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About the cover: The bright sun reflects through a rig's derrick owned by Lovelace Well Drilling Inc. at a jobsite in Wisconsin. The rig is a Drilltech TM40 mounted on a Peterbilt truck. Lovelace, headquartered in Argyle, Wisconsin, has been in business since 1910, and does well drilling, pump systems, septic systems, and more. Photo submitted by Scott Kok of Lovelace Well Drilling.

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Rehabilitating Jordan's Phosphate Mines

WellJet revitalized 21 wells for one of the country's major industries.

By Jennifer Strawn

The need to properly develop, maintain, and rehabilitate water wells is essential around the world, but it's most critical in arid environments like the Middle East where surface water is scarce.

In Jordan, groundwater is a major water source for its rapidly increasing population. In fact, in 2009 the nation constructed the Disi Water Conveyance Project, which pumped 100 million m^3 (cubic meters) of water per year from the Disi Aquifer in southern Jordan.

The water from 55 new wells in the project was piped 200 miles to the country's capital, Amman, where the population has more than doubled since 2004. However, there was not a significant increase in water supply availability.

"The company that drilled the wells was having trouble getting them to produce both the volume of water and the efficiency that the wells were supposed to provide," recalls Charles Carner, vice president of WellJet in Camarillo, California. "The drilling fluid solidified, so they weren't able to get it to break down and remove it."

Taking a Look

American consultants familiar with WellJet's rehabilitation process suggested the company take a look at the project. To simulate the issues the contractors were experiencing in Jordan, WellJet built a model according to the specifications of the wells they were drilling in Jordan and clogged it with bentonite. Then, they sent a video demonstration of how their jetting tool could penetrate the gravel pack to break up the bentonite.

The patented WellJet uses highly pressurized water in a laminar flow to remove encrustation inside the well casing, open plugged perforations, and penetrate into the gravel pack to break up deposits impeding water flow.

Water jetting is not new, but it previously had limited value for well development and rehabilitation because it was difficult to generate enough pressure to have any effect on the deposits adhering to steel water wells or to maintain pressure downhole.

With the combination of pressures from 15,000 to 20,000 pounds per square inch and the ability to maintain that pressure 1000 to 2000 feet below ground, the WellJet tool solves both of those problems.

As a result of the demonstration, WellJet was brought onto the Disi Water Project to work on several low-producing wells. The well development process then drew the attention of Khost Aqua Consult (KAC), a groundwater well and rehabilitation company in Jordan. Together, WellJet and KAC obtained the contract on a project at a nearby phosphate mine.

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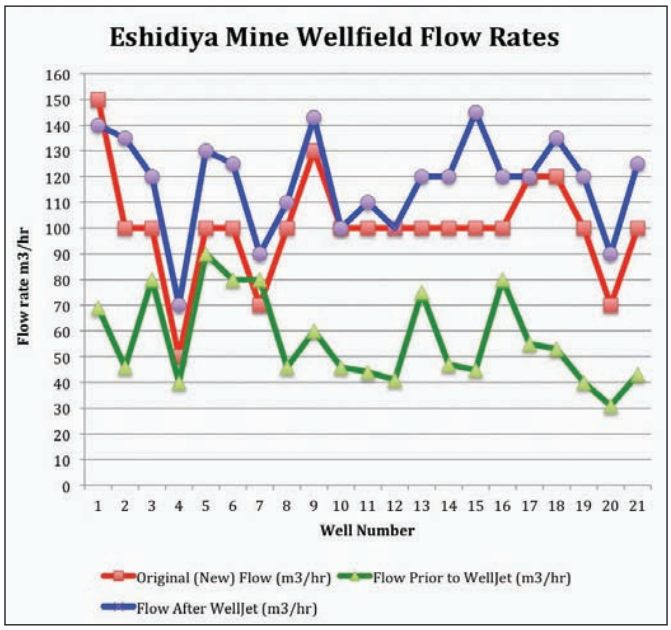

Flow rates at the Eshidiya Mine Wellfield in Jordan.

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Phosphates are one of the country's major exports, accounting for $593 million of Jordan's $9.8 billion in exports in 2015. Large quantities of water are needed to mine phosphate. The water is used for a slurry separating the phosphate from sand and clay in the matrix.

Jordan Phosphate Mines Co. is the only phosphate mining company in the country and operates three mines: Russeifa, Hassa, and Eshidiya. At the Eshidiya mine, located in southern Jordan east of Al Jafr, the flow rates had dropped drastically.

When new in 1991, the wells produced 50-150 m^3/hour (220-660 gpm). When WellJet was brought in to rehabilitate the wells, the most productive well had dropped below 100 m^3/hour (440 gpm). The least productive well had a flow rate of 31 m^3/hour (251 gpm). The average decline was about 42%. Static water levels that ranged from 69-113 meters (226-371 feet) had dropped to 72-119 meters (236-390 feet).

"By the time you see encrustation or buildup in a well, it's like the tip of an iceberg," Carner says. "There is a portion of the iceberg that's visible above the surface, but the greater mass is below the surface. The same is true of deteriorating performance in water wells."

In the gravel pack there may be sand dams or bacterial growth. Beyond the gravel pack there can be residual mud cake and most wells—even older wells—have some residual drilling fluid.

Two years prior, the mining company attempted to solve the problem by drilling a new wellfield. The wells had to be drilled deeper than their existing wells and cost the company millions of dollars, much more than the cost of rehabilitating the existing wells.

"There's a demand not only to produce water, but to reduce the cost and the energy consumption to produce that water," Carner says. "It's making sure the process is efficient. Jordan has almost no energy reserves, so maintaining the efficiency of the wells is very important."

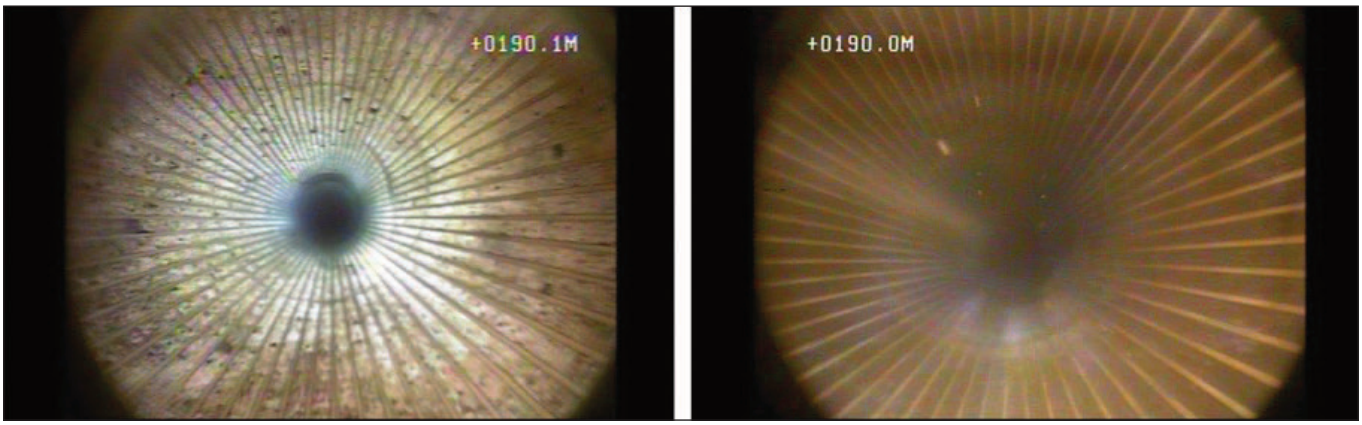
WellJet operations at the Eshidiya Mine Wellfield in Jordan. The mine is for phosphates, one of the leading exports of Jordan.

Out of the 21 wells the mine needed 14 to operate, so WellJet/KAC began by rehabilitating seven wells already out of service.

As a test case to prove the technology worked, WellJet/KAC began with well No. 9. First, its crew ran a camera down the hole to capture the condition of the well. In some cases, it found the wells had been sabotaged and foreign objects had become lodged downhole.

"There were pieces of pumps and pipes and junk down the well," Carner says. "One well had a bunch of rocks down there, so we put the jetting tool down there to break up the rocks before we jetted the well."

After the objects were removed, WellJet/KAC began at the bottom of the perforated area and continued through the production zone. For most of the wells, the fill was a mixture of drill mud, fine sand, and iron scale.



Before and after images of a well that was rehabilitated by WellJet at the Eshidiya Mine Wellfield.

After jetting the wells, the WellJet team dual-swab surge blocked and airlifted the well to remove fill that came in from the jetting process before running a camera downhole to inspect it. Once everything looked good downhole, they replaced the equipment and started test pumping.

"The flowmeter was calibrated to cubic meters per hour, and we're used to using gallons per minute," Carner says. "We were looking at that flowmeter trying to get a sense of how well we were doing without looking too nervous."

Getting the Results

The result was more than 500 gpm—a 139% increase prior to rehabilitation and 10% better than the well's original 1991 performance.

"They were very impressed," Carner says. "But they were still skeptical."

Each of the company's engineers did his own calculations from the flowmeter. After several hours of pumping, the engineers left without saying a word, Carner remembers.

The next day, WellJet returned to the wellfield to find twice as many executives from the mine there. They were shocked by the results.

"It made for a good comparison," Carner says. "It was the exact same well pump and bowl arrangement that was used as before."

When a well is rehabilitated the motor, pump, or bowl assembly is often changed or dropped deeper. This improves performance, but can make it difficult to compare the before and after.

"The first thing they said was 'We can't believe this!'" Carner says. "The second thing they said was 'This is fantastic!' and the third thing they said was 'What was that other company that has been rehabilitating our wells been doing?'"

There are many options for cleaning an inside of a well, whether it be brushes, acids, shock treatments, or even explosives. But getting enough energy out into the gravel pack and beyond to the near-wellbore formation can be challenging. The ability for the WellJet tool to remove the heavily encrusted deposits made it a good option for the mine.

After the first successful well, WellJet and KAC completed the other seven wells. As the wells were put back online, they took the rest of the wells offline and rehabilitated them. Within months, all 21 wells were rehabilitated without affecting the operation of the mine.

When all the wells were complete, flow rates had improved from a low of 70 m^3/hour to a high of 145 m^3/hour. Average flow rate was 118 m^3/hour (519 gpm) with an average flow rate improvement of 61 m^3/hour or 122%.

Compared to the production when the wells were new, the flow rates improved an average of 17 m^3/hour (75 gpm) or 19%—despite a 20-foot decrease in water levels throughout the wellfield.

"Our wells are now producing more water, with greater efficiency and lower energy consumption than when brand new 25 years ago," says Dr. Shafik Alshkar, CEO of Jordan Phosphate Mines.

Continuing the Work

Now, WellJet and KAC are scheduled to rehabilitate the wellfields at Jordan Phosphate Mines' other mines and a multi-well project for the Jordan Petroleum Refining Co. The projects are a part of WellJet's continued global growth initiative focused on the water-challenged environments of the Middle East and North Africa.

Looking back on the project, Carner admits it can be difficult to work in a foreign country. This is particularly true in the Middle East, where you're struggling with language barriers and working in remote areas with extreme heat and a lack of access to additional supplies or spare parts.

"You simply have to be ready for difficulties and surprises," Carner says. "If something breaks in the field, you have to figure out how to fix it or have a spare on hand."

All of the challenges are worthwhile, though—especially when you realize you're doing something meaningful.

"The people are wonderful, incredibly friendly, and welcoming," Carner says. "When you can go in and work on a project, have success with an international partner, and do something good for the people and that country's economy, it's a good feeling." WWJ

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