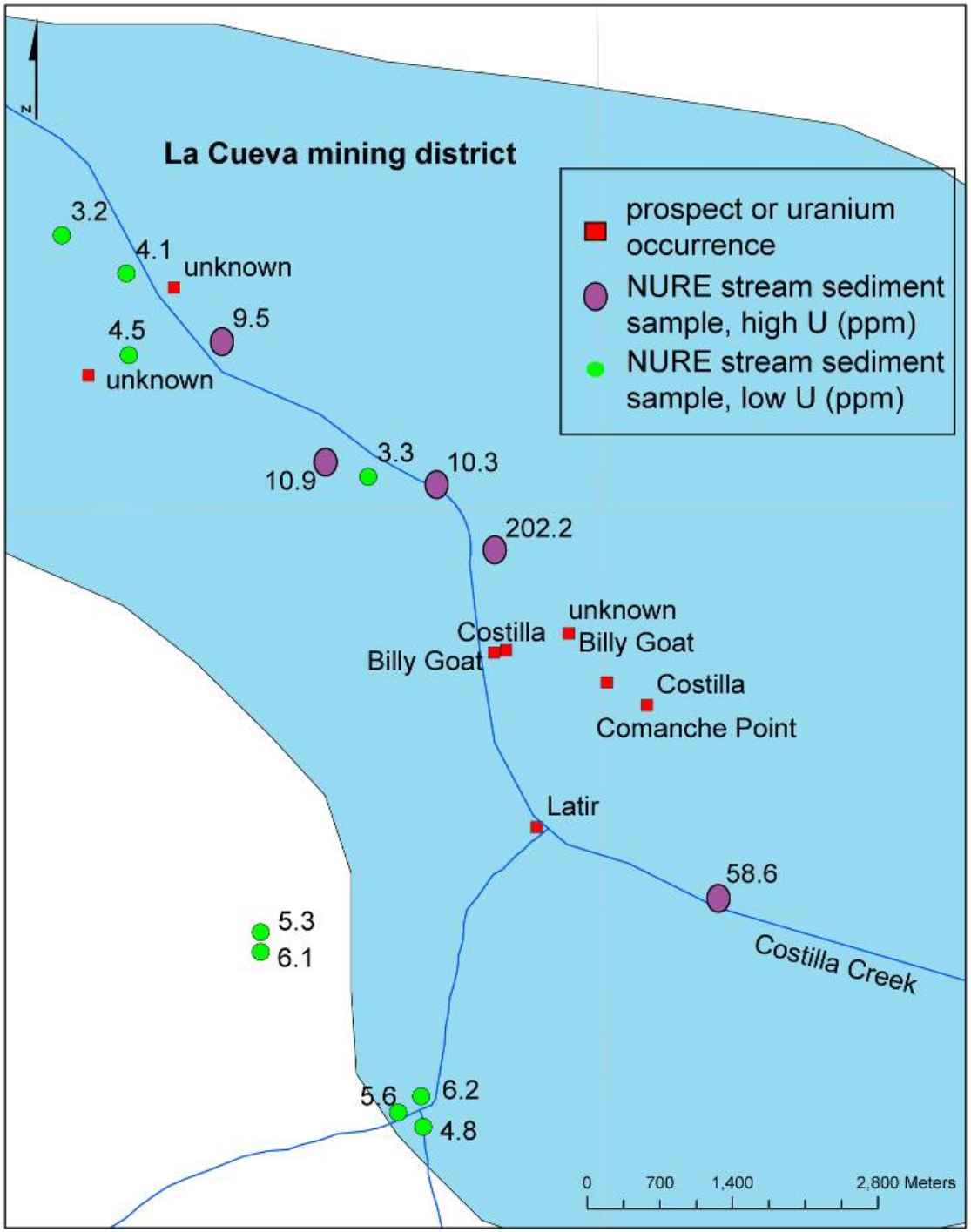


Distribution of NURE water samples in New Mexico

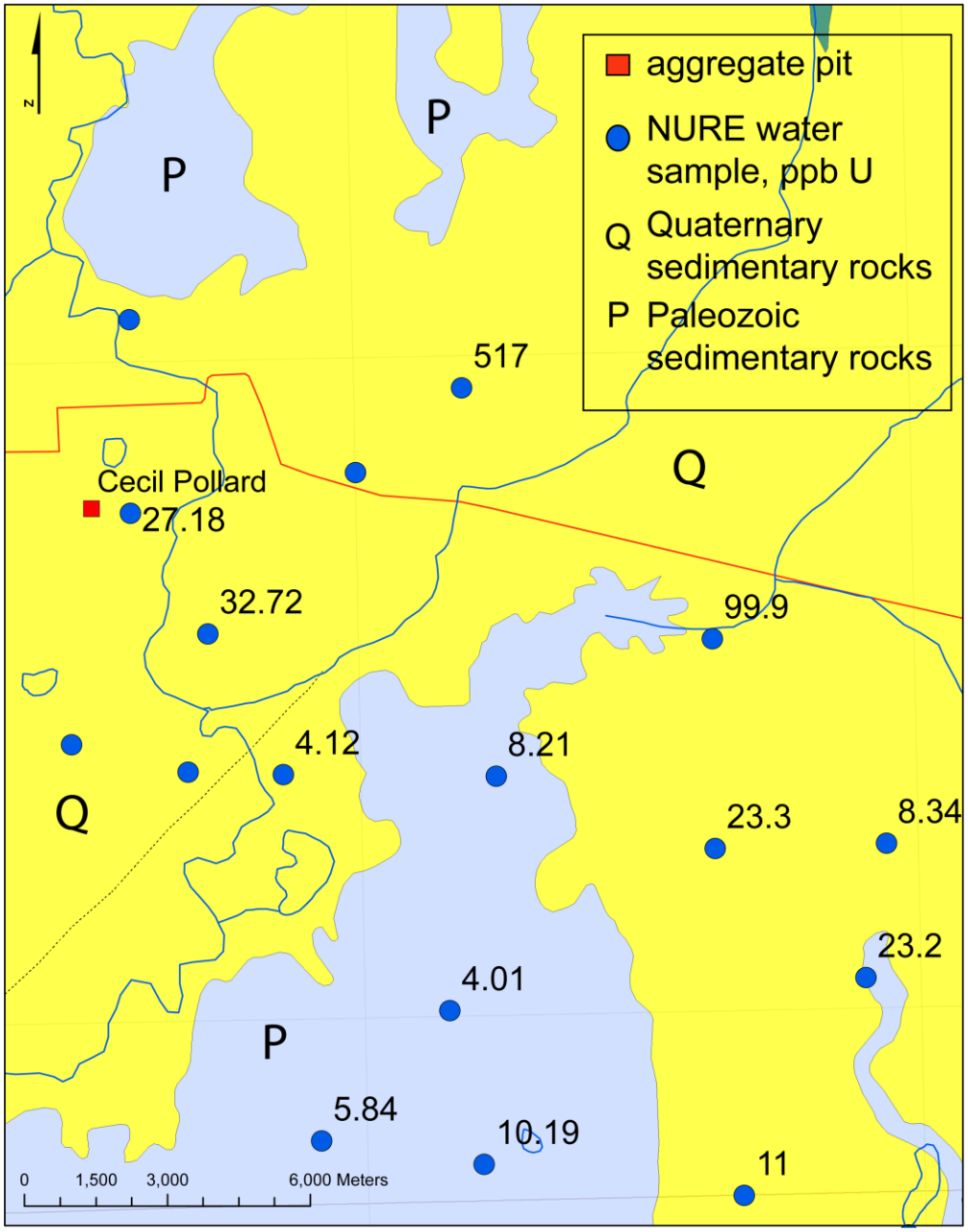
ISSUES AND CONCERNS ENCOUNTERED WITH THE NURE DATA

- Different laboratories
- Normality of the data
- Below detection values
- Identification of geochemical anomalies and background
- Scale of the survey
- Geochemical anomaly maps


Mining Districts
Commodity Category
industrial minerals
metals
uranium
0
37.5
75
150 Kilometers



Uranium in stream-sediment samples in the La Cueva mining district, Taos County



Uranium in water samples in eastern New Mexico, possibly from the Ogallala Formation

Conclusions—NURE Data

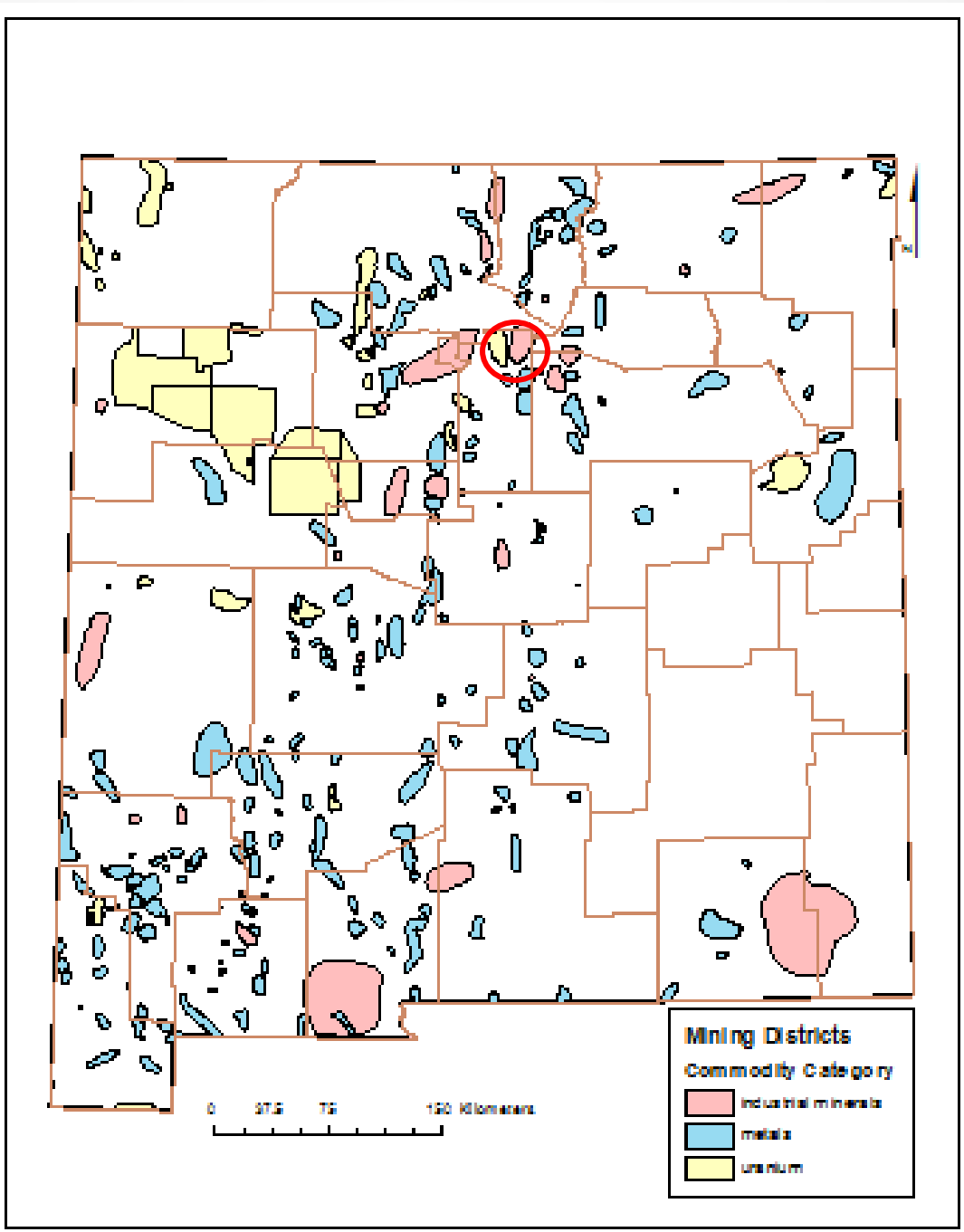
- Incorporation of various data sets into ArcMap has resulted in identification of several areas with anonymously high U concentrations
- Only a few areas examined thus far in NM at the scale of the NURE data are a result of solely contamination from mining and other anthropogenic inputs
- Most areas are a result of natural processes related to local rock chemistry, weathering, or formation of mineral deposits

Uranium in the Española Basin, Santa Fe County

Drinking-Water Treatment


Membrane Filtration


Anion Exchange


Mining Districts
Commodity Category
industrial minerals
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37.5
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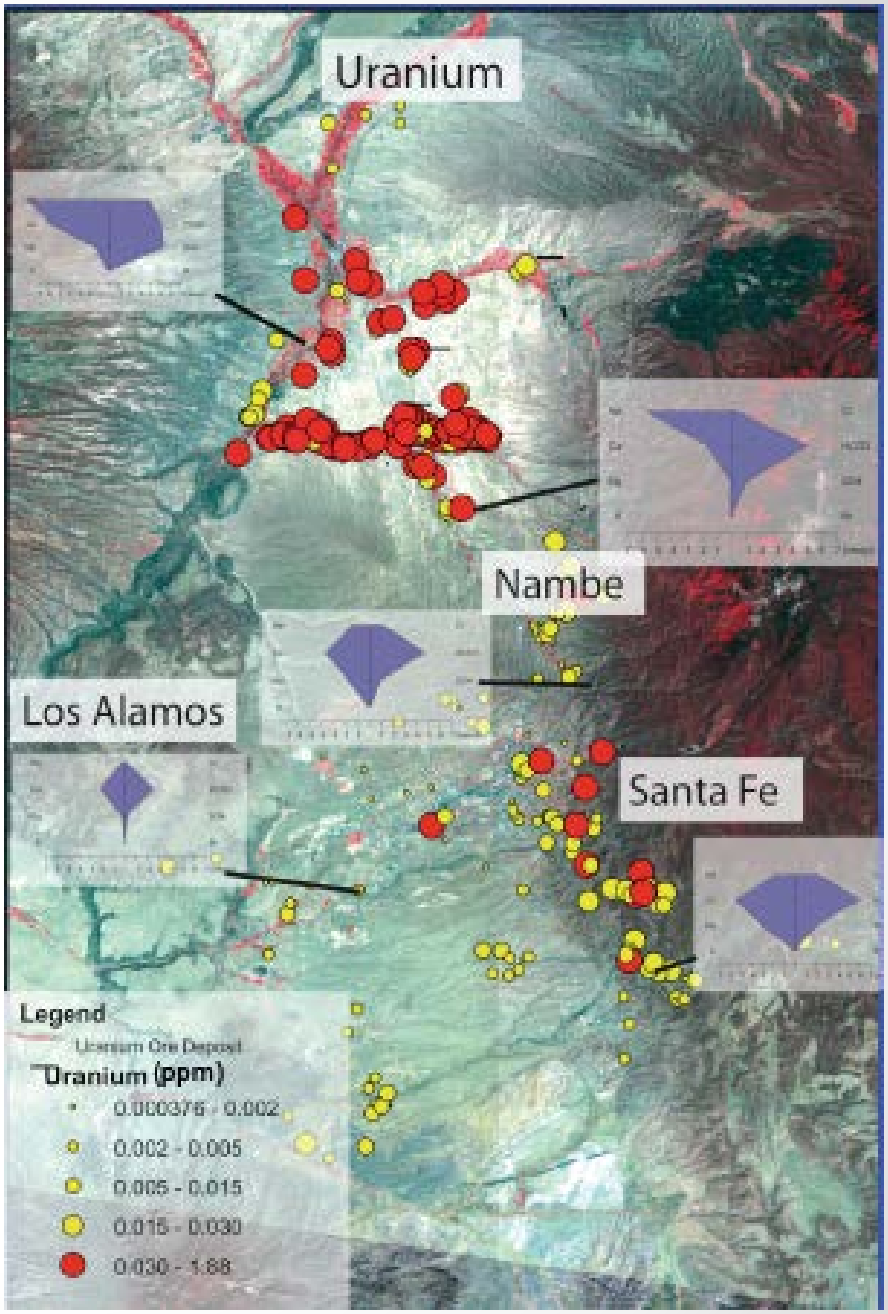
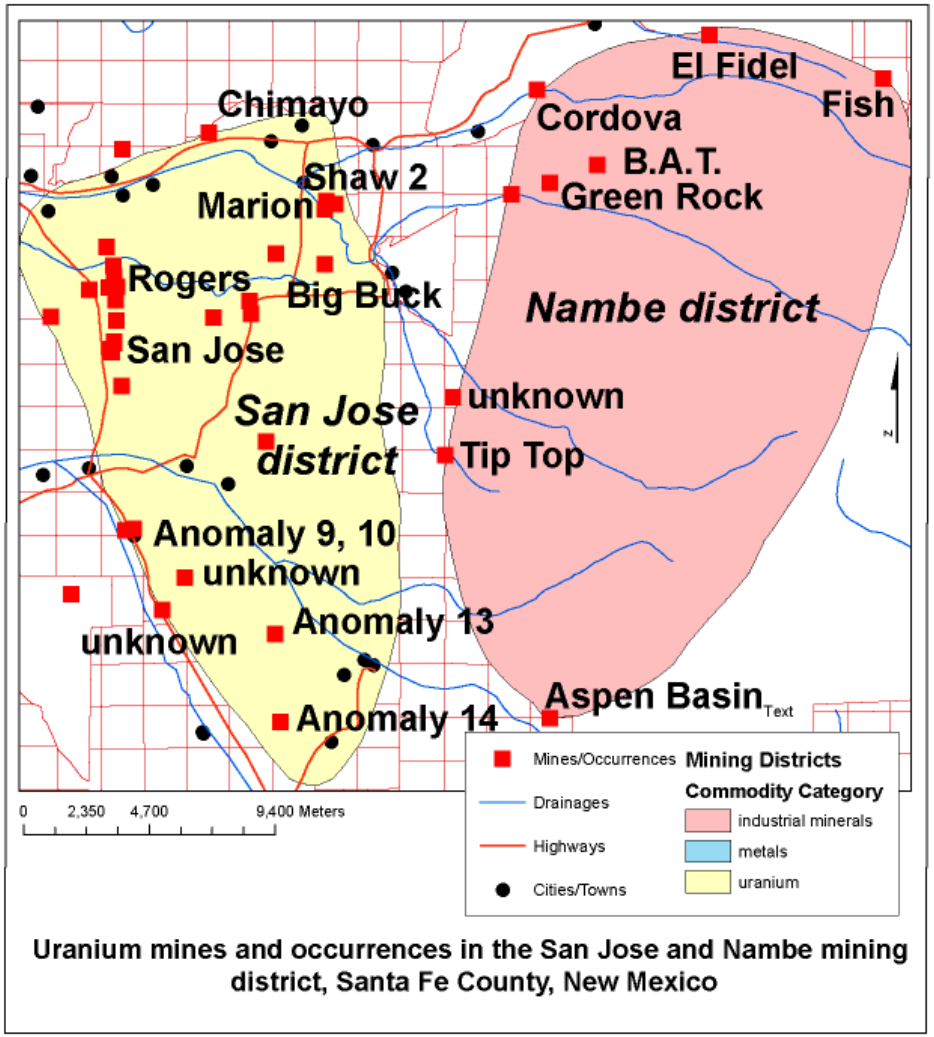
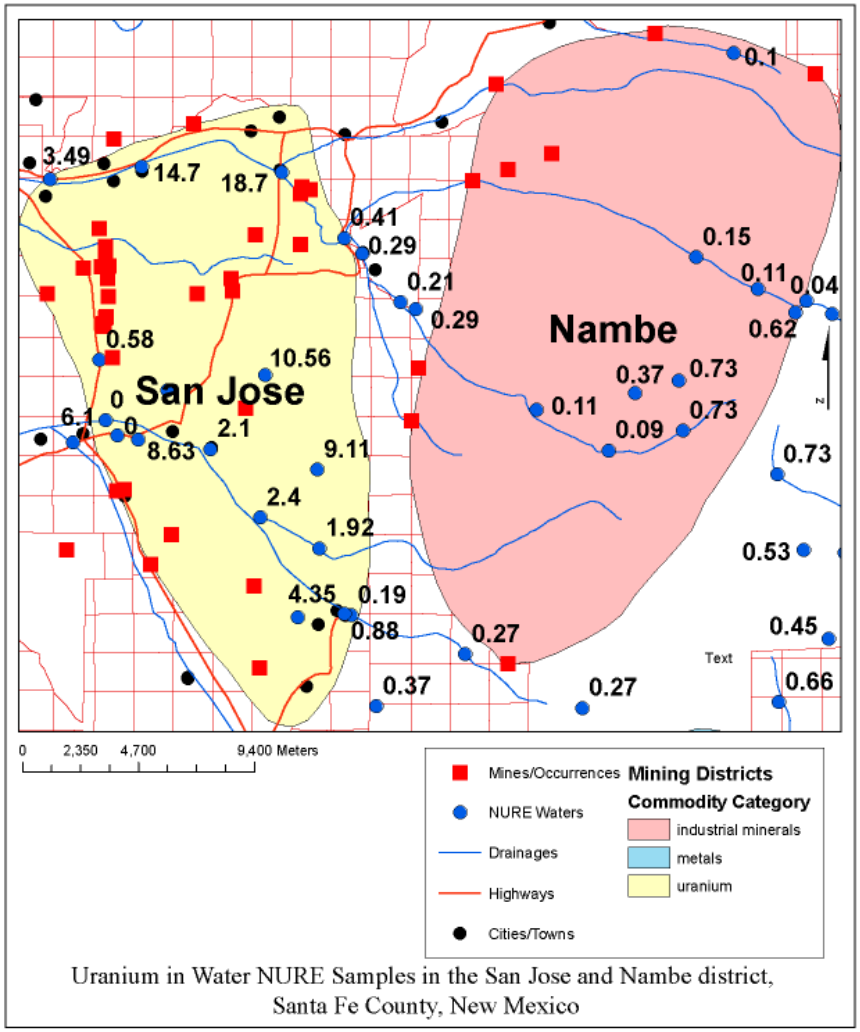
- Sampling by the New Mexico Environment Department and Los Alamos National Laboratory have shown elevated concentrations of uranium in drinking water in the Española Basin
- Many samples have concentrations of dissolved uranium that exceed 100 μg/L and some as much as 1,820 μg/L within the Española Basin





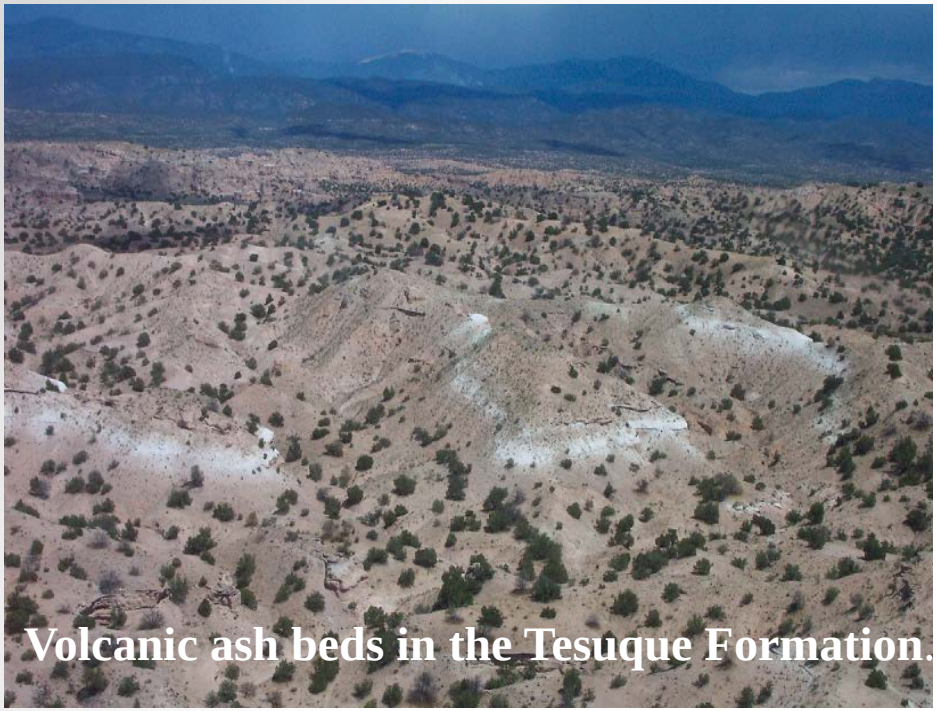
Uranium mines and occurrences in the San Jose and Nambe mining district, Santa Fe County, New Mexico



Uranium in Water NURE Samples in the San Jose and Nambe district, Santa Fe County, New Mexico

Uranium prospects (red), mining districts (yellow, pink), water samples (blue) in the San Jose and eastern Nambe mining districts, Santa Fe County

SOURCE OF URANIUM



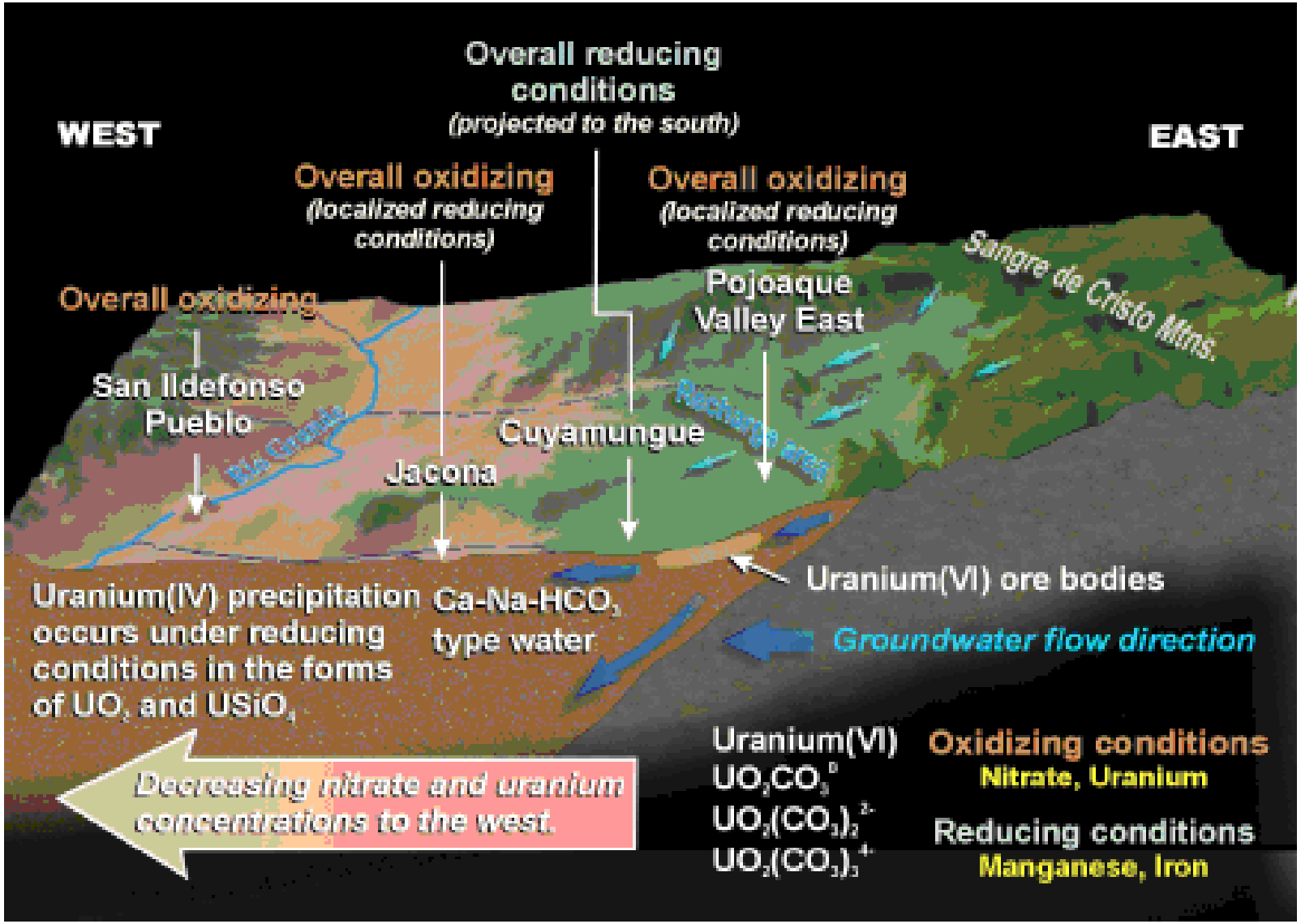
Volcanic ash beds in the Tesuque Formation.

Shaw No. 2 prospect

Reworked ash beds

Uranium with clay galls and organic material, San Jose mine

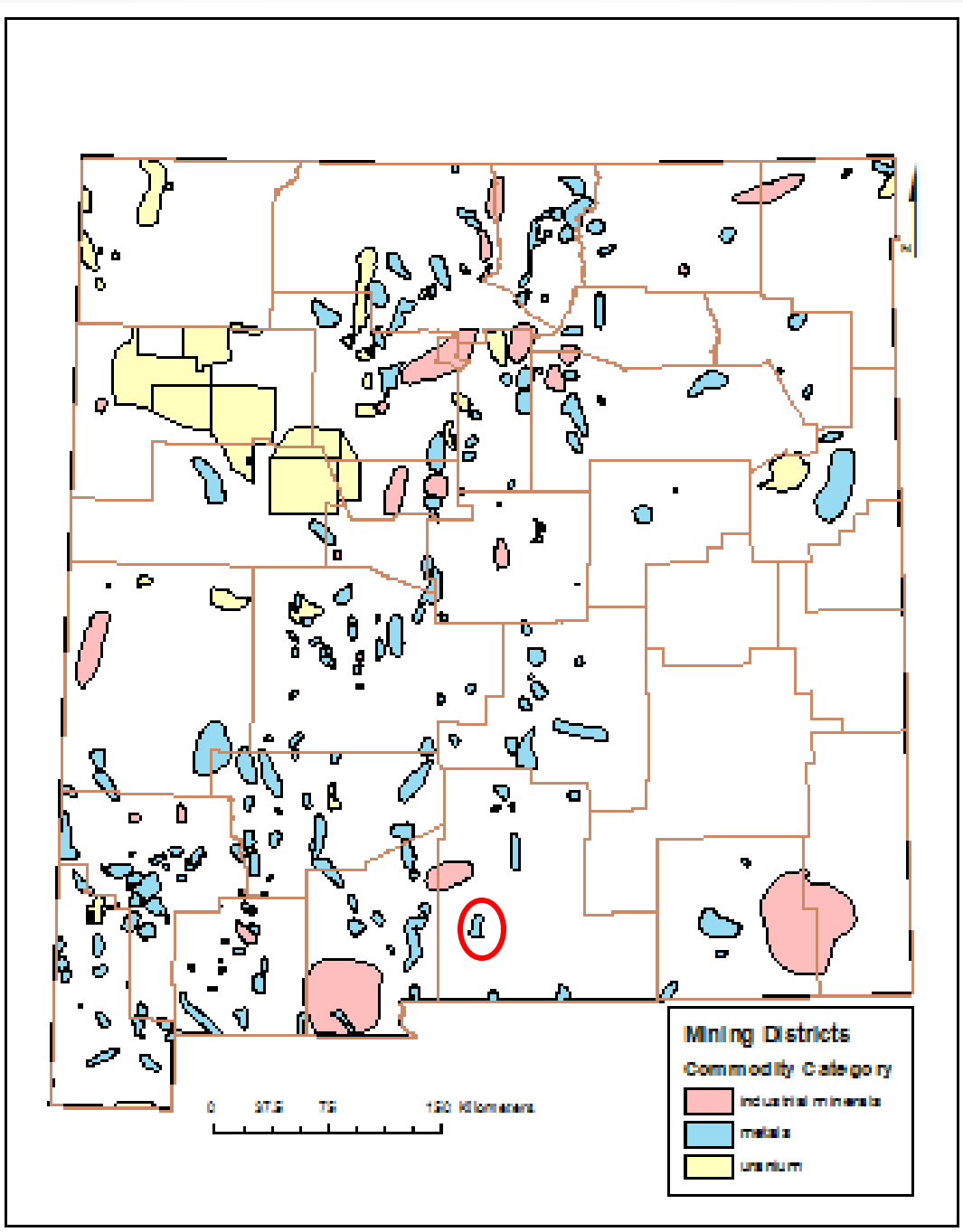
Hydrochemical Conceptual Model for Part of the Española Basin, New Mexico



Conclusions—U in Española Basin

- Uranium from
  - o Proterozoic granite, pegmatites, and veins
  - o Tesuque Formation sandstone U deposits
  - o Rhyolitic ash beds found interbedded within the Tesuque Formation
- Mineralization that is not of economic grade can be of great concern for contaminating water supply wells

Orogrande district, Otero County


Mining Districts
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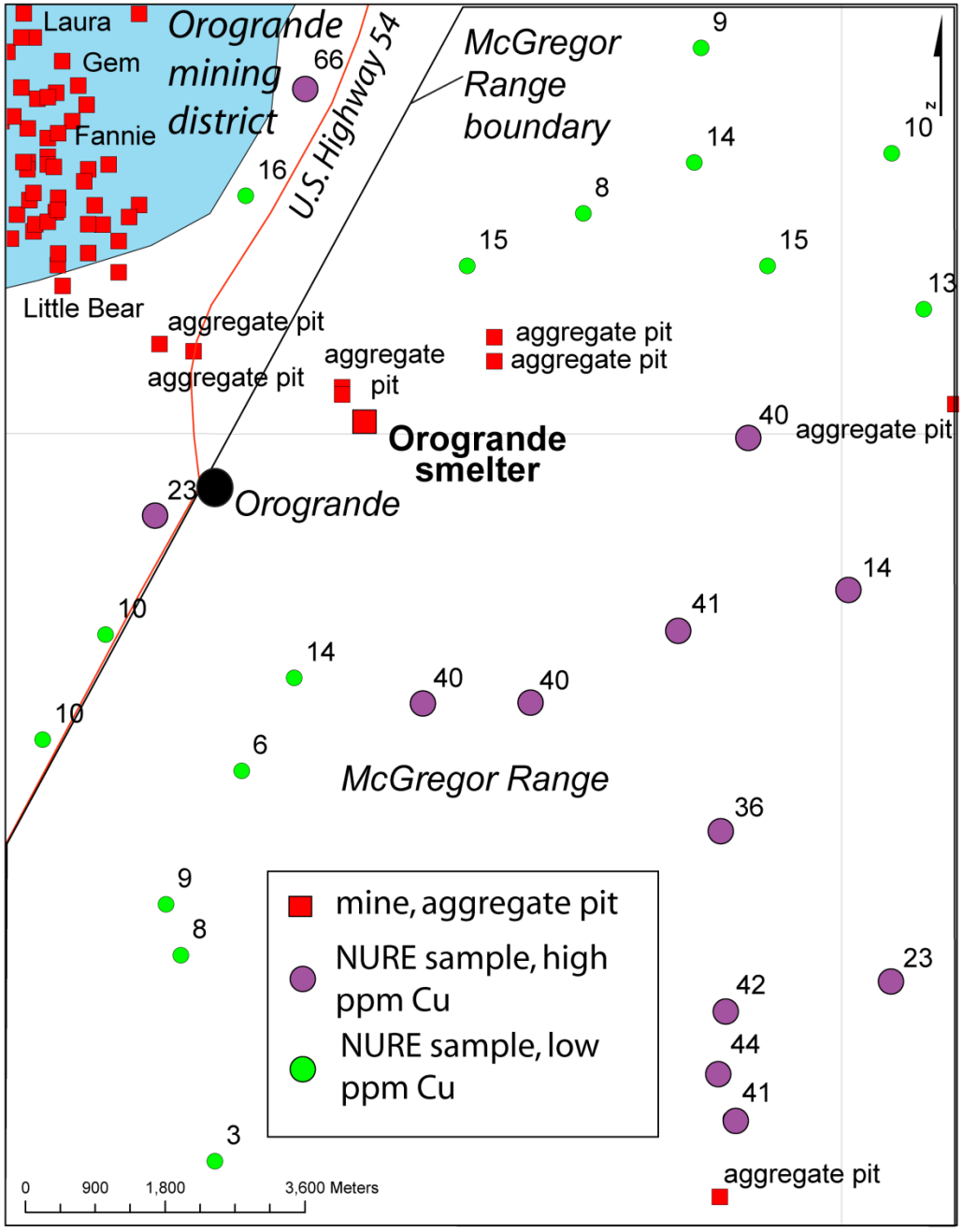
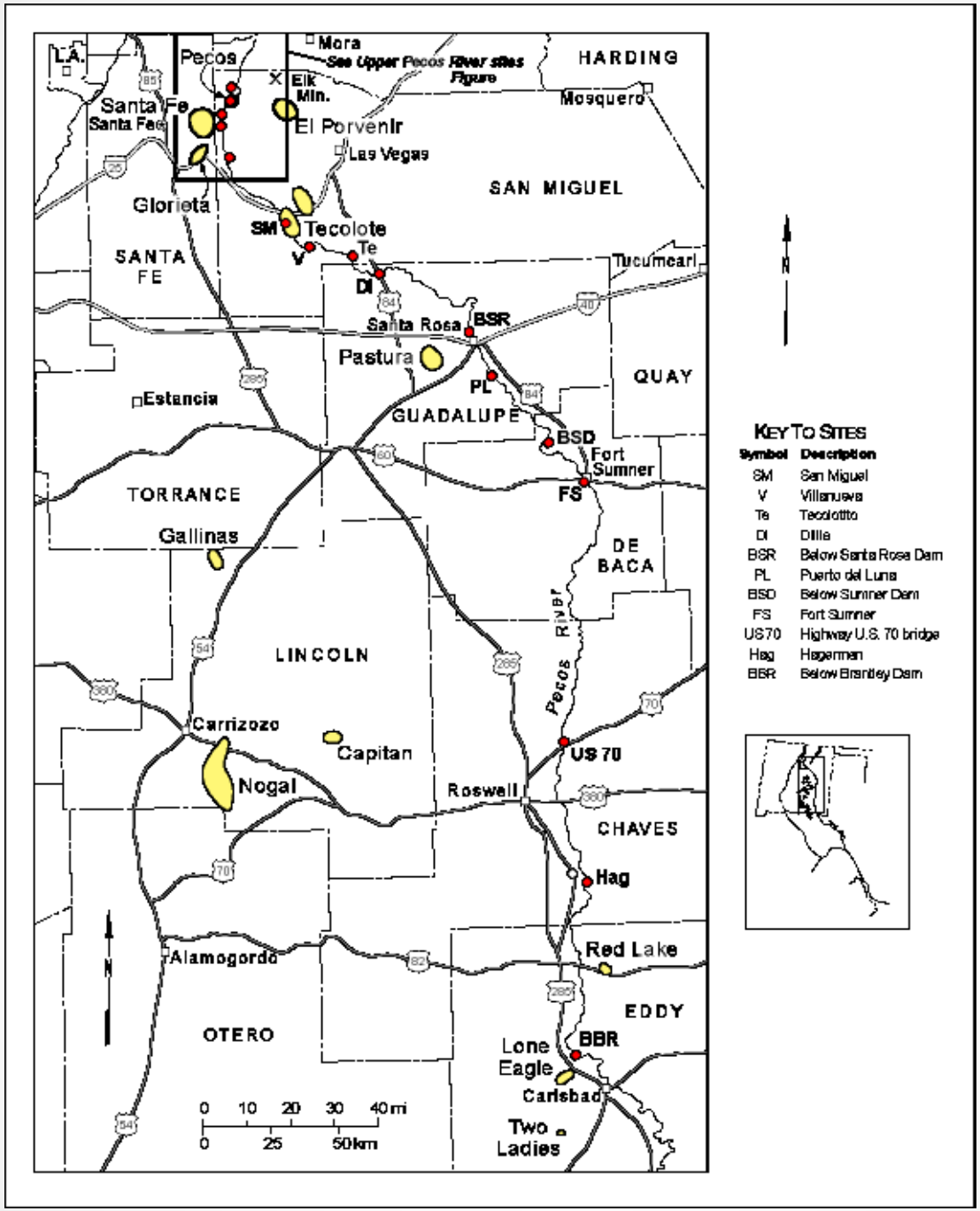


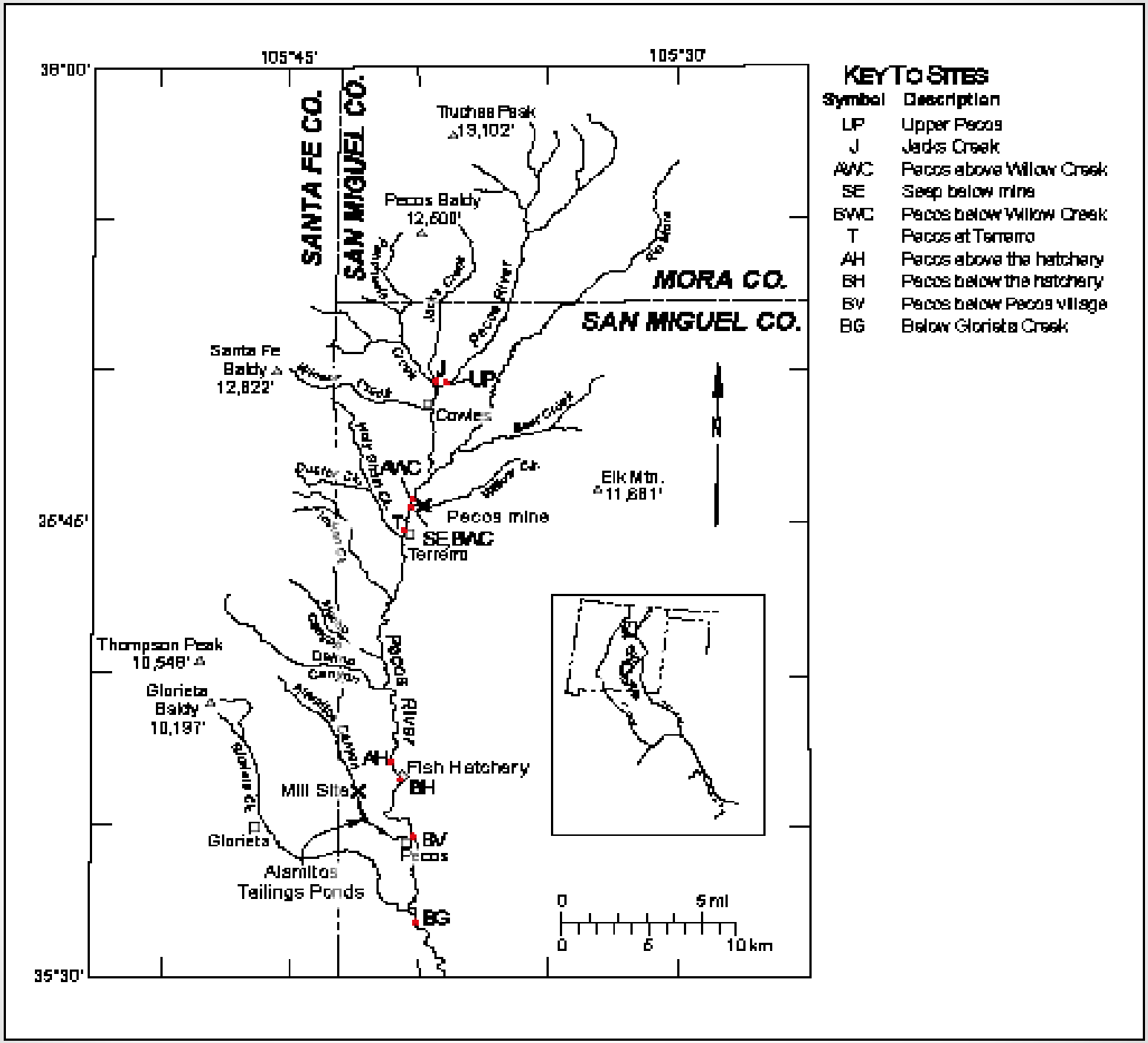
Copper in stream-sediment samples in the Orogrande area, Otero County. Note the samples (in purple) high in copper south and east of the Orogrande smelter (section 14, T22S, R8E) that is likely due to contamination from the smelter

Terrero (Pecos) mine, Willow Creek district, San Miguel County

Terrero (Pecos) mine

- Volcanogenic massive-sulfide deposit containing Pb, Zn, Cu, Ag, and Au as sulfide minerals with pyrite
- Mined on and off for 42 years beginning in 1902
- Generated ~70,000 m3 of waste rock, which was a source of acidic drainage
- The ore was shipped 18 km SW by aerial tram to the Alamitos Canyon mill where the mill tailings were deposited along Alamitos Canyon
- Point sources of contamination for Pb, Zn, Cu, Se, Cd, and Cr
- Reclamation began in the early 1990s until about 2003
- 9 yr study (1992-2000) of geochemistry of stream sediments and water along the Pecos River

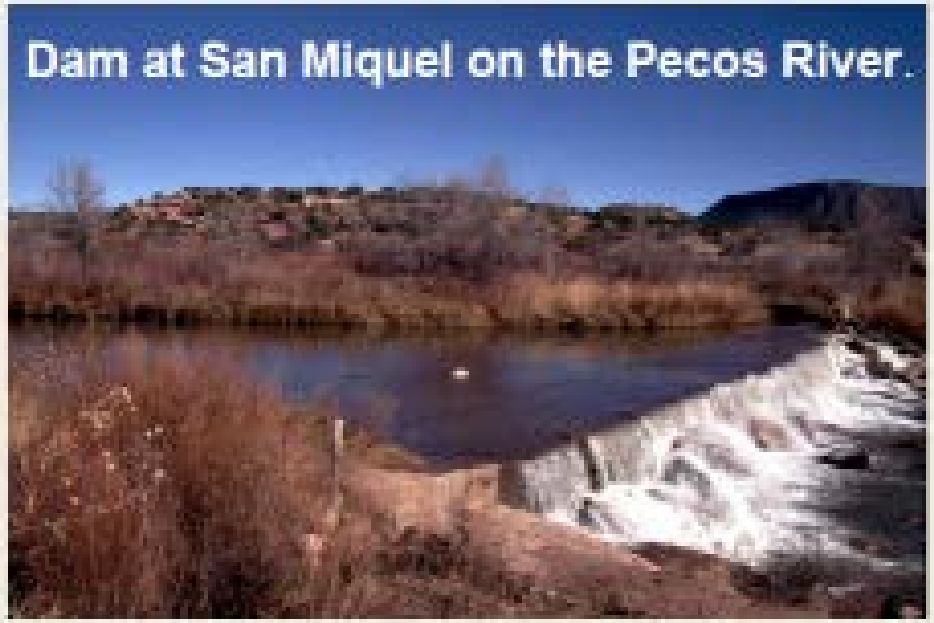

L.A.
Pecos
Mora
See Upper Pecos River sites Figure
HARDING
Elk Min.
Santa Fe
Santa Fe
El Porvenir
Mosquero
Las Vegas
SAN MIGUEL
Glorieta
SM
Tecolote
Te
V
SANTA FE
Tucumcari
DI
Santa Rosa
BSR
Pastura
QUAY
PL
Estancia
GUADALUPE
BSD
Fort Sumner
FS
TORRANCE
Gallinas
DE BACA
Pecos River
LINCOLN
Carrizozo
Capitan
US 70
Nogal
Roswell
CHAVES
Hag
Alamogordo
Red Lake
EDDY
OTERO
BBR
Lone Eagle
Carlsbad
Two Ladies
0 10 20 30 40 mi
0 25 50km
N
KEY TO SITES
Symbol Description
SM San Miguel
V Villanueva
Te Tecolotto
DI Dilia
BSR Below Santa Rosa Dam
PL Puerto del Luna
BSD Below Sumner Dam
FS Fort Sumner
US70 Highway U.S. 70 bridge
Hag Hagerman
BBR Below Brantley Dam

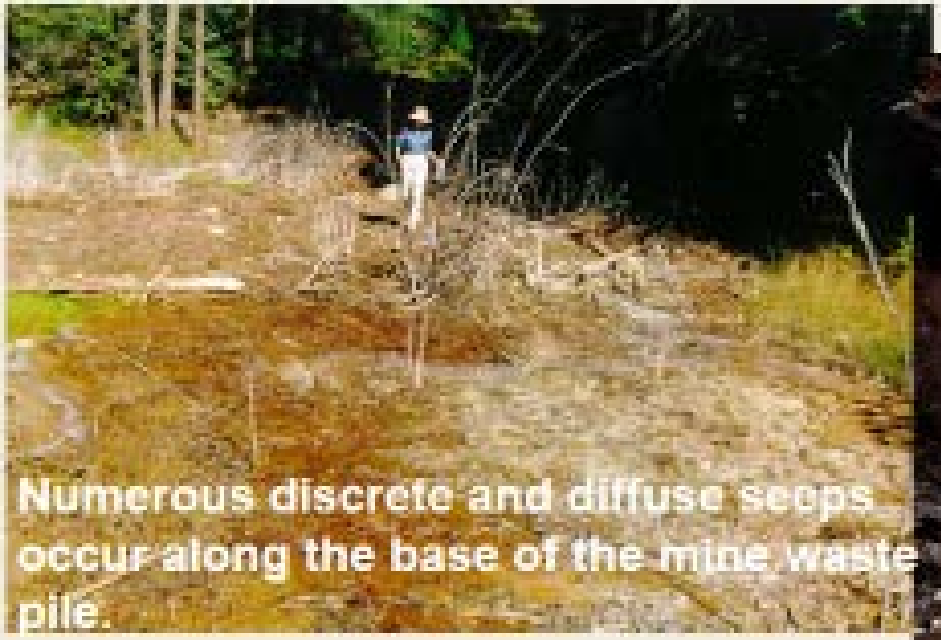


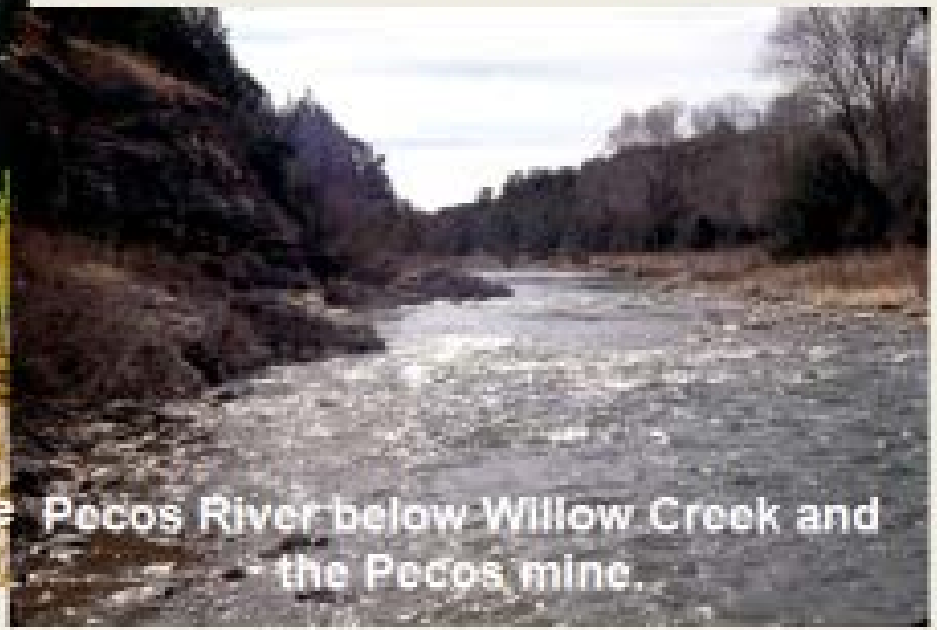
KEY TO SITES

Symbol	Description
UP	Upper Pecos
J	Jacks Creek
AWC	Pecos above Willow Creek
SE	Seep below mine
BWC	Pecos below Willow Creek
T	Pecos at Terrero
AH	Pecos above the hatchery
BH	Pecos below the hatchery
BV	Pecos below Pecos village
BG	Below Glorieta Creek

Pecos River area—stream sediments draining a VMS deposit


Dam at San Miquel on the Pecos River.


Numerous discrete and diffuse seeps occur along the base of the mine waste pile.

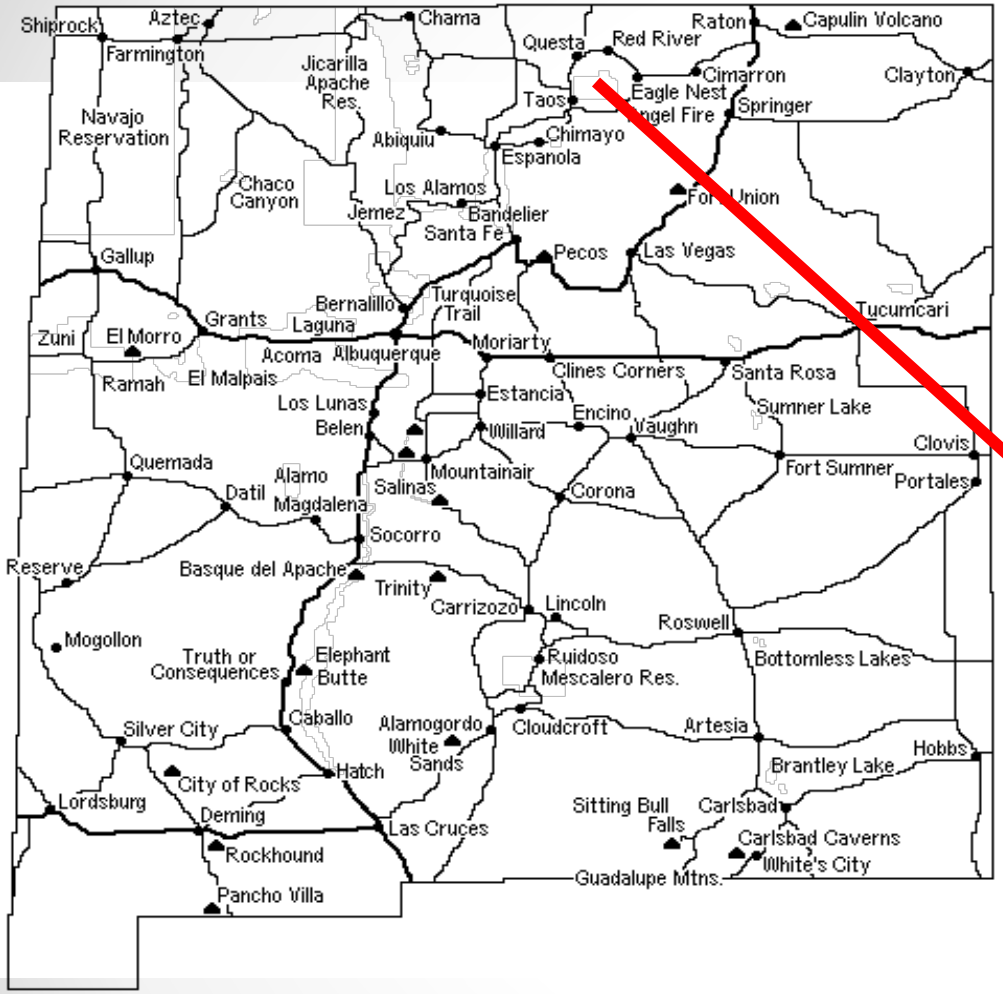

Pecos River below Willow Creek and the Pecos mine.

Conclusions—Terrero mine

- Cu, Pb, Zn, and other metals were eroded and leached from the Terrero mine waste pile and the tailings
- Overall metal concentrations dramatically decrease in stream sediments below Pecos Village, mostly due to dilution of sediment derived from the red bed sedimentary units
- Decrease in concentrations with time since reclamation began, especially in the immediate vicinity of the Pecos mine
  - Cu levels from 310 to 92 ppm
  - Cd from 17 to 4.7 ppm
  - Pb from 300 to 160 ppm
  - Zn from 3100 to 2080 ppm

Questa weathering study, Taos County

Questa mine is located 5 miles east of the town of Questa in Taos County in north central New Mexico.



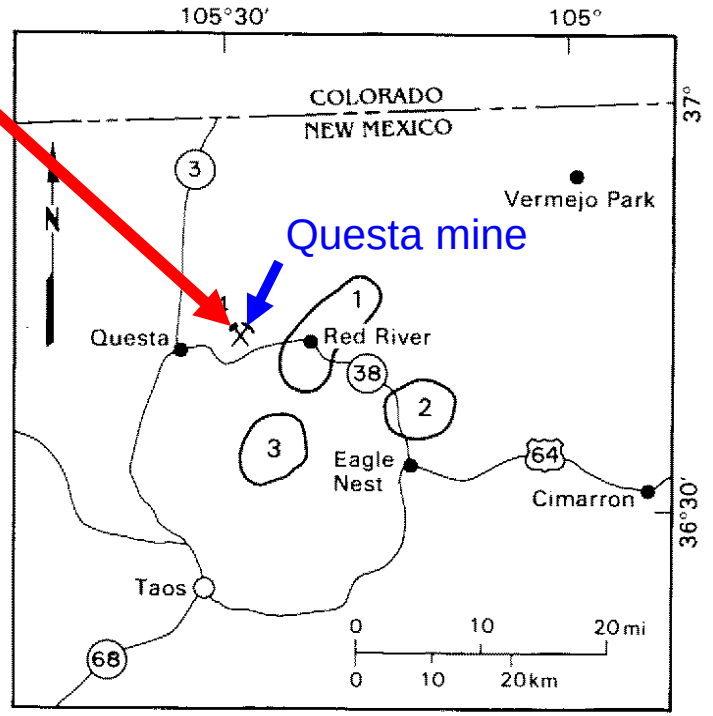
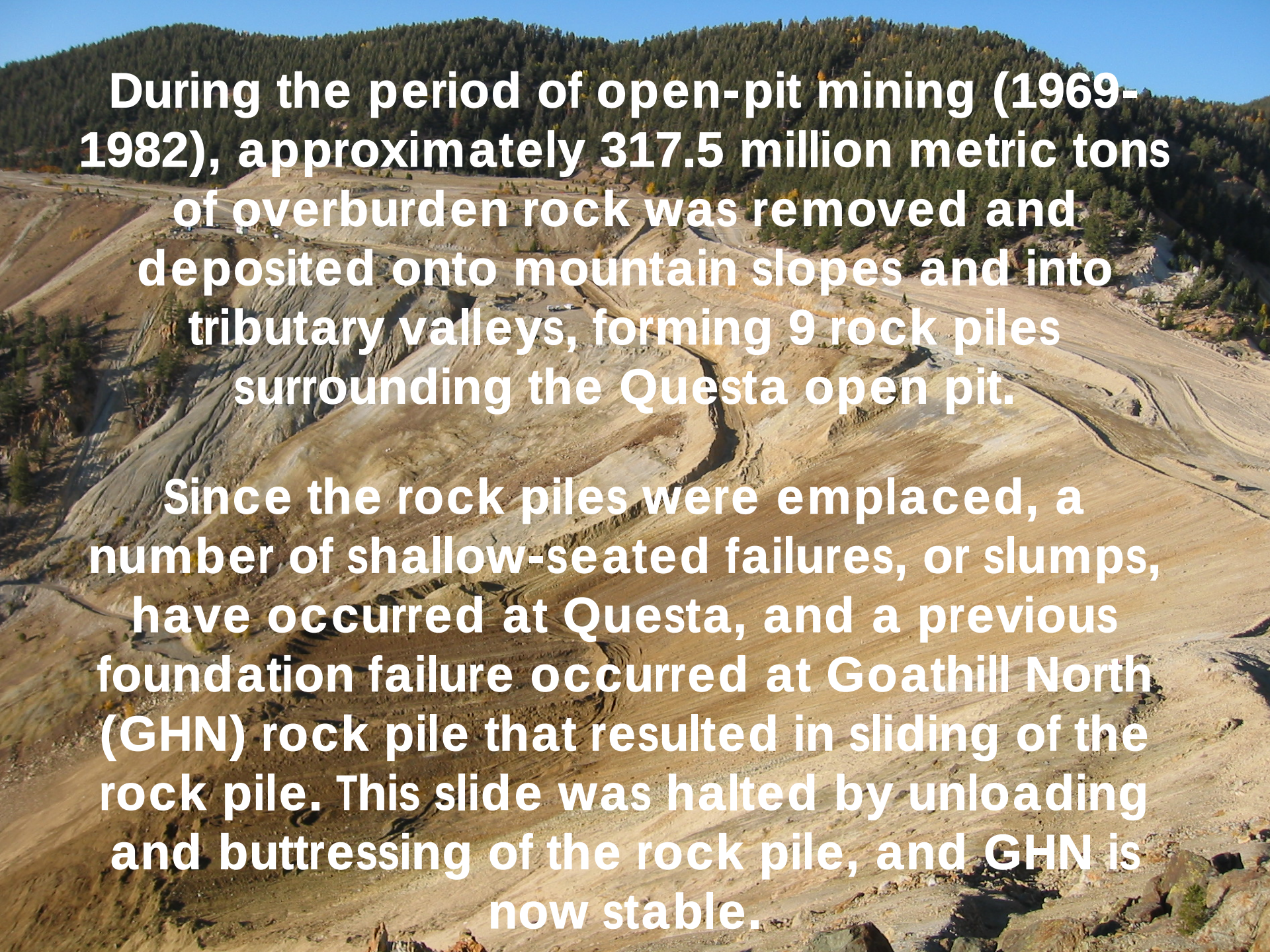


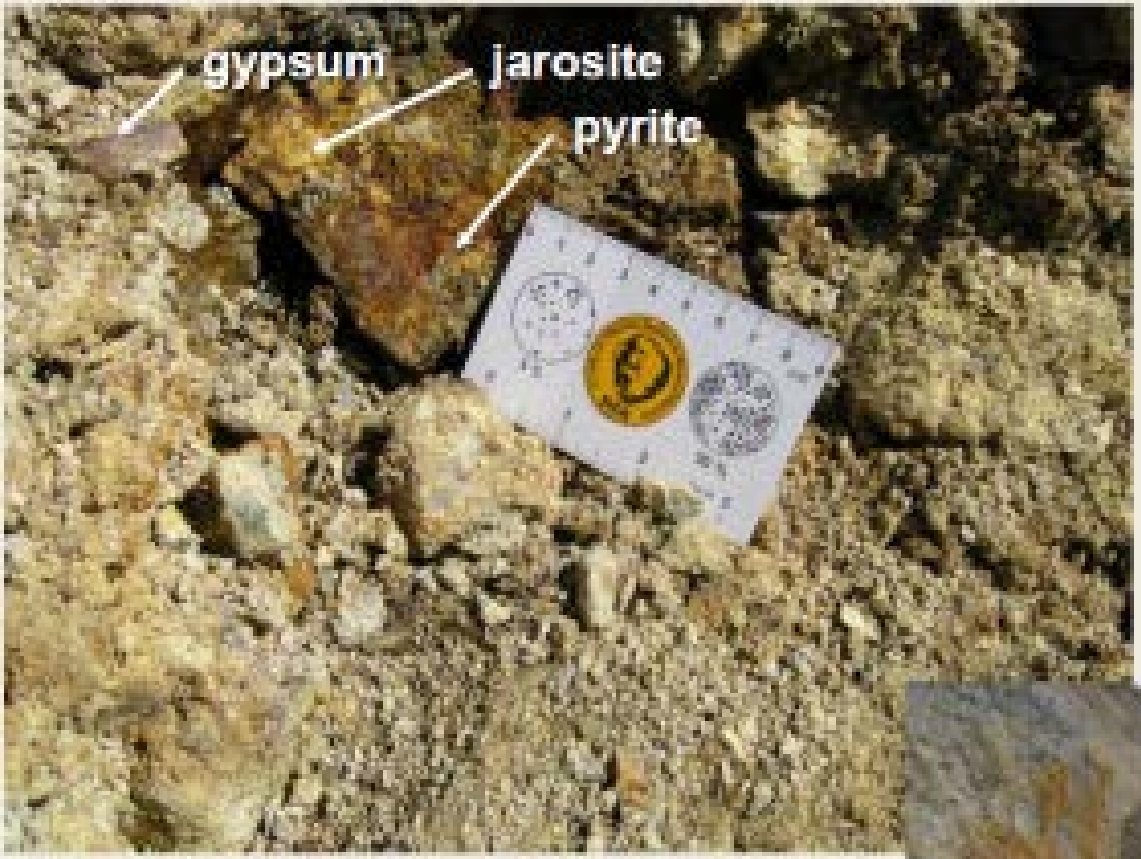
FIGURE 1. Location map of the Red River mining district. 1 = Red River district; 2 = Elizabethtown-Baldy district; 3 = Twining district; 4 = Molycorp Questa mine.



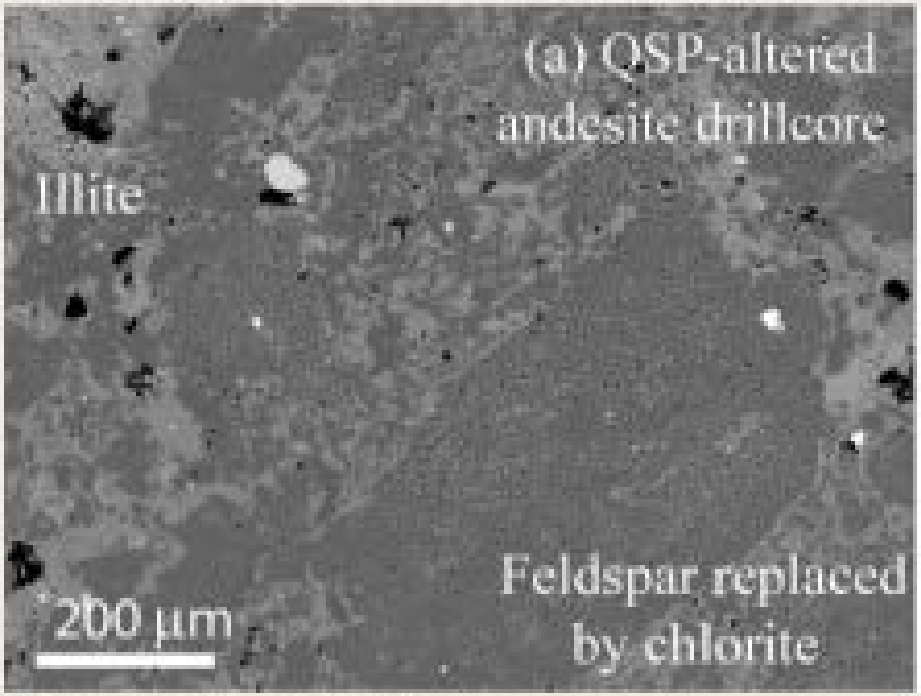
During the period of open-pit mining (1969-1982), approximately 317.5 million metric tons of overburden rock was removed and deposited onto mountain slopes and into tributary valleys, forming 9 rock piles surrounding the Questa open pit.

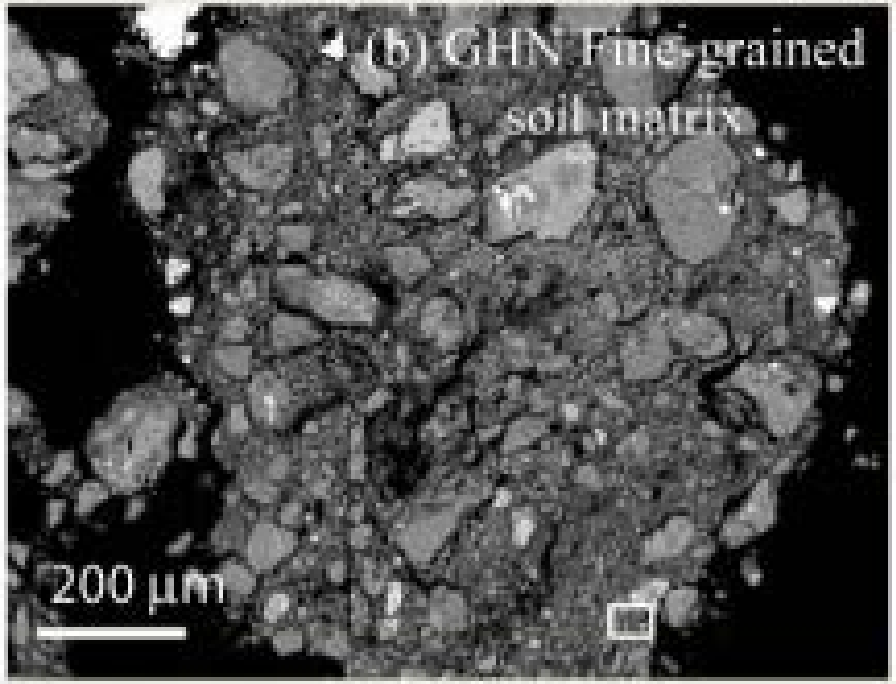
Since the rock piles were emplaced, a number of shallow-seated failures, or slumps, have occurred at Questa, and a previous foundation failure occurred at Goathill North (GHN) rock pile that resulted in sliding of the rock pile. This slide was halted by unloading and buttressing of the rock pile, and GHN is now stable.

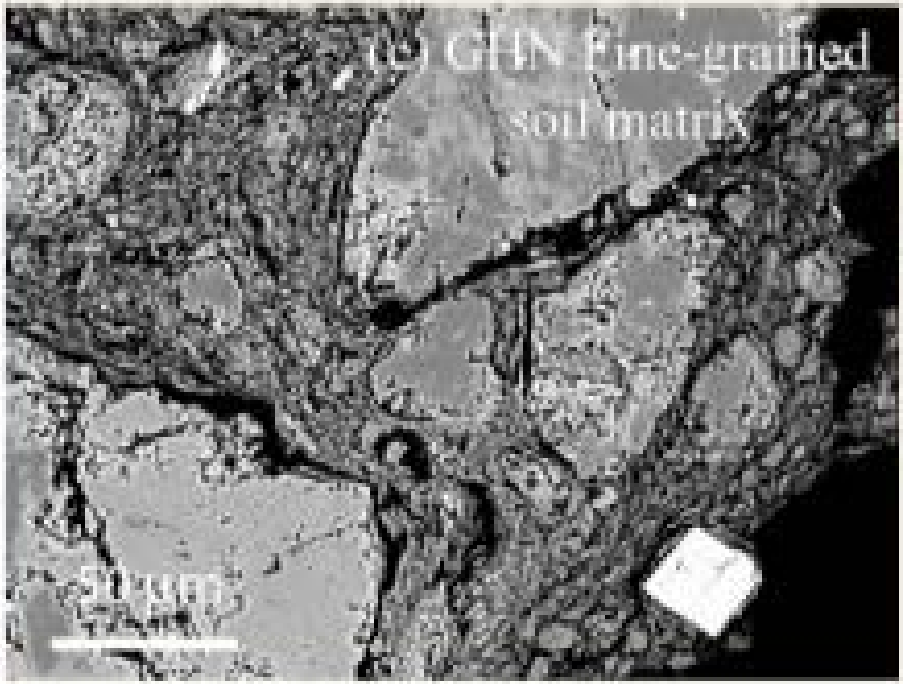
weathering


gypsum
jarosite
pyrite

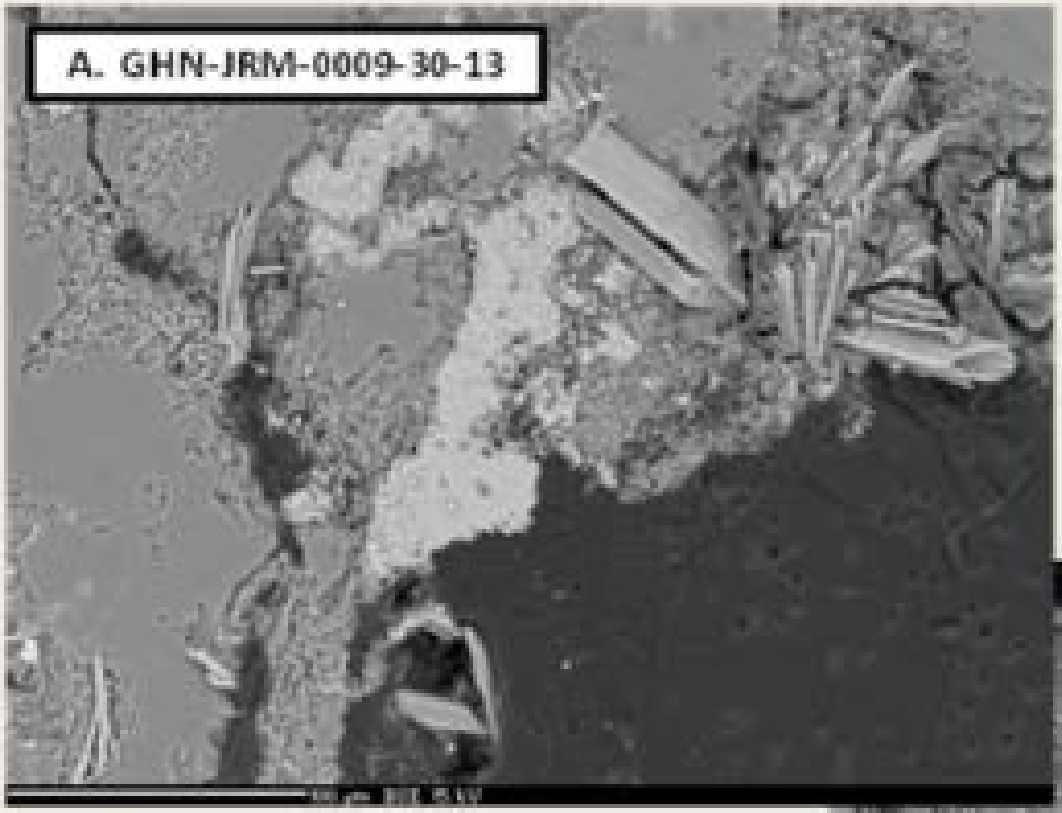

Shallow Slope Failure After Rain on
Sugar Shack West

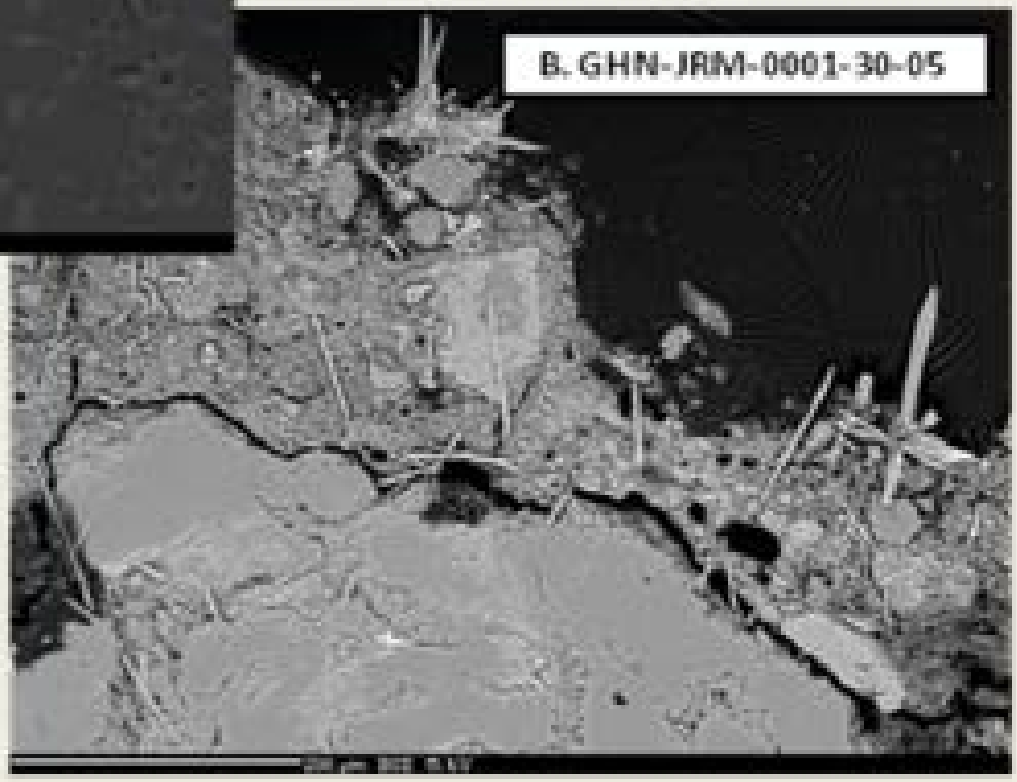






Weathering—In rock piles, the fine-grained soil matrix is weathered, while interiors of rock fragments are not





These are typical weathering textures. Note the lack of weathering of the rock fragments.

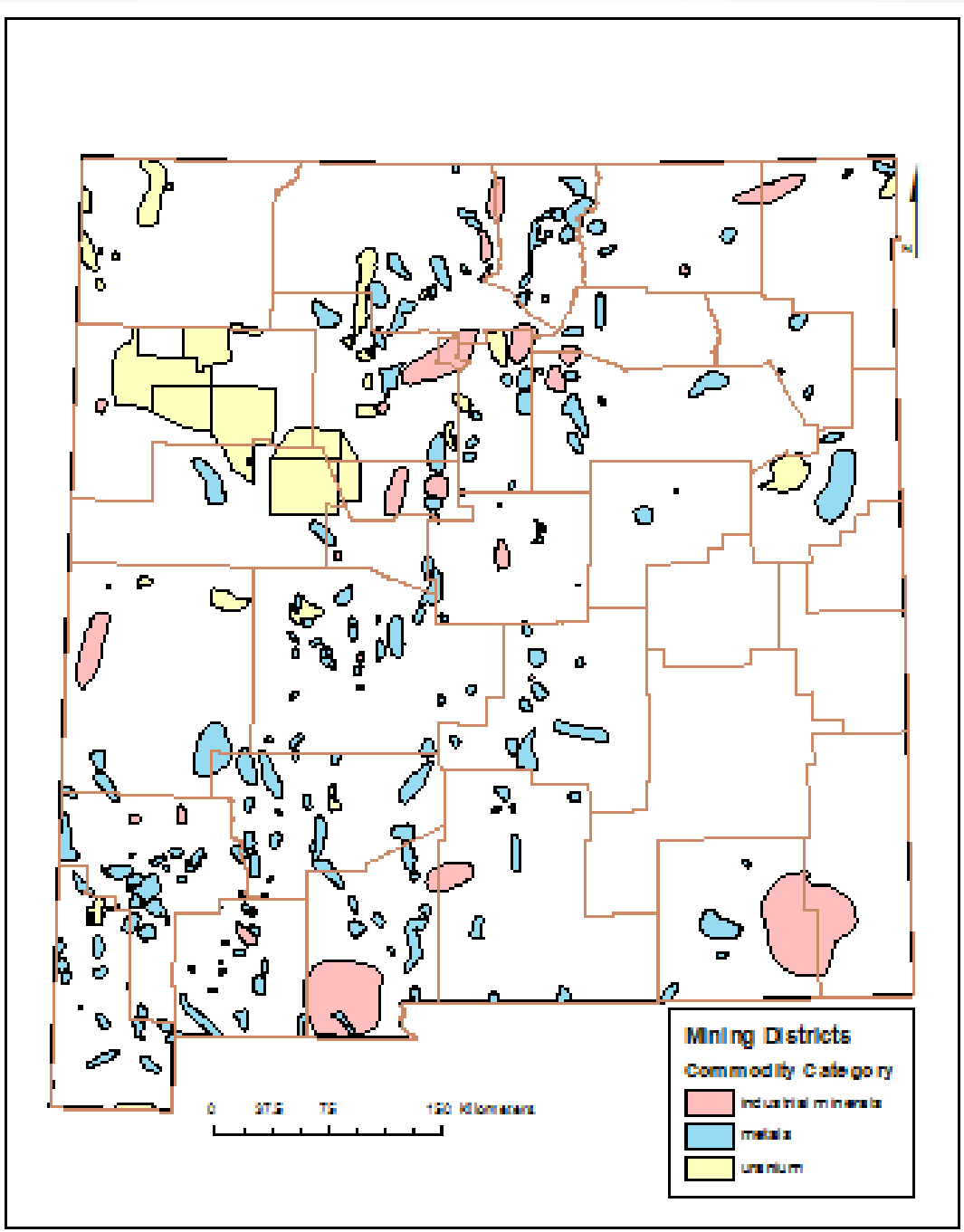
Conclusions—Questa

- Predominant weathering reactions in the GHN rock pile are oxidation of pyrite, dissolution of carbonate, and formation of sulfate minerals (gypsum, jarosite, and soluble, efflorescent salts)
- Clays are predominantly from the pre-mining hydrothermal alteration, not the result of chemical precipitation in the rock piles under low pH during weathering over the last 25-40 years

Other data

Other data

- Geochemical analyses of mineral deposits throughout New Mexico
- Geochemical analyses of mine dumps in Sierra and Otero Counties


Mining Districts
Commodity Category
industrial minerals
metals
uranium
0
37.5
75
150 Kilometers

LESSONS LEARNED

- NURE data provides a first order of geochemical background conditions in NM, especially for U
- Some areas in NM have elevated U in water, which is a result of natural processes not mining
- Some areas in NM have elevated metals in stream sediments or soils, but not in water that are possibly a result of mining
- Weathering in most mine waste rock piles involve the oxidation of pyrite, dissolution of carbonate, and formation of sulfate minerals, but little if any clay minerals are forming as a result of weathering; instead the clays are from pre-mining altered rocks

LESSONS LEARNED

- Differences in chemistry of MIW within the various mining districts in NM are due to differences in geology, type of mineral deposits, and alteration of adjacent rocks, including weathering
- Each area is site-specific and must be examined in detail and over a period of time to determine the cause of the adverse MIW

LESSONS LEARNED

- However, as more people are building houses in and near mining districts, even natural geochemical anomalies could become a health problem and may have to be addressed in some manner
- More detailed sampling is required in these areas
- Additional analysis and evaluation of these data sets is on-going

More Information

- http://geoinfo.nmt.edu/staff/mclemore/projects/home.html
- http://geoinfo.nmt.edu/
- https://nmgs.nmt.edu/publications/guidebooks/home.cfm?ListBy=Number

- ginger@nmbg.nmt.edu