# Filtration and One of the World's Deepest Underground Laboratories

**Goal:** Build one of the world's deepest, most sophisticated underground laboratory: the Sanford Underground Research Facility (Sanford Laboratory).

**Site:** The former Homestake gold mine in Lead, South Dakota, once the largest producer of gold in America. Closed since 2003.

**Problem:** How to dewater the mine while filtering mine water containing ammonia and iron particulates before discharge into a cold-water fishery.

**Design Team:** The Environmental and Operational personnel at the Sanford Lab and Yardney Water Management Systems.

**Solution:** A custom-designed, custom-built Yardney reverse-stacked and stratified multi-media filter system (24 filters) with a newly discovered media method for extracting micronized iron.

The Sanford Laboratory has opened a research campus 4,850 feet underground where two important physics experiments will be protected from disruption by cosmic rays. One experiment will search for a mysterious substance called "dark matter." The other will search for a rare form of radioactive decay. Those experiments will begin taking data in 2013.

The Homestake gold mine produced more than 40 million ounces of gold, but the mine also was a physics landmark. Nuclear chemist Ray Davies installed a solar neutrino detector on the 4,850-foot level in the mid-1960s. Davis went on to win a share of the 2002 Nobel Prize for Physics for that work. Homestake was sealed shut in 2003, because the cost of mining gold there exceeded the price. (There was no crystal ball showing the future economic turn that would skyrocket the value of gold).

Barrick Gold Corporation bought the Homestake Mining Co. in 2002. In 2006 Barrick donated the mine in Lead to the state of South Dakota for use as a science laboratory. The South Dakota Science and Technology Authority (SDSTA) became the managing agency. The donation included Homestake's water treatment plant. For SDSTA's Ken Noren, lead treatment plant operator, and Duane Ennis, lead maintenance facility tech for the plant, the switch from mining to science meant their jobs were going to get very busy, challenging and demanding. John Scheetz, Environmental Manager for SDSTA, tells the story.

"When the mine closed, they turned off the pumps," Scheetz says. "The mine is very deep. It drops to about 8,000 ft. below the collar (top) of the shaft. Water rose to 4,530 feet below the collar. But, the experiments were planned for the 4,850 ft. level, so we had to dewater the mine past that level.

"The project team understood we needed to pump the water out, treat it and discharge it. But when the water sat in the mine for a continued period of time, it reached quasi-equilibrium with the wall rock. The Homestake mine is an iron-hosted deposit despite a lot of gold being brought out of it. When the water came to quasi-equilibrium with the wall rock, the iron was exposed to water and dissolved. While that doesn't sound like a problem, when we pump that water up to the surface, the iron precipitates into 1 micron-sized iron particles as the water becomes oxygenated," Scheetz says. "The iron precipitate would then interfere with other processes downstream."

Step one was to take an older water treatment plant—"although still a very good one," Scheetz says—and modify it so the plant could remove the iron before it entered the rest of the treatment system being developed.

"We looked at a lot of different technologies," he said. "We looked at a process that used chemicals and millina filters, where we would dose the water and enhance the precipitation and coagulation of the iron. That involved a lot of chemicals, and it didn't work very well."

Scheetz said the team looked at another couple of technologies and one seemed promising—filtration. Initially they rented filters from a number of vendors to test them. Yardney also loaned SDSTA a test filter and put its design team and experts to work with the SDSTA team.

Scheetz says the Yardney people were "excellent" partners. "They are very knowledgeable, very helpful. They had a good appreciation of some of the uniqueness of our problem once it was explained to them."

Ron Gamble, Yardney's industrial field sales manager, says, "The mine water was characterized by a pH of 7 to 8, iron concentrations of 20 to 30 mg/L and ammonia of 3 to 4 mg/L. Equilibrium with the iron-bearing host rock under reducing conditions and the breakdown of thiocyanate (SCN) to ammonia contributed to the water chemistry.

"Several challenges also needed to be addressed. These included the high water treatment flow rate of 2,000 GPM, the desire for effluent water quality below 1 NTU for discharge into the environment, and the need for reducing the amount of backwash water created in the filtration process."

In a brief four-week period, the teams designed and piloted a reverse-stacked and stratified Multi-Media filter system. Gamble states, "the system significantly outperformed the temporary sand filter systems that were currently in use at the time, providing better effluent water quality and running more efficiently due to less frequent backwash events."

Scheetz says, "Yardney built those filters for us and did a great job." In November 2009, the full-scale, multi-tank, multi-skid system was installed and put on-line. "From design to build, it was less than six months," he says. "Yardney also built those filters very quickly for us. They have a good reputation for building good quality equipment for a good value. They were very competitive pricing-wise. I think most companies are looking for that."

The teams also devised a new method for extracting iron. “We used that Yardney test filter to hone in on the right type of media and bed that would be most effective to filter out this very small iron-sized particle,” Scheetz says. “After testing for several months, we came up with a conclusion on how to make it work.”

The new system required filter beds consisting of anthracite, granite and gravel. “Very fortuitously for us, iron wants to stick to that media. It’s kind of strange in some ways that a very-fine particle would stick to a bed of not-very-fine particles. You’d expect it to blow right through. But, if you operate the filter at the correct pressure and have the correct volume of water flowing through the filters, you don’t put too much energy into the flow. At the exact right flow rate and pressure, the particles will stick to the media,” Scheetz says. “But if you increase the flow rate too fast, the iron will continue right through the media. So there’s a very odd range at which we operate the filters to have them work effectively in terms of flow. And that’s very important.”

The filters are backwashed every certain number of hours depending upon the amount of iron in the water that they are pumping at the time. Water in some locations of the mine contains more iron than others.

Backwashing the filter purges the bed. It is backwashed to a tank where polymers are added to enhance the size of the iron particles before sending it to a filter bag. “It’s a geotextile bag that traps the iron and then lets clean water flow out of the bag. That way we don’t have to use dewatering filter presses and belt filters, which are associated with a lot of labor, mess and cost,” he says.

After clean, filtered water exits the filters, it is mixed with other water that is being treated on-site. It is then run through rotating biological contactors to remove the ammonia before being discharged into Gold Run Creek and on to Whitewood Creek, a cold-water fishery.

“We’ve been very successful,” Scheetz says. “The water quality and water biology of the stream has been very good. We test it once a year for complete biological health, fish, macroinvertebrates and algae.

“Ken and Duane are the real heroes who made this work,” Scheetz says. “They deserve to be credited with the success of the filters, because they did so much work with Yardney to make everything go. Those guys worked with Yardney very closely to lay all that out. The people here worked with Yardney every day, talking to them, giving them ideas and specifications for certain things on those filters so we could run them properly. Without them and Yardney’s equipment, the program would not have been successful.

Scheetz said the SDSTA was a satisfied customer. “Yardney was just great to work with in terms of a company; in terms of knowledge, of course; and also in terms of price and experience. We would certainly work with Yardney again if we had an opportunity to do this on a bigger scale.”

# # #