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EVENTS

2006-07 CALENDAR OF EVENTS

September 2006
10-13—APWA International Public Works Congress & Exposition, New Orleans, LA.
18-19—NASTT Horizontal Directional Drilling Good Practices Course, East Gwillimbury, Ontario
23-29—IPLOCA Convention 2006, Barcelona, Spain
27-30—ASCE Annual Conference & Exposition, Chicago, IL
25-29—2006 International Pipeline Conference & Exposition, Calgary, Alberta
26-28—No-Dig Live 2006, Stoneleigh Park, Coventry, United Kingdom

October 2006
2-5—FTTH Council 2006 FTTH Conference & Expo, Las Vegas, NV
21-25—WEFTEC 2006 Annual Conference & Expo, Dallas, TX
26-27—8th International Trenchless Technology Research Colloquium, Sydney, Australia
29-Nov. 2—2006 International No-Dig Conference, Brisbane, Australia

November 2006
6-7—2nd Annual Western Regional No-Dig Conference & Exposition, Walnut Creek, CA
5-7—AEM Annual Conference, Boca Raton, FL
14—NASTT Laterals Good Practices Course, Edmonton, Alberta
15—2006 Alberta Trenchless Technology Symposium, Edmonton, Alberta
21-22—BAUMA-China 2006, Shanghai, China

December 2006
5—NASTT Horizontal Directional Drilling Good Practices Course, Phoenix, AZ
6-7—2006 Damage Prevention Conference & Expo, Phoenix, AZ

January 2007
21-25—DCA’s 46th Annual Convention, Paradise Island, Bahamas
22-26—World of Concrete 2007, Las Vegas, NV
30-Feb. 1—2007 Underground Construction Technology International Conference & Exposition

February 2007
7-10—2007 Pumper and Cleaner Environmental Expo International, Nashville, TN
11-14—NUCA Utility Construction EXPO’07, Las Vegas, NV
18-21—ASCE Geo-Denver 2007, Denver, CO
21-25—PipeLine Contractors Association Annual Conference, Aventura, FL

March 2007
6-8—2007 CGA Excavation Safety Conference & Expo, Orlando, FL
21-25—2007 AGC Annual Convention, San Antonio, TX

April 2007
15-20—No-Dig Live 2007 Conference & Exhibition, San Diego, CA
18-19—NASTT Pipe Bursting Good Practices Course, San Diego, CA
18-19—NASTT Lateral Rehabilitation & Replacement Good Practices Course, San Diego, CA
18-19—ISTT Pressure Pipe Design Course, San Diego, CA
19-20—NASSCO Pipeline Assessment Certification Program, San Diego, CA
23-29—BAUMA 2007, Munich, Germany

May 2007
5-10—World Tunnel Congress and ITA General Assembly, Prague, Czech Republic
6-8—2007 ASCE Construction Research Congress, Grand Bahama Island, Bahamas

June 2007
6-9—CSCE Annual General Meeting and Conference, Yellowknife, Northwest Territories
10-13—Rapid Excavation and Tunneling Conference RETC 2007, Toronto, Ontario
17-21—AWWA Conference & Exposition, Toronto, Ont.

July 2007
8-11—ASCE International Pipeline Conference 2007, Boston, MA

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The SPR dual locking mechanism creates a very strong mechanical lock which can withstand strong deformational forces (in Japan SPR installations have maintained structural integrity after strong earthquakes, even though the host pipe failed).

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MESSAGE

FROM THE WESTT CHAIRMAN

Dr. Samuel T. Ariaratnam

AS THE CURRENT CHAPTER CHAIRMAN, I would like to personally invite you to read this inaugural issue of the Western Trenchless Review. The Western Society for Trenchless Technology (WESTT) was formed in 2004 as a regional chapter of the North American Society for Trenchless Technology (NASTT), covering a four State region comprised of Arizona, California, Nevada, and New Mexico. WESTT has a volunteer Board of Directors, with representation from academia, government, and industry covering all four States.

Quoting directly from the by-laws, our objective is to “advance the science and practice of Trenchless Technology for the public benefit; to promote and conduct education, training, study, and research in said science and practice for the public benefit; and to make available information thereof to all interested and concerned parties.” WESTT aims to be a source of connecting individuals interested in learning about adoption of various trenchless techniques as a viable solution to their infrastructure needs. Sharing of experiences is an excellent way for evaluating the suitability of a particular method to your specific situation.

Our inaugural Chapter event was the First Annual Western Regional No-Dig Conference and Exhibition held on November 14-15, 2005 in Tempe, Arizona. The event attracted over 130 people and 21 sponsoring vendor companies. The opening keynote address, entitled “Tracking Down the Roots of Our Sanitary Sewers” was delivered by noted historian Jon Schladweiler. Incidentally, Jon was featured in the July 27, 2005 History Channel special on the “History of Sewers”.

There were a total of fifteen technical papers given by presenters, mainly from the four State region. The conference featured a repetition of papers given at No-Dig 2005 in Orlando in May 2005. The peer-reviewed format ensured that only papers of high quality were presented. In addition, the NASTT-developed, “Pipe Bursting Good Practices” course was given by myself, and Dr. David Bennett from Bennett-Staheli Engineers, as a post-conference short-course. Attended by 25 people, this course provided attendees with information on ways to engage in a successful pipe bursting projects.

The Second Annual Western Regional No-Dig Conference and Exhibition will be held in mid-November in Sacramento, California. For further information about this event, please contact either Jennifer Glynn at jglynn@rmcwater.com (925-627-4100) or myself. We anticipate another informative program filled with technical content and vendor booths. Keeping with our philosophy, the presentations will be a repetition of peer-reviewed papers given at No-Dig 2006 this past March in Nashville by WESTT members.

I look forward to another excellent year for trenchless activities in the Western region and welcome new members to join the Western Chapter. Please feel free to contact me at ariaratnam@asu.edu or (480) 965-7399 if you require any information on WESTT or trenchless in general.

Warmest regards,
Dr. Samuel T. Ariaratnam
Chairman, WESTT

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THE NORTH AMERICAN SOCIETY for Trenchless Technology recently celebrated its 15th No-Dig, which is not so much a testimony to the longevity of NASTT, but is more an affirmation of the validity and relevance of the Society's education and training mission. Less noticed, but perhaps more significant to NASTT long-term training strategy, was the Western Chapter’s highly successful Mini-No-Dig held in Phoenix in November 2005.

The NASTT annual No-Dig technical sessions are recognized for their high quality. The key is the selection and peer review process employed by NASTT, which focuses on relevance and quality. The process is simple: get volunteers with expertise in trenchless to ensure that the technical session content meets quality standards. Fortunately, NASTT has a number of members who qualify as experts and are willing to volunteer their time and effort for this purpose. Many of these volunteers are WESTT members, and again I thank you for your help.

Typically 1,400 to 1,500 individuals attend the NASTT annual No-Dig each year, which, although impressive, does not begin to include all who could benefit from attending No-Dig. The WESTT leadership came up with an innovative concept. Realizing that many Mini-No-Dig attendees were unable to attend the 2005 No-Dig held in Orlando, or may not have had heard these presentations when at No-Dig, WESTT decided to provide a second bite at the apple for its members and others in the region. Hence, the Mini-No-Dig concept - it worked beautifully! I saw first-hand the enthusiasm of the attendees. The WESTT leadership is to be congratulated for coming up with such an innovative approach to fulfilling the Society’s education mission. Clearly, the Mini-No-Dig concept is a real winner and should serve as a model for other chapters.

Again, congratulations and good luck!
John Hemphill, Executive Director
North American Society
For Trenchless Technology

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**MESSAGE FROM THE NASTT EXECUTIVE DIRECTOR**

John Hemphill

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THE AMERICAN FIBERGLASS CIPP REVOLUTION

By Richard “Monte” Montemarano, VP of Sales and Marketing, iPL Technologies, U.S., Inc.

Cured-in-Place-Pipe is a real solution for the rehabilitation of sewer and drainage pipes that are rapidly deteriorating in the United States. The technology of CIPP has brought with it a number of advantages that has made CIPP one of the fastest growing choices for pipe rehabilitation in the world.

For the past 20 years, CIPP in the U.S. market has been done with felt based lining solutions. These solutions have enabled customers to avoid digging up and replacing ever-increasing amounts of damaged pipes, saving the American citizen hundreds of millions of dollars. Now, with the introduction of UV light cured fiberglass lining technology, the advantages of CIPP are about to take a quantum leap in providing the U.S. a longer lasting more environmentally friendly solution.

Facts about Felt

Before we discuss this jump in technology with UV cured fiberglass lining, (UVCFG), we need to understand the facts about felt liners and their properties. Felt CIPP liners have the following characteristics:

1) A maximum flexural strength of 300,000psi
2) Are cured using hot water or steam
3) Can utilize polyester or vinyl ester resin and epoxy resin
4) The felt tube is “wet out” on the job sight.
5) The “wet out” felt is inverted into the host pipe or in rare cases, pulled through.
6) Felt liners are in most cases bonded to the host pipe
7) Have an ever increasing wall thickness to ensure a 300,000psi flexural strength
8) Have been tested and certified to have a 9% rate of leakage, (IKT report, 2005)
9) Have a 50% utilization rate in Europe

With all of the advantages that felt lining has provided the marketplace, there are some problems when using felt lining that need to be considered:

1) Air bubbles are common in the wetting out process, which can cause leaks.
2) The wetting out process in neighborhood; release a variety of chemicals and their associated odors into the air, an environmental hazard for both workers and the neighborhood.
3) The curing process releases a variety of chemicals into the sewer and drainage systems which can end up in ground water and fresh water systems.
4) The curing process for felt liners is heat sensitive, causing installation problems in high temperature climates.
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5) Is pulled into the host pipe 
6) Is a stand alone pipe, at least as strong as the original host pipe 
7) Has a thin wall thickness to ensure to maximize flow 
8) Has been tested and certified to have a 0% rate of leakage (IKT report, 2005)
9) Is used for 50% of the European market for CIPP.

The Installation Advantage
With dramatic difference in product quality come a remarkable difference in the way the product is installed.
UVCFG has an inner and outer liner foil. They hold the resin in place which has been procured to 10% at the factory. The outer foil is light proof and since the resin cures under light and not heat, the outside temperature is not an issue for UVCFG.
The liner is pulled through the pipe with a winch and capped on both ends. The “gates” allow for the UV light cable to be pulled by a computer monitored process. Once the liner is in place, the UV light chain inserted and the ends of the liner are capped, the liner is pressurized to 7 psi. The UV light chain is equipped with a camera to inspect the liner installation BEFORE it is cured. When there is visual assurance of a quality fit, the lights are turned on and the liner is cured at anywhere from 5 to 10 feet per minute. The camera on the light chain monitors the curing process.

The R.O.I.
Overall, UVCFG is at least a 30% more cost effective solution than felt. Although the material is more expensive, the set-up, reduced amount of spot repairs and fast curing times all reduce the total cost of a job dramatically. Even if a bid for felt is the same as UVCFG, the un-stated reduction in the cost of the job is less time for all of the peripheral services such as bypass pumping and traffic control. In addition to the great financial return on investment on UVCFG, it is not only neighborhood friendly because or reduced noise and smell, but it is guaranteed for 80 years! No other lining technology will give that warranty, if any at all.
With the higher quality, speed and longevity of UVCFG, it is only a matter of time before this technology becomes a real alternative to felt in the U.S. marketplace.

For further information on iPL Technologies and their products, please call Richard “Monte” Montemarano, VP of Sales and Marketing at 858-909-0010x225 or e-mail to monte@ipltechnologies.com.

The Environmental Difference
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A Higher Quality Product
The most impressive aspect of UVCFG is the product itself. Compare these properties to the properties of felt that were mentioned previously:
1) A maximum flexural strength of 1,700,000 psi
2) Is cured using ultra violet light
3) Can utilize polyester or vinyl ester resin
4) Liner is pre-manufactured under high-
It Pays to be a NASTT Member!

NASTT is a not-for-profit, educational and technical society that is dedicated to promoting the benefits of trenchless technology for the public awareness through education and training. Founded in 1990, NASTT is the definitive resource for trenchless professionals, like you, who are concerned with underground systems and the applications of trenchless technology. NASTT connects you to the people and businesses involved in the trenchless industry.

NASTT is your link to thousands of trenchless professionals and leaders working in regional, national, and international levels. Membership is open to individuals, agencies, and companies involved with providing gas, water, sewage, communications, and electrical services. If you’re interested or involved in underground systems and the application of trenchless technology, then NASTT membership is right for you.

NASTT Members Receive:
- Participation in committee work
- Involvement in your regional chapter
- Opportunity to serve on the No-Dig Program Committee

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NASTT Education & Training Programs offered:
- Annual No-Dig Conference & Exhibition
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- Lateral Rehabilitation & Replacement Good Practices
- Pipe Bursting Good Practices
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Santa Monica, CA
eugenia-chusid@ci.santa-monica.ca.us

Jennifer Glynn, Director
Consultants
RMC Water and Environment
Walnut Creek, CA
jglynn@rmcwater.com

Dave Mathy, Director
Consultants
DCM Engineering
Walnut Creek, CA
dmathy@dcm-engineering.com

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No-Dig 2006 was held from March 26-31 at the Opryland Hotel in Nashville, Tennessee, and the event attracted over 1,400 attendees to the conference and exhibition. This was the 15th anniversary of the inaugural event, held in 1991. There were over 90 peer-reviewed technical paper presentations, spanning all aspects of trenchless construction. Three post-conference seminars were delivered including: 1) Lateral Rehabilitation & Replacement Good Practices; 2) HDD Good Practices; and 3) NASSCO Pipeline Assessment Certification Program (PACP). A pre-conference seminar on “Introduction to Trenchless 101 - New Construction & Rehabilitation” was held for those individuals new to the technologies who wanted to gain a better understanding prior to attending the technical sessions. The 5th Educational Fund Auction & Reception raised over $40,000 for educational activities, including student support. The Gala Awards Dinner & Reception featured a performed by the Cirque Odyssey troupe, which thoroughly entertained the sold-out audience.

No-Dig 2007 will be held at the Town & Country Resort and Convention Center in San Diego, California, with the theme being “Riding the Wave of Trenchless Technology”. The Conference Program Committee received a record 182 abstracts, of which 112 were selected for presentation. In keeping with recent tradition, all of these papers will go through a rigorous peer-review process to ensure technical merit prior to publication in the conference proceedings.

We are pleased to have the National Telecommunications Damage Prevention Council (NTDPC) sponsoring a special session on “Underground Damage Prevention”. This is an important topic when dealing with trenchless projects. Due to San Diego’s close proximity to Mexico and its high Spanish-speaking population, the conference will offer a special Spanish-only course on “Introduction to Trenchless Technologies” on the morning of July 16. It is anticipated that this course will attract interested individuals from Mexico and other Spanish-speaking countries. This year’s goal is to attract over 2,000 attendees, and raise over $50,000 at the 6th Annual Educational Fund Auction. These are high target goals; however I am confident that those who attend this year’s event will enjoy the high-quality technical paper presentations, informative vendor exhibits, and social interactions. Be sure to visit www.nastt.org for updated conference information.

Highlights of the event will include:
- 8th Annual No-Dig Golf Classic at the Riverwalk Golf Club
- NASTT’s 6th Annual Educational Fund Auction & Reception
- Gala Awards Dinner & Reception featuring some excellent entertainment for the evening
- Pre- and Post-conference short-courses

I encourage you to attend this 16th Annual No-Dig event, and bring along the family for an excellent adventure in sunny, picturesque San Diego!

Warmest wishes,
Dr. Samuel T. Ariaratnam
Arizona State University
2007 No-Dig Show Program Chair
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Remove the soil. And remove the risk.

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I. History
The City of Los Angeles (the City) operates and maintains more than 6,500 miles of sewers that serve more than four million people.

In October 2004 the City entered into a settlement agreement which, among other requirements, stipulates that the City must continue its current $2-billion, 10-year sewer renewal program, and enhance its efforts by increasing the lengths of sewers being renewed to an average of 60 miles per year. In order to meet the requirements and deliver the increased number of projects in a timely manner, the Secondary Sewer Renewal Program (SSRP), more commonly referred to as the 60-Mile Program, was created. This program is dedicated to planning, design, and construction of some of the Settlement Agreement Projects (SAP).

II. Protocol
A protocol has been set up to expedite the delivery of these projects. As part of this process, the City has been subdivided into more than 210 sewersheds (see Figure 1). Based on the maintenance records and history of sanitary sewer overflows (SSO), the sheds are prioritized and the sewers are televised to document their condition. Based on the condition report, City engineers prepare the pre-design report, design documents, process the project through bid and award, and manage the construction. An average of 25 projects per year are planned.

III. Design
Given the increased workload of the 60-Mile Program, the Bureau of Engineering (BOE) created a standardized document for design where all viable rehabilitation methods and materials are detailed (for instance, the rehabilitation methods and the liners are all listed). This protocol/method works very well with the SSRP program, because the program deals with small sewers exclusively (6 inch to 15 inch sewers).

The design itself also conforms to a very well defined regimen. First, the defects are categorized into root intrusion/blockage or various structural defects. Peripheral issues are also studied; among them hydraulic adequacy and appurtenant structures (e.g. addition of maintenance hole for maintenance access improvement). Then the appropriate rehabilitation method is assigned. Three rehabilitation methods are feasible: remove and replace, lining, or a combination thereof. The lining can be any of the City’s approved materials, structural or nonstructural. When there is more than one option to repair a reach, a quick cost benefit analysis is performed to find the most economical solution. Additional factors, such as traffic conditions, will also have impacts on the selection of rehabilitation methods.

IV. Computer Applications (Customized Design Tool)
BOE contracted the services of MARRS Services Inc, a consulting firm from Santa Fe Springs, California, to develop a GIS-based desktop application for further streamlining the design.
This application, Sewer Management Automated Renewal Tracking System (SMARTS©), centralizes and integrates a vast amount of spatial and non-spatial information such as sewer systems, sub-structure utilities, parcels, aerial photographs, and digital pipe assessment and visualizes the locations and other important characteristics of damaged pipes (see Figure 2). By utilizing ArcObjects and database technology, SMARTS© application provides customized features to help engineers quickly identify factors relating to sewer repair and allows them to complete design more efficiently.

Inherent to the designs are several repetitive calculation requirements, generation of tables, extensive research, and development of vicinity maps as well as key maps (Figure 3). This is where SMARTS© comes through with a rigorous software to change the traditional way of completing a design. Time needed to perform these tasks is significantly reduced. For instance, several tasks, traditionally performed in sequential order, such as utility investigation and looking at aerial maps etc. can be performed simultaneously. This is enabled by the software that shows information on several processes on the same screen (Figure 4). Also, instead of inputting the traditional data to complete a design, it is automated by SMARTS© based on pre-design reports and the engineers’ work. SMARTS© facilitates the preparation of design packages. The final bid documents generated from SMARTS© are not the typical plans and profiles, but a tabular list of pipe reaches and a specific rehabilitation/replacement method specified combined with the City’s Wastewater Master Specifications. Again, this software is evolving as the SSRP program progresses. The SMARTS© program is expected to fully mature during the next year. Numerous quality assurance and quality control (QA/QC) procedures have been implemented to allow rapid identification of errors.

V. Results

This innovative and streamlined approach to design has yielded a substantial increase in productivity. It is estimated that a typical pre-design report will be completed in four months and the completion of the design can be achieved in four to six months.

VI. Cost

Once the engineer finishes the design of a project, he/she prepares a more detailed City Engineer’s estimate. Typically, standard unit costs are used to prepare this estimate for removal and replacement, for lining, and for different bedding material or encasement. The SSRP program is entirely funded by the City; it will be paid for by the sewer service charge. No Federal or State assistance is involved.

VII. Duration

The Settlement Agreement is in effect until the end of fiscal year 2013/2014, but the protocols established for SSRP are expected to be used beyond that.
Geotechnical Engineering for Trenchless Projects

by David C. Mathy, DCM Engineering

Success in trenchless pipeline design and construction depends on the combined experience and contributions of owners, engineers and contractors. A thorough and complete geotechnical engineering investigation specifically addressing the proposed method of trenchless installation is a key component to this success. In fact, the level of importance placed on the geotechnical engineering investigation for a trenchless project by both designers and contractors is significantly greater than that for conventional open-cut trenching. As a result, the expectations of experienced owners, designers and contractors are higher and the scope and detail of the geotechnical investigation is greater (i.e. the geotechnical bar is at its highest for trenchless design and construction). From the geotechnical engineer's point of view, the most significant challenge on trenchless projects is that of completely understanding and appreciating the capabilities and limitations of various old, evolving, and emerging trenchless technologies and relating subsurface conditions to those technologies. This requires experience, judgment and specific effort on the part of the geotechnical engineer to keep up with trenchless literature and trenchless construction case histories (i.e. trenchless construction precedent).

Geotechnical conditions influence all surface and underground construction. The influence of geotechnical conditions is significantly greater for pipelines potentially involving thousands of feet of continuous excavation than for buildings involving localized excavations within relatively small footprint areas. An understanding of geologic setting, and the geologic process as they determine geotechnical conditions, provides a framework upon which to characterize the range of subsurface conditions along a proposed pipeline alignment, including changing soil and soil properties, changes from soil to bedrock, changing bedrock and bedrock properties and changing groundwater conditions. Traditional methods of open-cut pipeline construction are somewhat forgiving in excavating through variable subsurface conditions. Trenchless methods of construction are far more complex than open-cut trenching and as a result are much more sensitive (and less forgiving) to subsurface conditions and variations in subsurface conditions along a pipeline alignment. In fact, there are certain combinations of subsurface conditions where trenchless methods may not be feasible (e.g., small diameter microtunnel pipe jacking through cobbles and boulders which are too large for a microtunnel boring machine to ingest and crush, or through fills with oversize debris, metal, wood or other man-made obstructions).

Many design engineers and most owners arrive at trenchless technologies through the pipeline utility industry and conventional open-cut installation of buried utilities. As a result, some designers and owners still allow or even specify geotechnical investigations which are typical for open-cut pipeline design and construction, rather than the more rigorous geotechnical investigations required for trenchless design and construction. While trenchless projects may involve some aspects of open-cut methods (e.g. shaft and pit shoring and dewatering), the geotechnical engineering investiga-

DCM Engineering

GEOTECHNICAL ENGINEERING for
• Trenchless Planning and Design
• Trenchless Construction Solutions
• Claims Evaluations

David C. Mathy Dru R. Nielson
Robert A. Kahl Marc M. Gelinus

Walnut Creek 925.945.0677
California www.dcm-engineering.com
tion should be specifically approached as trenchless design; not as open-cut trenching. Table Nos. 1 and 2 are qualitative comparisons of the principal geologic and geotechnical factors that influence open-cut trenching pipeline design and construction and trenchless pipeline design and construction. As illustrated in Tables 1 and 2, trenchless methods are far more sensitive to many more subsurface conditions than open-cut trenching. In addition to typical geotechnical engineering properties and analysis for open cut trenching, a trenchless geotechnical engineering investigation may have to address any one of many unique soil and bedrock properties and impacts on trenchless construction, such as:

- Tunnelman’s Ground Classification (Terzaghi, 1950, Heuer, 1974);
- Cobbles and boulders, size and distribution;
- Cobbles and boulders, unconfined compressive strength;
- Man-made obstructions, fills and fill composition;
- Tunnel overcut stability and systemic settlement;
- Tunnel face stability;
- Clay and claystone swelling;
- Bedrock abrasiveness;
- Bedrock fracturing, faulting and jointing;
- Bedrock slake/durability;
- Bedrock strength;
- Soil cementation;
- Soft ground bearing capacity to support tunnel boring machine weight and steering corrections;
- Pipe/soil friction and pipe jacking loads;
- Reaction wall/thrust block capacity;
- Break-out and break-in tunnel portal cut stability (e.g. stand-up time) in shaft shoring;
- Soil improvement via displacement grouting, permeation grouting, jet grouting, etc.
- Cavity expansion theory and ground heave for pipe bursting;
- Vibrations from pneumatic pipe bursting;
- Borehole stability;
- Hydrofacture and loss of drilling fluids, slurries and lubricants;
- Bore path soil plasticity and grain size distribution for drilling fluid design (e.g. composition, density, viscosity);
- Soil and groundwater chemistry with respect to drilling muds;
- Flow factor for bore path soils;
- Shaft recompression settlement upon backfilling;
- Slurry separation plant components as a function of soil composition;
- Mixed face tunnel conditions; and
- Change-in-face tunnel conditions.

While trenchless methods offer distinct advantages in the areas of public disruption, shoring, dewatering, bedding and backfill, they pose many new challenges as illustrated in Tables 1 and 2. Therefore, understanding subsurface conditions and possessing the judgment and experience necessary for providing a sound framework for interpreting and representing geotechnical information along a pipeline alignment is critical to trenchless methods. Without a thorough and accurate understanding and representation of geotechnical conditions, vital features of the subsurface that can adversely impact trenchless construction may be missed. The more complex the geologic setting, the more important this understanding and representation becomes.

The typical design geotechnical investigation for trenchless projects should be completed in the following four phases:

**Phase I**

Geologic setting and development history of alignment (and alignment alternatives).

**Phase II**

Preliminary subsurface investigation (borings, test pits, large diameter borings, laboratory testing, cone penetration tests, geophysical testing, etc., widely spaced along the pipeline alignment).

**Phase III**

Final subsurface investigation (borings at all shafts/pits, mid-drive borings, test pits, large diameter borings, laboratory testing, cone penetration tests, geophysical testing, groundwater monitoring wells, etc.).

**Phase IV**

a) Construction inspections and observation/documentation of the consistency of excavated soils/bedrock with the geotechnical data.
b) Observation of trenchless construction and meeting with contractors to adjust and improve the design and construction process for both the current and future projects.

For smaller projects, the first three phases of investigation are sometimes combined into a single continuous effort. For larger projects, each phase may be independent. Under ideal circumstances, each phase is completed by the same geotechnical engineering firm, allowing for continuity of information, data interpretation and analysis. The cost of a geotechnical engineering investigation for a trenchless project varies in accordance with the complexity of underlying geology, site conditions, and trenchless method; however, for typical projects the geotechnical cost is generally on the order of 1% to 5% of construction cost.

The project geotechnical engineer should possess a strong record of experience in:
1. The local geology, area development history, and general construction precedent in the area; and
2. The method(s) of trenchless construction proposed and specific trenchless construction precedent in similar geologic settings.

Ideally, this combination of experiences will come from one firm. If not, and depending on the size and complexity of the project, it may be necessary to retain two geotechnical firms; one with local experience to develop all geotechnical data (and a geotechnical data report, GDR), and one to interpret the data with respect to the proposed trenchless method and develop design and construction conclusions and recommendations, as well as a geotechnical design summary report, GDSR. For a completed discussion of GDR, GDSR and geotechnical baseline reports (GBR), see “Geotechnical Baseline Reports for Underground Construction” by Randy Essex, ASCE, 1997.

The scope of subsurface investigation and laboratory testing should vary as a function of geologic setting and complexity along the pipeline alignment and the proposed trenchless method. As an example, a typical microtunnel pipe jacking project will include borings at each jacking and receiving shaft, mid-drive borings if the shafts are more than 500 feet apart, groundwater monitoring wells at shafts, continuous sampling through the tunnel zone (plus one tunnel diameter above and below), and interval sampling elsewhere and detailed laboratory testing with emphasis on soil gradation, plasticity, strength, compressibility and permeability. Photo Nos. 2 through 4 illustrate one common example of additional scope of work required for trenchless tunneling or directional drilling in an area where the geologic setting indicates that cobbles and boulders may be present. The conventional drill rig in Photo No. 2 is using an 8-inch hollow stem auger. This small diameter drill rig is not capable of retrieving samples of cobbles or boulders. In geologic settings where cobbles and boulders are likely, a large diameter drill rig as shown in Photo No. 3 will be required to measure and retrieve samples (Photo Nos. 4 and 5). These cobbles and boulders can then be measured for distribution, maximum particle size and unconfined compression strength. Such measures would not be typically undertaken for open-cut trenching.

For all trenchless projects, the geotechnical engineering investigation objective is to:
1. Define alignment site conditions and development history and geology and anticipated changes in subsurface conditions (e.g. alluvium to bedrock, native soils to fill, man-made and natural obstructions, etc.).
2. Define soil composition (i.e. clay, silt, sand, gravel, cobble and boulders).
3. Define soil consistency (i.e. very soft to hard for silts and clays and very loose to very dense for sands and gravels, typically done through correlation with field standard penetration test blow count, N).
4. Define soil behavior (i.e. raveling, squeezing, running, flowing, swelling in accordance with the Tunnelman’s Ground Classification of Soils).
5. Define groundwater elevation and estimated soil permeabilities, groundwater flow rates and dewatering limitations (e.g. at shafts/pits).

All of these geotechnical factors are critical to successful design and construction of a trenchless project. In many cases, these determinations are used in the contract documents as the basis of bids (e.g. GBR). Proper identification, interpretation and definition of these subsurface conditions will minimize surprises during construction, and in the most severe of adverse conditions failure of the trenchless method and reverting to open-cut trenching.

It is important to keep in mind and appreciate that a typical geotechnical engineering investigation for a trenchless project such as a 4,000 foot long, 24-inch diameter microtunnel pipe jacking project...
with borings at 400-foot intervals and continuous sampling in the tunnel zone will expose less than 0.01% of the total tunnel excavation. Filling the gaps between borings with carefully considered interpretations of subsurface conditions based on experience and good judgment is vitally important.

The contractor will excavate 100% of the soil/bedrock along the pipeline alignment, and any significant differences from the subsurface conditions described in the geotechnical investigation report and contract documents may result in pipeline deviation from line and grade, emergency (911) excavations to remove obstructions, construction delays, potential construction claims, and disruption to the community served by the project.

TABLE 1
TRENCHLESS TECHNOLOGY COMPARISONS

<table>
<thead>
<tr>
<th>Geologic/Geotechnical Factor</th>
<th>Open Cut Trenching</th>
<th>Microtunneling Pits</th>
<th>Tunnel</th>
<th>HDD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Shoring</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>2. Groundwater &amp; dewatering</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>3. Unstable soils (raveling, running, flowing - no stand-up time)</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>4. Contamination above pipe zone</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>5. Bedding &amp; backfill</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>6. Recompression settlement</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>7. Obstructions: fill debris, metal, wood, tree roots, oversize material</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>8. Soil gradation down to 2 micron</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>9. Gravels/cobbles/boulders, size and distribution</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>10. Cobbles/boulders, compressive strength, abrasiveness</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>11. Stiff, high plasticity clays</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>12. Squeezing/swelling clays and swelling claystones</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>13. Bedrock hardness/strength</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>14. Bedrock fracturing/jointing</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>15. Bedrock abrasiveness</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>16. Bedrock durability</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>17. Variable soil/bedrock cementation</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>18. Mixed-face condition</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>19. Changed-face condition</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>20. Soft ground and MTBM bearing capacity steering corrections</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>21. Pipe friction, tunnel overcut and lubrication</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>22. Reaction wall bearing capacity</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>23. Tunnel and tunnel face stability (potential for overexcavation/voids)</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>24. Shallow cover, hydrofracture and slurry loss</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>25. Shallow cover, ground heave</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>26. Systemic settlement</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>

*not critical, important, critical

TABLE 2
TRENCHLESS TECHNOLOGY COMPARISONS

<table>
<thead>
<tr>
<th>Geologic/Geotechnical Factor</th>
<th>Open Cut Trenching</th>
<th>Trenchless Replacement Insertion Pipe</th>
<th>Pipe</th>
<th>Pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Shoring</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>2. Groundwater &amp; dewatering</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>3. Unstable soils (no stand-up time)</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>4. Contaminated soil above pipe zone</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>5. Contaminated soil in pipe zone</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>6. Bedding &amp; backfill</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>7. Recompression settlement</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>8. Existing pipe type</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>9. Existing pipe condition (sags, point repairs, collars)</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>10. Upsizing percentage</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>11. Existing pipe bedding and backfill</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>12. Native soil/bedrock conditions and original trench width</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>13. Depth of cover</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>14. Overcrossing utilities</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>15. Parallel utilities</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>16. Overlying structures</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>17. Vibrations</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>18. Ground heave</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>19. Systemic settlement</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>20. Hydrofracture</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>21. Reach length</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>22. Reach linearity</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>23. Available layout area</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>for new pipe fusion</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>24. Pipe friction and installation loads on pipe</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>
The City of Santa Monica's wastewater collection system is a complex network of 150 miles with mostly gravity pipelines of clay or reinforced concrete, and are on average forty-five years old. After the earthquake, the City performed comprehensive investigation of the existing system. This review included studies of the existing utilities plans, history and maintenance records, global CCTV inspection and its review, flow monitoring, maintenance holes inspection, and dye, smoke, and soil testing.

The results of this investigation were: approximately 85% of the sewer main sustained some form of damage due to the earthquake (broken or missing pipe, offset joint and lots of cracks), 48% of the existing maintenance holes had cracks, missing bricks and mortar, and 35% of the existing system was undersized and not in conformance with the current engineering design criteria and City ordinances.

FEMA agreed to provide funding for the repairs ($79,000,000), and the City added additional funding for the upgrade to the existing system ($5,000,000 +/-). All repair work was divided into seventeen contracts.

Santa Monica, like other cities in the Los Angeles area, is very densely zoned; it has a mix of single family homes, multi unit residential apartment buildings, and high rise commercial buildings - all in a 3 square mile area. As the entertainment industry is widely represented in our City, film and sound studios could be found in many areas of the city; consequently noise and vibration can be quite disruptive to their production schedules.

In order to reduce inconvenience and disruption to the public and business community, the City decided to use trenchless methods of repair and/or new installation wherever possible. In the areas where the sewer pipes did not need to be upsized, plans and specifications directed the contractor to select one of a variety of lining methods (CIPP, Folded and Formed PVC, Deformed/Reformed HDPE or Spiral Wound PVC Profile Wall Liner Pipe). In the areas that needed upsizing, pipe-bursting was the method of choice, and for new installation, open cut and/or Microtunneling was specified. Construction had to be completed over a five-year period.

Trenchless rehabilitation of the existing system with any lining method brings challenges related to water use issues. Installation of lining materials temporarily blocks lateral connections at the sewer main until robotic cutters can restore the lateral openings. This period varies from 3 to 10 hours, depending on the type of lining product, length of the reach (main-
Use Statement had to be submitted with the bid.
Proposed products had to meet the stringent test criteria set forth in the “Greenbook” Section 210-2.3.3 Chemical Resistance Test, better known as the “pickle jar test”.

For Pipe-Bursting Project
Contractors had to submit:
- Construction procedure for pipe installation.
- Dimensions, locations, surface construction, profile, depth, method of excavation, shoring, and bracing for the insertion and receiving pits.
- Locations, sizes, and construction methods for the service reconnection pits.
- Physical properties and specifications for piping material.
- Pipe fusion/welding (pulling methods) operators shall be certified by the fusion/welding equipment manufacturers.
- Equipment technical data and operating procedures.
- Certification by the Trenchless Pipe Replacement System Manufacturer as the user of their system.
- Manufacturers’ recommendations for handling, storage, and repair of pipe and fittings.
- Method of construction, reconnection, and restoration of existing laterals and maintenance holes (MH).
- Sewer bypass plans and methods.
- Contingency plans for approval for the following potential conditions:
  a. Damage to replacement pipelines’ structural integrity and repair
  b. Loss and return to line and grade
  c. Soil settlement

Some of the Submittals and Requirements for Microtunneling Projects:
- Complete Microtunneling Work Plan.
- Identify the Microtunneling Boring Machine to be used (MTBM), provide drawings and specifications for the MTBM, and trailing equipment, including any future modifications.
- Specific gravities and viscosities of the slurry mixture and description of additives for slurry.
- Method and details of spoil removal.
- Details, including pipe rail elevations, of pipe guide rail setup of jacking frame setup for each proposed jacking pit, including calculations of the anticipated jacking forces, and a contractor’s statement of allowing jacking force on pipe and factor of safety.
- Detailed plan showing the locations, type, and size of the intermediate jacking stations, and method for installing them in the shaft with design drawings of cans, manufacturer’s data, and layout of intermediate jacks within the cans.
- Detailed description of the lubricant mix and the proposed pressures for pumping, with the anticipated volumes of material to be used.
- Method of controlling line and grade of the tunneling operation.
- Grouting plan at machine launch and recovery.
- Ground surface/settlement monitoring plan and remediation plan for pavement settlement.
- Resumes of the key staff and a schedule of the tunneling work.
- Site security arrangements and traffic plans.
- List of shaft construction equipment.
- Structural basis of design and details of the proposed jacking pipe and joints.
- Detailed description of the quality control methods proposed for tunneling operation.

There were also requirements for corrective actions and recommendations for addressing problems. Detailed Post-Video inspection was done to allow for visual inspection of the quality of pipe and pipelining installation. The construction management and inspection group assigned to the project had extensive experience in overseeing this type of project.

The overall Project was a success. All construction operations were completed on time and within budget. By using trenchless methods of repair/installation, the City saved approximately $10,000,000. This money would be used by the City to replace, upgrade, or relin additional sewer mains which were not a part of the original scope of work for the Renovation of Santa Monica’s Earthquake Damaged Sewers Project.

Eugenia Chusid is a Civil Engineer Associate/Project Manager with the City of Santa Monica, Department of EPWM, Civil Engineering and Architecture Division, and has been involved with the following Organizations/Associations American Society of Civil Engineering (ASCE), 18 years; American Public Works Associations (APWA), 17 years; Construction Institute (CI), 17 years; American Society for Trenchless Technology (NASTT), 10 years; Rehabilitation Task Force, 18 years; GREENBOOK Joint committee- Secretary, 5 years; ASTM - Committee F36 on Technology and Underground Utilities, 6 years.
The City of West Jordan is one of Utah’s fastest growing cities, and currently ranks as the sixth largest city in Utah with a population of roughly 100,000. Both industrial and residential growth has continued at a high rate for several years and shows little indication of slowing at the present time. The City of West Jordan is one of the few communities in Salt Lake County that has significant amounts of undeveloped ground between the city and the mountains, which is available for future development. Within this rapidly expanding city, there are several industrial parks, including the Bagley Industrial Park, which boasts tenants such as Dannon Yogurt, Interstate Brick, and Kraftmade, with new industrial tenants arriving every year. These growth conditions, along with dated infrastructure, have required recent upgrades to accommodate the needs of current and future users.

One such circumstance, initiated by David Murphy, P.E. with the City’s Engineering Capital Projects Division, was the expansion of the sewer outfall from the Bagley Industrial Park. While planning for the rapid growth within the industrial park and anticipating full build-out conditions by 2030, the City of West Jordan identified the upsizing of the outfall as a priority project. In order to mitigate the challenges associated with the proposed improvements, Project Engineering Consultants, Ltd., (PEC), was retained to provide planning, design, and construction management for the Bagley Industrial Park sewer pipeline project.

At initiation of the project, PEC collected video and logs of the system, compiled flow data, evaluated the main sewer lines servicing the industrial park, and revised the City’s sewer master plan. The existing outfall for the industrial park consisted of 4,000 LF of 10-inch I.D. concrete pipe in the Old Bingham Highway. Preliminary engineering analysis demonstrated that this outfall was undersized, approaching capacity during peak flows, and would require upsizing to 18 inches O.D. in order to accommodate recent growth and future demands.

The initial concept for this project was to commence with conventional cut-and-cover methods, either by installing a parallel line or replacing the pipeline within the existing trench. Upon additional investigation however, it was discovered that the project corridor was extremely constrained by existing travel lanes and access to the industrial park, right-of-way, landscaping including walkways, decorative concrete, and stone/concrete fencing, as well as an overabundance of underground and overhead utilities including communication lines, fiber optics, high voltage power, intermediate and high pressure gas lines. Additionally, the introduction of new tenants to the industrial park required immediate upgrades to the system that would require construction during the harsh winter months, and budget constraints threatened to limit the extent of the improvements. Due to these restrictions, typical excavation alternatives became less attractive, and trenchless methods were considered.

As part of the preliminary engineering, PEC prepared a design alternative analysis comparing conventional trenching with pipe bursting. Preliminary geotechnical analysis established that the soil conditions along the proposed alignment were variable, and consisted of silty to clayey gravel, gravelly clay and clayey to silty sand and silt. The laboratory densities of the soils proved to be generally moderate and did not appear to represent very high densities. This was a critical factor in determining the feasibility of pipe bursting, particularly since backfill that is dense or highly compacted is likely to result in heave at the ground surface, or transmit the bursting stresses to the adjacent utilities.

Conversely, poorly compacted or moderately dense or loose backfill is more readily able to accommodate the volume change resulting from the pipe bursting operations, and less likely to cause heave or stress on adjacent utilities. Highly granular backfill is also less likely to accommodate volume change, while cohesive backfill is more likely to accommodate the volume change that occurs around the burst pipe. Therefore, soil conditions proved to be within the intermediate ranges concerning difficulty for pipe bursting. Some concerns remained regarding stress to adjacent utilities, particularly with the 6-inch high-pressure gas
High Density Polyethylene Pipe (HDPE) was selected for the pipe bursting project. DR-17 HDPE was specified because of its ability to meet the pressures and strains that would be exhibited during this unconventional triple upsize burst. HDPE provided the contractor the ability to weld a full-day's pull together, approximately 400 LF, prior to beginning each day's operation and string it inside the construction path during the pipe bursting operation.

To further complicate the potential for pipe bursting, the 18-inch O.D. would be a triple upsize and would require a 22-inch bursting head. This would constitute a 120% increase in size and would place this burst within experimental ranges. The challenges associated with pipe bursting were calculated and investigated further, the outcome of which provided a conclusion that bursting was feasible on this project.

Pipe bursting challenges for upsizing.

Drill Pipe (AA, Case, DitchWitch, Vermeer)
Tri-Cone Drill Bits
Sonde Housings
Starter Rods
Transition Subs
Crossovers
Jaw Dies
Mud Pump Parts
Economical Rock Reamers
Drilling Fluids
Swivels
Portable Breakout Units
Railhead Products
Rod Wipers
Flow Meters
DCI Locating Equipment
Duct Installation Tools
Reamers
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open-cut segment. Additionally, the anticipated construction duration was also reduced by an excess of 30% due to elimination of complications with backfill moisture content, bracing of existing utilities, and paving restrictions generated by winter weather conditions. It was apparent at the project bid opening that the contractors concurred with the anticipated benefits of pipe bursting. All of the bids came in under the engineer’s estimate, with the successful bid indicating pipe bursting costs were 24% less per linear foot when compared to open-cut costs.

Noland and Sons Construction Co., Inc., a local contractor with pipe bursting experience was the successful contractor. The Project Manager for Noland and Sons was Doug Noland. The equipment Noland chose for this challenging burst was a pneumatic bursting head with a leading edge cutter to split the concrete pipe. The equipment was manufactured by TT Technologies and included a 20-ton Grundowinch and Grundoburst® pneumatic bursting head. The TT Technologies representative was Jim Moore, who provided technical support throughout the project to the contractor and PEC. It was determined that the existing manholes throughout the project would require replacement. This provided Noland the perfect location for their insertion and receiving pits for the bursting operation, and provided them ample spacing for their daily bursting operations with the 400 LF lengths between manholes.

The benefits of pipe bursting continued to be manifested throughout construction, as the contractor was able to maintain complete access to the industrial park and maintain full operation of adjacent travel lanes throughout construction. Furthermore, the 10-inch concrete pipe in Old Bingham Highway earmarked for upsizing did not contain any service laterals to contend with during the installation. This provided the additional impetus for pipe bursting over conventional trenching.

Although bentonite lubrication would typically have been used for this type of burst, extremely cold weather prevented its use. Even with bursting rates varying widely throughout the project, sometimes one-half of typical production rates, the contractor was able to maintain an aggressive schedule during the pipe bursting portion of the project. The only delay to the project occurred within the open-cut section as the contractor struggled with the failure of the trench wall and with utility bracing.

In summary, the pipe bursting alternative, through proper engineering and cost effective design solutions, planning, and construction, allowed the contractor to avoid lane closures that would restrict heavy truck traffic, eliminated right-of-way constraints and the potential need for construction easements, avoided costly repairs to surface infrastructure, eliminated impacts to the buried and overhead utilities, and avoided additional environmental impacts such as noise, dust, and exhausts. Additionally, the project was completed on an expedited construction schedule during harsh winter conditions.

Pipe bursting has proved once again to be a cost effective trenchless alternative method that can triumph during extreme conditions and provide upsizing ability unparalleled by conventional installation methods. Even during these extreme conditions, pipe bursting provided the shortest construction timetable, with the least amount of impacts to the traveling public, business, existing infrastructure, and other utilities in a much more compact construction footprint.

For further information or project inquiries, please contact:
Project Engineering Consultants, Ltd.
8819 South Redwood Road, Suite C
West Jordan, Utah, 84088
Phone: (801) 495-4240 / Fax: (801) 495-4244
Email: leo@pecutah.com
The Genesis of a Condition-Based Asset Management Program for Critical Water Pipelines

By Bruce Johnson and Myron Shenkiryk

After a large water transmission main failed in 1999, the City of Tucson implemented a proactive pipeline protection programs in the country in order to ensure that another failure of this type would not occur in the future.

Bruce Johnson, Deputy Director for the Tucson Water Department, comments. “The catastrophic failure of the 96” water main provided an unparalleled challenge and opportunity for our water utility to enhance its credibility with the public. The decision to provide all engineering design services and repair management using in-house staff, facing a very critical time frame for completion, demonstrated in a very public way the professionalism and capability of the department.”

Catastrophic Failure

The City of Tucson, Arizona, maintains over 4,000 miles of drinking water mains serving a customer base of 680,000 people over a 375 square mile area. The backbone of the city’s water supply system is twenty miles of transmission mains, ranging in diameters from 48 to 96 inches. These pipelines were constructed with Prestressed Concrete Cylinder Pipe (PCCP). The design of these large diameter water transmission mains relies on a high strength steel wire wrapped helically around a concrete core. The prestressing wire is then coated with mortar to provide corrosion protection. However, over the years deterioration may occur. For PCCP mains, corrosion can cause premature failure of the prestressing wire. In the event a sufficient number of wires break, the structural integrity of the pipe becomes compromised.

Such a scenario occurred in 1999, when a section of the 96-inch diameter PCCP suddenly failed, resulting in a loss of 38 million gallons of treated water from an upstream reservoir. The failure challenged Tucson’s capabilities to meet their customer demands and caused significant property damage to several homes, and as Tucson was in the initial stages of a severe drought, the failure and its effects became the lead story on the evening news.

A forensic investigation concluded that damage to the pipe section during field modifications may have accelerated failure of the prestressing wires due to a combination of corrosion from aggressive soil conditions and wet/dry cycling of the soil in contact with the pipe. The cost of the catastrophic failure, including property damage, was $4.3 million.

New Strategy/Vision

Like most cities, Tucson believed that the pipe installed would serve for many years with little or no maintenance required. PCCP has in general been a very durable, cost-effective solution for large diameter pipelines. However, in some cases, construction problems, defects, poor design or manufacture, or poor operating practices have accelerated corrosion problems. In Tucson, when the failure occurred, Tucson Water’s management team immediately set out to quickly establish a “Preventative and Predictive Maintenance Strategy for PCCP” to minimize the risk of future failures in their transmission main system.

Britt Klein, Tucson Water Maintenance and Operations Superintendent, has been involved with developing this proactive strategy, and describes his Department’s actions. “The catastrophic failure of 96” PCCP was a wake-up call for Tucson Water. The failure served as a prime example of the devastating effects a pipeline failure of this size can have on our ability to deliver water, on our community and on our staff. It also manifested the fact that we did not have a program in place that would alert us to the risk associated with distressed PCCP regions. The first thirty-two hours after the pipe had failed were spent stabilizing the environment and ensuring our customers were placed back in service as quickly as possible. The next seven years were spent ensuring that we would use the best technology available to identify distressed pipe and prevent this type of failure from occurring again. Seven years later, we are using technologies that are best in class to ensure reliability of our most critical water transmission lines.”

Klein consulted with several PCCP owners, including John Galleher, San Diego County Water Authority Senior Engineer. Galleher has been involved with inspection, monitoring and rehabilitation of PCCP since the early 1990’s.

Mr. Galleher invited Britt Klein and his team to visit San Diego to share the PCCP management program that Galleher had implement-
ed. The open communication between water agencies provided an effective way to disseminate information and avoid costly duplication of various strategies. The information shared between Tucson and SDCWA provided the foundation for Tucson’s proactive management strategy.

Klein also became an active participant in the PCCP User’s Group, formed in 1995 to provide a forum for owners to share their experiences regarding inspection, monitoring and rehabilitation of PCCP. Currently there are over 15 owners involved with this group who meet on a regular basis to discuss the latest innovations. The most recent User’s Group meeting was held in Tucson, Arizona in April, 2006.

After receiving input from owners and vendors during these meetings, Tucson adopted a proactive program to assess the condition of all their PCCP mains and implemented numerous risk management strategies to ensure the safe and reliable operation of the PCCP transmission mains. Their approach to condition-based asset management enables Tucson to check on any individual section of PCCP and obtain near real-time information on the condition of each spool of pipe.

**Tucson’s Inspection and Monitoring Plan**

Over the past few years, significant advancements have taken place in the development and application of technologies designed to inspect and manage PCCP. Such advances have provided new ways to manage the risk associated with a catastrophic failure in these large-diameter pipelines.

As recently as 1997, a pipeline operator had little information on the extent and rate of deterioration of prestressing wires for PCCP. Engineers could only rely on visual inspection and corrosion surveys to try to identify pipes which could be approaching a critical structural condition. While the information from these inspections was useful, they did not provide sufficient information to make long-term management decisions on the serviceability of the pipeline. Since 1997, new technologies have been developed that provide a more comprehensive picture on the condition of PCCP. P-Wave® electromagnetic inspections can be performed to detect electromagnetic anomalies associated with broken prestressing wires. SoundPrint®
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The Evolution of Data Inspection
acoustic monitoring is used to monitor the sounds being transmitted through a pipeline to detect and locate a wire break event as it occurs. Part of Tucson’s “Preventative and Predictive Maintenance Strategy for PCCP” included both P-Wave® electromagnetic inspections and SoundPrint® acoustic monitoring. In addition to using these new technologies, Tucson also performed visual and manual sounding inspections to identify cracking, other visible defects, and pipes in an incipient state of failure.

With the results from the inspections, a comprehensive assessment of the baseline condition of a pipeline is ascertained. Using the estimated wire break information, a structural analysis was performed to determine the level of risk associated with a distressed pipe section. This analysis relied on a non-linear finite element model to determine the significance of certain levels of wire break damage for a given pipe design. For instance, estimates can be made on how many wire breaks will cause failure of the pipe.

Based on the results of the analysis, sections of pipe were labeled in good condition, scheduled for replacement/repair, or additional monitoring. Overall, less than 1% of Tucson Water’s PCCP inspected showed areas of concern. It was deemed that the pipe sections with minor to moderate levels of structural deterioration could be managed with acoustic monitoring. With this technology, the rate of deterioration of the prestressing wires can be obtained. If any pipe sections approach an unacceptable level of risk, as determined by the structural analysis, Tucson can intervene with a repair/replacement strategy.

**An Integrated Dynamic Approach to PCCP Integrity Management**

In most cases, electromagnetic inspections will provide a good approximation of the number of existing breaks in the prestressing wire for a given pipe section. Acoustic monitoring can identify and locate wire breaks as they occur on a continuing basis. This information has been used to identify and replace distressed pipe and to assist in the development of repair or replacement programs. However, until recently, this data was used only as part of a static approach; that is, the information collected from periodic assessment programs permitted decisions on the basis of an analytical or subjective assessment of risk of failure at that particular point in time. This can lead to the adoption of inadequate or overly conservative mitigation strategies.

With the recent development of an acoustic monitoring system utilizing acoustic fiber optics (AFO), the cost of managing systems has decreased significantly while the reliability and efficiency has increased. Owners can now consider the application of permanent acoustic monitoring of critical lines to continuously track their condition. This system consists of a continuous acoustic optical fiber installed inside the pipeline. Up to 10 miles of fiber can be connected to one proprietary optical processing and data acquisition system. Subject to sensitivity testing, the system may also be able to detect leaks and third party damage, thereby providing the capability of complete pipeline integrity monitoring. With permanent acoustic monitoring, the piping network should only have to be scheduled for dewatering when replacement or internal repairs are required.

Tucson is presently implementing this integrated dynamic approach to managing risk. Tucson Water has recently installed a fiber optic monitoring system through all 20 miles of their PCCP system. The fiber will be used to permanently monitor the condition of their transmission mains. As time progresses, Tucson will be able to see how many wire breaks are present on any individual section of PCCP. This information will include both the baseline electromagnetic information and the continuous deterioration data from the acoustic system, enabling Tucson to know the condition of their pipeline at any given time.

Dr. Samuel Ariaratnam, a faculty member at Arizona State University’s Del E. Webb School of Construction, states that AFO gives owners real time information on the condition or structural health of their existing buried assets and he believes that one day chips will be embedded in new pipe to provide continuous monitoring of pipeline condition. Technological advancements in the infrastructure industry are vital to reducing costs through a proactive approach to assessment of vital water pipelines.
Armed with this type of data, Tucson can make intelligent, cost-effective decisions on how best to manage their transmission mains. If a pipe section approaches an unacceptable level of risk, alarms are generated so the pipe is identified and repaired as needed. This ensures that appropriately scaled repair/strengthening projects are implemented as needed, and eliminates the chance of being forced to perform overly conservative repairs of pipe sections based on limited knowledge of their condition. Perhaps most importantly, it also minimizes the risk of failure. Tucson already credits the program as having averted one potential failure of a pipe segment.

This combination of electromagnetic inspection, acoustic monitoring, structural modeling, and risk management allows agencies to optimize PCCP management and offers a far more sophisticated and cost-effective solution to assuring pipeline integrity than current “static” practices.

Mike Gritzuk, Pima County’s Director of Wastewater Management, has been involved in PCCP condition assessment and rehabilitation methods for many years. Gritzuk states, “The proactive assessment methods employed by Tucson Water through the use of such methods as acoustic fiber optics and incorporating their Pipeline Risk Management System is state-of-the-art today, and complies with the emerging federal and state Capacity Management Operations and Maintenance (CMOM) regulations and asset management programs. These diagnostic methods are the most advanced techniques available today in managing acceptable levels of risk and planning/programming a cost effective approach to rehabilitation of PCCP. Tucson Water’s management of their PCCP rehab program serves as a model that other utilities can follow.”

Media Day
It is interesting to note that based on the success of the Preventative and Predictive Maintenance Strategy for PCCP, the media in Tucson has taken a new angle. On Monday, March 13, 2006, the City of Tucson held a media day with several local television stations and the local print media attending. The focus of the meeting/tour was to inform the community of the steps Tucson Water has taken to prevent another catastrophic failure in their water transmission system.

Fernando B. Molina, Tucson Water’s Public Information Supervisor had the following thoughts on the media event. “The maintenance work being performed on our transmission lines provided an excellent opportunity to inform the community of our efforts to utilize new technology to assist in monitoring the stability of our distribution system. This is important, since much of our facilities are generally hidden from view or buried underground, and most media coverage focuses on the line breaks that may occur from time to time. The interest and participation by various media groups helped to reinforce our credibility in the community, and demonstrated our commitment to maintaining the community’s water system.”

Bruce Johnson is the Deputy Director for the Tucson Water Department, Email: bruce.johnson@tucsonaz.gov
Myron Shenkiryk is the Southwest Regional Manager for Pure Technologies US Inc., Tel: 602-686-0311 Email: myron.shenkiryk@soundprint.com

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Unique Trenchless Solutions for Sewers in Southern California

By D. Craig Camp, Jacobs Associates

In his over 25-year career in underground construction, Craig Camp, Senior Engineer at Jacobs Associates, has handled over 80 trenchless projects, installing more than 200,000 feet of pipeline throughout the United States. Contractors, engineers, and project owners, both public and private, have called upon Mr. Camp to help resolve troubled trenchless issues. Two of his recent jobs, the Redwood Trunk Sewer in Oxnard, and Inverted Siphon No. 7 Replacement Design in Ojai, have received kudos from the American Public Works Association. Mr. Camp revisits his experience on these projects, as well as the Meiners Oaks Trunk Sewer crossing of the Ventura River in Ojai, which received an award from the Consulting Engineers and Land Surveyors of California.

A seasoned microtunneling expert, Mr. Camp has taught for the Colorado School of Mines Microtunneling Short Course. The North American Society for Trenchless Technology (NASTT) and American Society of Civil Engineers have published Mr. Camp's writings on “Fast Track Design and Installation of a 30-inch Casing Pipe Crossing the Ventura River” in their 2004 Proceedings for No-Dig and Pipelines, respectively. Mr. Camp holds a degree in Mining Engineering from the University of Idaho.

NASTT recently recognized Jacobs Associates with a NASTT 15th Anniversary Industry Achievement Award for “significant contributions to the development of technology and to the growth of the trenchless industry in the last 15 years.” Jacobs Associates, an engineering consulting firm based on the United States West Coast, celebrates its 50th anniversary this year.

Redwood Trunk Sewer

This interceptor sewer, as originally envisioned, contained four major reaches for a total of approximately 45,000 feet. The southern two reaches, Redwood and Ventura, consisted of approximately 15,000 feet of 48 to 60-inch sewer, and 10,000 feet of 42-inch gravity sewer, respectively. The ground conditions consisted of flowing silts and sands at approximately 40 feet of depth with approximately 10 to 20 feet of groundwater above the sewer. The two northern reaches, Hemlock and Gonzales, consisted of 36 to 12-inch gravity sewers. The Hemlock reach comprises a gravity sewer and force main. The shallowest and smallest diameter gravity sewer portion faced ground conditions of dry sand. The larger diameter sewer faced similar ground conditions, but with groundwater approximating the tunnel horizon in some locations. The Hemlock reach faced flowing silts and sands with approximately 10 feet of groundwater. Additionally, in a few areas the ground contained refined petroleum products.

Jacobs Associates, as a subconsultant to Kennedy/Jenks, provided design services to evaluate trenchless design and construction alternatives. The design team determined early on that, due to the soil conditions, microtunneling likely would provide a cost benefit and reduce social impacts for the southern section. Final design confirmed that microtunneling offered clear cost, schedule, and social benefits for the southern reaches. The northern reaches and the Hemlock reach bid as a separate, open trench construction contract with microtunneling as a viable option.

Final design consolidated the southern reaches, which in preliminary design listed four different diameters, into two diameters, thereby reducing the number of machines required for the project. Jacobs Associates' final design services included specifications for microtunneling, shaft construction, and ground movement monitoring; mark-up of drawings for constructability; and an engineer's estimate of microtunneling construction costs.

The design involved several details of note. The maximum distance between manholes measured 500 feet; the contractor had a choice to either complete 500-foot drives or drive 1,000 feet and install intermediate manholes. The railroad permitted the gravity sewer to pass under its tracks without a steel casing. Concrete-lined storm channels paralleled the deep sewer for several thousand feet. Additionally, the sewer passed under another storm channel. At
another location, sewer construction took place at the end of the airport, under the take-off and landing pattern. The landing pattern required special operating parameters and hours, as the surface equipment stood in direct conflict with the aircraft.

The Redwood Trunk Sewer, which bid in late 2003, reached a price that confirmed this project as the largest microtunneling project in the North American market as measured by footage, and second largest as measured by bid price, $33.4 million. This price fell in the midrange of the engineer’s estimate. Construction utilized typical interlocking sheet pile jacking shafts with 20-foot long segments of Hobas jacking pipe. The microtunneling portion concluded in early 2006 after two years of construction. The Redwood Trunk Sewer received a 2005 Project of the Year award in the environment category from the American Public Works Association, Ventura County Chapter.

Meiners Oaks Trunk Sewer Relocation

Also known as the Ventura River Crossing, the Meiners Oaks Trunk Sewer Relocation called for replacement of approximately 5,000 feet of existing wastewater pipeline that parallels and also crosses the Ventura River in Ojai, California. Scour during river flows had put the existing pipeline at risk. The project owner, the Ojai Valley Sanitary District, requested an inverted siphon to replace the current sewer line, formerly constructed utilizing open-cut construction methods - an accepted practice at the time, but no longer preferable since the local riverbed became designated as an environmentally sensitive area. The replacement plan called for horizontal directional drilling (HDD).

A diagonal crossing design - the hypotenuse of a right triangle formed by the legs of the existing sewer - reduced the total footage of pipeline from approximately 5,000 to 3,000 feet. At each end of the crossing, connections to the existing pipeline included facilities for sending and receiving pigs. The crossing, designed to act as an inverted siphon, featured an HDD design, which had the added benefit of improving the system hydraulics for this reach of gravity sewer. The inverted siphon design comprised three 10- to 12-inch diameter HDPE carrier pipes, and three 2-inch diameter HDPE conduits, installed within a steel casing. Structures at each end transitioned the flow based upon flow volume in order for the inverted siphon to operate. Jacobs Associates, as a subconsultant to Boyle Engineering, provided engineering support services to facilitate final design of the project. These services include assistance in evaluating geotechnical impacts, HDD plan and profile, technical specifications, cost estimating for the HDD crossing, and risk management. Follow-on services included construction monitoring and inspection. The project’s cost estimate rang in at approximately $2.5 million.

Before commencing with the pilot hole drilling, steel surface casing had stabilized the entrance hole and its surrounding alluvium, which consisted of mostly sand cobbles and boulders. As an additional benefit, the surface casing fulfilled Caltrans’ requirement for a steel casing under their roadway. Installation via pipe ramming
drew the surface casing approximately 100 feet. The oversized, 48-inch casing allowed an additional, 30-inch casing to be driven inside, in the event that the first casing installation failed. The drill path then advanced from the upstream end to the downstream end, and the HDD rig re-mobilized and moved to the downstream end. The back reaming and pullback took place from the downstream end. Assembly of the steel casing and HDPE carriers occurred on the upstream end, which could accommodate the 3,000-foot-long pipelines, laid out behind the hole.

The project design accounted for the line to have one carrier to accommodate normal flow, a second for wet weather flow, and a third in the event that one of the other two carriers became disabled. A 30-inch steel casing enclosed all three carriers.

Construction of the Meiners Oaks Trunk Sewer Relocation finished within budget and schedule. The entire project, from initiation of design through completion of the HDD installation, lasted approximately one year. The Consulting Engineers and Land Surveyors of California pinned the job with an Engineering Excellence Merit Award in 2005.

**Inverted Siphon No. 7 Replacement Design**

Due to the success of the Meiners Oaks Trunk Sewer Relocation, the Ojai Valley Sanitation District requested that replacement of the San Antonio Creek Sewer also use HDD. This sewer required replacement due to a washout, which destroyed the area immediately east of the San Antonio Creek and exposed the downstream end of the sewer. The District uses inverted siphons as a common crossing tool and has developed a vertical profile and hydraulic flow requirements that have proven successful over years of operations. The design requires one carrier for daily peak flows and a second carrier to accommodate wet weather flows. The downstream end of the inverted siphon, typically less steep than the upstream end, lies between 8 and 10 degrees.

The new sewer consists of a 12-inch interior diameter carrier pipe for an inverted siphon, installed with directional drilling methods for approximately 1,200 feet. The project included a second line parallel to and near this alignment. Installation of the second carrier, approximately the same size as the first, would use the same profile and right of way. The contractor had the choice of one drill path with two carriers installed in one hole, or two parallel drill paths, one for each carrier.

The Inverted Siphon No. 7 Replacement alignment shows the existing sewer in green and new sewer in red.

The drill path, designed to stay in the formation rock and avoid the riverbed materials, advanced from the downstream end to the upstream end. This path proceeded at approximately 8 to 10 degrees through fill, placed due to the recent washout, into river alluvium and then formational claystone. A steel surface casing, installed by pipe ramming through the fill and alluvium, prevented collapse of the hole. The entrance angle, kept at approximately 8 to 10 degrees, accounted for favorable siphon hydraulics and provided maximum velocity for cleaning. The upstream side of the project required a steep exit angle in order to create the tie-in point between the river and the roadway. The contractor elected to complete the project with two parallel drill paths and pulled the carrier pipes in from the upstream to downstream side as three long segments, with the segments joined together as the carrier pipe was installed.

From design through construction, the project wrapped up within one year. Jacobs Associates, as a subconsultant to Boyle Engineering, provided HDD design services, including a Geotechnical Baseline Report to assist with the bidding of this fast-track design project. The American Public Works Association, Ventura County Chapter, awarded the Inverted Siphon No. 7 Replacement with a 2005 Project of the Year in the disasters and emergency construction category.

For further information or project inquiries, please call Jacobs and Associates at 415.249.8209 or visit their website at www.jacobssf.com.
A profile of the Inverted Siphon No. 7 Replacement illustrates a steep exit angle for the drill path.
Pipe bursting material can be a very volatile subject. It has been a stumbling block to the use of pipe bursting technologies with some utilities around the country. Many of these utilities are so invested in certain pipe materials that it is almost impossible for them to consider other piping materials. While there is a high level of familiarity with the application of HDPE pipe in pipe bursting, there is still considerable interest, in other pipe material options, by owners, engineers and contractors.

Various pipe manufacturers are working diligently with pipe bursting equipment developers and manufacturers to find real world ways to adapt their pipe products to pipe bursting installations. It takes the extensive experience of these parties to find suitable ways to install what is best described as sectional, gasketed pipe in the pipe bursting process. There are many factors to consider in what is necessary for these pipe materials to work in pipe bursting applications.

**Pipe Bursting Overview**

With the recent introduction of new hydraulically powered static pipe bursting system, contractors now have the ability to split and replace ductile iron, steel and lined pipes, as well as pipes with ductile iron and steel repairs.

During the static bursting process, specially designed bladed rollers are pulled through an existing line by a hydraulically powered bursting unit. As the bladed rollers are pulled through, they split the host pipe. An expander attached to the rollers forces the fragmented pipe into the surrounding soil while simultaneously pulling in the new pipe.

The bladed roller configuration is an essential part of static bursting success for steel and ductile iron pipe materials. The specially designed bladed rollers actually split the host pipe instead of ripping or tearing it. This is a clean process and prevents potential damage to the product pipe.

The old pipe must be fractured or split, the remaining fragments compacted in to the surrounding backfill, and the new pipe pulled/pushed in before the temporary annular space, created by the pipe bursting tool, begins to collapse and get a firm grip on the new pipe. Once the soil has a firm grip on the pipe, it is very difficult if not all but impossible to continue to move the column of new pipe forward.

**Product Pipe Options**

**HDPE FOR SEWER AND WATER, MDPE FOR NATURAL GAS**

The industry is very knowledgeable about this pipe material and pipe bursting installations. Fusion welded joints help to make this type of pipe into a one-piece pipe section to whatever length is required for a pipe bursting reach. For example, a section to be replaced is 500 feet long; a string of PE pipe will be welded together into a string slightly longer than 500 feet and will be laid down in alignment with the launching pit. This method represents at least 95% of all pipe bursting installations. This procedure always requires adequate lay-down area. Fusion welding this type of pipe during the pipe bursting process is very time-consuming and generally not performed in the field. Because of years of field experience a number of ways to connect PE pipe to the pipe bursting tooling have been developed. They are generally all reliable with various advantages to the methods. Both pneumatic and static pipe bursting systems can be used for this type of pipe.

**Fusion Welded PVC**

The water and sewer industry are just beginning to see this relatively new type of PVC pipe. It is butt fusion welded, similar to PE, and offers a PVC pipe that is suitable for many pipe bursting applications. Although the pipe is somewhat stiffer, thus requiring longer launching pits. 5:1 ratio (Length to Depth), the fusion procedures for welding this type of pipe must be adhered to very precisely. Experience has shown that the typical scratching on the outside diameter (OD) of the pipe is within the manufacturers allowances. This type of pipe cannot withstand the heavy hammering action of a pneumatic pipe bursting system. Because the pipe is stiffer than HDPE for example, it must be installed with a static pipe bursting system so as not fracture the pipes connection to the pipe bursting tooling.

**Restrained Joint Ductile Iron Pipe**

This is another new application for a type of pipe that has been on the scene for a very long time. The bell and spigot restrained joint configuration requires that the pipe be pulled backwards (spigot end first). This allows each consecutive bell joint to act like an additional pipe bursting expander. Only a static pipe bursting system should be used for this type of pipe. The pipe is assembled...
PIPE BURSTING MATERIAL

The advantage of this cartridge loading approach is there is no need for a pipe staging area. The new replacement pipe can be unloaded, as needed, from a truck and at the end of the day there is no pipe left on site. This process requires the pipe bursting system to start and stop repeatedly. Each joint is made-up in the launch pit, pulled in and then the stopped while the next section of pipe is lowered into the launch pit and assembled to the previous joint.

Loose polyethylene encasement of the ductile iron pipe is not done, as the wrap will be severely damaged by the old pipes fragments during the installation. A pushing jack may be used to help the column forward during difficult bursting operations.

**Restrained Joint C-900 PVC Pipe**

C-900 PVC pipe with a restrained joint utilizes a spline and groove assembly that is very strong. This pipe is assembled and pulled much the same as restrained joint ductile iron pipe. Only static pipe bursting systems should be used due to the stiffness of the pipe. The connection of the PVC pipe to the bursting head consists of an adapter using the pipe and a steel pulling head of the same configuration as the pipe joint. A cartridge loading method can be used. However, this type of pipe appears to be flexible enough to join together before a pipe burst and insert through the launch pit with minimum bending.

**Non-Restrained Joint Ductile Iron Pipe**

This type of pipe has a very low profile joint and was developed primarily for pipe jacking type installations. When pipe bursting with non-restrained joint pipe it is normal to place the static bursting system pulling rods through the length of the joint at a time in the launching pit and pulled one joint at a time. The joints are made up quite quickly, usually in just a couple of minutes.

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each new pipe section and connect to a backup clamp that essentially helps to push the column of pipe from the backside. This insures that the non-restrained pipe joints stay in compression thus staying together. The internal lining of the new pipe must be protected from the rods or cable used to pull the pipe. In many situations, the rods are sheathed inside small diameter plastic pipe. This helps prevent any rubbing damage to the lining.

**Vitrified Clay Pipe (VCP) with Jacking Type Joints**

This particular pipe product is much the same as other non-restrained pipe types. Because this is a clay pipe, special care will be necessary to keep the column in good alignment. These pipe sections come with a layer of compressive material at the joints to help equalize the jacking pressures against the end of each section. Clay pipe is quite heavy and you would expect to see some sort of pushing jack in use along with the static pipe bursting system. This type of pipe is installed using the cartridge loading method.

**Welded Steel Pipe**

Welded steel is installed by pulling with static pipe bursting systems. The pipe is by definition flexible. So it can be welded together and then pulled in similar to PE pipe. The reality is that this pipe is not really that flexible and probably will need to be welded together as each joint goes in.

**Conclusion**

The specified pipe and specific pipe bursting equipment should have a proven history similar with the intended application and service environment, as well as data that reflects third-party testing, to substantiate suitability of the pipe by physical property and chemical resistance claims of the manufacturer. The pipe bursting equipment system(s) to be used should be proven to be capable of the required pipe replacement.

The structural condition of the existing pipe also needs to be evaluated and point repairs identified. CCTV is a very useful tool in identifying many pipe defects. Recent CCTV tapes and logs should be included as part of the plans and specifications for projects. Multiple pipe bursting systems and replacement pipes may be evaluated and subsequently specified. Since all systems are not alike, pipe and pipe bursting system capabilities must be evaluated to determine the proper selection for the project under consideration.

There are other types of restrained joint and non-restrained joint pipe that can be installed with similar methods. Consulting with well-qualified pipe bursting consultants and knowledgeable equipment manufacturers can help to make these applications possible.

For further information on TT Technologies, call 650-208-9035 or e-mail to pipedr96@aol.com.

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**This static bursting project in Alabama featured an 8-inch diameter ductile iron product pipe with a special flush joint. Note the Quicklock bursting rods sleeved with PE already rodded through the ductile iron product pipe. Host pipe replaced was 8-inch VCP gravity sewer main.**
Tempe Town Lake is one of Arizona’s most popular urban outdoor destinations, with more than two million people visiting each year to boat, fish and attend concerts, firework shows and a variety of festivals. It is also one of the fastest growing urban areas in the United States. Tempe Town Lakes sewer system needed to be upgraded to support a growing population. Being an environmentally sensitive and public location, the construction site required careful attention.

When the sewer rehabilitation project contract was awarded to a major trenchless technology contractor, they selected Rain for Rent, Chandler, Arizona to provide equipment and service solutions for the bypass pumping portion of the project.

The scope of the project required a complete high-flow bypass system consisting of pumps, piping, and service technicians for the duration of the project. Rain for Rent provided 111,000 feet (21 miles) of 20 to 24 inch HDPE pipe to bypass the existing sewer lines that ranged in diameter from 15 to 56 inches. The six pump stations required twelve DV-300i 12 inch pumps; eight DV-400 16 inch pumps, two DV-350 14 inch and five DV-150i, 6 inch Power Prime™ pumps, along with two automatic-start Flygt submersible pumps, complete with portable generators. Sound attenuated pumps were used near noise sensitive residential areas.

Rain for Rent’s Engineering Team designed a bypass pumping and piping system to handle the maximum flow rates projected by the City with a built-in safety factor. This system successfully bypassed a peak flow of 85 MGD with a maximum designed capacity of 110 MGD.

The project contractors, vendors and engineers diligently worked individually and as a team with the construction manager during the pipe inspections, which lasted over two weeks.

One of the many pumping challenges involved a deep manhole with a 37 foot suction lift. Vacuum prime pumps cannot prime with a suction lift this deep, so Rain for Rent designed a solution with an automated submersible pump system complete with float controls and powered by two large generators. Additionally, unforeseen groundwater fluctuations caused an 18 foot deep suction pit’s groundwater level to rise within 10 feet of grade. These various pumping challenges were met successfully and the project was completed on time.

For further information on Rain for Rent, call 661-399-9128 or visit their website at www.rainforrent.com.
Western Oilfields Supply Company (WOSCO) began in 1934 when entrepreneur Charles P. Lake arrived in Bakersfield, California with a business vision. The company’s original business was the sale of used oilfield equipment, pipe, and boiler tube. During the depression and throughout the 1940s, WOSCO manufactured water well casing, clothesline poles, resleeved threaded tubular oilfield pipe, and rental pipelines.

After WWII, agricultural development exploded in California’s great San Joaquin Valley. Charles Lake saw an opportunity to rent irrigation pipe and sprinklers to farmers. In 1948, Rain for Rent was incorporated as the nation’s first irrigation equipment rental company. A foundry was built to cast irrigation valves and fittings, and in 1969, a tube mill was purchased to manufacture aluminum pipe.

Charles Lake’s two sons, Don and Jerry, came back to the family business after WWII with new ideas for growth. The company began to expand into construction pipeline rentals for pre-wets and dust control work for the California interstate highway system that was being built. New offices were opened in Arizona, Idaho, and New Mexico to expand the irrigation and construction business.

In 1981, West Side Pump and ASC Tubing were acquired to grow turbine pump sales and increase aluminum tubing manufacturing capabilities. By the late 1980s, the company was well positioned in the Western United States as the premier pipe and pump rental provider and the West’s largest irrigation dealer.

1990 brought a leadership transition from the second to the third generation of the Lake Family. Industrial business opportunities became the focus of unprecedented growth. In 1991, Land and Marine Tank Rental was acquired. This was the beginning of a nationwide push to provide tank and liquid storage rental equipment to petrochemical, environmental and industrial customers across this great nation.

New products and services are continually being introduced to provide better solutions more efficiently. A well maintained, state-of-the-art rental fleet is the foundation of our service capabilities.

Our products are supported by engineering professionals, Bypass Pump SWAT Team, and Filtration and Separation specialists. Rain for Rent has the capability to design, oversee, and operate complete liquid handling systems.

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Booming Indio, California in Riverside County, just east of Palm Springs, needed to modify its sewer infrastructure to support an influx of new residents. Further compounding the city's development pressures was a local Native American's casino's new 17-story hotel construction project. With commitments to provide service upon the hotel's opening, Indio's Valley Sanitary District needed to act fast. That's when the district turned to Dudek for a solution.

The project had several design challenges, including the district's opposition to using pump stations for conveying wastewater, and a major interstate running through half of the project's path. Dudek opted to upgrade the 1,300 foot inverted sewer siphon from a 15-inch carrier pipe to 54-inch high-density polyethylene (HDPE) casing, with 14, 16, 20, and 24-inch diameter carrier pipes for additional capacity, and staged hydraulic use to maintain cleansing velocity. This successful and timely installation, which can accommodate a range of flows for years to come, became the largest diameter HDPE pipeline to be installed using horizontal directional drilling (HDD) construction.

This is just one example of how Dudek, a Southern California engineering and environmental consulting firm, has helped clients achieve trenchless technology success since the concept first became practice over 20 years ago. As a strong advocate and early adopter of trenchless technology for its many environmental and time-saving benefits, Dudek has used various methods for numerous rehabilitation and new installation projects, including microtunneling up to 84-inch diameter and HDD with diameters up to 54 inches and lengths up to 3,000 feet.

To achieve optimal success such as that of Valley Sanitary District's HDD installation, which was completed ahead of schedule, Dudek suggests municipalities:
- Analyze project timetables. Often times, trenchless technology can save months and even years in environmental planning, design, and permitting phases.
- Communicate constantly. Coordination of multiple agencies for design review and approval requires early and frequent communication to continue moving projects forward.
- Prepare environmental documentation, and obtain necessary permits. Trenchless installations can substantially reduce physical surface-level impacts.
- Investigate existing soil conditions. While trenchless methods can be used in nearly all soil conditions, having more geotechnical information available results in less construction risk, and more competition in bidding.
- Hire experienced contractors. Contractors specializing in trenchless technology can execute custom installation methods quickly and accurately.

Steve Deering is a Dudek principal and professional engineer with 33 years experience. He can be contacted at 760.479.4101, sdeering@dudek.com.
Sauereisen Advances Anti-Corrosion Technology

By David Snider

Materials to Protect and Restore Wastewater Infrastructure

Sauereisen continues to innovate with materials and application methods for the municipal wastewater industry. The company's materials prevent corrosion to vulnerable concrete and steel infrastructure. In addition, Sauereisen products prohibit water inflow & infiltration, a prevalent problem in wastewater collection systems.

Since entering the wastewater market over 30 years ago, the company's credibility has grown one project at a time. Its earliest installations involved dual lining protection using an impermeable urethane membrane beneath a gunite-applied, acid-resistant refractory. The silicate-formulated refractory offered utility based on its resistance to full concentrations of sulfuric acid.

In time, Sauereisen progressed into more economical, user-friendly coatings and linings technology. These incorporated organic polymers specifically formulated for the municipal wastewater environment.

The Sauereisen Research Laboratory's thorough understanding of the microbiologically induced corrosion process is the key to differentiating their linings from others. Where other vendors have pursued a coatings "arms race" relative to certain physical properties, Sauereisen has maintained its focus on why such materials are needed in the first place. Their assertion is that corrosion resistance is the most critical factor in predicting the long-term success of a material in a chemically aggressive environment.

Consequently, Sauereisen's epoxy-based SewerGard 210 family of products was designed to exhibit low permeability. This enhances corrosion resistance and extends the longevity of underground infrastructure such as manholes and lift stations. SewerGard is available in several variations to accommodate desired thickness and methods of application.

One grade of SewerGard may be spincast to allow manhole restoration projects to proceed safely and easily from ground level. A trowel, an airless pump, or a roller may apply other grades of SewerGard. Spray application of SewerGard is ideal for larger areas and for preventing corrosion in new construction projects. Several treatment plants have specified it as part of their asset management programs.

Sauereisen's original No. 210 is one of the few epoxy mortars to have stood the test of time as determined by John Sauereisen Advances Anti-Corrosion Technology

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With a quarter century of innovation in wastewater, Sauereisen's protective lining technologies provide grit chambers, sedimentation tanks, and neutralization basins with a seamless barrier against corrosion and abrasion.

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Redner’s corrosion evaluation in Los Angeles during the 1980’s. Since then, the company’s material offerings for wastewater have proliferated. In response to regional dilemmas relating to combined sewer overflow issues, Sauereisen has introduced several waterstops, sealants, and complementary substrate repair materials.

Established in 1899, Sauereisen delivers the credibility that can only be attained by a history of success. From collection systems to treatment plants, Sauereisen offers the technology and experience to generate confidence.

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Phone: 412.963.0303 Fax: 412.963.7620
e-mail: wastewater@sauereisen.com
www.sauereisen.com

About the Author: David Snider, Western Regional Manager, Sauereisen, Inc. draws upon 25 years of experience in his tenure with Sauereisen. Mr. Snider’s experience as a lab technician, field service rep, material specialist, and formulator has prepared him to speak extensively in the corrosion field through organizations such as NACE, SSPC, and SME.

Bennett Staheli Engineers serves their clients from offices in Folsom, CA and Seattle, WA with a wide range of trenchless engineering services, mirroring the diversity and expertise of our staff. We are a specialty consulting engineering firm focusing on Trenchless Engineering. The principals of the firm are recognized industry leaders in developing innovative, cost-effective solutions to complex, real-world problems. The firm specializes in feasibility studies, geotechnical evaluations, full design services, bid services, and construction management services for microtunneling, pipe jacking, tunneling, HDD, pipe bursting, pipe ramming, and pipe rehabilitation methods.

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A manhole cone section with epoxy applied prior to placement as a means of preventive maintenance.

At left: A severely corroded lift-station prior to restoration. Above: The same lift-station after restoration.
Specialized Services Company

Based in Phoenix, Arizona SSC is the leading underground construction specialist in the Southwest.

SSC operates three divisions: Directional Drilling, Auger Bore & Tunneling, and Vacuum Excavating/Utility Potholing. In addition to a variety of other trenchless services intended for various project conditions.

These include:
❖ Pipe Ramming
❖ Pipe Bursting
❖ Skidding
❖ Large Diameter Tunneling

Complementing its construction business, the company also offers Consulting and Subsurface Utility Engineering (S.U.E.) services. Arvid Veidmark III, co-owner and senior estimator is a strong advocate of Trenchless Technology and has been consulting on these applications since 1997. SSC clients range from large municipalities to small privately owned companies. Their valuable contributions have helped clients to redesign their structures, change their cultures, improve customer satisfaction, and increase their operational effectiveness.

SSC was founded in 1969, by the Veidmark family. Owners include Marcia Veidmark, Arvid III, and Aaron Veidmark, who all share in the daily operation of the company. Over the years the business has adapted to specialize solely in trenchless technology and has grown to 34 employees. It is recognized as the leading authority on Arizona’s underground and has been the recipient of several awards including:
❖ AAAME: Academy for the Advancement of Small, Minority and Women-owned Enterprises
❖ Phoenix Chamber of Commerce: Small Business Award for “Response to Adversity”
❖ Arizona State University: Spirit of Enterprise “Emerging Entrepreneur Award”

A Case for S.U.E.

By Arvid L. Veidmark, III

An “undisclosed” trash pile delays Specialized Services largest bore project and threatens a $50,000 loss.

The Project:
Specialized Services (SSC) was hired in April of 2005 as a sub tier subcontractor by the Arizona Department of Transportation (ADOT) to install a Siphon under Loop 202, near Interstate 10. The 30-in diameter RGRCP pipe was intended to divert irrigation tail water from a Salt River Project retention basin to a pump station. The project called for a 502-ft jack & bore to install a 60” diameter casing.

The Company:
Before the Siphon project, a 310-ft bore with a 60-in steel casing was SSC’s longest bore for this size casing, and that was using a conventional auger. In this case they had to increase the length by nearly 200-ft, and maintain line and grade to connect the basin on the other side of the I10 freeway. 39 years of experience in trenchless technology taught them that planning, preparation, and proper equipment were critical to success. So after carefully plotting a pathway under the freeway, they used an operator controlled BMTA and a laser set up on a fixed-base platform to control the accuracy of the bore. With two five-man crews working twelve-hour shifts, the bore was expected to take 30 days to complete. Then the unexpected happened.

The Challenge:
It was slow going for the first 220-ft due to the hard Arizona soil, but it wasn’t until they struck a 56-ft pile of concrete debris, left behind by a previous highway construction crew, that progress came to a screeching halt. What should have taken three days turned into a painstaking eight. Large chunks of concrete shredded the costly bit, forcing SSC to have to remove much of the debris by hand. Dropping from 20-ft to around 7-ft per day, the company was forced to file for a condition change with ADOT to try and recoup some of the rising costs of the delay, which had now tolled over $50,000. Although SSC was meticulous in their planning, and Salt River Project thoroughly surveyed the area, they were still reliant on “as-built” plans, which are notoriously unreliable (and in this case true to form).

The Solution:
Over the years, it has become more and more unclear as to whose responsibility it is to specify appropriate solutions for specific project conditions. What was once left up to the contractor’s discretion has now become the role of the design engineer, who in many cases has little knowledge of trenchless technology.

The Siphon project is just one of many examples where contractors have found themselves in a similar dilemma, although in most cases it is a damaged utility that causes the delay, not a pile of concrete. Without proper education and guidance, it is nearly impossible for busy design engineers to really understand all the requirements of trenchless construction.

Hence the birth of Subsurface Utility Engineering. 

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Hence the birth of Subsurface Utility Engineering.
Engineering (S.U.E.), a process that accurately locates and maps underground utilities during the early design of a highway project. This relatively new branch of engineering offers a single, reliable source of mapping, coordination, assessment, and communication to concerned parties. It combines traditional methods such as records research, plotting, and design with methodology such as vacuum technology and utility mapping. Its benefits are enormous and it is now recognized as “Best Practice” by the Federal Highway Administration and the National Transportation Board, as well as ADOT, who has been utilizing a S.U.E. group since 1992.

ADOT’s primary goal is to provide a transportation system that meets the needs of the citizens of Arizona. This is a tall order, considering that Phoenix is one of the fastest growing cities in the nation. Over a five-year period, ADOT plans to spend over $2.8 billion for highway improvement projects in Maricopa County alone. Considering the fact that for every $1.00 spent on S.U.E., the overall project can realize a savings of about $4.62, how much can and has been saved on these projects? Fortunately for SSC, they were able to recoup about thirty percent of their losses from ADOT, but that is not always the case.

The Benefits:

Even with the problems SSC experienced, the bore was accurate to within 2-inches of its target, and the project was considered a big success. Without even realizing it, SSC had been practicing S.U.E. processes for many years, which turned out to be a huge benefit for ADOT. One example is how their quality control practices, planning processes, and expertise in vacuum technology afforded them the ability to avoid a 48” storm drain that was directly in the path of the bore.

Prompted by this situation and the experiences of others in the field, SSC now offers this vital service. SSC is one of the few companies in Arizona with the in-house staff and equipment to provide Subsurface Utility Engineering. Because of this, SSC offers better service, better quality control, and better value to its clients in the performance of the S.U.E. process. Owner Arvid Veldmark, III, invests much of his time consulting and educating engineers and project managers on the benefits of utilizing S.U.E when specifying trenchless technology.

Arvid Veldmark is co-owner and estimator of Specialized Services, a Phoenix based underground construction and consulting company, specializing in drilling, boring and vacuum excavation since 1969. Arvid has more than two decades of operational experience and has been consulting since 1997 when he succeeded Arvid Jr. as co-owner of SSC. He holds multiple licenses and certifications.

For more information contact: arvid@sscboring.com/www.sscboring.com 602-997-6164

The Federal Highway Administration (FHWA) commissioned Purdue University to find out how effective SUE is in reducing costs on highway projects. Free copies of Purdue’s January 2000 report, “Cost Savings on Highway Projects Utilizing Subsurface Utility Engineering” Publication No. FHWA-IF-00-014, may be obtained from FHWA.

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Over the years, trenchless technology has earned acceptance in our industry as a more cost-effective method of pipe installation that causes less disruption to street traffic, driveways, and landscaping. However, when faced with a wide selection of materials and processes, not all engineers and city officials are 100-percent certain what type of pipe is best suited for a particular trenchless application. The main choices are typically thermoplastic (PVC and HDPE) and metallic pipe. While it’s true that there are ideal applications for each of these products, it’s a good idea to look at the following factors in order to properly evaluate the options.

Pipe History and Performance

Although metallic pipe has been around for many years, its track record has shown a tendency toward corrosion, a major liability. Most reported leaks in pressurized water systems occur in metal pipe due to corrosion, wasting billions of gallons of treated water at a significant cost to municipalities and homeowners. Corrosion is not a problem, however, with thermoplastic materials, as they are non-conductors, and are immune to electrochemical reactions caused by acids, bases and salts. The most widely used thermoplastic material, PVC, has an impressive reputation for longevity, durability, low maintenance, and ease of assembly. In sizes 4-inch and larger, about two-thirds of new buried water pipe, and at least three-fourths of new buried sanitary sewer pipe, today are PVC.

In the trenchless industry, the first non-metallic, fully corrosion-resistant PVC restrained-joint piping system was introduced in the late 1980s, based on a spline-lock concept originally developed by CertainTeed Corporation in the 1970s. The Certa-Lok™ system has proven itself not only in directional drilling applications, with millions of feet successfully installed, but also in other demanding applications, including open trench construction, where a restrained joint can eliminate the time and expense of constructing poured concrete thrust blocks - plus some soil conditions will simply not support the use of thrust blocks. Other critical applications include above-and-below ground mining, agricultural irrigation, and deep water wells.
Today, PVC restrained joint pipe continues to help advance trenchless construction all over the world. And, the benefits don’t stop with corrosion resistance just ask the municipality of Novato, California, which recently relied on trenchless technology utilizing 500 feet of 12-inch Certa-Lok restrained joint PVC pipe. For Novato, trenchless installation of pipe through the town’s business district greatly minimized the headaches pedestrians would have had with conventional construction practices. As with numerous other areas of commerce and high-traffic locations that need water main repairs, the small downtown Novato businesses could not afford the disruption to daily routines that open trench work would have created.

Restrained joint PVC pipe is also being used increasingly in pipebursting projects, as fused and strung-out pipe is often not compatible with the deep-pit space constraints common with this construction method.

Compatibility with Existing Systems
Since most of the U.S. water and sewer pipelines being installed today are now PVC, it’s natural for a city considering pipeline replacement or extension through directional drilling processes to want to follow suit. Pipelines that are exclusively PVC function more smoothly, as conventional utility components that the city already owns can be used for maintenance. Water and sewer projects involving other piping materials require that municipalities purchase and stock new equipment and fittings to service the non-standard pipe.

Pressure Handling Capacity
One of the first considerations in the product evaluation phase of a project is to look at pressure ratings of competing plastic pipe products. Here, great care must be exercised, as thermoplastic materials manufactured to AWWA standards are currently rated using different systems and safety factors, which can result in an unfair comparison. Using a consistent 2:1 safety factor, higher-strength PVC requires a much thinner wall than the most common alternative thermoplastic material in order to achieve the same pressure rating. Because of this, a smaller diameter of PVC pipe can often be used in a project. For example, a transmission line project in the town of Oakland, Tennessee this year was able to use 16-inch Certa-Lok, where it would have had to use 20-inch HDPE pipe to get the same flow performance. This lowered costs for the municipality, and enabled directional drillers to make smaller bores and take up less space. Comparing common sizes and pressure ratings, PVC will always have a larger inside diameter, which results in significantly improved flow performance and pumping efficiency.
Joint Integrity
For most installations, this is rarely a governing factor, as both fused HDPE/PVC joints and mechanically restrained joints such as Certa-Lok have sufficient strength for most pulls. When properly assembled, both fused and gasketed restrained-joint systems are leak-free and have the required pressure integrity. The big difference between the two is the time and money invested in fusing joints, which requires special equipment and trained operators. Furthermore, the entire string of fused pipe needs to be joined before pullback starts. In many urban and crowded areas, there simply isn’t room to do this, and several hundred feet of streets and driveways can wind up getting blocked. With today’s mechanical spline-lock joints, assembly of pipe sections takes place step-by-step as the pullback continues. This causes considerably less traffic disruption, and requires a much smaller staging area. This feature is particularly important where the installation method involves lowering pipe into a deep, narrow pit. In these cases, gasketed restrained-joint PVC pipe will be the more practical option.

Agency Approvals
As many water systems have hydrants, approval of the pipe for use in fire-protection systems is critical. Check to make sure that the pipe you’re considering has been tested and is approved by the recognized certifying agencies, typically UL.

Applications
As stated earlier, restrained-joint PVC has been successfully used for both water projects and sanitary sewer systems. PVC pipe is particularly appropriate for applications where sewer specifications require a precise grade, due to its superior rigidity and beam strength as compared to alternative plastic pipes. And now, with the countless documented successes in water and sewer applications, the industry has gone on to develop restrained-joint PVC for telecommunications and electrical projects as well. So it’s clear to see that PVC pipe has demonstrated a solid 50-year history throughout North America, and that manufacturers are committed to introducing new and innovative products for our industry.

For more information on restrained-joint PVC pipe for directional drilling, e-mail Steve Gross at steve.b.gross@saint-gobain.com or visit www.certainteed.com. For general information on PVC pipe, visit www.uni-bell.org.

GU Manhole Base Liner with 1 Piece PVC Riser

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Waterline Rehabilitation - Pipe Bursting, Trend of the Future

Improvements were recently made to the water distribution system in Technical Area 1 on Sandia National Laboratories (SNL), utilizing trenchless technology to replace deteriorated portions of the waterline throughout the tech area. A total of 4,450 LF of 6" to 12" waterline was replaced during this project; approximately 66% through pipe bursting and 34% through open-cut-and-replace.

Due to the number of unknown underground utilities, with multiple utility systems running parallel and crossing each other, and the close proximity of these utilities to the waterline requiring rehabilitation, SNL and AUI used a three-step approach to this project. For each segment of pipe to be evaluated for rehabilitation, the first step was doing a CCTV of the line to determine the condition of the line and any service connections; the second step was determination if the segment was a candidate for pipe bursting; the third step was to pothole the line, find the service connections and utilities in close proximity, and proceed to replace the segment through pipe bursting, or through more traditional means if the situation warranted. Through thirty-seven RFI’s, the AUI project team and the SNL team worked to build solutions to problems or questions developing as the project unfolded.

There were approximately 700 potholes through the duration of this project. At one intersection alone, there were 21 undocumented utilities. Upon locating these utilities, AUI would coordinate with SNL representatives to get a GPS reading on the utility line, determine if the line was active or inactive, and add the line to the as-built documents for this project. Each situation concerning an unknown underground facility presented unique challenges, including the need for penetration permits, and modification to the proposed waterline installation plan to avoid conflicts with these facilities.
AUI and Southwest Sewer Service (the subcontractor providing CCTV services) worked closely with the SNL project engineers to determine which lines were sound, which lines would be replaced through pipe bursting, and which would be replaced by other means. This three step process did present some challenges through the first few segments of pipe, but the SNL/AUI/Subcontractor team soon fell into a process groove that allowed one segment of pipe to be started, while another was finishing with rehabilitation.

This project occurred throughout Technical Area 1 on various streets heavily traveled by both vehicles and pedestrians, near SNL employee work areas and parking lots. The AUI team was challenged with keeping traffic flowing, keeping the affected work areas and employees informed, maintaining safety and space for pedestrians, and promoting construction area safety awareness for those who might find themselves in the construction area.

Throughout this project, maintaining water service to offices and laboratories was a critical issue. AUI was able to work out a schedule with the SNL representatives, so that the shoo-fly or bypass waterlines could be set in place and water service to these facilities would only be interrupted long enough to connect into these temporary lines (less than 2 hours). The process would be reversed to re-connect the facilities to the water distribution system once the waterline serving the facility was replaced.

Although only about one half of the originally intended footage (approximately 5,500 LF) of pipe was actually replaced through pipe bursting, AUI counts this project among its successes. Our work on this project proves that when existing conditions are right, pipe bursting is quicker, and more cost effective, than the traditional open-cut-and-replace method. We have learned, along with the SNL engineers on this project, that pipe bursting is not the most effective choice for pipe replacement in areas with significant numbers of unknown utilities, numerous utility crossings, or where the distance between utility lines is minimal or unknown. AUI is proud to have participated in this project for SNL, which was an adventure into utilizing trenchless technology as an efficient and effective means of rehabilitating waterline in a highly congested area, for which maintaining the water supply was a crucial issue.

For further information or project inquiries, please contact AUI Inc. Trenchless Manager Michael Rocco Email: rocco@auiinc.net Office Phone: 505-242-4848 ext. 3004 Mobile Phone: 505-975-6999

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“We know we have to earn your business every day”
An Innovative Approach to Varied Locating Challenges

The DigiTrak Eclipse Locating System

By Siggi Finnsson, Digital Control Inc.

Introduction

John Mercer and Peter Hambling founded Digital Control Incorporated (DCI) in 1988 to develop an advanced Horizontal Directional Drilling (HDD) drill head locating system. In 1991, the first DigiTrak® locating system was introduced by DCI. This system effectively doubled the capacity of any other locator at the time, with an operating depth of 20 feet, and was the first walk-over system to display both roll and pitch orientation of the tool head. Subsequent and continuous advancements have made the DigiTrak® product line of HDD locators the most widely recognized and used around the world.

Locating System Technology

TERMINOLOGY:

— Transmitter: A transmitting device placed inside a housing at the front of the drill string
— Receiver: A handheld locating device used to locate the position of the transmitter
— Remote Display: A remote readout on the drilling machine
— Locator: The person tasked with locating the transmitter by using the receiver
— Operator: The person sitting at the controls of the drilling machine

An HDD transmitter emits a dipole magnetic field and data which is picked up by a receiver and turned into usable locating information. This information is then used to make steering decisions to direct the drill head along a predetermined path. Not only is it important to locate the transmitter, but its direction (locate point), and a host of other data such as drill head orientation (clock), and inclination (pitch), needs to be efficiently transmitted to the receiver. From the locator’s standpoint, this needs to be achieved in a simple and effective manner to insure as an efficient operation as possible.

DigiTrak® Eclipse® Locating System

The Eclipse locating system consists of a receiver, seen on the right hand side in figure 1, a remote display on the left, a battery charger sitting in between the two and an assortment of transmitters.

This system is most commonly used as a walk over system (the locator is required to walk over the bore path and track the drill head as the pilot bore advances). Later, its use as a magnetic guidance system will be described.

When used as a walk over locating system there are four different transmitters that can be used with the Eclipse locating system. Each one of these is sewer grade, that is, the pitch or inclination is measured in 0.1% or 0.1 degree increments. These are a standard transmitter, with a depth range of 50 ft, a dual frequency transmitter with a depth range of 40 to 60 ft. The third is a smaller transmitter, depth range 16 ft, intended for smaller machines employing smaller drill heads. The fourth transmitter is a wire line transmitter which is powered by an above ground power source, most often the drill machine battery, through a wire that runs on the inside of the drill pipe. Its depth range is 80 ft.

Short case histories

Following are three short project stories describing the various features of the Eclipse locating system.

Sanitary Sewer Project in Berea, Ohio

In November 2003, Precision Directional Boring (PDB) was hired as a subcontractor to directionally drill a sanitary sewer project in Berea, Ohio using a DitchWitch® JT 2720 directional drilling machine. The project consisted of installing 400 ft of 12” Certainteed-Certa-Lok C-900 PVC pipe with a fall of 0.75%. Ground conditions consisted of fairly uniform hard clay. One of the most challenging aspects of this project was that at the first manhole the invert depth of the pipe was planned at 38 ft, while at the last manhole the invert depth was 41 ft. Based on the demanding specifications, PDB decided to use their Eclipse locating system with the dual frequency transmitter. Along with the Eclipse system a process called Arrow Bore was used, which calls for placing relief tubes every 30 ft, allowing checking of the line and grade on a regular basis. In order to reach the first manhole depth, the machine had to be set back 200 ft, requiring PDB to rely solely on the locating system to keep the bore on line and to reach the desired depth before verification at the first relief tube. According to Willard Roth, President of PDB, the front and rear locate feature and depth accuracy of the Eclipse system enabled them to hit the first target precisely on line and depth. The same was true for all thirteen of the relief tubes. Due to the exacting nature of this installation, the pilot bore took

Figure 1: DigiTrak Eclipse locating system.

Figure 2: The drill ready to launch the pilot bore.
The target’s 100 yards away.

The drill’s alongside the railroad track.

There’s a train coming.

Good thing your HDD equipment is ahead of the curve.

Every job comes with its fair share of pitfalls. And if your equipment isn’t on the cutting edge, then you’re really fighting an uphill battle. That’s why it pays to work with a company like DCI. We continue to push the boundaries of HDD technology and set new standards of ingenuity and innovation for the industry—and for our customers.

In fact, since the introduction of the first DigiTrak® locating system in 1991, we’ve been arming our customers with the most revolutionary HDD equipment found on the planet. From the locating systems above, to the transmitters below, our full line of intuitive, accurate products and 24/7 customer support is there to keep your job on track—and help you stay ahead of the curve.

For more information, visit digitrak.com or call us at (800) 288-3610. Because when it comes to getting your jobs done right, we’ve always got our eyes on what’s up ahead. DCI. We’re leaders in the field.
about 4 days to complete. After installation, the pipe was inspected and the invert was found to be only 0.5” off of the planned depth at the first manhole and about 2” at the final manhole. This was more than acceptable to the project engineer.

Verizon FTTP Project in South Lake, Texas

Dakota Directional out of Ennis, Texas is a contractor working on a large FTTP (Fiber To The Premise) project for the Verizon telephone company. On January 18, 2005 they set up to do a fairly typical bore using their Vermeer® D16x20 drilling machine. This run was to install 290 ft of 2” HDPE conduit at a depth of 3 ft for a fiber optic line in a residential area. The bore was drilled at an upward slope, generally following the surface, where the elevation at the end of the bore was about 6.2 ft higher than at the entry point. Ground conditions consisted of loam, some clay and a rocky section at the beginning of the bore. The Eclipse DataLog feature was used to document the bore. Figure 3 shows the bore profile after downloading from the Eclipse receiver on the computer using the Eclipse DataLog software.

Drilling started in the morning. About 27 ft from the starting pit, a gas line at a depth of 6 ft had to be crossed. Due to rocky conditions at the beginning of the bore, the bore path was changed to get beneath the rocky section. As a result the bore path ended up being about 2 ft deeper than planned for the first 10 rods or so, and brought the bore closer to the gas pipe than originally anticipated. Once past the rocky section, boring continued without any problems. The 290 ft pilot bore was finished in about 90 minutes. The pullback was completed just before noon, allowing the crew to set up and complete a second similar bore in the afternoon.

A-12 Highway crossing near Driebergen, Netherlands

The DigiTrak Eclipse Short Steering Tool (SSTTM) is a magnetic guidance wire line system designed to work with the Eclipse walk over locating system. The SST transmitter provides the industry standard guidance tool information: roll in 360 distinct increments, inclination in either 0.1% or degree increments, and compass heading (yaw angle), in 0.1 degree increments.

Van de Beek BV is an accomplished HDD contracting firm located in Neerinjen in the Netherlands, and they completed a bore in February 2005 using their Vermeer® D50x100 machine and the Eclipse SST system. The project called for installing 2 x 6.3 in and 3 x 4.9 in conduits underneath the A-12 highway for the Enecon utility company. Total length of the bore was planned at 590 ft at a maximum depth of 21 ft. Ground conditions consisted of fairly uniform, sandy clay. Figure 4 shows the SST software screen with the completed bore. The bore plan called for an approximately 130 ft straight section, a gentle turn to the left, and then straight again for the remainder. While excavating the entry pit, an unmarked power line was discovered on the left side of the pit, and with trees on the right side, the machine could not be repositioned. Figure 4. Eclipse SST main screen showing the A-12 highway crossing.

A new reference yaw heading to the left of the power line was established and using the walkover capability, the bore started. After about 65 ft, a right hand turn was started, and using the Eclipse receiver the tool housing was guided on to the original heading. The new bore path reached the originally planned path end, which diverted the bore path about 3.3 ft to the right of the planned exit point. The final feet were drilled and tracked using the walkover method. The pilot bore was completed in 6 hours, and all 5 conduits bundled together were installed in 2 hours, which included pre-reaming.

Summary

The DigiTrak Eclipse locating system has been designed to be user friendly, simple to use, very accurate and fast, with a short learning curve allowing locators quick proficiency in its use. A second consideration is the flexibility, allowing the same system to be used on a multitude of differing projects. By using the same locating system for most of their diverse work, an HDD contractor can have greater confidence when tackling more complex projects.
Pacific Multilining acquires New CIPP Lining System

After acquiring the exclusive manufacturing and licensing rights to the MultiLiner® Cured-in-Place-Pipe lining system in the 13 Western United States, Canada, and Mexico, Pacific Multilining Inc. opened the doors to their 21,000 sq.ft. manufacturing facility in 2001. With the vision of supplying a stronger and better alternative to the felt inversion system, Pacific Multilining Inc. started manufacturing MultiLiner®; a pulled-in-place seamless fibreglass CIPP liner. Pacific Multilining Inc. was the first to introduce a European-developed fibreglass CIPP liner into North America.

MultiLiner® is approx. 4 - 5 times stronger than standard felt CIPP liners, which allows MultiLiner® to use a thinner material thickness, resulting in an overall higher flow capacity in the relined pipe. On average, MultiLiner® uses approx. 30% less resin than any felt liner for the same application.

With a shelf-life after impregnation of up to 6 weeks, Pacific Multilining Inc. can supply MultiLiner® pre-impregnated to contractors throughout North America, allowing contractors to focus solely on installation – not the manufacturing or impregnation process. As Pacific Multilining Inc. also rents out the MultiLiner® control equipment necessary for the installation, and since boilers very often can be rented locally, even smaller contractors can use CIPP lining with no investment.

MultiLiner® is pulled into place by means of a winch, inflated with air, and cured by a mixture of steam and air, taking approximately 3 hours in smaller and medium sized diameters. MultiLiner® can be delivered pre-impregnated and ready to install in 6” - 48” diameters. It can also be cured by means of UV light - a curing technique which allows for even faster curing in smaller diameters, and a shelf life of up to 6 months after impregnation.

Developed in Europe and successfully installed there since 1993, more than 50% of all CIPP liners installed in Germany are made of fibreglass, and in Asia fibreglass CIPP liners are gaining ground. Currently, MultiLiner® is also being manufactured in Singapore and Australia. Pacific Multilining Inc. continues to increase their production and number of customers, as the demand seems to be never-ending in a CIPP lining market estimated to be approximately 1 Billion US$ per year in the US alone, and increasing 10 - 15% per year.

More and more cities throughout North America are realizing the numerous benefits of trenchless rehabilitation, instead of the old-fashioned open cut method, which in most cases is more expensive, but also includes significant social costs and inconvenience. Cities can stretch their budgets longer, and get more work done for the same amount of money.

Meanwhile, Pacific Multilining Inc. continues to stretch into new areas looking for more contractors to install MultiLiner®.

For further information, contact
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Pipe Genie —

New Pulling Cones
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For 15 years, Pipe Genie has been manufacturing innovative equipment for plumbers based on 30 years experience in plumbing and underground pipe work. As an ongoing effort to improve the efficiency of trenchless work, Pipe Genie manufactures two types of patented hybrid pulling cones that save work and time on the job...‘hollow’ and ‘saddle’.

The patented hollow cones allow liquid to flow through the cone during the pulling operation, allowing contractors to work in a live line, and eliminate the need for bypass pumps and reduction in pressure, resulting in a lighter work load on the equipment. The hollow cones are at the heart of Pipe Genie’s patented upsizing technique. For example, when upsizing a line from 8 inches to 12 inches, debris can flow through the cones and into the new pipe. After the pulling operation is complete, the debris is then removed with a high pressure jetter or a hydrovac system. Furthermore, the hollow cones allow for doubling up chain or cable when pulling through difficult or unexpected conditions, and also have the ability to back the cones up should an unforeseen obstacle be encountered.

Pipe Genie’s patented saddle cones provide the ability to pull two sewer or water lines simultaneously in a ‘piggy-back’ configuration, effectively completing two tasks in only one operation. In both cases, time savings are realized by eliminating steps and reducing job costs. This has the effect of making quotes more competitive and profit margins healthier.

Pipe Genie manufactures a series of pulling machines, with power ratings from 20 tons pulling pressure to 240 tons, allowing the combination of hollow or saddle cones, when matched with Pipe Genie pulling power, to tackle even the most challenging situations with relative ease.

The company also manufactures a complete line of accessory items, including two types of pipe cutters, three types of boring units, a light weight, all-aluminium butt fuser, and inner bead reamers.

The two models of pipe cutters are “the Slice” and “the Pipe Shark”. The Slice will easily handle 1” copper pipes with brass fittings or Schedule 80 gas lines, while the Pipe Shark will cut the bigger lines, while at the same time irrigating surrounding soil to reduce compaction.

Boring Units are available in three models...impact (Hammer Bore), high-pressure water (Hydro Bore), and hydraulic (Pilot Bore), which can serve dual roles as both a boring machine and a pulling machine. That way, once the pilot hole has been pushed through, the machine can then pull the new pipe back!

The new MKII butt fuser has been made lighter and more portable for ease of use, and once the new pipe is in, the Bead Demon inner bead reamer (available in 20’ and 40’ kits) will put the finishing touches on the job!

When it comes to trenchless underground work, Pipe Genie is the clear leader and innovator, because our equipment is made by plumbers for plumbers.
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Contrary to popular belief, your constituents don’t always want to see their tax dollars at work.

Constituents are fickle. They want the best public works as long as it doesn’t inconvenience them. Which is why the city of Elmhurst voted for Insituform’s 30 years of trenchless technology experience to repair its sewer lines. While digging and replacing sewer lines can take weeks, we had service back up and running before residents got home from work the same day. No disruptions. No property restoration. No angry phone calls. And best of all, our speed and experience meant that Elmhurst’s entire repair efforts were completed on schedule and within budget. To see how we can save tax dollars and headaches for your city, call us at 800-234-2992 or visit our website at www.insituform.com. Because only our experience shows.
GOT A SMALL JOB?
WE’VE GOT THE PERFECT TOOLS TO BRING IT ALL DOWN TO SIZE.

You wouldn’t pull out your 3 wood to sink a 4-foot putt. So why use your big tools for your smallest jobs? Whether you’re installing fiber to the home or drilling a short shot from the street to the sidewalk, we have a complete line of tools that are up to the task, no matter how under-powered your rig may be. Designed to maximize efficiency as well as your profitability, our roster of smaller-sized drill rods, reamers and bits packs a big bite so you can always make the most of what you’ve got under the hood. Because the way we see it, there’s no reason for your small jobs to turn into a big deal. For more information, give us a call at 1-800-558-7500 (805-614-4344 outside the U.S.). And let us get your short game on par.