ADEQ
Arizona Department of Environmental Quality
Janice K. Brewer, Governor
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FACT SHEET

Ambient Groundwater Quality of the Butler Valley Basin: A 2008-2012 Baseline Study – December 2012

INTRODUCTION

A baseline groundwater quality study of the Butler Valley basin was conducted from 2008 through 2012 by the Arizona Department of Environmental Quality (ADEQ) Ambient Groundwater Monitoring Program. ADEQ carried out this task pursuant to Arizona Revised Statutes §49-225 that mandates ongoing monitoring of waters of the state including aquifers. The fact sheet is a synopsis of the ADEQ Open File Report 12-06.[1]

The Butler Valley groundwater basin covers approximately 288 square miles in western Arizona within La Paz County (Map 1). The basin is located in a remote area; the only paved vehicle access is via Alamo Dam Road. Lightly populated and largely undeveloped, only an estimated 12 people reside within the basin.[2] Low-intensity livestock grazing is the predominant land use in Butler Valley; the El Paso Natural Gas Compressor Station and Butler Valley Farm are among the few economic ventures within the basin. Although nothing currently remains of the base, Camp Bouse, located in the northeast part of the basin, was a top-secret tank training facility for the U.S. Army during World War II.

The valley floor covers roughly 160 square miles and slopes gently southwestward. The basin is bordered by the Bouse Hills and Buckskin Mountains on the north, by the Little Buckskin Mountains on the east, by the Harcuvar Mountains on the south, and by the Granite Wash Mountains on the west. Elevations range from 4,957 feet above mean sea level (amsl) in the Harcuvar Mountains to 1,345 feet amsl at the 1.5-mile-wide "Narrows" where Cunningham Wash flows into the Ranegras Plain basin at a gap between the Granite Wash Mountains and the Bouse Hills. The basin consists predominantly of federal land managed by the Bureau of Land Management (56 percent) and State Trust lands (44 percent); less than 1 percent is private land which mostly consists of small parcels of patented mining claims.[2]

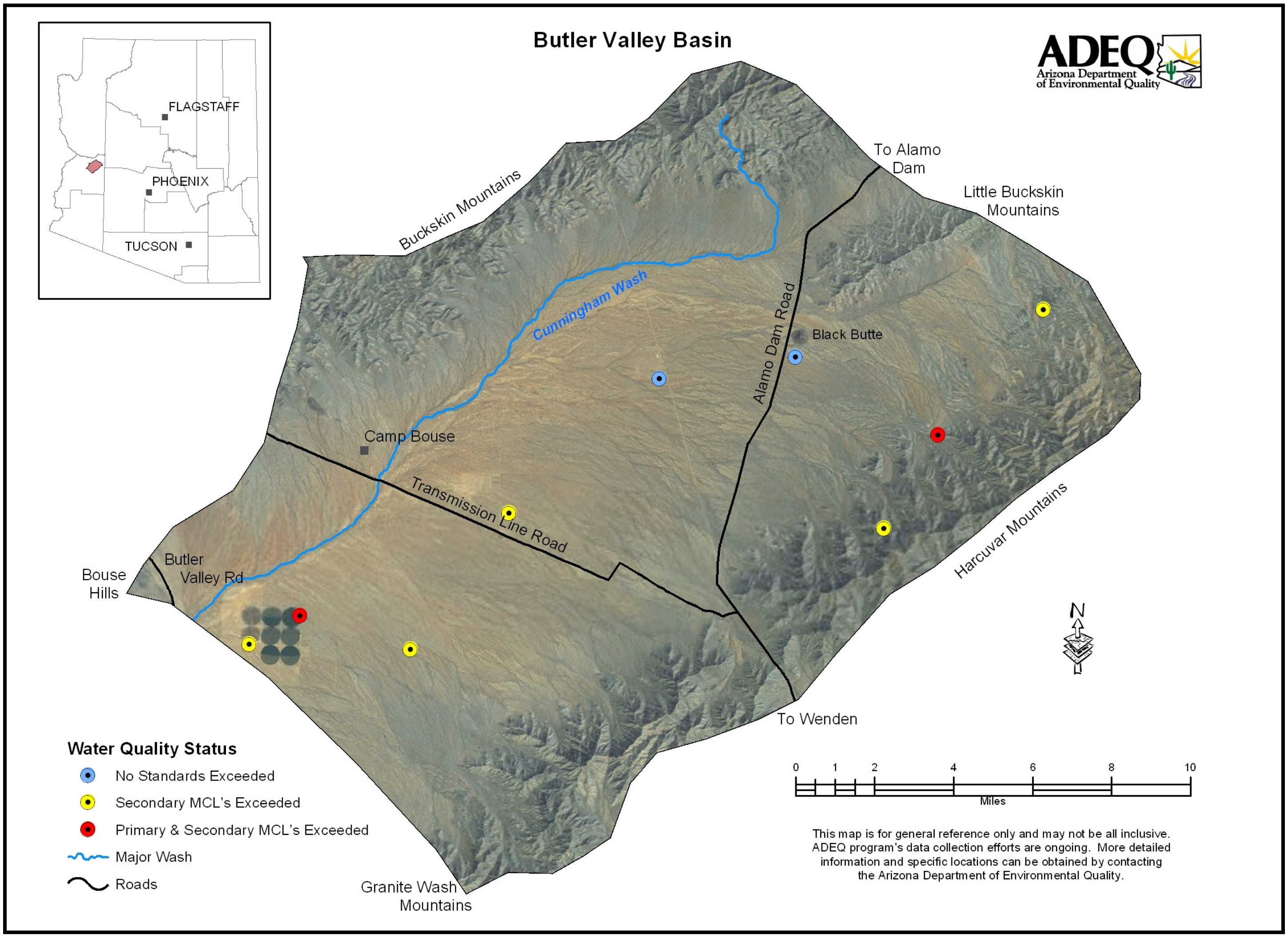
HYDROLOGY

Butler Valley is drained by Cunningham Wash, an ephemeral stream that heads in the Buckskin Mountains and is a tributary to the Colorado River.[2] There are no perennial or intermittent steams or lakes within the basin. Groundwater is the sole source for all domestic and irrigation purposes as well as most stock uses in the basin.[3]

Figure 1. ADEQ's Susan Determann collects a sample from Hangman's Well in the foothills of the Harcuvar Mountains. The former windmill is now solar powered and is used for stock watering.

Alluvial deposits are the principal aquifer in the basin. Groundwater occurs primarily in the basin-fill sediments composed of silt, sand, clay, and gravel beds found in the valley floor. Based on limited data, these deposits range in thickness from 525 feet to 1,450 feet.[3] Depths to groundwater range from 145 feet below land surface (bls) to 513 feet bls.[3] Small volumes of groundwater may also occur in mountain areas in thin alluvium, and in fractured and weathered volcanic, granitic, metamorphic, and sedimentary rocks. There is an estimated 6.5 million acre-feet of water available in the basin to a depth of 1,200 feet.[2]

Groundwater flows from the northeast to the southwest in Butler Valley. The water level gradient is low throughout most of the basin but increases in the southwestern portion as a result of a cone of depression caused by a cluster of irrigation wells at Butler Valley Farm.[3]



Map 1. Sample sites in the Butler Valley basin are color-coded according to their water quality status: No Standards Exceeded, Secondary MCLs Exceeded, and Primary and Secondary MCLs Exceeded.

METHODS OF INVESTIGATION

To characterize the basin's regional groundwater quality, samples were collected from nine sites consisting of eight wells and one spring. The wells produced water for stock (six wells) and irrigation (two wells) use; the spring provides water for stock. All samples were collected from sites located in the center and southern parts of the basin; no wells or springs were available for sampling in northern portions of the basin.

Inorganic constituents and oxygen and deuterium isotopes were collected at all nine sites. Other samples collected include nitrogen isotopes and radon at six sites, and radionuclides at three sites. Sampling protocol followed the *ADEQ Quality Assurance Project Plan* (www.azdeq.gov/function/programs/lab/). The effects of sampling equipment and procedures were not found to be significant based on seven quality assurance/quality control tests.

WATER QUALITY SAMPLING RESULTS

Groundwater sample results were compared with the Safe Drinking Water Act (SDWA) water quality standards. Public drinking water systems must meet these enforceable, health-based, water quality standards, called Primary Maximum Contaminant Levels (MCLs), when supplying water to their customers. Primary MCLs are based on a daily lifetime (70 years) consumption of two liters of water.[4] Of the nine sites sampled, two sites (22 percent) had constituent concentrations that exceeded Primary MCLs. Constituents exceeding Primary MCLs include fluoride (one site), and uranium (one site).

Groundwater sample results were also compared with SDWA water quality guidelines. Public drinking water systems are encouraged by the SDWA to meet these unenforceable, aesthetics-based water quality guidelines, called Secondary MCLs, when supplying water to their customers. Water exceeding Secondary MCLs may be unpleasant to drink and/or create unwanted cosmetic or laundry effects but is not considered a health concern.[4] Of the nine sites sampled, seven (78 percent) had constituent concentrations that exceeded Secondary MCLs. Constituents above Secondary MCLs include chloride (three sites), fluoride (two sites), manganese (one site), sulfate (three sites), and total dissolved solids or TDS (five sites).

Figure 2 – Situated high above Butler Valley, a stock watering trough served by Dripping Springs in the Harcuvar Mountains is stagnant because of a frozen water line. A fresh sample from the spring was obtained higher up the pipeline and met all water quality standards except total dissolved solids (TDS).

Radon is a naturally occurring, intermediate breakdown product from the radioactive decay of uranium-238 to lead-206. Of the six sites sampled for radon, none exceeded the proposed 4,000 picocuries per liter (pCi/L) standard that would apply if Arizona establishes a multimedia program to address the health risks from radon in indoor air. Two sites exceeded the proposed 300 pCi/L standard that would apply if Arizona does not develop a multimedia program. [4]

GROUNDWATER COMPOSITION

Groundwater chemistry varies throughout Butler Valley but evolves into a sodium-mixed chemistry in down-gradient portions of the basin. Levels of pH measured in the field were *alkaline* (above seven standard units) at all nine sites. TDS concentrations were considered *fresh* (below 999 mg/L) at six sites and *slightly saline* (1,000 - 3,000 mg/L) at three sites. Hardness concentrations were *soft* (below 75 mg/L) at two sites, *moderately hard* (75 - 150 mg/L) at two sites, *hard* (150 - 300 mg/L) at one site, *very hard* (300 - 600 mg/L) at two sites, *extremely hard* (> 600 mg/L) at two sites.

Most trace elements such as aluminum, antimony, beryllium, cadmium, iron, lead, mercury, nickel, silver, thallium, and zinc were rarely detected. Arsenic, barium, boron, chromium, copper, fluoride, manganese, selenium, and strontium were detected at more than 20 percent of the sites.

ISOTOPE COMPOSITION

Samples collected at six sites had much lighter isotope values than what would be expected from recharge originating from recent precipitation in Butler Valley or the surrounding low elevation mountains and are far more depleted than is possible given the basin's elevation. The samples likely consist of paleowater or "old recharge" that was predominantly recharged 8,000 - 12,000 years ago when the basin's climate was cooler and subject to less evaporation.[5] Sites with "old recharge" were found throughout the basin but particularly in down-gradient sites in the valley floor.

Figure 3 – In Butler Valley, rancher Frank Herschkowitz watches ADEQ's Elizabeth Boettcher collect a sample from Jug Head Well. The sample from the 280-foot-deep stock well met all water quality standards except for total dissolved solids (TDS).

Situated slightly higher on the precipitation trajectory are samples from two wells that appear to consist primarily of "old recharge" but appear to also receive more recent recharge. These "mixed recharge" sites are located up-gradient from sites that had groundwater consisting of old recharge.[5]

The most up-gradient isotope sample collected in the eastern portion of the basin is higher on the precipitation trajectory and more enriched than all the other samples in Butler Valley. The isotope values from this stock well suggest that much of the groundwater consists of "recent recharge" stemming from local precipitation.

Groundwater samples for nitrogen isotope ($\delta^{15}N$) analysis were collected at six sites. The $\delta^{15}N$ values ranged from -0.3 to +3.0 0/00 while nitrate values ranged from non-detect to 3.5 mg/L. Based on the isotope results, it appears that the nitrogen source is from either natural soil organic matter and/or inorganic fertilizer.

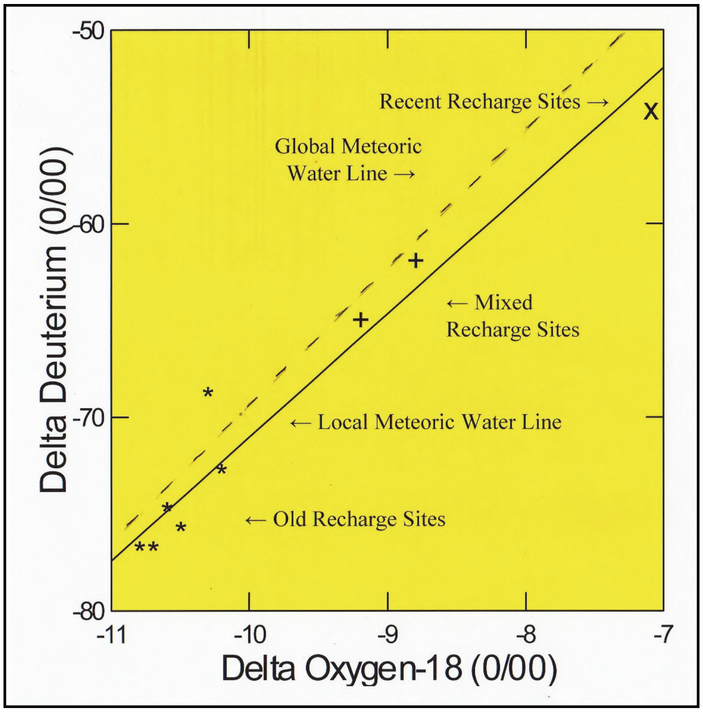


*Figure 4 – The isotope samples are plotted according to their oxygen-18 and deuterium values and fall into three groups: recharge from recent precipitation (site = X), mixed recharge (site = +), and old recharge (site = *) from precipitation that occurred roughly 10,000 years ago when the basin's climate was much cooler.*

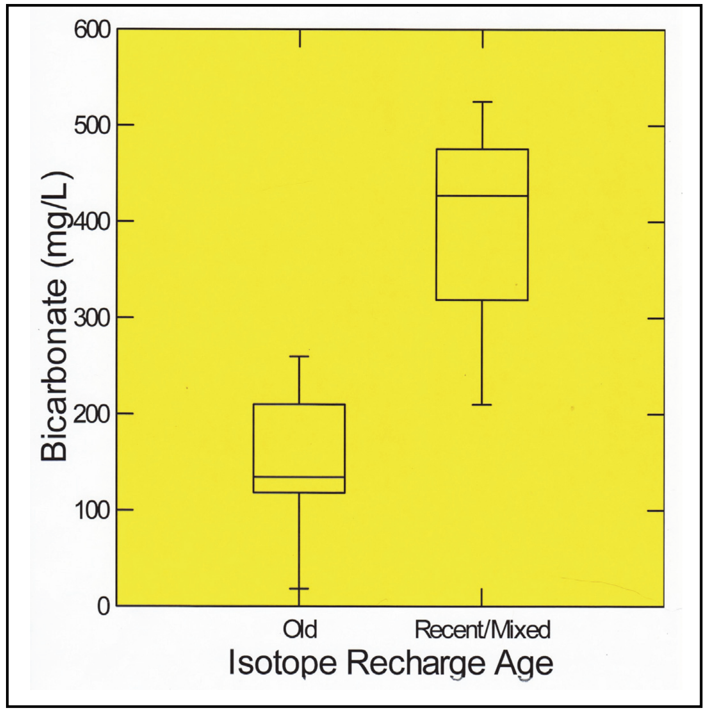


Figure 5 – Sample sites with recent/mixed recharge have significantly higher bicarbonate concentrations than sample sites derived from old recharge (Kruskal-Wallis, $p \leq 0.05$). Elevated bicarbonate concentrations are often associated with recharge areas.

GROUNDWATER PATTERNS

Some groundwater constituent concentrations appear to be influenced by recharge age and geology. Constituents such as magnesium, bicarbonate, copper, oxygen-18 and deuterium had significantly greater concentrations in "recent/mixed recharge" than "old recharge" (Kruskal-Wallis test, $p \leq 0.05$). Constituents such as hardness, calcium, magnesium, and bicarbonate had significantly greater concentrations in sites located in hard rock than in alluvium; the opposite pattern occurred with temperature (Kruskal-Wallis test, $p \leq 0.05$).

DISCUSSION

Butler Valley is a small, remote basin located in western Arizona. Groundwater development has been limited; with the exception of some irrigation wells clustered at Butler Valley Farm, all operational wells and flowing springs in the basin were sampled. Still, only nine groundwater samples were able to be collected and no samples were obtained from large portions of the basin.

Despite collecting few samples, the study was still able to make some limited characterizations concerning groundwater quality in the basin. Generally, groundwater appears to be suitable for drinking water purposes. Primary MCLs were exceeded for fluoride and uranium at one site apiece while exceedances involving Secondary MCLs were more frequent. Previous assessments of groundwater quality in Butler Valley indicated arsenic, lead, and nitrate exceeded health-based water standards.[2]

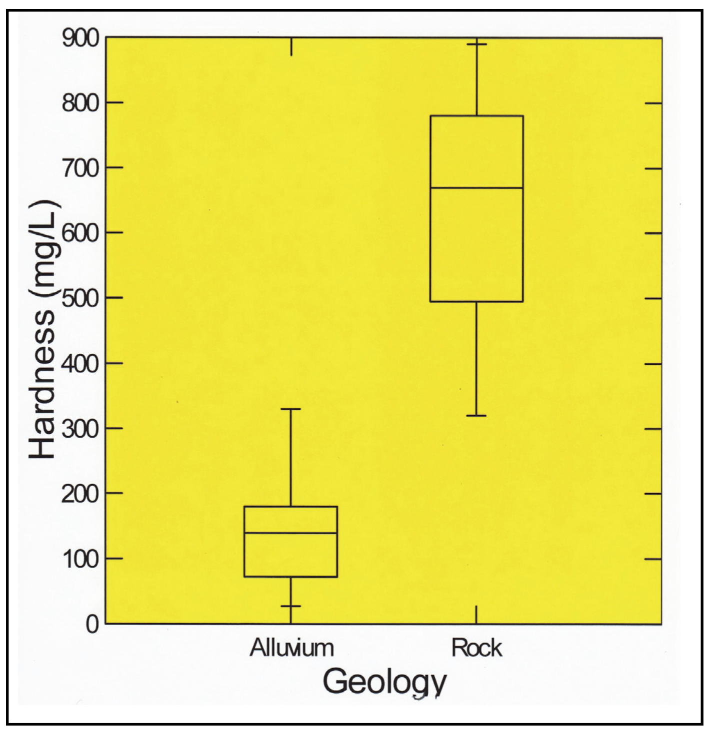


Figure 6 – Sample sites located in rock have significantly higher hardness concentrations than sample sites located in alluvium (Kruskal-Wallis, $p \leq 0.05$). Elevated hardness concentrations are often associated with recharge areas while, in down-gradient areas, sodium becomes the dominant cation softening the groundwater.

However, the ADEQ study found arsenic and nitrate concentrations were all below standards and lead was not detected in any samples.

In the ADEQ study, the elevated fluoride concentration is controlled by calcium through precipitation or dissolution of the mineral, fluorite. In a chemically closed hydrologic system, calcium is removed from solution by precipitation of calcium carbonate and the formation of smectite clays. High concentrations of dissolved fluoride may occur in groundwater depleted in calcium if a source of fluoride ions is available for dissolution.[6] The uranium exceedance occurred in a sample collected from a well drilled in the granite rock of the Harcuvar Mountains. Radionuclide concentrations are often elevated in groundwater residing in granitic geology.[7]

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azdeq.gov/environ/water/assessment/ambient.html#studies

Maps by Jean Ann Rodine

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