An Invaluable $25 Investment: Using Isotopes to Better Characterize the Groundwater Quality of the Gila Valley Sub-Basin, Southeastern Arizona

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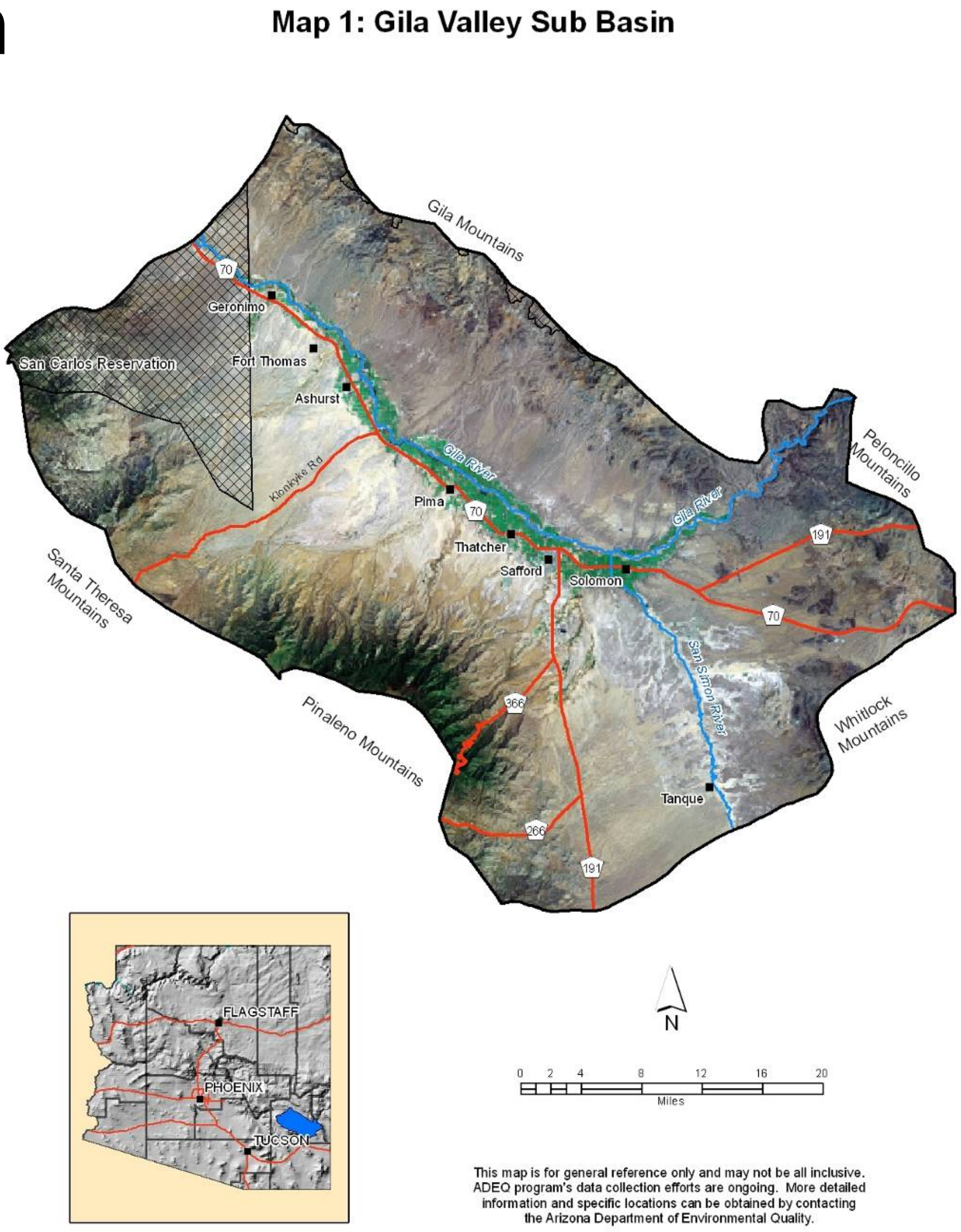
Presentation Outline

- Overview of the Gila Valley sub-basin
- Evaluate a 1995 ADEQ GW study of the area
- Discuss challenges of the 2004 study
- Compare the results of the two studies

Gila Valley Sub-basin of the Safford Basin

- Includes the drainage of the Gila River downstream of the Gila Box Riparian National Conservation Area to the tribal lands of the San Carlos Apache Nation.

- Headwaters of the Gila River are in the Gila National Forest in New Mexico; eventually the flow is impounded downstream behind Coolidge Dam.



Gila River carrying a heavy sediment load after summer rains flowing from the Gila Box into the Gila Valley

Farming is the major industry in the Gila Valley

Around 40,000 acres are irrigated with a combination of surface water from the Gila River and groundwater from shallow irrigation wells.

Irrigation well near the community of Geronimo

Gila Valley sub-basin includes land ranging in elevation from alluvial valleys to the summit of Mt. Graham

ADEQ Gila Valley Sub-basin Study

- Charged with characterizing the groundwater quality of the Gila Valley sub-basin in 2004
- Provided funding to sample 65 sites
- Six month time span to spend project funds (sample plan, contact well owners for sampling permission and field work)
- Only assistance on project came from help in the field from an intern borrowed from another unit and an administrative assistant.

How Best to Conduct Study?

- Used a 1995 ADEQ study of the Gila Valley sub-basin as a starting point
- 81 groundwater quality samples were collected
- Inorganic samples collected at every site
- Radionuclide and pesticide samples at targeted sites

1995 ADEQ Study Findings

- Report contained brief “vague” conclusions
- Pesticides were “not detected”
- Standards for nitrate “occasionally exceeded”
- Standards for fluoride, arsenic, and radionuclides “rarely exceeded”
- TDS concentrations are “high”

Deficiencies in the 1995 Study

- Confusion between those collecting data and those writing report
- Deficiencies in sampling protocol and data validation
- Targeted sampling strategy resulted in clusters of samples and large areas without GW data
- Cluttered data presentation
- Minimal analysis of data collected

Deficiencies in the 1995 Study

- Sample sites were not linked to specific aquifers and/or recharge sources
- As such, water quality differences between recharge sources / aquifers could not be assessed
- The relationship between groundwater and the Gila River was not explored

Ways to Overcome the Problems Encountered in the 1995 Study

- Collecting and analyzing data is done by the same person
- Random stratified sampling is used for better spatial coverage of sub-basin
- Oxygen and hydrogen isotope samples collected at each site to help determine source of water

Study Challenges to Overcome:

- The sub-basin contains:
  - Multiple aquifers
  - Encompasses 1,642 square miles
  - Ranges in elevation from 2,600 to 10,713 feet

View from atop Mt. Graham

Cultural Study Challenges to Overcome

- Permission needed from owners to sample the selected wells and springs

- The sub-basin is in a politically conservative area; there are long-standing water rights issues between irrigation districts and neighboring tribal governments

People are leery of cooperating with government employees working on water-related topics

or

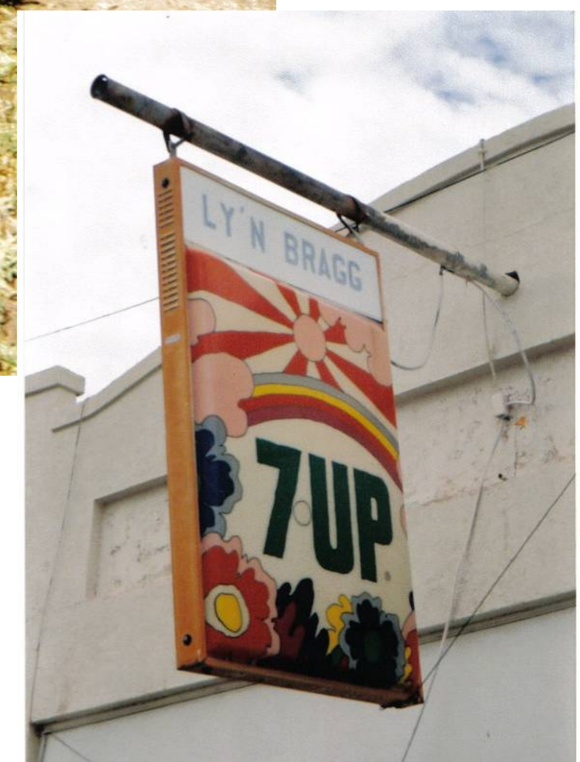
How would local residents react when asked if we could purge and collect a sample from their well?

Field Work Consisted of “Mostly” Friendly Well Owners, Creatures and Establishments

Well Owner
↓

↑
Gila Monster

Local Color
↓



2004 Sampling Sites Included:

Goat Windmill

Wells used for stock watering and irrigation use.

Irrigation well near Artesia

2004 Sampling Sites included:
Municipal wells, springs and artesian wells.

City of Safford municipal well
↓

Kimball Hot Artesian Well used for "recreational" purposes.
→

Heliograph Spring near the summit of Mt. Graham
↓

2004 GW Quality Data

- QA/QC acceptable based on equipment blanks, duplicate and split sample correlations, cation/anion balances, TDS/SC ratios, etc

- Water chemistry largely sodium-chloride/mixed

- 60% of sites had *fresh* water (TDS < 1000 mg/L)

- Samples consisted almost equally of *soft*, *moderately hard*, *hard* and *very hard* water

1995 vs. 2004 Study: Raw Data Comparison

- Percentage of sample sites exceeding health based standards:

- Arsenic: 1995 (32 %) 2004 (32 %)
- Fluoride: 1995 (15 %) 2004 (31 %)
- Nitrate: 1995 (10 %) 2004 (6 %)

- Antimony, barium, beryllium, cadmium, chromium, copper, lead, mercury, selenium, and thallium: **0 %** for both 1995 and 2004

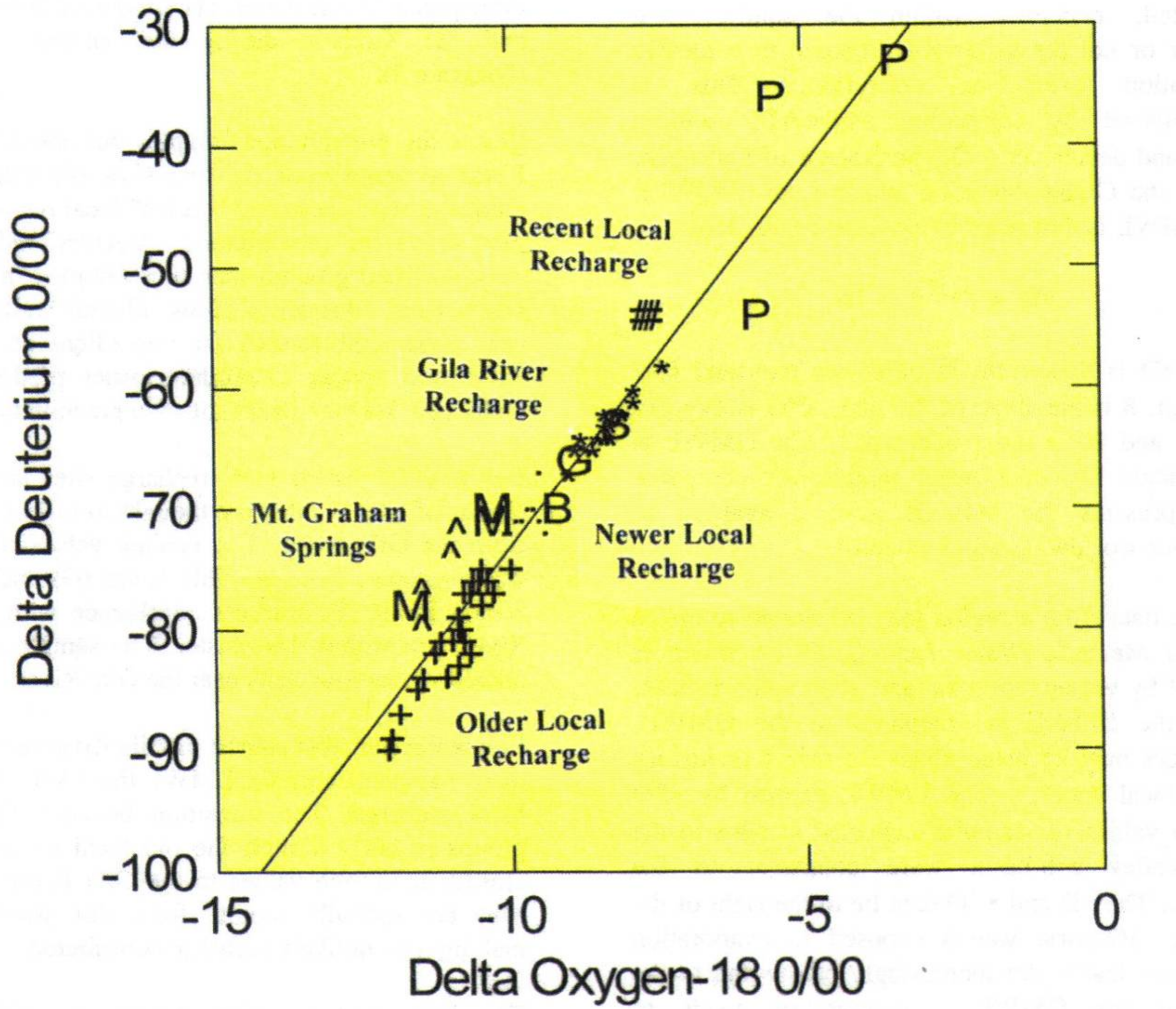
1995 vs. 2004 Study: Raw Data Comparison

- Percentage of sample sites exceeding aesthetics based standards:

- TDS: 1995 (71 %) 2004 (66 %)
- Fluoride: 1995 (44 %) 2004 (39 %)
- pH-field: 1995 (14 %) 2004 (17 %)
- Chloride 1995 (35 %) 2004 (45 %)
- Sulfate 1995 (32 %) 2004 (45 %)

Two Major Sources of GW Recharge

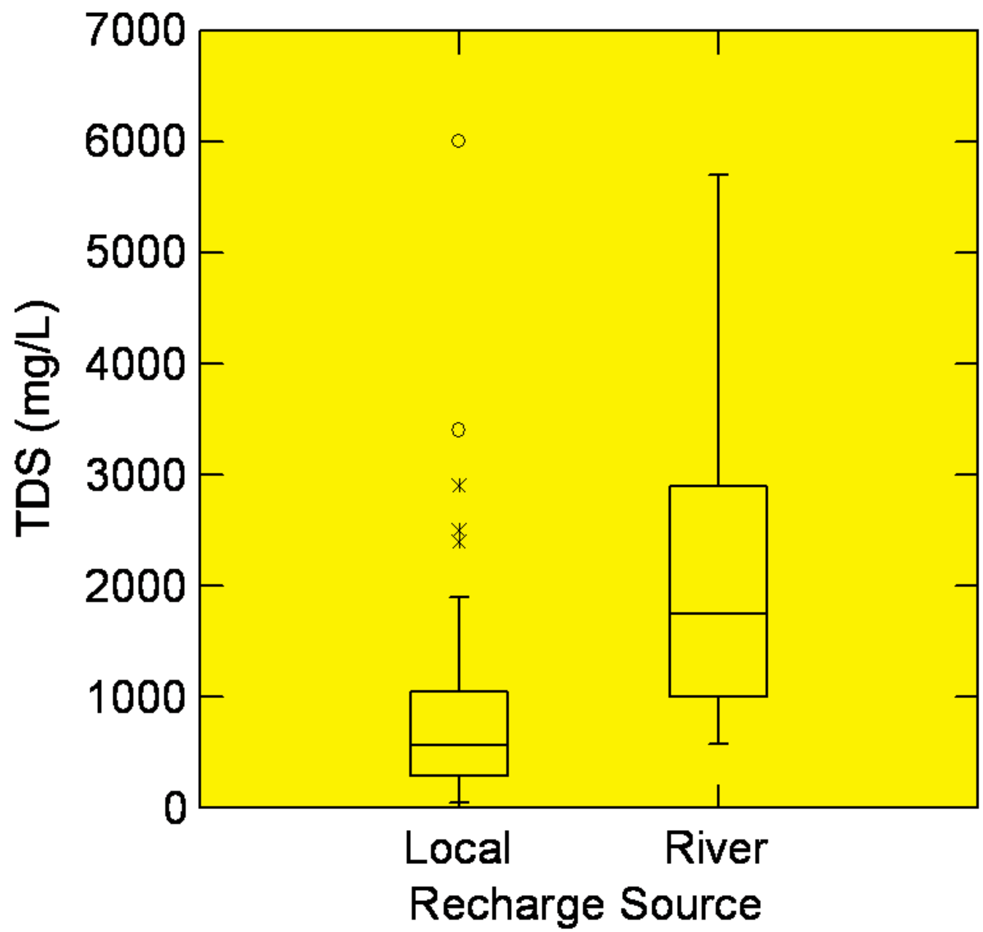
- Gila River
- Local precipitation which is subdivided into four types
- 6 surface water and 3 precipitation isotope samples were also collected



GW Quality Patterns

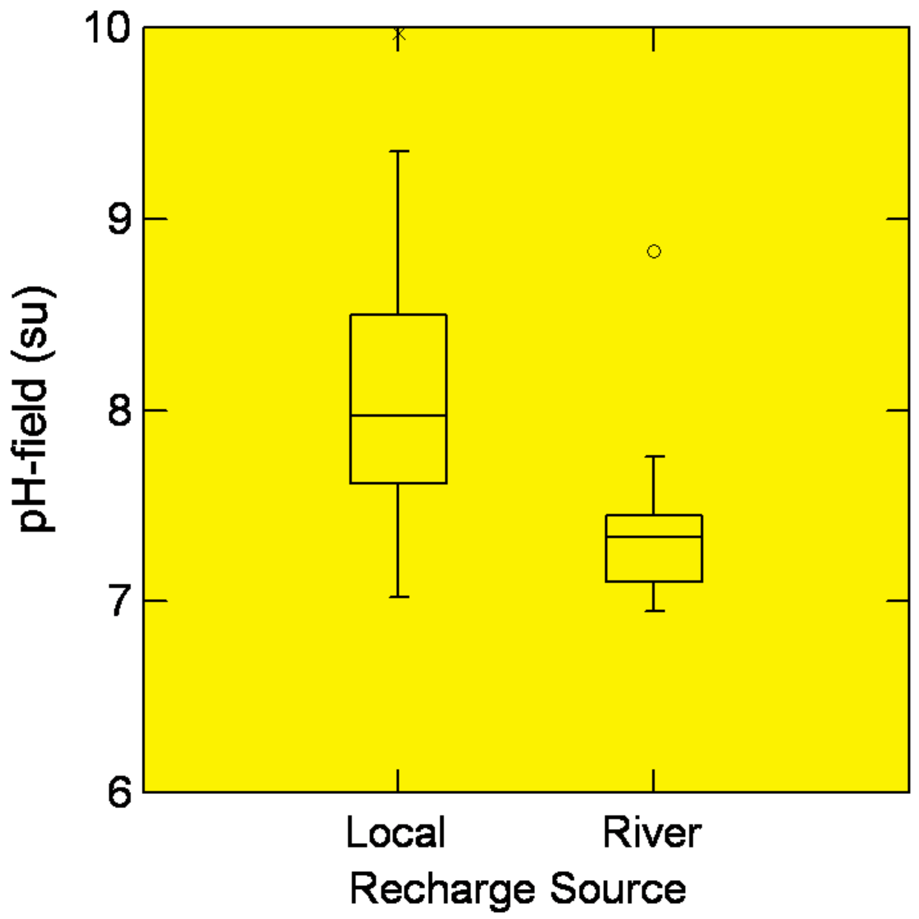
- Based on isotope data, well location and well characteristics, comparisons could be made between recharge sources.

- TDS concentrations in the Gila River recharge (or younger alluvium) are significantly higher than those in the local precipitation recharge (or older alluvium) (Kruskal-Wallis test, $p \leq 0.01$)



GW Quality Patterns

- TDS, hardness, major ions, nitrate and boron concentrations in the Gila River recharge (or younger alluvium) are significantly higher than those in local precipitation recharge (or older alluvium); the opposite pattern occurs with pH-field (Kruskal-Wallis test, p ≤ 0.05)



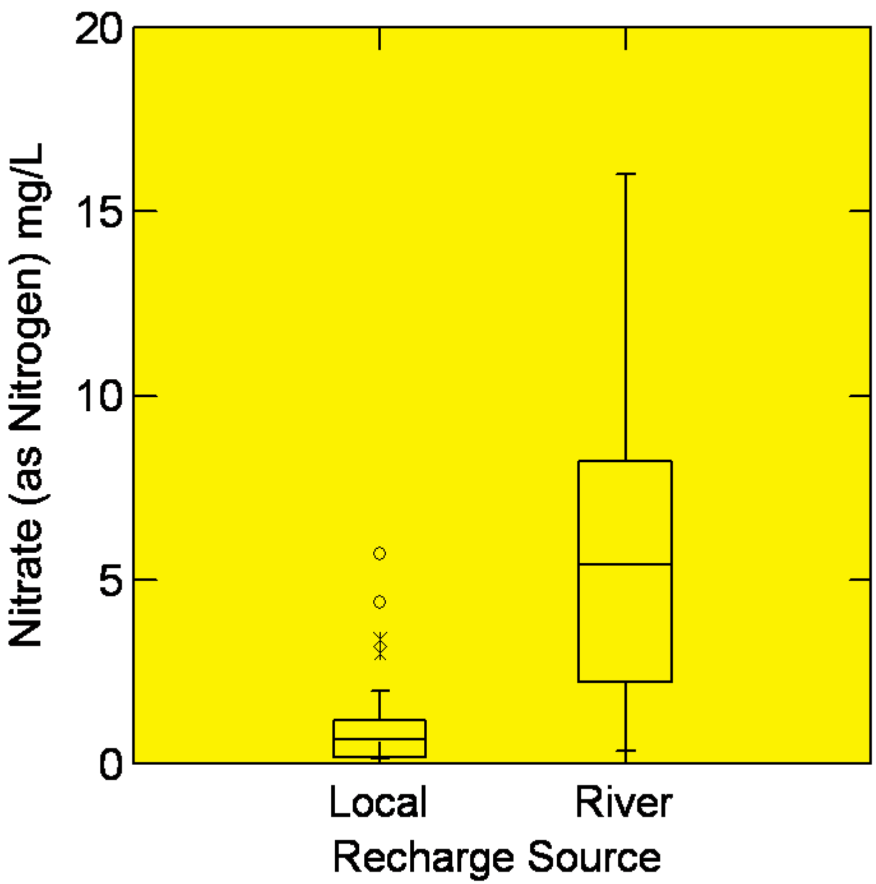
Reevaluated 1995 GW Data

- Classified the 1995 sample sites by aquifer (younger alluvium vs. older alluvium) based well location, well characteristics and aided by insights gained from the 2004 isotope results

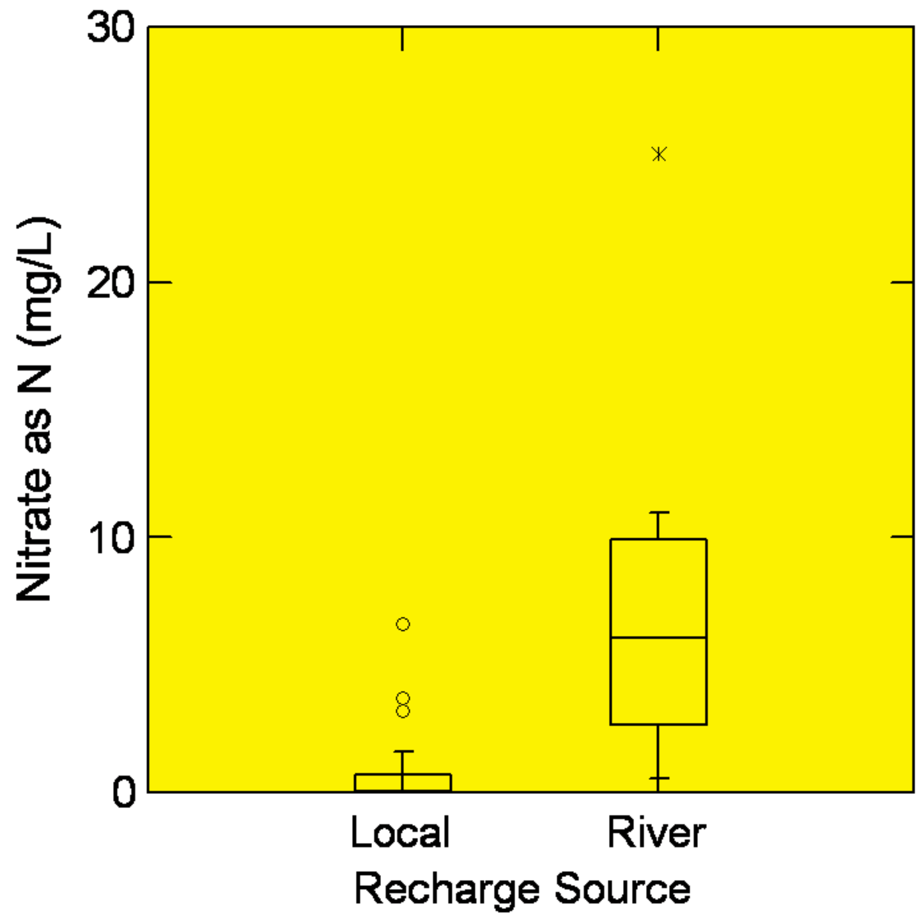
- TDS, hardness, major ions, nitrate and boron concentrations in the Gila River recharge (or younger alluvium) are significantly higher than those in local precipitation recharge (or older alluvium); the opposite pattern occurs with pH-field (Kruskal-Wallis test, $p \leq 0.05$)

- The groundwater quality patterns revealed by the 1995 data are the same as by the 2004 data

Nitrate Comparison
1995 vs. 2004

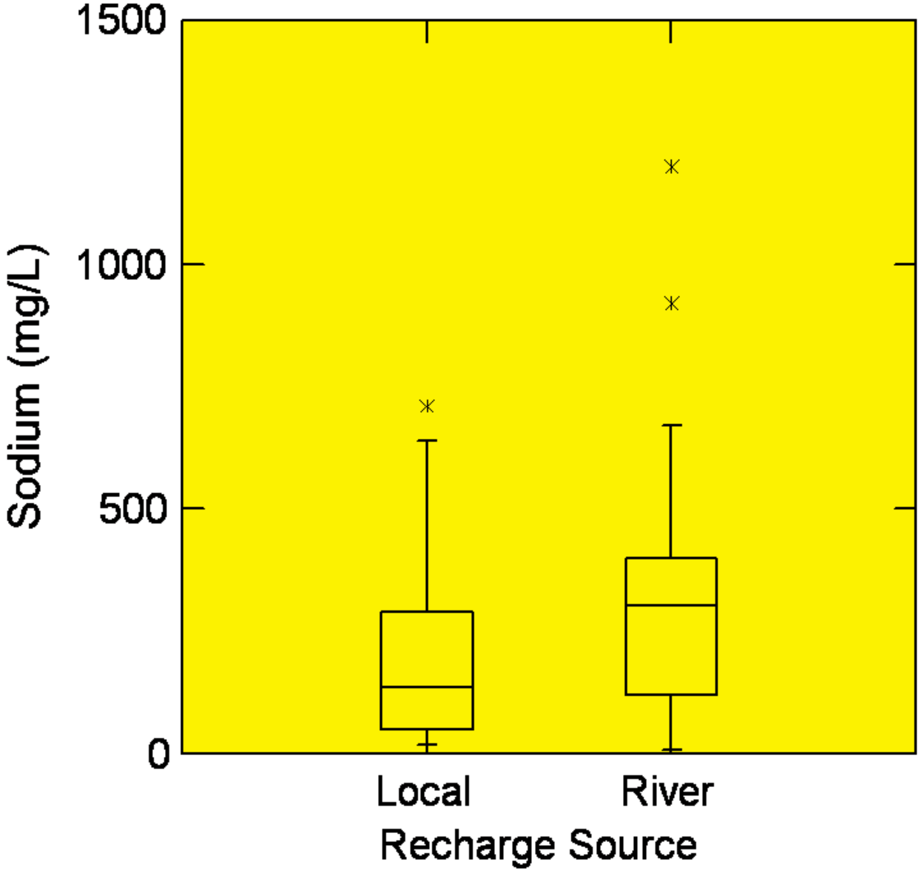


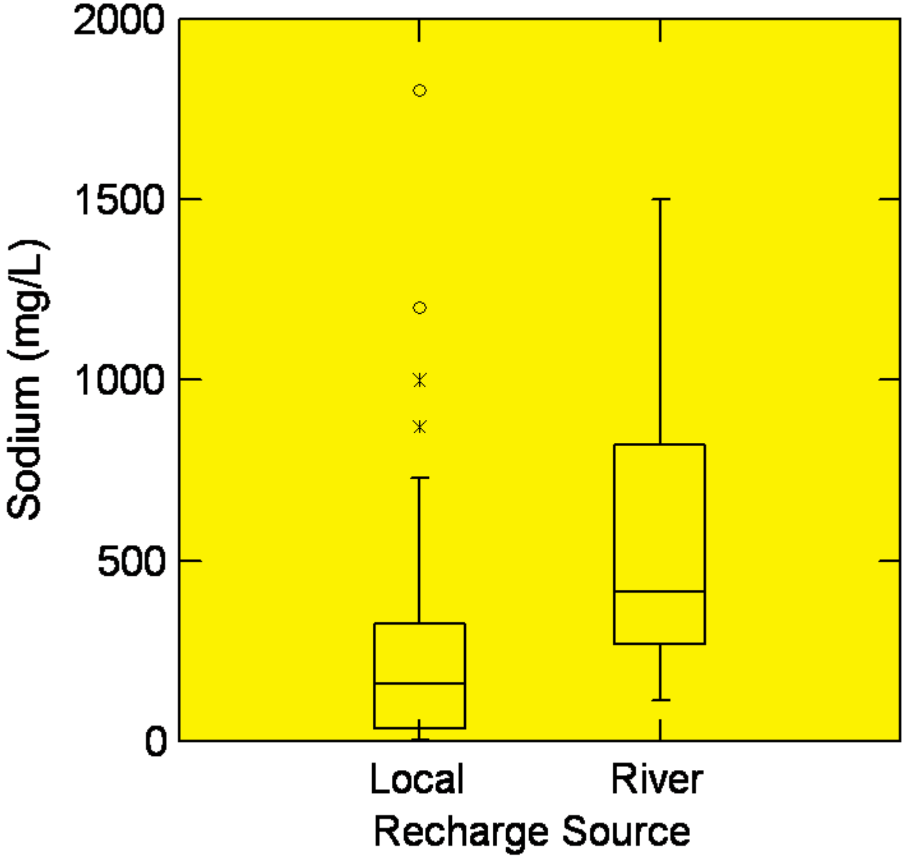
1995 Data



2004 Data

Sodium Comparison 1995 vs. 2004





1995 Data **2004 Data**

Study Confirmed Groundwater - Surface Water Relationships

- Connected the recharge in the younger alluvium to flow in the Gila River

- TDS concentrations increase from 600 mg/L when diverted at the head of the Gila Valley to 2,150 mg/L below the sub-basin because of inflow of saline groundwater.

Study Conclusions

- Raw data for the 1995 and 2004 studies were similar.
- Little “new” was groundwater quality information was “discovered” in the 2004 study.
- However, the use of isotopes to determine recharge sources allowed more conclusions to be drawn from the water quality data even though 20 percent fewer inorganic samples were collected.
- Thus the collection of isotope samples and a little more careful work in 1995 could have avoided the costs associated with the 2004 study.

Isotope Suggestions

- Oxygen and hydrogen isotope samples are inexpensive and low maintenance (small quantity of water needed, no refrigeration or preservatives and a have long holding time).

- In Arizona, isotope samples tend to be most valuable in basins with perennial streams, such as along the Colorado River and Gila River, whose headwaters are in distant high elevation mountains as they tend to have different isotopic values than local precipitation.

Caveat

- The Gila Valley sub-basin is a complex hydrologic system; the 2004 study can certainly be improved upon.
- But it does show how collecting an inexpensive, low maintenance isotope sample can dramatically improve the hydrologic analysis of groundwater quality data.