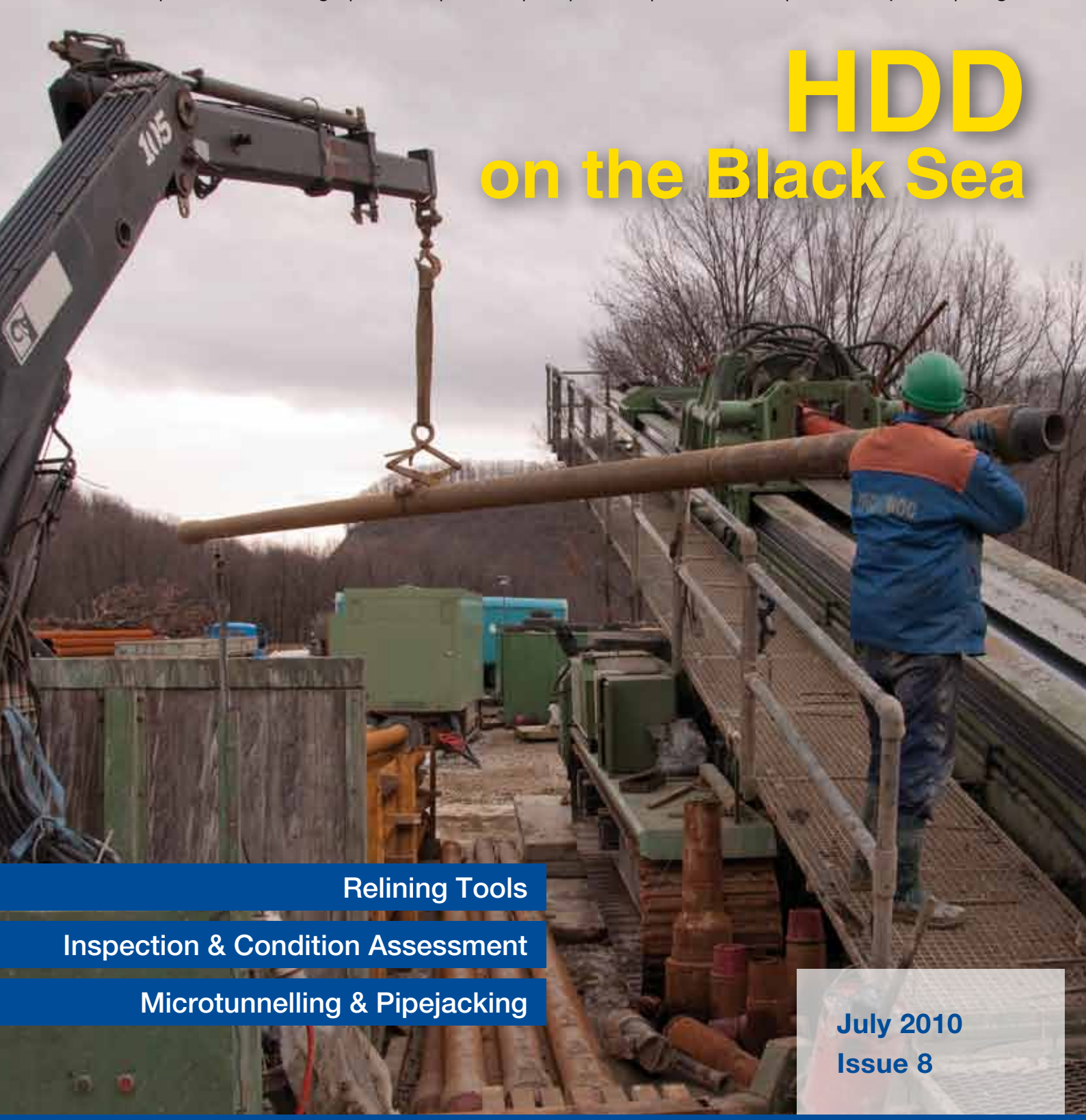
TRENCHLESS international

In this issue | Trinidad & Tobago | Bahrain | Tunisia | UK | Russia | South Africa | Czech Republic | Bulgaria



HDD on the Black Sea

Relining Tools

Inspection & Condition Assessment

Microtunnelling & Pipejacking

July 2010
Issue 8

The official magazine of the ISTT

ISTT

Dec Downey
ISTT Chairman

IT IS MORE than 20 years since the Netherlands Society (NSTT) became the first national society for Trenchless Technology in 1988, followed in 1989 by Scandinavia, France, Germany and the United States. So it was a privilege to attend the NASTT 20th anniversary celebrations in Schaumburg, Illinois, in early May. Many thanks to Chris Brahler and his committee for their kind invitation to dinner and to Bernie Krzys and his Benjamin Media team for a great exhibition and conference. It's almost a given that they would break new records and so they did! It was really good to see some of the founding committee members, Richard Thomasson, Tom Iseley and Bill Gray and they only look a day or two older than their photographs in the excellent booklet published by NASTT to celebrate the occasion.

The NASTT booklet is an excellent read, in a section entitled "2010....and beyond" various past chairmen describe the impact of education and training over the years, a subject that NASTT does very well through courses developed and delivered at national and regional events, the contributions of its university links and fundraising events, particularly the Educational Fund Auction, which has raised over $US300,00 since 2002 to support the student chapters. Richard Thomasson, Bill Gray, Tom Iseley, Glenn Boyce, Ray Sterling and Michael Addritt all had a contribution to make on the importance of training and I particularly liked Mike's observation about promoting trenchless being like missionary work. It rang a bell for me during the event in a conversation with Sergio Palazzo and Paolo Dequech from ABRATT who asked specifically how ISTT could help them provide educational programs in Brazil to improve the understanding of trenchless in their fast emerging markets. To be effective ISTT, in partnership with Affiliate Societies, has to get over the barrier of language and multicultural business practice to instill a level of understanding of the basics of our technologies to help inform the dialogue between owners, engineering firms and contractors. In "2010...and beyond" Tom Iseley referred to the excellent Good Practice Courses being developed and Chris Brahler, looking forward, highlighted the environmental benefits and the greening of underground construction by increasing use of Trenchless Technology.

I am pleased to say that NASTT's Mike Willmets and ISTT's John Hemphill have had some constructive discussions about access to training materials and future developments of the resources so that for future events such as the International No-Dig in Singapore or looking further ahead to events in Berlin or Brazil which may be enhanced with workshops and round tables we can bring together the experience of our Affiliated Societies and find better ways of dissemination for the public benefit. I had planned this month to visit Russia to assist RSTT and their partners Sibico with No-Dig Moscow, but a mishap in our postal system robbed me of my passport at a critical time in the visa process. My apologies to the organisers, I had been looking forward to battling with the Moscow Metro and meeting many of the old friends from 2008. I am sure it was a good show.

Since the last issue of *Trenchless International* we have heard of the passing of Donald Rees who was a founding member of ISTT and served as a Guarantor for many years. Don, a pioneer in tunnelling, CCTV and in so many other aspects of our business continued to prompt your Executive Sub Committee with thought provoking letters and advice well after he had retired to Portugal. At the inaugural No-Dig in London in 1985 Don presented a paper titled "Is there a No-Dig future?" If you can get hold of a copy of the proceedings "Trenchless Construction for Utilities", do revisit his keynote address and you will see that his contributions hit the target, dead centre!

If not before, I hope to see you all in Singapore in November – I will be visiting at the end of June to work with our partners Westrade and the Public Utilities Board to promote the event and build on their detailed planning for what promises to be a memorable show.

Best wishes

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John Hemphill
ISTT Executive Director

WE HAVE REACHED the halfway point of 2010. Trenchless Affiliated Societies have accomplished much in educating users on the benefits and opportunities of trenchless methods and applications. And Affiliated Societies still have many fine education and training programs that they will offer between now and the end of the year.

In early May, Chairman Dec Downey, Vice Chairman Sam Ariaratnam and I attended one such outstanding Affiliate event – NASTT's annual No-Dig Show in Chicago. At the NASTT No-Dig, we ran into a number of fellow ISTT members who were participating in the conference. Andrezei Kuliczkowski, PFTT; Sam Ariaratnam, ISTT Vice-Chairman and NASTT; and Juan Gutierrez, CISTT presented technical papers that were well received by attendees. Paulo Dequech and Sergio Pallazzo, ABRATT, were there promoting their upcoming Latin America No-Dig to be held in July in Sao Paulo. Derek Choi, CHKSTT, was also there taking in the conference and exhibition.

In early June, Sam Ariaratnam and I head to Cartagena de Indias to participate in the Colombian Society's first official conference as a member of ISTT – CISTT No-Dig. Also in June, Dec Downey attends the Singapore National Water Week to promote the ISTT 2010 International No-Dig to take place in Singapore in November.

Anticipation is building for the 28th Annual International No-Dig Conference and Exhibition, scheduled for 8-10 November at the Suntec Singapore International Convention and Exhibition Centre. The 2010 International No-Dig promises to be a huge success. We have had to expand the exhibit space to accommodate the demand of exhibitors. The conference will feature over 50 technical papers presented by authors from more than 20 countries.

At the 2010 International No-Dig, ISTT will formally recognise distinguished contributions in the trenchless industry. ISTT No-Dig Awards have been presented annually to deserving individuals, companies and organisations since 1986. All Award winners receive formal recognition at the No-Dig Gala Dinner and are listed on the ISTT website. We are accepting applications for the Awards through 30 July.

I encourage any ISTT member who in 2009 participated in innovative programs and projects in the areas of (1) academic research, (2) trenchless projects, (3) new trenchless tools, material or systems, or (4) a student paper on trenchless to apply for the award. Applications can be made on the ISTT website www.istt.com

The 2010 International No-Dig has it all – technical presentations by experts from throughout the world; an exhibit that features the latest in trenchless products and services; and a program that provides attendees an opportunity to network and that recognises recent achievements in the industry. If you have not already made plans to attend, I encourage you to do so. I invite you to go to www.nodigsingapore.com to find out more about the 2010 ISTT No-Dig.

I send everyone best wishes and hope to see you in Singapore.

Gazprom's Dzhubga – Lazarevskoye – Sochi Pipeline, part of the infrastructure being developed for the 2014 Winter Olympics, is using horizontal directional drilling.

World wrap

Billions invested in London's water infrastructure
Over the next five years, Thames Water will invest nearly £5 billion in upgrades to ageing water pipes, sewers and treatment plants in London and the Thames Valley.
Turn to page 16 for an in depth look under London.

No-Dig helps keep Venice afloat
Trenchless Technology has been used to install a new pipeline in the iconic water city of Venice, designed to protect heritage buildings from the catastrophic effect of fires.

Pentagon engaged in underground mapping
The Defense Advanced Research Projects Agency of the United States Pentagon has launched a project to map the earth's underground features using Trenchless Technology.

HDD protects Black Sea coast
Horizontal directional drilling has been used by Gazprom to install sections of the Dzhubga – Lazarevskoye – Sochi gas pipeline in Russia. See page 26 for further details.

Drilling down Grand Avenue
The city council of Lindenhurst, Illinois, will use horizontal directional drilling to install sections of a new water main.

Microtunnelling in Malaysia for river health
Tunnel boring machines are helping construct multimillion dollar sewer infrastructure on the Malaysian island of Sarawak, which will facilitate dramatic improvements in the water quality of surrounding rivers.

Caribbean beaches left untouched with HDD
The National Gas Company of Trinidad and Tobago is using horizontal directional drilling in the construction of a new offshore gas pipeline. See page 22 for further details.

CIPP in Saudi Arabia
The sewer system of Al-Khobar City, in the Eastern Province of Saudi Arabia, has been repaired using cured-in-place pipe.

Jamaica set for sewer upgrades
The Jamaican Government has allocated $US26.4 million for the rehabilitation and expansion of water and sewer systems in Port Antonio.

Looking after lagoons in Sri Lanka
Welding has been completed on a pipeline shore approach and lagoon crossing using horizontal directional drilling in Sri Lanka.

Keep up to date with this news and more by subscribing to the *Trenchless International* online update.

www.trenchlessinternational.com

Industry recognition for Louisiana legend

Marlin O. Gonzales has been announced as the 2010 recipient of the NASTT Chairman's Award for Outstanding Lifetime Achievement, which honours individuals whose career has been marked by outstanding service to the Society. Alongside other NASTT award winners, Mr Gonzales was honoured at No-Dig Chicago's Gala Dinner Event, held on 4 May. Previous recipients of the Lifetime Achievement award have included Trent Ralston, Bernie Krzys, Tom Iseley and Bill Gray.

Marlin and Patricia Gonzales.

Charles Machine Works acquires Hammerhead

Charles Machine Works (CMW), manufacturer of Ditch Witch underground construction equipment, has recently acquired 100 per cent ownership of Hammerhead Trenchless Equipment. Hammerhead designs and manufactures piercing tools, bursting systems, pneumatic hammers and horizontal directional drilling tools, which are used in the trenchless installation or repair of communication, water, sewer and gas conduits. Earth Tool Company (ETC), the Wisconsin-based manufacturer of Hammerhead products, will now become a wholly-owned subsidiary of CMW.


Brian Metcalf, Hammerhead.

Talking Trenchless in the Middle East

Abu Dhabi has successfully hosted the sixth Trenchless Middle East event, confirming the annual exhibition and conference as a key feature in the calendar of the international trenchless industry. On 15–17 March, representatives of 50 companies, coming from 15 different countries, gathered to present an exhibition of the latest innovations in Trenchless Technology. Over the same period, delegates attended an international conference, which facilitated dialogue between regional municipalities, utility administrators, contractors and consultants operating in the region.

Experts converge on Singapore

The International No-Dig 2010 Conference to be held in Singapore from 8–10 November, will be a truly international affair, featuring conference papers from no less than 22 countries. The Singapore event will be the 28th International No-Dig Conference, and will be held in conjunction with an international exhibition of trenchless equipment, products and services. The exhibition space is already 90 per cent sold, with exhibitors representing a diverse mix of countries, including the United Kingdom, the United States, Denmark, Italy, Australia, Japan, China, Malaysia and the United Arab Emirates (UAE).

Can't wait for the next edition of *Trenchless International?*
Get the latest news at www.trenchlessinternational.com/news

Dora completes her duties

Thames Water has completed a £80 million scheme to stop London homes flooding with sewage. The three-year project involved a tunnel boring machine, known locally as 'Dora the Bora', constructing a 3.2 km, 2.8 m diameter sewer to carry excess rainwater and sewage during storms. Dora took seven months to bore through 70,000 tonnes of earth, 20 m below London.

Israeli expertise utilised in the Caribbean

Following approval from the Israeli economic cabinet, Mekorat Development & Enterprise, the National Water Company of Israel, is poised to sign a $US110 million contract with Trinidad and Tobago's Water & Sewerage Authority (WASA).

HDD firms intersect

Two North American firms that specialise in horizontal directional drilling, Brotherton Pipeline and Direct Horizontal, have merged their equipment and workforce to form Brotherton-Direct. "This newly found partnership provides the large diameter bore experience and financial backing that I have desired for many years to take the next step in the directional drilling market," said Brotherton Pipeline founder Jim Brotherton.

Wessex pipes go high-tech with ice

Wessex Water is currently undergoing a £10 million rehabilitation of water mains in Bridgewater, England. The project, known as Operation Clean and Clear, will involve relining, replacing and cleaning 27 km of water pipe. A number of innovative trenchless techniques will be used in the project, such as relining water mains using CCTV equipment, cleaning the pipes with ice, and flushing mains to remove the build up of iron sediments.

Expansion of microtunnelling markets

Akkerman exhibits its products and services.

Trenchless equipment manufacturer Akkerman Inc. is expanding into new markets, having recently appointed representatives in the Middle East, Russia and Asia. The US-based manufacturer of microtunnelling, pipe jacking, guided boring and earth pressure balance equipment will be represented by Trenchers Land Digging & Filling LLC in the United Arab Emirates and by Asia Contech Inc. in India. International Construction Equipment Far East will become an Akkerman agent in Singapore, while Intertorg will facilitate sales in Russia.

Robotics help Bahrain boost sewer capacity

Relining is being used throughout a major sewer rehabilitation project undertaken by the Bahrain Ministry of Works. The $US17 million project involves the upgrade of 1.46 km of sewer pipes, with diameters of 500–700 mm, in the capital of Manama. German trenchless specialist Frisch & Faust Tiefbau GmbH has been contracted to complete the repairs, and will use robots to reline the existing pipes.

Sewer upgrades commence in Hawaii

A major trenchless sewer rehabilitation project using CIPP commenced in Honolulu in mid-May. The $US9.2 million project, to be performed by Insituform Technologies, involves the repair of 2.3 km of 24 and 30 inch pipe using CIPP. In addition, CIPP will also be used to rehabilitate 518 m of 8 and 10 inch pipe, while 3.6 km of 24, 26 and 30 inch pipe will be cleaned. The project also includes the revitalisation of 19 manholes with epoxy liner.

Can't wait for the next edition of *Trenchless International?*
Get the latest news at www.trenchlessinternational.com/news

Donald Frank Rees 1918-2010:

No-Dig loses one of its pioneering figures

Donald Rees OBE, a much-acclaimed businessman and pioneer of the trenchless industry, has recently passed away aged 91.

DONALD, WHO GREW up in Cheltenham and London, commanded a unit of Royal Engineers in India, Burma and Malaya during World War II. After the war, he took over the family road surfacing company, and began undertaking public works underground.

Under his guidance, the company developed innovative 'no-dig' methods of restoring old sewage systems, pioneering the use of CCTV and developing the Rees Mini-Tunnel. The company's products and services were utilised throughout the United Kingdom, as well as the US, South America and South East Asia.

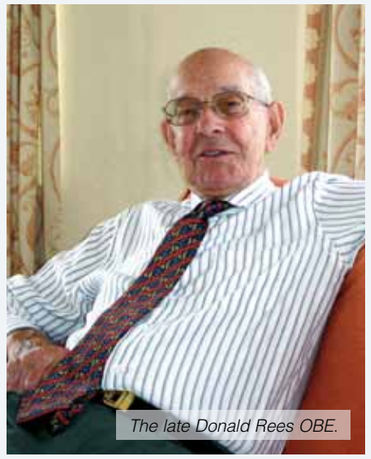
Donald opened the inaugural No-Dig conference in London in 1985, and played an important role in the formation of the ISTT in 1986. He also helped organise the 1987 Conference, and acted as an ISTT Guarantor for almost 20 years.

Founding chairman of the ISTT Ted Flaxman recalled "Donald was a splendid character who will be long remembered for his innovative thinking and warm friendliness."

Donald's contribution to the engineering industry was recognised by many prestigious accolades, including Design Council Awards for the Mini-Tunnel and CCTV Camera System, and the Queen's Award for Industry.

He was honoured with an Order of the British Empire for his services to British exports, and also became a Master of the Worshipful Company of Paviors, a Fellow of the Institution of Public Health Engineers and a Companion of the Institution of Civil Engineers.

In 1983, Donald and his wife Mary retired to Portugal and became active members of the expatriate community. Mary and Donald were married for 55 years. In 2002 Mary passed away. Donald leaves behind six sons, eleven grandchildren and three great-grandchildren.



The late Donald Rees OBE.

Trenchless International opens Houston office!

GREAT SOUTHERN PRESS, publishers of *Trenchless International*, has opened a new office in Houston, Texas.

Headed up by David Entringer, the Houston office will allow us to serve the needs of US-based customers with even greater efficiency. David will also work with clients from the rest of North America, South America and Europe.

David is a lifelong Houston local and graduate of Texas A&M. He has previously worked in procurement in the energy industry and looks forward to getting to know all of our North American-based readers and advertisers.

David can be contacted on +1 210 535 7335 or via email dentringer@gs-press.com

With offices in London, UK; Melbourne, Australia; and now Houston, USA; Great Southern Press brings a truly global perspective to the trenchless industry and *Trenchless International*.

The Trenchless International team. L–R Editor Chris Bland, David Entringer, Kate Pemberton and Brett Thompson.

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Pure Technologies extends into China

CANADIAN-BASED FIRM PURE Technologies and Hong Kong family-owned business Balama Prima Group have announced the establishment of Pure Technologies (China), a joint venture between the two companies to be led by Jon Boon.

Pure Technologies (China) will work in leak detection in pressure pipelines, including oil and gas systems, and will represent the interests of Pure Technologies in China, Hong Kong, Taiwan and Macau.

Mr Boon, an industry expert, has been appointed General Manager of the new company. Mr Boon has over twenty years' experience in the water industry, and is the current Chairman of the China Hong Kong Society for Trenchless Technology. He has also served as past Chairman of the United Kingdom Society of Trenchless Technology.

Pure Technologies President and Chief Operating Officer Jack Elliot said "I am delighted to have Balama Prima and Mr Boon as part of the Pure team and I am confident that they will make a significant contribution to Pure's growth in the Asia-Pacific region."

Mr Boon will report to Managing Director of Pure Technologies (China) Derek Choi.

Upcoming Events

Singapore International Water Week
Singapore
28 June–2 July 2010
www.siww.com.sg

No-Dig Latin America
Sao Paulo, Brazil
21–22 July 2010
www.abratt.org.br/nodig2010

CzSTT No-Dig Conference and Exhibition
Liberec, Czech Republic
14–15 September 2010
www.czstt.cz

UKSTT No-Dig Live
Coventry, UK
5–7 October
www.nodiglive.co.uk

Trenchless Live 2010
Coffs Harbour, New South Wales, Australia
15–18 October 2010
www.trenchless2010.com

International No-Dig 2010
Singapore
8–10 November 2010
www.nodigsingapore.com

Vietwater 2010
Ho Chi Minh City, Vietnam
10–12 November 2010

Bauma China
Shanghai, China
23–26 November 2010
www.bauma-china.com

UCT
25–27 January 2011
Houston, United States
www.uctonline.com

NASTT No-Dig Show 2011
Washington, DC, United States
27–31 March 2011
www.nodigshow.com

International No-Dig 2011
Berlin, Germany
2–5 May 2011
www.istt.com

WASSER BERLIN 2–5 May 2011
www.wasser-berlin.com

ICUEE
Louisville, Kentucky, United States
4–6 October 2011
www.icuee.com

International No-Dig 2012
Sao Paulo, Brazil
14–16 May 2012
www.nodigshow2012.com

Under London

London was first settled by the Romans in 43 AD, and has been a major settlement for two thousand years. As a result, it was one of the first cities to develop an extensive system of underground infrastructure. *Trenchless International* takes a look into the history of this subterranean world, and traces the developments of the water and wastewater systems Londoners enjoy today.

The medieval city

The first London sewers were merely sloping open ditches that used gravity to convey sewage and rubbish into the River Thames. By the beginning of the thirteenth century, population growth had rendered the existing water supply inadequate, and twelve new water conduits were constructed. These pipes were up to 1.6 km in length, and used gravity to transport water from natural springs into the heart of the city. Wealthy Londoners sometimes obtained permission to bring a connection into their homes, but for everyone else, water was hand-delivered from the conduits.

The earliest recorded mention of the conduits comes from a fourteenth century document, which ordered the construction of a conduit to remove wastes from the King's kitchen.

However, during the Middle Ages, most people simply threw their waste from upper storey windows out onto the street, where the slops drained into gutters. Sewage was collected in cesspools, and privy-cleaners periodically gathered the waste to be deposited in landfills outside the city or on the banks of the Thames.

Mains installation, Euston Road, London.

Medieval water infrastructure was similarly rudimentary. It was not uncommon for Londoners to drink water taken directly from the river, although this was often polluted with sewage.

In the early modern period the city's population rose from an estimated 50,000 in 1530 to approximately 225,000 in 1605 due to increased trading and immigration of the Tudor golden age. In 1613, a three metre wide canal, known as the 'New River', began transporting water approximately 37 miles from springs in Hertfordshire to inner-city London. This source still forms a valuable part of London's water supply today.

A smelly problem emerges

As the population grew and industry increased, wastewater was becoming an increasingly odorous presence in the growing city. To combat this problem, King Henry VIII decreed that homeowners were responsible for cleaning the portion of the sewer that travelled through their property, and established a Commission of Sewers to enforce this regulation.

However, it was not until 1668 that London's oldest proper sewer was constructed at Ludgate Hill. It was originally an open channel, large enough to be used by boats, but was covered in 1732. More sewers were built in the early 1700s, and were typically constructed from natural watercourses.

Yet, these were primarily used for stormwater, and most homes still relied on cesspools. For those living in the houses that lined London Bridge, a simpler option was available – simply dropping their waste straight into the river.

Bazalgette's brilliant scheme

During the first half of the nineteenth century, London more than doubled in size as the industrial revolution led to the elevation of the British Empire and its capital led the world. Yet no new wastewater infrastructure was developed. As a result, the Thames effectively became an open sewer, and thousands of Londoners perished in devastating cholera epidemics.

Renewing London's Victorian water mains Leicester Square.

At the time, it was widely believed that cholera was spread by the smell of sewage, known as the 'miasma'. Hence, health officials argued that removing the source of the stench was an urgent imperative.

However, what stirred the government into action was not the deaths in the slums, but the Great Stink of 1858, in which the Houses of Parliament, located on the banks of the Thames, were infected with the noxious stench that had enveloped the city.

After being forced to endure the Great Stink, Parliament assigned Joseph Bazalgette, Chief Engineer of the Metropolitan Board of Works, £3 million [approximately £2 billion in today's money] to enact his innovative scheme to remove wastewater from London. Bazalgette planned to build new sewers to intercept the existing drains before they hit the Thames, then, relying on gravity, these sewers would transport wastewater down the Thames Valley. At Crossness, the sewage would be pumped back to ground level, before being dumped at sea during high tide.

Cleaning the ring main.

Between 1859 and 1865, nearly 18,000 km of sewers were installed, using 318 million bricks. Most of the tunnels were constructed using cut and cover techniques, although mining was also used in some sections.

The tunnels were designed with an oval shape, which provided added strength and created an uninterrupted flow, and constructed using Portland cement, a new material with the durability required to withstand the weight of London.

Also, displaying great foresight, Bazalgette built the sewers with an extra 60 per cent capacity to account for future growth.

Early tunnelling

As well as being the site of one of the first modern sewer systems, London also witnessed some early advances in tunnelling, a technology which rapidly advanced in the nineteenth century in response to the demands of industrial development.

The most famous example is the Thames Tunnel, which is still used today for the East London underground. The Tunnel, designed by Marc Brunel and constructed by his son Isambard Kingdom Brunel, was the first use of the tunnelling shield. Like many tunnelling jobs, it was situated not far below the riverbed, and encountered very soft, saturated soils. The tunnel started in 1825, and was opened to the public until 1843.

Marc Brunel's first patent for a tunnel shield was in 1818, and is the basis of modern open shields, including individual cells or compartments and the use of hydraulic jacks. He originally conceived using a large circular shield, but due to manufacturing problems Brunel developed a rectangular shield in 1823 to drive the large tunnel under the Thames.

British engineers P.W. Barlow and J.H. Greathead obtained a patent on a circular shield in 1864, which introduced major innovations still in use today, including cast iron segments to line the tunnel, compressed air to keep water at bay, and a grouting pan to inject grout into the voids behind the segments.

In 1870 this Shield was used to construct the Tower Subway, the world's first underground tube railway. Previously the tunnels were developed by means of cut and cover. The cable operated train was used as a shuttle service between the two banks of the Thames. Due to poor patronage it was open for less than a year, however many other tunnels constructed at this time remain in operation today.

Bullion and bombs

London's tunnel network has also been the site of several intriguing incidents in the city's history.

In 1836, the Bank of England vault was accidentally infiltrated by a sewer-worker engaged in repairs. Although he could have easily carried away a fortune in bullion, this upright citizen instead informed the Bank Directors of the security breach. As his story was initially doubted, the man arranged to meet the Directors in the vault one evening, and dramatically emerged from under the floorboards. For his honesty, the Bank rewarded him with £800.

London tunnels also became a centre of activity during World War II. The War Rooms, constructed as a bunker originally covered three acres and came into operation in 1939. The centrepiece of the War Rooms is the Cabinet Room itself, Winston Churchill and the War Cabinet used the underground network to conduct more than 100 meetings up until the end of the war.

Underground constructions such as railway stations were used during World War II as air raid shelters. In 1942, during the London blitz, an underground refuge known as the Kingsway Tunnels was constructed to provide air-raid shelter for up to 8,000 people, and be used as government headquarters in the event of invasion. However, the tunnels were never used as a shelter for civilians, and towards the end of the war they were taken over by the research and development arm of MI6. After the war the Post Office ran the telephone exchange from the tunnels and now its successor, BT, has put them up for sale.

Twenty-first century London

Today, Londoners enjoy a first class water and wastewater system, that enjoys the benefits of innovative Trenchless Technology installation and repair techniques. Dumping sewage in the river and at sea ceased entirely in 1997, and the Thames is once again a healthy waterway, home to fish and waterbirds.

The private company Thames Water is now responsible for managing this underground infrastructure, and currently supplies 8.5 million residents with drinking water, and removes sewage for 13.6 million customers in London and the Thames Valley.

**Images courtesy of Thames Water*

Checking for underground leaks outside Parliament.

Sweet home Chicago

Trenchless International **magazine was in attendance at the NASTT's 2010 No-Dig Conference and Exhibition. The event was held in Chicago from 2–7 May and celebrated the 20th Anniversary of the NASTT.**

THE 2010 EVENT brought together attendees from North America and across the globe, offering a technical program and an exhibition hall featuring all the latest trenchless products and services.

The NASTT's No-Dig Show Kick-Off Breakfast, sponsored by *Trenchless International* magazine and Kenny Constructions, featured the musical and comedic stylings of Tim Cavanaugh. Trenchless industry expert Keith Hanks received the 2010 Trenchless Technology Person of the Year Award.

The technical program featured over 135 technical papers on five-concurrent tracks. Delegates rose early to take advantage of the educational opportunities afforded by the comprehensive program.

The Exhibition Hall was officially opened by Program Chair Mark Hallett, together with the program committee. The ribbon cutting was followed by celebratory champagne and cake in honour of the NASTT's twenty year milestone.

Companies from North America and abroad, offering trenchless products and services, exhibited to hundreds of delegates and visitors. Machinery large and small was on display, together with demonstrations, pop corn and a race car!

The well-attended Gala Dinner afforded the opportunity to recognise the five founding members of the NASTT, Stephen Cordes, Norman Sirma, Richard Thomasson, Tom Iseley and the late Michael Argent.

A special addition to the Gala Awards dinner was the Trent Ralston Award for Young Trenchless Achievement. The award was presented to Professor Jason Lueke from Arizona University. The late Trent Ralston's family were present for the presentation of the award.

Given the success of the No-Dig 2010, anticipation is already mounting for the 2011 NASTT No-Dig event, to be held in Washington D.C. from 27–31 March.


The 2010 Chicago Exhibition No-Dig is officially opened.

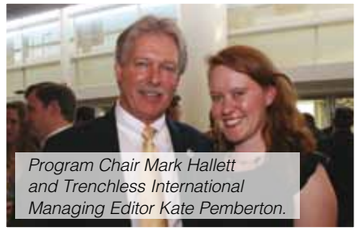

Dr Sam Ariaratnam, Chris Bland, Derek Choi & Jim and Janette Rankin.


Rob McKim, Joe Barsoom, Tom Iseley and Ray Sterling.


Happy 20th Anniversary NASTT!

NASTT Founding Members - Stephen Cordes, Tom Iseley, Norman Sirma and Richard Thomasson.


Leonard Ingram assists comedian Tim Cavanaugh.


Program Chair Mark Hallett and Trenchless International Managing Editor Kate Pemberton.


Winner of the Trent Ralston Award for Young Trenchless Achievement Professor Jason Lueke and Recipient of NASTT Chairman's Award for Outstanding Lifetime Service Marlin O. Gonzales.


George Ragula, Dave Krywiak and Dr Samuel Ariaratnam.


NASTT Student Chapter representatives.


David Entringer and Joanne Hughes.


Jack Burnam, Chris Brahler and Keith Hanks.

Trenchless on display.

The canon of drilling fluid

Frank Canon, guru of the industry and Baroid Industrial Drilling Products representative, recently found time to chat with *Trenchless International* about his experience in the industry and his vision for the future.

FRANK IS A widely known figure within the drilling industry, and has over 35 years experience in oilfield, water well, HDD, tunnelling, microtunnelling, auger boring and foundations drilling.

In 1999 he was named the North American Trenchless Technology person of the year, and he also sat on the NASTT Board of Directors from 2001–2005.

Given his wealth of knowledge and engaging presentation style, Frank spends much of his time delivering training to members of the industry, and conducts approximately 40 seminars each year.

Frank is passionate about the importance of ongoing education, particularly given the number of new recruits that have entered the industry in the last decade.

"The more training we can do the better it is for the industry in general." However, he observes that "I don't think we've been doing quite as much training as we did in the earlier days."

In particular, Frank emphasised the importance of keeping engineers responsible for writing project specifications aware of the capabilities of key equipment.

NASTT Program Chair Mark Hallett thanks Baroid for donating to the Education Fund Auction.

"I think it's very nice to see the engineers come out and learn about the industry that they are writing specifications for."

At a recent Vermeer Maxi Rig Seminar, he spoke on drilling fluids, the interaction between fluids and soils, and recycling procedures.

Frank says that drilling fluids play an important role in the success of HDD projects. "It's with the use of fluids that we have lubricity at the hole, reduce friction, stabilise the borehole. Then after the fluid has been injected the bentonite can turn into a grout like substance. Drilling fluid can also work as a coolant for the transmitters and provide soil stabilisation so we can maintain an open hole."

Frank also spoke about the change he has witnessed over his years in the industry, due to improvements in technology and the manufacture of ever larger equipment.

"I feel sorry for the guys who are coming into the HDD industry today, as they have not witnessed the evolution of the equipment, especially the mixing equipment we had to work with," he said.

"In the early 1990s, what we have today would have seemed like science fiction. In the early days, to mix one sack of bentonite, it would take up to half an hour. Today you are talking less than five minutes."

Another advance in the technology has been automatic drill pipe loading.

"When I first got started with HDD, I'd go out to a jobsite to work with someone and they always seemed to be shorthanded, I always wound up hand racking the drill pipe. Now most drill rigs have automatic rod loaders.

> What we have today would have seemed like science fiction in the early 1990s.

Frank Canon and Rene Albert.

Drill accuracy has also increased. "In the early days it was a sort of 'poke and hope', and now there is a lot more science involved."

"It will be interesting to see if the equipment we have 15 years from now makes such advances as seen in the previous 15 years."

Not only have improvements in technology advanced the industry as a whole, they have also contributed to the success of Baroid.

Frank says that the improvements in drilling fluid and locating systems are important to the respect the company enjoys, and also cites "the tooling improvements that we've seen in the previous 20 years" as an important achievement.

One of the other key changes has been the increasing size of rigs. "I remember when a mid-size rig used to be a 25,000 pound rig, and now it's up around 100,000 pounds.

"The maxi rigs are just amazing. And that's the way that the industry is going now, it's to the larger and larger rigs."

These machines can tackle increasingly complex drives with larger product lines over longer distances.

"I remember back in the early 1990s at the UCT show in Houston there was a panel discussion on 'is the 10,000 ft bore feasible?' and now it's been done."

The longest drive that Frank has ever been involved with was approximately 30 feet over one mile in south Texas.

One of the most interesting jobs was "island hopping in Venice, Italy." The project involved the installation of electric lines to power tidal power gates.

Frank has worked in temperatures from minus 30 to over 50 degrees Celsius. He says that getting to travel and meet a diverse mix of people are some of the most enjoyable aspects of his job.

"It's really amazing that a driller in Australia has the same concerns as a driller in Russia, who has the same concerns as a driller in Louisiana in the States.

"It's interesting to see some of these guys at the international shows get together and start comparing notes. It's funny – when you see a group of people from the rigs together. If you know that one of them is a locator, they are usually all locators. If you see a mud-mixing guy, they're usually all mud mixing guys.

When questioned, Frank was optimistic about the future of the industry, despite the economic challenges of the past few years.

"HDD is coming into its maturity, and it's more and more widely accepted as an installation process, and it's a fairly green process. We can do it with only causing minor disruptions."

Conserving Caribbean coasts with HDD

The National Gas Company of Trinidad and Tobago is using horizontal directional drilling to protect the shoreline in the construction of a new offshore gas pipeline.

THE NORTH – Eastern Offshore (NEO) pipeline will transport natural gas from the Angostura Field, located off the north-east coast of Trinidad, to the New Abyssinia Accumulator Station, then on to the existing Trinidad and Tobago gas distribution network.

The 93.5 km, 36 inch diameter pipeline will be composed of an 83 km offshore section, running from the BHP Billiton Gas Export Platform (GEP), currently under construction in the Angostura Field, to landfall at Mayaro Bay. It will also include a 10.5 km onshore section that will traverse the remaining distance to the Accumulator Station.

This pipeline is intended to open access to a new field where there is no gas pipeline infrastructure, and also creates an opportunity to develop other marginal gas fields, as it lowers the infrastructure development cost for other players.

The National Gas Company (NGC), which is wholly owned by the Government of Trinidad and Tobago, has been responsible for the construction of the pipeline. Meanwhile, BHP will construct the platform and its associated pipeline infrastructure.

HDD will be used to install the landfall section of the pipe, to prevent cutting through the coastline and thereby minimise disruption to this sensitive environment. In addition, only water-based environmentally-friendly bentonite will be used.

The laying of the HDD pipe string began in late 2009, and since then directional drilling work has been conducted on a 24 hour basis. According to Assistant Project Manager Gayapersad Beharry, HDD has been successfully used to install a 1.25 km section of 12 inch pipe, and work on a second 36 inch HDD installation is currently underway. Progress on this 1.65 km section has been facing some challenges, but Mr Beharry is confident that these will soon be overcome.

Work on the onshore segment was started in January 2010 and should be completed by August, while offshore pipe installation began in April. The NGC has imported 8,054 lengths of pipe for the project from India, and the sections to be installed underwater have been concrete coated to ensure the stability of the pipeline on the seabed and offer protection from third party damage.

It is intended that the entire pipeline will be commissioned by early 2011.

HDD drills Tunisian sands

Directional drilling is making inroads in Africa. In Tunisia, one of the country's largest contractors has purchased a rig to lay pipe in the capital Tunis.

TUNISIA IS THE northern most country in Africa; the nation is bordered by the Mediterranean Sea, Libya and Algeria.

Bouchamaoui Industries is one of the largest contractors in the country. One of the company's major activities is pipe laying, and it recently increased its fleet with the purchase of HDD machine TERRA-JET 5415 S.

The first training bore was 84 m (275 ft) long and took place in highly compacted sand. A HDPE pipe OD 315 mm (12 inch) had to be pulled in nearby a petrol refinery.

Pilot bore

The pilot bore was achieved in approximately three hours. With a drill depth of 2.2 m, the locating of the drill head was easy to perform and the drill head reached the arrival pit on target.

Backreaming and pipe pulling

Due to the high compaction of the sand, the backreaming was done in two steps. The first intermediate reaming was 260 mm (10 inch) in diameter, and the second reaming was 360 mm (14 inch) in diameter. The bentonite of the local producer Sofap proved appropriate for the compacted ground conditions. "The ADBS of the TERRA-JET 5415 S made the back reaming relaxing for the operator," said the company.

The company also said that this patented system automatically and within milliseconds adjusts the working speed of the drill to suit the ground conditions. In soft ground the drill operates at maximum speed, while in hard ground it moves more slowly. If the drill head hits an unexpected obstacle, the ADBS reduces the drilling speed immediately and automatically drills very slowly through the obstacle.

Machine technology

The TERRA-JET 5415 S may drill directional bores up to 200 m (660 ft) long and 520 mm (20 inch) in diameter, depending on ground conditions. Torque and pullback force are produced by separate hydraulic circuits, allowing the maximum torque of 5,400 Nm (4,000 ft. lbs) and the maximum pullback force of 150 kN (15 tonnes, 33,000 lbs) to be used simultaneously under full load.

The drilling fluid volume is 200 litres per minute (53 gpm). The mixing system, responsible for mixing the bentonite into the drilling fluid via an injector (venture hopper), is located on board the HDD machine. This patent removes the need for an extra mixing system and a second engine.

Bouchamaoui decided to purchase their machine without the driver's cabin. They may retrofit the cabin later as it can be assembled within a few hours. The operator sits in a comfortable seat, which can be adjusted to suit the body shape and weight of the operator. The seat can also rotate, allowing the operator to face the drilling or observe the drilling machine.

Owner of Bouchamaoui, Raouf Bouchamaoui and Technical Director Farhat Foued said that they were quite satisfied with the performance of the TERRA-JET 5415 S and their team.

The TERRA-JET 5415 S drives into the starting position nearby the refinery. It is driven by its two joy sticks.

The machine is ready to operate.

The pilot bore begins.

Durban water pipe replacement project nears completion

In October 2009, *Trenchless International* reported on the use of pipe cracking in the eThekwini Municipality Asbestos Cement (AC) Pipe Replacement Project in Durban, South Africa. Now, as this three-year project nears completion, we provide an update.

THE $US205 MILLION Asbestos Cement (AC) Pipe Replacement Project is a major scheme to replace 1,750 km of ageing water pipe throughout Durban, a city on the east coast of South Africa and part of the eThekwini Municipality.

Project management was provided by Aurecon, an international engineering and project management company, and work commenced in July 2007. Approximately 60 km of pipe has been laid per month, and so far 1,600 km has been installed. At this rate, the project is on schedule for completion in June 2010.

The ageing asbestos cement water pipes, measuring 160 mm in diameter, are being replaced with modified polyvinyl chloride (mPVC) and high density polyethylene (HDPE) pipe.

"The old pipes were desperately in need of replacement," said eThekwini Project Executive Alan Kee.

"Bursts were occurring on a daily basis and the effective life span of the pipes had come to an end. We had to devise a way to replace the pipes whilst keeping disruption to service to a minimum," he said.

The project has relied heavily on moling and pipe cracking. These technologies were chosen as they are modern, cost-effective and environmentally friendly.

Moling was used in the suburbs of Kingsburgh and Amanzimtoti, and in parts of Hillcrest and Kloof. This process involves using a moling machine to excavate under the existing surface of a road or driveway. The rocket shaped, pneumatically driven machine is placed in a specially prepared launch pit on either side of the road. Then, directed by an internal telescope, the machine digs the required bore.

"As moling helps to minimise the surface excavation required, it is an ideal technology to use on busy roads in built-up areas. It is also useful when working in the suburbs, as the necessity for costly driveway reinstatements is avoided," said Project Manager Jochen Dedekind.

However, moling can only be used in soft soil conditions, and when hard rock is encountered hand excavation is required.

Above: The compact pipe is guided into the mouth of the old asbestos cement (AC) water pipe.
Left: The Netherlands Ambassador to South Africa Rob de Vos broke a shovel to launch the Trenchless Technology pilot program.

Another No-Dig technology, pipe cracking, also known as pipe bursting, was extensively used in the city centre of Durban, where 15,000 m of AC pipe was successfully replaced with HDPE pipe. This process involved shutting down the main to be replaced, excavating and removing a small section of pipe and inserting a hydraulically powered cracking head.

"The head is drawn through the old pipe by means of a winch. As it moves forward, by hydraulic action, it expands and bursts the pipe and at the same time pulls through a new HDPE pipe, of similar or larger dimension," Mr Kee said.

In some cases CCTV cameras were placed into the old pipes prior to pipe cracking to ensure that the new pipe was smoothly pulled through the old AC pipe.

With the project on the verge of completion, the project managers were full of praise for the successful repairs, particularly the use of no-dig techniques.

"eThekwini Municipality is to be commended on the innovative approach taken in combining traditional and trenchless technologies on this massive project," said Mr Dedekind.

Now that the new pipes have been successfully installed, citizens and local government will start reaping the benefits. The new pipes have a fifty year lifespan and should significantly reduce the number of bursts, saving the municipality $US31.8 million per year.

HDD rig in action on the Black Sea shore crossing.

Gold medal for green pipeline

The construction of a gas pipeline to supply 2014 Winter Olympic Games venues is setting new standards for environmental management in Russia, with an innovative use of directional drilling and microtunnelling affording maximum protection for the Black Sea coastal ecosystem.

THE 177 KM Dzhubga – Lazarevskoye – Sochi Pipeline is part of the infrastructure being developed by the Russian Government in preparation for the 2014 Winter Olympics, and is intended to reduce the energy deficiency on the Caucasian coast of the Black Sea. When complete, its transport capacity of 3.8 billion cubic metres per annum (Bcm/a) will ensure gas supply to Olympic venues in the mountain area of Sochi, as well as the many resorts operating in the region.

A large component of the 530 mm diameter pipeline will be offshore, with a 159.9 km section located in the Black Sea approximately 4.5 km from the Dzhubga to Sochi coastline. Landfalls for the pipeline are located in the vicinity of Dzhubga, Novomikhailovka, Tuapse and Kudepsta.

Gazprom will own and operate the pipeline, while Stroygazmontazh has been contracted for construction. Construction work on the Dzhubga – Lazarevskoye – Sochi Pipeline began in September 2009, and is scheduled for completion in June 2010. The construction process has required detailed planning and considerable technical expertise, as the route traverses difficult and varied terrain.

Displaying a drill head used in bore parts of the Dzhubga – Lazarevskoye – Sochi pipeline.

HDD safeguards Black Sea coast

On land, the pipeline must negotiate large changes in elevation and steep rock formations. Accordingly, horizontal directional drilling (HDD) has been used to install the pipeline in these areas.

In addition, the Black Sea coast is part of the Sochi National Park and one of the most carefully conserved ecosystems in Russia. To avoid harming local wildlife, pipeline installation was scheduled to take into account the life cycle of native fauna. HDD was used to install the shore approaches near Tuapse and Kudepsta, further minimising disruption to this fragile coastal environment. According to a Gazprom spokesperson, this is the first time that HDD has been used in a shore approach in Russia.

Manoeuvring pipe into place.

The use of HDD not only helped preserve the coastal ecosystem, but also allowed the pipe to negotiate the steep coastal cliffs. While ultimately successful, engineers working on this process were forced to use innovation to overcome a serious technical challenge.

A Gazprom spokesperson said "During directional drilling, the construction team faced the problem of mud disappearing into natural cavities or 'voids' in the rocks. The team found a way out by filling the voids with a cement-concrete solution. After solidification, drilling was able to continue."

In addition to HDD, microtunnelling was used to install the pipeline at all river crossings, which offered further environmental protection.

The decision to construct a gas pipeline on the seabed will also reduce the need for construction on industrial, agricultural and forest lands. While making the project more expensive, these various environmental protection measures were considered by Gazprom to be more than worthwhile, and a company spokesperson was able to report that all works were conducted without impacting the surrounding landscape.

Drilling know-how comes down under

Leading international trenchless firms Vermeer, Baroid Industrial Drilling Products and Prime Horizontal joined forces in May to tour the Maxi HDD Rig Training Seminar along the east coast of Australia.

BEGINNING IN THE harbour city of Sydney on 17–18 May, the seminar then travelled south to Melbourne on the 24–25 May, before finishing up in beach-side Brisbane on 26–27.

The seminar offered advanced technical training for experienced members of the industry. Speakers included Baroid Senior Account Representative Frank Canon, Vermeer Global Trenchless Support Manager Rene Albert, and Prime Horizontal Company President John Teer.

These three have a wealth of experience in the HDD and drilling industry, and were keen to share their expertise with younger engineers.

Rene stressed the importance of providing advanced training on HDD. "Sixty per cent of the project is preparation, and that can only come if you are properly trained. That's what we try to provide.

"We focus this week specifically with the engineering requirements – what do you need to consider when installing large pipes by means of HDD? And that ranges from machine selection, to pipes stresses, to drilling principles, hole sizes, and hydraulics."

Day 1 began with Rene testing participants on the basic requirements of HDD pipe installation, and providing a general outline on HDD principles. Next, Frank assumed the podium, and offered several in-depth sessions on drilling fluids. The afternoon was capped off with a session on product stresses delivered by Rene, before John shared his expertise on MWD navigation.

Day 2 offered another full and stimulating schedule of sessions. The morning kicked off with Rene leading sessions on rig capabilities and estimated pull-back force, then Frank and Rene joined forces to talk on the general principles of recycling. Rene then discussed large rig jobsite, before John led a session on intersect drilling. The day finished with a case presentation of an actual project, delivered by a different local contractor in each city.

Vermeer's Maxi Rig.

However, time wasn't only spent in the classroom, and there were plenty on breaks throughout each day, and a dinner after Day 1, for participants to socialise and network.

This was the first time the seminars had been conducted in Australia, and Rene confessed that he was a little apprehensive about speaking to local audiences.

"When I got into this business, the first book I ever read on drilling was the *Australian Drillers Guide*, so I was very nervous coming here. Because I read the book, and thought these guys must know a lot about HDD, we were all very well prepared and ready to answer any questions that might be here."

Fortunately, his high expectations of Australian drilling expertise were not disappointed.

"The first day in most cases is silent, but then on the second day they open up and ask a lot of good, detailed questions. So it has been fun to date."

Rene also cited Australia as one of the most dynamic regions in the trenchless industry and a possible market for future maxi rig sales.

"We were successful this year in selling a few rigs in China, a few rigs in the US, and based on what we see here we think we will probably sell one or two in this area as well."

However, he emphasised that the seminar event was about education rather than advertising.

"The target of this course is not to talk about the equipment, so we really refrain from making any promotion for the Vermeer line of maxi rigs. But, what I can tell you is we build maxi rig equipment between 150 and 600 metric tonnes, capable of drilling holes up to 1.8 m in diameter, and 2.5 km long."

Rene was also quietly optimistic about the future of the industry, foreseeing that conditions will remain constant, with growth in some areas.

"The market for machines will go steady, with slight growth in maxi rigs because of the natural gas and all the gasification projects going on around the world. There is a trend to geothermal and a trend to coal seam gas, so we move in that direction."

Advanced pipeline systems inspection and monitoring developments

One of the keynote speakers at the Trenchless Technologies in Asia Pacific Hong Kong 2009 conference was Professor Lucio Soibelman from the Civil and Environmental Engineering Department at Carnegie Mellon University. His talk introduced Carnegie's Mellon Civil and Environmental Engineering Department Advanced Infrastructure Systems (AIS) Group vision and presented an overview of three AIS pipeline related research efforts.

THESE RESEARCH EFFORTS included one that uses advanced computer vision to classify sewer inspection data acquired by robotic equipment, one that developed advanced geospatial data mining tools to support water distribution system pipe management, and one that is developing and testing new sensor monitoring systems for gas pipelines.

Intelligent inspection

Professor Soibelman first described the Carnegie Mellon University Civil and Environmental Engineering Department AIS group's vision. According to this vision infrastructure systems and the processes to design, build, and operate those systems must become intelligent, able to continuously determine their conditions, perform self-assessment and support proactive decision making that improves their performances, increases their life spans and reduces life-cycle costs and impacts. This is a vision of data-driven intelligent decision making about, and in some cases by, infrastructure systems, subsystems and components. The data is collected at different times and frequencies from sensors of different types, modalities (including humans) and accuracies. These sensors have been rationally selected and placed to best support the collection of data that will be needed over the entire life-cycle of the system. Those data are effortlessly collected, modeled, analysed, mined and transformed into useful information about the condition and behaviour of the system.

The information derived from these data continually informs intelligent decision making within the processes that make up the life-cycle of the system. In fact, the information not only influences the operation of a specific system, but goes on to influence the design of the future generations of designs. Such a vision requires research and development in the areas of sensors, data modelling and analysis, simulation, decision support, visualisation and human-computer interfaces, to name but a few of the issues that need to be addressed to deliver this vision. Research that places these ICT systems into realistic large-scale test beds and evaluates their performance is critically needed. Research is also needed to help understand where ICT is most effectively being deployed in practice and leading to clear economic benefit.

Some of this needed research is being conducted by the AIS group at Carnegie Mellon in clusters of research related to sensor development, mobile/wearable computer systems for infrastructure-oriented data collection applications, advanced data modelling and management tools to improve classification and retrieval of the ever increasing amount of data generated by new data acquisition tools, novel data mining and analysis tools, system level approaches for using combinations of sensors, data analysis, and advanced reasoning.

Professor Soibelman introduced research being conducted that aims to support regularly and proactively assess conditions of sewer infrastructure systems to ensure their structural integrity and continuity of services. This research is a critical step to advance the state of automated pipeline inspection and condition assessment. Currently, a critical issue is to address realistic defect detection that deals with real sewer inspection data. In his presentation Professor Soibelman introduced the findings of a research project that seeks to enable automated detection of defects in sewer pipelines from inspection videos and images acquired by robotic equipment. The need for and the challenges of automated defect detection in sewer infrastructure condition monitoring were presented. Based on a general detection and recognition model established in this research, a change detection based approach, which is tailored to solve the challenges in the sewer pipeline domain, was presented and illustrated through case study.

To process effectively the large volumes of visual data collected by the robot's optical sensor during inspection of the internal pipe wall surface this research proposed a multilayer approach for automated defect detection and recognition of pipeline defects.

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In the first process block "Detector", the model flags regions of interest (ROIs), such as problematic areas and/or critical pipe patterns in the images. Each of these flagged ROIs is input to a "1st level classifier" that broadly recognises it as a false alarm or as a defect. The defect is then input to a second level classifier that further discriminates it from among several different defects, for example: a crack, a fracture, roots, corrosion, or a lining failure. The defect, such as a crack, can still be input to a classifier at the next level that determines if it is a horizontal or spiral crack. A final classifier may determine the degree of relevancy of the defect, for example, 'immediate attention,' 'further monitoring,' or 'safe to ignore'. This automated defect detection and recognition capability can facilitate robotic intelligence and multi-sensor based pipe inspection by locating and framing ROIs, and recognising the framed ROIs as true defects or false alarms (non-defects). Then, based upon the flagged ROIs and detection results, the intelligent crawler can make further intelligent decisions, for example:

1

Call for further sensing or other actions automatically. For example, if a true defect is detected, videos or images of higher quality could be recorded for subsequent maintenance decision support; or other inspection sensors could be started up to acquire appropriate inspection data.

2

Guide further analysis for target recognition. For example, according to a municipal authority's need for inspection, a particular need is to identify and quantitatively measure extents of corrosion within a certain pipe segment. An automatically detected defect can be further classified as "corrosion" or "non-corrosion". If corrosion has been recognised, a laser scanner could be further used to acquire data so that a quantitative measurement is conducted. Hence, the municipality's need for identifying and quantitatively measuring extents of corrosion can be achieved automatically.

Geospatial analysis

The second research introduced by Professor Soibelman was research that is supporting the development of advanced geospatial data mining tools introducing an example of breakage analysis for water distribution systems. On a macro scale, the spatial analysis of failure data might provide insights on physical condition trends present in a physical network system. On the one hand, sensing specific pipes can provide information about their individual condition, just like medical exams provide diagnosis of the health of individuals. On the other hand, spatial analysis aims to provide information about the condition of a population of assets, for instance pipes, much like the work of epidemiologist identifying outbreak of diseases in a country or state. One example of interesting trends in spatially referenced failure data is the presence of clusters of failures in space, for example sets of failures that are close to each other.

Such clusters might be indicators that some underlying and possibly unknown common cause might exist. By using a detection of cluster approach that is specific for the case of failure in physical network systems, we identified critical areas in a water distribution system. Pipe breakage data was used in such research. However, in principle, any measure of pipe condition can be used to the identification of abnormal patterns in the systems. Therefore, as monitoring systems become widespread, better data can be used to perform system wide spatial analysis of failure in network systems. After detecting such clusters, the factors associated with failures have been analysed to in order to identify possible causes and guide future decision in replacement and design. In an ongoing work, several data mining approaches, which address the specific challenges that spatially referenced data, have been used in order to identify interesting attributes associated with water pipe clusters.

Structural health case study

Finally Professor Soibelman introduced a project that is evaluating technologies for the monitoring of gas pipeline delivery integrity, through a ubiquitous network of sensors and controllers to detect and diagnose incipient defects, leaks, and failures. Structural health monitoring of buried pipelines is of vital importance as infrastructures age. Ultrasonic guided waves are a popular method for inspecting buried pipes, due to their potential for long propagation. Unfortunately, the large number of wave modes present, and the effects of dispersion in a pipeline make analysis of the received signals difficult. He presented preliminary results of tests that were developed to assess the capability of Lead Zirconate Titanate (PZT) wafers to fully illuminate a pipe presenting data that shows rich illumination proving that a single PZT wafer can illuminate the circumference of pipes with sufficient energy for defect detection, localisation, and classification. The output of this illumination clearly shows multiple modes and multiple path information illuminating the pipe.

He then introduced a Time Reversal Acoustics methodology that is being developed to support a focusing approach that increases with a greater number of wave modes and a greater degree of dispersion supporting defect detection and localisation. The use of Time Reversal Acoustics to compensate for these complex signals, and improve performance for the detection of faults in a pipeline shows a potential for a reduction in the power and hardware requirements of fault detection systems creating the possibility of the development and application of those systems for pipeline monitoring and not just for inspection.

Professor Soibelman introduced research being conducted that aims to support regularly and proactively assess conditions of sewer infrastructure systems to ensure their structural integrity and continuity of services.

Workers with microtunnelling equipment on the North Side District Cooling project.

Inspection and rehabilitation of a deep, high flowing large diameter sewer

by Kevin Bainbridge from City of Hamilton and David Crowder and Gerald Bauer from R.V. Anderson Associates Limited.

Inspection and condition is a challenging component of any rehabilitation program. In Canada one project team developed innovative planning and specialised equipment to achieve a positive outcome for the city of Hamilton, Ontario.

The City of Hamilton, located 70 km west of Toronto, owns, operates, and maintains a large underground network of sewers. Three separate large diameter combined sewer systems (The Eastern Sanitary Interceptor, The Western Sanitary Interceptor, and the Red Hill Trunk Sewer) collect combined storm and sanitary flows from the City's vast sewer network and conveys them through these above sewers to Hamilton's only treatment plant – the Woodward Avenue Wastewater Treatment Plant.

The City's Asset Management Group, with a mandate to carry out sewer inspections, determine rehabilitation needs, and manage the entire sewer system, has deemed that large diameter combined trunk sewers, as 'Critical Assets', have a zero tolerance for failure.

The Western Sanitary Interceptor (WSI) CSO is a hand mined sanitary sewer tunnel that collects and conveys more than 35 per cent of the city's total sewage flow from outlying suburbs; winds its way underground through heavily populated and environmentally sensitive areas in the western core of the City.

Accurate condition assessments of large diameter, deep, high-flowing interceptors remain one of the most significant challenges facing Hamilton's Asset Management Group. In 1998, the City commissioned a combined CCTV/Sonar inspection of the WSI. Of the 15 km stretch, approximately 1.5 km was strategically selected for inspection. A 270 m segment of the inspected sewer running under Locke Street, from York Boulevard to Barton Street (a heavily populated area) showed significant cracking and infiltration.

This particular segment of sewer is approximately 28 m deep, has an internal diameter of 1,525 mm and is located within 1 km of Hamilton Harbor, which is an environmentally sensitive area that would be greatly affected by discharges resulting from a sewer failure. Given the criticality of this sewer, the City had deemed it to have a zero tolerance for failure, and as such, a proactive management strategy and intervention practice was implemented.

Building the team

Due to the extreme depth, consistent high flow, and limited access, it was determined that the inspection and rehabilitation of this 270 m long sewer segment would be a difficult process, and would have to be undertaken in several phases. It would require a team with diverse skills and extensive experience in Trenchless Technology, sewer rehabilitation, and confined space entry procedures who could work together as an integrated and cohesive unit.

This team was made up of the City of Hamilton Engineering Services Group, who are leaders in the industry in assessing and determining the need to rehabilitate their critical infrastructure, and R.V. Anderson Associates Limited (RVA), who have worked closely with the City to rehabilitate and replace its underground services for nearly a decade. The team also included PipeFlo Contracting Corp. (PipeFlo), who are the local expert in confined space entry and deep sewer inspection and have significant experience working on the City's sewer system.

As a result of the team's combined effort, an approach was developed to address a number of challenges that expanded the project's complexity far beyond a typical sewer rehabilitation project.

Project objectives

The ultimate goal of this project was to undertake a thorough investigation to determine the scope of rehabilitation that would be required for the section of sewer identified in the 1998 CCTV/Sonar report as having significant cracking and infiltration problems.

The complexity of this project demanded a lengthy planning period to ensure that the project could be executed safely and successfully. A significant portion of the two-year planning phase was spent developing contractor pre-qualification documents that would address the significant risks associated with undertaking this work.

These included: working around scheduling limitations due to rain events and their effect on the sewer's flows, the anticipated hazardous working environment within the sewer, and the operational/management challenges inherent in coordinating project activities.

Once the pre-qualification documents were created, a public expression of interest (EOI) was issued by the City to be responded to by all and any interested parties. Upon completion of the EOI, two contractors were prequalified to bid. Upon review of the subsequent bid submissions received by the City, the contract was awarded to PipeFlo, and Phase One of the project was initiated.

In order to carry-out continuous man-entry inspections for a deep high-flowing large diameter sewer, a number of activities needed to be addressed including safety documents and training, manhole modifications

Team planning and project planning

In order to carry-out continuous man-entry inspections for a deep high-flowing large diameter sewer, a number of activities needed to be addressed.

Safety documents and training

Due to the nature of the environment within pipe, extensive safety procedures were documented and training was undertaken for all team members, including confined space entry, fall arrest, specialised equipment, and mock rescue scenarios.

Manhole modification

Two existing manhole shafts were modified to provide access for workers and equipment during detailed inspection and rehabilitation. The work included removing the top 3 m cone section of both manholes, and removing existing ladders and safety platforms. Modifications also included installing a temporary shaft extension (for equipment access), which was subsequently replaced with a continuous concrete shaft extension to street level and installing a large, custom, rectangular shaped manhole cover to accommodate future maintenance.

A temporary scaffold 'man-lift' was set up over one of the shafts to lower personnel and equipment into the sewer.

Flow diversion plan

During the initial planning stage, it was identified that a large portion of the flow could be diverted temporarily into a nearby CSO tank (the City's Main-King CSO) in order to allow for person-entry inspections during low flow periods and to eliminate the need for an expensive mechanical bypass.

The team developed and implemented a detailed flow diversion plan and lock out procedure, while an access road was constructed to one of several flow diversion chambers located in a remote valley underneath a highway overpass.

Strategy and logistics planning

Creation of the Execution Documents was undertaken as a team effort between RVA, PipeFlo and City of Hamilton Operational staff. The team had to determine the limitations, characteristics and logistics of diverting the flow to the Main-King CSO Tank in a safe and effective manner, and develop lockout procedures and an overall plan for the completion of the work. Because the pipe involved two 45-degree bends, special consideration had to be made for the use of equipment and the safety of man-entry.

Creation of MAThW Vehicle

To assist the technicians working in a 1,524 mm diameter sewer, PipeFlo designed and built a Modular Apparatus Three-Wheeled (MAThW) vehicle that would carry various types of equipment and would be used for the third phase of cleaning as well as during the grouting operations. The MAThW would also have enough space for two technicians to sit and operate the equipment in relative comfort. A replica segment of the pipe was set up in PipeFlo's equipment yard in order to allow the team to practice using the MAThW vehicle and fine tune its construction.

Dry run practice

A full scale dry run operation was undertaken in order to confirm and evaluate PipeFlo Contracting's ability to safely lower and raise both man and equipment down the 28 m deep manhole shaft. This dry run was monitored by team members from the City/RVA and by an outside safety consultant. The results of the dry run were reviewed in a post dry run debrief meeting. Minor issues that were identified during the dry run were addressed at the meeting and solutions were implemented into PipeFlo's confined space entry and rescue plan.

Sewer cleaning operations

Heavy debris cleaning was required prior to carrying out the inspection and rehabilitation work. As standard cleaning operations would not be effective due to the depth of the sewer and high flow levels, specialised equipment was created to suit the required depth, flow and distance.

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The cleaning was completed in three stages:

1. Heavy debris cleaning – A specialised high velocity nozzle head was used to flush heavy debris, which was then removed using a custom-made air assist vacuum tube to lift it to the surface for disposal.
2. Man entry for calcite cleaning – A man entry team manually removed calcite deposits from the pipe walls.
3. Spray cleaning – the MAThW vehicle was lowered in to the sewer to spray the pipe walls using a custom made arm with rotating spray nozzles to further clean the pipe wall.

Man-entry inspections

Once the cleaning was complete, the inspection of the sewer-Phase II of the project could proceed. Initially, the City planned only to conduct an inspection to verify data from the 1998 report; however, the City decided to include an assessment of the sewer's structural integrity as well.

This included exploration of:

- Pipe wall thickness and concrete strength verification – concrete cores were extracted from the pipe walls inside the sewer to confirm concrete thickness and strength.
- External void detection – Ground Penetrating Radar (GPR) was used to detect voids outside of the pipe walls, the first time this procedure had been undertaken locally.
- Pipe wall void detection – while using GPR to locate external voids, the team discovered voids within the pipe wall as well, likely a result of the concrete pouring practices used in the 1960s when the sewer was constructed. These voids were located and sealed.
- Boreholes – boreholes were drilled from the surface to confirm soil strata around the pipe, and to determine the ground water table level and the hydraulic head that would be present during grouting.
- Groundwater infiltration – water samples were collected from the ongoing infiltration to determine sediment accumulation and rate of ground water infiltration.

The inspections confirmed that debris was entering the pipe, which would require immediate rehabilitation. While the man-entry team completed their inspection, the technicians created a detailed location map for each crack requiring injection and sealing.

Based on the information retrieved from the inspection, PipeFlo made modifications to the MAThW vehicle to accommodate sealing operations, and completed further dry-land training with the replica pipe to ensure that all man-entry team members were proficient in the use of the refitted MAThW vehicle and equipment.

The final phase of the project involved sealing the cracks, which was carried out by several man-entry shifts, using the MAThW vehicle and location map created during the inspection phase.

Project challenges and solutions

To overcome various challenges dealing with deep high-flowing sewers, the project team used a multi-phased planning process prior to the implementation of the project.

Temporary elevator for sewer access.

Manhole modification.

Planning

Putting together a project of this magnitude, the likes of which had never previously been attempted by the City, required the team to think creatively in the planning and development of solutions to overcome challenges as they were identified.

The entire planning process took over two years, given that the team had to work to identify the scope of work required, the operational and communication challenges, and address the risks inherent in the sewer environment.

Contract documents

One main challenge was to determine the specific qualifications required of the contractor in order to carry out the work. Because of the uncertainty surrounding the condition of the sewer and contractor's preparedness to execute the work, the contract itself was structured using a phased approach. This would allow the City to terminate the contract at specific milestones if the working conditions in the sewer were too hazardous, if a significant change in scope was required, or if the contractor could not demonstrate adequate capability to execute the work.

Team development

One of the major factors in the success of this project was the ability of the City, RVA and PipeFlo to communicate efficiently and to work collaboratively towards a common objective. This ensured the effective management of risks associated with undertaking the work.

The focal point of this communication occurred around the use of the City's Main-King CSO tank. In order to establish this communication protocol, a number of meetings were established between team members and stakeholders. Once a communications protocol was established, cross training was implemented to ensure continuity in project implementation.

Diverting flow

In addition to the use of the CSO tank, an inflatable flow-through plug was installed to act as a temporary weir wall in an upstream flow diversion chamber to divert flow away from the CSO tank and to gain additional working time. However there were still a number of conditions that had to be met in order to make use of the CSO Tank:

- The tank had to be dry prior to beginning the shift.
- The team could only fill the tank to approximately 25 per cent of the total capacity. This would reduce the likelihood of overflow should there be any unexpected need for the tank.
- Work could only be done during "dry" weather periods. City staff needed to be able to drain fully the tank before the next rain event, a process that can take up to twelve hours.

To accommodate these conditions, the team developed a 72 hour go/no-go checklist to determine if a shift would be feasible.

Accessibility

There were a number of factors affecting accessibility:

- Depth – at 28 m deep, team members had to undergo specialised training to safely enter/work in the sewer.
- Manholes – manholes had to be modified in order to allow access of equipment and men.
- Pipe configuration – with two 45-degree bends in the pipe, line-of-sight was compromised and special considerations were required with regards to the visual surveillance of the team.

During the planning stage, it was decided that the teams could only enter the pipe up to 150 m before compromising safety due to the risk of tangled ropes, loss of visual surveillance, and difficulty of rescue. This meant that the teams had to complete the setup twice, once from each manhole, to allow work to take place along the entire length of the pipe.

Health and safety

Lockout procedures – under the initially developed lockout procedures, the team members in the pipe were required to hold the keys for the gates and vehicles being used, in order to prevent the accidental opening of the gates.

However, due to the time constraints surrounding the setup, these team members were not able to physically attend to the lockout of the gates, which were 4 km and 1 km away, respectively. A solution was developed where the ground team did the lockout, placed all of the keys in a lockbox and the team in the pipes held the key to the lockbox. This allowed for a safe and secure shift, while conforming to the time restraints that were a part of the entry logistics.

Exhaustion

With a diameter of only 1,525 mm, the sewer was not large enough for a person of average height to stand upright. This meant that two teams were needed to switch out periodically over the eight hour shift in order to avoid exhaustion and physical strain. With the work initially scheduled overnight to take advantage of lower flow levels, crew members had the added challenge of acclimatizing themselves between day and night schedules.

Confined space entry – all team members were required to undergo specialised, advanced confined space entry training. This included vertical and horizontal access rescue training, which involved several field practices, as well as training and certification in the use of Scott air-packs and re-breathers and the use of the military grade communication system employed during the project.

Flow levels – working at night during low flow periods allowed for the maximum reduction of risk to the man-entry teams.

Dry land rescue training.

Developing technology

Working in constant flow and penetrating the sewer to a distance of up to 150 m at a time presented technical challenges for the contractor. As a result, PipeFlo developed innovative equipment to assist the teams in carrying out the work, including the MAThW vehicle that was designed with space for team members to be seated while working, a rotating sprayer unit for pipe wall cleaning and outfitted with containers to carry equipment and grout pumps.

Communication

In order to ensure the safety of the crew below, a live communication link between the command truck and the technicians working in the sewer needed to be established. This included the use of military-quality rescue ropes containing a communication line, which provided a continuous two-way communication between technicians and the command truck through the use of throat microphones and ear pieces.

Simultaneously, a video camera and additional lighting were deployed from a downstream manhole, providing the camera truck with a constant view of the technicians in the pipe, creating a record of the work being done, and providing additional lighting for the team. A wireless system was set up to transmit the visual data 300 m back to the command truck located the upstream manhole, visual and auditory data were monitored simultaneously.

The magnitude of repair to a sewer and the selection of rehabilitation methods are dependent on the pipe size and depth. The deeper the pipe is buried, the greater the degree of difficulty in accessing it for rehabilitation and inspection. However, the consequence of failure of a sanitary sewer resulting in a CSO discharge in to the environment is greater than a storm sewer drain, regardless of size.

Historically, the industry did not use a forward thinking process with regards to the management of critical infrastructure – assets were repaired when they broke, or added when a need became apparent. A proactive approach, like the one adopted by the City of Hamilton, allows for better management and sustainment of assets.

Engineering staff are now understanding and applying broader financial management and governance principles within their organisation, which helps to allocate funding with regards to their infrastructure. This approach defers outright replacement of assets and lowers overall management costs. Benefits of a more proactive approach include:

- Enhanced life expectancy of assets
- Improved risk management
- Improved service level management.

Environmentally, proactive asset management represents a significant contribution to sustainability because of the extension of the life cycle of the asset, and avoidance of the need to expend resources and energy renewing the infrastructure prematurely. It maintains infrastructure in better operating condition, which allows it to properly perform its role in protecting the environment.

Reviewing relining tools and techniques

Relining tools play an increasingly important role within pipe rehabilitation and repair. In this *Trenchless International* feature we preview some new innovations in relining technology, and report on an award-winning relining project carried out by Per Aarsleff. We also take a look at a co-operation agreement between Sekisui and Brandenburger, as well as a new cleaning system developed by Whirlwind.

Extending the life span of underground infrastructure

Throughout the high density urban areas of North America, Asia, Europe and the United Kingdom, water and wastewater systems are largely reliant on pipes that were installed fifty, sixty, or even one hundred years ago. Much of this infrastructure is now ageing rapidly, and councils and water authorities around the world are being faced with the problems of leaks, pipe deterioration, and infiltration from tree roots.

TO ENSURE THE secure supply of drinking water and the efficient removal of sewerage, existing infrastructure must be replaced with more modern and resilient pipes. However, installing new pipes using conventional open cut technology could be an extremely costly option, requiring a huge allocation of funds and manpower, and causing significant disruption to residents and business.

By contrast, relining can be a cost-effective, time-efficient and non-disruptive means to rehabilitate existing underground infrastructure. As demand for relining solutions increases, numerous companies are developing innovative tools and techniques to make this procedure even more effective. Here, we preview some of the latest products on offer from leading relining firms.

Brandenburger

Brandenburger currently offers UV light-curing GFRP liners, with circular profiles of DN 150–1,000 and egg-shaped profiles of 200/300–800/1200. These have wall thickness of 3.5–9.8 mm (UV light-curing), while larger wall thickness are also available with combination curing (light and heat). The liners come in lengths of up to 300 m. The company also offers BlueTec UV light-curing equipment, with different types available to meet various construction site requirements, including comfort, portability, and compactness.

In addition, Brandenburger has also recently released the BB^{plus} liner, which features a smoother and more homogenous surface than conventional liners. This creates a reduced contact surface for the sewage flowing through, meaning that the liner becomes more resistant and long-lasting. Although the BB^{plus} liner is installed under greater pressure than most liners, it still uses the same easy and conventional handling techniques.

In the future, Brandenburger aims to produce liners that are even more efficient to install. A company representative →

said "The key issues in future liner developments will be to make relining products still easier to handle and install, to simplify processes and make them more secure."

Reline America

Reline America is the exclusive North American manufacturer of the Blue-Tek and more abrasive resistant Blue-Tek/AR3 UV GRP-CIPP liners. "These fibreglass technologies have a product life of more than 50 years and offer simple, cost-effective installation," said the company. The seamless, spirally-wound liners are environmentally safe and have a six-month, non-refrigerated shelf-life.

The company also produces Quality-Tracker System installation equipment, and operates an on-site research and development department to constantly develop new trenchless pipe rehabilitation products.

Perma-Liner Industries

Perma-Liner is another firm at the forefront of CIPP technology. It produces a resin that is 100 per cent solids epoxy, with no shrinkage to allow annular space between the host pipe and the new liner, eliminating the chance of roots infiltrating the sewer system. This epoxy resin has a cure time of three hours without using external heat sources.

The liner and resin supplied by Perma-Liner has been shown to exceed the standards of ASTM F-1216-07b CIPP installation and physical property requirements, which specify a minimum lifespan of 50 years.

Aqua-Pipe

Aqua-Pipe is a standalone structural liner that can withstand loads and internal pressures without assistance from the residual strength of the existing pipe.

Aqua-Pipe is made of two circular woven polyester jackets with a watertight polymeric membrane fused to the inner jacket, and can be used to structurally rehabilitate all types of water mains 6–12 inches in diameter. The liner is pulled in place and cured by circulating hot water.

The proprietary epoxy resin has no effect on water and contains no styrene. Cast iron and ductile iron water mains are the most common pipe materials which have been rehabilitated to date, but other material types, including asbestos cement, steel, PVC and concrete, can also be rehabilitated if required.

Sekisui Rib Loc

A project using the Sekisui Rib Loc system has produced the world's largest spirally-wound pipe, weighing in at almost 100 tonnes. Interflow installed the 633 m long liner, 2.4 m in diameter, within a concrete sewer pipe travelling underneath the suburbs of Sydney, Australia. The project was completed by producing an in-situ pipe by spirally winding a composite plastic strip at a fixed diameter within the host pipe – in live flow.

This world-record project has now been selected for display at Sydney's premier science museum, The Powerhouse, where visitors can learn more about relining technology via a video presentation, animation and interactive model.

"We hope that some of the 500,000 visitors that enter the museum each year will be interested by this example of a trenchless solution to a public infrastructure project. Hopefully this exposure will be beneficial for our industry," said Interflow Director of Products and Technical Services Ian Bateman.

Aarsleff Pipe Technologies

Aarsleff Pipe Technologies manufacture and install CIPP linings with felt liners of dimensions up to DN 2,200 mm. In addition, they install glass reinforced liners of dimensions up to DN 1,200 mm, and manufacture glass reinforced pipes for slip lining in dimensions up to DN 3,000 mm.

Since the beginning of 2009, Aarsleff Pipe Technologies has begun curing Aarsleff CIPP Lining using LED light. A company representative said, "For years, light has been applied for many different types of curing processes. However, early on in the development process, we decided to develop an entirely new generation of light that would be more energy-saving and more efficient compared to existing types of light. The result was LED."

The diodes applied in this method are highly efficient, meaning that curing occurs quite quickly, creating environmental and economic benefits. In addition, the equipment involved occupies little space, allowing the renewal of pipes even under very poor access conditions.

At present, Aarsleff Pipe Technologies has three complete LED units, and in the future intends to further develop its LED curing system. The company will also focus upon improving the optimisation of glass reinforced CIPP linings cured with UV light.

Stefan Schikora, Werner Reiner, Holger Zinn and Jacqueline Gruettner.

Sekisui SPR and Brandenburger sales co-operation

German-based trenchless rehabilitation firms Sekisui SPR and Brandenburger have entered into a sales co-operation agreement that will mutually expand their product portfolio and further strengthen their international market position.

PRIOR TO THIS agreement, both companies were facing challenges regarding their position in the rehabilitation market. Sekisui SPR was lacking a light-curing glass fibre liner and was confronted with the choice of either developing its own product or collaborating with a different manufacturer. The market for UV liner is already well covered by established manufacturers and more parties are joining in. In light of this, the decision was made to acquire a partner. According to Sekisui NordiTube Managing Director Werner Reiner, Brandenburger was selected because "it is a pioneer in this field and a technology leader".

Meanwhile, Sekisui was able to expand Brandenburger's range of pipe liners, which were previously limited to a width of DN 1,000. Now, with this co-operation, the company can work in the sewage area of DN 100 up to diameters of 5 m, and for pressure lines ranging from DN 100 to DN 1,000.

Also, with its subsidiary Sekisui Norditube, Sekisui SPR has products for the classic pipe-lining mode, including needled felt and warm water curing. Additionally, the company produces different wound pipe processes, which are especially useful for the rehabilitation of large profiles of different cross-section shapes.

Sekisui was also an attractive business partner for Brandenburger given its experience in international markets, including Germany and France. "In partnering with the global player Sekisui SPR, we see the opportunity to make use of existing sales structures for our product and thereby find improved access to markets in which we were too weakly present," explains Brandenburger Director Holger Zinn.

Representatives from both companies spoke enthusiastically about the agreement. Mr Reiner said "Sekisui SPR and Brandenburger have different product portfolios that complement each other excellently."

Mr Zinn adds "The sales co-operation opens possibilities for both corporations to mutually make use of resources worldwide and to offer the customer a comprehensive program for their specific rehabilitation tasks."

This co-operation benefits the customer by offering a broader range of processes, and a greater network of planners and consultants. The agreement will help rehabilitation companies receive the optimal service for their individual needs, explains Brandenburger Sales Manager Jacqueline Gruettner.

"Tenders are placed on the market with several conduits of different diameters, lengths and conditions. If you can flexibly offer complete solutions with the most suitable process for the individual case, then this also offers advantages for the client," adds Sekisui NordiTube Sales Manager Stefan Schikora.

First responses from customers have been definitely positive, reports Mr Zinn. The new co-operation was presented to an expert audience for the first time at the 8th German Pipe Liner Day in Hanover on 27 April.

CIPP foils Danish rats

by Peter Hjortdal, Århus Vand A/S.

At the SSTT's annual meeting in Bergen, Norway, Århus Vand A/S and the contractor Per Aarsleff A/S won the audience's, as well as the professional jury's, No-Dig award for the most innovative project – the longest CIPP project in Aarhus municipality to date.

IS IT POSSIBLE to carry out CIPP lining by means of the No-Dig method in a 400 m long sewer pipe – with a cross-sectional area of 2 m? When the liner alone weighs 140 tonnes and the pipe system is not suitable for lining?

Yes, it is possible, and the method is also cost-efficient. This was the good news from Århus Vand A/S in Denmark. In mid-March 2010, following nine weeks work, Århus Vand A/S could, in co-operation with the Danish engineering contractor Per Aarsleff A/S, admit water back into the 400 m long sewer pipe after a well-executed renewal. The sewer pipe was situated below a large sports centre and the lining operation was completed without disturbing one blade of grass on the playing fields.

Project background

The playing fields at Viby Stadium in Aarhus have been severely plagued by rats running freely both above and below ground. The rats have gnawed their way through the existing sewer pipe and all the way up to the playing fields, and in some places, the fields have been undermined by the rats' activities. The legislation governing such matters is clear – the sewer pipe had to be renewed. The pipeline runs beneath two playing fields, an athletics field and the sports centre buildings. The project is the biggest CIPP lining project so far in Aarhus. Århus Vand A/S and Aarsleff have, in co-operation, found a new and unconventional way for this lining project to be completed within the old sewer system while accounting for the difficult circumstances.

The pipe system is a difficult cross sectional shape and not particularly suitable for CIPP lining. CCTV inspection clearly revealed that conditions were excellent for rats due to the existing flat benches in the geometry of the pipe. So the geometry of the old sewer pipe had to be converted. However, the football fields in Aarhus are very precious and a section of the pipe is, as mentioned, situated below a sports centre. Therefore, the solution was No-Dig to avoid excavation in the fields and the large cost of diverting the pipe away from beneath the buildings.

To complete the project, the companies had to think unconventionally.

Project data

- 140 tonnes of liner
- 42 mm thick liner
- 2 m square cross section of sewer pipe
- Minimisation of social costs Minimal disturbance to local residents
- Rat elimination
- High focus on occupational health and safety issues
- Safeguarding of good working conditions
- Protection of the surrounding environment
- Winter work possible
- Satisfied sports ground owners
- Partnering co-operation at a high level
- Partnering co-operation pays off

The pipe course below the playing field prior to renewal.

L–R: Åsa Snith Chairman SSTT Sweden, Peter Hjortdal Århus Vand, Magnar Sekse Chairman SSTT Norway.

Sophisticated technology

The cross-sectional shape of the pipe was quite unusual and had been cast in-situ in the 1950s. This added to the challenge of renewing the pipe. The advantages of applying a liner in pipes attacked by rats is that the rats rarely attack this type of renewal and that the liner has no joints. From a capacity perspective, the repair team could not allow large reductions of the cross-sectional area, as the capacity of the pipe had to be maintained.

One of the disadvantages was the specific cross-sectional shape. Therefore, the benches were cut off to convert the geometry of the old sewer pipe to best effect. New, rounded benches were cast, so that the pipe cross section now looks more like a v-shaped pipe but still with a flat cover. The static dimensioning of the liner was a challenge due to the geometry of the pipe. A model showed that restraints were required in the top of the pipe. This was solved by installing a corrosion-resistant steel profile.

140 tonnes of liner on its way down into the abyss.

Successful partnering co-operation

In the partnering co-operation between Århus Vand A/S and Per Aarsleff A/S both parties contributed a choice of solutions and decisions at a very early stage. Everybody focused on quality and costs and consequently everyone felt that they had ownership of the project. This meant that the project costs were sustainable and the outcome was successful. The people at and around the stadium can now look forward to a new season where the turf is unaffected by the major renewal project – and without rats as spectators.

In partnership, the team managed to find a method to avoid bypass pumping. This was achieved by sealing off the pipe and letting the water run backwards in the system and through a major collector pipeline to a nearby treatment plant. In regard to occupational health and safety, the project was also a success. We held regular safety meetings where everyone involved participated and where many constructive proposals were presented. For example, we put up CCTV in the pipeline during the conversion of the benches, we put up fixed lighting for eight weeks and we carried out a safety drill (evacuation drill).

Overall there was a feeling of satisfaction from the project managers in a company that has an occupational health and safety certificate.

Getting into a cleaning whirlwind

The latest innovations in trenchless pipe cleaning technology offer more thorough and efficient cleaning of pipe surfaces. Here, we review a new cleaning system developed by Whirlwind, which introduced aggregate into air flow to provide a uniform cleaning pattern.

THE WHIRLWIND FORCED Air Vortex Aggregate Cleaning system (FAVAC) begins by establishing airflow in the pipe to be cleaned. The Whirlwind blowers produce sufficient air power to generate a turbulent airflow through the pipe work. The blowers can be controlled to produce sufficient air to provide a low pressure, high velocity, and turbulent airflow. Air from the blowers is discharged into the main via flexible outlet pipe work.

First, a low pressure airflow is applied to the section to be cleaned, which removes any residual water from the pipeline. The hot air produced by the blowers will then dry the surface of the pipe and the tubercles. Both the free airflow and initial pressures may then be established. As the main is cleaned, the pressure within the system will drop and the airflow will increase.

Aggregate is stored in pressurised hoppers, and is fed from the hopper into the outlet pipe work in a controlled manner using a pressurised conveyor. The speed of the conveyor is variable so different application rates can be achieved, dependent on the level of contamination. This allows a uniform distribution of aggregate into the air flow and along the pipeline.

The turbulent nature of the air flow causes the aggregate to be thrown against the pipe wall, impinging and dislodging the tubercles from the inside of the pipe. The tubercles are broken down by the aggregate and carried along the pipeline with the air flow. This leaves a clean, dry surface on which to apply a new pipe lining.

A hose is connected between the pipeline and receiver to transfer the waste aggregate and tubercle debris from the pipeline to the receiver. The aggregate and tubercle debris is separated from the air flow inside the receiver and the air flow is discharged from the receiver via a filter.

The waste resulting from the cleaning operation may be used as backfill around the pipe following completion of the lining operations. This, combined with the elimination of water from the cleaning operation, significantly reduces the environmental impact of the FAVAC system.

The FAVAC system is currently available in several different machines. The Whirlwind Phantom cleans pipes 125–300 mm in diameter, while the Whirlwind Tornado is designed for pipes 75–125 mm in diameter. Finally, the Whirlwind Harrier is able to clean and reline pipes 12–75 mm in diameter. These machines may be used in several combinations to provide cleaning capabilities for pipes with an internal diameter of up to 450 mm.

Pipe cleaning technology will become increasingly important over the next few years as the European water industry strives to meet new standard is regarding lead in water supplies. The current standard, defined by the Water Supply (Water Quality) Regulations 2000, specifies that the maximum amount of lead is 25 µg/l. In December 2013, however, a new standard of 10 µg/l will come into force.

It is well documented that this standard can only be achieved by replacement or cleaning and relining. Of these, relining is clearing the most cost-effective and efficient option. In the UK alone there are seven million homes supplied with water that travels along lead pipes, and to replace all of these would cost £8 billion and require resources well beyond the current capacity of the water industry.

Meanwhile, the same pipes could be cleaned of rust and accumulated deposits and then relined at only a fraction of this cost, reducing the financial burden on both water companies and the taxpayer. The final result will be full compliance with regulations, providing safe drinking water for the whole of the UK.

From eyesore to idyll

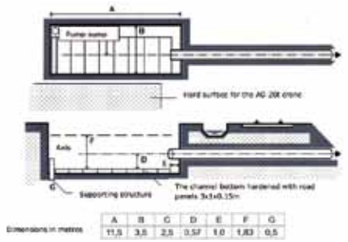
Pipejacking has helped transform an abandoned quarry into a picturesque lake in the Czech Republic.

THE MEDARD – LIBIK QUARRY, located west of Sokolov Town in the Czech Republic, was once an important source of coal in the region. However, due to the diversification of energy sources and strict environmental requirements, demand for coal declined in the mid-1990s, and the Czech Government decided to cease mining in the area.

There remained the question of how to redevelop the now inactive quarry. The aim was to eliminate the effects of mining activities and facilitate a return to human activity, as the quarry had devastated the surrounding landscape, destroying the settlement, industrial enterprises, agricultural land, roads, streams and historical and cultural monuments.

Various alternatives were assessed, but it was ultimately decided to flood the residual shaft of the quarry with water from the Ohře River. This would create the Medard – Libík lake, which would raise the aesthetic and environmental value of the area and create a facility for sporting, recreation, bathing and game fishing activities. It was intended to build cycling lanes, walking tracks and other sporting facilities on the edge of lake, with the hope that this would attract entrepreneurs who would build guest-houses, cafes and restaurants.

To transport the water from the Ohře River to the quarry, it was necessary to install an underground water pipe. The intake facility is situated on the Ohře River bank, close to the road that runs between Citice Village and Sokolov Town, and the route was designed to create the shortest possible line between the quarry edge and the Ohře River. Given that the pipe route traverses towns, roads and railway lines, open cut installation was not an option, and instead pipejacking will be used.



Dimensions of the starting shaft.

The partially flooded Medard – Libik quarry.

The pipejacking will be done by Vodohospodářské stavby Teplice (VHS Teplice), which has many years of experience in trenchless works throughout the Czech Republic. The firm has been subcontracted by Sdružení SVATAVA; the general supplier of the conduit, operating under EUROVIA, a.s. The conduit investor is Sokolovská uhelná společnost.

The jacking will install 56 m of double Hobas DN 1,200 mm pipe under the Sokolov – Citice road and Sokolov – Cheb railway. Two parallel jackings of DN 1,400 mm steel pipes will be done for the above pipe. The outlet facility is connected to the jacking and situated at the dump in the southern part of the mine. The slip is connected to the open channel and proceeds to the adapted bottom of the mine.

The VHS Teplice experts have already constructed similar underground structures when flooding the Ležáky mine and when dewatering the ČSM Mstišov quarry. On these projects there was a hazard of a slide of the opencast quarry slopes, and this will also present a potential challenge at Medard – Libik

The success of the project is based upon the high quality starting shaft, operated by the AD 20 tonne mobile crane. The shaft has to comply with the regulations of the Czech Mining Authority – the state supervisory authority for jacking technology.

The starting shaft buttress wall has to be perpendicular to the jacking axis and must allow the pressure for the whole borehole to be spread into the surrounding natural ground. The slope of sidewalls is 1:0.5 for a cohesive soil; for a frictional soil, it is necessary to encase the starting shaft according to the approved design.

The first steel pipe DN 1,400 mm jacking before completion, jacked under the Czech Railway and the road towards the supply facility near the Ohře River.

View of the face of the steel pipe DN 1,400 mm jacking.

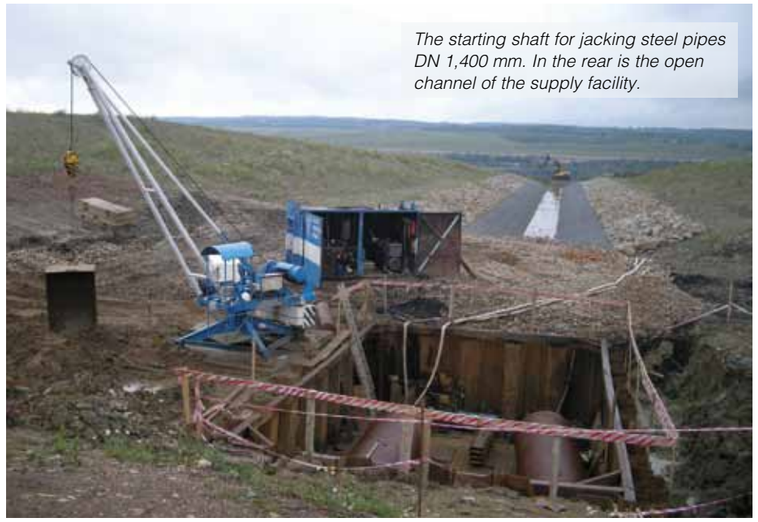
The slope of the starting shaft hard bottom shall be equal to the slope of the jacked sleeve. The directional and height tolerance is 1 cm per 1 running metre at maximum.

When jacking a steel pipe, the steel pipe is jacked while removing earth inside the pipe. The muck extracted at the jacking face is loaded onto a trolley, transported to the starting shaft in the trolley and then to the surface using hoisting equipment. When the whole length of the pipe has been jacked, another pipe is brought to the starting shaft using hoisting equipment, which is welded together with the already jacked pipe. This procedure is repeated until the whole jacking process has been completed.

Depending on the geological conditions, a steel ring may be welded onto the outside surface of the pipe to reduce friction. A ring welded on the inside wall of the pipe improves the workability in the case it is a cohesive soil. A linear hydro motor, located in the rear part of the starting shaft, produces the force necessary to jack the pipe face into the soil and overcome the friction of the outer skin and the soil. It pushes, through the adjustable adapter pieces and transition spacer, onto the rear face of the pipe and jacks it into the soil. Extraction of muck from the starting shaft is mostly done using a light derrick.

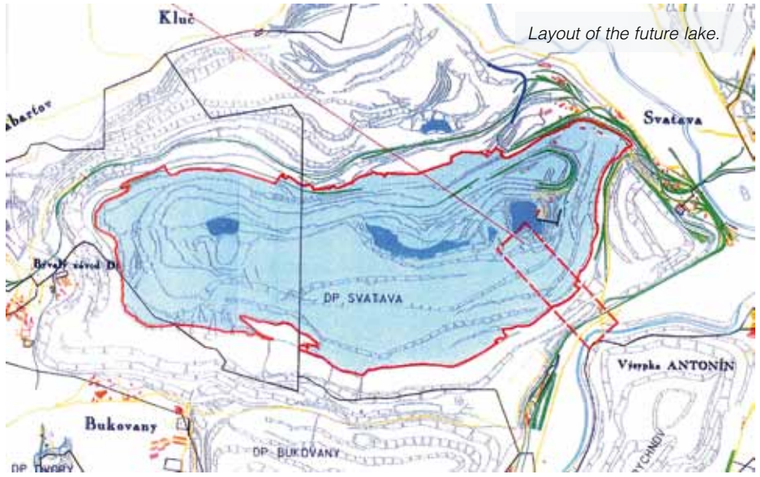
Steel pipes may be jacked in the soils and rocks with workability class 1 to 4 (ČSN 733050). When employing small blasting operations, the smallest sleeve diameter is DN 1,200 mm. A pre-condition for defining the jacking technology and method statement is the geological and hydro-geological survey made in the location of the starting and end shafts.

Engineers working on the project were faced with the technical challenge of transporting water from the river to the quarry, and also ensuring that the water in the lake was kept at a constant level. When the water level in the lake drops, the water will be supplied from the Ohře River, and when the water level in the lake rises during heavy rains, the water will be brought through an overflow into the Ohře River. The design of the facility allows it to be fully closed by flood-gates designed for a two-directional pressure.



The starting shaft for jacking steel pipes DN 1,400 mm. In the rear is the open channel of the supply facility.

Starting shaft, view towards the underpassed railway line.



Layout of the future lake.

The water quality in the lake will be a sensitive issue. One of the measures will be limiting the water supply through the water-collecting facility after the lake has been filled so that further water supply in the lake just replaces the evaporation from a free water surface. This, apart from the unwanted water level fluctuation in the lake, will also minimise the supply of nutrients in the supply water.

The water-collecting facility construction commenced in 2009, and it is intended that filling the lake with water will commence in late 2010. The filling could be completed, at the average hydrological conditions (flow-rate in the Ohře River) in 2011 to 2012.

Once the quarry has been flooded, the Medard – Libik lake will once again become a beautiful part of the North-West Bohemia, and Trenchless Technology will have played a vital role within this revitalisation.

The front shield in the air before installation.

No-Dig in Dalum

by Vilmer Jensen, COWI A/S

What is the solution when large pipes have to be installed in a city where open excavation is impossible, the groundwater table is high and groundwater lowering is not permitted? An ideal option is pipejacking with compressed air. That was the solution chosen in a major sewerage project in the Danish city of Dalum, where engineers had to work within a high density urban area and a partly protected nature reserve.

THE OBJECTIVE OF the project was to reduce overflow from the combined sewerage system into a nearby river, and prevent flooding of low-lying residential areas during heavy rain storms. Danish utility owner VCS Denmark used pipejacking with compressed air to install 750 m of 2.5 m and 1.6 m internal diameter pipes. This method is new in Denmark but will most likely be used much more in the future.

COWI was the consultant and Arkil the main contractor on the project, while all pipejacking work was executed by German-based subcontractor Meyer & John.

Under pressure

Pipejacking with compressed air involves bringing the working chamber with open excavation front under the same pressure as the actual groundwater. This allows soil to be excavated dry even if the ground contains sand or silt. In this project the groundwater table was 6–7 m above pipe crown. All pipes were to be installed in glacial till with water carrying sand and silt layers containing boulders of variable size. The air pressure in the working chamber was therefore kept 0.6–0.7 bar above atmospheric pressure. The actual soil conditions, in combination with high groundwater pressure, made pipejacking with compressed air very advantageous. Consequently, the soil could be excavated dry without risk of collapse of the excavation front causing influx of water and liquefied soil, which could generate settlements and damage to constructions at ground level. Furthermore, the open face allows easy access to the front for handling big boulders should they appear.

In order to make the soil impervious and solid, and bring the target point outside the pit wall, soil improvement was required where the boring machine penetrated the wall of the pits. This was achieved by high pressure injection of concrete through bore holes into the start and end points.


Celebration of a breakthrough.


Installation of the boring machine.


The operator at work in the front.

At the same time the displaced soil and water was pressed up through another bore hole. Concrete blocks of 5 m² were established 8 m below ground, allowing the starting pit to be cut away and the initial boring to begin, including installation of the shield, without causing any infiltration of water into the pit.

When the boring machine travelled approximately 4.5 m into the concrete block, the air pressure system was put into operation and the remaining parts of the back-up equipment with air locks were installed. The total length of the boring machine and back-up equipment was 22 m. The front shield was equipped with a road header excavation tool and a belt conveyer for moving the muck into wagons. Behind the working chamber, which comprised a road header and a conveyer, were two air locks for passage of operators and the soil wagons.

The muck could have been conveyed wet from a full face slurry machine by pumping to a separation plant beside the entrance pit, but this option was rejected because of the noise problems it would have caused in the surrounding residential area.

Four jacks with a total pressing capacity of 1,200 tonnes were installed in the starting pit. These pushed the pipes into the soil through the pit wall at the same rate that the soil was excavated in the front. The daily progress of the 2.5 m diameter pipes was approximately 6 m. Three injection tubes for bentonite lubrication on the outside of the pipes were installed at every third pipe to reduce the friction. When the pipejacking drive had finished, a suspension of cement was injected through the same tubes to replace the bentonite lubricant in order to fill possible cavities and fix the pipe position.


A look into the airlock.

Meanwhile, in the target pit a reception pot with a double seal was welded against the pit wall. When the boring machine reached the reception pot it was put under the same overpressure as the working chamber. When the front shield had cut through the pit wall and completely passed the seals in the reception pot, the air pressure in the working chamber was lowered to atmospheric pressure.

Hitting the target

The boring machine was guided by a laser steering system, in which the laser beam hit a target board in the front. Depending on the deviation of the laser beam from the target centre, the shield operator could extend or shrink the steering cylinders that were mounted in four positions behind the cutting shoe. The maximum deviation from the designed alignment was only several millimetres.

Safety precautions were highly prioritised through the entire project. Two of the drives had to be installed in soil polluted with vinyl chloride and other chlorinated compounds, which came from a dry cleaning shop previously located in the area. To manage this issue, the air quality was continually measured with a portable monitoring device. When air pollution was detected, operators inside the tunnel connected their face masks to a pipe system which supplied them with fresh air. Furthermore, the workers had weekly medical checks, while blood tests were conducted during periods when the pipejacking took place in polluted soil. The site was also supervised around the clock and standby equipment was available in case of failure or emergency.

San Francisco shakedown

by Anne Rees

Microtunnelling has played a key role in the construction of the New Crystal Springs Bypass Tunnel in San Francisco, the tunnel will secure safe water supply for the earthquake-prone city.

THE SAN FRANCISCO region of California, located on the San Andreas Fault, is renowned for being a hotspot of seismic activity. In 1906 a massive earthquake devastated the city, and more recently, the 1989 Loma Prieta earthquake reached 6.9 on the Richter scale and caused the death of 63 people.

Not only do such quakes cause fatalities and damage to property, but they can also imperil the local water supply. City engineers have long feared that a critical stretch of the Hetchy Hetchy Regional Water transmission system, installed in 1969, could fail during high precipitation and major seismic events.

The concrete cylinder pipe, 96 inches in diameter, transported water from the East Bay to supply the population of San Francisco. Located only 1.5–3 m below the surface, and passing next to a slope that had failed twice during the mid-1990s, there was a high risk that the conduit could be damaged during future earthquakes, with potentially devastating consequences.

Given this possibility, the San Francisco Public Utilities Commission (SFPUC) decided to replace the 1,280 m water pipeline, installing a new welded steel pipe within a tunnel bored deep into the bedrock.

Beginning in 2008, the New Crystal Springs Bypass Tunnel (NCSBT) is one of 85 schemes being conducted within a $US4.3 billion San Francisco Water System Improvement Program (WSIP).

Jacobs Associates, a San Francisco-based international engineering firm, provided construction management services for the NCSBT, and are also working on several other WISP projects, including the new Irvington and Bay tunnels. Meanwhile, Shank/Balfour Beatty JV were awarded the $US55.67 million contract for construction of the tunnel.

The first stage of the project involved the construction of a South (launch) shaft and North (receiving) shaft, which were excavated during July and August 2009 using a combination of mechanical excavation and drill and blast.

The shafts were then connected by a 2.4 m diameter tunnel, constructed by a specially designed single shield tunnel boring machine (TBM). The 47.2 m TBM was designed by ML Shank Co, while the shield was manufactured by Hitachi Zosen, and the cutters were provided by Herrenknecht. The machine also features five gantry cars and two muck conveyers, and has a torque of 593,920 foot-lbs and an operating thrust of 1,150,000 lbs.

Although many contractors name their TBMs to ward off bad luck, it was the preference of Mike Shank to leave his machine nameless. Instead, it was decorated with logos of the entities involved.

The TBM was designed to work within the sometimes unpredictable ground conditions of the San Francisco area, which include sandstone and Franciscan melange. The technical baseline report anticipated that the Franciscan melange may cause squeezing, so the machine had a tapered design, with a front diameter of 370.76 cm and a back diameter of 363.22 cm.

Fortunately, squeezing ground proved not to be a major issue. NCSBT Project Assistant Construction Manager Sarah Wilson said "We never saw any squeeze come on during excavation or over a weekend, or anything that interfered with erecting the initial support."

Walking out of the tunnel at the end of shift.

Tunnel curve looking south.

In addition, the TBM featured 23 disc cutters 17 inches in diameter, which were capable of cutting through the relatively hard sandstone.

The major parts of the TBM arrived from Japan in July 2010, and the machine was assembled on-site, which took approximately two months. On 30 September 2009, the TBM sections were lowered by crane into the South Shaft, before being reassembled at the base. Tunnelling began 10 November, and rings of concrete segments were installed inside the tunnel to provide ground support.

Tunnelling occurred at a downhill grade of 1.2 per cent. This grade was determined by the contractor, who was able to select a grade between 0.2–3 per cent by determining the depth of the drive shaft. If there had been significant amounts of water on site, the downhill grade could have presented some challenges, but fortunately this did not become a matter of concern.

After travelling approximately 18 m per day, the TBM arrived at the North Shaft ahead of schedule on 24 March 2010, and was then disassembled. The shield remained in place in the receiving shaft, while the other components were backed out of the tunnel and removed from the South Shaft.

It is possible that these components will be recycled on future projects. "Based on the way the contractor removed them, I suspect he's going to reuse them. They weren't completely destroyed when he was using them [and] he removed them in sensible sections," said Ms Wilson.

Once the tunnelling was completed in early May, construction began on the installation of a 2.4 m diameter welded steel pipe.

After this process is finished, the new pipe must be tied-in to the existing system, which involves shutting down the pipeline for approximately one month. This process is conducted in winter, when water demand is at its lowest, and the SFPUC re-routes the entire system to avoid affecting supply. The first shut down, to tie-in the receiving end, occurred in February and March 2010, while the second shut down, for the drive shaft end, will take place in January 2011.

According to Ms Wilson, the tie-in process is "not simple or trivial but it went perfectly during the first shut down, so we have high hopes that the second shut down will also go perfectly".

One of the key challenges of the NCSBT project was to complete all necessary works without adversely affecting local residents. The project site is completely surrounded by family homes, and some occupants expressed reservations about having a construction project in their backyard. To mitigate these concerns, maintaining good public relations became a priority for the construction managers.

Jacobs Associates telephoned individual home owners each time a blast was due to occur, and a blog was used to inform the public about project activities. In addition, outreach events were held at the local Starbucks, where community members could drop in to have their questions answered.

Also, the contract required the installation of noise and vibration monitors, which would operate 24 hours per day. If anything approached the project limits, an alert was sent to the personal mobile phones of the project managers. Although the alert was sent on several occasions, these were false alarms and the limits were never actually exceeded.

Environmental protection was also an important feature of project management. "Especially being in California, there are a lot of environmental requirements that we've had to pay attention to, and really work with the permitting agencies to keep them apprised of little developments in the project," said Ms Wilson.

In addition, the tunnel was classified as potentially gassy, and air quality was constantly monitored to ensure the safety of the 40 workers on site. On several occasions gas was detected and the tunnel was ventilated, but this never impacted the progress of work.

Although not scheduled for completion until September 2011, the NCSBT has already made excellent progress, with both the tunnelling and first tie-in completed ahead of schedule. Ms Wilson attributes this to a combination of favourable ground conditions, the TBM design and the positive attitude of the contractors. Given this track record, it seems likely that the project will come to a successful conclusion, securing safe water supply for San Francisco for many years to come.

The New Crystal Springs Bypass Tunnel TBM.

Herrenknecht EPB 2400 tunnel boring machine.

Getting bored in Bulgaria

The successful completion of a microtunnelling project in Bulgaria has showcased the engineering expertise of this Eastern European nation. A tunnel boring machine was used to install a new sewer pipe in the city of Plovdiv to avoid interrupting road and rail traffic.

THE PROJECT INVOLVED the construction of a back-up pipe for the Northern open sewer under the Plovdiv – Burgas railroad and Eastern ring-road. The construction of the facility was necessary to increase the capacity of the existing sewer, and secure the effective operation of the newly built Northern wastewater pumping station. The project was carried out by Stroitelna Mehanizatsia PLC, and was funded by the Ministry of Environment and Water (MEW), the European Bank for Reconstruction and Development (EBRD), and the Swiss Government.

The project was executed by a Herrenknecht EPB 2400 tunnel boring machine (TBM) and was conducted in six stages between September 2009 and February 2010. The first stage involved the construction of the starting and receiving shafts, which was followed by the installation of the TBM. Next, the TBM constructed a steel pipe tunnel. After the boring stage, the TBM and auxiliary installations were dismounted, and a fibreglass operation pipe was inserted into the steel pipe. Finally, the operation pipe was cemented into the steel jacket pipe, and the pipe entrance and exit were constructed. In total, 52 m of new sewer pipe was installed, with a diameter of 2,400 mm.

The execution of the project was quite technically complicated as the pipe was installed in close proximity to a river, and was required to travel under the railroad and ring-road without disturbing traffic. Yet, despite these challenging conditions, the project was carried out according to plan, and works were completed within the expected time frame.

Present at the opening of the new sewer were Minister of Regional Development and Public Works Rosen Plevneliev, Governor of Plovdiv Ivan Totev, and Executive Director of Stroiltelna Mehanizatsia Stefan Zhelyazkov, who is also Chairman of the Bulgarian Association of Trenchless Technology (BATT).

Mr Plevneliev expressed his satisfaction at the speed and quality of the project, as well as its innovative use of trenchless techniques.

Similarly, Mr Zhelyazkov praised the project management. "Ivan Totev was smiling but he took his responsibility to personally oversee the execution of the work very seriously," he said.

Mr Zhelyazkov emphasised that the project caused no interruption to either road traffic or train schedules, bringing this Bulgarian project in line with international engineering and infrastructure standards.

Breakthrough in Bulgaria.

Beating the heat in Bahrain

Microtunnelling will help the residents of Bahrain keep their cool and reduce their carbon footprint, as the North Shore District Cooling project in the capital of Manama is using tunnel boring machines to construct a new water pipe network.

THE NORTH SHORE District Cooling project is being developed by Tabreed, the world's largest district cooling company, while Atkins is the lead consultant and construction supervisor.

District cooling involves supplying cooling as a utility service, similar to electricity and water. Instead of using local cooling systems in each building, one central source is used to generate chilled water for an entire district. This water is then distributed for cooling via a network of pipelines.

This centralised cooling method has environmental and economic benefits for both the customer and cooling supplier, and is becoming increasingly popular in hot climates where air-conditioning dominates energy usage.

The North Shore project, which is the first of its kind in Bahrain, involves the production and distribution of 23,000 tonnes of chilled water via 14 km of pipes and several energy transfer stations.

When complete, this system will supply cooling to the Bahrain World Trade Centre and other developments south of the King Faisal Highway, significantly reducing the cost of providing air-conditioning to offices, residential buildings and shopping malls.

Microtunnelling has been a major feature of this four-year project. Atkins Site Operations Manager Ian Cordingley said "We struggled to install large diameter insulated steel pipes through relatively confined streets. Two very busy highways had to be crossed four times and we used Herrenknecht AVN machines to do the work, this ensuring no disruption whatsoever to the traffic above."

In late May construction was completed on two 86 m microtunnels beneath the King Faisal Highway, which were bored at a rate of approximately 6 m per day. The parallel 900 mm insulated carbon steel pipes were installed more than 10 m below ground, without impacting on the traffic above. These pipes will transport district cooling water from the Diplomatic Area chiller plant to Bahrain Financial Harbour, Reef Island, and other developments in the area.

Mr Cordingley said "It is not easy to drill through 86 m of earth with such little disturbance to the surroundings. The team did a fantastic job in ensuring we deliver a chilled water network that will make the cooling of developments in Manama more economical and help in reducing Bahrain's carbon footprint."

Meanwhile, the longest drive was for the chiller plant cooling water outfall, which measured 154 m in length and had an outside diameter of 1,956 mm.

Atkins is extremely satisfied with the decision to use Herrenknecht equipment. "In each case the alignment was near perfect, so using the AVN machines was a good choice," said Mr Cordingley.

"Further work in the centre of Manama is scheduled and it would be good to use the same type of machinery, but as yet no firm decisions have been taken."

The Diplomatic Area chiller plant is also nearing completion, and work on the North Side District Cooling project will be concluded later this year.

Breakthrough in Bahrain.

How to select access chamber coatings

by Ian Bateman, Interflow

Manhole maintenance is essential to the upkeep of the entire wastewater system. Ian Bateman from Australasian relining company Interflow looks at the role of calcium aluminate cements in the strategy for renewing access chamber and underground structures.

THE TRENCHLESS SEWER rehabilitation industry is well established in Australia and New Zealand and has grown from its origins in pipeline rehabilitation to now include additional parts of the network such as house service lines, lateral connection junctions, and access chambers.

In recent years the importance of renewing and sealing the entire sewer network to prevent leaks, infiltration and collapses has been widely recognised by many sewer asset owners. One aspect that is becoming increasingly important is renewal of access chambers (also referred to as manholes, maintenance holes, or utility holes).

Access chambers represent a significant proportion of the total surface area of a sewer network. The table below puts this into perspective.

A program that leaves the access chamber untreated, leaves up to 30 per cent of the network untreated. Additionally, if the main pipeline is relined, the level of hydrogen sulphide present in the sewer atmosphere will typically increase because the gas sink present in the host pipe walls has been removed. This may result in an accelerated rate of gas attack at the access chambers.

Given that it is accepted that access chambers do require a rehabilitation strategy the questions then become:

1. When do they need to be rehabilitated?
2. How do we determine the condition of the asset?
3. What are the most appropriate products to use?

These are essentially the same questions that apply to the pipelines but the dynamics with access chambers are quite different.

When do access chambers need to be rehabilitated?

When answering this question as it applies to pipelines, asset owners will typically take an approach that considers the condition of the asset and the criticality of asset (i.e. the consequence of failure). Based on ranking each asset according to its criticality and condition, a priority matrix can be created that identifies which pipelines should be done and when.

The same approach seems reasonable for access chambers but there are significant differences in two areas:

a. The cost dynamics
b. The method of condition assessment.

It is important to understand the difference in cost dynamics that apply to pipeline rehabilitation versus access chamber rehabilitation. When a pipe is renewed a liner is placed inside the host pipe and it is typically assumed that the existing pipe is fully deteriorated. In other words, no attempt is made to determine the condition of the existing pipe and to offer a solution that replaces its lost strength. It is simply too difficult to assess the remaining strength of pipe so the industry takes a conservative approach and assumes its strength is zero. As a consequence, from an asset management point of view, there is no sliding scale of renewal costs as the asset deteriorates. Whether the asset has lost all of its strength or only five per cent of its strength the relining cost will be the same. Therefore the optimum renewal time for the pipe (from a lifecycle cost point of view) will be just before it fails.

This is not the case with access chamber rehabilitation. There are several types of products that can be applied to access chambers each with very different cost dynamics:

Distance between access chambers – 50 m Diameter of chamber – 1,050 mm	
Pipe diameter	Percentage of total network surface area residing in the access chambers
150 mm	30 per cent
225 mm	22 per cent
300 mm	17 per cent

Protective coating

A protective coating can be applied to a structure that has not undergone significant structural loss. For all intents the structure remaining is fully intact. Under this scenario a thin protective layer can be applied. The coating would not need to offer any structural characteristic. It would be capable of withstanding the gas attack and therefore extending the asset life. This would be considered to be taking a preventative maintenance approach. The costs for this type of coating would be relatively low compared to the other types of coatings. The types of products would include thin polymeric coatings such as polyurea, polyurethane and epoxy and cementitious products such as calcium aluminate cement.

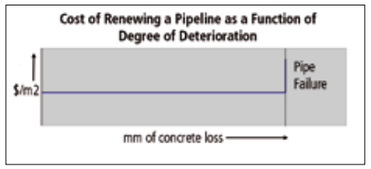
Condition of access chamber	Type of product needed	Thin, non-structural polymeric coating	Thick, structural polymeric coating	Calcium Aluminate Cement
		Polyurea, polyurethane, high purity epoxy	Epoxy mortar, highly filled epoxies	
Minimal structural loss (e.g. less than 20 mm) at a loss rate of less than 5 mm per year	Protective Coating	Suitable	Suitable	Suitable
Minimal structural loss (e.g. less than 20 mm) at a loss rate greater than 5 mm per year	Protective Coating	Suitable	Suitable	Unsuitable Would need to be top coated with a polymeric product
Some structural loss that requires reinstatement. Rate loss of concrete less than 5 mm per year	Rebuild Coating	Unsuitable	Suitable	Suitable
Some structural loss that requires reinstatement. Rate loss of concrete greater than 5 mm per year	Rebuild Coating	Unsuitable	Suitable	Unsuitable Would need to be top coated with a polymeric product
Complete structural loss	Reconstruct	Unsuitable	Unsuitable	Unsuitable

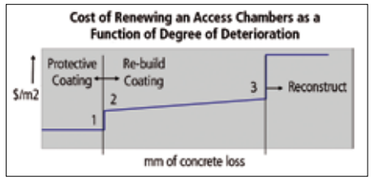
Rebuild coatings

A rebuild coating would be needed where the structural integrity of the existing access chamber has been compromised. In this case it is appropriate to reinstate the lost structure with a material that has some structural strength and it would need to be applied in a thickness commensurate with the degree of deterioration. Typically costs for this type of treatment would be up to double that of the protective coating and gradually increase as the thickness of product increases (i.e. the amount required to restore the structural strength).

Reconstruct

A reconstruct is needed when the existing access chamber has lost nearly all of its structure. In this case some form of reconstruction technique is needed. This can include reboring a new access chamber, slip lining the existing chamber or internally reconstructing. Naturally this situation is very expensive and would expect to cost at least four times more than the protective coating.





From the foregoing discussion it can be appreciated that the optimum time to renew an access chamber from an economic point of view is not necessarily obvious. The graphs above express the difference in cost dynamics between access chambers and pipelines. The optimum economic time for a pipeline is towards the end of its life. For an access chamber it could be at points 1, 2 or 3.

How do we determine the condition of an access chamber?

Determining the condition of a pipeline is a relatively difficult task that has developed significantly and is now able to be performed in a consistent way by skilled operators that follow techniques and guidelines set out by industry standards. The tool of choice in all cases is CCTV footage that is subsequently interpreted by a skilled operator.

An access chamber has one significant benefit over a pipeline in that it is accessible. As such we are not limited to assessing the condition by using images. We can actually take core samples directly from the access chamber. This is particularly helpful in circumstances where the access chamber was cast in-situ, because it tells us exactly how thick the structure is, not just how much concrete has been lost.

There are significant benefits in taking core samples from manholes. If we were to only look at the images, the condition of each appears equivalent, i.e. one would probably conclude that the chamber is structurally sound and requires only a protective coating. However after taking a core sample, a very different conclusion was drawn.

Given the costs of each solution are potentially very different, and that the risk profile of each is very different, the consequences of using only a visual assessment to determine the condition of the access chamber can be quite serious. →

What are the most appropriate products to use to rehabilitate access chambers?

In access chambers the two broad families of materials that tend to be used around the world are polymeric coatings and hydrogen sulphide resistant cementitious products such as calcium aluminate cement (CAC). The two families of materials have benefits in different areas. Broadly speaking CACs will be very cost-effective and can be used both as a protective coating (thickness of approximately 12 mm) and as a rebuild coating by applying the product at a thickness equivalent to the amount of concrete lost.

The relative cost-effectiveness of CACs has seen an increased interest in recent times in the Australian and New Zealand market. CACs can be applied in relatively high thicknesses and will typically have compressive strengths greater than the existing concrete structure. This means that a 'best of both worlds' result can be achieved. But where does this product sit in the overall product choice equation?

The limitation of CACs are where the pH of the substrate is expected to be lower (more acidic) than two. In this circumstance a polymeric coating would be required on top of a CAC.

Access chambers represent a significant proportion of the total surface area of a sewer network.

In summary, at low pHs polymeric coatings must be used (either alone or one top of a CAC). At higher (less acidic) pHs, CACs or a polymer coating can be used.

This in turn leads to the question – how do we determine the pH of the substrate? Direct measurement in practice is not feasible. The most simplistic and accurate method of determining the pH of an access chamber is to determine the rate of attack of the existing concrete surface. If the pH is less than two, one would expect to see a rapid rate of gas attack – in the order of 5 mm per year. Therefore if we know the age of the access chamber and the depth of gas attack (from the core sample) we can determine how aggressive the conditions inside the access chamber are and whether a polymer coating is required.

The table on the previous page attempts to summarise the product choices available according to the condition of the access chamber and hence identify where each product fits in the market. It does not make any attempt to rank the suitable products by cost-effectiveness.

Summary

In order to obtain the optimum solution for access chamber rehabilitation there are many factors to consider and the approach may need to be a little different to that taken for pipelines. The cost dynamics of the rehabilitation solutions are very different, meaning the optimum time in the lifecycle to perform the work may not be immediately obvious. Furthermore, the condition of the access chamber can be determined quite accurately by coring, and as such a specific solution can be determined based on the results. If we overlay the final factor, which is the rate of gas attack, we can further refine the product choice.

If these factors are taken into account the asset owner has the opportunity to receive the optimum product choice and thus minimise rehabilitation costs and maximise value for money.

An experienced pipeline renewal company such as Interflow can offer clients an objective condition assessment method and offer a full range of products including both polymeric coatings and CACs. As such the most cost-effective product can be applied to the structure based on its condition.

New manhole HDD drill with rod lift

Swiss producer of trenchless pipe and cable laying equipment TERRA AG has developed a manhole HDD drill with the capacity to undertake directional bores from manhole to manhole, as well as from manholes to nearby homes.

THE TERRA MINI-JET MJS 1600 is a manhole HDD drill for directional bores of up to 50 m, with a minimum turning radius of 15 m. The directional bore can be reamed in several steps up to 300 mm. The machine is equipped with a torque of 1,600 Nm and thrust and pull back forces of 60 kN.

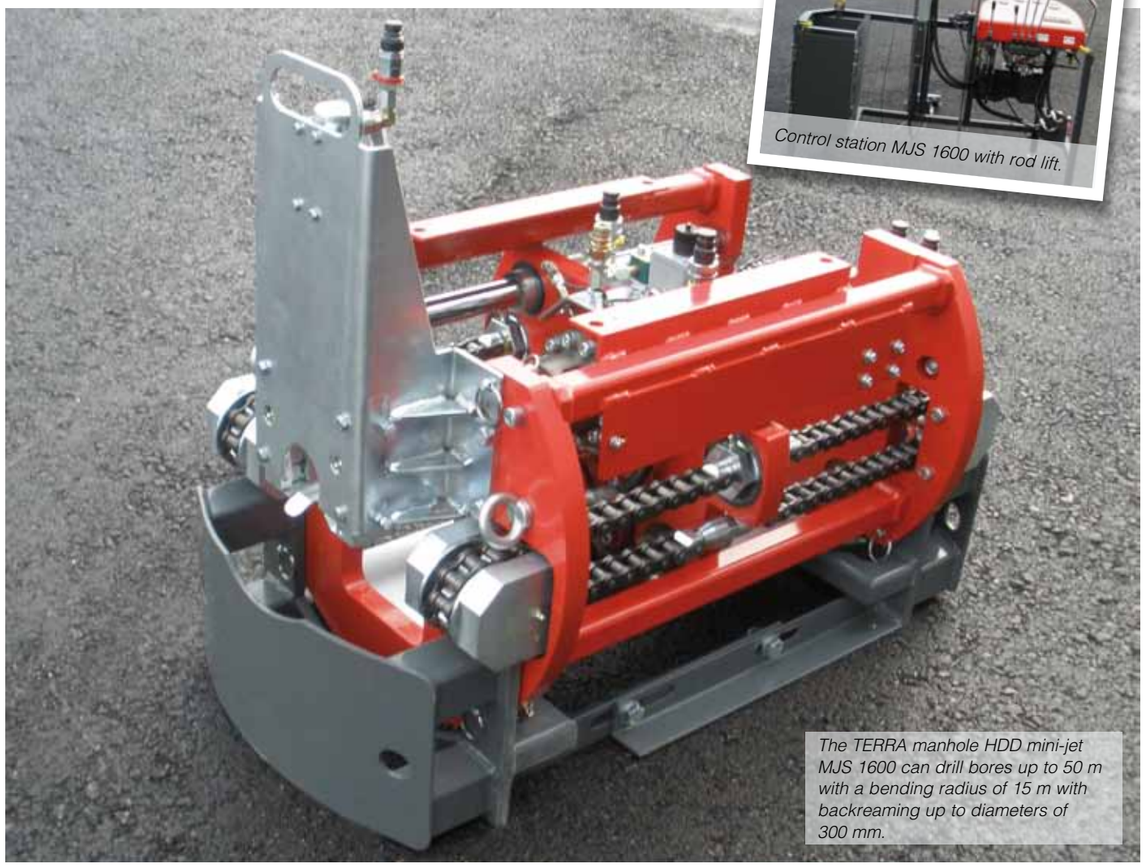
At a depth of 0.8 m it can lay telephone cables, at 1.2 m water mains can be installed, while gas or power lines can be laid at 1.6 m. This pipe laying method was developed over a two year period in close co-operation with the French water supplier SADE.

The MJS 1600 can drill from manholes with an internal diameter of 1 m, and can fit through manhole entrances of just 0.62 m. For smaller entrances, the manhole cover frame can be removed. First, the drill's bed frame is lowered into the manhole and tightened hydraulically in position and then the manhole drill is lifted vertically through the manhole cover and bolted onto the bed frame.

The entire operation of the TERRA MINI-JET MJS 1600 is controlled from the surface, where the operator, control station, rod magazine and rod lift are all positioned. There is no requirement to enter the manhole during drilling and back reaming work. Instead, the operator inserts a new drill rod into the rod lift, which transfers the rod into the manhole and positions it inside the drilling machine. The new drill rod is then screwed into the last drill rod. Inductive sensors make this operation possible even where the operator does not have a view into the manhole. The rod lift may also be positioned at an angle over the drilling machine if it is not located directly below the manhole entrance.

Drilling and back reaming take place with bentonite drilling fluid pressure of 0-55 bar (0-800 psi) and drilling fluid volumes of 0-38 ltr/min (0-9 gpm). This makes the TERRA MINI-JET MJS 1600 a small but effective HDD machine.

Control station MJS 1600 with rod lift.



The TERRA manhole HDD mini-jet MJS 1600 can drill bores up to 50 m with a bending radius of 15 m with backreaming up to diameters of 300 mm.

Promoting trenchless safety

by Mark Bruce

Cross Bore Safety Association promotes safe practices to protect from damage, injury and death caused by utility intersections.

Cross bores are defined as "an intersection of an existing underground utility or underground structure by a second utility resulting in direct contact between the transactions of the utilities that compromises the integrity of either utility or underground structure". As early as 1976 the US National Transportation Safety Board investigated an explosion of a cross bore of a natural gas line into a sanitary sewer line that resulted in two deaths.

Ploughs, percussion moles and horizontal directional drills are trenchless technologies that offer the advantage of minimal disruption to the surface and streets while providing cost effective installation. These methods do not allow for an operator to observe the installation path.

If an energised utility is inadvertently installed into a sewer, it can be cut by rotating drain cleaning equipment or occasionally by high pressure jetting equipment. Such electrical lines and gas lines can result in immediate danger to construction, drain cleaning personnel and the public. When gas lines are encountered and cut by cleaning tools, the sewer becomes pressurised, forcing gas into the structure. Catastrophic explosions are then the likely result.

> Improved locating of existing utilities and legacy inspection projects will decrease cross bores.

Proactive utilities and contractors have developed elimination processes for new construction and legacy installations. Legacy cross bore elimination projects to identify and remove gas lines from sewers have found an average of two to three cross bores per mile inspected. Cross bores have been found at homes, schools and a hospital.

Cross bores damage other utilities resulting in increased maintenance and repairs. State regulations in over 40 US states require some level of sewer operator marking to identify location of sewers. These requirements are not uniform, do not provide depth and have been variably enforced. Contractors have supported enhanced marking requirements. Sewer operators have frequently resisted expanded marking of sewers.

Continuing accounts of damage, injury or death from explosions resulting from cross bores and damages of many types of utilities have led to action by the construction industry, governmental regulators and utilities. The Cross Bore Safety Association (CBSA), www.crossboresafety.org, has been offering an opportunity to provide awareness of the cross bore issue and share the best concepts for cross bore elimination.

Education and training of drain cleaners, construction personnel and utility managers is essential. Better safety instructions provided with equipment will help. Improved locating of existing utilities and legacy inspection projects will decrease cross bores.

Prevention efforts are cost effective while also being morally responsible

Recently the Minnesota Office of Pipeline Safety issued requirements to gas distribution companies to prevent creation of and verify that cross bores have not been created during new construction. Most utilities and contractors have adopted visual means, potholing or CCTV cameras, as effective methods. Mapping and GIS implementation are receiving higher attention as means to store inspection information and verify that areas have been inspected and cleared.


Mark Bruce.

> Proactive utilities and contractors have developed elimination processes for new construction and legacy installations.

GPR, acoustic and seismic have been used or considered, but have not yet found significant favour in cross bore elimination projects. Continuous wave signal devices have been recently proposed as a method for cross bore identification. Forward looking horizontal directional tooling has been under research for several years. The current best technologies and procedures now in use offer the opportunity to allow continued use of Trenchless Technology for safe installation of utilities.

Mark Bruce is the Chairman of Cross Bore Safety Association. Mr Bruce is also a Past Chair of the North American Society for Trenchless Technology.

About ISTT/Membership

The ISTT is the umbrella organisation for trenchless technologists in over 40 countries of the world. In 22 countries groups of trenchless technologists have their own national groups which are affiliated while the remainder are registered directly with the ISTT.

Trenchless technology covers the repair, maintenance, upgrade and new installation of underground utility services using equipment and techniques which avoid or considerably reduce the need for excavation. The ISTT promotes research, training and the more extensive use of trenchless technology through publications, co-operation with other NGOs, an annual international conference and an interactive website.

Trenchless technology is recognised as an Environmentally Sustainable Technology and is particularly suited for use in densely populated urban areas by reducing disruption to peoples daily lives, social costs (traffic congestion, damage to road surfaces and buildings, air quality), noise and dust. Trenchless technologies also have a considerably reduced carbon footprint compared to trenching in most situations.

ISTT Membership/Directory

Please complete the following form.

Please note: Entry in the ISTT Directory is free to Corporate Members but only if the Industry Sector is completed.

Alternatively, you can fill in this form online at www.istt.com

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