Operation of a 1.5 MGD Arsenic Treatment Facility

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IN SEPTEMBER 2003, THE CITY OF PHOENIX COMMISSIONED THE NATION'S FIRST ARSENIC REMOVAL FACILITY for potable water. As many of you are aware, the Environmental Protection Agency is lowering the MCL for arsenic from 50 parts per billion (ppb) to 10 ppb effective January 2006. In response to this change in the standards, the City decided to build a full-scale Arsenic Treatment Facility (ATF) as a demonstration project and identify operational issues prior to implementing the technology at the City's 22 well sites that have an arsenic concentration greater than 10 ppb.

The demonstration facility was built at Well 280, which has a capacity of 2.5 MGD and is located north of Tatum Boulevard off Cave Creek Road. The well site also contains a 1.0-MG reservoir, sodium hypochlorite generator, and booster pump station for pressure zone 9. Water quality for Well 280 is presented below.

- 16.5 ppb arsenic
- 12 mg/L sulfate
- 1.5 mg/L nitrate
- 48 mg/L silica
- 7.6 pH
- 214 mg/L alkalinity as CaC03
- 291 mg/L TDS
- 0.5 mg/L fluoride
- 0.003 mg/L selenium
- 22 mg/L chloride
- 0.03 mg/L iron
- 0.002 mg/L manganese
- 27 deg. C average temp.

Figure 1- COP Arsenic Treatment Facility at Well 280

Due to the water quality and ease of operation, the City chose to implement an adsorption process using granular iron media (GIM). GIM is a throw-away media that can be hauled to a non-hazardous waste landfill after exhausted. At the pH range of Well 280, the process requires no chemical addition other than chlorine to disinfect the media. The process is fairly simple to operate and includes a pre-filter (50 micron mechanical screen), two 14-foot-diameter steel contactors with media, rate-of-flow control valves, equalization basin, spent media drain area, PLC, and several valves & flowmeters. Figure 1 shows the overall ATF.

As the ATF is on-line, the water passes through two contactors (in series) making it a lead-lag operation. The City chose to implement two contactors to provide flexibility and excess adsorptive capacity should the standard be lowered again in the future. In addition, once the media in one contactor is exhausted, having dual contactors allows the operator to run the system through one contactor until new media is installed. Each contactor contains 12-inches of garnet as support media and 2.8 feet of GIM resulting in a 2.5-minute empty bed contact time (EBCT).

Adding some safety factors, the City set a water quality goal of 8 ppb for arsenic. Because the AFT will remove arsenic to a concentration less than 2 ppb, the ATF was designed to treat only a portion of the well's flow to create a blended arsenic concentration of 8 ppb from the untreated bypass flow plus treated flow. The advantages of partial-stream treatment include lower operation & maintenance costs due to reduced media replacement and lower capital improvement costs due to a smaller overall facility. To meet the City's water quality goal, the bypass flow is set at 690 gpm. If the actual flows move outside the set ranges, an alarm will be sent to SCADA and the well will shutdown. Currently, only an alarm is sent. After January 2006, the well will shutdown. Since the blended concentration of arsenic is dependent on the flows, if the capacity of the well changes (due to declining water level or operational problems), the flow split ratio will need to be recalculated and manually adjusted.

The ATF has 12 modes of operation programmed into the PLC. The mode of operation can be changed easily by the touch of a button on the PLC display panel. In most cases, changing modes is accomplished with automated valves. The modes of operation for the ATF are summarized below.

Mode 1 — Normal Operation, Contactor A Lead
Mode 2 — Normal Operation, Contactor B Lead
Mode 3 — Parallel Operation
Mode 4 — Contactor A Backwash, Contactor B in Operation
Mode 5 — Contactor B Backwash, Contactor A in Operation
Mode 6 — Contactor A Backwash, Contactor B Off
Mode 7 — Contactor B Backwash, Contactor A Off
Mode 8 — Contactor B On Only, Contactor A Off
Mode 9 — Contactor A On Only, Contactor B Off
Mode 10 — Disinfect Both Contactors
Mode 11 — Drain Both Contactors to EQ Basin (Manual)

Mode 12 — Drain Contactor to Media Waste Containment Area (Manual)

For normal operation, the ATF will be in either Mode 1 or Mode 2. Currently, an operator visits the site daily to record/log the pressure, pH, chlorine residual, turbidity, and water temperature at several different locations (the well water, effluent of Contactor A, and effluent of Contactor B). In addition, field test strips are being used to determine the arsenic concentration in the lag contactor. When the lag contactor has an arsenic concentration of 2 ppb, the media in the lead contactor is exhausted and needs replacement. The arsenic field test strips will accurately measure arsenic to 4 ppb but will start to change color at 2 ppb. Once an operator observes the color change, samples will be collected and analyzed through the lab for verification. When the lag contactor reaches an arsenic concentration of 2 ppb, the operator will take the lead contractor off-line and operate in Mode 8 or Mode 9 with a single contactor in-line until new media is installed. With the average arsenic concentration, the media in one contactor would need to be replaced after 3 months if the well ran 24 hours a day continuously. However, since the City uses its wells for peak demands only, it is projected that the media in one contactor will need to be replaced every 6 to 7 months.

In addition to the daily log sheets and arsenic test strips, other maintenance functions include cleaning the pre-filter screen, media rinse, and media backwash. After operating the ATF we found the following pressure losses and resulting triggers for maintenance activities.

Location	Initial Pressure Loss	Event
Pre-filter	1.5 psi	7 psi triggers self cleaning of screen (automatic)
Contactor A	5.4 psi	10 psi triggers backwash (operator performs)
Contactor B	5.4 psi	10 psi triggers backwash (operator performs)
Total ATF	25 psi initially with a max. of 40 psi backpressure on well	

The 25 to 40 psi backpressure on the well resulted in a reduction of the well capacity of up to 150 gpm, though the typical reduction observed has been around 100 gpm.

The purpose of the pre-filter is to reduce the well pump-to-waste time during well start-up and to reduce media backwash events. Therefore, the entire well flow goes through the pre-filter. The pre-filter is self cleaning and is triggered by a 7 psi differential pressure loss across the screen. This self cleaning function is automatic and we have found that it occurs approximately every 12 hours of operation.

The backwash and media rinse events utilize the same modes of operation and discharge to the equalization basin. Sump pumps in the equalization basin pump the backwash/rinse water to the sewer. Backwash/rinse water is supplied from the booster pump station at a hydraulic loading rate of 10 gpm/ft2 and flow rate of 1540 gpm. For both backwash or media rinse events, an operator will collect waste stream samples and when the turbidity is found to be below 100 NTUs, the event will be stopped.

A backwash event is performed after the differential pressure loss across the contactor is 10 psi. It is expected that a backwash event will last 30 minutes and will occur monthly. A media rinse is only performed when new media is installed to release the fines generated in transport and installation. Initial media rinse events lasted 40 minutes. Figure 2 shows the equalization basin after initial rinse. The average iron concentration in the rinse water was 52.4 mg/L.

The City has elected to contract out the loading and unloading of the media when replacement is needed. During loading, we found it was best to load the media in layers and chlorinate the media as it is loaded due to the initial chlorine demands. It takes approximately 5 hours per container to load the media. For media removal, the contractor has two options. One option is to drain the media to the spent media drain area using Mode 12. Once the water is drained off to the equalization basin, a front-end loader can be used on the approach ramp to gather the media. The second option is to use a vactor truck to unload the media from the contactor. For either method, the media will be hauled to a landfill for disposal.

In conclusion, the ATF is running successfully with minimal manual maintenance. As operation of the new ATF continues, we will continue gathering data to improve the treatment process. The primary changes we will implement in the next phase (for other sites) include the following:

1. A common header for all branch piping.
2. Less automation — the operators need to be present for all mode changes and can thus manually change the required valve positions for a maintenance event (for valves < 12-inches in size).

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Figure 2 — Equalization Basin after Media Rinse