AN INVESTIGATION OF ENERGY USE, POTABLE WATER AND WASTEWATER TREATMENT AT BENSON, ARIZONA

By Brian Billy[1], Dr. Muniram Budhu[2], and Dr. Robert Casavant[3]

Background

The City of Benson is located in southeastern Arizona, approximately 45 miles south of Tucson, AZ, along Interstate 10 (I-10). It is located within Cochise County and has a population of 4,934 (2006 census). From 2000 to 2005, the area experienced a growth rate of 4.7%. The city is located within the Upper San Pedro Watershed at an elevation of 3,580 ft above sea level. The city utilizes groundwater as its sole water source. In early 2007, wells that produced water containing elevated levels of arsenic were taken off line, and the water system was modified so that all water was supplied by low-arsenic wells located in the upper southwest region of the city. Compliance with the EPA's present arsenic rule is an issue of concern for Benson. The water uses in the area are: municipal, agricultural, livestock, industrial, and riparian. This study deals only with the municipal use. The electricity provider for the City of Benson is Sulphur Springs Valley Electric Cooperative (referred to herein as Sulfur Springs).

WATER

Supply & Pumping

In 2007, the City of Benson pumped approximately 842 acre-ft (af) of water. There are 1794 connections. The average per capita water usage is 150 gallons,. The four wells that currently supply the city are Jennella (Fig. 1), Cochise College, 302, and 291. Figure 2 shows the relative location of the wells and tanks. The Cochise College and Jennella Wells work in tandem and currently provide 80% of the total water supply to the City of Benson. The 302 and 291 wells supply the Benson west tanks and the growing population along State Route 90. Static water depths have been measured at 463 ft, 450 ft, 580 ft, and 571 ft respectively. Tthe water table has not shown a significant amount of drawdown with the current pumping regime.

Figure 1: Jannella Well, Benson, AZ

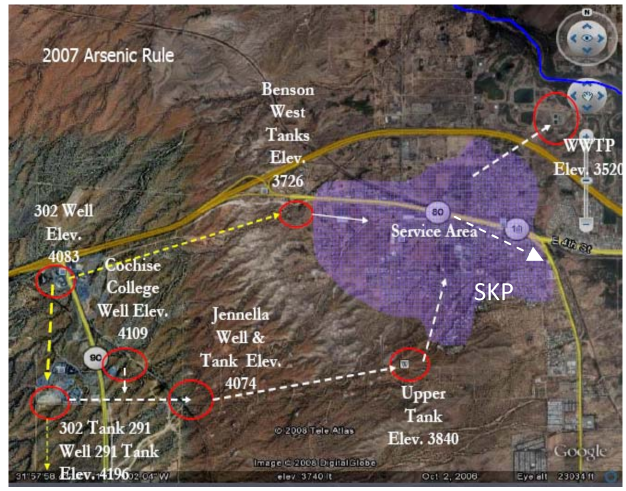

Figure 2: Wells and Tank locations in Benson, AZ

Treatment

The quality of the groundwater is good enough that routine chlorination at the source is not required. In the event of bacterial exceedance, the system is spot chlorinated and flushed. The water quality is monitored daily and monthly compilations of lab results are submitted to the Arizona Department of Environmental Quality.

Transmission, Storage & Distribution

Groundwater is pumped to the surface and conveyed to multiple storage tanks within the city. Two booster pumps are needed to supply the SKP development area and convey water from the 302 well to the 302 tank. The total system production is approximately 274 million gallons annually and total storage capacity is 2.45 million gallons. The topography allows for the distribution system to convey the water via gravity through 4-in., 6-in., and 8-in. pipes. Distribution occurs over the area with maximum elevation difference of 616 ft. Pressure reducing valves are utilized to maintain a pressure of 40-80 psi within the service regions. The ability to utilize gravity for conveyance from storage is one of the major efficiencies within the Benson system.

WASTEWATER TREATMENT

The wastewater treatment plant (WWTP) is located in the northern part of town (see Fig. 2) along I-10, north of the main business district at elevation 3,515 feet. The service area includes the main business district and residential areas west of the San Pedro River. The original treatment plant (pond system) was moved to its current location in 1960 and was completely rebuilt in 2002. The flows are metered at both the influent and effluent pump stations. The effluent is used to irrigate the city golf course.

Collection / Conveyance

The city's wastewater is conveyed to the plant via gravity and received at an average rate of approximately 420,000 gallons per day (gpd). During the peak season the flow rate increases to nearly 520,000 gpd. The system works efficiently and there have been no significant maintenance issues. The installed collection piping is a combination of concrete, vitreous clay, and PVC types.

Treatment

The WWTP is automated and can be monitored remotely from a computer terminal utilizing SCADA software. The SCADA system monitors water levels within the influent station wet well and turns on the influent pumping system as needed. Multiple pumps are on standby for times when influent flows exceed single pump capacity. The total maximum pumping horsepower available for influent is 60 hp. The motors utilize 3-phase power and are complete with surge protection and soft start capability. The total length of wastewater travel in the WWTP has been estimated at 0.25 miles. Once influent is received from the wet well, the remaining WWTP process is gravity-driven. The processing starts with influent passing into an agitated grit chamber where it is injected with air. Blowers are utilized for this process and represent one of the major energy consumers, since they run 24 hrs a day. The sludge passes through a mechanical screen and through a series of gated chambers for introduction into the bioreactor where it is treated by an activated sludge process and aeration. Average residence time of the sludge is approximately 48 hours. Air is constantly injected to promote digestion. The processed wastewater passes through clarifiers and sand filters, treated with chlorine and UV light, and then passed to the effluent storage area. The lab analysis for the process is performed daily and monthly reports are developed for review by the Arizona Department of Environmental Quality.

Time and duration of pumping operations are dependent upon the levels in the influent pump station and the effluent storage areas. These areas have thresholds programmed into the system to automatically increase/decrease the amount of processing. The elevation change is approximately 14-16 feet from the bar screen to the effluent storage ponds. The effluent pump station, which is fully automated, delivers the effluent to the storage ponds. In the event that overflow or bypass is needed, the plant can revert back to its original operations and store the waste in its backup aeration ponds, which are normally dry. This process is only needed during the monsoon season. There is no discharge of effluent; the vast-majority is used to irrigate the city-owned golf course, which pays no fee for the reclaimed water.

The effluent is also used to wash down equipment in the WWTP, and once used is re-circulated for treatment within the facility. Sludge processing continues to the drying beds, where there is sufficient area to obtain good drying times in the Arizona sun. The sludge is then transported to the local solid waste facility for disposal.

SYSTEM METRICS

Benson Potable Water System (2007)	
Number of Gallons Pumped	274,563,200
Service Population	5,000
Gallons Pumped per Day	752,228
Gallons Used per Person per Day	150
Annual kWh Usage	856,659
kWh/kgal	3.12

Benson Wastewater Treatment Plant	
Gallons of Wastewater Processed	135,360,000
Service Population	5,000
Average Gallons Processed per Day	370,850
Gallons Processed per Person per Day	74
Annual kWh Usage	984,516
kWh/kgal	7.27

Table 1: Water Distribution and Wastewater Treatment Plant Metrics

Table 1 show the metrics used in the analysis. Monthly water pumping data were provided by the City of Benson Engineering Department. The wastewater processing energy expenditures were provided by Sulphur Springs. The wastewater processing data were provided on a monthly time step by plant personnel and are estimates derived from 2008 billing records. The records for gas usage were not considered since they were not readily available and are only used for back up generators that are periodically tested. Since the water distribution operations were modified in 2007 to accommodate new arsenic standards, the data in Table 1 reflect the operations of a system within its transition period.

RECOMMENDATIONS/SUGGESTIONS

Presented below are best practice recommendations and suggestions developed as part of our qualitative evaluation.

NO OR MINIMAL COST

- Balance revenue and expenses.
- Understand how energy and water are utilized in the system.
- Review system plans, specifications, and records before considering upgrades/improvements.
- Evaluate costs for different available water sources.
- Secure operations and maintenance guides and training for city staff when new systems/components are installed.
- Further investigate blending of high- and low-arsenic ground water supplies.

LOW TO MODERATE COST

- Evaluate pumps, blowers, and motors for upgrade to either high-efficiency or VFD, as appropriate.
- Investigate available technologies for arsenic and other heavy metal reduction for future consideration.
- Consider high-efficiency ballasts and bulbs in the UV disinfection process, and elsewhere within the facility.
- Adequately ventilate or sunshield all electrical and mechanical equipment in warm weather.
- Utilize off-peak power usage strategies.
- Develop water audits and implement leak detection programs.
- Implement water budgets and rate structures.
- Create financial (or other) incentives for water customers to conserve.
- Adopt water-efficient codes and ordinances.
- Create water conservation education programs.

MODERATE TO HIGH COST

- Identify and eliminate areas where there are inefficiencies in potable water booster pumping and pressure management.
- Replace old meters and install automated units.
- Optimize treatment processes to reduce water and energy consumption.
- Reduce friction/energy losses in pumps, fans, pipes, valves, and production wells.
- Utilize renewable energy, as appropriate.

CONTACT INFORMATION

- [1]Graduate student (lead author), Dept of Civil Engineering and Engineering Mechanics, University of Arizona, email: bbilly@email.arizona.edu
- [2]Professor, Dept of Civil Engineering and Engineering Mechanics, University of Arizona, email: budhu@email.arizona.edu, tel: (520) 621-2145
- [2]Research Associate Professor, Dept of Mining and Geological Engineering, University of Arizona, tel: (520) 260-8826. Also [3]Science and Research Manager, Arizona State Parks, email: rcasavant@azstateparks.gov
- Benson water system. Contact Brad Hamilton, City Engineer or Al Carruthers, Water Supervisor, tel: (520) 586-2245.

- Benson WWTP. Contact Larry Napier: (520) 586-2245.
- Sulphur Springs Valley Electric Cooperative. Contact Dave Bane: (520) 515-3472.
- Project Sponsor: Arizona Water Institute.
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