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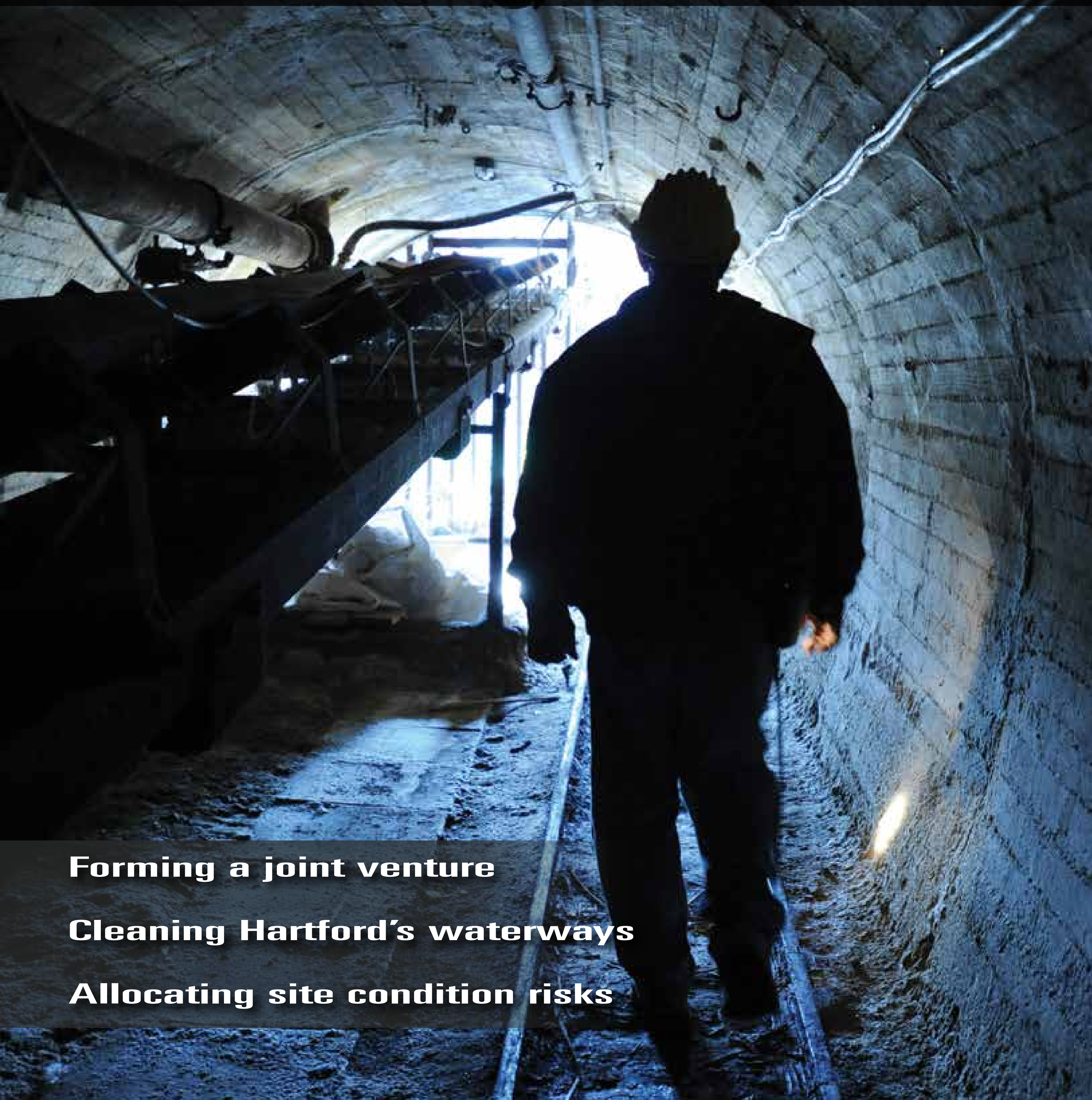
THE OFFICIAL PUBLICATION OF UCA OF SME   WWW.TUCMAGAZINE.COM   VOLUME 9 NO 1 MARCH 2015



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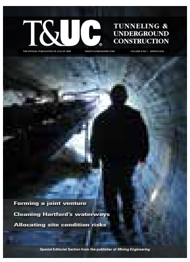
COVER STORY



In this issue — Joint ventures have existed in the tunneling and underground construction industry for as long as the industry itself. Yet there is still some confusion about the roles of the each player in a joint venture. Michael Roach of Traylor Bros. Inc., sheds some light on the process, beginning on page 56

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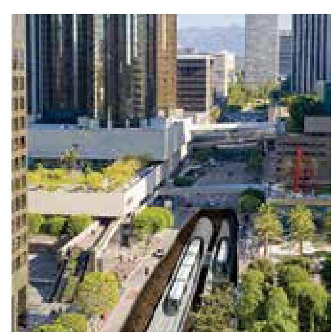

DEPARTMENTS

CHAIRMAN'S COLUMN

Exciting times

Surely the underground industry is an exciting one. Things are always changing. Despite advances in geotechnical exploration, as well as new techniques for predicting what lies in front of the tunnel boring machine, the ground frequently behaves differently than we expect. This, of course, causes those of us in the "prediction-making" business to be less specific and more general in our characterizations, and those of us in the "prediction-using" business to complain about the prediction-makers' lack of X-ray vision.

And the weather can sometimes get the best of us. As I write this (January), it's snowing in New York City and we've just postponed the Fox Conference. The Fox Conference has been rescheduled for March 16 at the same location, the Graduate Center, City University of New York. And we are expecting the same quality conference to take place then. This rescheduling is a good example of how the people in our industry are able to address change.

The Underground Construction Association of SME (UCA) recently endorsed the new "Guidelines for Improved Risk Management Practice on Tunnel and Underground Projects in the United States." This document is an outgrowth of the insurance industry's 2006 "A Code of Practice for Risk Management of Tunnel Works," that has been adapted to U.S. contracting practices. The "Guidelines" recommend a detailed process for doing a risk assessment, and developing a list of mitigations. The new risk management guidelines are currently being reviewed by SME's attorneys and will soon be available for viewing on the UCA and *Tunneling & Underground Construction* websites.

And, no, the UCA did not do a risk assessment for the Fox Conference, nor did we develop a set of pre-thought-out contingency plans. So how were we able to so quickly change our plans and reschedule the Fox Conference for March? Because, not unlike the day-to-day operations of an underground construction project, the management and staff had the resources, knowledge and ability to deal with things that do not go exactly as planned. In many cases, it simply is not cost effective to take the time and effort necessary to dream up every possible failure mechanism. But the people in the underground industry are some of the most competent in the construction business. That is one reason why this industry has had the innovative growth during the past quarter-century, resulting in more cost-efficient projects.

How is it that we are all so enthusiastic about this industry? The wide variety of problems and solutions is part of what makes our business so engaging. That's why we love the underground business — it's an exciting and unpredictable art. Otherwise, we wouldn't stay interested for so many years. ■

William W. Edgerton, UCA of SME Chairman

Obama administration calls for improvements to nation's infrastructure

Vice President Joe Biden toured the Blue Plains clean water project in Washington, D.C. and used the occasion to promote the Obama administrations plan to invest in infrastructure projects.

On Jan. 30, the Obama administration announced new steps federal agencies are taking to attract private money for projects on upgrading roads, bridges and other infrastructure.

Among the steps is a new Water Finance Center at the U.S. Environmental Protection Agency that will work with state and local governments, utilities and the private sector to use federal grants to leverage private capital to address more than $600 billion in needs for drinking water and waste water management over the next 20 years, *The Associated Press* reported.

A separate Agriculture Department program, the Rural Opportunity Investment Initiative, will be aimed at attracting private funding for rural projects and improving access to USDA credit programs.

The administration is proposing to create a new municipal bond for public-private partnerships.

Biden discussed the importance of modern infrastructure at the Blue Plains project that is designed to reduce the flow of billions of gallons of contaminated sewer water into the Anacostia River.

"If we're going to lead the world in the 21st century, and we are leading the world in the 21st century, we have to have the most modern infrastructure in the world," Biden said, adding that businesses don't want to locate in places where water is dirty, bridges aren't up to date or there are no connections to railways.

It has been several years since Congress has passed a long-term measure to pay for spending on highways and other projects. Last year, President Obama put forward a $302-billion, four-year proposal partly paid for by overhauling the corporate tax system, but the proposal stalled on Capitol Hill.

Obama, Biden and other officials argue that U.S. competitiveness is being hindered by aging infrastructure. They say projects to replace or upgrade infrastructure will help the economy and create jobs.

President Obama launched the Build America Investment Initiative in July 2014, calling on federal agencies to find new ways to increase investment in ports, roads, bridges, broadband networks, drinking water and sewer systems and other projects by facilitating partnerships between federal, state and local governments and private sector investors. ■

Access pit for Bertha repairs completed in Seattle

The Washington State Department of Transportation (WSDOT) said the contractor building a highway tunnel under downtown Seattle has finished digging a 37-m- (120-ft-) deep pit that can be used to access and repair the broken tunneling machine.

State officials say Seattle Tunnel Partners' crews removed the final scoop of soil on Jan. 29. They've moved about 15,300 m^3 (20,000 cu yd) of material since mid-October. Next, they will build a concrete cradle at the bottom of the pit to support the tunnel boring machine, called Bertha. The contractor hopes Bertha will be able to chew through the pit's 6.1-m- (20-ft-) thick concrete southern wall to reach the access pit. If that doesn't work, the contractor will create the opening.

Once Bertha is in the access pit, workers will use a massive crane to hoist the tunneling machine's front end to the surface for repairs.

The plan is to move Highway 99 under the city, replacing the aging Alaskan Way viaduct. The tunneling machine broke down in December 2013 after drilling about 305 m (1,000 ft) of the 3.2-km (2-mile) tunnel.

In other news from Seattle, two Republican state senators proposed new legislation that would scrap the tunnel-boring project in Seattle and retrofit the Alaskan Way Viaduct instead.

Sens. Michael Baumgartner, R-Spokane, and Doug Ericksen, R-Ferndale, introduced Senate Bill 5646, which aims to end the spending on the tunnel project.

But Sen. Curtis King, R-Yakima, chairman of the Senate Transportation Committee, said the plan is dead on arrival and he would not allow the bill a hearing.

The bill's architects vow they won't stop their fight to bury Bertha.

"What's not acceptable is to just pretend this giant white elephant boondoggle in the ground is working just swimmingly," said Baumgartner, "No one believes that."

For months the world's largest TBM has been damaged and sitting idle underneath Seattle.

(Continued on page 5)

Robbins TBM begins work on North Link project

Tucked away on a small jobsite in a quiet neighborhood bordering a busy interstate highway, a Robbins earth pressure balance (EPB) tunnel boring machine (TBM) underwent onsite first time assembly (OFTA). The OFTA method allows for TBMs to be initially assembled onsite, and results in time and cost savings to the contractor.

On Nov. 17, 2014, unbeknownst to commuters driving by, the 6.65-m (21.8 ft) TBM rumbled to life and began its journey south into the city of Seattle, WA.

The machine, for contractor JCM North Link LLC (a joint venture of Jay Dee, Coluccio and Michels); is excavating for the North Link Project, which is an extension of Seattle's light rail system. The project required twin 5.8-km (3.6-mile) tunnels through glacial till and sand. JCM utilized a refurbished Hitachi Zosen machine in its fleet for the first tunnel, which was launched in summer 2014, and the Robbins EPB for the second. This isn't the Robbins machine's first project; prior to North Link, it bored mixed ground tunnels for Singapore's Downtown Line.

Urban tunneling brings unique challenges to the project. The tunnel will travel under a university campus, where there is concern about noise and vibration from the machine's movements. Research and preparation have been done to mitigate these foreseeable issues. The compact jobsite also caused complications during assembly, with a long, narrow setup that required creative storage methods for parts and systems.

JCM is confident that refurbished TBMs are the best solution given the tight project schedule. Designed for use on multiple tunnels in mixed ground, the Robbins EPB features a steel frame 30 percent heavier than other EPBs on the market, with components intended for 10,000 hours of workable life. "Ten years ago, EPB tunneling in mixed ground below the water table was not that common … it would have been considered a big risk to use a refurbished machine. Now, many EPBs have been specified to deal with more challenging conditions, so there are a quite a lot more out there to be refurbished. This [solution] increases our ability to get a TBM to launch sooner, and is also more cost-effective," said Glen Frank, project manager for JCM North Link, on using a refurbished machine.

Robbins continuous conveyors are running behind both TBMs. "We've had great success with Robbins conveyors [on past projects]," said Frank. "Without the conveyor, we couldn't do this job. They cut down on costs and vibration, and allow us to use rubber-tired vehicles, rather than trains, for transport in the tunnels. We feel that Robbins conveyors are the best quality out there."

The Robbins TBM was assembled on site in Seattle, WA.

Both machines will travel from the North Link site in northern Seattle south to the Roosevelt station site near the University of Washington campus, adding length to the recently completed University Link tunnels. The tunnels are all part of a larger transit system scheme for project owner Sound Transit, intended to provide a quick and alternative transportation option to Seattle's outdated surface bus system, and to help alleviate the city's traffic congestion. The tunnels are expected to go online in 2021. ■

Bertha: Legislation to kill SR-99 project proposed

(Continued from page 4)

Setbacks have plagued the multibillion-dollar project. Baumgartner said enough is enough and that it's time to pull the plug on Bertha.

"It risks potentially sucking up every transportation dollar in the state," he said.

The bill would fill the hole dug by Bertha and instead retrofit the viaduct, all in an effort to stop what Baumgartner called wasteful spending.

But King said the bill wouldn't get a chance to see the light of day, adding that taxpayers need to have faith that Bertha will dig again.

King said the vision set forth by Washington State Department of Transportation and its contractor, Seattle Tunnel Partners, needs to have a chance to come to light.

"Those people that have their hair on fire, just put them out for a while and calm down," said King. "Let the people work together and get this project done."

Contractors said their next step is to replace Bertha's damaged cutter head. ■

Design, build and PPP program delivery practices are not used on large tunnel projects in Austria

by David R. Klug

In North America and the rest of the world, it is now in vogue to promote the use of design build and public private partnership (PPP) for major tunnel projects, as there is the perception that these project delivery methods can deliver a completed tunnel project faster and at a lower cost to the owner than conventional project delivery methods. There is a debate ongoing within the tunnel industry if this is true or just a passing fad promoted by individuals and/or companies to project owners as a means for them to get a project without expending political capital or having to secure financing in advance; and pushing the risk to stakeholders other than themselves.

I have a great deal of admiration for the Austrian tunneling industry, beginning with their formal introduction of New Austrian Tunneling Method (NATM) to the United States in the early 1980s. Since that time, I have become business associates and close friends with many people in the Austrian tunnel design and tunnel construction industry. Over the past 30 years, I have visited many Austrian tunnel projects under construction as part of my European Tunnel Seminar (ETS) programs, where we have observed many tunnel projects being constructed in complex geological conditions in the Alps. In planning for ETS # 9, I was given the opportunity to visit four major Austrian tunnel projects under construction and had the opportunity to meet with the owners, design engineers (for the owner and contractor) and saw presentations given on each explaining the project delivery methods being implemented and why that delivery method was selected.

During the week of ETS # 9, Sept. 28 to Oct. 4, 2014, we visited the Brenner Base Tunnel (BBT) project near Innsbruck. The BBT is a straight, flat, twin high-speed rail tunnel between Austria and Italy. At 64 km (38.4 miles), it is the longest tunnel currently under excavation in the world. We then visited the Bosruck Road Tunnel Rehabilitation project near Bosruck, Austria and proceeded to the OEBB Koralm Tunnel Program using both NATM and tunnel boring machine (TBM) construction practices near Koralm, Austria. This is a 32.8-km- (19.7-mile-) long double track railroad tunnel program under construction using NATM drill-and-blast and TBM/precast segment tunnel construction practices. Later in the week, we visited the U-Bahn Vienna Metro project in downtown Vienna that is an expansion of the subway program that services the greater Vienna area. All of the mentioned tunnel projects are major expansions in terms of cost and scope to the transportation infrastructure of Austria.

At each project visited, we were given a presentation on the scope of the project, the geological conditions through which the tunnels must be constructed, the equipment and construction procedures used to construct the project, and the project construction costs. And we were presented with the construction delivery model used by each owner to take the project from concept to construction. After the presentation, each owner was very open and provided the ETS group a question-and-answer session. All of our Austrian hosts were most gracious and open in explaining their projects and the basis for their decision making.

One of the primary purposes of ETS # 9 was to learn about the project delivery methods used in Austria to deliver major tunnel projects and programs. If you study the history of the tunnel industry, North America tends to track behind Europe in proven technology and contracting practices. At each project, we were given detailed information on the project delivery methods used and learned that each project has the same project delivery model.

Preferred tunnel project delivery method – bid build with an extra cost toolbox

In Austria, the owners were a knowledgeable and involved project partner with the design engineers and the contractors on all of the projects we visited. In all of the project presentations, it was quite clear that the owner and his technical representative were in charge of the project from conception to completion. The owners were extremely knowledgeable about their respective projects and what they expect from the contractors and they acknowledged that they were not there to destroy the contractor but to work with him. The owners stated "we own the ground and are responsible for any geological changes," thus their preferred method for contract delivery is: bid build with an extra cost toolbox. With this type of contract, it is easy to address changed conditions as technical people from the various parties meet, decide on the corrective action required to solve the problem. Corrective action is then taken and paid for based on the cost in the bid document toolbox. Lawyers are not invited to the meetings and rarely are they required to get involved in a project resolution. Plus, project quality does not have to be compromised to meet a budgetary constraint. Using this construction model, the costs to build major tunnel projects in Austria are much lower than in North America. One item that may assist in the lower cost model is that the Austrian contractors do not have to bond 100 percent of a contract value, it can be a low as 10 percent of the contract value.

Austrian position on design build and PPP project delivery methods

At every project presentation, the owners were asked if they ever considered design build and PPP contract delivery methods for their project. The responses were unanimous from all parties present: these contracting models should not be used for tunnel projects where there can be unplanned/uncharted geological conditions that must be addressed in a prompt and professional manner or the problem can easily expand into higher costs and project delays. Again, the various owners acknowledged that they must take responsibility for the changed geological condition and manage the proper corrective action in conjunction with the contractors and the engineers, a team approach.

It was pointed out that PPP is more a financing model than a project contracting model and with PPP contracts the financier frequently has more control over the construction of the project than the design engineers and the contractors due the various financial factors and procedures that impact the final project price.

Going forward in North America

There are some lessons to be learned from what is currently taking place in Austria. In Austria, large complex tunnel projects are being built faster and at a lower cost and with less legal party involvement than in North America. The key to the success in Austria appears to be that the owners are knowledgeable and take leadership control of a project versus owners in North America who want to assign the risk to others and abdicate their responsibilities as the project leader.

Possible actions for consideration in North America:

- The owner should own the ground regardless of the contract delivery model – DBB, DB, PPP.
- The owner should control and manage the project quality control/quality assurance program.
- The "tool box approach" to cost reimbursement should apply to all contracting models.
- The owner should do more to promote a project team concept with the owner taking the lead.

Summary

Austria, Germany and Switzerland are special places in regard to tunnel construction, with very knowledgeable owners, a very experienced work force, highly motivated construction companies and a construction culture that breeds the project team concept. While we may not be able to build tunnels at the same cost as they do in central Europe, we can learn from them on the various factors that contribute to their success.

Your comments and opinions would be most appreciated.

David R. Klug, President
David R. Klug & Associates Inc.
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New York Harbor tunnel proposal discussed

The first of seven public hearings sponsored by the Port Authority of New York and New Jersey about how to better move cargo across the New York Harbor was held on Jan. 23 and included a proposal of a cross-harbor freight tunnel.

Supporters of the tunnel argue that the tunnel would remove thousands of trucks from the region's surface roads, but also admit that it is an expensive option – as much as $10 billion.

NJ.com reported that Vincent Pellecchia, an official with the Tri-State Transportation Campaign, a nonprofit research group, told the port authority groups, "In terms of congestion, these rail tunnel alternatives can remove 500,000 trucks annually from our roads, reducing daily commercial truck traffic in New York City and its surrounding counties by up to over 47 million vehicle-miles traveled by trucks."

A cross-harbor freight rail link has been contemplated by the Port Authority since its founding in 1921, and has been revived in recent years to address a projected 37-percent growth in cargo movement over the next two decades.

A Port Authority study of alternatives to address that growth estimated the cost of a tunnel at $7.4 billion to $10.2 billion, depending on the design: trains only; one track or two; trains single or double-stacked with shipping containers; or train tracks and truck lanes.

The tunnel would run about 6.4 km (4 miles) under the harbor between existing rail yards at 65th Street in Brooklyn and the Greenville section of Jersey City, just south of Liberty State Park. Rob Gottheim, an aide to Rep. Gerald Nadler (D-Brooklyn), a leading supporter of the tunnel, said in an interview after the hearing that the project was in its infancy, and that choosing the best alternative was the task at hand, not deciding who would pay for it.

"It's going to need a number of sources (of funding)," Gottheim said. "It's going to need the Port Authority; it's going to need the federal government; maybe private (investment)." ■

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In the early 1900s, Allentown's pioneering technology was first developed for taxidermy purposes when its originator Carl Akeley, a famous hunter and professor, devised a method for spraying plaster onto a wire frame. The outcome was a strong, thick plaster coating that didn't slump from the frame or set before being fully placed.

Forty years later, a new process was developed involving the use of pressure tanks to force stiff mortar through a hose. This new wet-process became known as shotcrete - and the rest is history.

"In this day and age, very few companies are able to succeed in business for over 100 years," says Patrick Bridger, president of Putzmeister Shotcrete Technology. "We are very proud of our longevity, and see it as a testament to our reputation for quality, and the value we have brought our customers for more than a century."

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Throughout the years, numerous milestones have been achieved:

- 1900s - Carl Akeley develops method for spraying plaster onto wire frames.
- 1910 - First Cement Gun introduced at New York Concrete Show.
- 1911 - Patents and trademarks issued for the Cement Gun and its Gunite process.
- 1950s - Wet-process shotcrete application developed.

SPM 307 Nozzle Carrier

- 1960s - Dry-process rotary gun developed.
- 1970s - Swing-tube technology used on wet-process shotcrete equipment, making application and use more practical.
- 2007 - Company acquired by Putzmeister America, Inc., resulting in most comprehensive line of sprayed concrete equipment. Name changed from Allentown Equipment to Allentown Shotcrete Technology, Inc.
- 2008 - Allentown becomes exclusive United States distributor of the Sika/Aliva family of wet- and dry-process shotcrete equipment.
- 2009 - Putzmeister America's Special Application Business forms partnership between Allentown, Esser Pipe Technology and Maxon Industries, Inc., creating a comprehensive systems approach for tunnel and mining, dam and power generation, transportation, marine and off shore projects. MacLean Engineering, in partnership with Allentown, develops new self-contained shotcrete spraying machine.
- 2010 - Allentown Celebrates 100th Anniversary.
- 2012 - Allentown Shotcrete Technology, Inc. is re-branded Putzmeister Shotcrete Technology.

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two of the five cross passages. The cross passages lay approximately 100 ft below groundwater level and mostly within the highly pervious Key Largo formation that had been determined to become potentially unstable during tunneling. Pre-freezing analyses were conducted to determine a ground freezing design that would achieve the required thickness of frozen ground within the relatively short timeframe. This resulted in a system consisting of two concentric rings of freeze pipes, horizontally drilled and installed from within the Eastbound tunnel. Freezing was initiated following a grouting program to reduce permeability of the formation and the velocity of groundwater flow that could inhibit freeze closure. Freezing operations were extensively instrumented and monitored throughout the program to ensure closure had been successfully achieved.

Specialty geotechnical contractor Moretrench, headquartered in Rockaway, New Jersey, offers a range of services for tunneling and underground construction, including ground freezing, dewatering and groundwater control, and various grouting techniques. The company's capability and versatility were recently demonstrated in two very different projects.

Port of Miami, Miami, Florida *(pictured upper left)*

At the Port of Miami in Florida, ground freezing was recently used for the first time in North America for construction for

OSIS Augmentation and Relief Sewer, Columbus, Ohio *(pictured lower left and right)*

For Phase 2 of a 23,000 foot-long storm and sanitary overflow and relief sewer in Columbus, OH, three deep shafts were to be installed through highly variable karstic rock under hydrostatic head of up to 150 feet. Solution features ranged from small fissures to large voids. It was estimated that inflows of thousands of gallons per minute could be anticipated during shaft excavation. Pre-grouting of the rock was therefore required by the bid documents. The shafts extended through shale underlain by three distinct strata of limestone. A specially designed suite of four balanced-stable grouts was developed by Moretrench to cater to the highly variable conditions present throughout. Grouting was performed through a double row of holes outside the shaft perimeters, with grouting parameters monitored by an automated data system. The grouting program as designed successfully addressed the challenging conditions, allowing the general contractor to excavate to design depth with minimal water inflow.

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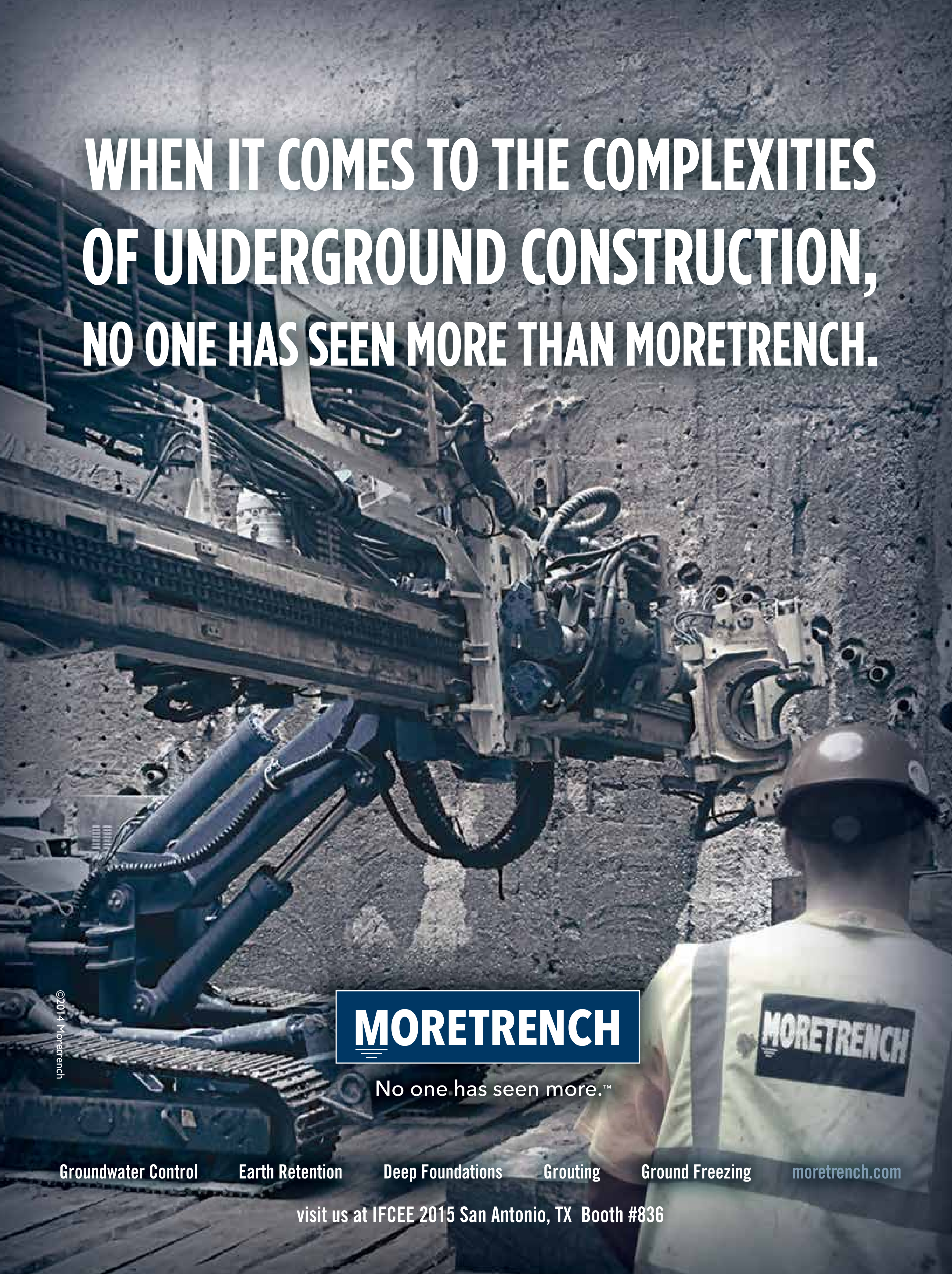
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Robbins

TBM and continuous conveyor system were assembled onsite alongside Washington's busiest highway, on a jobsite the width of a city street. The machine recently passed through a difficult section of dense clay and is now excavating at good rates of 24 m (78.84 ft) per day.

Robbins' continuously advancing conveyors are designed to increase the efficiency of muck removal and streamline tunneling logistics. At the Indianapolis Deep Rock Tunnel Connector (DRTC) Project, a Robbins continuous conveyor system (pictured below) including both horizontal and vertical conveyors runs behind a 6.2 m (20.2 ft) Robbins Main Beam TBM. Additionally, the tunnel contains two uncommon 90-degree curves requiring a specialty conveyor system, designed by Robbins. After setting three world records and completing its initial breakthrough in July 2014, the machine was launched again and is currently working on the next phase of the tunnel.

Robbins' field service personnel bring years of experience to each project. At the New York City Harbor Siphons Project (pictured upper left), Robbins repaired a 3.6 m (11.8 ft) Caterpillar EPB TBM that was left damaged after the infamous Hurricane Sandy pummeled the jobsite, leaving the machine idle for almost a year. A dedicated Robbins field service crew was brought onsite to repair the TBM, and just four months

later the machine recommenced boring and successfully broke through in late January 2015. On the other side of the globe at Australia's Grosvenor Decline Tunnel (pictured left), Robbins field service oversaw the operation of a unique hybrid 8.0 m (26.2 ft) Single Shield/EPB TBM that broke through in February 2015. The machine completed two decline tunnels for the mine, and reached rates 10 times higher than the conventionally-used road header excavation method.

With major projects currently underway in North America and abroad, Robbins continues to lead the tunneling industry in innovation and partnership. For more information about Robbins and our past and present projects, visit **www.TheRobbinsCompany.com** or call +1 (440) 248-3303.

Robbins
RELIABLE | RESPONSIVE

Setting the Tunneling Standard

With over 60 years of experience, The Robbins Company is the world's foremost developer and manufacturer of advanced underground construction machinery. Robbins TBMs made swift headway on many worldwide projects in 2014, and will continue this progress in 2015. Innovative concepts keep expanding the company's scope, from efficient TBM assembly methods to high-performance machine designs resulting in landmark performances in soft ground and hard rock.

Committed to Partnership and Innovation

Robbins is a total supply company, offering the complete tunneling solution. Robbins can supply everything from the TBM to all supporting components, such as cutters, conveyors, field service personnel and technical support. Additionally, Robbins brings innovative solutions to each project they are involved on. One example of this is Robbins' time-saving Onsite First Time Assembly (OFTA) method, first used at Canada's Niagara Tunnel Project in 2006. The method results in significant time savings and cost reductions for the contractor, all by initially assembling the TBM at the jobsite rather than in a manufacturing facility. OFTA has been carried out successfully on multiple projects and with all types of TBMs. At the North Link Project in Seattle, Washington, a refurbished 6.65 m (21.8 ft) Robbins Earth Pressure Balance (EPB)

North America's Leader in Geotechnical Construction

Hayward Baker handles geotechnical challenges both large and small. Our extensive experience with the full range of ground modification techniques has been applied to hundreds of tunneling projects. Commonly applied tunneling services include earth retention, underpinning, waterproofing, soil improvement, and ground stabilization.

Seattle, WA
Brightwater Conveyance System

Construction of the Brightwater Conveyance System required surgical jet grouting to facilitate tunneling operations. Utilizing their proprietary jet grouting equipment, Hayward Baker created soilcrete blocks outside of four deep vertical shafts to assist with both TBM and hand-mined tunneling operations. The ground improvements allowed TBMs to be launched or received into and out of the shafts without the risk of water and ground run-in. Overlapping columns to depths of 94 feet compose the soilcrete blocks.

Brightwater Conveyance System

Los Angeles, CA
Lower North Outfall Sewer Rehabilitation Project

Rehabilitation of the 82-year-old Lower North Outfall Sewer included grouting around the outside of the tunnel to densify and strengthen the soil above the tunnel in order to protect the overlying structures from settlement. Hayward Baker performed permeation and fracture grouting through over 3,500 holes from within the tunnel, stabilizing the overlying structures. State-of-the-art survey technology and proprietary grouting instrumentation allowed Hayward Baker to first probe the soil to determine existing conditions, and then observe the soil response during grouting, while monitoring the ground surface in real time.

Lower North Outfall Sewer

Los Angeles, CA
Metro Gold Line C800

Construction of twin subway tunnels for the LA Metro's Gold Line would cause ground loss, endangering overlying structures unless the soils surrounding the tunneling zone were treated prior to excavation. Using conventional horizontal drilling to install steel and PVC sleeve port grout pipes, Hayward Baker performed chemical grouting to stabilize soils, and fracture grouting to protect overlying structures. Heave and settlements were monitored by exterior remote robotic total stations and interior wireless tiltmeters.

St. Louis, MO
Baumgartner Tunnel Alignment

Water-bearing rock formations in the path of the Baumgartner Tunnel Alignment needed to be sealed. Unsafe levels of hydrogen sulfide forced the grouting to be performed from the surface in advance of the tunneling operation. Hayward Baker drilled and grouted the water-bearing rock formations along a 1,200-foot-long segment of the proposed 20,000-foot-long, 12-foot-diameter combined sewer tunnel. A total of 40,000 feet of grout holes was drilled to complete the project. Depths of the drill holes were approximately 170 feet from ground surface.

Big Bend Tunnel Improvement
Big Bend, WV

Big Bend rail tunnel, constructed in 1932, required extensive ground and wall improvements over a 1,200 foot stretch due to its age and frequent use. Hayward Baker stabilized the tunnel walls with cement-bentonite structural grout, several rows of rock bolts and dowels, and compaction grout underpinning. Epoxy and cement grouting were utilized to repair an existing fracture of the tunnel liner along the spring line. Hayward Baker also stabilized the invert with compaction grouting at approximately 4,000 locations.

Big Bend Tunnel Improvement

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Geotechnical Construction
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Mining Equipment Ltd.

12-ton explosion proof diesel locomotive pulling 8 cubic meter side-dump muck cars out of the tunnel.

Mining Equipment has been supplying the mining and tunneling industries with top quality rolling stock for more than 30 years. They supply diesel and battery locomotives up to 35 tons. As well as a complete line of non-propelled rolling stock including muck cars, flat cars, personnel cars, segment car and concrete agitator cars.

Recently Mining Equipment has supplied a string of rolling stock including 5th wheel dump muck cars to Stillwater Mining in Montana. The cars will be used to haul muck out of a new TBM mined tunnel.

Another recent project for Mining Equipment was the New Irvington Tunnel in northern California. 12-Ton explosion proof diesel locomotives were supplied as well as a large spread of 5th wheel dump muck cars, flat cars and personnel cars.

Mining Equipment is based in Durango, Colorado. There primary shop is in Farmington, New Mexico. They also have a fabrication facility near Shanghai, China and an office in North Bay, Ontario.

25-ton diesel locomotive pulling a string of 15 cubic meter capacity roll-over muck cars through a dump at their mine in Papua New Guinea.

Mining Equipment Ltd.
Telephone: +1-970-259-0412
Fax: +1-970-259-5149
www.miningequipmentltd.com

Leading the Way

Every structure needs a strong foundation and John Malcolm established Malcolm Drilling Co. Inc. (Malcolm) on a strong foundation of hard work, dedication and an unwavering commitment to pursue new technologies. Over the course of 50 years the company has become one of the country's foremost practitioner and authorities in deep foundation, retention systems and ground improvement work, operating the largest fleet of drilling equipment in the country (valued at more than $190 million). Malcolm is committed to reinvesting capital back into the company in the form of state of practice equipment and cutting-edge technology, which allows the company to serve client needs on a broad geographic basis.

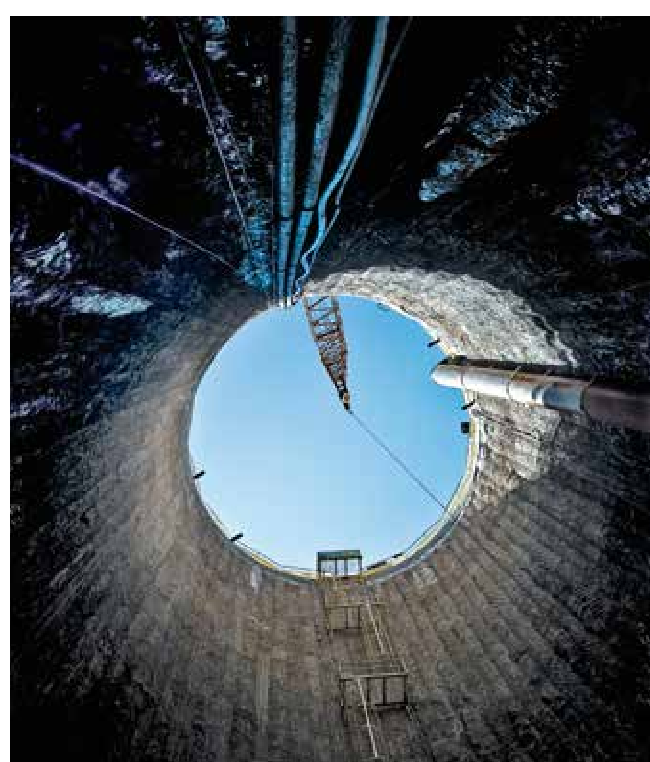
Malcolm's list of core services as it relates to tunneling includes access shafts, excavation support systems, cutoff and secant pile walls, jet grouting, deep soil mixing, cutter soil mixing and dewatering. The company has augmented its construction and engineering expertise along with a strong safety record into an equally impressive resume that represents a significant number of high-profile, highly challenging tunneling projects throughout North America.

Malcolm crews recently completed work on the Alaskan Viaduct Replacement Project (SR 99), in Seattle where we installed the support of excavation (SOE) which incorporates large-diameter secant piles to construct the portal for Bertha, the world's largest tunnel boring machine (TMB).Various ground improvement techniques were used to construct several TBM Safe-Haven's in challenging glacial till with a myriad of undocumented obstructions. At the Port of Miami Tunnel Project in Florida, Malcolm installed the launch and retrieval pit for the TBM incorporating various Soil Cement Mixing techniques for the SOE as well as the break-in and break-out structures in highly permeable limestone. For the New Irvington Tunnel in California, we drilled very deep Secant Piles to construct the access shaft in rock with verticality requirements which until recently were unachievable.

Our large equipment fleet and highly skilled personnel affords Malcolm the unique ability to comply with the most rigorous schedule compression, while delivering a high quality product in the most difficult ground conditions. Our experience facilitates a Design/Build approach to projects and allows for timely collaboration with owners and contractors. We provide these services nationwide through our regional offices. We welcome the opportunity to work with you in developing the most efficient and cost effective solution to your next project.

Look to the Blue

Malcolm Drilling
www.malcolmdrilling.com



FKC-Lake Shore

FKC-Lake Shore serves the underground heavy civil and mining industries throughout North and South America. We offer design-build-install services for innovative hoisting, elevator, and vertical conveyance systems used to transport personnel and material. Our Field Services Division provides routine maintenance, inspections, wire rope NDT, and 24/7 emergency repair of electrical and mechanical systems.

Products/Services:

- Vertical Belts
- Skips
- Hoists
- Sheaves
- Elevators
- Cages
- Headframes
- Brakeman Cars
- Controls
- Field Services
- Wire Rope NDT

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DSI Underground Systems offers a complete selection of ground control solutions for the Civil, Mining and Foundation markets. We have been a leader in the underground support business in North America since 1920.

We are a global leader in tunnel and shaft construction, focused on engineered and tailored products to support our customers and industry.

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DSI is proud to bring an expanded group of products to the job site:

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- ALWAG – Support Systems
- Biomarine – Tunnel Rescue Equipment
- Boart – Probe and Roof Bolting Equipment
- CBE – Segment Moulds – Precast Segment Moulds, Related Equipment & Plants
- ChemGrout – Grouting Equipment
- Condat – Ground Conditioning Chemicals and Lubricants
- Cooper & Turner – Bolts and Sockets for Precast Segments
- Montabert – Excavator Drilling Attachments & Replacement Drifters
- Dywidag – Bolts and Accessories including DSI Threadbar, Friction Bolts and Omega Bolts
- ES – Rubber Segment Gaskets
- Geodata – Monitoring Equipment
- Häny – Grouting Systems
- Promat International – Fire Protection Products
- Tunnel Tec – TBM Cutting Tools
- Vik Orsta – CT-Bolts – Double Corrosion Protection
- Weldgrip – Fiberglass Bolts and Dowels
- WIRTH – TBM, Pile Top Rigs
- ACI – Steel Ribs, Liner Plates, Lattice Girders, Lagging and Miscellaneous Support Items
- ACI – Tunnel Fabrications and Accessories

Atlas Copco Innovation

Founded in 1873 as AB Atlas, the company manufactured its first drill in 1898. Continuous innovation followed, and in 1936 Atlas introduced a one-man rock drill that could be equipped with a pneumatic pusher leg. This became the basis for the “Swedish method,” a modern and lighter drilling technology. In the same year, the company pioneered the use of “down-the-hole” drilling. And in 1937, Atlas manufactured a rock shovel loader for the mining industry. Over the years, the Atlas Copco legacy continued to grow.

Today, the Atlas Copco mining product range includes:

- Blast hole drilling rigs
- Exploration drilling equipment
- Ground engineering equipment
- Rock reinforcement equipment
- Large rotary and DTH blast hole rigs
- Raiseboring equipment
- Face drilling rigs and scalers
- Underground loading and hauling vehicles
- Rock drilling tools, hammers, bits

Atlas Copco has a heritage of innovation and service that stretches over more than 140 years. But rather than rest on their reputation and strong standing, they continue to develop new ways for their mining customers to work more safely and more productively.

Atlas Copco
www.atlascopco.us

Lachel & Associates, Inc.

Lachel & Associates, Inc., a Schnabel Engineering company, specializes in design and construction management services for tunneling and other heavy civil construction projects in the areas of transportation, water and wastewater infrastructure, and hydroelectric power. Our goal is to meet the needs of clients by providing fully integrated management and technical services that are objective, thorough, and effective.

We combine our expertise in the design and construction of underground structures with a keen understanding of the nuances and interrelationships of geology, hydrogeology, and geotechnics on underground projects. From inception, through design, risk assessment, estimating, construction, and operations, we provide time-critical answers to difficult questions that help make certain the project comes in on time and within budget.

Founded in 1976 as a tunneling engineering firm, Lachel has a long history of providing tunnel design services to contractors, owners, and other A/E firms for projects across the United States.

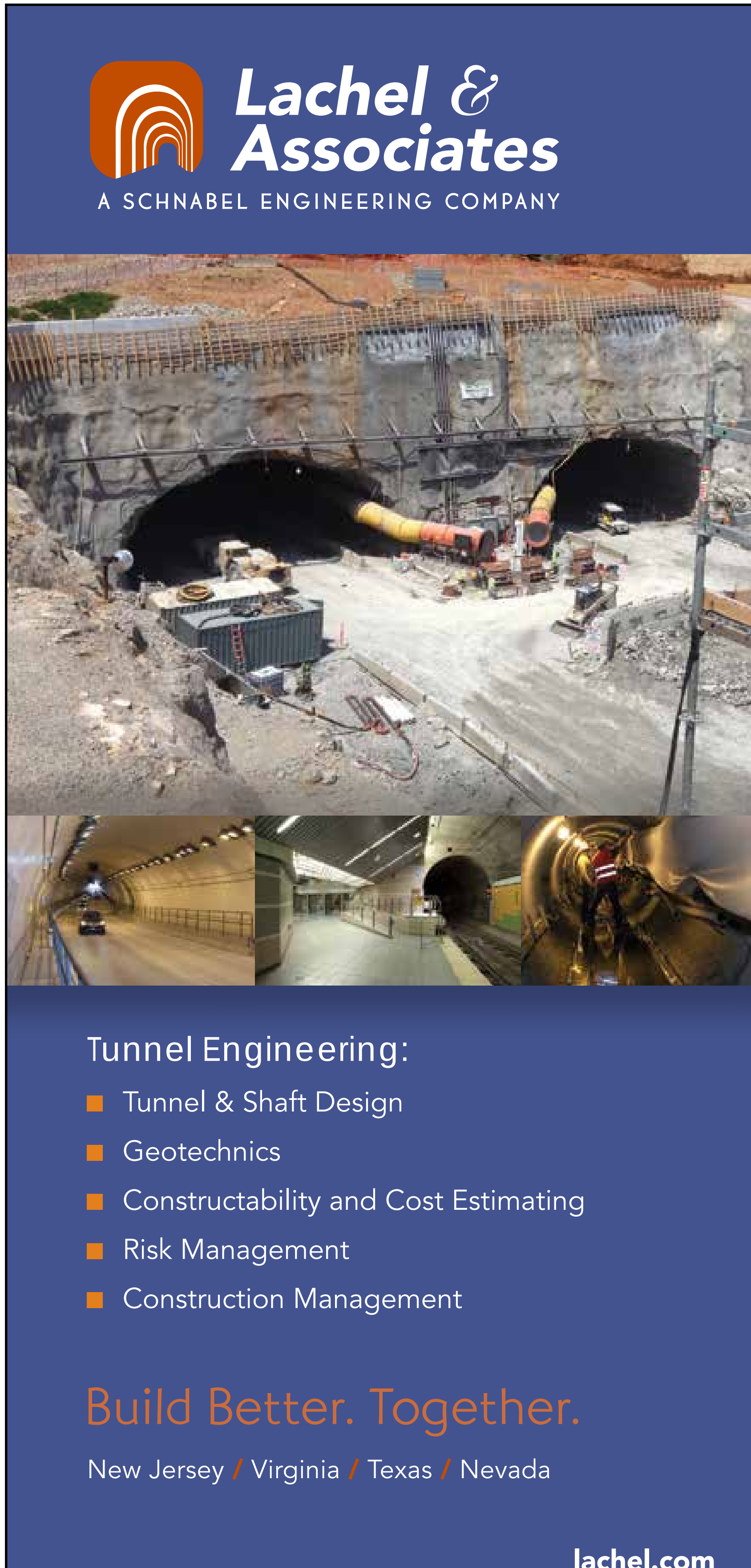
Notable recent projects include:

- DC Water Clean Rivers Program, Washington, DC
- Loudon Water Raw Water Supply Tunnel, Leesburg, VA
- Waller Creek Flood Tunnel, Austin, TX

TUNNEL DESIGN SERVICES
Some of our design services for tunnels and underground projects include:

- Feasibility Studies
- Alignment Optimization
- Assessment of Geotechnical Conditions
- Tunnel Initial and Final Support Design
- Numerical Methods for Design
- SEM / NATM
- Cavern Design
- Shaft Design
- Risk Management
- Constructability Review and Cost Estimating
- Construction Documents/Design Reports/GBRs

Lachel & Associates
A SCHNABEL ENGINEERING COMPANY



Hatch Mott MacDonald

Tunnel engineering is one of Hatch Mott MacDonald's core services. For a wide-range of public and private clients, we have engineered transportation tunnel solutions for roadway, passenger rail, freight rail, subway, pedestrian, cable and communications projects. Our expertise spans a broad-range of capabilities from the planning and implementation of new facilities to the inspection and rehabilitation of existing facilities.

Our involvement in tunneling began more than a century ago, dating back to our founders' involvement with London's underground road and rail systems in 1902, and Toronto's subway system in 1954. Our association with these clients continues today – a testimony to the trust, confidence, and professional relationship we build with our clients and to the quality of our work.

With more than 75 offices throughout North America, Hatch Mott MacDonald offers a full-range of services to handle any size project – from a small inspection assignment to world-class, multi-billion-dollar transit programs.

Our goal is to deliver client projects in an environmentally responsible manner, with value-added design and construction methods – minimizing programmatic risk along the way.

A Successful Project Takes All Sizes

Small Brokk Played Huge Role in POMT Cross Passage Work

New underground routes connecting Watson Island and Dodge Island beneath Biscayne Bay near Miami wouldn't have been possible without some key players, both big and small.

A huge tunnel boring machine (TBM) was the star of the Port of Miami Tunnel (POMT) project, but a strong contender for best supporting equipment was a relatively tiny machine: the Brokk 400.

While the Brokk 400 is only 14 feet long, 5 feet wide and less than 6 feet tall, it packs a powerful punch. The size-power combination was a big reason design-build contractor Bouygues Civil Works Florida used one to create cross passages between the project's twin 4,200-foot traffic tunnels, which are set to open in May 2014.

Inside the passages, the machine delivered tremendous force with a hydraulic breaker to excavate hard soil, some of which was artificially reinforced with grout or through a freezing process to add stability. The next step was to place support ribs at 3½-foot intervals. The machine grasped the top section of each steel rib with a beam manipulator retooled specifically for the job, carried it to the installation point, lifted and positioned it, then held it in place while miners bolted on the lower sections.

Throughout the process, the Brokk machine enhanced safety for the miners. The remote control kept the operator away from potential cave-ins, and the electric drive ensured crewmembers weren't exposed to dangerous emissions.

All in all, the relatively small player gave a winning performance that delivered big results.

The Brokk 400, equipped with a hydraulic breaker, knocked out chunks of the concrete casing in one of the main traffic tunnels to begin one of the five cross passages in the POMT project.

Brokk, Inc.
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Monroe, WA 98272 USA
Telephone: +1-360-794-1277
Email: info@brokkinc.com
www.brokk.com

A close-up view of the beam manipulator designed specifically for the POMT project by Brokk's sister company, Kinshofer. Crews used the remote-controlled Brokk 400 and this beam manipulator to pick up and maneuver the steel support ribs into place in each cross passage.

Premier Pipe Systems Manufacturer for over 85 Years

Since 1925, Naylor Pipe Company has been the premier manufacturer of Spiralweld pipe systems.

Naylor Spiralweld is available in diameters from 4” through 96” and wall thickness from 14 Ga. through 1/2” wall. The Spiralweld pipe is complemented with all types of fittings, fabrications to specification, and joint connections, including the exclusive Naylor Wedgelock Coupling, to complete your pipe system.

Naylor Spiral Buttweld pipe features two welds along the spiral seam. This creates a pipe structure in which the weld is as strong or stronger than the parent metal.

The Naylor manufacturing process creates a pipe that maintains an accurate diameter throughout its length. The uniformity of the pipe ends speed connection, whether mechanically coupled or welded.

Uniform wall thickness is assured because tolerances of steel strip are governed by the standards established by the American Iron and Steel Institute. In addition, the pipe is furnished in any required length with a cutting tolerance of plus or minus 1/8”. In addition to carbon steel, spiralweld pipe can be formed from many steel grades, including abrasion resistant, weathering (A-588) and stainless.

Every length of Naylor Pipe is inspected and where required hydrostatically tested to applicable ASTM specifications. The pipe is available in lighter weights than other pipe making it possible to save money, not only on initial cost, but also in

transportation, handling and installation. By sizing the diameter of the pipe to the exact requirements, with exact lengths and factory-sized ends, the greatest economies can be realized.

Quotations are immediately available on inquiry.

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Rapid Set® Cement Products for Tunneling and Mining

CTS Cement Manufacturing Corporation is the largest manufacturer of Rapid Set® fast-setting hydraulic cement, well known for its versatility and high performance. Rapid Set® products are used for underground roadway repair, shotcrete, grout, cribbing for long- wall mining- mostly coal mining, and the precast concrete tunnel segment industry. Rapid Set® cement is not only a more durable alternative to portland cement on many projects, but its rapid-setting properties also make it an ideal solution for today's schedule- and budget-driven projects.

Rapid Set® cement offers reduced shrinkage and superior resistance to chemical attack. It achieves strength much faster and many installations can be put into service in as little time as one hour. Rapid Set® cement reaches typical compressive strengths in a few hours that an equivalent portland cement mix would require one month to achieve. In fact, Rapid Set® cement is a high performance binder that outperforms portland cement-based products consistently. Durability, versatility, speed and ease-of-use along with cost benefits are just some of the many benefits Rapid Set® cement offers.

Headquartered in Cypress, California, CTS manufactures Rapid Set® in the United States. Rapid Set® is distributed through a network of distributors and dealers throughout the United States and Canada. To learn more about Rapid Set® cement, visit www.ctscement.com or call 800-929-3030.

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Rapid Set®
Construction Cement Products

Alpine Equipment

Alpine Equipment is the industry leader in hydraulic rock and concrete grinder attachments, roadheaders, shaft sinkers and soil remediation equipment, with over 40 years of expertise in North America. Our customers range from owner-operators to the largest tunneling firms. Alpine supplies attachments for construction, demolition, excavation, scaling, trenching, mining and tunneling. The rotary cutter heads come in range of sizes to fit on skid steer loaders, backhoes and excavators or any equipment with a hydraulic circuit. With a range of options and customizations, we can get you working more efficiently and with more precision than your current tools. Many of our customers are using the cutter head for concrete scaling projects for highway rehab or shotcrete clean up. The power, flexibility and precision of the Alpine concrete grinder enable this as a highly useful tool in a variety of jobs.

In addition to rotary cutterheads, Alpine also supplies state-of-the-art in situ soil mixing and remediation equipment. Remediation equipment includes mixing attachments and wet or dry amendment delivery systems.

With increased Natural Gas production, we have supplied the industry with mixers for solidification of drilling mud, whether on site or in container batches. The power and efficiency of our mixers have yielded significant production increases, allowing you to reduce costs and finish on time.

Contact Alpine Equipment for cutterheads, new & used roadheaders, ITC tunneling machines and soil mixing equipment.

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ILF Consultants, Inc.

ILF USA specializes in tunnel and underground engineering, foundation and retaining systems for permanent and temporary works, and construction engineering services throughout North America.

Our team can assist clients with engineering solutions in energy, water, infrastructure, and natural resources markets applying cutting edge technology and providing services including; project consulting, engineering design and planning, pre-bid services, construction management, project management, and risk management/claim avoidance and mitigation.

ILF USA has expertise in design-build, P3's, and conventional contract delivery methods. Depending on requirements, we can serve as an owners engineer or as a construction engineer for contractors. For more information contact either Conrad Felice at (425) 505-2907 or James Morrison at (231) 944-9732.

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Schauenburg Flexadux Corporation

Schauenburg Flexadux Corporation was founded in the USA, in 1974 as a manufacturer of flexible ventilation ducting and is backed by a half century of worldwide engineering experience. Over the years, Schauenburg Flexadux has become a trusted name in manufacturing and distributing company, servicing the mining and tunneling industries.

Flexible ventilation division provides 14, 18 or 24oz material to comply with all tunneling and mining needs.

- Lay flat (positive pressure) ventilation
- Spiral (exhaust / blower) ventilation
- Custom fittings
- High pressure couplers
- Inflatable and parachute stoppings for mine or tunnel barricade

Rigid fiberglass division combining a filament winding process and phenolic resin creates a fiberglass that is low weight and resilient, withstanding impact and high negative or positive pressures. In addition, the rigid fiberglass ducting has excellent corrosion resistance and meets or exceeds all MSHA requirements.

- Fiberglass ventilation
- Custom fabricated fittings.

Custom welding and fabricated division provides customized fabricated equipment for the tunneling and mining industries.

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- Chutes
- Mine doors
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SCHAUENBURG
Flexadux Corp.

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Schauenburg Fiberglass Ventilation Ducting in fiberglass, flexible suction and flexible forced ventilation are manufactured for use in mining and tunneling applications. From our filament winding process and phenolic resin for maximum fiberglass duct strength to our CD24 brattice with it's unique 5 layers (3 vinyl 2 scrim). We strive to bring you the best in mining and tunneling ventilation.

Fiberglass

- Durable suction duct
- + / - pressure
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Flexible Suction

- Expand / contract length
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- Low cost

All products are flame resistant and meet the or exceeds MSHA standards.

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A company of the SCHAUENBURG International Group

Antraquip Corporation

Antraquip Corp. has established itself as a leading designer, manufacturer and supplier of roadheaders, hydraulic rock grinders (roadheader attachments), shaft sinkers, specialty tracked machines with a variety of boom options, and tunnel support systems. The newest addition to the Antraquip product line are diamond tipped rock saw attachments for excavators designed to cut hard rock and reinforced concrete for specialty applications. Antraquip machines, built to the highest technical standards, are being used all over the world in a variety of civil engineering and mining projects.

Antraquip offers not only standard roadheaders in the 12 to 75 ton weight classes but is proud to offer project oriented engineering solutions. Some of the recent projects have included AQM roadheaders equipped with customized drilling attachments and fully automated remote control operation. Antraquip also provides various tunnel support products including lattice girders, steel sets, and arch canopy systems which they have supplied to some of the highest profile projects in North America in recent years.

In addition to offering project consultations, innovative rock cutting solutions and tunnel support systems, Antraquip recognizes the importance of after sales service. Their commitment to offering the best service and technical support is carried out by highly proficient and experienced service technicians and reinforced with the largest roadheader parts inventory in North America. Innovation, reliablility and experience offered by Antraquip, continues to make them your reliable partner for any tunnel or mining project.

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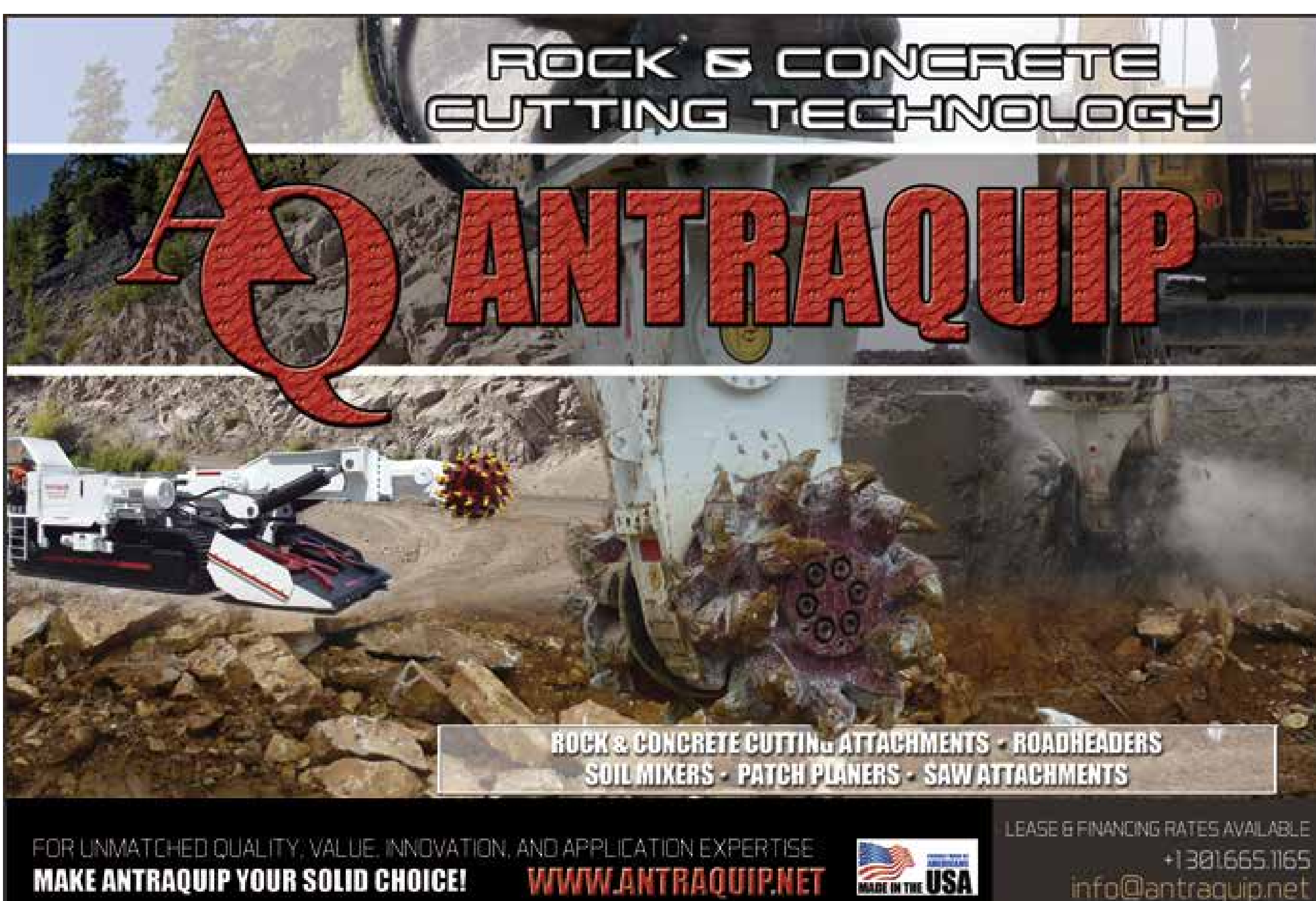

Tensar International Corporation

Tensar International Corporation (Tensar) offers a number of solutions to support the unique requirements of mining and tunneling construction. Tensar® Mining Systems include a family of polymeric grid products.

Made from high-strength, corrosion-resistant polymers, these geosynthetic reinforcement products are lightweight and easy to handle; this allows for safe, quick and easy installation, resulting in significantly fewer back, hand and facial injuries. Compared with metal reinforcement products, Tensar mining products can reduce installation and material handling time up to 75%.

Our Mining Systems offer cost-effective solutions for a wide range of underground mine and tunnel applications, including:

- Rib Control (Tensar® TriAx® and BX Mining Grid)
- Roof Control (Tensar® TriAx® and Tensar® UX3340 Roof Mats)
- Longwall Screens (Minex™ Rock Mesh)
- Highwall Screens (Tensar® TriAx® Mining Grid)
- Road Reinforcement (Spectra® Roadway Improvement System)

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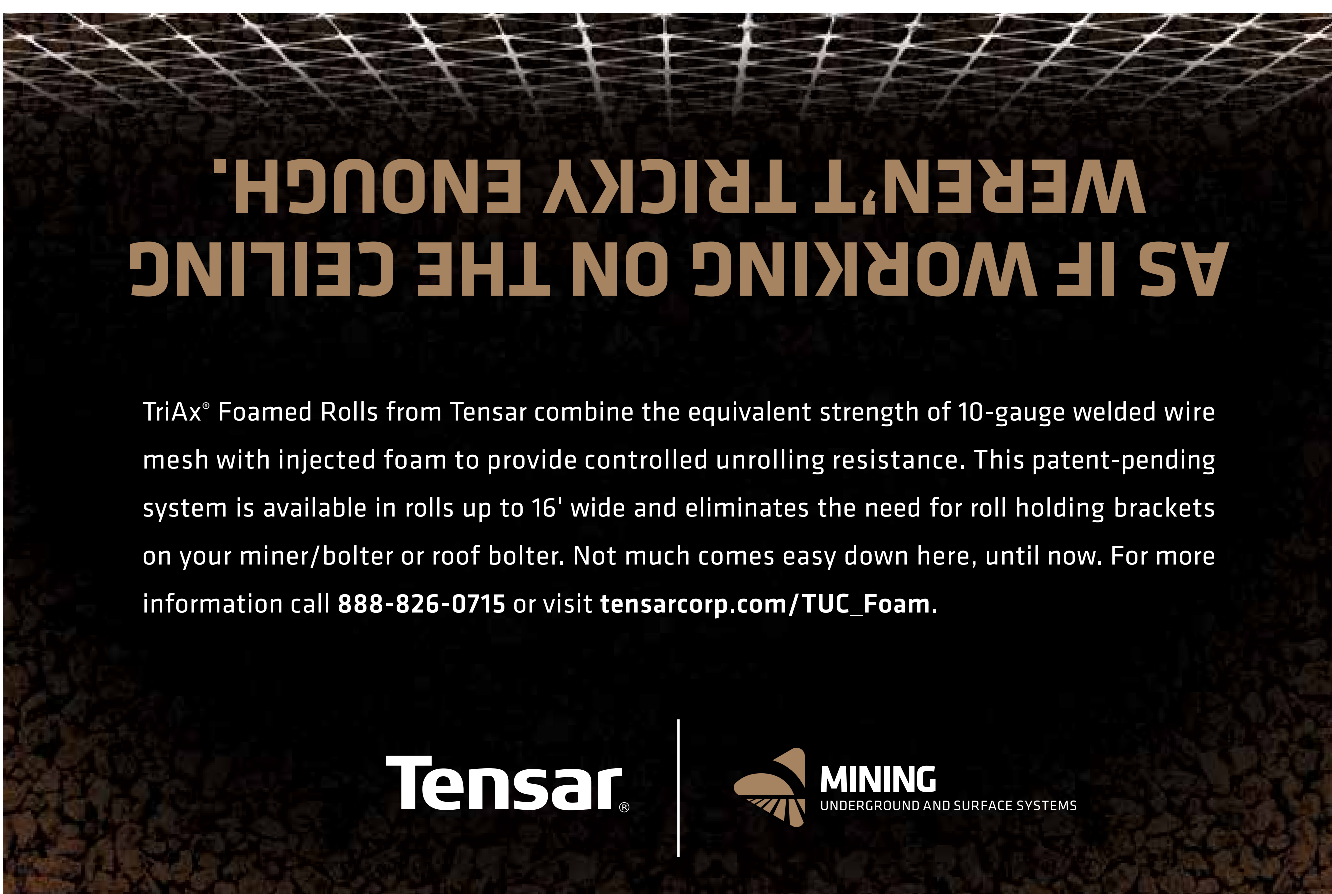
www.tensarcorp.com



Parsons: Connecting infrastructure across the globe

Celebrating 70 years of growth, Parsons is the premier source for end-to-end design-build transportation engineering capabilities, including expert multidisciplinary planning, all phases of construction and implementation, and maintenance and improvements. The firm employs more than 15,000 professionals around the world who are prepared to meet every technical and management challenge and to persevere until the job is done.

Parsons' Tunnel Division has contributed to hundreds of international tunnel projects, including the Caldecott Tunnel improvement project, which involves the construction of a fourth bore through the Berkeley Hills, near Oakland, California, and the Washington, D.C., Metro twin-tunnel program, cited by the American Underground Association as one of the most significant tunneling projects in the last 10 years.

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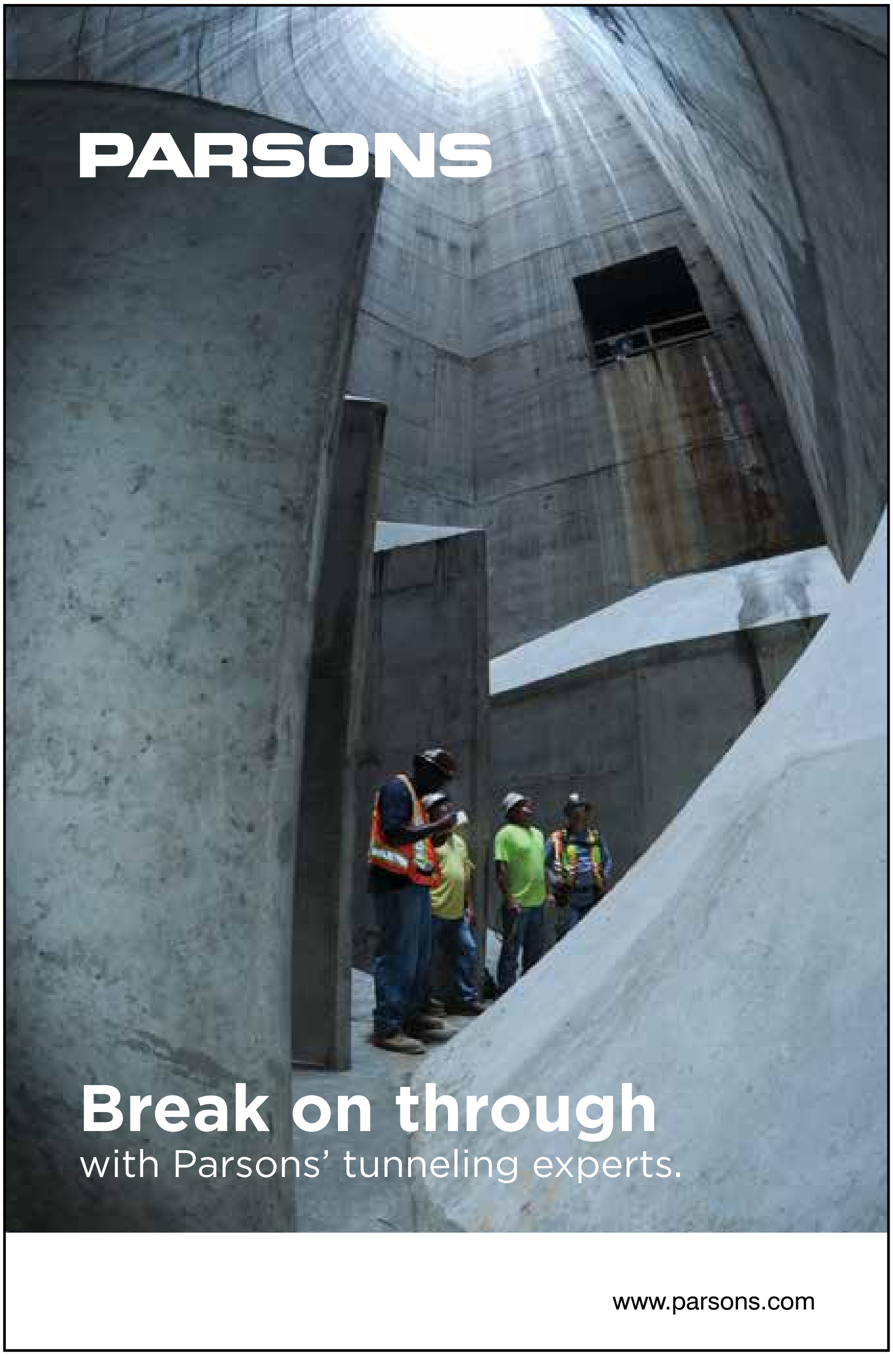

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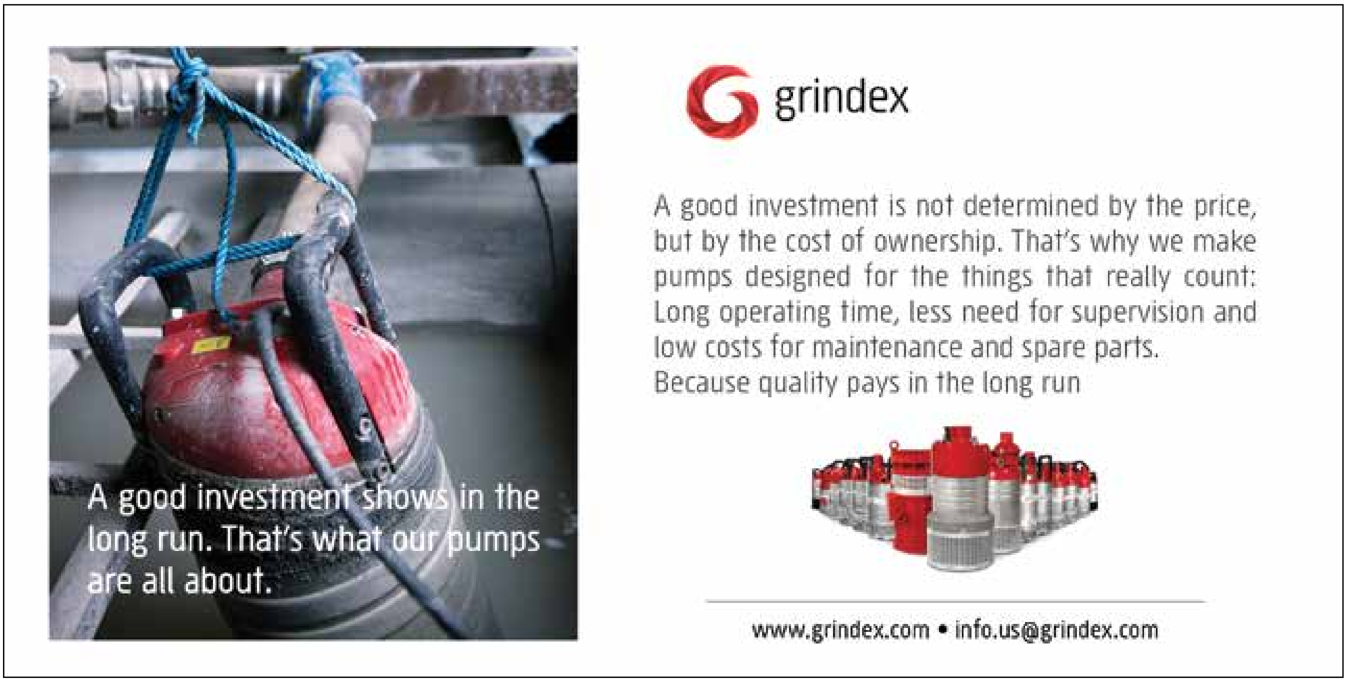

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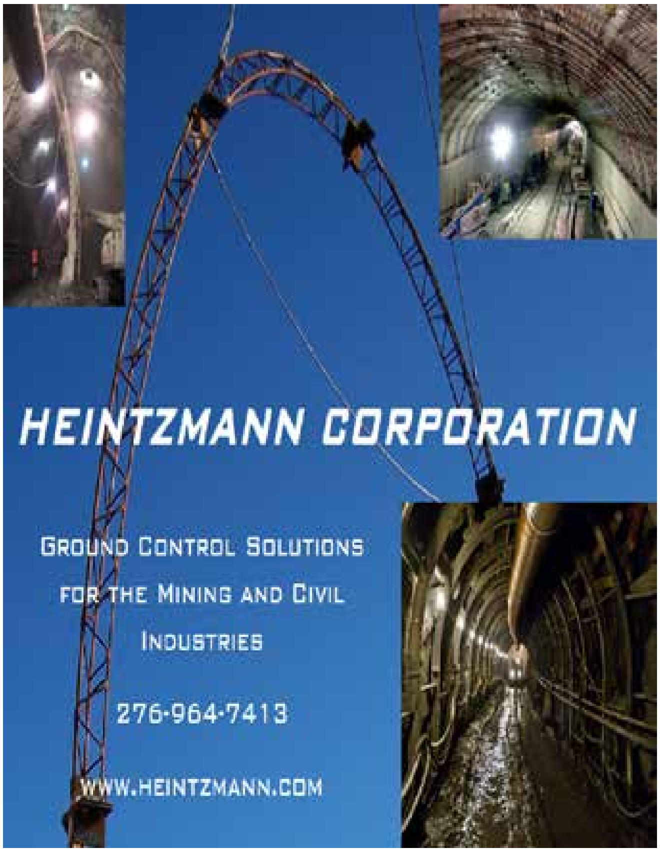

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FEATURE ARTICLE

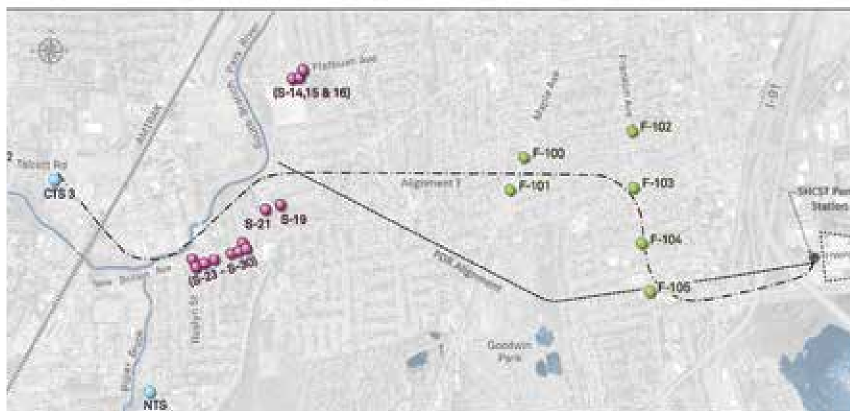
Cleaning Hartford waterways through underground storage

The South Hartford Conveyance and Storage Tunnel (SHCST) project is a significant component of the Hartford Metropolitan District's (MDC) long-term control plan (LTCP), which is overseen by the Connecticut Department of Energy and Environmental Protection (CTDEEP). This project will address a portion of the MDC's Clean Water Project (CWP), which will reduce combined sewer overflows (CSOs), eliminate sanitary sewer overflows (SSOs), and reduce nitrogen released into the Connecticut River.

The purpose of the SHCST project is to eliminate West Hartford and Newington SSOs, eliminate Franklin area CSOs discharging to Wethersfield Cove and minimize CSO discharges to the South Branch Park River. The locations of each overflow are shown in Fig. 1.

FIG. 1

Location of CSOs and SSOs tributary to the SHCST.



In 2010, the district prepared a preliminary design report (PDR) for the SHCST project, which included relief of the Folly Brook trunk sewer and proposed to keep the tunnel boring machine (TBM) retrieval shaft within the city limits of Hartford. Figure 1 shows the 2010 PDR recommended tunnel route. Subsequent to the PDR, the objectives of the SHCST have slightly shifted. In accordance with ongoing revisions to the LTCP, relief of the Folly Brook Trunk Sewer is no longer necessary. Additionally, the MDC has decided to perform less sewer separation in the Franklin Avenue drainage area. To replace the sewer separation, new relief points are proposed within the Franklin area and will be diverted to the SHCST. Figure 1 also shows the current recommended tunnel route (Alignment F).

During 2012, the MDC conducted an evaluation of the potential of connecting the proposed North Tunnel (originally proposed as an independent tunnel with its own pump station) into the South Hartford Conveyance and Storage Tunnel. This evaluation concluded that the two proposed tunnels could reasonably be connected together and operated as a single tunnel system utilizing the tunnel pump station at the eastern terminus of the South Hartford Tunnel (Fig. 2). It also was concluded that this alternative was less costly than two independent tunnel systems.

During dry weather, the SHCST will not receive flow, as the existing MDC collection system can adequately convey flow to the Hartford Water Pollution Control Facility (HWPCF). During wet weather, when the capacity of the existing collection system is exceeded, the SHCST will receive overflows that would have previously discharged directly to receiving waters.

This paper summarizes the final design of the SHCST project. New diversion structures will be constructed at each CSO/SSO relief point to divert overflows to new consolidation sewers (near surface). These, in turn, will discharge flow to hydraulic drop shafts that will convey the flow in a controlled manner to the deep rock storage tunnel. Once in the tunnel, flow will be pumped to the new headworks at the HWPCF. The components of the SHCST project described in this paper are as follows:

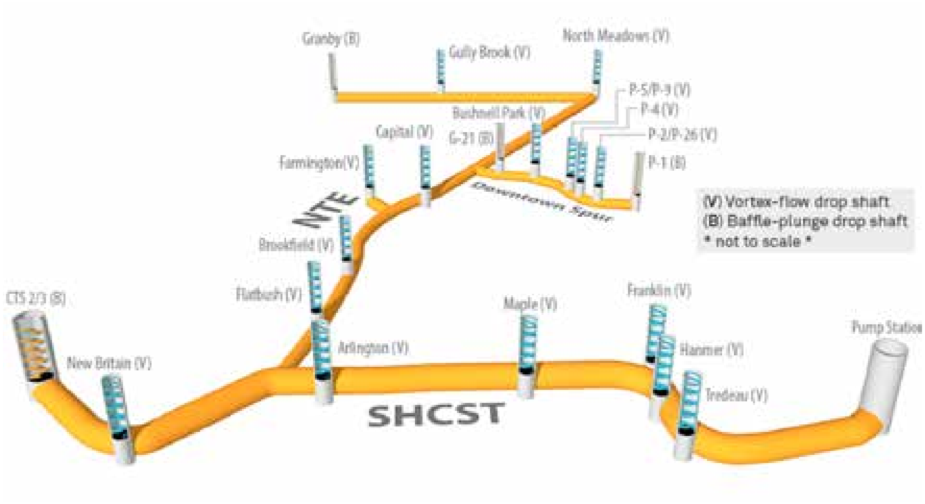
- Deep rock tunnel (5.4 m or 18 ft interior diameter at 6,644 m or 21,800 ft) with a TBM launch shaft near the HWPCF in Hartford and a TBM retrieval shaft in West Hartford.
- 3,718 m (12,200 ft) of near-surface consolidation sewers (0.61 to 1.68 m or 24 in. to 66 in. in diameter).
- Seven hydraulic drop shafts.

Verya Nasri, William Bent and William Hogan

Verya Nasria, member UCA of SME, **and William Bent** are chief tunnel engineer, and vice president with AECOM, New York and Rocky Hill, CT, respectively; and **William Hogan**, member UCA of SME, is retired, Metropolitan District Commission, Hartford, CT and construction attorney, Stites & Harbison, PLLC, email Verya.Nasri@aecom.com.

FIG. 2

SHCST and North Tunnel integration.



- 189.3 ML/d (50 million gal/day) tunnel dewatering pump station.
- Odor control at all potential air release points.

Design criteria

The sizing of the tunnel was based on the volumes from the one-year, 18-year and 25-year design storm per the LTCP and updated collection system modeling from the MDC's program management consultant. The LTCP specified a different level of control for each tributary area. Table 1 shows the peak flows and volumes to be stored in the SHCST for each major source and respective design storm.

Surge, air entrainment and pressure waves can occur and result in CSO tunnels filling rapidly, with detrimental results such as geysering, blowback and flow instabilities. Based on the hydraulic analysis, it appears that surge in the SHCST is unlikely, due to the relatively large tunnel diameter in comparison to the incoming peak flows.

Sediment deposition can present an ongoing maintenance burden if not controlled. Based upon the initial sediment deposition analysis and modeling, a slope of 0.1 percent appears adequate for the deep rock tunnel to cost-effectively minimize sediment deposition issues. This slope is consistent with the state of practice for other large diameter CSO tunnels, as steeper slopes will increase project cost. The tunnel will still require periodic maintenance to remove sediment buildup over the life of the facility.

The capacity of the tunnel dewatering pump station has been established by the MDC as 189.3 ML/d (50 million gal/day). At this rate, the 25-year design volume for the North and South tunnels will be dewatered in 4.2 days. The one-year design volume would be dewatered in approximately 2.5 days. A typical CSO tunnel is dewatered in 24 to 48 hours.

The operation of the tunnel must not result in odor complaints. As such, odor control has been assumed at each drop shaft location.

An alignment study was conducted to evaluate various configurations of rock tunnels and consolidation conduits. Seven conceptual rock tunnel alignments and associated consolidation conduit options were developed and evaluated. The purpose of this alignment study was to identify a cost-effective and acceptable tunnel alignment that balances the expectations of the many stakeholders impacted by the project.

All the alignments began in property owned by the district adjacent to the HWPCF. However, three different locations were identified as possible deep rock termination points. Two of these locations were located in space owned by various city of Hartford departments on the east side of the South Branch of the Park River and the third was in an unused parking lot on Talcott Road in a light industrial area on the west side of the river (in West Hartford). This third location significantly reduced the length of consolidation conduits and allowed the South Branch of the Park River to be crossed deeply in rock using the deep rock tunnel instead of crossing the river with shallower and more risky consolidation conduit.

A systematic approach was established to comparatively score each alternative. The cost estimate was used as the quantitative assessment for each alternative and was not included in the weighted ranking, which is the qualitative assessment. Three stakeholder impact categories were defined that consisted of high-, medium- and low-impact evaluation factors. Each evaluation factor was given a raw score and a weight, which depended on its category. The score of each alignment alternative was then determined as the weighted sum of all evaluation factors for that alternative. Alignment F was identified as the preferred alignment

TABLE 2

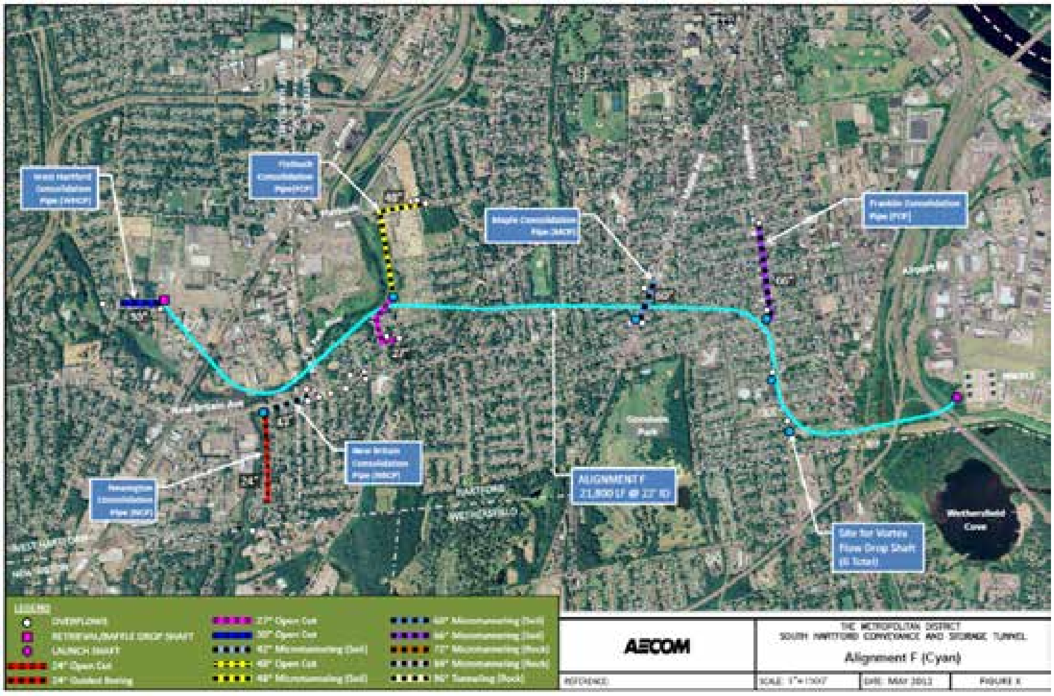
Tributary overflows to the SHCST.

Contribution	Design storm	Peak flow (MGD)	Volume (Mgal)
West Hartford/ Newington SSO	25-yr	27	17
South Branch Park River CSO	1-yr	68	6
Franklin Area Relief	18-yr	313	39
Total			**62**

and recommended to advance to final design. This alignment provides the maximum reduction in consolidation conduit length which reduces the associated cost, business impacts and construction risk. Figure 3 shows the configuration of the selected Alignment (Alternative F).

FIG. 3

Selected alignment (Alternative F).



Geotechnical settings

The site area lies in the central lowlands physiographic province that extends in a north-south direction in the middle of the state. The central lowland area consists mainly of the sedimentary rocks and the associated igneous basalts of Triassic and Jurassic age. The Hartford Basin of Connecticut and southern Massachusetts is a half graben in structure, 145 km (90 miles) long, and filled with approximately 4,000 m (13,000 ft) of sedimentary rocks, and basaltic lavas and intrusions (Hubert et al., 1978). The source area for the sedimentary rocks was mainly the metamorphic rocks of the Eastern Highlands. Volcanic flows separated the deposition of the lacustrine and fluvial deposits, which were derived from the erosion of the highlands to the east. Displacements along the faults continued throughout the depositional period. The depositional sequence resulted in a series of features including the alluvial fan, lake, alluvial mudflats and floodplain deposits separated by basaltic flows.

Following the deposition of most of the sediments, the tectonic activity continued along the east edge of the basin. Displacements along the eastern border fault rotated the basin downward to the east that resulted in the easterly dipping beds. The Jurassic extensional tectonics are associated with the separation of the continents. That was the last major tectonic episode affecting the geology of the region. Age dating of the Triassic/Jurassic faulting in southern Connecticut has indicated that the last activity along the faults was approximately 175 million years ago (NNEC, 1975). All faults in the project area are, therefore, considered to be inactive.

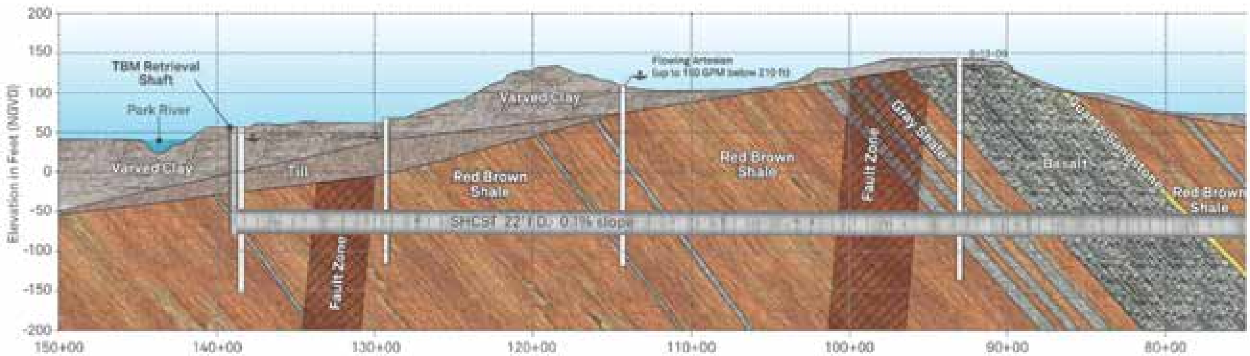
The region has undergone a period of glaciations that has reshaped the terrain. Glaciers ground down the area's peaks, scraping away any weak or weathered rock and laying down a heterogeneous layer of ground-up rock. This till layer is present over much of the lower lying bedrock surfaces. The sediments of Glacial Lake Hitchcock filled in the deeply incised Connecticut River Valley. The lake deposits are present in varying forms from Rocky Hill, Connecticut to northern Vermont. Glaciers shaped the topography and left the area with much of the topographic relief present today. More recent alluvial deposits are common along the Connecticut and Park rivers and their tributaries.

In the site area, the following soils are present overlying the bedrock, in general order of sequence from ground surface downwards: artificial fill, alluvium, beach deposits of Lake Hitchcock, glaciolacustrine deposits, glaciofluvial deposits and glacial till. Bedrock is not widely exposed in the project area. The formations that are in the general vicinity of the project and potentially could be encountered along the proposed tunnel are the Portland Arkose, the Hampden Basalt and the East Berlin Formation. These units consist of shale and basalt with fractured and fault zones (Fig. 4).

The final geotechnical investigation program consists of 55 deep rock borings, 50 shallow borings and five geophysical survey lines. The program includes geophysical logging (acoustic televiewer) performed in 21 of the deep borings and five of the shallow rock borings, water pressure (packer) testing performed in 30 of the deep borings and eight of the shallow rock borings, six in-situ stress determinations in two deep boreholes, falling head tests completed in the soil profile in selected borings, observation wells installed in 13 of the deep borings as well as 13 of the shal-

FIG. 4

SHCST selected alignment (Alternative F).



low borings, and 22 vibrating wire piezometers installed in 16 borings. The program also included the monitoring of ground water levels and the completion of soil and rock laboratory testing. Several phases of comprehensive geotechnical investigations were planned and implemented in order to obtain sufficient subsurface information for design and address the geotechnical challenges discussed in the following section.

Geotechnical challenges

There were several geotechnical challenges that needed to be investigated and addressed during the design. The main geotechnical challenges were:

Consolidation settlement of varved clay as a result of ground water lowering due to shaft and tunnel construction and the settlement impact to the existing facilities.

Faults and fracture zones along the tunnel drive and tunnel construction impact.

Artesian ground water inflow for a portion of the tunnel drive and design and construction impacts.

In order to evaluate the impact of consolidation settlement on the facilities, the extent, thickness, and physical and mechanical properties of varved clay had to be established first. Test borings were drilled along the tunnel alignment as well as the shafts to establish the subsurface profile and varved clay thickness. In situ tests, such as falling head and packer tests, were performed to establish the permeability of the soils and rock. Geotechnical laboratory tests were performed to establish the properties of soil and bedrock as well as consolidation characteristics of the varved clay.

Consolidation settlement may impact several existing facilities in the vicinity of the launch shaft and starter tunnel. These facilities include a flood control embankment dike, transmission towers, railroad tracks, wastewater facility structures and a pump station. Other facilities that may have potential impact are the Amtrak Rail and residential and industrial buildings along the tunnel alignment.

In order to evaluate the impact of consolidation settlement of the varved clay as a result of the tunnel and shaft construction, a three-dimensional model was utilized. The effect of ground water lowering at the bottom of varved clay layer increases the effective stress in varved clay and results in consolidation settlement. The time rate of change in effective stress (i.e., pore water pressure reduction) was calculated using the MIDAS GTS finite element program based on transient flow analysis and the consolidation settlement was calculated in accordance with one-dimensional consolidation theory.

Three-dimensional modeling provided sufficient results to compute the total settlement and angular distortion of the facilities with time. The settlement associated with tunnel ground relaxation was also evaluated using finite element model and is found to be negligible due to the deep rock nature of tunnel alignment. The finite element modelling results were used to address and mitigate the settlement of the facilities to an acceptable level.

Faults and fracture zones were evaluated based on the borings drilled along the tunnel alignment. A desktop study was performed first to identify the potential fault and fracture locations based on the regional geological maps, previous tunnel projects in the vicinity and published papers. The field investigation programs were performed in four sequential phases to ensure cost-effective, targeted and focused investigations in the fault and fracture zones.

Artesian ground water pressure was identified to be present in bedrock in the central portion of the tunnel alignment. The artesian pressures were measured in the boreholes and pressures as high as 10 m (30 ft) above the ground surface were recorded. The effect of artesian pressure on the tunnel construction as well as the tunnel lining has been accounted for.

Based on the above geotechnical challenges and evaluation of cost estimate and risk mitigation, it was concluded that shielded TBM with a one-pass lining system is the preferred alternative for the deep rock tunnel.

Main tunnel

The deep rock tunnel would be approximately 6,644 m (21,800 ft) in length and have a finished internal diameter of 5.4 m (18 ft). The tunnel will be excavated by a TBM that is suitable for tunneling in hard rock conditions. The tunnel profile is entirely within bedrock at a depth low enough to accommodate the North tunnel system (part of a separate contract). There are several different types of rock TBMs that are manufactured to operate in specific types of ground conditions. These include main beam, single shield, double shield and convertible (hybrid) hard rock/earth pressure balance (EPB) machines. The selection of the appropriate type of the TBM is an important decision that will impact the type of final lining, construction safety, quality, cost and schedule. The final recommendation on the type of rock TBM was based on several factors among which rock and ground water conditions along the tunnel alignment represent very important considerations. This selection was based directly on the borehole data obtained from the final design geotechnical investigation program.

It is anticipated that the rock mass along the tunnel alignment will primarily consist of competent shale, sandstone and basalt bedding dipping 10° to 20° with occasional known fault zones.

The size of the construction shafts depends on the TBM diameter, TBM type and the dimensions of the permanent structures that will be housed in each shaft. For a 6 m (20 ft) diameter TBM (required to excavate the 5.4 m (18 ft) ID tunnel), the minimum clear shaft diameters that are required to allow launching and retrieval of the TBM are 10.7 m (35 ft) and 9.1 m (30 ft), respectively. Larger diameters may be required to accommodate the permanent structures or to suit the contractor's means and methods.

Key considerations in selecting the appropriate shaft construction methods include preventing ground water drawdown and providing support of excavation. The shafts will be excavated using two methods for ground support. Slurry wall panels or secant piles, laid out to approximate a circular shape, will extend from top of grade through overburden and will anchor into top of competent rock. The retaining walls will act as temporary support walls during construction and a final liner will be installed for permanent support of the shaft.

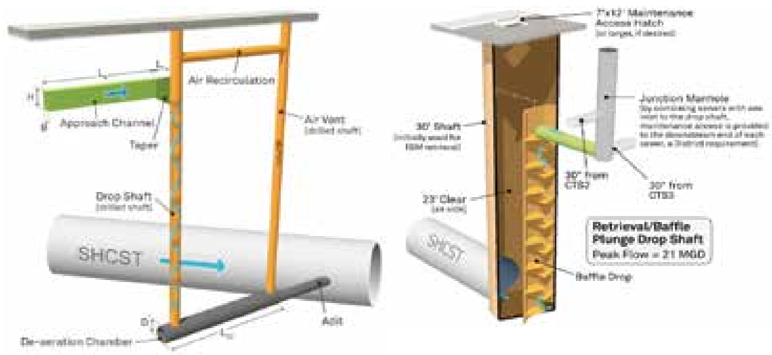
Through the rock, the shaft will be excavated using drill-and-blast methods and the rock face will be supported using rock dowels and sprayed shotcrete.

Starter and tail tunnels will be required to assemble the TBM and to store equipment and muck cars. The starter and tail tunnels will be excavated by drill-and-blast methods with a horseshoe cross-section. Systematic probing and pre-excavation grouting will be used to minimize ground water inflow from the shafts and starter and tail tunnels and reduce ground water drawdown.

The anticipated ground conditions along the tunnel alignment necessitate the use of final lining for the tunnel to meet the design criteria and ensure long-term stability, durability and hydraulic performance. One- and two-pass lining systems were considered initially as viable options for the SHCST. The choice of tunnel lining system depends on ground characteristics and ground water conditions along the tunnel alignment and the construction cost of each option. One-pass lining system was selected based on the geotechnical challenges discussed in the previous section and as a means of risk mitigation.

FIG. 5

Vortex and baffle drop shaft alternatives.



Important considerations in the design of tunnel lining include the following:

- Durability and ability to withstand the service environment without significant degradation during the tunnel design life.
- Constructability.
- Life cycle cost.

A quantitative approach, adopted by the U.S. Environmental Protection Agency (EPA) and American Society of Civil Engineers (ASCE), is used to assess the corrosion of the final lining. This approach estimates the loss of material as a function of time, concrete properties and CSO characteristics.

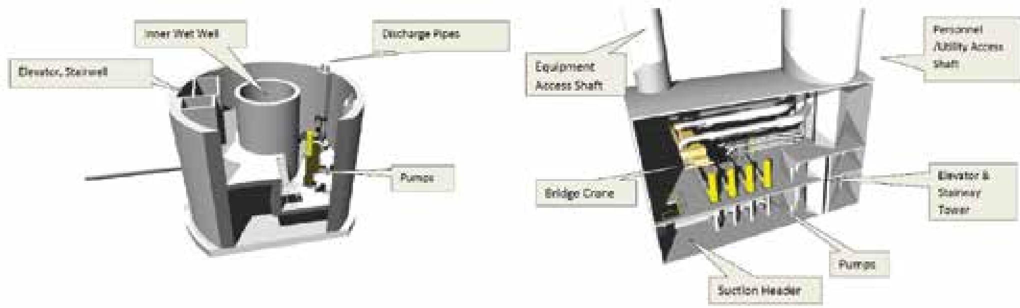
The tunnel design was advanced based on the following considerations:

- Define geotechnical parameters for tunnel analysis and design.
- Perform ground water infiltration and ground settlement analysis to quantify the risk of consolidation settlement due to dewatering.
- Analyze geotechnical data to support the selection of the tunnel lining system and type of TBM.

Site plans were prepared to identify existing site conditions, areas for site access, staging and operations, work zone layouts and constraints, equipment and materials storage, utility protection and relocations, site drainage and grading, erosion and sedimentation controls, and electrical power requirements. A temporary site plan and a permanent site plan were developed at the TBM launch site and tunnel pump station. The temporary site plan designates specific areas during construction for the tunnel boring machine, the tunnel crane pad, the tunnel mucking

FIG. 6

Cavern and shaft pump station alternatives.



operations, short- and long-term storage areas for tunnel segments, the pump station crane pad, contractor offices, workshops, storage areas and parking areas. The permanent site plan identifies the locations of the tunnel pump station, screening/degritting building, HVAC and electric buildings and odor control facilities.

A conceptual planning level cost estimate, schedule and contract packaging was performed. Costs from similar historical projects were obtained and utilized to develop unit costs and extrapolated for the SHCST project. A detailed cost estimate was performed to estimate the construction cost of the main deep rock tunnel, TBM launch shaft and TBM retrieval shaft associated with the selected Alignment F. The cost estimate for the entire SHCST project is approximately $500 million. The project construction duration is estimated at 72 months.

The recommended contract packaging is to release six construction contracts: 1) preliminary utility relocation, 2) tunnel, 3) pump station, 4) Franklin/ Maple consolidation conduits, 5) Flatbush/Arlington/Newington/New Britain consolidation conduits and 6) West Hartford consolidation conduit. The contracts were grouped to align construction skill sets but allow for the phased release of the bid packages. The overall construction schedule is to be coordinated such that the tunnel, pump station and consolidation conduit contracts are constructed independently but conclude coincidently.

MDC management has stated that a goal for the project is that odor complaints must not occur. Therefore, the odor control strategy for the SHSCT system is focused on minimizing odors from the two main shafts at the tunnel ends and at the six intermediate drop shaft sites. Ventilation rates of approximately 2,300 to 2,400 m^3/min (80,000 to 85,000 cfm) have been estimated for the upstream and downstream shaft. Ventilation rates ranging from 65 to 210 m^3/min (2,300 to 7,500 cfm) have been estimated for the intermediate drop shafts.

Active fan driven odor control systems are recommended at the tunnel ends and passive systems are proposed for the six intermediate drop shafts. Activated carbon is recommended as the odor control treatment process. The odor control systems can be located in buildings above grade and possibly even below grade in vaults, particularly for smaller systems. This is to address visual impacts in neighborhoods from these industrial-type treatment systems. Early estimates of footprint size indicate the larger odor control facilities at the tunnel ends can be roughly 185 m^2 (2,000 sq ft) in area and the smaller systems at the intermediate drop shafts can be roughly 28 m^2 (300 sq ft) in overall size.

Drop shafts

Seven hydraulic drop shafts are used to convey flow in a controlled manner from the shallower consolidation conduits to the deep rock tunnel. A two-level screening process was used to assess the characteristics of each site and to recommend either a baffle-plunge or tangential vortex based upon cost effectiveness, hydraulic performance, and operation and maintenance considerations (Fig. 5).

The tangential vortex drop structure type was selected for all of the sites along the tunnel alignment (with the exception of the TBM retrieval site) due to its widely accepted use for deep rock CSO storage tunnels, history of acceptable performance and cost effectiveness when compared to the baffle-plunge drop structure. The baffle-plunge drop structure type was selected for the deep rock tunnel TBM retrieval site because of the existence of the larger diameter shaft being constructed at this site for the TBM retrieval. Once such a large shaft is present, the baffle-plunge becomes ideally suited for such applications because of its compact surface area impact. Based on the drop shaft selections, potential operations criteria and maintenance requirements were developed for each of the proposed drop structure sites.

CSO/SSO consolidation conduits

New diversion structures constructed near existing CSO/SSO locations will utilize transverse or side flow weirs to direct the design overflows from existing pipes into the consolidation conduits. These conduits then convey flows to the deep rock tunnel through either vortex or baffle drop shafts.

The consolidation conduits will be installed using a combination of microtunneling, guided boring, shallow rock tunneling, and open cut construction techniques. It is anticipated that three consolidation pipe branches along the selected alignment will be installed using microtunneling methods. This includes a 61 cm (24 in.) guided bore of the Newington Consolidation Pipe (NCP), a 107 cm (42 in.) microtunnel installation of the New Britain Consolidation Pipe (NBCP), and a 122 cm (48 in.) microtunnel installation of the Flatbush Consolidation Pipe (FCP). When considering microtunneling as the likely means of installation, effort has been made to locate conduits within soil. However, there is the potential for mixed-face microtunneling in areas of till.

The open cut method of pipe installation will be utilized for installation of the 76 cm (30 in.) West Hartford Consolidation Pipe (WHCP), the southern section of the 61 cm (24 in.) NCP and the 69 cm (27 in.) Arlington Consolidation Pipe (ACP). The open cut method creates more temporary disturbance to traffic, businesses and residences as this work is performed primarily within the roadways. However, it may be the preferred installation method due to the depth of the pipe, geotechnical conditions, and cost considerations. Open cut installations typically will be shallower than microtunneling installations.

Based on existing geotechnical information, it is anticipated that the 168 cm (66 in.) Franklin Avenue Consolidation Pipe (FACP) and the 152 cm (60 in.) Maple Avenue Consolidation Pipe (MACP) will be constructed using an open face rock tunneling machine. Consideration is given to standardizing the diameters of these tunnel consolidation sewers to potentially reduce costs.

Pump station

The TPS is designed to pump out the SHCST following storm events so that the flow can be treated at the HWPCF. At this point, stored flows will receive adequate treatment prior to discharge to the Connecticut River. The proposed TPS will be located within the HWPCF complex.

The TPS will be designed to pump out at a maximum 189.3 ML/d (50 million gal/day) capacity. This rate will allow the 235 ML (62 million gal) SHCST to be pumped out within 55 hours. The proposed tunnel invert elevation at the TPS site is –52 m (-170 ft) and the discharge elevation at the plant is +2 m (+6 ft). Therefore, the total maximum static head is 54 m (176 ft).

The recommended pump equipment consists of four 16.7 million gal/day vertical, nonclog centrifugal pumps. This will provide a firm pumping capacity of 189.3 ML/d (50 million gal/day) with one unit out of service. Variable frequency drives (VFDs) are recommended for the pumps as turn-down capability to approximately 15.1 to 18.9 ML/d (4 to 5 million gal/day) can be achieved.

The TPS will discharge directly to the new Headworks facility currently under design at the HWPCF. The force main is currently sized to be 91 cm (36 in.) in diameter. The recommended connection point at the discharge end is at a new junction structure upstream of the new influent pumping station. A surge tank will be provided on the discharge force main to minimize surges in the system. The surge tank will be situated at the TPS site.

Two pump station configurations were initially presented as the finalist options. One of these is a cavern pump station and the other is a circular pump station with a suction header pipe system (Fig. 6). To allow for a more informed decision on pump station type, MDC personnel visited both types of facilities at other deep operating installations. Following those site visits, the circular pump station layout was fitted with a bridge crane at the lower level. This made both configurations the same from a maintenance perspective. The city of Hartford building department office was also consulted at this time to assess requirements for this deep pump station to comply with the current 2005 Connecticut State Code governing this facility. A second means of egress (i.e., a second stair tower) and compartmentation of the floor area of the below grade levels were identified as the more extensive requirements of the code. The layouts for both finalist pump station configurations were then modified to address these more significant building code requirements. A comparative assessment of the capital costs of these two configurations was then prepared and concluded that the cost of the circular pump station is less than that of the cavern pump station. On this basis, the circular pump station is recommended for the project.

A new 9,800 kW overhead electrical power service from CL&P will be required for the TBM. This power feed will be converted to a permanent power feed for the TPS, once the TPS is completed and made operational. Current power requirements for the TPS and related facilities are on the order of 3,055 kW.

Screenings and grit capture will be accomplished in a separate 10.7 m (35 ft) diameter dedicated shaft. The shaft, which will be used as the launch shaft for the TBM tunnel, will be converted to the grit/screenings shaft. Bar screens will be provided to protect the TPS pumps from solids and debris that would either clog or damage the pumps. A rake lowered by crane will either push or pull the screenings up from the shaft. Grit and other heavier debris will be removed from the pit by a clamshell bucket. The screenings shaft will be used for tunnel construction, allowing construction of the TPS to proceed in parallel with tunnel construction.

The TPS and the grit/screenings facility will be roughly 46 m (150 ft) apart and will be connected with a 122 cm (48 in.) diameter suction header. An at-grade building will be constructed to house support facilities critical to the operation of the pump station and to allow for pump station access and egress. Personnel access/egress will be by elevator. A separate stair tower will be provided for emergency situations. The grit/screenings facility will also be enclosed in a building to better contain odors and to promote a more visually appealing facility to neighboring businesses.

Conclusions

This paper presented the design of a deep rock conveyance and storage tunnel, drop shafts, consolidation conduits and a pump station in Hartford, CT. The geological settings, subsurface investigation program and geotechnical challenges were discussed and the general aspects of the preferred alignment selection were described. Relevant alternatives for the drop shafts and the pump station were explained and recommended options were presented. (References available from the authors.) ■

FEATURE ARTICLE

What's in a name? A look at the who, what and why of forming a joint venture partnership

There's a bit of confusion and misinformation in the tunneling and underground construction industry regarding contractor joint ventures. If it was all so clear I would not have been "asked" to write this article. For those of us on the contractors' side of the fence, joint venture business relationships have been a part of life for a long time. But even for contractors, there can be a bit of confusion, and it normally begins on bid day.

How often have you received bid results and wondered (out loud, usually), "Who the hell are the Lake Mead Intake Constructors"? or the "Regional Connector Constructors"? Once you get past the name, you see that there is nothing behind Oz's curtain other than a couple of contractors bidding and building work in an attempt to make a profit. So take a few minutes to read the rest of this, and I'll do my best to dispel a few myths.

What is a joint venture?

In some form or fashion, joint ventures are as old as industry itself. In the United States, some of the earliest (and largest) joint ventures involved the railroads and oil companies in the late 1800s. In the United States' underground construction industry, joint venture names such as, Healy-Greenfield, Green and Winston, Gates & Fox and Walsh, Shea-Ball, Kenny-Paschen and S&M-Traylor bring back memories of successful joint ventures that operated over many projects.

There are nearly as many definitions for joint ventures (JVs) as there are attorneys. A short and simple definition is, "an association of two or more companies engaged in a singular, for-profit business enterprise without actual partnership or incorporation." That's it. Two or more contractors decide to partner up for one or more projects.

One benefit of the JV relationship is that the partners typically do not need to file incorporation documents, or articles of organization within the state where they intend to operate. So it is a relatively easy business arrangement to pull together. Other benefits of the JV arrangement include:

- Oportunities to gain new expertise and capacity.
- The ability for firms to move into new geographic markets.
- JV agreements are not long-term commitments.
- Sharing of financial support for a project.
- Sharing of financial risks within a project.

Regional Connector Constructors Joint Venture is led by Skanska USA Civil West California District Inc. (Skanska), in partnership with Traylor Bros. Inc. (Traylor). The joint venture will work on a light rail system in Los Angeles, CA.

- Provides access to a larger pool of skilled project personnel.

Some drawbacks we hear about include:

- Differing management philosophies and expectations among partners.
- An inequitable level of expertise and/or investment

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between the partners.

- Can complicate dispute resolutions with the owner and between partners.

Joint ventures operate within a joint venture agreement (JVA), which is nothing more than the "rule book" under which the JV will conduct itself. JVAs can be as long and as detailed, or as short and to the point as the parties feel comfortable with. A typical agreement will include topics such as:

1. Formulation and termination of the joint venture.
2. Proportionate share (joint venture percentages).
3. Management.
4. Working capital.
5. Accounting.
6. Bonds and indemnification.
7. Insurance.
8. Bankruptcy or other default.
9. Equipment, plant, materials and supplies.

The Blue Plains Tunnel project in Washington, D.C. is being built by the joint venture of Impregilo-Healy-Parsons.

And any other provisions specific to the particular project(s).

JV versus LLC

So what's the difference between a joint venture and a limited liability company (LLC)? Without dragging the attorneys and accountants in, a few of the differences are:

Cost of formation. Joint ventures can be set up without a lot of cost and paperwork. As stated, JV partners are typically not required to file operating documentation with the state. LLCs are required to file documentation, and, more often than not, pay operating fees to the state.

Taxes. A joint venture does not file taxes with the Internal Revenue Service. Joint venture partners report their share of profits and losses directly on their tax returns. An LLC can elect to report profits and losses as a corporation or partnership. If the LLC elects to file taxes as a partnership, the member companies report profits and losses on their individual tax returns, as a joint venture would. If the LLC elects to pay taxes as a corporation, it is subject to double taxation, because its members still have to report distributions on their tax returns. And that's as deep as we're going into U.S. Tax Code.

Liability. This is the biggest difference between a joint venture and a limited liability company. LLC members enjoy personal asset protection against debts and obligations of the LLC (hence, the name). In an LLC, member debts do not extend beyond the amount of their investment. Partners in a joint venture have unlimited liability for the debts and obligations of the JV, being bound by "joint and several liability" in 46 of the U.S. 50 states.

The natural question following this explanation is, "With liability being such an issue, why would construction companies ever choose to form a joint venture over forming an LLC?" The answer lies with the project owners that we contract with. Most owners are public agencies (municipal entities or authorities, cities, states), where statutes do not allow for contraction with LLCs. They want the protection afforded by unlimited liability — access to deep pockets should something go wrong.

Three simple reasons why construction companies form joint ventures

Forget about tax law and attorneys. We form joint ventures for the same reason we do most everything – to maximize profit for the company. Here are the three main reasons that joint ventures are formed.

Share risk (and reward). Underground construction projects carry substantial risks, so much so that an entire industry has bloomed around these risks. By bringing in one or more partners, the financial risk is spread according to the joint venture membership percentages. The flip side is that the profits from the project are likewise split along the same percentages.

Check estimate. During the procurement, or bid phase, each partner prepares a complete and independent cost estimate, based on their own preferred means and methods. Following a comparison of estimates, all partners are (relatively) assured that they are all looking at the same job, leaving less chance of bidding scary low or embarrassingly high.

Remove competition. A consequential effect of forming a joint venture is that bidders are removed from the field. Each partner teamed up in a joint venture for a particular project is one less bidder out of the field. History shows us that joint ventures can take an eight or nine bidder field and reduce it to, say four or five bidders.

It can be argued that a fourth benefit, the sharing of resources, is also a reason for forming JVs. I would say that the sharing of personnel, equipment or particular experiences among JV partners falls more into the category of partner selection.

A relatively rare teaming agreement nowadays is the "line item joint venture." Under this arrangement, each partner takes on responsibility for constructing distinct portions of the work, typically based on a client's bid item listing. Internally, each partner bears its own risk for profitability on its share of the work, and typically keeps its own accounting records. Even in such agreements, the overall joint venture is still bound by joint and severable liability for the completion of the project. This type of arrangement can contain a lot of duplicated costs, with only a marginal decrease in overall project risk, which is why we see very few line item joint ventures these days.

You can't pick your neighbors, but you can pick your JV partners

Several dynamics go into the selection of partners for a particular project or series of projects. Among the many factors are:

- Past working relationship between the companies, either as JV partners or neighbors on adjoining projects.
- Past experience on similar work.
- Geographic location (local partner/local knowledge).
- Current workload/backlog.
- Available resources.
- Financial viability.
- Owners contract delivery model (bid/build, design bid build, PPP).
- Requests from bonding companies to share the risk due to project size.

Hand-in-hand with selecting partners is deciding which partner will be the lead, sponsor or managing partner of the joint venture (all three designations are interchangeable). Many of the same factors listed previously help dictate which company will lead. And by lead, I don't mean that it has to be a 70/30, 60/40 split, or some other less than equal share arrangement (although those are most common). Some joint ventures are 50/50 arrangements. The lead partner typically provides all administrative, accounting and most of the project management support for the project.

The name of the joint venture will generally let you know which partner is managing the effort, as its company name will be listed first. "Traylor/Shea, a joint venture" would be a Traylor-led effort. Similarly, "Shea/Traylor, a joint venture" would be a J.F. Shea-led endeavor. Confusion can arise when partners get cute and give their teams names like the aforementioned "Regional Connector Constructors." More on that later.

Generally speaking, the lead will be decided before the particular project advertises for bidding, or at the onset of the prequalification stage. In either case, the lead partner will organize the prequalification and estimating effort, including the solicitation of quotes from subcontractors and suppliers.[1]

More on JV names

So, Regional Connector Constructors is Skanska/Traylor and Vegas Tunnel Constructors is Healy/Impregilo. Confusing? How do you think the city of Los Angeles felt having very similar, connecting and concurrent projects NOS-ECIS (Kenny/Shea/Traylor/Frontier-Kemper) and NEIS (Traylor/Shea/Frontier-Kemper/Kenny)? And will the Maryland MDOT and MTA ever keep from confusing its four Purple Line proposers — Purple Line Transit Partners, Purple Plus Alliance, Maryland Purple Line Partners and Maryland Transit Connectors? Puckers my lips just typing it.

In summary, joint ventures between various contracting parties pursuing a project have become the standard for the industry, as the major underground infrastructure increases in size of the contract and in the complexity of the work. When my father entered the tunnel industry in the Detroit area during the 1950s, a $20-million dollar tunnel was considered a large project. The company I am now working for, Traylor Bros. Inc., is bidding on and successfully constructing $1 billion dollar plus tunnel and bridge projects and almost always in some form of a joint venture. I hope this article assists the industry in better understanding why joint ventures are created and how they are implemented at the project level.

Please contact me if you have any questions or require any clarifications on the information presented. I am not a lawyer, but I play one in my company when required. ■

[1] This is always a point of confusion with subs and suppliers but it need not be. Let's take a look at an instance where a supplier is trying to ensure that his quote gets in the right hands. XYZ Supply Inc. wants to provide a quotation to the Alpha/Beta JV. Alpha is the sponsor (of course Beta is the minor partner), but XYZ has a relationship with Beta. Who should XYZ contact? The answer is that it doesn't matter. If XYZ feels more comfortable dealing with Beta, they should contact Beta. Beta is going to forward any quotes received to Alpha anyway. And at the end of the day, Alpha and Beta are going to share all quotes received, regardless of whether this JV won the job or not.

FEATURE ARTICLE

The allocation of differing site condition risk

Construction projects involve a great many risks. The risk that material prices will increase during construction or that the work under construction will be destroyed by fire, storm or some other act of God are just a few examples. In tunneling or other underground projects, one of the most significant risks is that the subsurface conditions encountered during construction will differ from what is expected. Each of these risks must be accounted for, managed and, ultimately, the duty of one party or the other to bear. The primary tool used to allocate the risks among the parties is the construction contract.

> "It is always wise to look ahead, but difficult to look further than you can see."
>
> Winston Churchill

How construction contracts allocate the risk that subsurface conditions will differ have changed substantially over the past century. Today, construction contracts typically allocate the risk through a series of provisions. The first is the differing site condition or changed condition clause. That clause, when included, typically provides that the owner bears the risk that the subsurface conditions will differ from what is indicated in the contract documents or what is reasonably expected. The second clause is one that provides that the contractor must conduct a reasonable site investigation and bear the risk of any conditions that such an investigation would reveal. The third provision includes disclaimers that are often included in geotechnical data provided by the owner (or the owner's engineer) to the contractor which attempts to limit the information on which the contractor can rely. Because these risk-allocating devices seem to be somewhat conflicting, a brief discussion of each provides critical insight in understanding how the modern construction contract allocates the risk of differing site conditions.

The differing site condition clause

Zachary D. Jones

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At the start of the 20th century, construction contracts looked substantially different than they do today. For example, one contract for the construction of a public water tunnel in Chicago, IL, drafted around 1895 contained the following clause:

The contractor must take the work entirely at his own risk. No extra allowance will be made for quicksand, hardpan or boulders.

This allocation, placing the risk squarely at the feet of the contractor, seems to be fairly common for the era. At the time, the prevailing view was that owners, whose business was not solely focused on building projects, were in no better position than contractors, who were in the business of building projects, to understand what conditions would be encountered during construction. At that time, however, soil mechanics was just emerging as a reliable science; and even if the science were understood, the technology to economically explore subsurface conditions was largely inaccessible due to excessive cost and other limiting factors. But as the 20th century dawned, it was met with a rapid expansion of both the science of soil mechanics and the drilling and sampling technology that made that science affordable and accessible.

The 20th century also marked an increase in the widespread construction of underground utilities and other critical infrastructure. As this shift occurred, the position occupied by owners and contractors also shifted. Owners who commissioned underground projects began engaging numerous experts well-versed in soil mechanics and subsurface exploration. These experts commissioned more expansive explorations to study the existing conditions and used that study to inform the design of foundations and other subsurface elements. Importantly, most of this information gathering occurred prior to selecting a contractor. Moreover, the development of standard procurement policies, which institutionalized the design-bid-build format, placed the owner in a position of information superiority when compared to the contractor, who tends to have less time to review the information than does the owner. Also, it is the owner, not the contractor, who tends to not only select the location of the project, but also the location and amount of geotechnical exploration. This fundamental change in position resulted in a recognition that it was both economically inefficient as well as inequitable to place the risk of differing site conditions on the contractor when the owner is in the best position to identify, manage and ultimately bear the risk associated with differing site conditions. Accordingly, the federal construction contract incorporated the first standard changed condition clause — now known as the differing site condition clause — in the first part of 20th century. Shortly thereafter, other standard form construction contracts followed suit.

The differing site condition clause benefits both the owner and the contractor. The clause is intended to discourage contractors from including large contingencies in their bids to account for the possibility of differing site conditions resulting in lower prices on bid day. If such contingencies are included, and differing conditions are never encountered, contractors end up receiving windfalls. Moreover, without the differing site condition clause, reasonable contractors are forced to include such contingencies. Ultimately, without a differing site condition clause, the owner is guaranteed to pay an expense that may not actually be needed. If the owner is required to award the contract to the low bidder, the failure to include a differing site condition clause all but ensures an owner will award the contract to the contractor who failed to account for all the risks.

Site investigation clause

The differing site condition clause is intended to allocate the risk of unknown site conditions. It was never intended to allocate the risk of conditions known to exist when the construction contract was executed. The site investigation clause is intended to serve this purpose.

Many early site investigation clauses included reference to patent or observable conditions. These references clarified the risk allocation: while the owner assumed the risk of unknown conditions, the contractor assumed the risk of conditions of which the owner had informed the contractor or conditions that the contractor had observed during the site investigation.

Over time, the site investigation clause began to encroach upon the differing site condition clause. Cases litigated in various courts indicate that as contracts containing this new risk allocation were disputed, owners began to assert that the site investigation clause actually transferred risk to the contractor that would otherwise belong to the owner under the differing site condition clause. In fact, some argued that the site investigation clause actually negated the contractor's ability to claim a differing site condition existed if the contractor could have discovered the condition.

The limits of the site investigation clause have become somewhat settled. Most authorities have arrived at a reasonable middle ground. The line ultimately drawn is usually that the risks assumed by the owner are the conditions not discoverable by a reasonable investigation. The key question that remains, however, is what constitutes a reasonable investigation. While some debate remains, most agree that it depends on a few finite factors: the time allowed, access given, and what is common in the area or trade. The most well-reasoned responses to that question also presuppose that the inclusion of a differing site condition clause necessarily prohibits requiring a contractor to recreate the geotechnical investigation that the owner has already conducted. Ultimately, the site investigation clause is best understood as requiring the contractor to enter into the contract with its eyes open — without burying its head in the sand.

Geotechnical disclaimers

Disclaimers related to the risk of subsurface conditions come in one of three primary varieties. The first are those that attempt to disclaim the contractor's reliance on geotechnical data provided. The second are those that state that the geotechnical data provided are not part of the contract. The third mirrors the site investigation clause by stating that the contractor must conduct his/her own investigation. The third disclaimer is almost always included when the contract does not include a differing site condition clause.

The first two types of disclaimers are limited by several legal principles often not readably identifiable by a reading of the contract. The first principle is known as the Spearin doctrine. That doctrine, put simply, is that owners generally must guarantee the accuracy of the plans and specifications provided to contractors. The second is that when anyone provides information in a business transaction, knowing that the one who receives that information will rely on it, that person providing the information bears some degree of responsibility to ensure the information is accurate. Finally, when a contract contains multiple provisions that appear to conflict, courts will interpret the clauses by reading them in a way that does not conflict and/or in a way that favors the party who did not draft the agreement. Taken as a whole, these three principles tend to limit the effect that disclaimers have on the risk allocation of subsurface conditions when the contract contains a differing site condition clause.

The actual language of the disclaimer matters. For example, many courts will look at how specific the disclaimer is. If the disclaimer addresses a discrete subsurface condition, e.g., water infiltration or subsurface rock, then courts may enforce the disclaimer reading an intent of the parties to place that specific risk on the contractor and all other subsurface risk on the owner. In this reading, the differing site condition clause is viewed as only transferring the risks not specifically addressed by the disclaimer.

The language in other sections of the contract may be important as well. For example, if the contract lists the "contract documents," and that list does not include the geotechnical report, a disclaimer that states the geotechnical report is not a contract document may be more significant. Many differing site condition clauses limit the right of a contractor to recover under the clause to indications made in the contract documents. Therefore, contracts that do not incorporate the geotechnical report provided by owners to contractors as contract documents may not accomplish the purpose intended by including the differing site condition clause in the contract.

Simply excluding the geotechnical report from the contract documents, however, is not the end of the story. Recall that providing information in a business transaction may bring with it some degree of responsibility to ensure the information is accurate. Further, if plans or specifications make reference to or rely on the geotechnical report, courts may import a warranty by the owner that the information given is accurate. As a result, a disclaimer that attempts to avoid this warranty may be limited or even ignored by some courts. The bottom line is that a disclaimer that conflicts with an otherwise clear allocation of subsurface condition risk creates, at best, a murky allocation of risk and, at worst, a nonsensical contract that may both lead to long and costly disputes and undermine the very benefit the differing site condition clause was included to obtain.

Conclusion

The risk that differing site conditions will exist is a significant risk when working underground. Contractors, engineers and owners involved in these projects usually recognize this and address the allocation of that risk in the construction contract. Including a differing site condition clause provides a way for the contractor to offer a price based on a level field of assumptions. If, however, the conditions encountered end up being different than expected, and that difference results in additional time or cost to complete the project, the owner is responsible to pay only for the time and cost actually incurred. Failing to allocate the risk in this manner, however, results in higher prices on bid day because contractors are forced to include contingencies to deal with adverse conditions if encountered. What is more, that higher price may end up being unnecessary if the actual conditions end up being just as expected.

Site investigation clauses also play a crucial role in analyzing how the risk is allocated. Contractors must ensure that they do not ignore obvious signs that a specific subsurface condition exists. While this usually does not require contractors to undertake extensive geotechnical investigation, a reasonably prebid investigation of the site is wise. Finally, disclaimers of geotechnical information cannot be blindly ignored. Owners and engineers, however, should carefully consider if including a disclaimer will undermine the very purpose of including a differing site condition clause in the first place. If the goal is the most economically efficient transaction, a clearly defined allocation of risk is in everyone's best interest. ■

UCA of SME NEWS & EVENTS

Wallace Hayward Baker Award given to Paul Schmall

Paul C. Schmall, Ph.D., P.E., D.GE, has been selected as the 2015 recipient of the Wallace Hayward Baker Award. The award was established in 2000 by the Geo-Institute of the American Society for Civil Engineers in recognition of the contributions of the late Wallace Hayward Baker to the field of ground modification. It is given annually in recognition of "ingenious innovation in the field of ground modification ... resourceful development of a new technology or the creative application of existing technology to achieve field performance not previously demonstrated." Schmall is vice president and chief engineer at Moretrench, a specialty geotechnical contractor.

Microtunneling achievement award winners announced

Reynaldo "Rene" Inosanto, of Frank Coluccio Construction Co., Greg Raines, of MWH Global, and John Grennan, of Ward and Burke, are the 2015 recipients of the Microtunneling Achievement Awards.

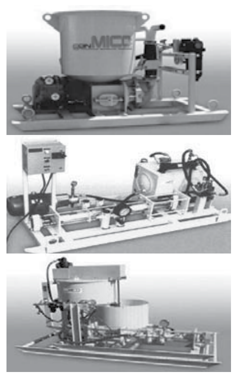
The winners were honored at the 2015 Microtunneling short course banquet dinner held Feb. 12 at the Colorado School of Mines, Golden, CO.

Created by short course organizers Tim Coss, of Microtunneling Inc., and Levent Ozdemir, of Ozdemir Engineering, the awards recognize the individuals and companies that have worked toward successfully completing complicated projects and advanced the industry. ■

Compiled by Jonathan Klug, David R. Klug & Associates

TUNNEL NAME	OWNER	LOCATION	STATE	TUNNEL USE	LENGTH (FEET)	WIDTH (FEET)	BID YEAR	STATUS
Gateway Tunnel	Amtrak	Newark	NJ	Subway	14,600	24.5	2016	Under study
2nd Ave. Phase 2-4	NYC-MTA	New York	NY	Subway	105,600	20	2015-20	Under study
Water Tunnel #3 bypass tunnel	NYC-DEP	New York	NY	Water	20,000	22	2015	Bid date 03/16/25
Water Tunnel #3 Stage 3 Kensico	NYC-DEP	New York	NY	Water	84,000	20	2017	Under design
Cross Harbor Freight Tunnel	NYC Reg. Develop. Authority	New York	NY	Highway	25,000	30	2016	Under study
South Conveyance Tunnel	City of Hartford	Hartford	CT	CSO	16,000	26	2015	RFQ under way
Red Line Tunnel - Cooks Lane Tunnel	MD Transit Administration	Baltimore	MD	Subway	14,000	22	2015	Under design
Red Line Tunnel - Downtown Tunnel	MD Transit Administration	Baltimore	MD	Subway	36,000	22	2015	Under design
Purple Line - Plymouth Tunnel	MD Transit Administration	Baltimore	MD	Subway	1,000	30x40	2015	Bid date 03/12/15
Northeast Branch Tunnel Northeast Boundary Tunnel	DC Water and Sewer Authority	Washington	DC	CSO CSO	11,300 17,500	15 23	2018 2021	Under design Under design
Virginia Ave. Tunnel	CSX Transportation	Washington	DC	Rail	3,800	21	2015	Clark Const. Awarded
Bellwood Tunnel Phase 1 Phase 2	City of Atlanta	Atlanta	GA	Water	6,000 21,000	12 12	2016 2016	
Olentangy Relief Sewer Tunnel	City of Columbus	Columbus	OH	Sewer	58,000	14	2016	Under design
Blacklick Creek San. Interceptor Tunnel	City of Columbus	Columbus	OH	Sewer	24,000	10	2015	Under design
Alum Creek Relief Tunnel Phase 1 Phase 2	City of Columbus	Columbus	OH	Sewer	30,000 21,000	18 14	2016 2017	Under design Under design
Doan Valley Storage Tunnel	NEORSD	Cleveland	OH	CSO	9,700	17	2017	Under design
Westerly Main Storage Tunnel	NEORSD	Cleveland	OH	CSO	12,300	24	2020	Under design
Shoreline Storage Tunnel	NEORSD	Cleveland	OH	CSO	16,100	21	2021	Under design
Southerly Storage Tunnel	NEORSD	Cleveland	OH	CSO	17,600	23	2024	Under design
Ohio Canal Interceptor Tunnel	City of Akron	Akron	OH	CSO	6,170	27	2015	Under design
Continental Rail Gateway	CRG Consortium	Detroit	MI	Rail	10,000	28	2015	Under design
ALCOSAN CSO Program	Allegheny Co. Sanitary Authority	Pittsburgh	PA	CSO	35,000	20	2016	Under design
Lower Pogues Run	Indianapolis DPW	Indianapolis	IN	CSO	9,000	18	2016	Under design
Fall Creek	Indianapolis DPW	Indianapolis	IN	CSO	19,600	18	2016	Under design
White River Tunnel	Indianapolis DPW	Indianapolis	IN	CSO	28,000	18	2016	Under design

TUNNEL NAME	OWNER	LOCATION	STATE	TUNNEL USE	LENGTH (FEET)	WIDTH (FEET)	BID YEAR	STATUS
Three Rivers Protection/Overflow	City of Fort Wayne	Fort Wayne	IN	CSO	26,400	12	2017	Under design
Des Plains Inflow Tunnel	MWRD of Greater Chicago	Chicago	IL	CSO	5,400	20	2015	Under design
St. Louis CSO Expansion	St. Louis MSD	St. Louis	MO	CSO	47,500	30	2014	Under design
KCMO Overflow Control Program	City of Kansas City, MO	Kansas City	MO	CSO	62,000	14	2014	Under design
Mill Creek Peaks Branch Tunnel	City of Dallas	Dallas	TX	CSO	5,500	26	2014	Under design
East Link Light Rail Extension	Sound Transit	Seattle	WA	Transit	30,000	22	2016	RFQ under way
L.A. Metro Regional Connector	Los Angeles MTA	Los Angeles	CA	Subway	20,000	20	2014	Skanska-Traylor JV Awarded
L.A. Metro Westside Extension Phase 1 Phase 2 Phase 3	Los Angeles MTA	Los Angeles	CA	Subway	42,000 26,500 26,500	20 20 20	2014 2015 2017	Skanska/Traylor, Shea awarded Under design Under design
Speulvada Pass Corridor	Los Angeles MTA	Los Angeles	CA	High/Trans.	55,500	60	2017	Under study
Northeast Interceptor Sewer 2A	LA Dept. of Water and Power	Los Angeles	CA	Sewer	18,500	18	2014	RFQ under way
River Supply Conduit - Units 5 and 6	LA Dept. of Water and Power	Los Angeles	CA	Water	8,608	12	2014	W.A. Rasic low bidder
River Supply Conduit - Unit 7	LA Dept. of Water and Power	Los Angeles	CA	Water	13,500	12	2015	Under design
JWPCP Effluent Outfall Tunnel project	Sanitation Districts of LA	Los Angeles	CA	Sewer	37,000	18	2015	Under design
Freeway 710 Tunnel	CALTRANS	Long Beach	CA	Highway	26,400	38	2016	Under design
BDCP Tunnel #1 BDCP Tunnel # 2	Bay Delta Conservation Plan	Sacramento	CA	Water	26,000 369,600	29 35	2017 2018	Under design Under design
SVRT BART	Santa Clara Valley Trans Authority	San Jose	CA	Subway	22,700	20	2016	Under design/ Delayed
Coxwell Bypass Tunnel program	City of Toronto	Toronto	ON	CSO	35,000	12	2015	Under design
Yonge St. Extension	Toronto Transit Commission	Toronto	ON	Subway	15,000	18	2016	Under study
Scarborough Rapid Transit Extension	Toronto Transit Commission	Toronto	ON	Subway	25,000	18	2017	Under design
CSS - East-West	City of Ottawa	Ottawa	ON	CSO	14,400	10	2015	Under design
CSS - North-South	City of Ottawa	Ottawa	ON	CSO	5,300	10	2015	Under design
Energy East Pipeline	TransCanada	Quebec City	QC	Oil	13,780	16	2015	Under design
Second Narrows Tunnel	City of Vancouver	Vancouver	BC	CSO	3,600	14	2013	Under design
UBC Line project	Trans Link	Vancouver	BC	Subway	12,000	18	2015	Under design
Northern Gateway Clore Tunnel Hoult Tunnel	Enbridge Northern	Kitimat	BC	Oil Oil	23,000 23,000	20 20	2014 2014	Under design Under design



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