



The theme for this issue of Technically Speaking is "Breakthrough Innovations." The contributors to this issue provide information about how they have worked with their clients in various parts of the world to help solve technical challenges by using innovative technical approaches or equipment and by developing unique business processes. If you are interested in knowing more about any of the projects featured, please contact the lead authors directly. To keep you up to date on our activities from around the world, we have also added a new section on page 7 called, "News from Golder."



## IN THIS ISSUE

**02** DATABASE SUPPORTS REGULATORY COMPLIANCE IN CHINA | STATE-OF-THE-ART DISPOSAL OF MINE TAILINGS IN TANZANIA **03** IMPROVING THE ENVIRONMENTAL PERFORMANCE OF COAL-FIRED POWER PLANTS **04** NEW PIERS FOR A RAILROAD BRIDGE IN CANADA **05** TUNNELING INCREASE DRIVES NEED FOR MASTERS PROGRAM IN ITALY | EXTRACTING MORE ENERGY FROM DIFFICULT ROCK FORMATIONS **06** DRIVING HELICAL PILES TO NEW DEPTHS | INNOVATION LEADS TO SAFE DRINKING WATER IN SOUTH AFRICA **07** NEWS FROM GOLDER **08** A LEVEL PLAYING FIELD FOR INTERNATIONAL PROPERTY TRANSACTIONS



## DATABASE SUPPORTS REGULATORY COMPLIANCE IN CHINA

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**As companies from all over the world show growing interest in China, they need to deal with a bewildering range of national, provincial and local environmental regulations – a task made easier through a database developed by Golder’s Shanghai office.**

China’s environmental regulatory framework is complex, and laws and regulations are constantly changing as the country moves toward industrialization and modernization. Further, the country’s entry into the World Trade Organization has brought a new range of regulations and scrutiny. For many foreign companies that have committed to fully comply with in-country laws and regulations, it is often a challenge to understand regulatory requirements for their operations. This has resulted in a need for a central database of environmental regulations at all government levels, from municipal to national. Golder’s Shanghai office took on this task, launching its Environmental Regulatory Database in November 2005.

This database contains a file system that incorporates regulatory documents on applicable environmental laws, regulations and standards issued from 1950 to the present. The regulatory documents, with English titles added where necessary, are classified according to topic and filed using a decision-tree structure.

Users can access this information through a Microsoft Access® table, searching under keywords or criteria such as Chinese title, English title, issuing authority, and issuing or revision date.

The database, which currently includes over 1,400 documents, is growing as more documents, particularly those at a local level and those that are industry-specific, are added and as information is updated. Golder Shanghai plans to expand the database to include health and safety requirements.



## STATE-OF-THE-ART DISPOSAL OF MINE TAILINGS IN TANZANIA

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**In the world’s first full-scale application, tailings from a gold mine in northern Tanzania are being stored on the surface as a paste, conserving scarce water supplies and reducing environmental impacts.**

Located in the Victorian Greenstone belt, the operators of the Bulyanhulu Mine needed an innovative method for tailings disposal. Approximately one quarter of the tailings are used as backfill underground; the remaining material requires surface disposal.

Conventional disposal often involves the preparation and placement of a water-based slurry, which is a diluted mix of water and granular material. In this case, however, available resources would have been strained by the need for large amounts of water to create the typical tailings slurry. In order to store large amounts of water, the operators of the mine would need to construct impoundment structures, such as dams. Instead, the mine operators opted for a disposal process called paste, which is a non-segregating thickened material. Paste has the advantage of pipeline transport but uses significantly less water than slurry and does not contain much “free” water which would be lost through evaporation. As the paste dries, there is minimal water seepage which enables the tailings to be stacked at up to a 10% slope, dramatically reducing the footprint of the final facility and the associated containment berms.

To allow this innovative surface-disposal application of paste technology, Golder designed the process plant and developed a detailed deposition plan that addressed climate, tailings composition, water and land availability, topography and transport methods. The material is piped from the mine to several towers constructed within cells located in the tailings disposal area. The paste is then pumped into cells surrounded by the berms. Deposited in thin layers, the paste will eventually be stacked to 20 metres (60 feet) above the original surface. A spillway structure collects rainwater and any seepage from the paste as it dries.

Experience gained from this method of storing mine tailings has led to similar plans being designed and implemented by other operations around the world.



## IMPROVING THE ENVIRONMENTAL PERFORMANCE OF COAL-FIRED POWER PLANTS

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According to the American Coal Ash Association, the coal-fired power industry disposed more than 66 million metric tons (73 million US short tons) of coal combustion products (CCPs) in the United States in 2004. Traditional disposal methods include using haul trucks to transport CCPs to "dry" landfills and/or hydraulically conveying CCPs to surface impoundments. These disposal techniques, which may include double-handling of CCPs, have been replaced by a more efficient and environmentally appropriate design at Great River Energy's Coal Creek Station in North Dakota, USA.

Golder Associates personnel in Lakewood, Colorado collaborated with Great River Energy's staff to

evaluate and design a state-of-the-art CCP disposal facility that uses the engineering properties of fly ash and bottom ash to form a structural shell for the containment of weaker flue gas desulfurization (FGD) sludge. The facility operates as a surface impoundment with an innovative liner head reduction system, enabling Great River Energy to eventually close the facility as a dry landfill and reduce long-term environmental liability. This new design also has the advantage of reducing or eliminating costly double-handling of CCPs, thereby reducing operational costs.

The result of this innovative design is that CCPs are more efficiently placed over an existing lined

facility, thus minimizing costly lateral expansions, conserving the site's valuable soil resources and reducing direct and indirect costs associated with CCP disposal. Costs have been further reduced by hydraulically conveying the CCPs via pipelines rather than continuing the historic practice of hauling CCPs by truck to the disposal area.

Golder's innovative CCP disposal design provides for long-term stability in an environmentally appropriate design. Similar opportunities exist for the coal-fired generation industry to move toward more sophisticated disposal designs that reduce costs and minimize environmental liability.

## NEW PIERS FOR A RAILROAD BRIDGE IN CANADA

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**A railroad bridge built in the 1880s on a stretch of one of Canada's major cross-country railroads has been given a new life through the first application of "micropiles" in Canada.**

The bridge, which spans approximately 230 meters (750 ft.) across the Nipigon River north of Lake Superior, was built of masonry piers on a timber foundation with the steel superstructure rising approximately 24 meters (80 ft) above the river. Designed for steam-powered trains, the aging foundation needed to be upgraded to support

today's heavier rail traffic. For the Canadian Pacific Railway, the choice was to shift the existing structure to two new piers (one of which would have been in the river) at a higher cost and significant disruption to train traffic, or find a way to reinforce the existing foundations and piers.

After evaluating a number of options, Golder and CPR concluded that micropiles would be the preferred solution. Golder designed a system of micropiles, which involves drilling small diameter holes into the ground beneath the existing foundations. Steel rods and casing are then inserted into the holes and surrounded with pressurized cement grout to provide the required resistance to support the loads applied to the foundations.

While micropile foundations have a history of being relatively expensive, the total cost of the work at Nipigon using micropiles was significantly less than the cost of constructing new bridge foundations and piers. Other benefits included the fact that unlike other types of piles which are installed by pile-driver, the micropile installation did not endanger the existing bridge structure through vibration, and could be done in the tight workspace that existed around the piers.

The work at Nipigon was done with minimal disruption to train traffic and minimal environmental impact, demonstrating this technology's viability as the appropriate solution for this situation.

## TUNNELING INCREASE DRIVES NEED FOR MASTERS PROGRAM IN ITALY

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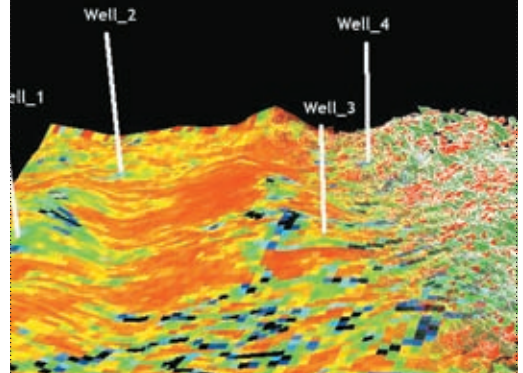
Worldwide growth in the construction of tunnels is increasing the need for knowledge in the latest tunneling methods, a need that is being met through a new Masters Degree program in Turin, Italy and made possible by recent developments in on-line educational technologies.

Gridlocked traffic in many cities is driving the expansion of subterranean transportation infrastructure, such as subway systems and underground roadways. In addition, growing demand for long-distance transportation of water and wastewater is resulting in an increase in demand for pipelines through urban areas. These are two reasons why construction is being pushed underground. Recent advances in mechanized equipment, involving machines that bore through rock like giant drills, make it possible to avoid the foundation-rattling techniques of other tunnel-building methods.

To meet the need for skills in the planning and management of tunneling projects, which can be very complex, the Politecnico di Torino, a technical university in Turin, recruited several companies, including Golder, to become sponsors of a graduate-level Masters program in Tunneling and Tunnel Boring Machine Technology. Sponsors provide financial support and contribute faculty to the program. To make it possible for world experts to be instructors, the Politecnico enabled the instructors to lead their lectures without leaving their home countries through the use of Web-based instruction technologies.

Students come to this program from all over the world to learn the latest techniques and share ideas in this growing field of construction. An innovative use of communications technologies has made it possible for the Politecnico di Torino to offer its students world class instruction in a very complex engineering discipline.

## EXTRACTING MORE ENERGY FROM DIFFICULT ROCK FORMATIONS



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In an energy-hungry world with depleting reserves, oil and gas companies must find better ways to extract hydrocarbons from bodies of rock where fractures have a big impact on the storage and flow of oil and natural gas. Some companies are getting better at understanding these challenging geological structures using a technique pioneered by Golder for modeling fractured rock formations.

"FracMan Reservoir Edition" (FRED) is the result of a multi-year consortium between major oil companies and Golder, which pioneered the Discrete Fracture Network (DFN) approach in the 1980s. This modeling approach differs from conventional continuum methods in that FRED allows geologists and reservoir engineers to characterize and model reservoir fracture systems as discrete objects. This approach helps to more accurately understand physical rock properties such as fracture connectivity, porosity and permeability.

FRED has been applied to a number of major reservoir studies around the world including studies done in North and South America, Europe, South and Southeast Asia and the Middle East. FRED is currently being used in Italy where it has been central to the ongoing development of the Val D'Agri reservoir, a key asset jointly owned by Shell and ENI. Golder staff have been working with the Shell project team to provide critical input into the development of a model of this large onshore fractured oil reservoir.

With FRED having been recently commercialised, oil and gas companies can now design drilling programs and enhanced hydrocarbon recovery programs to extract more oil and gas from these difficult rock formations, giving the world more options in its search for energy.



## DRIVING HELICAL PILES TO NEW DEPTHS

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A better way to support structures is becoming a commercial reality thanks to support from Golder's geotechnical engineers and our "integrated business solutions" group in Ontario, Canada.

Working like giant corkscrews, helical piles have been used since the 1800s to support lightweight structures such as wharfs and houses. Delivered to job sites in sections, the upper parts of the shaft are bolted to those below as the pile is driven into the ground by a hydraulic motor attached to the top of the shaft. In addition to the time and associated delays involved in detaching and re-attaching the motor for each pile section, there are limitations in the amount of torque (rotating force) which conventional hydraulic drives have been able to achieve.

To overcome such operational limitations, a patented drive device termed the "HSD Driver" was developed by HSD Foundation Technologies Corp. The drive, which boasts significant architectural advantages and is considered a "disruptive technology," attaches along the length of the shaft typically near ground level rather than at the top, allowing the installation of a continuous pile without the need for any joints. The engagement process along the shaft also allows multiplication of applied torque, enabling extension beyond existing maximum hydraulic drive capacities of roughly 150,000 ft-lbs. In the right ground conditions, higher torque can promote larger piles, deeper piles, and greater load-bearing capacity.

To help HSD bring this innovative system to market, Golder conducted a technical review of the HSD Driver and a financial review to determine the net present value of the device considering several distribution strategies. Golder has also supported HSD's bidding activities on several foundation projects, and is supporting their marketing and distribution activities in concert with HSD's legal and investment banking team.

The results will be wider application of a technology that can offer significant cost savings, reduced noise and lower environmental impacts compared to incumbent deep foundation options.



## INNOVATION LEADS TO SAFE DRINKING WATER IN SOUTH AFRICA

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Communities near South Africa's biggest coalfield will have better access to safe drinking water, thanks to a project initiated by mining companies that combines several mine water treatment technologies in a new way.

South Africa has long been dependent on its coal deposits to meet its energy needs. The coal industry has implemented mine water management measures based on water re-use, water storage and limited discharge to local rivers. However, due to economic pressures and technology limitations, limited mine water treatment has been done in the past. In the Witbank coalfields near Pretoria, the water resource problem has become acute as the fast-growing neighbouring communities have run out of additional sources of safe water to supply their people.

To meet this growing need, members of Golder's Johannesburg office have conceptualized and managed a project to take water pumped from the coal mines and treat it to a potable level of purity using treatment technologies, including neutralisation, ultra filtration and reverse osmosis.

Because of the urgent need for safe water, Golder worked with the mining companies and regulators to fast-track the approval process. A demonstration plant was constructed in August 2005 and has proven the treatment technology feasible.

Construction is now under way for a plant able to produce 20,000 cubic meters (5.3 million US gallons) per day to enhance municipal water supplies and help protect the health of the mines' neighbors. Another benefit is that by using water that naturally accumulates in the coal mines, costs for the mine operators are reduced, which may help prolong the economically viable life of the mines.



# News from Golder

## ASIA

### TSUNAMI RECOVERY

Following the devastation of the Indian Ocean tsunami of December 2004, people from our Jakarta, Indonesia office have been working on four rebuilding teams.

- ▶ One team has scouted parts of the province in order to identify opportunities for demolition waste recycling systems.
- ▶ One Golder team will be helping to rebuild 260 km (162 miles) of the main road along the west coast of North Sumatra, helping investigate the existing as well as alternative routes for full design and construction. This work is being funded by the U.S. government.
- ▶ Another team is helping build 2,000 houses in Aceh Province, a project funded by the Canadian Red Cross.
- ▶ The last team is involved with site selection, survey and ground investigation for a new school development in Banda Aceh, funded by the German government.

Fieldwork and innovative design in remote locations have been core capabilities of Golder's Indonesian operations over the past 13 years, skills that are put to good use as the rebuilding work is being done in areas with no public services – staff work from tent camps and are completely self-sufficient.

## CANADA

### GATEWAY ENGINEERING TEAM

Golder is a partner with Delcan and CH2MHILL in providing comprehensive ground engineering and environmental services to the Gateway Program Engineering Team. The Gateway Program is a CDN\$3 billion infrastructure project aimed at building trade between Asia and North America through the Port of Vancouver, Canada. The Delcan-Golder-CH2MHILL team has recently completed the Project Definition phase and is now moving into the implementation phase.

### CARBON MANAGEMENT AND ENERGY JOINT VENTURE

Golder Associates Ltd. and Netherlands-based Ecofys BV have joined forces to create a new company that will develop and deliver carbon management and sustainable energy consultancy services in Canada. Golder Ecofys Solutions Ltd. (GES) initially have staff in Ontario and British Columbia, and will evaluate its regional requirements during its first six months of operations.

## CHINA AND MONGOLIA

### MINING PROJECTS AWARDED

Mining project activity continues to develop in Asia and this is being reflected in the workload of our China operations. As well as working on a number of mining projects including Mundoro Mining's Maoling project, Golder has recently been commissioned to provide geotechnical, tailings and environmental related services for the Boka Gold Project in Yunnan, and geotechnical services for the Oyu Tolgoi copper project in Mongolia.

## PORTUGAL

### NEW OFFICE

We have incorporated a company in Portugal and opened an office in Oporto. While we continue our historical work at several mines in Portugal, our new team is also supervising the design and construction of waste water treatment plants and is expanding our services on large infrastructure projects such as a high speed railway and the redevelopment of Oporto, as well as continuing to offer services to the manufacturing, oil and gas and mining industries.

## RUSSIA

### PIPELINE WORK

For Sakhalin Energy Investment Company (Shell), Golder won a contract to provide third party environmental monitoring services for construction of approximately 150 river crossings along 500 miles of oil and gas pipelines on Sakhalin Island, Russia. Considered External Observers, Golder field teams will perform monitoring work from December 2005 through April 2006.

## TURKEY

### NEW OFFICE

Following our clients from West Europe, Selbin Dicturk Rossetti has moved back to Ankara to open a new operation for Golder in Turkey. Turkey, now engaged in a process to join the European Union, will be the youngest and most populous country of the EU. Many oil and gas pipelines are crossing the country and many more are planned to be built, as well as refineries, factories, major infrastructure improvements and new mines. Our plans currently include exploration of the markets and the formal incorporation of a company in Turkey by year end.

## UNITED STATES

### CONTRACTING COMPANY FORMED

Golder has created a subsidiary contracting company to provide our clients with streamlined construction services for the implementation of the innovative designs developed within the company. The new subsidiary, Golder Construction Services Inc., will provide clients the opportunity to maintain their trusted relationship with Golder as projects continue to construction, operations and maintenance.



## A LEVEL PLAYING FIELD FOR INTERNATIONAL PROPERTY TRANSACTIONS

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In a world where investment capital knows nothing of national boundaries, there is an increasing need for a widely accepted method of discovering, evaluating and reporting environmental risks. Investors, bankers and other professionals involved in property transactions need an internationally valid method of comparing the risks associated with potential real estate acquisitions to avoid unexpected environmental problems, whether that property is located in India, Thailand, England, South Africa, Canada or the United States.

Over the past 15 years, the U.S. industry standard ASTM E1527 has been used increasingly in countries around the world for conducting Phase I Environmental Site Assessments (ESAs). However, this standard received a significant update in November 2005 (ASTM E1527-05). The new standard requires that assessments be conducted under the purview of an Environmental Professional. It also calls for a more comprehensive review of local and "commonly known" information

regarding the property's previous uses, and requires more extensive reporting and documentation in the assessor's report.

Golder meets the market's needs through its International Due Diligence Team. These Environmental Professionals stay abreast of changes in regulatory and industry standards, and carry out procedures that are standardized and practiced. This team has already obtained globe-spanning results for BA Capital Partners, Eaton Corporation and other worldwide companies.



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### TECHNICALLY SPEAKING

Technically Speaking is published for valued clients and employees of Golder Associates. This quarterly newsletter includes articles showcasing innovative and technically challenging projects that Golder professionals have worked on throughout the world.

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### GOLDER ASSOCIATES

Golder Associates is a well-respected global group of consulting companies specializing in ground engineering and environmental services. By meeting client needs and building strong client relationships, our people have made Golder one of the most trusted sources of professional services in the world. Operating as an employee-owned group since our formation in 1960, Golder has created a unique culture with pride in ownership and a commitment to providing technically sound and cost-effective consulting and contracting services. We have experienced steady growth for more than four decades and have more than 4,500 people operating in local companies, with offices across Africa, Asia, Australia, Europe, North America and South America.

