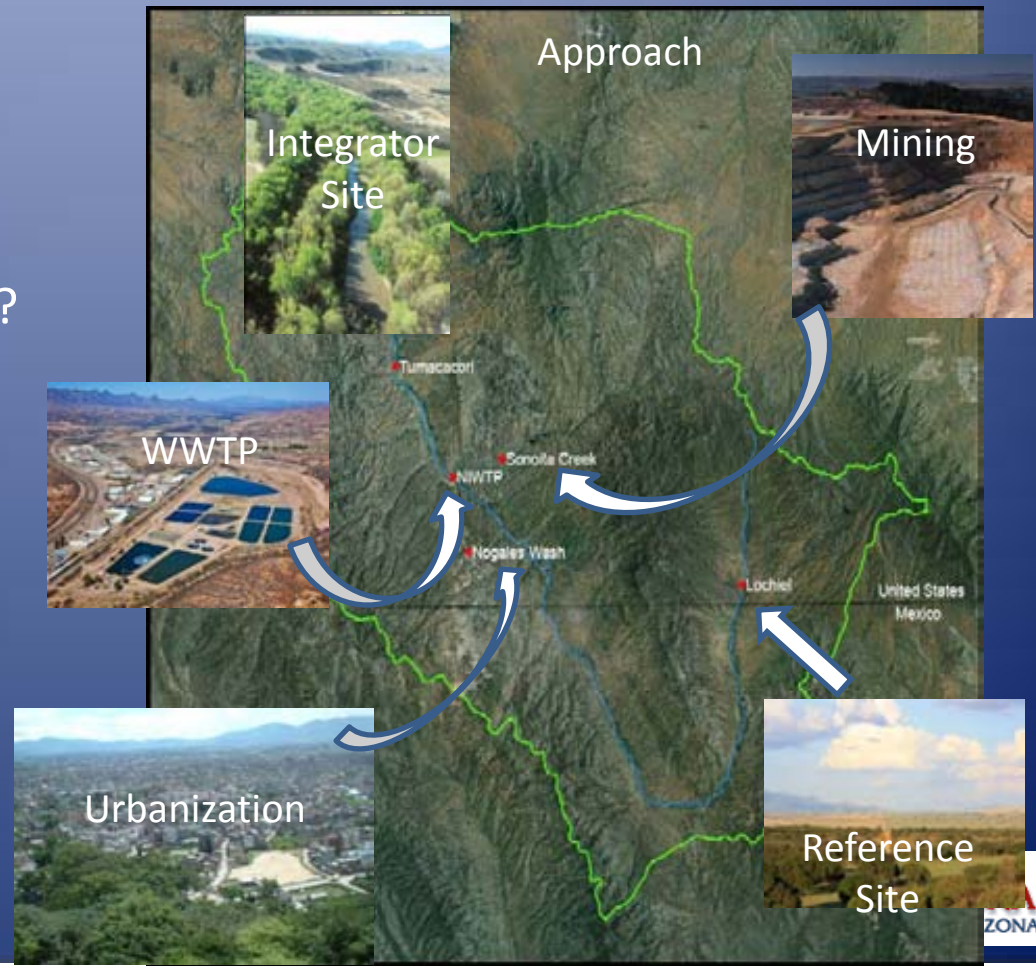


Linking hydrology, geology, geography, biology, and social science in the Upper Santa Cruz River Basin

James Callegary, Nick Paretti, Floyd Gray, Laura Norman, Kim Beisner, Katie Eddelman, Logan Matti, Diana Papoulias, Michael Lester, Charles van Riper, JR Bell, Rose McAndrew, Alexis Lincicome, Mark Brusseau, Dave Alvarez, Chris Scott, Prescott Vandervoet, and Sharon Megdal

Border Environmental Health Initiative

- Identify risks to water resources and the potential consequences to riparian ecosystems and ultimately human health.
- What inorganic and organic contaminants are present?
- What are the concentrations?
- What is the distribution of contaminants in the biotic and abiotic system?

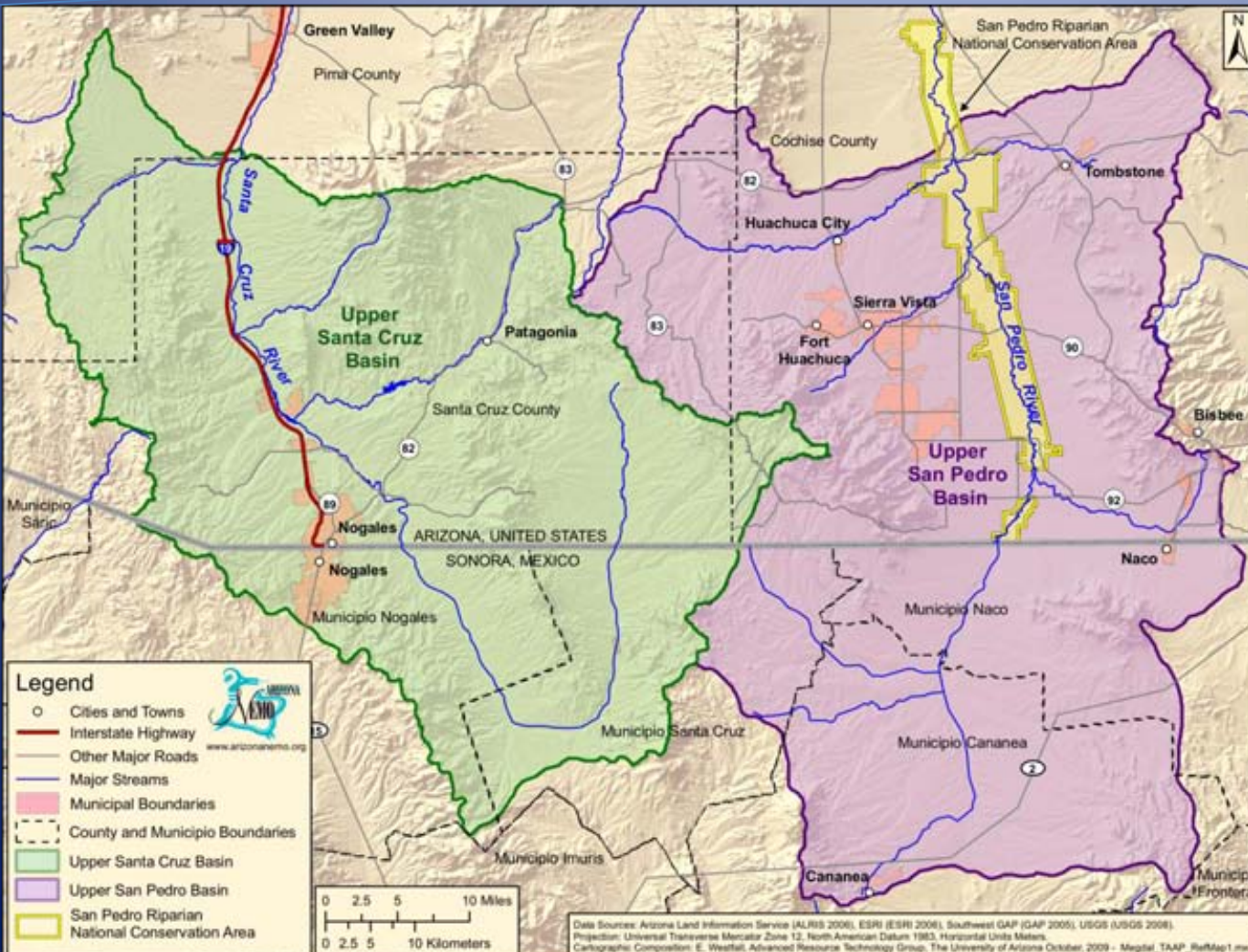


Approach

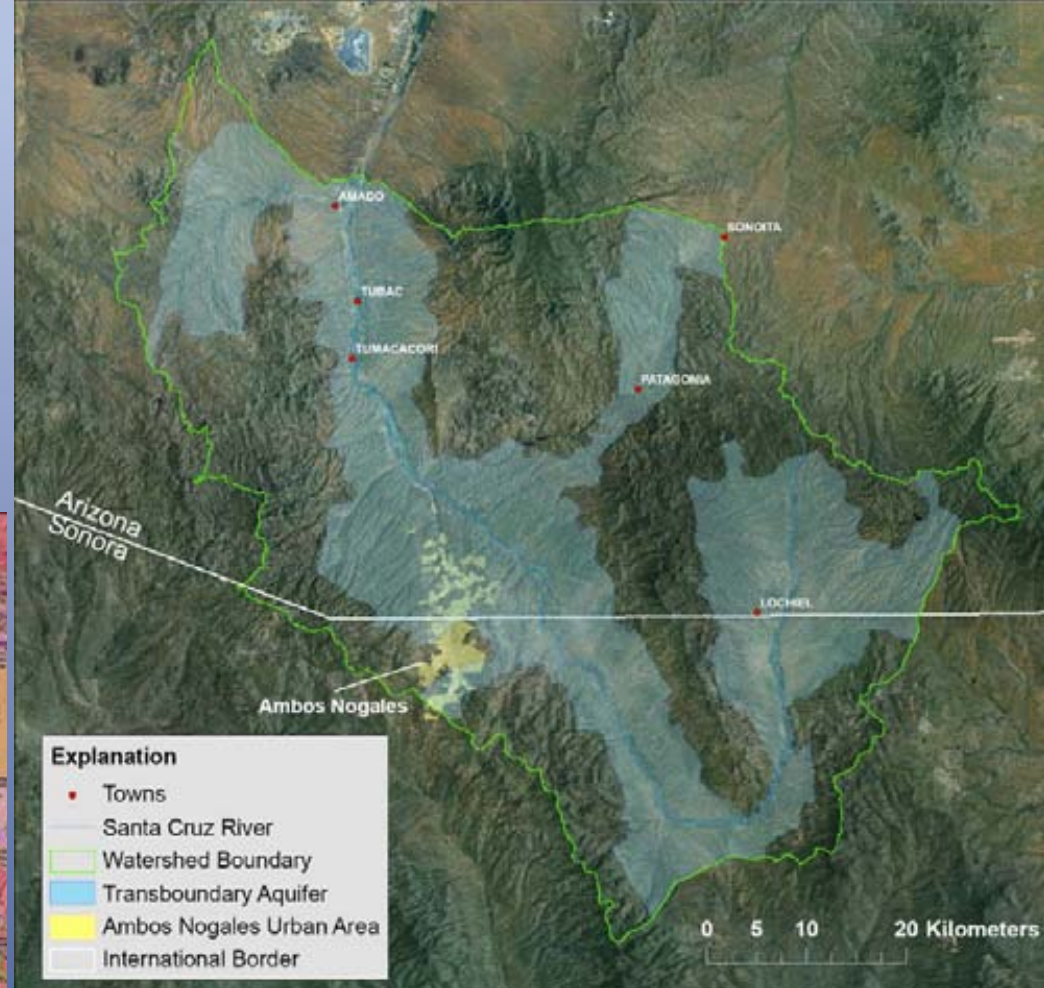
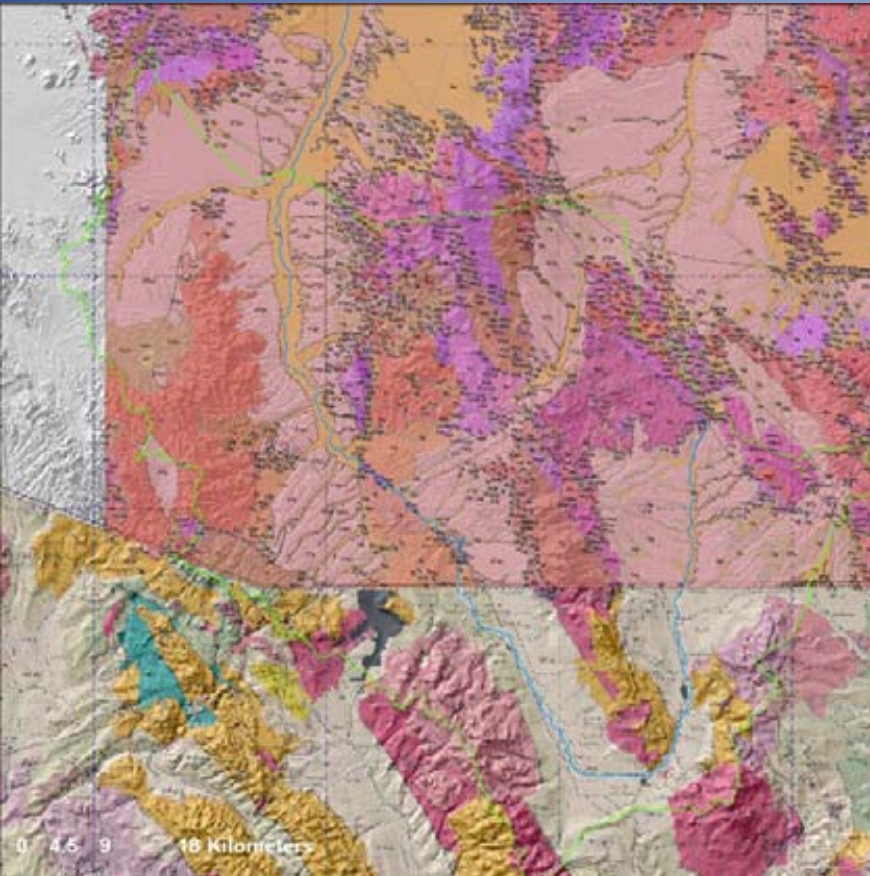
- Identify and quantify organic and inorganic contaminants in water, sediment, plants, aquatic macroinvertebrates, and fish at the 5 locations within the Watershed



US-Mexico Transboundary Aquifer Assessment Program Arizona-Sonora



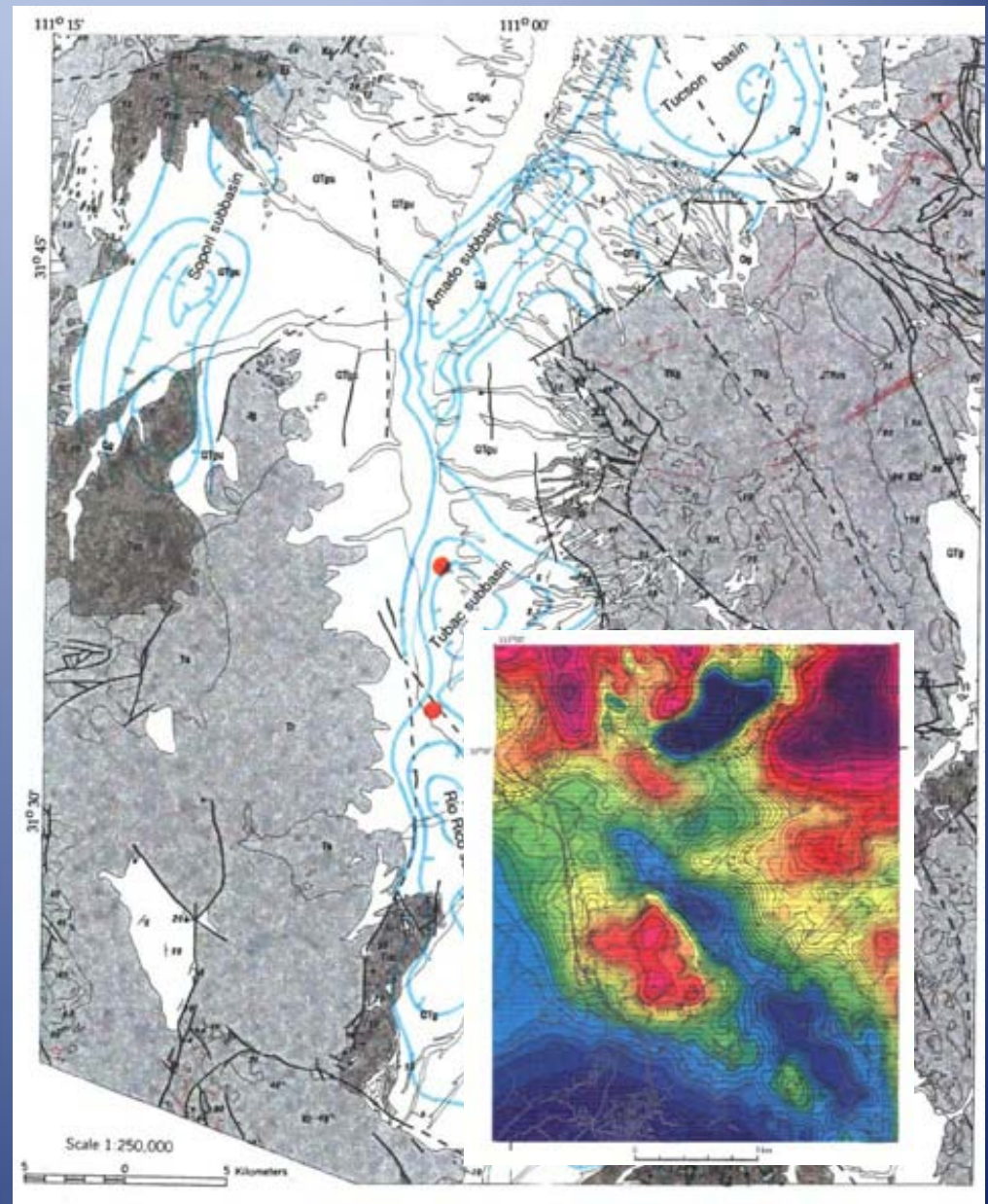
USGS Geologic Mapping Program



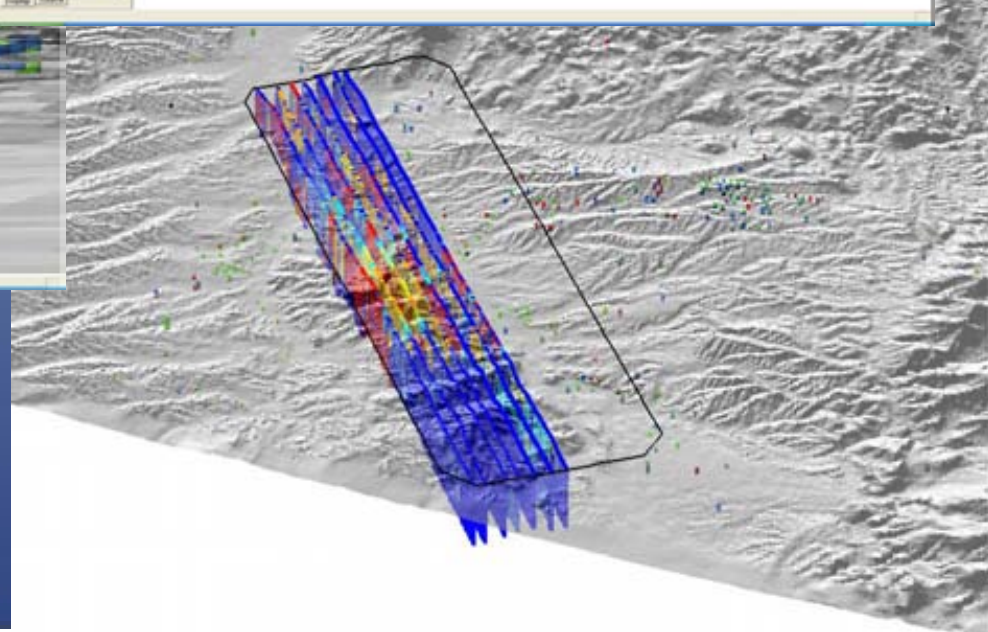
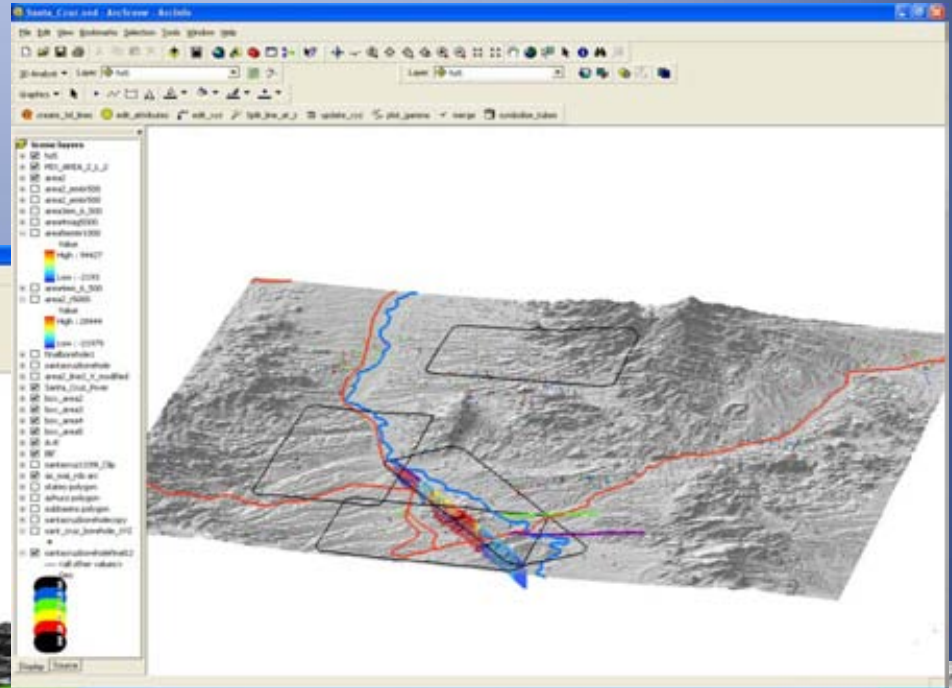
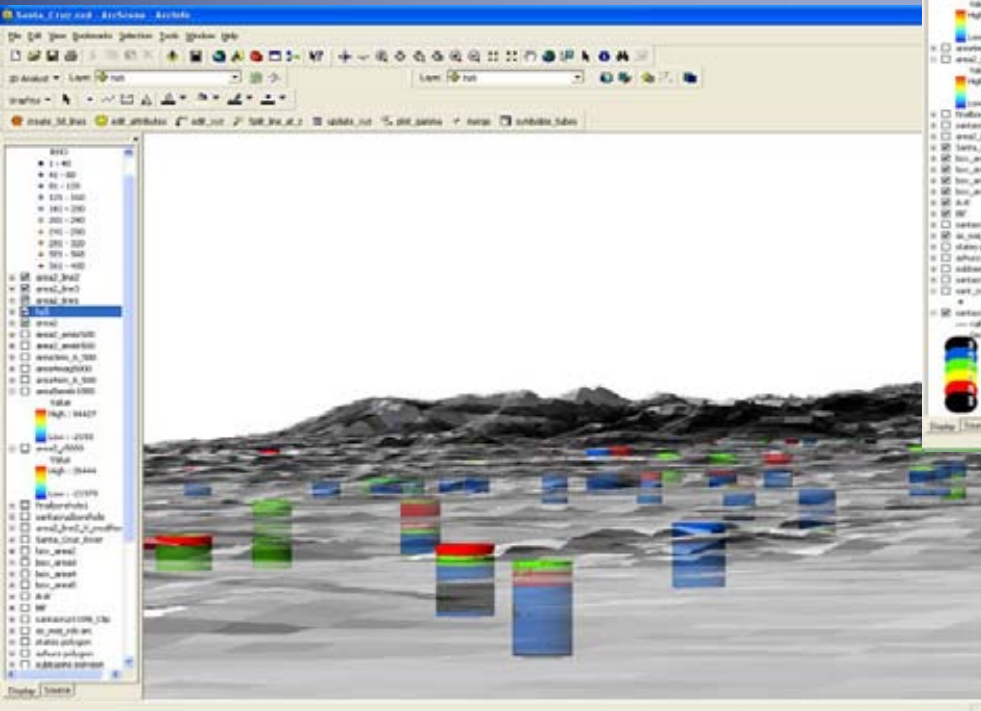
Aquifer Maps

Hydrogeologic Framework: Gravity and Magnetics (Gettings y Houser, 1997, USGS)

- Future work?: 3D gravity and magnetic modeling



Well Data and Airborne Geophysics





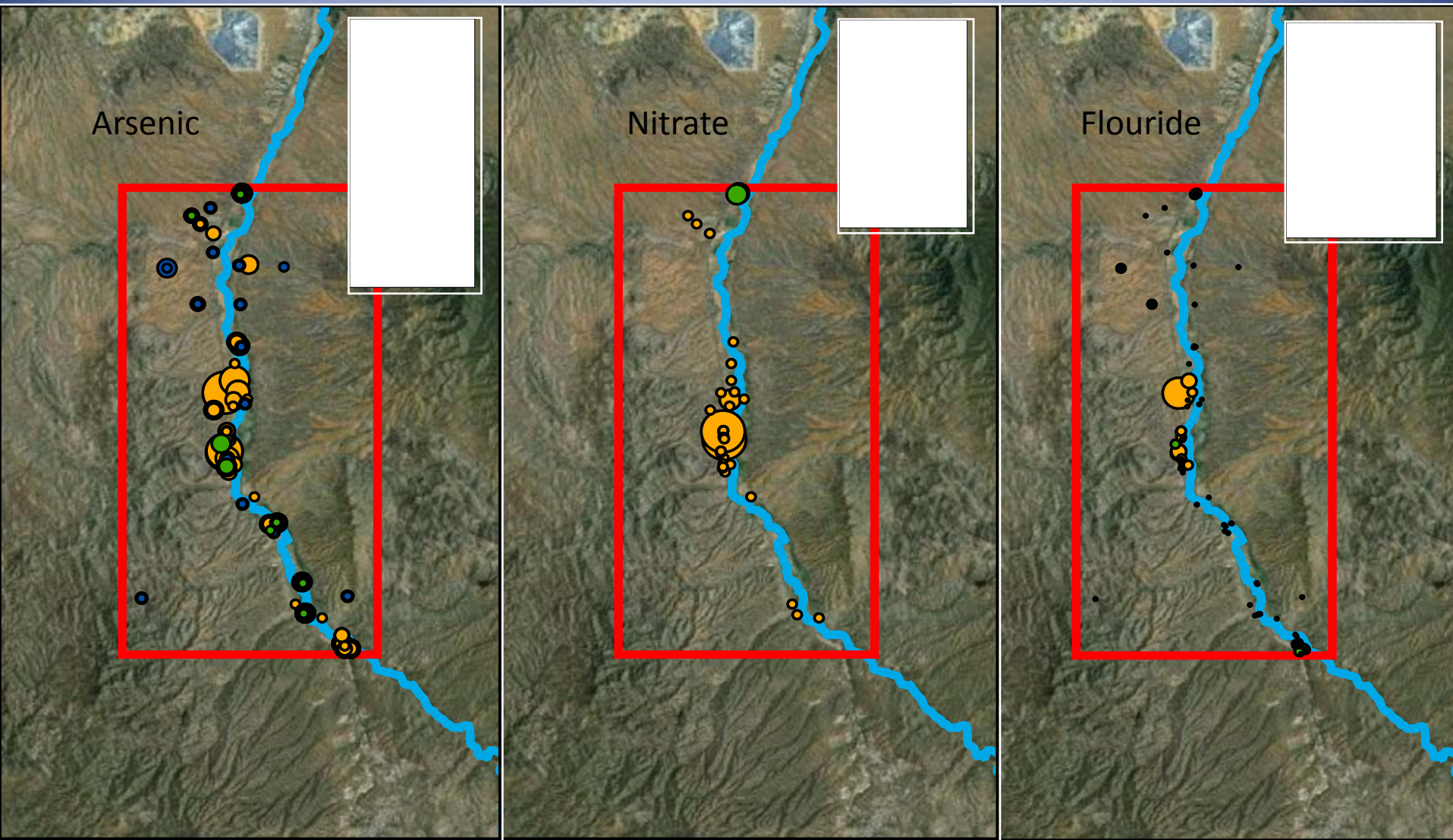
New Geophysical Surveys: Ground-based TEM



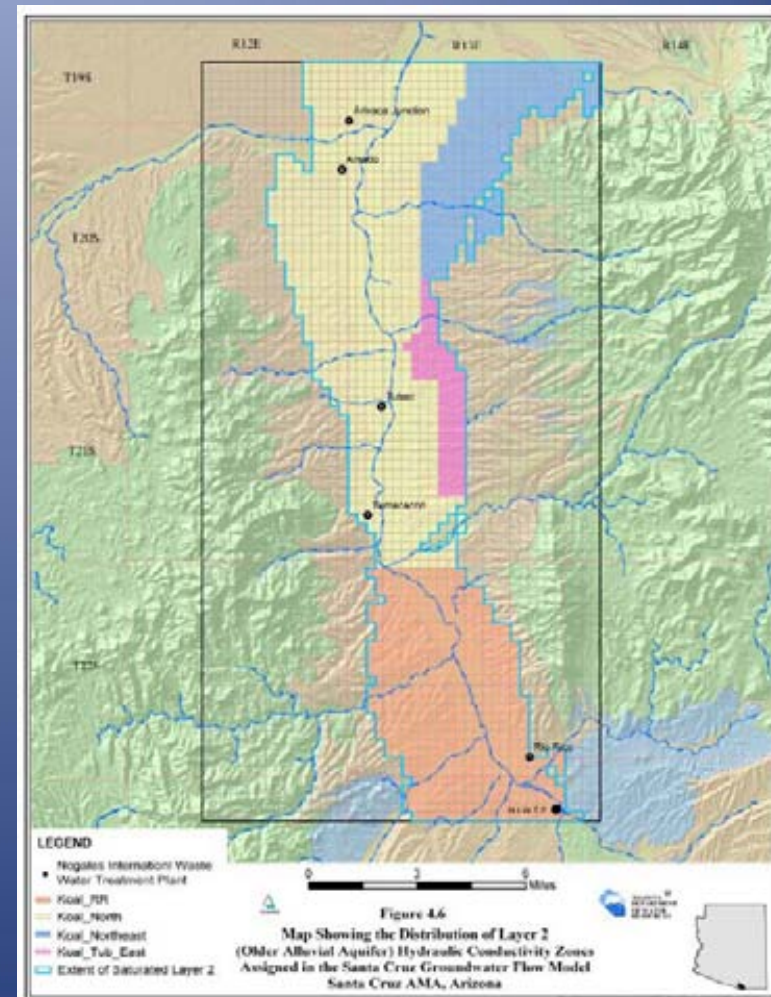
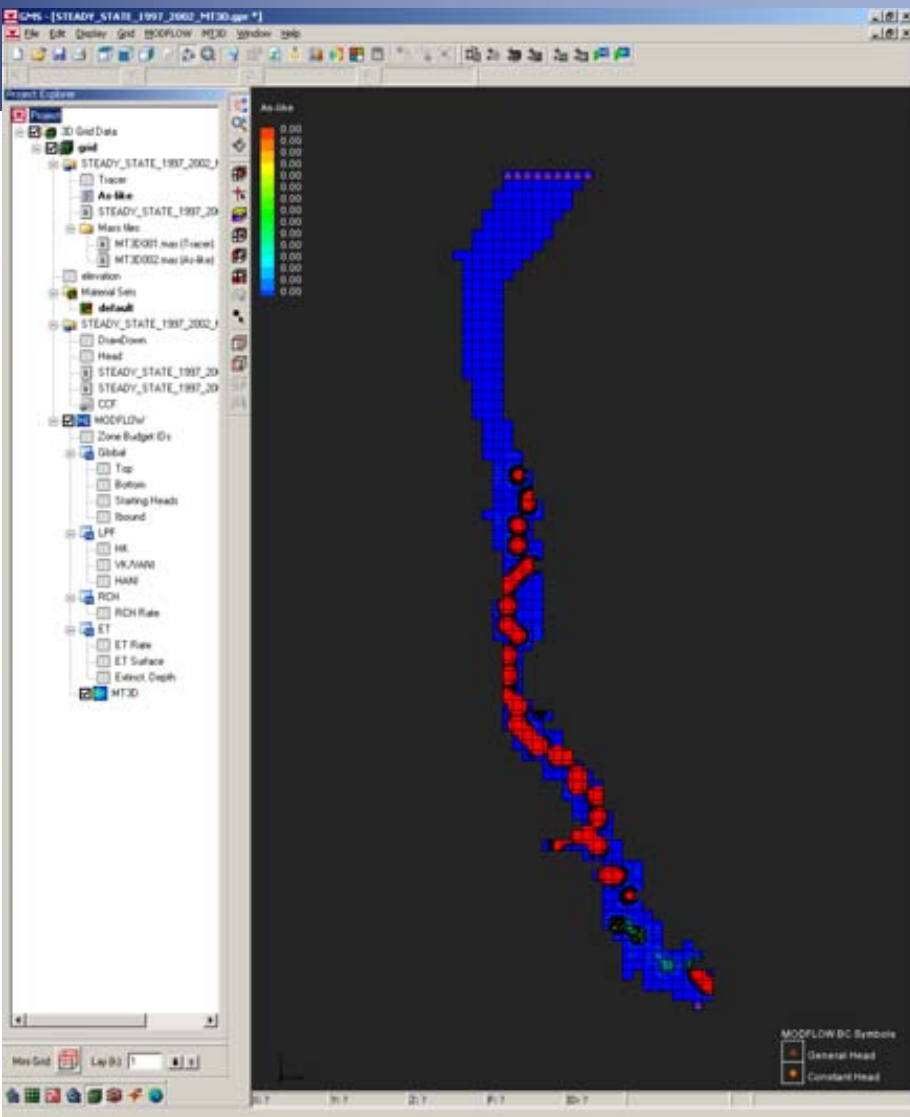
United States
Mexico

0 1 2 Kilometers

Geochemistry: Database



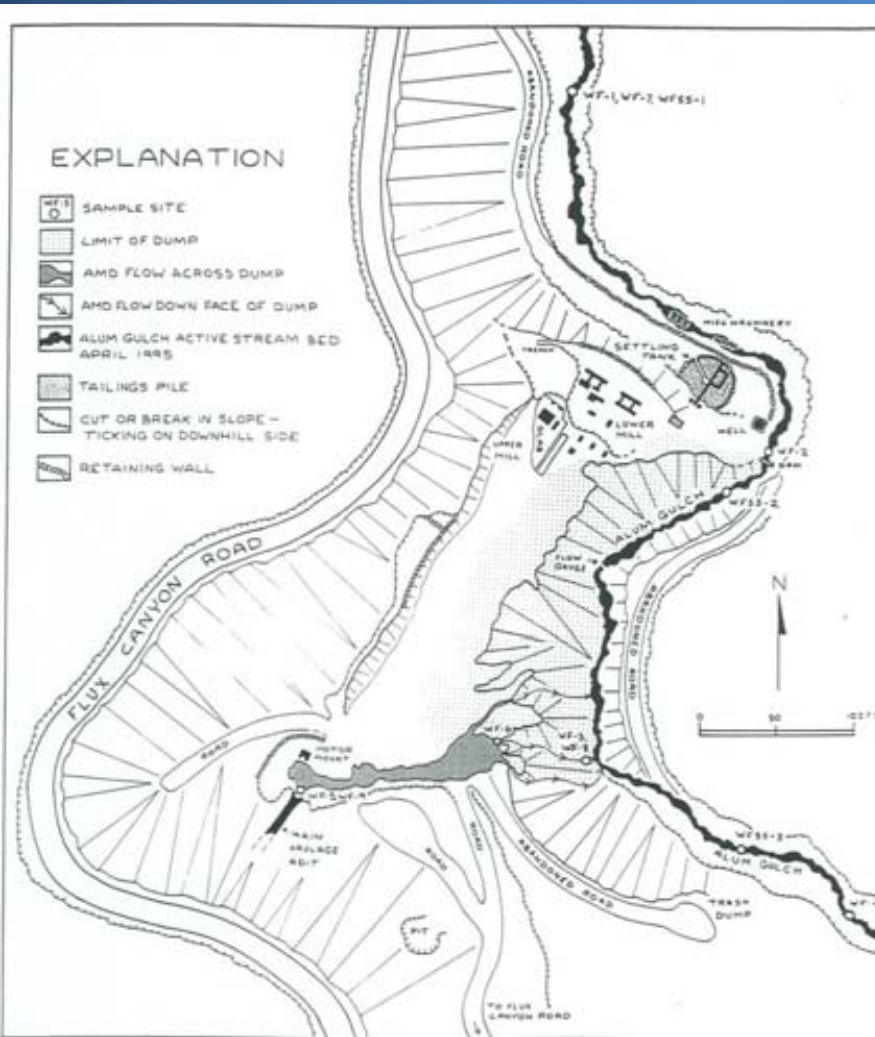
Contaminant Transport Modeling



Transboundary Aquifer Assessment Program

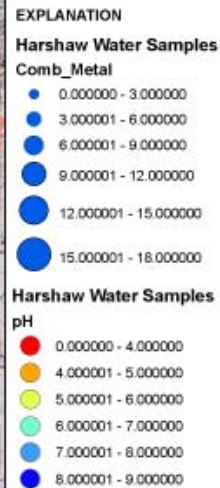
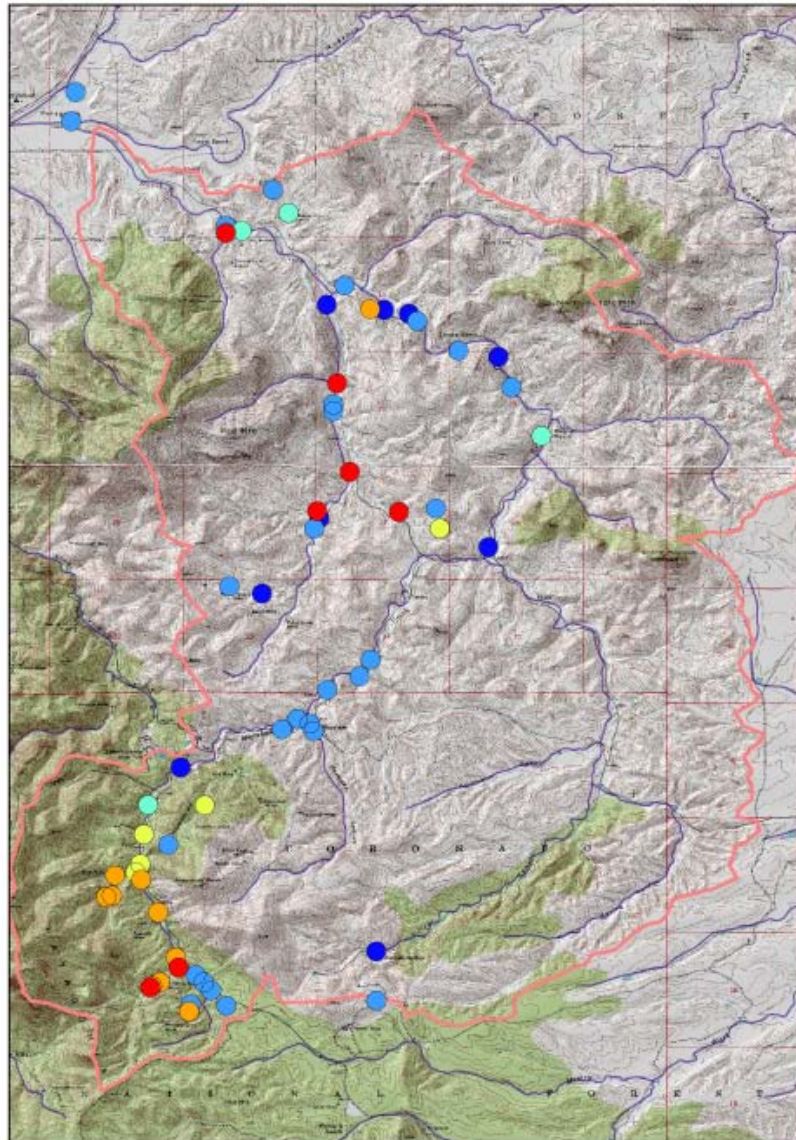
- Data collection of land use, zoning, economic and population growth, infrastructure, etc.
- Urban growth characterization and effect on watershed land use and hydrology
- Bi-national water balances and supply / demand analysis
- Groundwater Vulnerability Assessment
- Water quality assessments including anthropogenic impairments
- Assessment of institutional asymmetries and binational cooperation frameworks
- Improved linkages with international best practices (via ISARM)

Mining



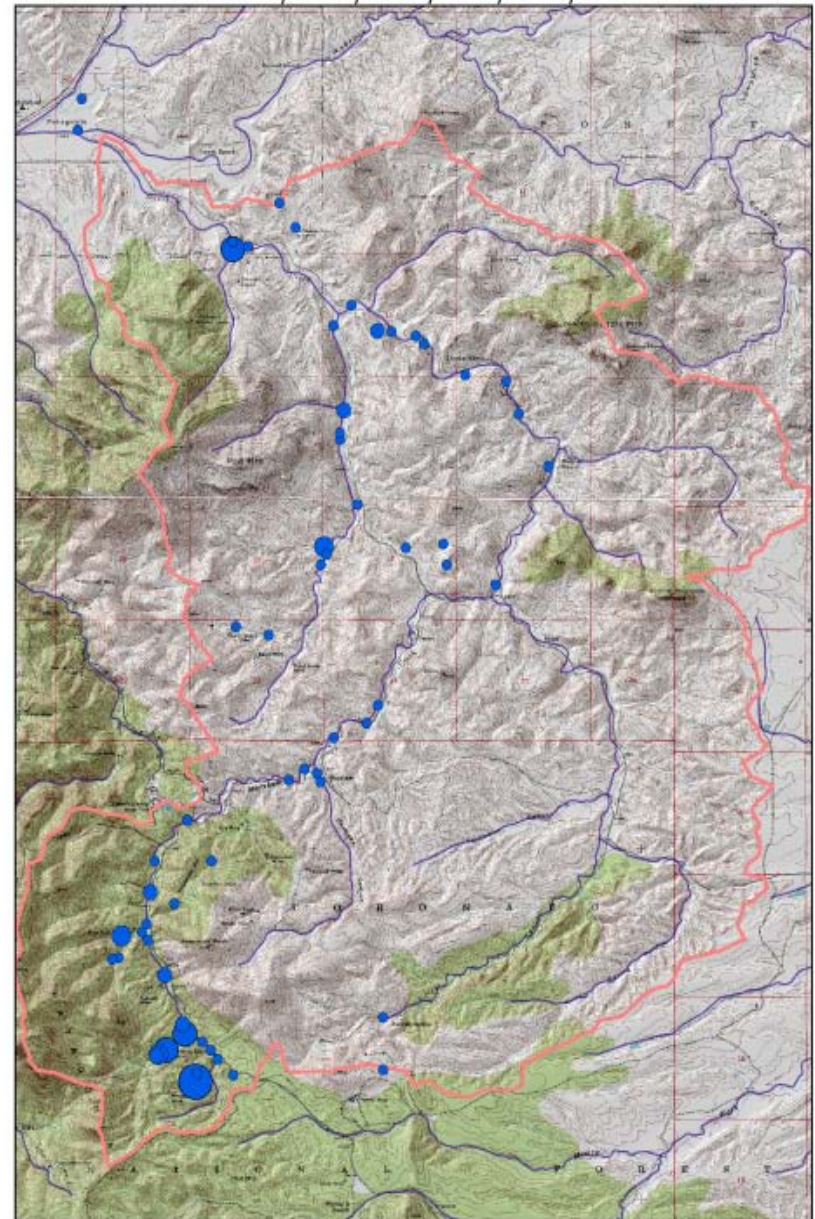
World's Fair Mine

Harshaw Watershed Samples by pH



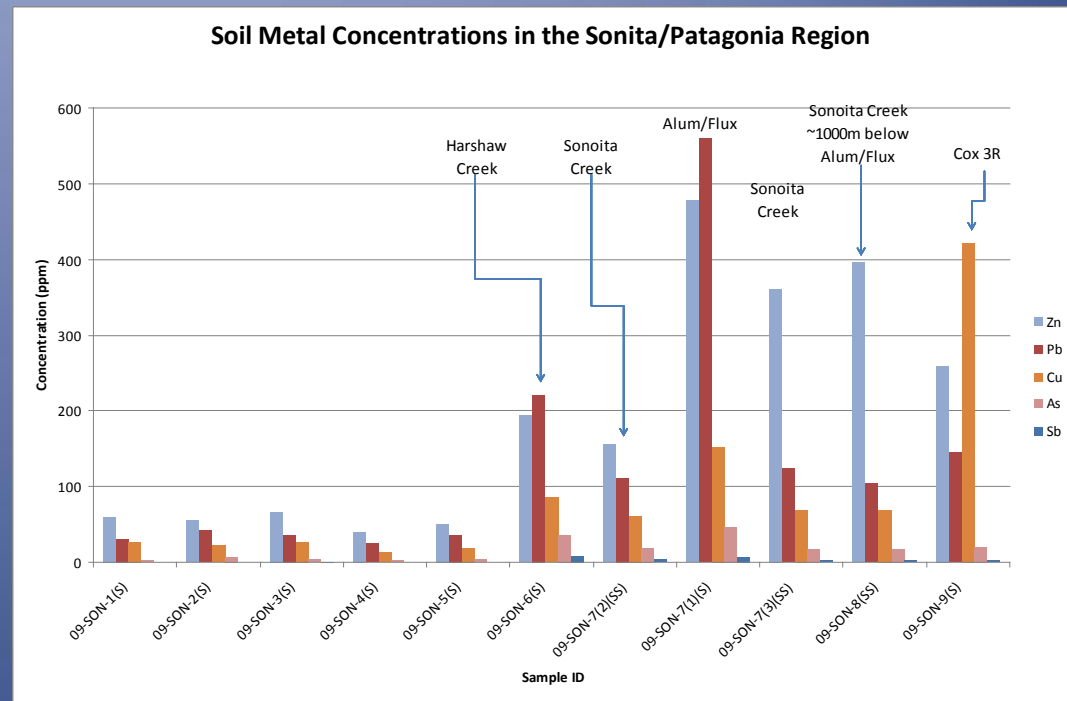
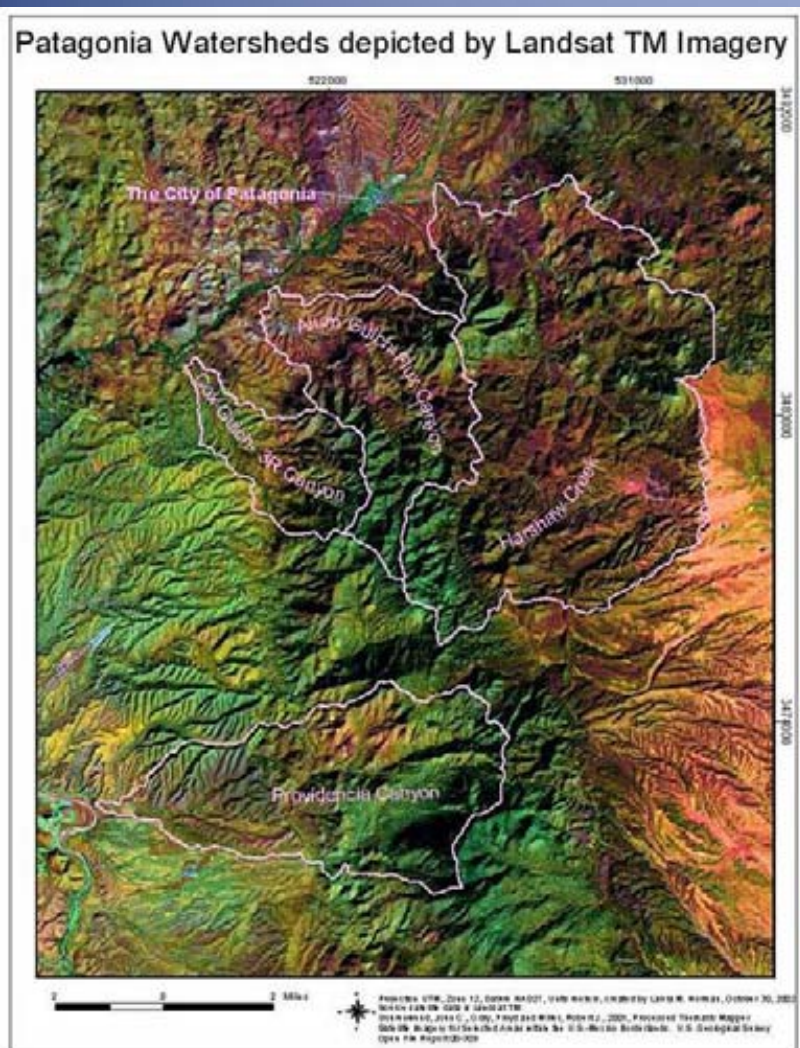
0 0.5 1 2 Miles

Harshaw Watershed Combined Metals Cu, Cd, Co, Zn, Pb, Ni



0 0.5 1 2 Miles

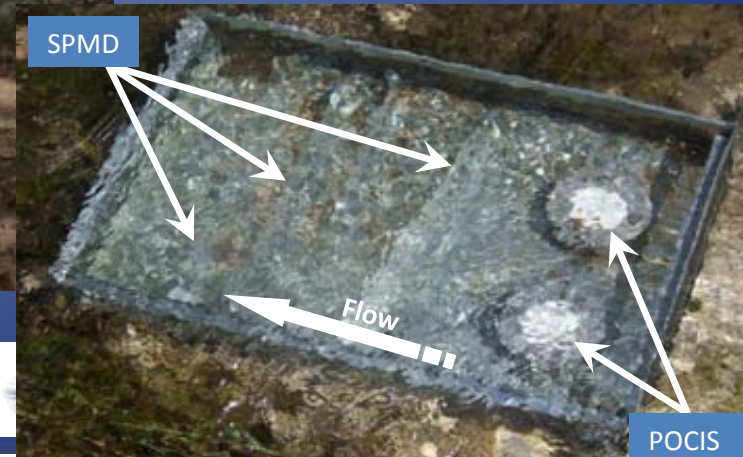
Soil Approach to Lake Patagonia - Downstream Target



Methods

Border Environmental Health Initiative

- Water
 - Point samples
 - Deployed passive samplers (organics only) for 1 month to obtain a time-integrated sample



Methods

- Sediment
 - Organic samples were a composite of fine sediments (< 0.06 mm)
 - Inorganic samples were a composite of fines and sands (0.06-2 mm)



Methods

- Tissue
 - Whole large fish, small fish composite, macroinvertebrate composite, algae, and plants (stem, leaves, roots)

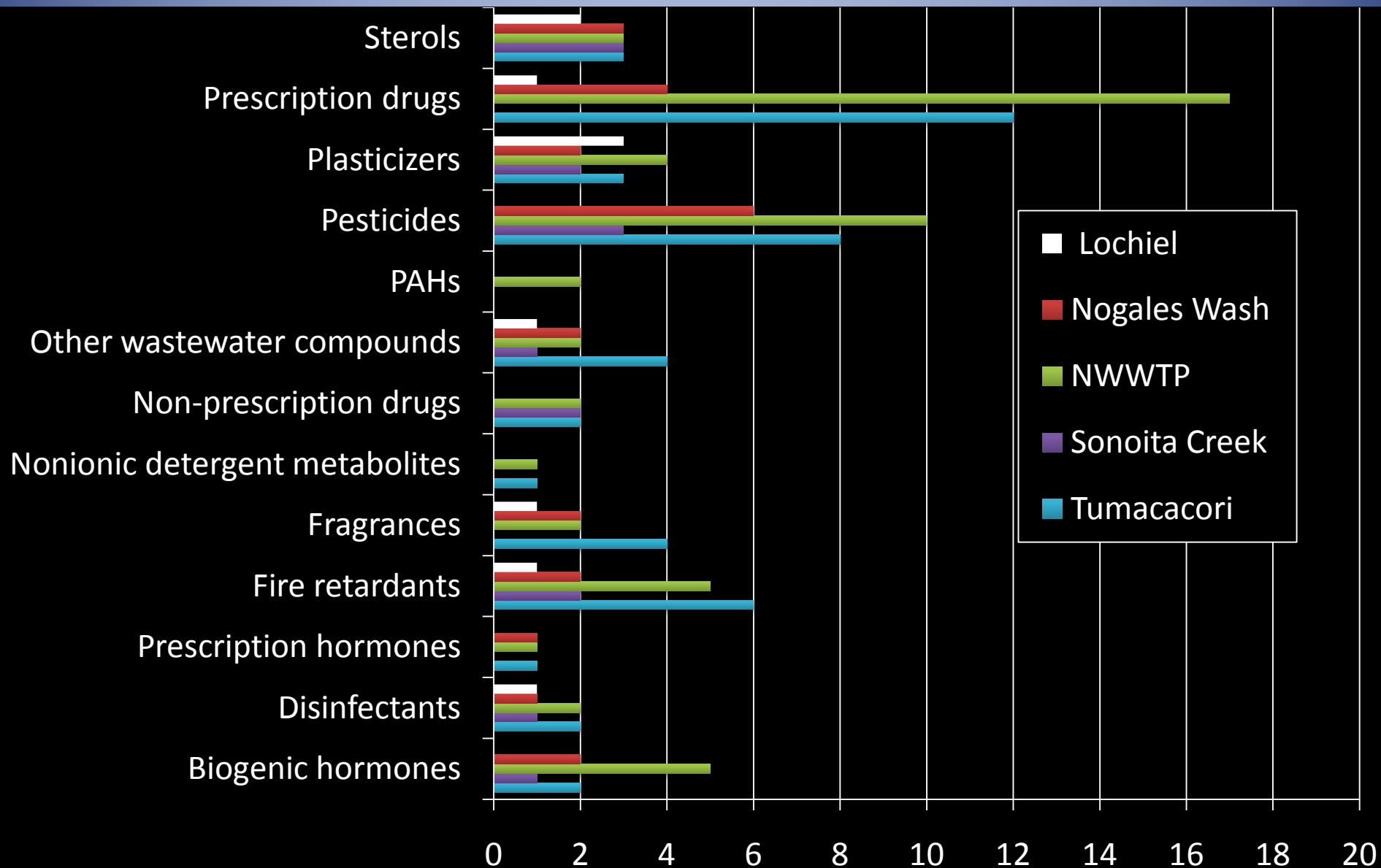


Birds and Contaminants

- Song Sparrows
- Heavy metal accumulation
 - Blood and feathers
- Humoral Immune Response

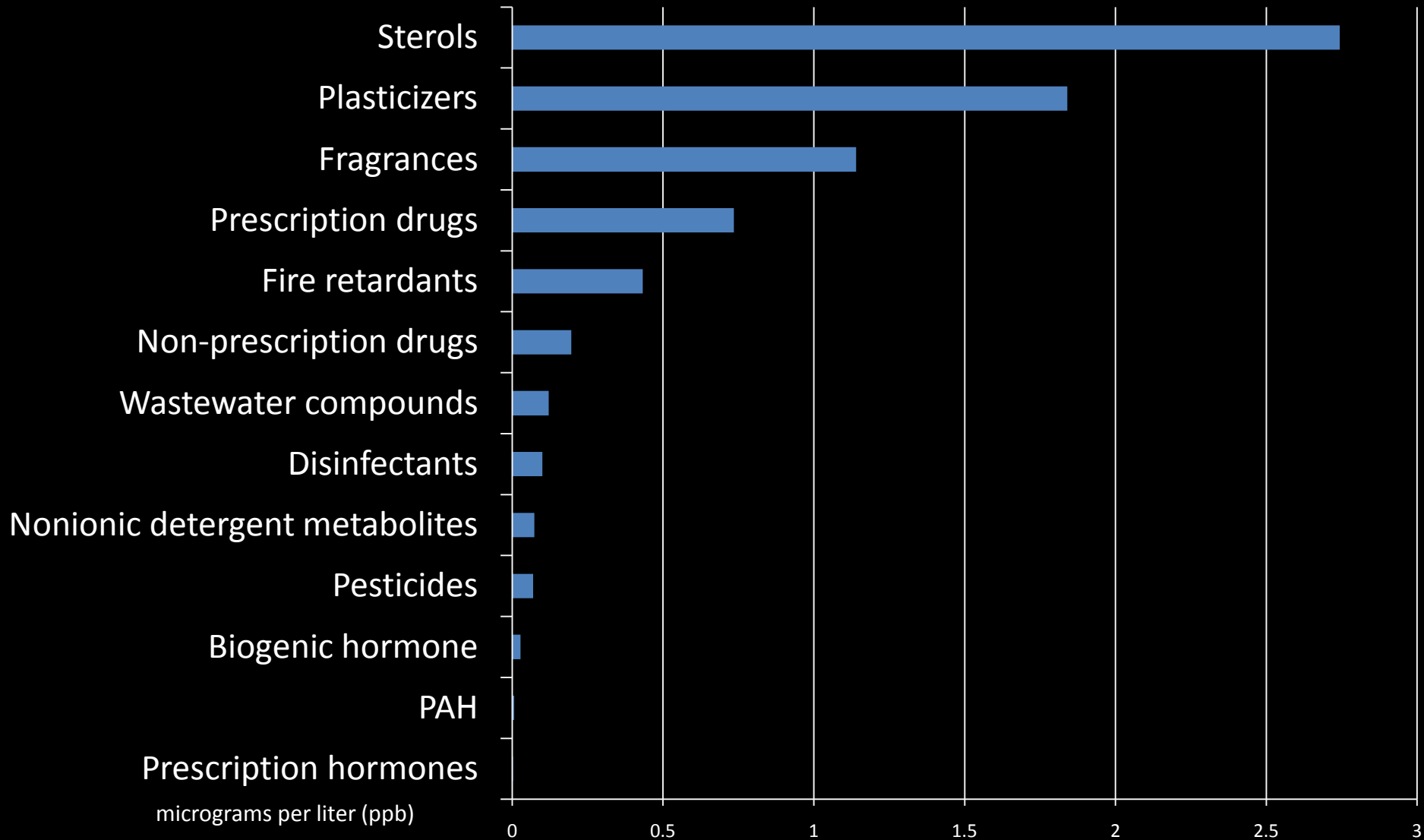


Organic Results-Water

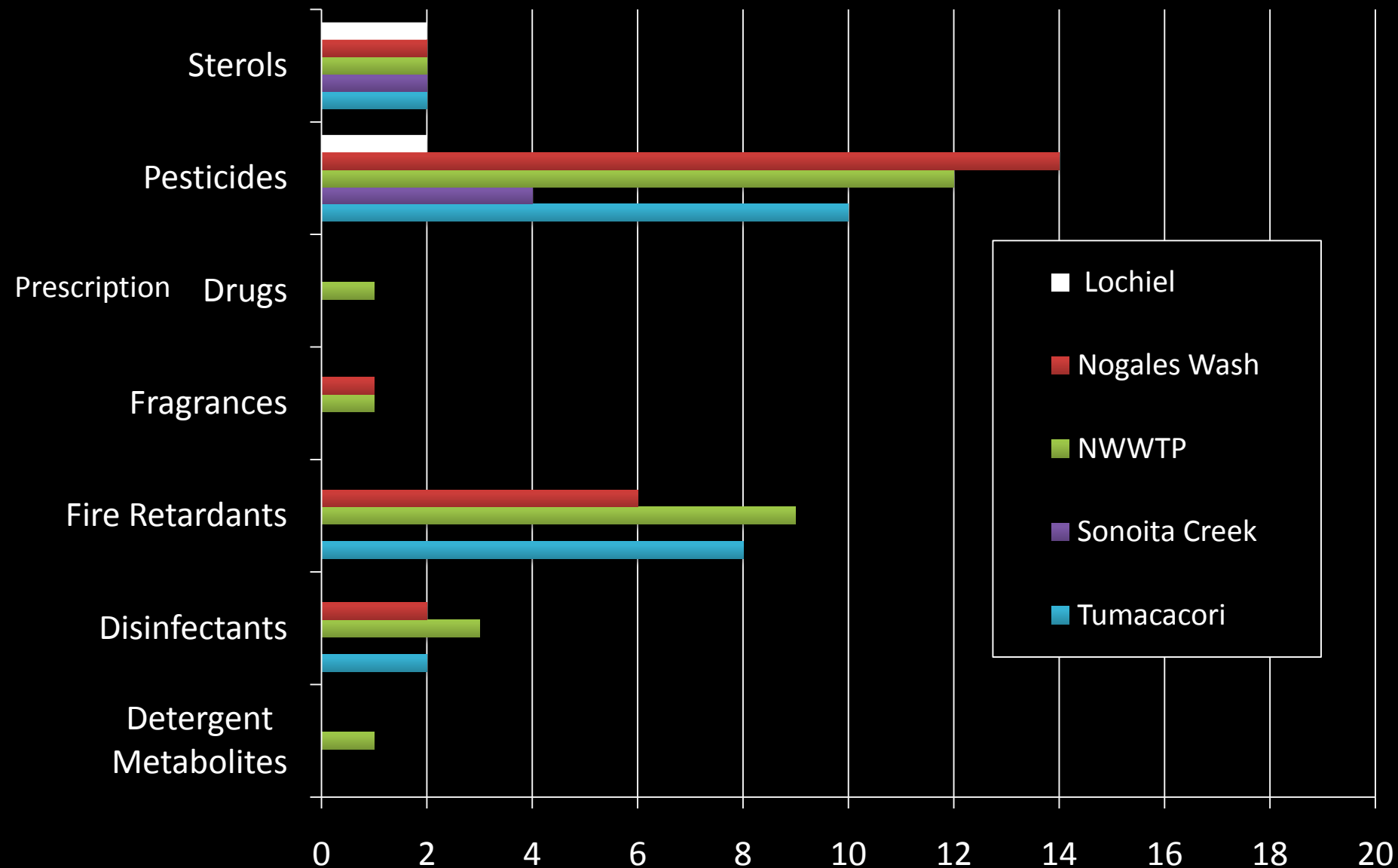


Water Concentrations

Maximum Concentration for the Group

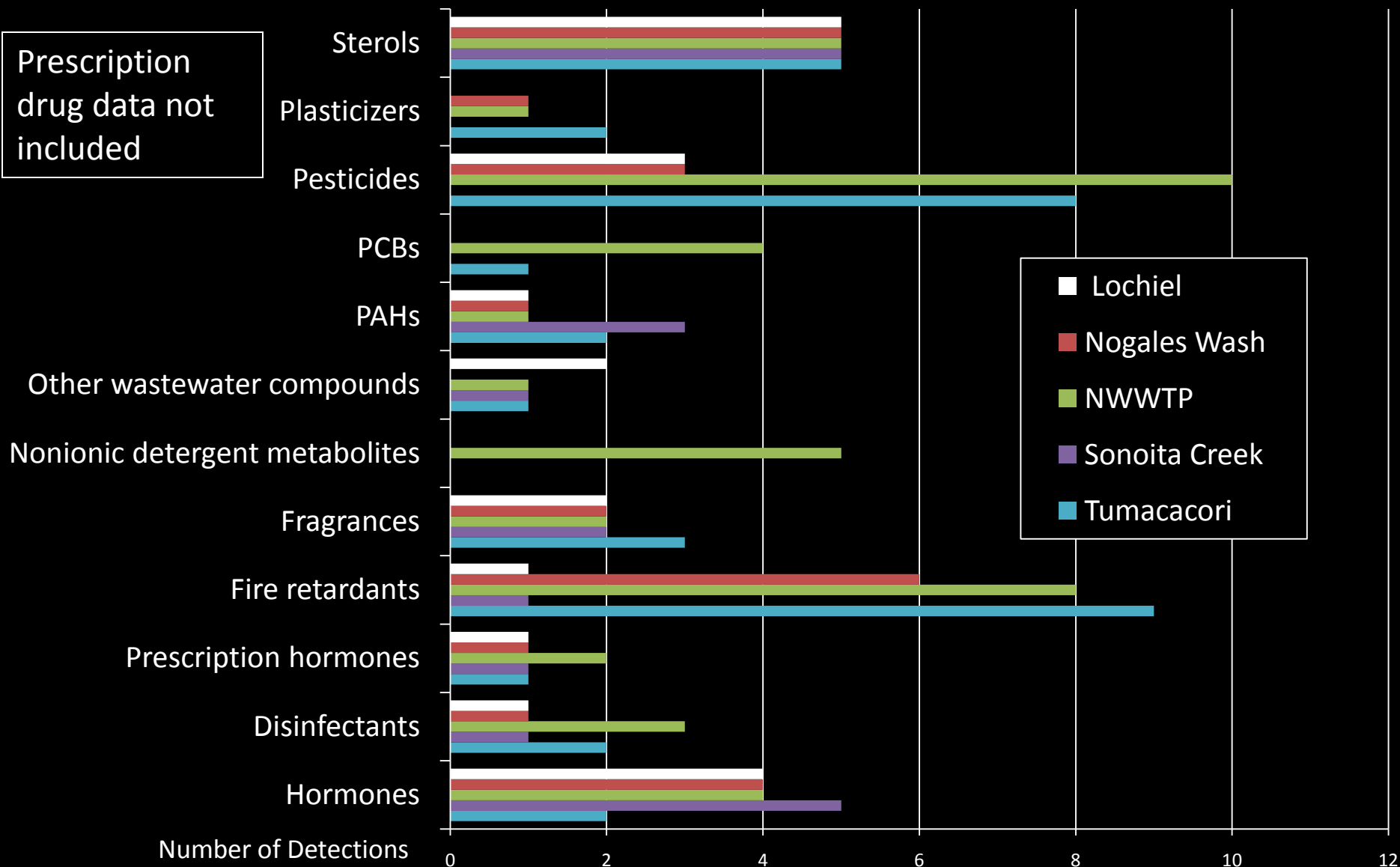


Organic Results-SPMD



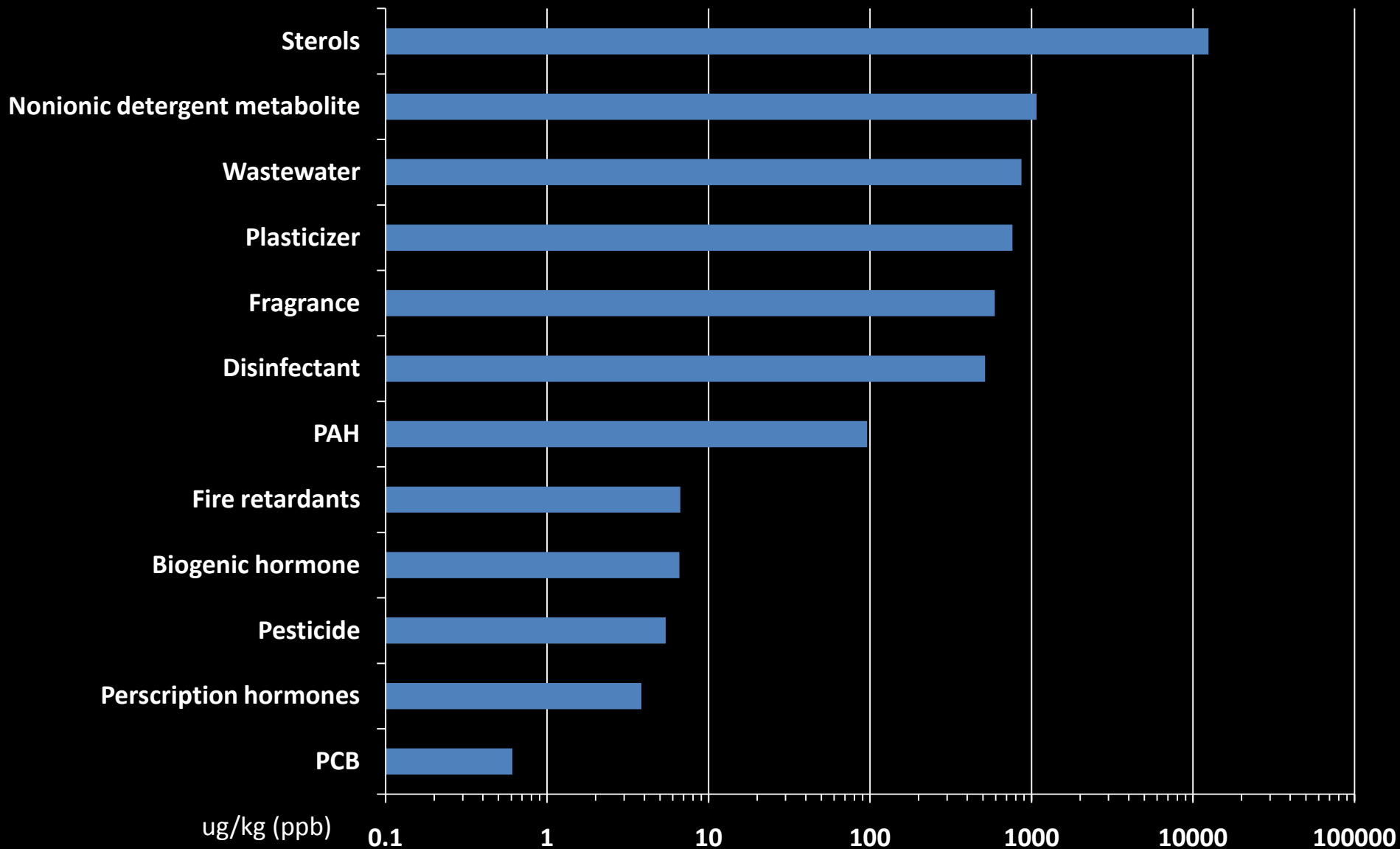
Organic Results-Sediment

Prescription
drug data not
included



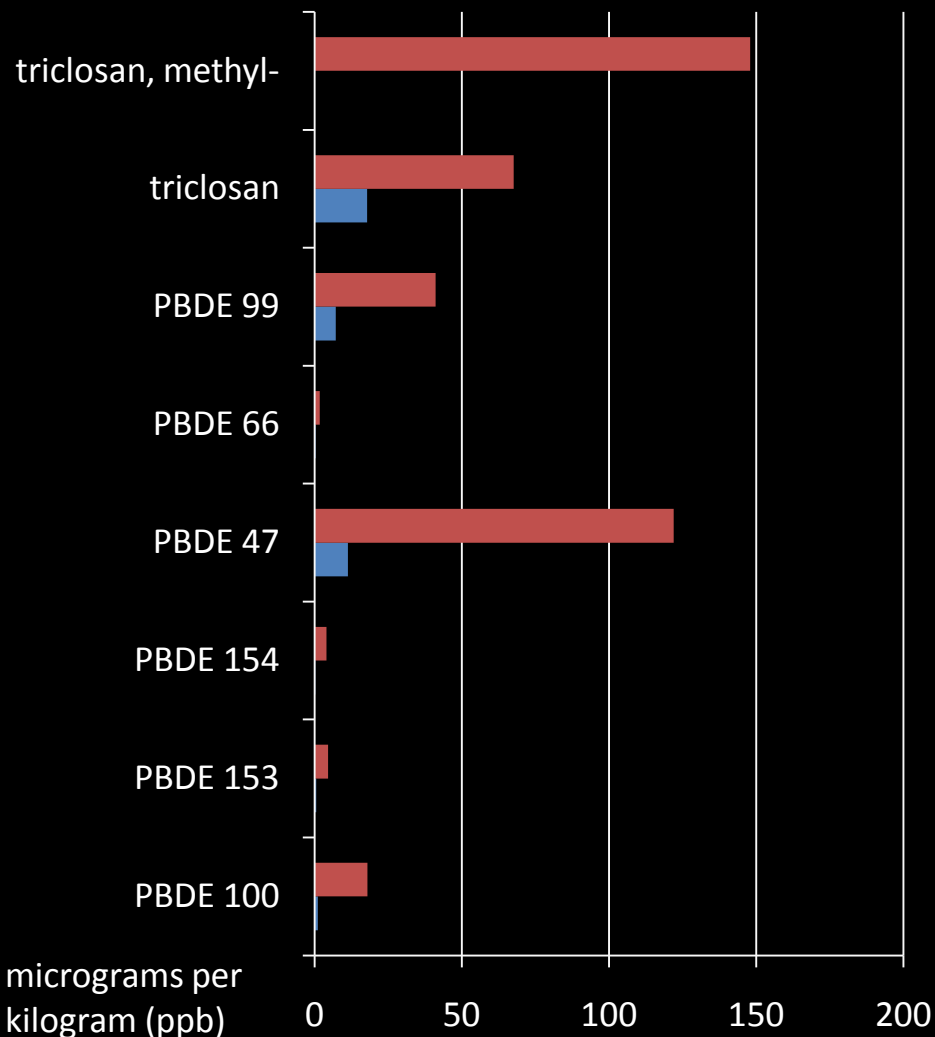
Sediment Concentrations

Maximum Concentration per group

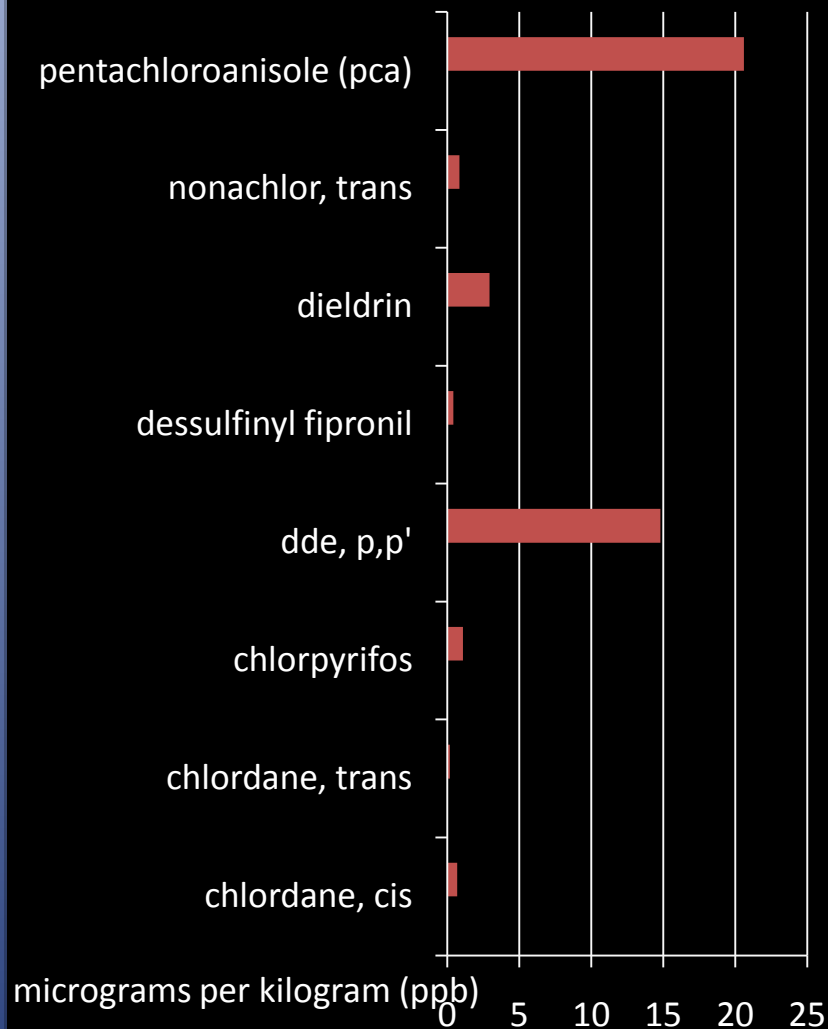


Organic Results-Macroinvertebrates at Tumacacori

■ Giant Water bug ■ Dragonfly larvae

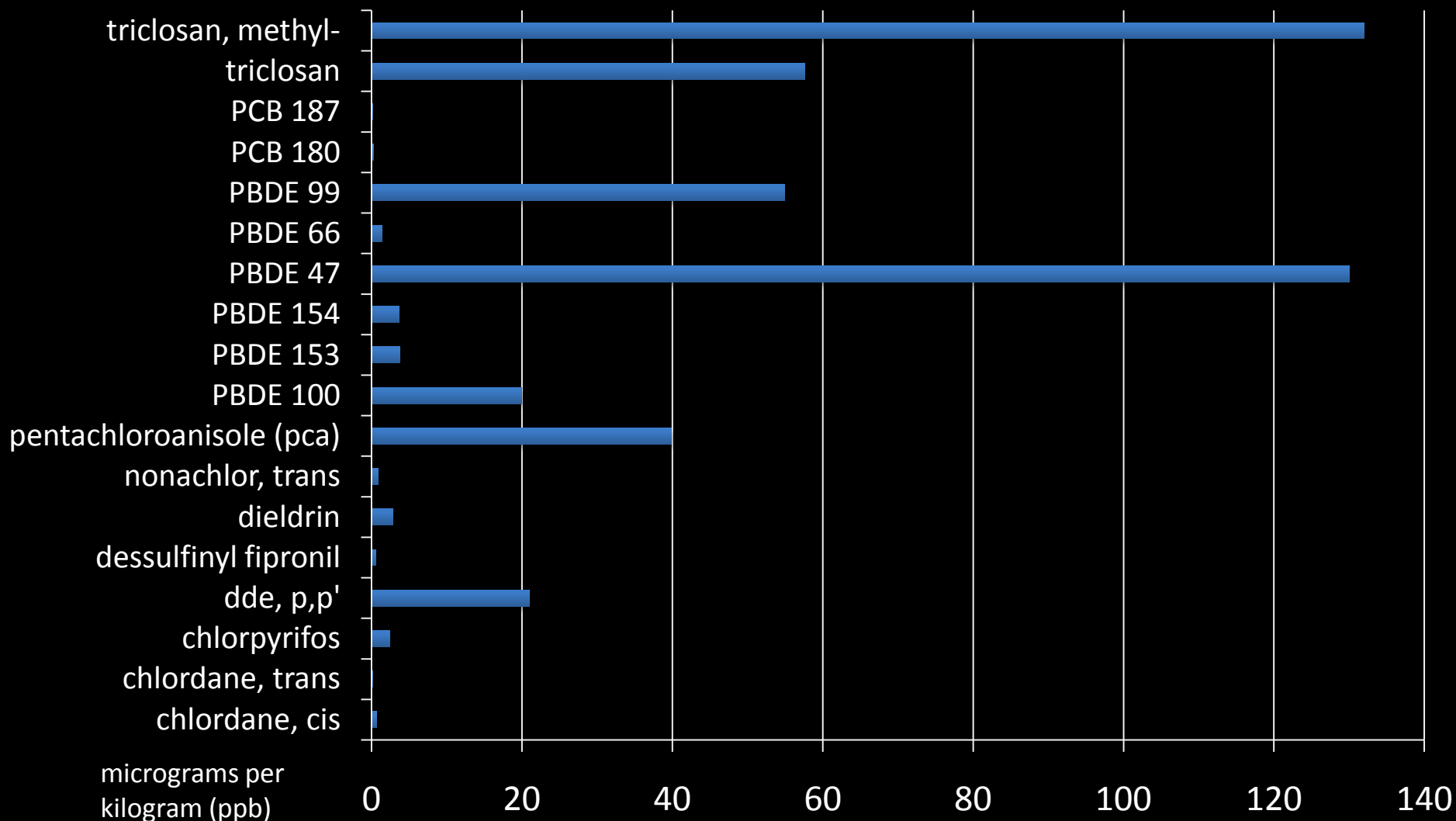


■ Giant Water bug

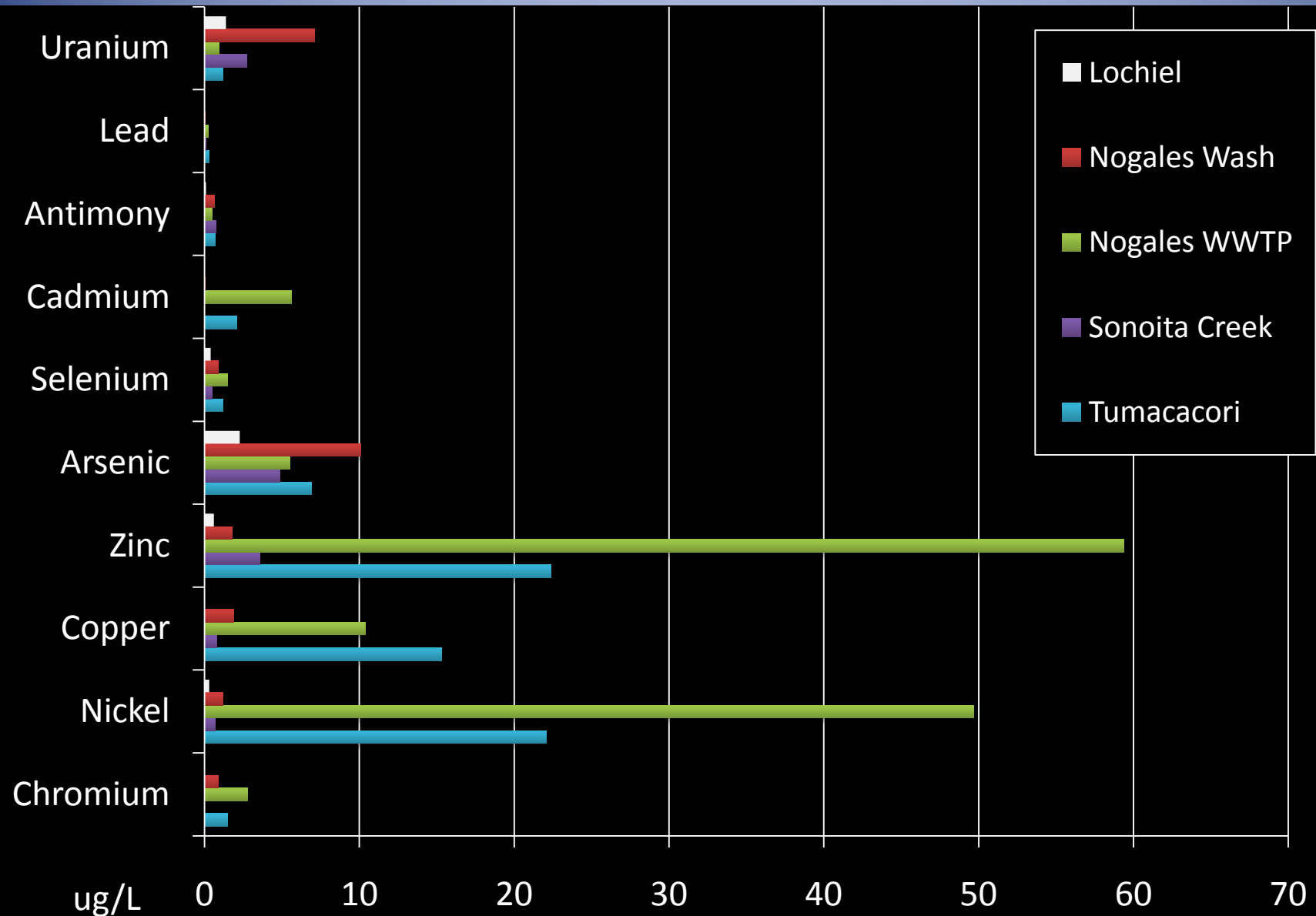


Organics Results-Fish

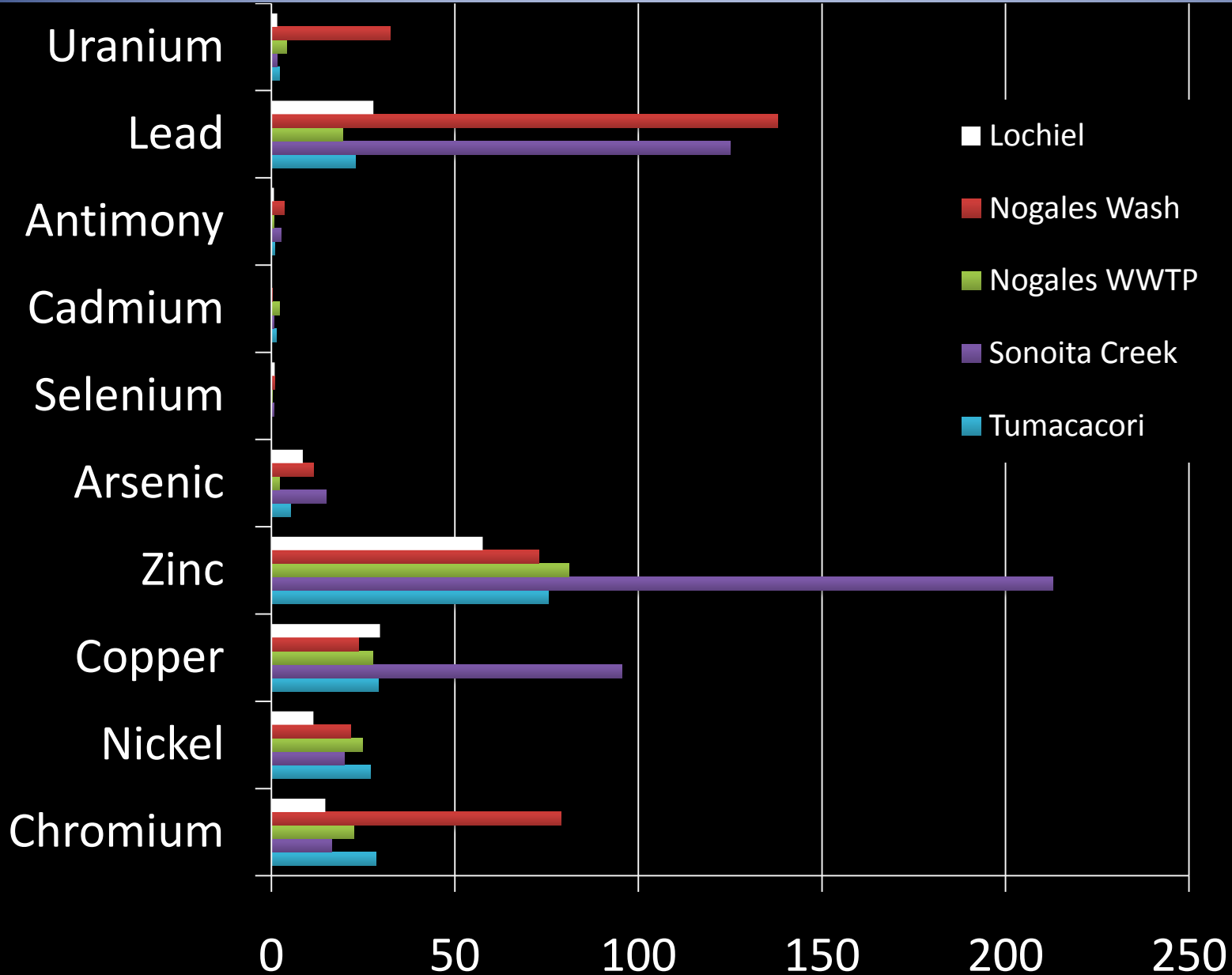
NWWTP (mosquito fish)



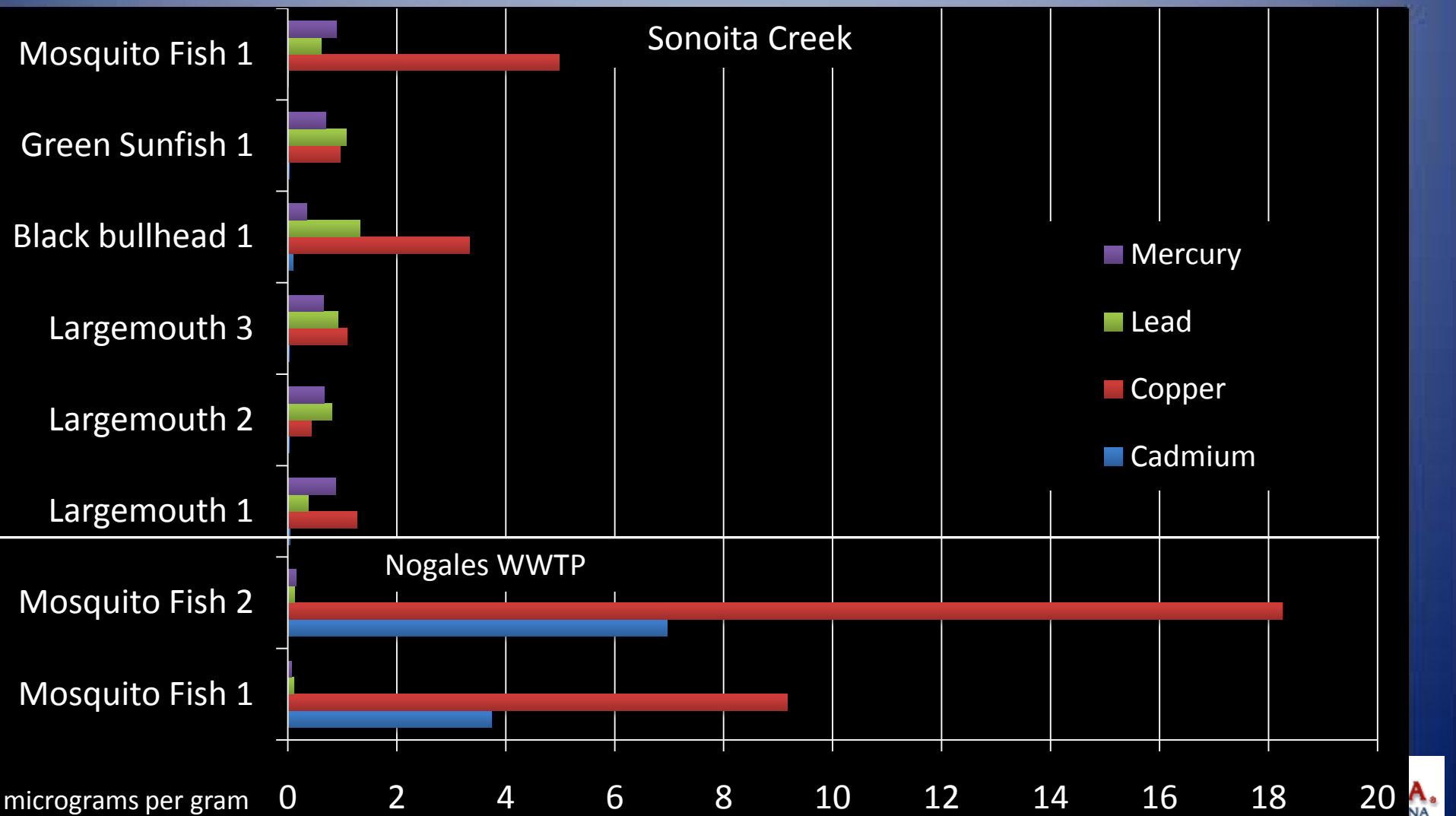
Trace Metals-Water



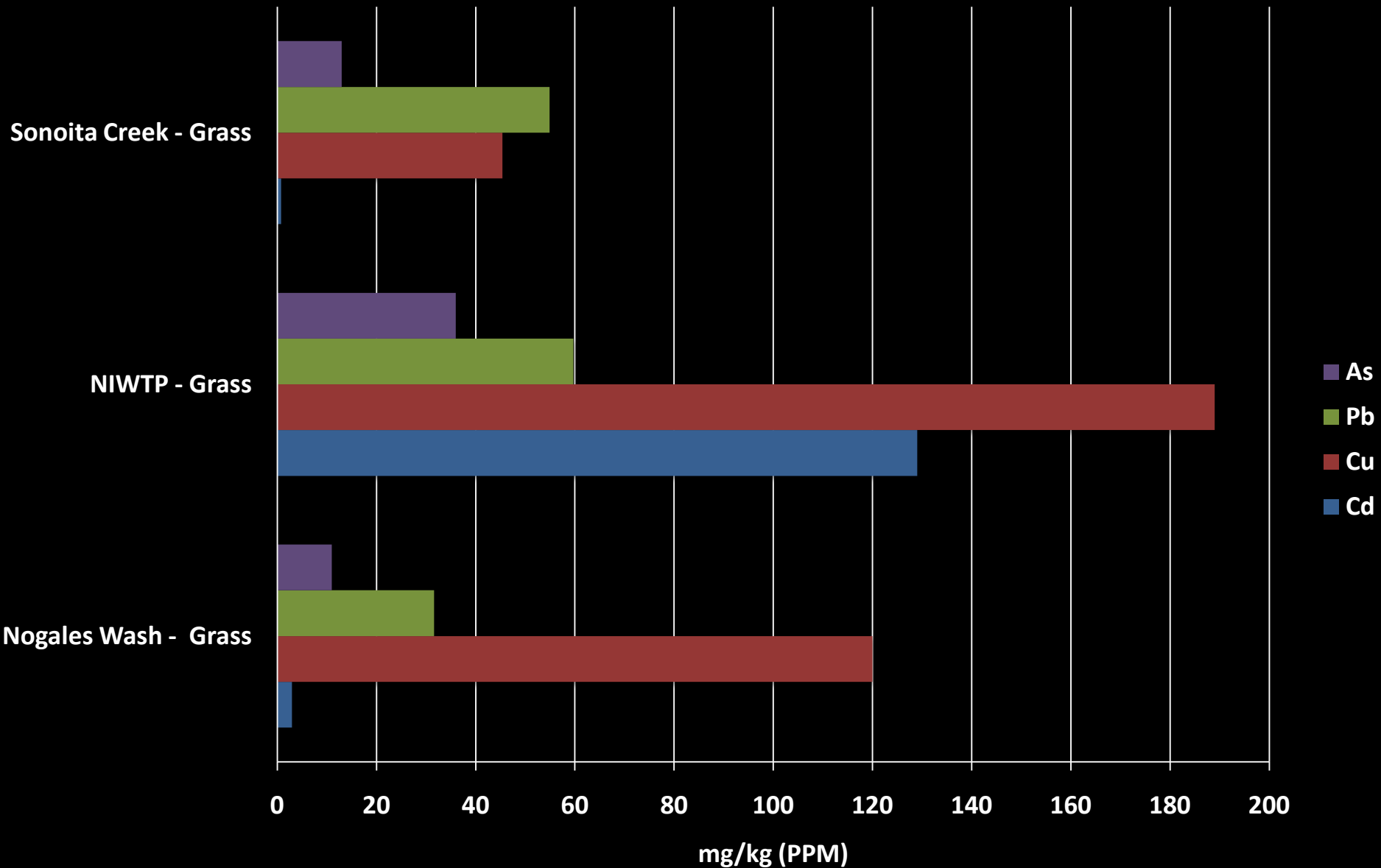
Metals-Sediment



Trace Metals-Fish



Metals-Plant Roots



Surface Water Modeling - WHY?

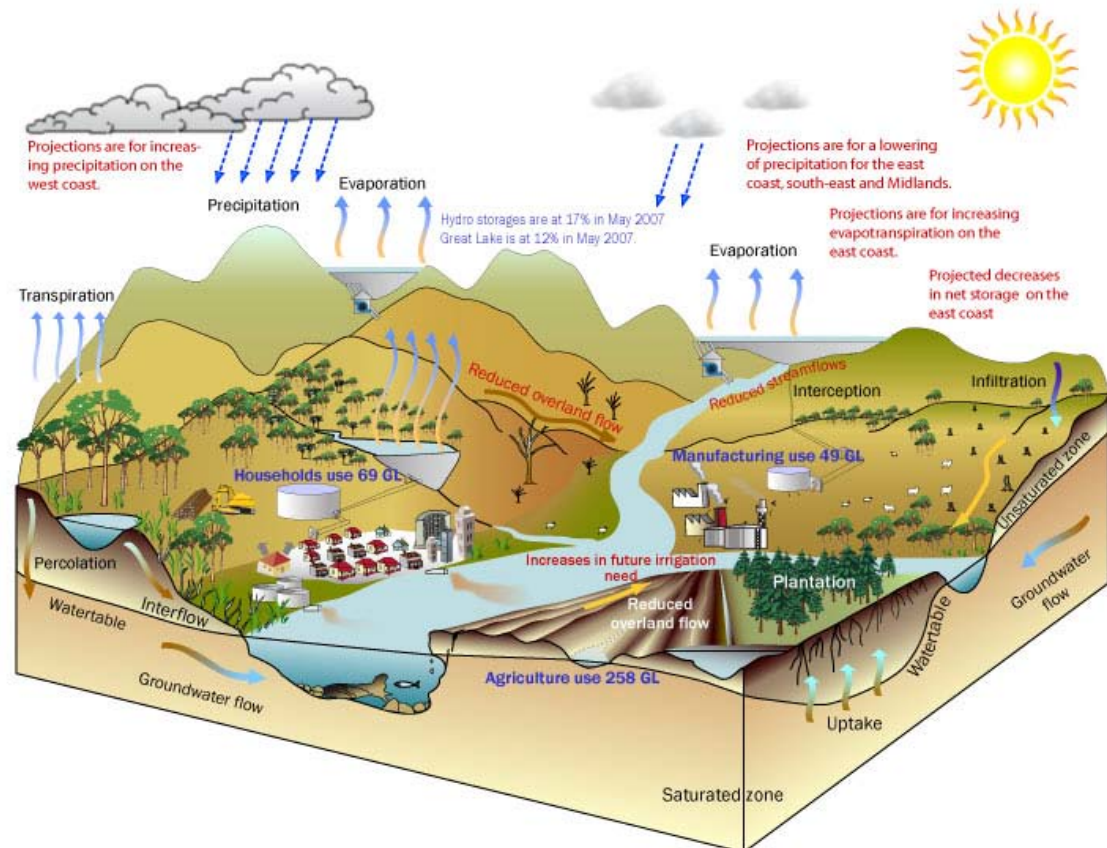
- To develop an understanding of the characteristics of the Upper Santa Cruz Watershed that control runoff
- To predict the movement of pesticides, sediments, and

Water Balance Equation

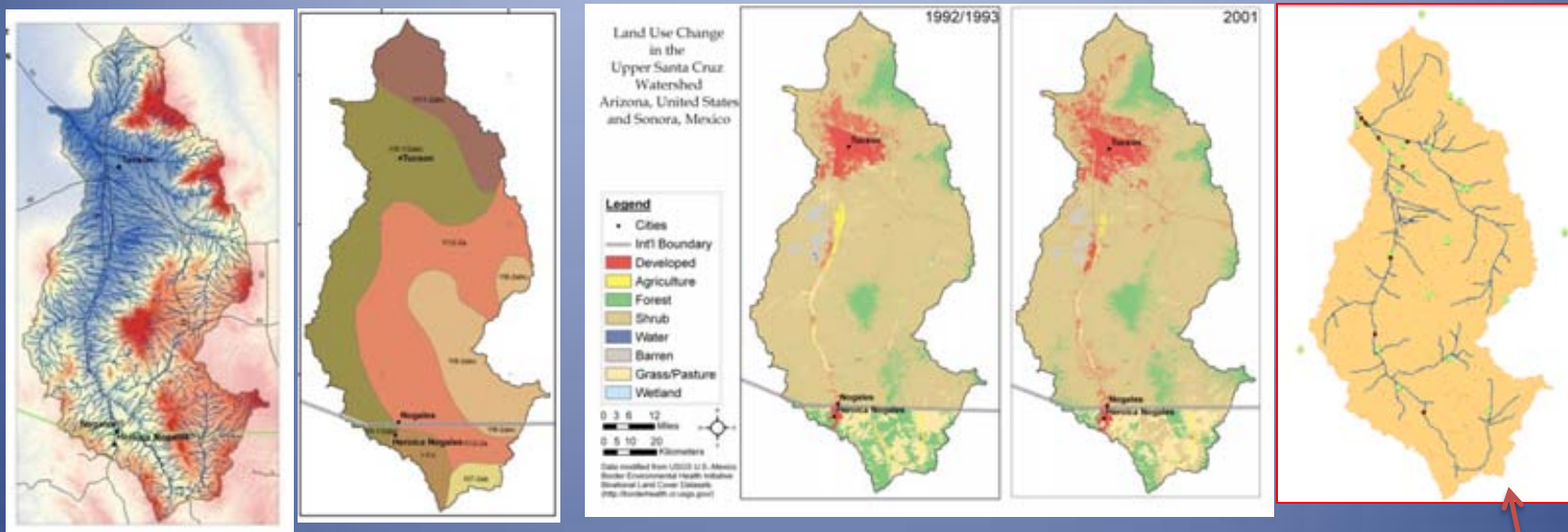
$$SW_t = SW + (R_{day} - Q_i - E_a - P_i - Q_{Ri})$$

Where:

SW: soil water content
T: time
R_{day}: amount of precipitation
Q_i: amount of surface runoff
E_a: amount of evapotranspiration
P_i: amount of percolation
Q_{Ri}: amount of return flow



Soil and Water Assessment Tool (SWAT) Input



- ❑ Developed by Dr. Jeff Arnold, USDA
- ❑ Requires real input for topography, soil properties, **vegetation/land management, and weather** → →
- ❑ Physically models water movement, sediment movement, crop growth, nutrient cycling
- ❑ Calibrated and validated using twenty-two weather stations and four USGS gage stations.

140 subbasins-12 digit hucs

CLIMATE DATA INPUT:

22 weather stations,
(1960/01 – 2008/04)

USGS gages

- Certaro (03/90 – 12/07)
- Tucson (10/90 – 12/07)
- Tubac (01/98 – 12/07)
- Nogales (01/88 – 12/07)



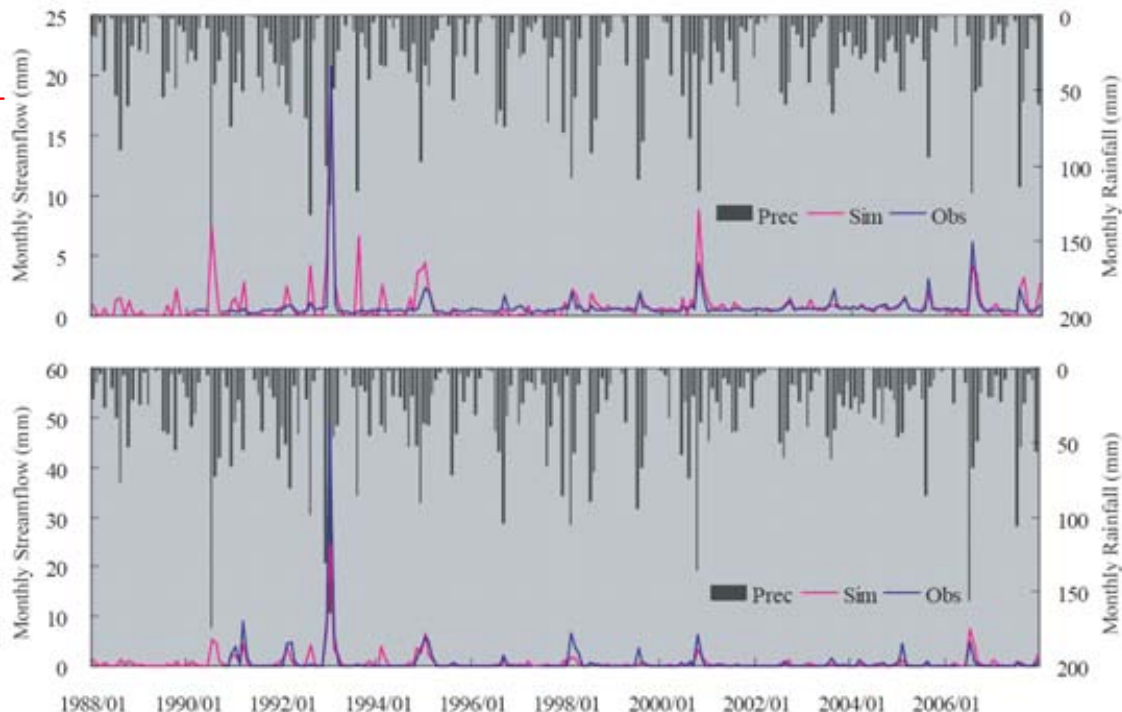
Nie, Wenming, Yuan, Yongping, Tallent-Halsell, Nita, Norman, Laura M., Jackson, Michael, and Erickson, Caroline, 2010, Assessing Surface Water Availability in the Upper Santa Cruz Watershed, 65th International Soil and Water Conservation Society (SWCS) Annual Conference, July 18-21, 2010, St. Louis, Missouri.

Calibration

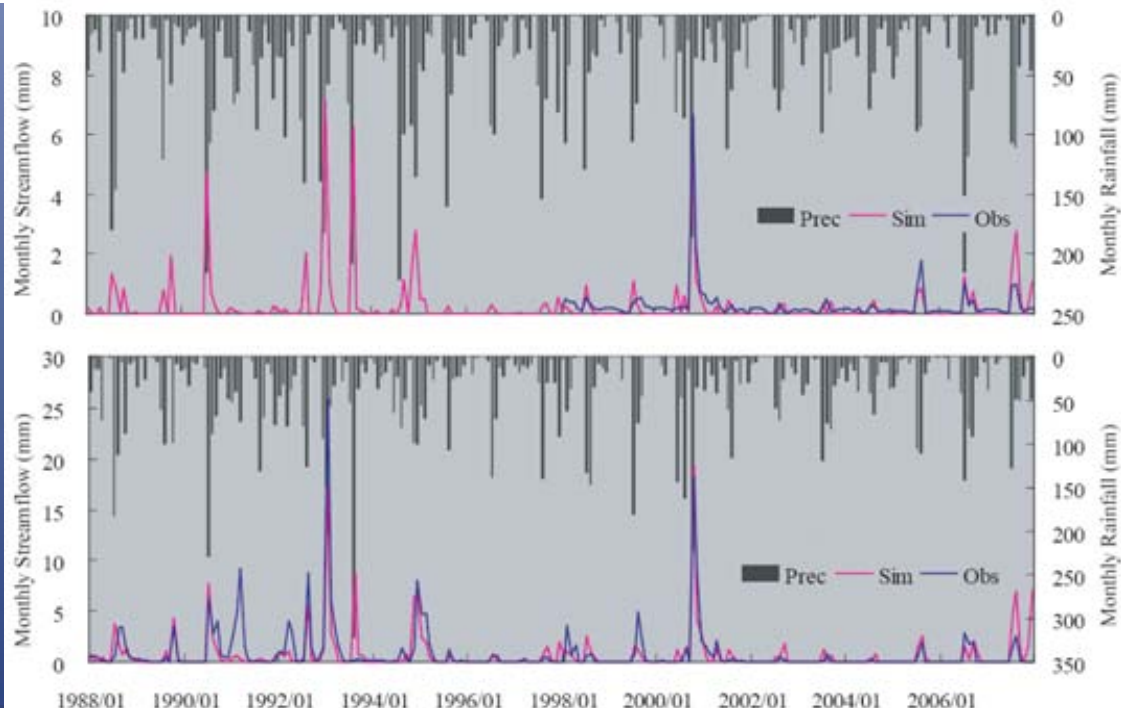
Monthly rainfall, and simulated and observed streamflow at four USGS gages→

The simulated monthly streamflow largely matches the observation-- suggesting that monthly streamflow can be described by the calibrated model.

Cortaro-Tucson gage



Tucson gage



Tubac gage

Nogales gage

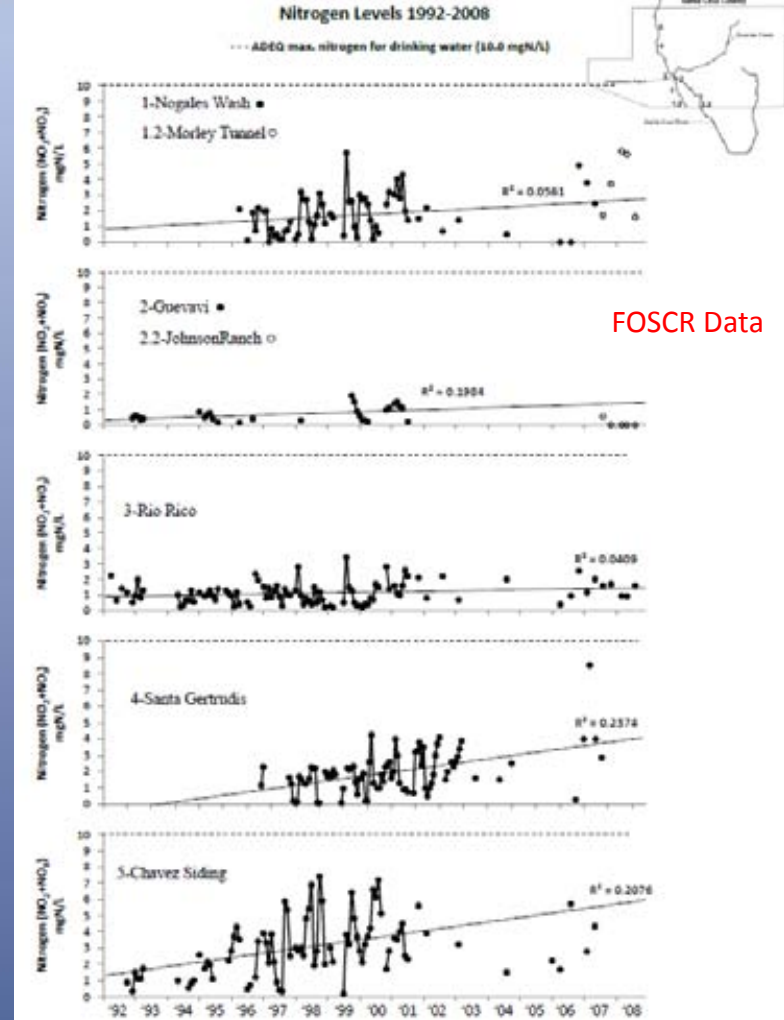
Nitrate

Sources

- Fertilizer
- Byproduct of decomposition of animal or human waste
 - Ranches
 - Septic systems
 - Wastewater Treatment plants

Health

- Algal blooms → decreased O₂
- Fish & Aquatic species → stress
- Human Health Effects
 - Nitrate toxicosis
 - Methemoglobinemia in infants (*blue baby syndrome*)

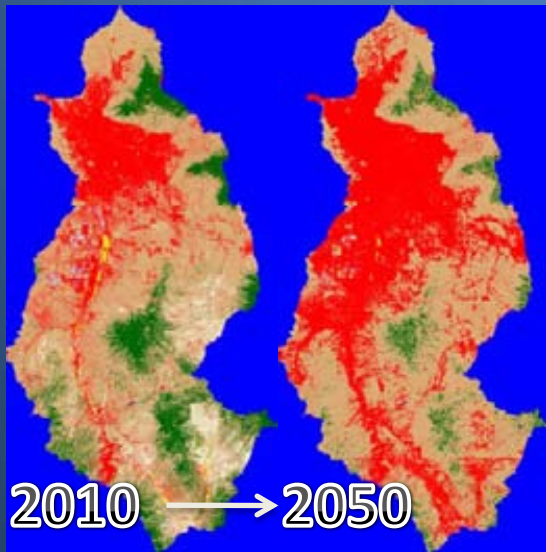


SWAT

- Simulating nitrate loads
- SWAT simulates nitrogen transformation, transport and loadings ...

Back to the Future

How will SLEUTH predicted urban growth and decreased grasslands & shrub from 2010 to 2050 impact future populations?



How will GCM precipitation or heat scenarios to 2050 impact future populations?

Bias Corrected and Downscaled Climate Projections from Meixner and Dominguez ~ Varied future precipitation w/ increase in temperature:

1. The **UKMO_Hadcm3** model shows a future increase in both summer and winter rainfall
2. **MPI_ECHAM5** shows a decrease in both summer and winter rainfall, with a larger summer decrease, and
3. **NCAR-CCSM3** also shows a decrease in precipitation but the winter season rainfall shows the largest change.

Predictive future **Land-use maps** and **Climate Change “maps”** can be fed into SWAT to look at future hydrologic response (*Channel Discharge, ET, Percolation, Surface runoff, Transmission loss, Water yield and Sediment yield*) & impacts on humans (*Real Estate Values, Quality of Life, Flooding and Erosion Control, Habitat Changes (Biodiversity)*)....

Flood Warning and modeling project in Nogales Sonora

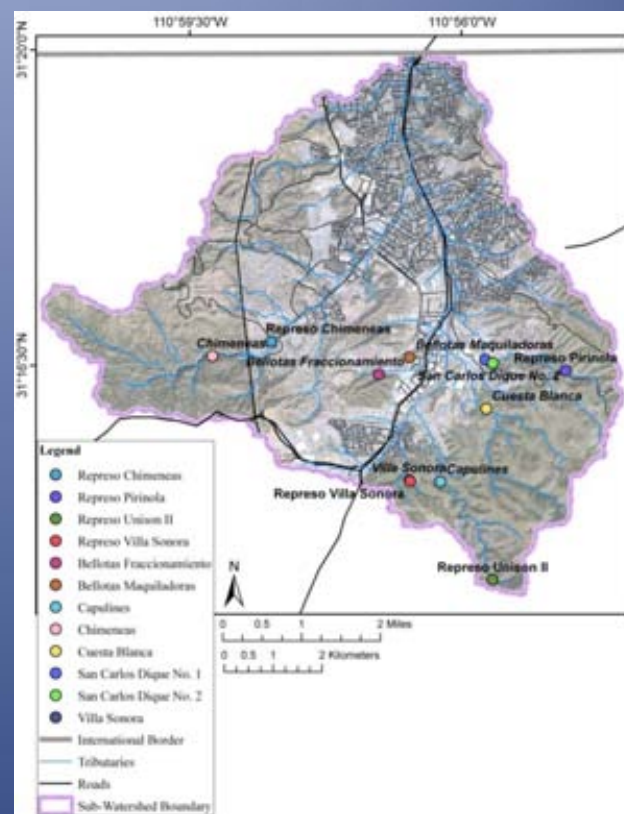
NORCOMM → Floyd Gray, USGS PI

Rain Gages and Radar



Precip On	Milimeter s (mm)	Inches (in.)
7/31/2010	1.524	0.06
7/30/2010	52.07	2.05
7/29/2010	17.78	0.7
7/28/2010	7.62	0.3
7/27/2010	13.208	0.52
7/22/2010	7.112	0.28
7/20/2010	1.27	0.05
7/19/2010	24.384	0.96

Rainfall-Runoff Modeling



▲ Nogales Instrument Configuration

Weather Station #1



Base Station



Nogales

Stream Gauge-Chimenea/Hospital

Stream Gauge #2-Nogales

Weather Station-COBACHI

Imuris Weather station

© 2011 Google
Image © 2011 DigitalGlobe

© 2011 INEGI

Nogales, Sonora Watershed



Legend

▲ stations

stream

order

1

2

3

4

Contributing to west branch: 262 km2

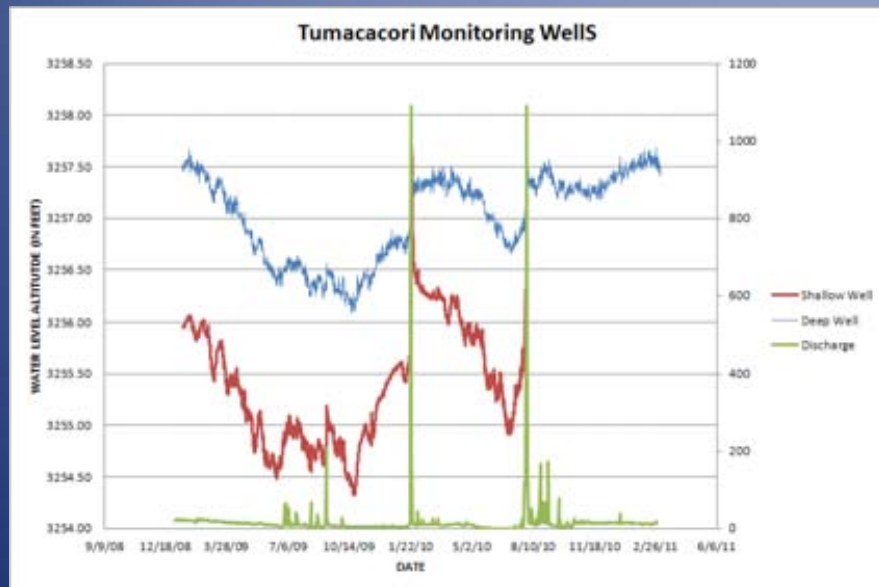
Contributing to east branch: 68.11 km2, mostly model according to

0 0.5 1 2 Miles

Tumacacori Emerging Contaminants

Groundwater-Surface Water Interactions

Water Levels and Streamgauge Data



Temperature and Streamgauge Data

