Water Poverty

A new program will improve water management and the lives of millions in Jordan.

HORIZONS
water environment solutions

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In 2010, after just two months of operation, Cypress Well No. 5 and the Cypress Water Production Facility (WPF) were shut down when consumers found the mineral deposits, color, taste, and odor of the new water to be objectionable. The City then returned to using water imported from Northern California and from the Colorado River by the Metropolitan Water District (MWD).

Improving Taste, Odor, and Customer Satisfaction

The City of Lomita, California, successfully addressed concerns expressed by its water consumers and developed a more cost-effective and reliable water supply.

Imported water is significantly more expensive than operating a local well and treatment system, and also carries the risk of drought or earthquakes interrupting the imported supplies. Naturally, the City of Lomita was eager to determine if its independent local groundwater supply could be brought back on line to provide water that is acceptable to consumers.

The City retained Hazen and Sawyer to test the treatment and operation of the system to determine if it could meet water quality goals and satisfy the concerns of its consumers, and to conduct a public education and outreach campaign prior to distribution of any blended water to the public.

Many municipalities, in California and throughout the world, face a growing threat to their water supply reliability. Developing systems to treat available groundwater to acceptable standards often offers a cost-effective alternative to importing water from distant sources. Blending sources can give operators valuable flexibility in meeting regulations and satisfying customers.
The direction from the City Council was to meet three specific goals:

- Water Hardness must be comparable to MWD supply in the range of 180 to 250 milligrams/Liter (mg/L), measured as calcium carbonate.
- Total Dissolved Solids (TDS), a measurement of salinity, must be in the range of 500 to 750 mg/L.
- Taste and odor must be palatable.

Hazen and Sawyer carefully tested and analyzed the well water to consider the causes of complaints and to evaluate possible adjustments to operations of the existing treatment and production facilities to improve the water quality. Trained panelists conducted flavor profile analysis to help identify the possible causes of taste and odor - the human nose can detect odors of some compounds at concentrations so low that laboratory techniques cannot detect them.

System Improvements

A number of system improvements were made based on the results of the flavor profile analysis and consequent laboratory analyses:

Sodium hypochlorite is injected into the well water prior to a filter with greensand media. Sodium hypochlorite acts as a disinfectant to prevent bacteria and viruses from growing in the water tank and distribution system, transforms iron and manganese to a form that can be removed on the greensand filter, and transforms hydrogen sulfide to elemental sulfur or sulfate. The hypochlorite dose was selected to both oxidize these elements or compounds and protect the water from bacteria growth at the furthest reaches of the distribution system.

Ammonia was added to the water after the filter to form chloramines for distribution system residual disinfection, at a chlorine-to-ammonia ratio to match the MWD water.

Another method of managing water quality at the Cypress WPF is to blend the treated well water thoroughly with MWD water at the plant and in the tank. Two blends of well and MWD water (60/40 and 50/50) were tested. Blending with MWD water that usually has lower TDS and hardness produces a finished water to meet Lomita’s water quality goals.
Aeration is now used to strip substances that can be released from water as a gas, such as methane and hydrogen sulfide. The tank inlet was modified to spray water into the tank headspace, providing aeration. Mixing and continued oxidation in the tank was shown to improve the taste of the blended water and significantly decrease methane levels.

The improved system was demonstrated to reliably meet the City’s hardness and TSS objectives.

Community Considerations

To assess the palatability of the water, a total of 139 residents participated in blind taste tests, which included two blends of well and MWD water (60/40 and 50/50) and 100% MWD water. Over 97% of participants found the appearance of the blended water acceptable and nearly 67% preferred some form of blended water to 100% MWD imported water. Nearly an equal number (66%) of participants could not distinguish between their current imported drinking water and either of the blended waters.

The cost of operating a local well and treatment system is also significantly less than purchasing water from MWD. City staff estimated a total cost of approximately $600 per acre-ft. to pump well water including labor, electricity, chemicals, operation and maintenance costs, and pumping fees to the Water Replenishment District for operating the Cypress Water Production Facility. The total estimated cost of purchasing MWD import water is currently approximately $1054/acre-ft, and projected to increase at a faster rate than that of producing water locally.

Lomita’s use of the groundwater well also improves the reliability of the City’s water supply. Available imported water supplies have been reduced in recent years by environmental restrictions in the Bay Delta and water shortages in the Colorado River. In the future, imported water will be further stretched to meet the demands of population growth, economic growth, and other competing interests.

Lomita, like many other cities and water districts, has positioned itself as more self-sufficient by operating an independent groundwater supply, a treatment system to meet all water quality and aesthetic standards, and a reservoir to provide reliable system pressure equalization and abundant storage. The combination of Cypress WPF water with imported MWD water allows the City of Lomita to take a leadership role in the region in progressively managing its water infrastructure and providing high quality water to its citizens and businesses.

Lomita residents taste blends of local well water with imported water, in addition to 100% imported water. Over 97% of participants found the appearance of the blended water acceptable and nearly 67% preferred some form of blended water to 100% MWD imported water.
Hazen and Sawyer is once again helping a municipality recover from the damage caused by an extreme weather event. The Bay Park Sewage Treatment Plant in Nassau County, New York, suffered major damage to its infrastructure when nine feet of saltwater surged into the basement and sub-basement during Superstorm Sandy.

In the immediate aftermath of the storm, the plant – which serves approximately 550,000 Nassau County residents – was declared a public health emergency. County and State critical response teams, including Hazen and Sawyer staff, rapidly mobilized to relieve sewage pressure valves throughout the Bay Park Sewage Treatment System and secure pumps to divert sewage from backing up into houses and onto streets.

Massive, industrial-sized sewage pumps were delivered to the plant from six states. While the plant was successfully returned to partial operation, a return to full operation could take up to twelve months.

The extensive damage caused in New York and New Jersey by Superstorm Sandy - and preventive measures from future major storms - will cost more than $70 billion, according to the latest estimates.

– examiner.com

The Bay Park plant before the storm (left) and after the saltwater flood caused by Superstorm Sandy (right).
Jordan is the fifth most water-poor country in the world on a per capita basis. The scarcity of water resources is one of the country’s greatest challenges and the agricultural and non-agricultural demands are increasing with time.

Improving Water Management in Jordan

One of the most pressing issues facing developing nations is maintaining an adequate supply of water for their growing populations. Water isn’t just the basis for life – it is also a precursor for successful business and industry.

Jordan is currently the fifth most water-poor country in the world with a per capita share of all water resources of 140 m³/year, less than 15% of the global average. Over the past few decades, the country’s economy has been adversely affected, and many ambitious private development projects have been cancelled, due to water shortage.

Because of the severe shortage, water is distributed via a fragile network at the rate of just 24 hours each week in some areas. In Zarqa, lack of funding for operations and maintenance has resulted in deterioration of the pipe network, currently laden with leaking piping, joints, and valves. Revenue from the users does not cover the costs for maintenance.
**Water and Wastewater Program**

In 2012, Hazen and Sawyer, in joint venture with Jordanian firm Dar Al Omran IE, was selected to be the program manager of the Water and Wastewater Network Projects component of a $275-million program funded by the Millennium Challenge Corporation, a U.S. agency within the State Department. This program addresses the Zarqa Governorate’s most critical water initiatives:

- Rehabilitation of existing water supply networks.
- Improvement of the wastewater collection system.
- Expansion of the As-Samra BOT Wastewater Treatment Plant, with treated effluent available to displace irrigation demands on clean water supply.
- Establishment of a Water Smart Program to improve household plumbing and develop smart water use programs in households.

The program will provide 98 million liters per day (mld) of additional water for domestic consumption to local communities and enhance wastewater collection for treatment and reuse in the Zarqa Governorate. Hazen and Sawyer/DAOIE will also design facilities and conduits for water transmission, storage, pumping and distribution.

**Zarqa Water Network Project**

At present, an estimated 57 percent of the potable water supply in Zarqa is lost through leaks in the water transmission and distribution network, with additional waste attributed to administrative losses. The Water Network Restructuring and Rehabilitation Project (Water Network Project) is designed to reduce water loss by constructing and repairing reservoirs, pump stations, and up to 67 kilometers (km) of primary, 927 kilometers of secondary, and 256 kilometers of tertiary pipes. The project will replace household connections and meters in the two poorest, most-populated water service areas of the Zarqa Governorate and will convert the system to gravity-fed distribution, which should improve customer service, reduce wear and tear on critical infrastructure, and extend the lifespan of the network.

Over 80 km of new primary and secondary piping, reservoirs, and pumping stations will be constructed to increase the capacity of the network to deliver water to the hill-top reservoirs and to supply 42 District Metering Areas (DMAs). The distribution piping network within each DMA will be rehabilitated to more effectively distribute water to the residents.

Jordan’s economy is driven by agriculture, and 62% of the national water supply is used for agricultural purposes. Part of a $275 million grant by the Millennium Challenge Corporation will enable upgrading of a wastewater treatment plant to accommodate reuse of effluent for agricultural purposes, freeing source water for human consumption.
Sewer line extensions will raise coverage rates to approximately 85 percent of the local population. These new customer connections will generate additional wastewater to be treated at the As-Samra Wastewater Treatment Plant and eventually reused for agricultural purposes downstream in the Jordan Valley.

**Program Mission**

When complete, the program will improve the quality of life of many residents of Jordan. The Water Network Program will strengthen and extend the life of the water distribution system, while the Wastewater Network Program will increase sewer coverage and enable wastewater reuse for critical agricultural purposes. The successful execution of this program will set Jordan on a path to improved public and environmental health, with consequent economic growth and prosperity.

The project includes technical and financial assistance to very poor households to improve plumbing, water storage, sewage connections, and general awareness of best practices for basic sanitation and efficient water use. All told, the Water Network Project will improve water supply to approximately one million residents.

**Zarqa Wastewater Network**

Zarqa Governorate is served by an inadequate sewer collection system that limits the collection of wastewater and endangers public health. The system regularly overflows into city streets and the surrounding environment, relies on pump stations that have insufficient capacity, and serves only 72 percent of the population.

The Wastewater Network Reinforcement and Expansion Project (Wastewater Network Project) will address these problems by replacing or rehabilitating up to 29 km of undersized trunk lines and expanding sewers by up to 140 km in the neighborhoods of East Zarqa and West Zarqa, both of which lack proper sewer connections. Sewer line extensions will raise coverage rates to approximately 85 percent of the local population. Wastewater will be prepared for reuse for agricultural purposes downstream in the Jordan Valley.
Innovative FOG Removal for Pump Stations

The accumulation of fats, oil, and grease can bring wastewater treatment to a standstill. Hazen and Sawyer implemented innovative dispersion systems at two pump stations that eliminated costly, odor-causing accumulations - a cost quickly recovered through reduced wet well cleaning costs.

FOG (fats, oil, and grease) has always been present in wastewater, but more and more wastewater pump stations are affected by the buildup of significant quantities of FOG in the wet wells.

The buildup can be extreme - the layer of FOG at the water surface can be several feet thick, stealing usable working volume, causing odor problems, and creating a mess during peak flow events. In some cases, the surface mat dries out and hardens to the point where crews need shovels to break through the surface to obtain wastewater samples.

The accumulated debris is also a fire hazard. In one instance, hot slag from overhead welding dropped onto the hardened layer of FOG and ignited, resulting in a shutdown of the pump station and a unique extinguishing situation for the local fire department.

Removing the hardened FOG layer is costly and extremely odorous. Worse, the results of the cleaning operations are often short-lived, with a new FOG layer forming and accumulating again within days after cleaning.

To better address FOG issues, Hazen and Sawyer has successfully utilized a Venturi-type customized FOG dispersion system at two pump stations.
For the Beaver Ruin Pump Station, a physical scale model of the existing wet well was constructed to evaluate the proposed FOG dispersion system before installation.

Large pumping stations in Metro-Atlanta, Georgia. The FOG dispersion systems are designed to create a strong surface agitation to break up accumulated debris and prevent the formation of a surface layer of FOG. The systems are installed in Gwinnett County’s 34-mgd Beaver Ruin Pump Station and Fulton County’s 95-mgd Riverside Road Pump Station. Prior to the FOG dispersion systems being installed, Beaver Ruin required about $60,000/year and Riverside Road more than $100,000/year in FOG cleaning operations, and both facilities suffered from poor performance and severe odor problems. The dispersion systems are simple and robust. They require minimal attention and maintenance, and work so effectively that both operating systems have already paid for themselves in reduced cleaning costs.

Beaver Ruin Pump Station

The Beaver Ruin Pump Station is a critical regional pump station in Gwinnett County’s collection and conveyance system. Since its startup in January 2002, the station has experienced numerous operational issues such as power outages, pump failures, pump deterioration, severe FOG buildup in the wet wells, excessive pump vibration, and multiple pump shaft failures resulting in higher than expected maintenance and repair costs. These issues have caused a number of pump station failures, compromising the reliability of the County’s collection and conveyance system.

Gwinnett County tasked Hazen and Sawyer to develop solutions to mitigate many of the pump station’s operational issues. Scaled physical modeling (shown above) was utilized to evaluate pump inlet conditions, second stage piping, and the FOG dispersion system. The physical model simulated the hydraulic conditions starting at the entrance to the wet well and into the suction of the second stage pump. The modeling revealed several problems with the wet well hydraulics and the hydraulics to the second stage pumps. Problems included air entrainment from an upstream weir, poor approaches to the pump suction elbows that resulted in suction vortices, and a severe imbalanced-flow issue at the second stage pump suction that included flow reversal at the eye of the impeller.

The modeling also revealed that the wet well’s existing serpentine approach channels to the pumps were not
A thick layer of FOG accumulation could be seen at Beaver Ruin as the chopper pump is lowered into place. A photo of the same wet well one day after the installation of the FOG dispersion system.

effective at improving pump hydraulics and actually created traps that contributed to the station’s significant FOG accumulations. The modeling confirmed that removal of the serpentine approach channels and the installation of a FOG dispersion system would have no adverse effect on the operation of the primary wastewater pumps and would be effective at minimizing FOG accumulations.

The wet well’s configuration was modified to resolve the hydraulic issues and minimize FOG build-up. Modifications to resolve the FOG build-up problems and other operational issues at the station included:

- A Venturi-type FOG dispersion system and piping to prevent FOG accumulation.
- Chopper-type motive pumps for the FOG dispersion system that also serve as wet well dewatering pumps.
- New flow cones to minimize the promulgation of vortices at the suction bell.
- Modification of the piping between the first and second stage pumps to remedy the flow imbalance issue.
- Bio-scrubbers to control odors.
- New vibration sensors to record vibrations in real time and protect the pumps before serious damage occurs.

After a single day of continuous operation of the FOG dispersion system, FOG accumulation in the wet wells at the pump station was reduced to virtually nothing. The before and after photos (below) of the Beaver Ruin wet well with the FOG Dispersion System operating show the dramatic and almost immediate results.

Riverside Road Pump Station

As part of a project to double the capacity of Fulton County’s Riverside Road Pump Station, Hazen and Sawyer was tasked to increase the reliability of the station, address odor issues, improve the aesthetics, and minimize FOG accumulation issues in the wet well. To remedy the FOG issues (which were also contributing significantly to the station’s odor issues, particularly during wet well cleaning operations), Hazen and Sawyer utilized
For the Riverside Road Pump Station, Hazen and Sawyer utilized CFD Modeling to locate the FOG dispersion system and ensure wet well hydraulics would not be adversely affected.

Computational Fluid Dynamics (CFD) modeling to verify that a new FOG dispersion system would not impact the hydraulics of the six, 900-HP wastewater pumps installed as part of the project.

New submersible chopper pumps were installed in each wet well to act as both a wet well dewatering pump and as a motive pump for the FOG dispersion system. The new FOG dispersion system runs for 30 minutes every hour and has proven to be quite successful at minimizing and preventing FOG accumulations. The new FOG dispersion system and new odor control system have eliminated odor complaints associated with the station.

Cost-Effective Solutions

The custom-designed FOG dispersion systems for these two pump stations have proven to be cost-effective at minimizing and preventing odorous and disruptive accumulations of FOG within the wet well. Rather than accumulating within the wet well, the FOG is sent with the pumped wastewater to the downstream wastewater treatment plant where it can be properly handled and disposed.

Venturi-type FOG dispersion systems are custom-designed solutions that are optimal for large pumping stations with deep wet wells; however, similar solutions can be developed for smaller wet wells and in wastewater treatment plants that may have scum accumulation problems in distribution boxes or channels.
The City of Portsmouth’s former Madbury Water Treatment Plant was a 3.5-mgd conventional sedimentation and filtration plant constructed in the 1950s. At more than 50 years old, the plant was starting to experience difficulty providing consistent and reliable treatment in accordance with current and potential future regulations.

The City piloted several treatment options before deciding to proceed with the design and construction of a new 4.0-mgd dissolved air flotation (DAF) and dual media filtration plant. In addition to providing a more flexible treatment process and operator-friendly design, the upgrade to the Madbury Water Treatment Plant included several state-of-the-art solutions to greatly reduce the plant’s energy consumption.

In July 2012, the new Madbury Water Treatment Plant officially received the prestigious LEED silver certification, New Hampshire’s first water treatment facility to receive recognition from the U.S. Green Building Council.

The completed plant went live in summer 2011 and was awarded LEED silver certification in July 2012.
During construction, sourced materials were primarily local and recycled in order to maximize sustainability and positive impact on the local community.

**Construction and Design Challenges**

The project was constructed on the existing site, which is located in the rural setting of Madbury, NH, several miles outside of the City of Portsmouth. The 20-acre site is mostly covered with undisturbed vegetated land, providing more than the typical space needed for new construction of a plant this size. However, the City was interested in pursuing Leadership in Energy and Environmental Design (LEED) Certification for the facility, and had recently adopted a new sustainability initiative. These two factors each required that disturbance of vegetated land be kept to a minimum and that open, permeable space on the completed construction site be maximized.

The existing plant provided a large portion of the City’s water demand, so taking the plant offline for any significant portion of time was not an option. Due to the outdated sedimentation process, residuals management at the plant was inefficient and required large areas of the site to be available to accept the large sludge volumes produced during sedimentation basin cleanout. Working within these constraints required careful construction phasing coordination, as several new process facilities were built in the same location as the existing facilities they were replacing.

**Efficient Solutions**

Hazen and Sawyer designed the new Madbury plant to incorporate energy-efficient best practices such as daylight harvesting to supplement building heat during winter months, solar panels for solar hot water collection, enhanced insulation of the treatment process piping and tanks, and waste reduction through zero liquid discharge in the treatment process.

Solar panels are among the sustainable design aspects incorporated in the new plant to help achieve LEED silver certification.
The new plant is among the first in the nation to use sidestream process water for HVAC purposes. Clean, filtered water is pulled from the effluent side of the filters and flows through the heat exchangers, which are located in the process pipe gallery. The process water sidestream provides a source of heat during the cold winter months, as well as a heat sink to cool the building during the summer months.

Most of the plant materials – many of them recycled – came from within 500 miles of Portsmouth and 80% of the construction waste was diverted from the landfill. Altogether, the energy-efficient upgrades over typical processes are expected to produce energy savings exceeding 24%, or $35,000 annually.

The Madbury WTP also now features more efficient/automatic plant control systems and improved SCADA. Residuals management at the old plant was cumbersome – the plant’s three sedimentation basins had no mechanical means to collect the settled solids and had to be cleaned out manually by operations staff washing residuals through floor drains with a hose. It was a labor intensive and inefficient process, generally producing a dilute sludge with a solids content of 0.25% or less, with one basin requiring cleanout every 7-14 days. Under the new automated system, solids are collected from the DAF tanks by mechanical means and pumped to drying beds, eliminating the need for manual removal of settled solids. The resulting DAF solids have a higher solids content (2-3%) than the settled solids collected by the previous sedimentation basins (0.1-0.25%), reducing the total volume of sludge to be processed. Excess water from DAF waste is collected in drying beds with pervious sand beds and returned through an underdrain system to the head of the plant where it is re-treated, resulting in a negligible amount of water being wasted from the treatment process.

**Rewarding Performance**

After eight years of planning, testing, design and construction, the plant was placed online during the summer of 2011. The new facility has experienced increased filter run times and organics removal. Filter runs in the old plant would struggle to reach 40 hours during the summer months when organic matter in the raw water was at its highest. Run times at the new plant have been extended to 48-72 hours for the same raw water conditions, frequently at higher flow rates than produced at the old plant. Filter turbidities would tend to approach 0.3 ntu during the tail end of the filter runs at the old plant, but new filters remain steady throughout their filter run times, consistently operating well below 0.05 ntu. The new plant also displays improved organics removal, which will serve to help the city in meeting their regulatory disinfection byproduct compliance.
Detailed descriptions of our AWARD WINNING work

Articles reprinted from industry-leading publications such as WE&T and the AWWA Journal

Abstracts from ACE, WEFTEC and other conferences from around the globe