ADEQ
Arizona Department of Environmental Quality
Janet Napolitano, Governor
Stephen A. Owens, ADEQ Director

FACT SHEET

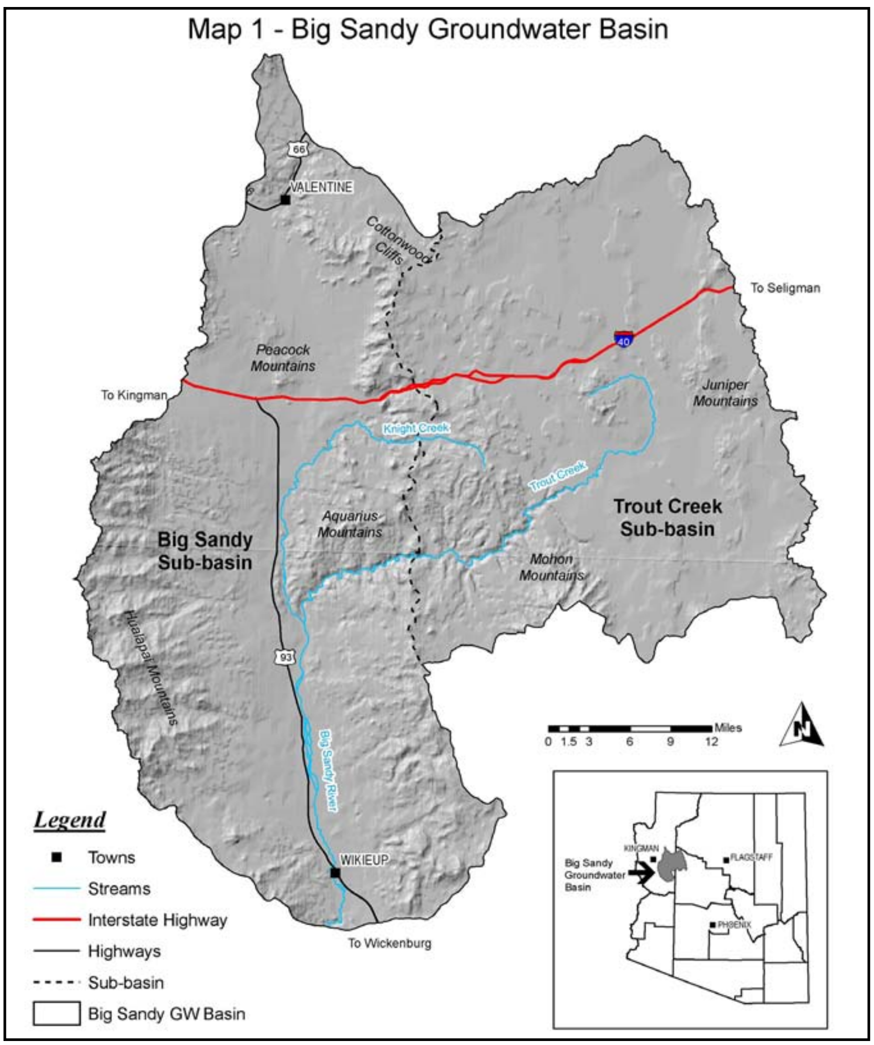
Ambient Groundwater Quality of the Big Sandy Basin
A 2003-04 Baseline Study – October 2006

INTRODUCTION

To support an Arizona Department of Environment Quality (ADEQ) Total Maximum Daily Load study examining elevated mercury concentrations in fish tissue, sediment and water from Alamo Lake, in 2003-2004, ADEQ conducted a baseline groundwater quality study of the Big Sandy basin (BIS).[1] This study was conducted by the ADEQ Ambient Groundwater Monitoring Program, as authorized by legislative mandate in Arizona Revised Statutes §49-225, and is a synopsis of the ADEQ Open File Report 06-09.[2]

The BIS covers approximately 1,900 square miles of rugged terrain in northwestern Arizona (Map 1) stretching from north of Route 66 to south of the town of Wikieup along U.S. Highway 93.[3] Located in Mohave and Yavapai Counties, most lands are federally managed by the Bureau of Land Management with the remainder consisting chiefly of State trust and private lands. Most of the basin is used as rangeland with private land increasingly subdivided for dispersed housing.

The basin is bounded to the west by the Hualapai Mountains, to the south by the Mohon Mountains, to the east by the Juniper and Aquarius Mountains, and to the north by the Peacock Mountains and Cottonwood Cliffs. The highest point in the basin is Hualapai Peak at 8,417 feet above mean sea level (amsl) and elevations descend southward to approximately 1,800 feet amsl at the Big Sandy River where it exits the basin south of Wikieup.[3] Climate is semiarid, characterized by hot summers and mild winters. Average annual precipitation decreases from almost 20 inches atop the Hualapai Mountains to around 10 inches in the Big Sandy Valley.



Map 1 - *The Big Sandy groundwater basin.*

HYDROLOGY

Knight Creek and Trout Creek (Figure 1) drain the northern part of the BIS and converge 15 miles north of Wikieup to form the Big Sandy River. This waterway flows southward exiting the basin and eventually debouching into the Santa Maria River just above Alamo Lake.

Groundwater is the source of the vast majority of water uses in the BIS and occurs in at least five hydrologic settings: floodplain alluvium, unconfined upper basin-fill, confined upper basin-fill, sedimentary rock in the east-northeast portion of the basin, and the consolidated bedrock of the Hualapai, Peacock, Aquarius, and Mohon Mountains. The main aquifer is the unconfined upper basin-fill which is capable of producing as much as 1,000 gallons per minute.[3]

Publication Number: FS 06-24

Figure 1 - *Meadow Lake is the headwaters of Fort Rock Creek which is a tributary of Trout Creek, the Three Sisters Buttes is in the background.*

Historically, the primary use of groundwater in the basin has been for irrigated agriculture in the Big Sandy Valley. However, since the early 1970s, most groundwater pumped in the BIS has been transported by pipeline to the Bill Williams basin for use at the Phelps Dodge Bagdad Mine (Figure 2). In 1980, it was estimated that approximately 2,000 acre-feet of groundwater was pumped annually in the basin with 95 percent of that water used at the Bagdad Mine.[3]

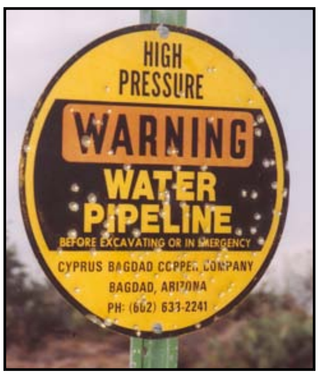


Figure 2 - *Phelps Dodge uses 95 percent of groundwater pumped in the Big Sandy basin—produced from deep wells along the Big Sandy River—for copper mining and processing at Bagdad in the Bill Williams basin.*

METHODS OF INVESTIGATION

To characterize regional groundwater quality, 57 groundwater samples were collected. Forty-three (43) wells, mainly from relatively shallow wells used for domestic or stock purposes and 14 springs (Figure 3) were sampled for inorganic constituents and isotopes of oxygen and hydrogen analyses. At selected sites, radon (37 sites), radiochemistry (30 sites), and ultra-clean mercury (21 sites) samples were also collected. ADEQ was unable to sample deep wells owned by the Phelps Dodge Corporation and used to pump water that is transported to Bagdad or those deep wells owned by Caithness Energy that were drilled for use at their proposed Big Sandy power plant.

Sampling protocol followed the ADEQ Quality Assurance Project Plan. Based on quality control data, the effects of sampling equipment and procedures were not found to be significant based on seven quality assurance/quality control tests.

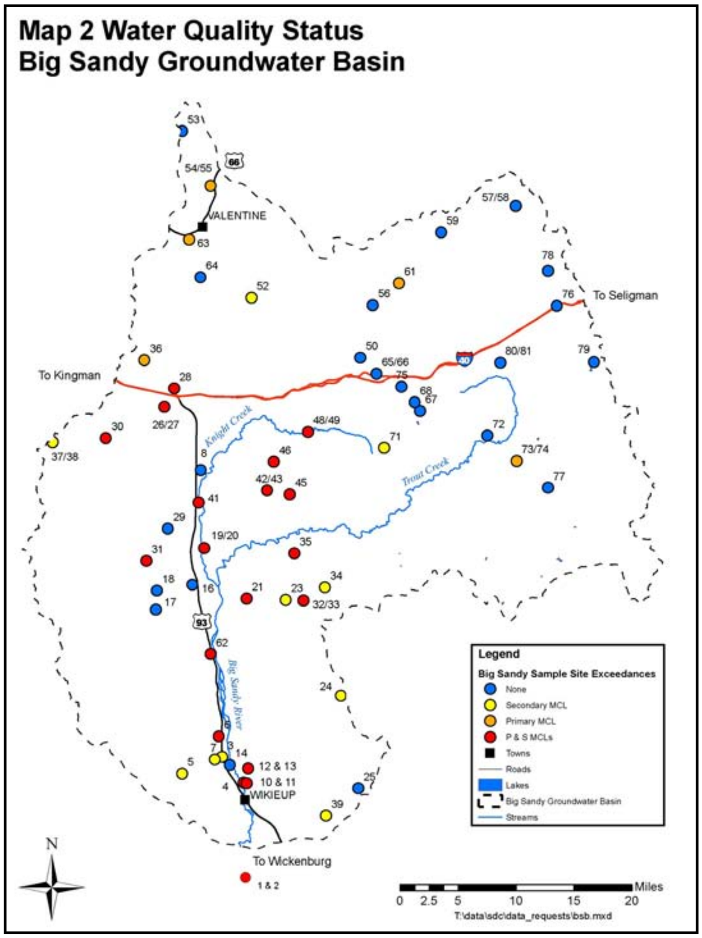
Figure 3 - *The extensive riparian areas and planted palm trees attest to the prodigious flow from Cofer Hot Springs east of Wikieup; the sample from this site had studies' highest arsenic concentration (0.125 mg/L).*

WATER QUALITY SAMPLING RESULTS

The groundwater sample results were compared with Environmental Protection Agency (EPA) Safe Drinking Water (SDW) water quality standards (Map 2). Of the 57 sites sampled, 24 (42 percent) met all federal water quality standards and guidelines (Figure 4).

EPA SDW Primary Maximum Contaminant Levels (MCLs) are enforceable, health-based water quality standards that public water systems must meet when supplying water to their customers. Primary MCLs are based on a daily lifetime consumption of two liters of water. Of the 57 sites sampled, 24 sites had concentrations of at least one constituent that exceeded a Primary MCL. Health-based exceedances included arsenic (11 sites), fluoride (11 sites), gross alpha (9 sites), lead (1 site), radium (1 site), and uranium (2 sites).

EPA SDW Secondary MCLs are unenforceable, aesthetics-based water quality guidelines for public water systems. Water with Secondary MCLs may be unpleasant to drink and/or create unwanted cosmetic or laundry effects but is not considered a health concern. At 29 sites, concentrations of at least one constituent exceeded a Secondary MCL. Aesthetics-based exceedances included chloride (4 sites), fluoride (20 sites), iron (3 sites), manganese (4 sites), pH-field (2 sites), sulfate (2 sites), and total dissolved solids or TDS (22 sites).



Map 2 - *Sample sites are color-coded according to their water quality standard status.*

Figure 4 - *Groundwater pumped from a 225-foot well pours into an unnamed reservoir to be used for irrigation north of Fort Rock Ranch located a few miles south of Interstate 40. Water from this well met all drinking water standards.*

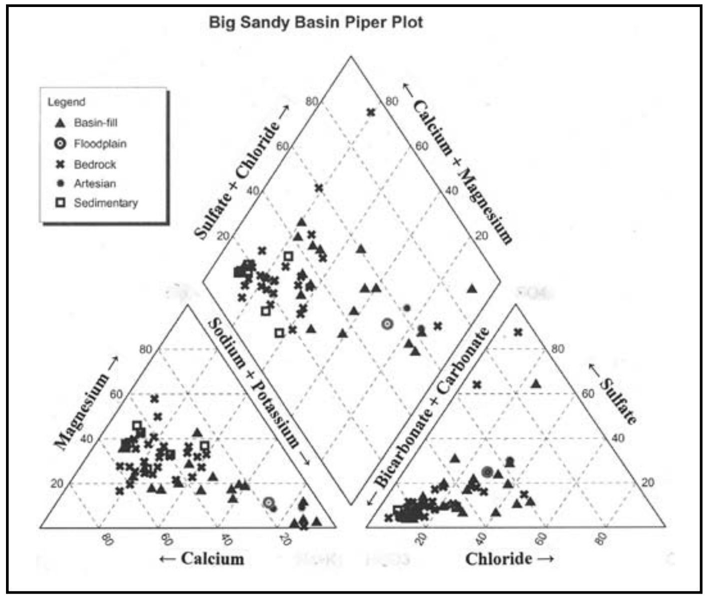


Figure 5 - *This diagram shows samples collected from bedrock and sedimentary water sources are predominantly of calcium/magnesium-bicarbonate chemistry, the basin-fill aquifer varies but tends towards a mixed-mixed chemistry and the artesian aquifer and floodplain aquifer tend toward a sodium-mixed chemistry.*

GROUNDWATER COMPOSITION

Analytical results indicated that groundwater in the BIS is generally slightly alkaline, fresh, and moderately hard to very hard based on pH, TDS and hardness analyses. Most groundwater sample sites were either of mixed-bicarbonate or calcium-bicarbonate water chemistry (Figure 5). Nitrate concentrations were generally low with no samples exceeding health-based standards. Among trace elements, only arsenic, boron, copper, fluoride, and zinc were detected at more than 20 percent of sample sites. Mercury was not detected in any sample submitted to the Arizona State Health Department Laboratory which has a Minimum Report Level of 0.0005 milligrams per liter (mg/L). The 21 ultra-clean mercury samples submitted to Frontier Laboratory had a mean concentration of 0.0000104 mg/L and a median concentration of 0.00000095 mg/L.

Patterns were found among groundwater sub-basins, aquifers, and recharge sources (ANOVA with Tukey test using log-transformed data, $p \leq 0.05$). Temperature, TDS, sodium, chloride, sulfate, fluoride (Figure 6), boron, iron and gross beta were higher in the down-gradient Big Sandy sub-basin than in the up-gradient Trout Creek sub-basin. Temperature, TDS, sodium, chloride, sulfate, fluoride, boron, and radon were higher in basin-fill or artesian aquifers than in sedimentary rock. Temperature, pH-lab, sodium, sulfate, and fluoride are higher at depleted recharge sites than at enriched recharge sites; the opposite pattern occurs with calcium, magnesium, hardness, and nitrate.

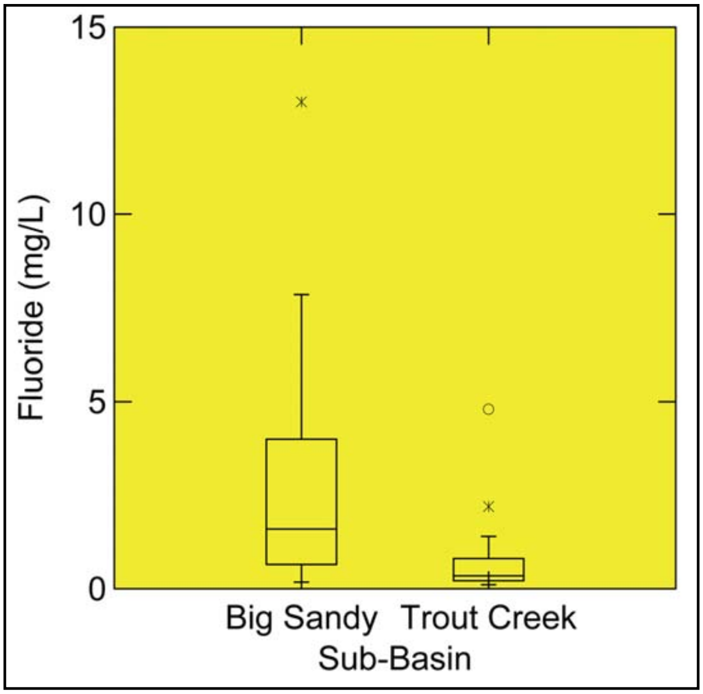


Figure 6 - *Fluoride concentrations in the Big Sandy sub-basin are generally higher than in the Trout Creek sub-basin (ANOVA test, $p \leq 0.01$). Water quality exceedances for fluoride (Secondary MCL is 2 mg/L, Primary MCL is 4 mg/L) also occur more frequently in the Big Sandy sub-basin. Fluoride concentrations are frequently low in recharge areas and increase with pH values.*

CONCLUSIONS

Of the 57 samples collected in the basin, less than half (24 samples) met all health and aesthetic water quality standards. Constituents most frequently exceeding health-based standards were arsenic, fluoride and gross alpha (Figure 7) while TDS and fluoride most commonly exceeded aesthetics-based standards. Most of these sites were located in the south-central portion of the basin; other areas—particularly in the northeast—had relatively few exceedances. These water quality exceedances appear to be the result of naturally occurring geochemical processes because of the relatively remote and undeveloped nature of the basin as well as other nearby groundwater basins having similar constituent exceedances. Analytical results and spatial patterns suggest that groundwater in the basin generally follows a flow path evolving from calcium-bicarbonate chemistry, indicative of recently recharged groundwater, in the sedimentary rock in the Trout Creek sub-basin to a more saline, mixed-bicarbonate chemistry with higher concentrations of constituents such as sodium, chloride, sulfate, fluoride and boron that are indicative of groundwater with a longer residence time.

While mercury was not detected over a health-based drinking water quality standard at any groundwater sample site, the ADEQ TMDL study indicated that this trace element is naturally present in the watershed from sources including volcanic and granitic rocks, their soil derivatives, and geothermal springs.[1] Other mercury watershed sources include runoff from historic gold mining areas and air deposition.[1]

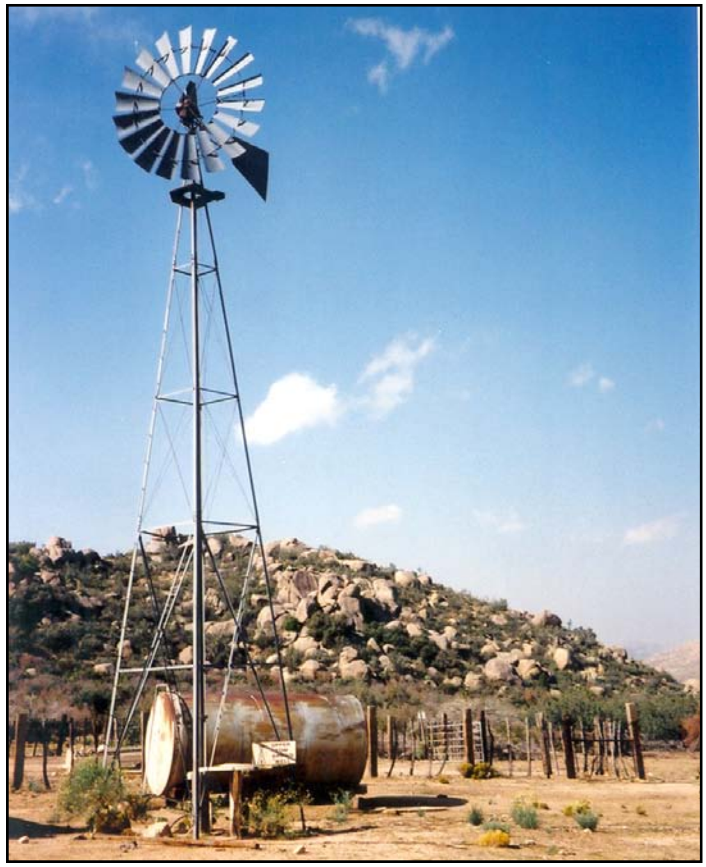


Figure 7 - *Upper Tom Brown Well had both gross alpha and radium-226 health-based, water quality exceedances, as did most sites sampled in the granite rock of the Aquarius Mountains.*

FOR MORE INFORMATION CONTACT:

Douglas C. Towne, ADEQ Hydrologist
Monitoring Unit, Water Quality Division
1110 W. Washington St. #5180C
Phoenix, AZ 85007
(602) 771-4412 or
1(800) 234-5677 Ext. 771-4412
Email: dct@azdeq.gov

Hearing impaired persons may call our TDD line at (602) 771-4829.

REFERENCES CITED

1 Fitch, S.T., 2006, Mercury Total Maximum Daily Load (TMDL) for Alamo Lake, Arizona: Arizona Department of Environmental Quality Open File Report 06-07, 54 p.

2 Towne, D.C., 2006, Ambient groundwater quality of the Big Sandy basin: A 2003-2004 baseline study: Arizona Department of Environmental Quality Open File Report 06-09, 66 p.

3 Arizona Department of Water Resources, 1994, Arizona Water Resources Assessment – Volume II, Hydrologic Summary, Hydrology Division, pp. 70-71.