Innovative Technologies for Assessment, Repair & Replacement of Under-ground Pipelines

2013 Annual Building Inspection Engineering
C★O★N★F★E★R★E★N★C★E
Sponsored by National Academy of Building Inspection Engineers

Feb 16, 2013

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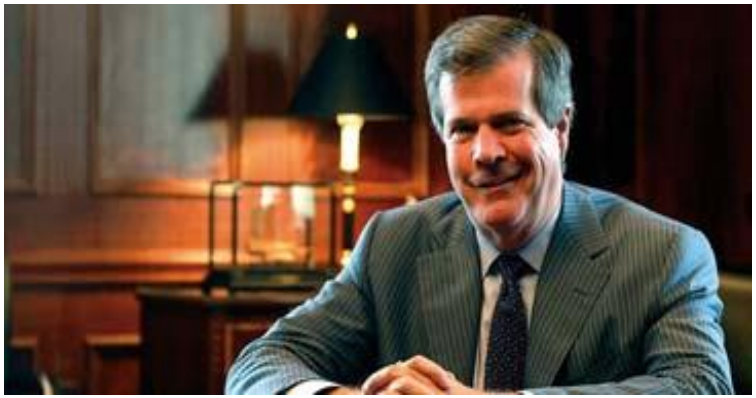
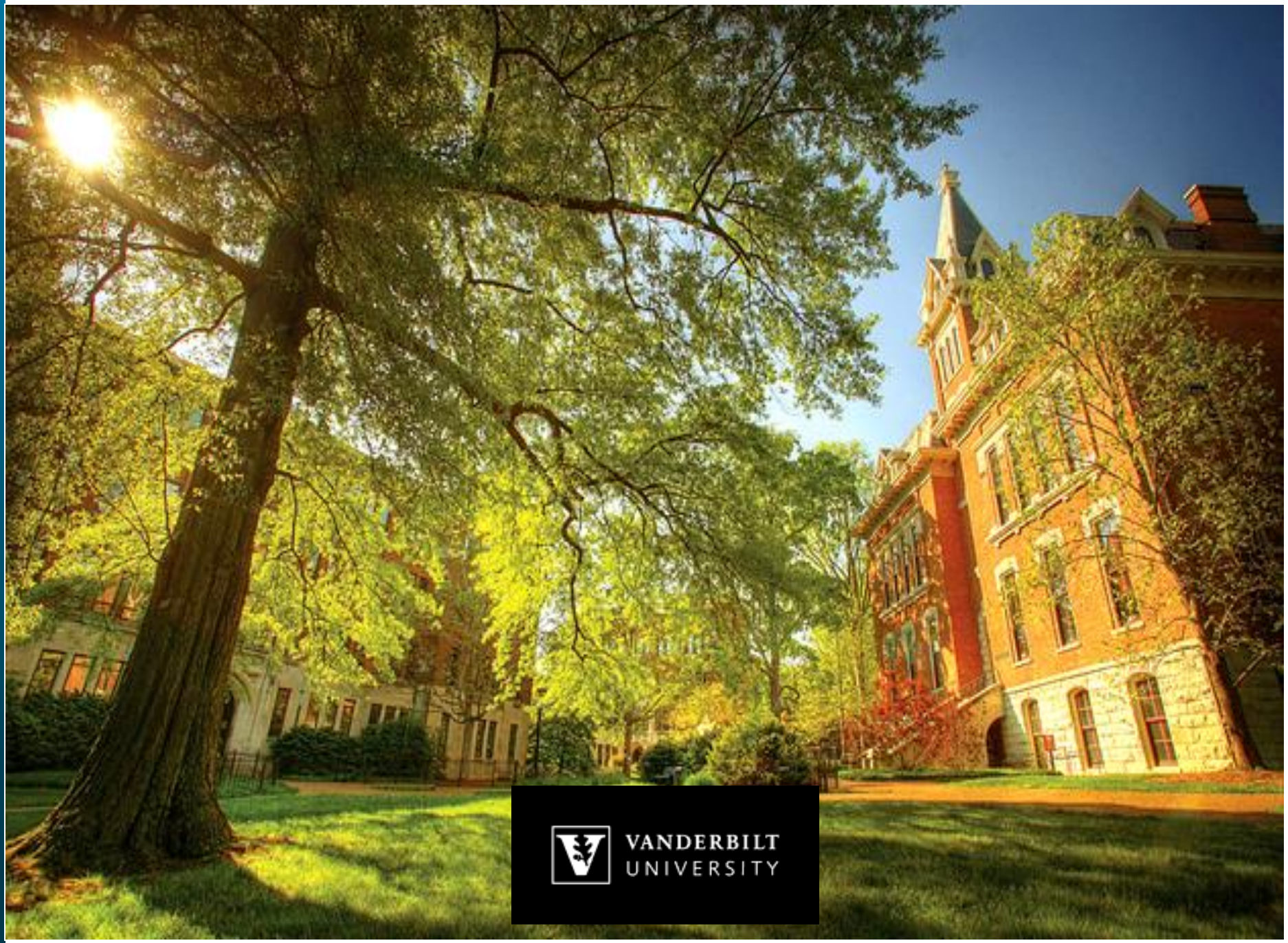
Nashville was settled in 1779 and permanently became state capital in 1843. The city has a population of nearly 570,000. The Metropolitan Statistical Area encompasses eight counties and has a population of 1.23 million.

Nashville.gov | Metro Government of Nashville & Davidson County, Tennessee




VANDERBILT
UNIVERSITY

In the heart of Nashville, an oasis has grown for over a century. Vanderbilt's 330 acres are home to architectural treasures and a national arboretum. Take a tour

"Nashville's a great city. It has sports, good food, good nightlife, and it's not so crowded that you can't get around." ~ Adam Meyer '12

Nashville is one of America's fastest growing cities, but it is also among the most livable.

VANDERBILT'S HOMETOWN of Nashville is a vibrant, engaging city known proudly as "Music City, U.S.A." Located just 1.5 km from downtown, the university's students, faculty, staff and visitors frequently cite Nashville as one of the perks of Vanderbilt.

U.S. NEWS COLLEGE COMPASS

Best Colleges 2012

Tuition and fees: $41,332 (2011-12)
Enrollment: 6,879
Setting: urban

#17 Vanderbilt University

Nashville, TN

Vanderbilt University has a total undergraduate enrollment of 6,879, with a gender distribution of 48.9 percent male students and 51.1 percent female students. 85.0 percent of the students live in college-owned, -operated, or -affiliated housing and 15.0 percent of students live off campus.

VANDERBILT School of Engineering

Happy 125th Anniversary!

Celebrating the School's past, creating its future

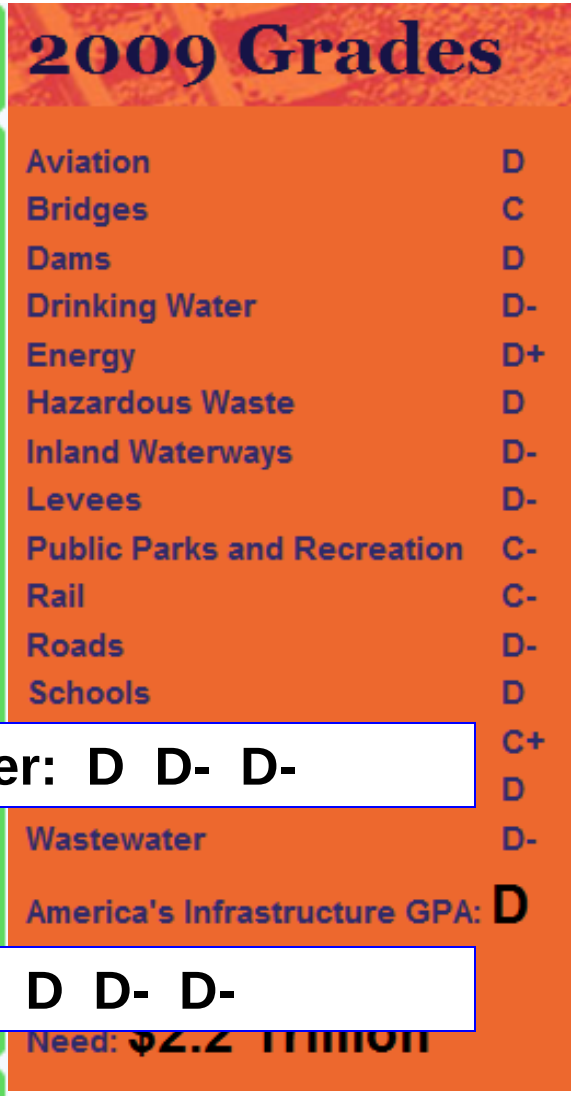
- Events & Lectures
- Message from the Dean
- Share Your Story
- Timeline & History
- Support VUSE
- **125th Home**

To mark its 125th anniversary, the School's annual distinguished lecture — The John R. and Donna S. Hall Engineering Lecture — becomes a special series bringing four notable engineering leaders to campus, one each in October, November, January and March. A kick-off birthday party in September launches the celebration. A special Engineering Celebration Dinner is set for October 20 during the university's reunion weekend. National Engineers Week in February will offer a number of opportunities for students and local alumni to celebrate, too. In May, we'll wrap up with a special party for engineering faculty and staff.

http://engineering.vanderbilt.edu/Home.aspx

http://engineering.vanderbilt.edu/cee/GraduateStudy/ConstructionManagement/index.php


INFRASTRUCTURE



Drinking Water: D D- D-

Waste Water: D D- D-

Out of sight,

Out of mind,

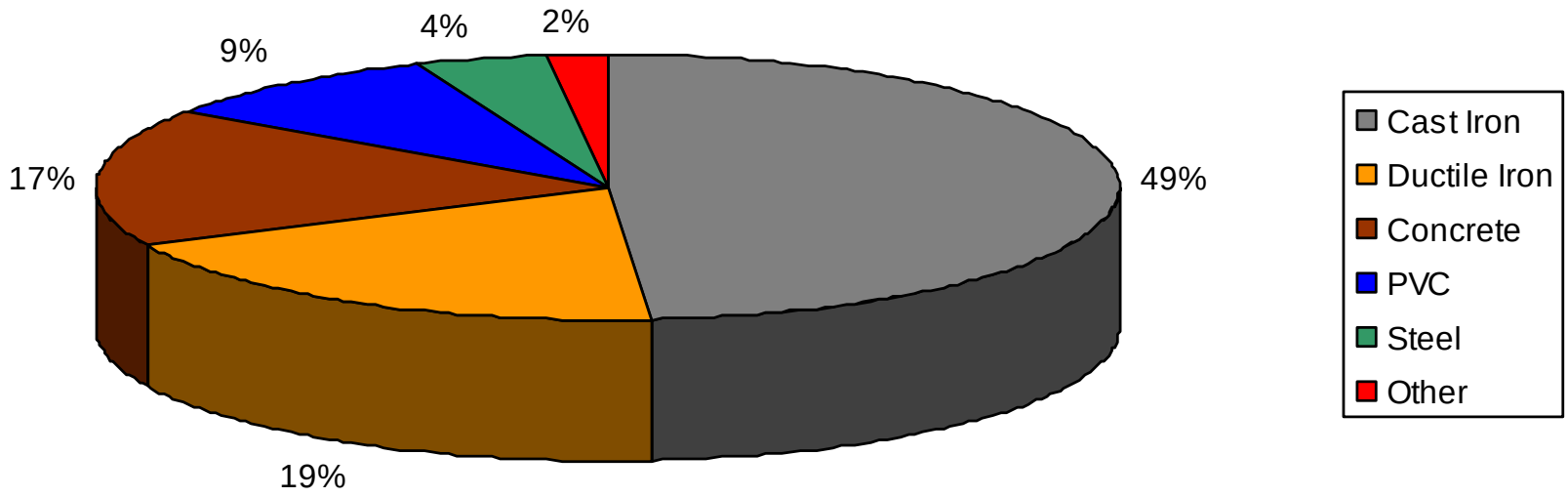
Out of order!

America's Drinking Water Infrastructure

- ***54,000*** *Drinking Water Systems Serving …*
- ***300 Million+*** *People in the U.S., Via …*
- ***2 Million*** *Miles of Water Distribution and Transmission Pipe*

U.S. Buried Water Pipe Inventory

1991 Approximate Inventory of Buried Pipe in Drinking Water Systems in U.S., *American Water Works Association (AWWA)*



Systems in Peril: Water Main Breaks

- ***700*** *Water Main Breaks / Day*
- ***250,000*** *Water Main Breaks / Year*
- ***2.2 Trillion*** *Gallons of Water Lost Annually*
- ***$2.98*** *Billion Lost in Revenue to Utilities / Year*
- ***29 %*** *Of Utilities do not Generate Enough Revenue to Cover Full Cost of Service*


WPRI

Cars swallowed by sinkhole in Wisconsin

Source: WISN

Added On March 14, 2011

Milwaukee police say a sinkhole was created when a 42-inch water main ruptured. WISN reports

http://www.cnn.com/video/#/video/us/2011/03/14/dnt.wi.sinkhole.wisn?hpt=T2

郑州某处主给水管道突然爆裂，2010

时隔5天，郑州另一处主给水管道又突然爆裂，2010

U.S. Waste Water Infrastructure

- ***16,000*** Waste *Water Systems Serving ……*
- ***250 Million+*** *People in the U.S., Via …*
- ***740,000*** *Miles of Gravity Sewers*
- ***60,000*** *Miles of Force Mains*
- ***500,000*** *Miles of Private Lateral Sewers*

Many systems have reached the **end of their useful design lives**.

Older systems are plagued by **chronic overflows** during major rainstorms and heavy snowmelt and are bringing about the discharge of raw sewage into U.S. surface waters.

The EPA estimated that the **volume of combined sewer overflows discharged nationwide is 850 billion gallons per year**.

Sanitary sewer overflows, caused by blocked or broken pipes, result in the release of as much as **10 billion gallons of raw sewage** yearly, according to the EPA.

Sewage spills foul San Francisco Bay over and over

Associated Press

By JASON DEAREN, Associated Press
Thu Feb 26, 3:23 pm ET

SAN FRANCISCO – Last weekend, 890,000 gallons of raw sewage and stormwater spilled into San Francisco Bay from an overloaded World War II-era treatment plant. Five days earlier, a ruptured pipe released 400,000 gallons of filth into the bay.

And those were just the big spills the public heard about.

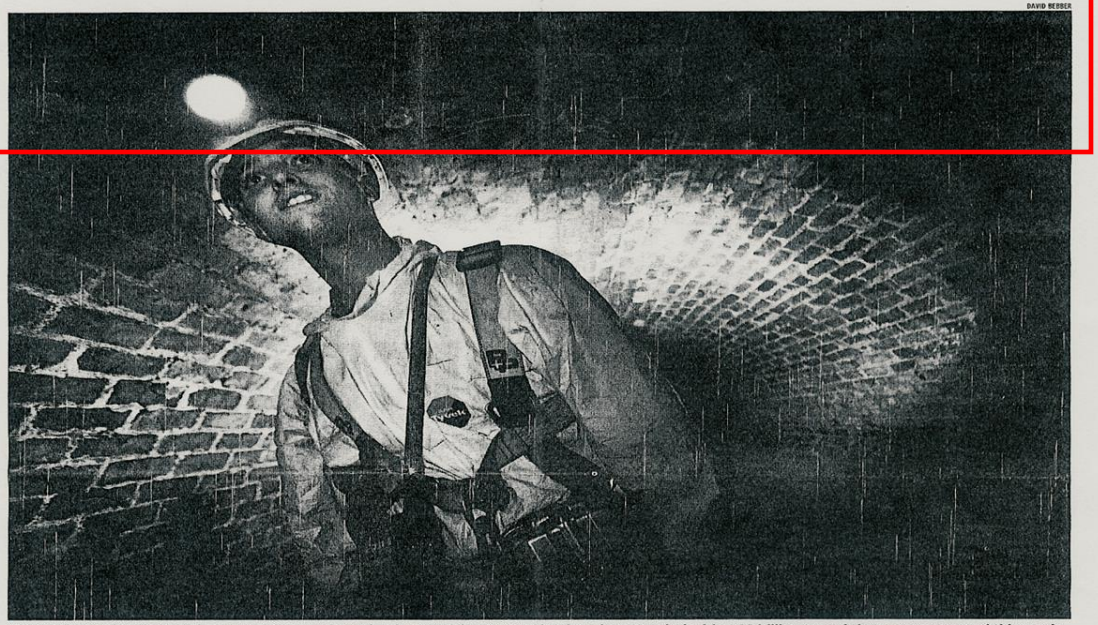
On average, human waste spills into the San Francisco Bay more than five times a day, fouling the waters and shorelines of this environmental jewel and recreational treasure.

The sewers are the arteries of London – and we're on the brink of a heart attack

The world-beating network that saved the city is buckling under the rising tide of our effluent

Helen Rumbelow

DAVID BEBBER



"The potential for flooding is colossal." A sewer worker inspects the system that is to be extended with a £2 billion tunnel that was announced this week

Put Rob Smith in one of the 40,000 miles of tunnels deep below London and he still has a good idea what is happening on the surface. If the water around his knees runs bright red, that means he is near the abattoirs in the East End; if there are foot-long chunks of hardened fat floating on the surface — "like feta cheese" — he is under the restaurant hot spot of Leicester Square.

When a particular pipe gushes suddenly by his shoulder, a shopper has relieved herself in Selfridges department store. If the water rises to his waist and is fragranced with pine freshener, he can tell it is just after the breakfast rush of bathroom flushings and cleanings. And if the water surges in a terrifying whoosh to fill the tunnel, he knows it is time to get out. There is heavy rain outside, and the marvel of engineering that is the London sewer system is about to fail, turning the Thames into a giant public convenience.

"We're firefighting," said Mr Smith, the catchment engineer for Thames Water, whose job is to make sure that the entire system works. "The rainfall is intense, and the system can't cope."

In the old days, the Thames ran with sewage and smelt awful. In 1858 — during the "Great Stink" — it smelt so bad that MPs could not bear to sit in the Houses of Parliament, which inspired them to ask Joseph Bazalgette to build the first modern sewerage system in the world. It saved the city from cholera and allowed London to become great.

If Bazalgette was around to inspect his tunnels with Mr Smith — as I did this week — he would be deeply saddened. The overflow pipes that he built to be used in emergencies now disgorge raw sewage into the Thames every week. This sewage does not sweep out to sea, but instead bobs 10 miles (16km) back and forth with the tide, re-creating what Disraeli then called "a Stygian pool, reeking with ineffable and unbearable horror".

On Thursday the Government announced that a £2 billion tunnel would be built to deal with the problem. But, as *The Times* descended into the gloom, it emerged that the failure is not just with the system, it is with us. We are not, as the Victorians were, grateful for our sewers. We abuse them, thinking that someone else will always clean up our mess.

"We live in an 'out of sight, out of mind' society," Mr Smith said. "It is horrendous, because the potential for flooding is colossal. This system was built really, really well by Bazalgette, but it does not take too many idiots for it all to go."

Mr Smith looks in good health, not like a man who has spent much of his 58 years underground. His free time is spent sailing. "I love to get out in the fresh air," he says.

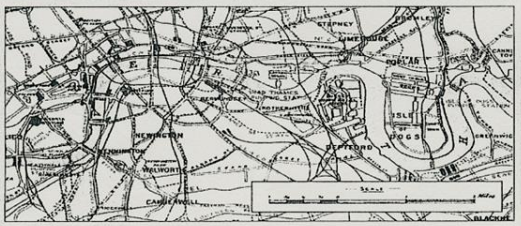
We meet at one of the sewerage command centres in East London, but before we start we must get dressed: hip-high waders, a helmet, a boiler suit, emergency breathing apparatus and a harness. A harness? "If you fall over, you'll be too slippery to pull out," Mr Smith said.

When the manhole is unscrewed, the whiff is not too bad, better than many a bachelor's bathroom. "That's because it's posh poo," joked one of Mr Smith's team of flushers, for this is affluent effluent from Hampstead. In fact the sewers do not stink, so diluted are they with water from baths, washing machines, industry and rain.

After I have climbed down a long, steel ladder, the tunnel ahead is utterly black. Mr Smith shines his torch downwards, to reveal that the puddle around our boots is moving, seething with tiny shrimp-like creatures.

Moving farther along this quiet overflow tunnel, boots sink a few inches lower into unspeakable sludge. This is when the sewer becomes an audio experience: unable to see anything in the darkness you hear only the booming of a second sewer overhead and the sloshing of each unsteady step.

When he stops, briefly, we can admire the glistening brickwork from Bazalgette's day, the domed roofs made neat by proud craftsmen. Mr Smith is infuriated by thrill-seekers who have begun to break into the sewers: their risk of drowning, either in heavy rain or when the flow is diverted, is great. Some were arrested when they trespassed into the high-security sewers under Downing Street, Buckingham Palace and the Houses of Parliament, which are alarmed and guarded.



Tunnel vision

- London has 40,000 miles (64,500km) of sewers. The 1930s map, left, shows their complexity. Laid end to end they would stretch twice around the world
- 52 million cubic metres of waste water pollutes the rivers Thames and Lee each year — enough to fill the Albert Hall 525 times
- 100 tonnes of cooking fat are dumped each year, costing £7 million to clear

Source: Times Database

"I made that mistake myself when I started out. I went to those tunnels without knowing and found myself staring at the barrel of a gun," he says. Intruders are usually rats, and goldfish and terrapins survive "for a time", he said, but stories of mutant aligators are a myth. His scariest discovery was of a live hand grenade, which he threw from a manhole on to wasteland.

The greatest fear of sewer workers is fat, which is poured hot and liquid down the sink but, on hitting cold water, solidifies and floats on the surface. When the sewer level rises, the fat sticks to the tunnel roof. Over time, the sewer clogs and it is eventually blocked shut. If you imagine the sewers as London's arteries, fat causes the heart attack. And, as Mr Smith puts it, "the sewers keep fatting up" with more restaurants, more negligence. "I love my job, I get a lot of job satisfaction, but I don't think I'd be up for starting out now, with the fat," he said.

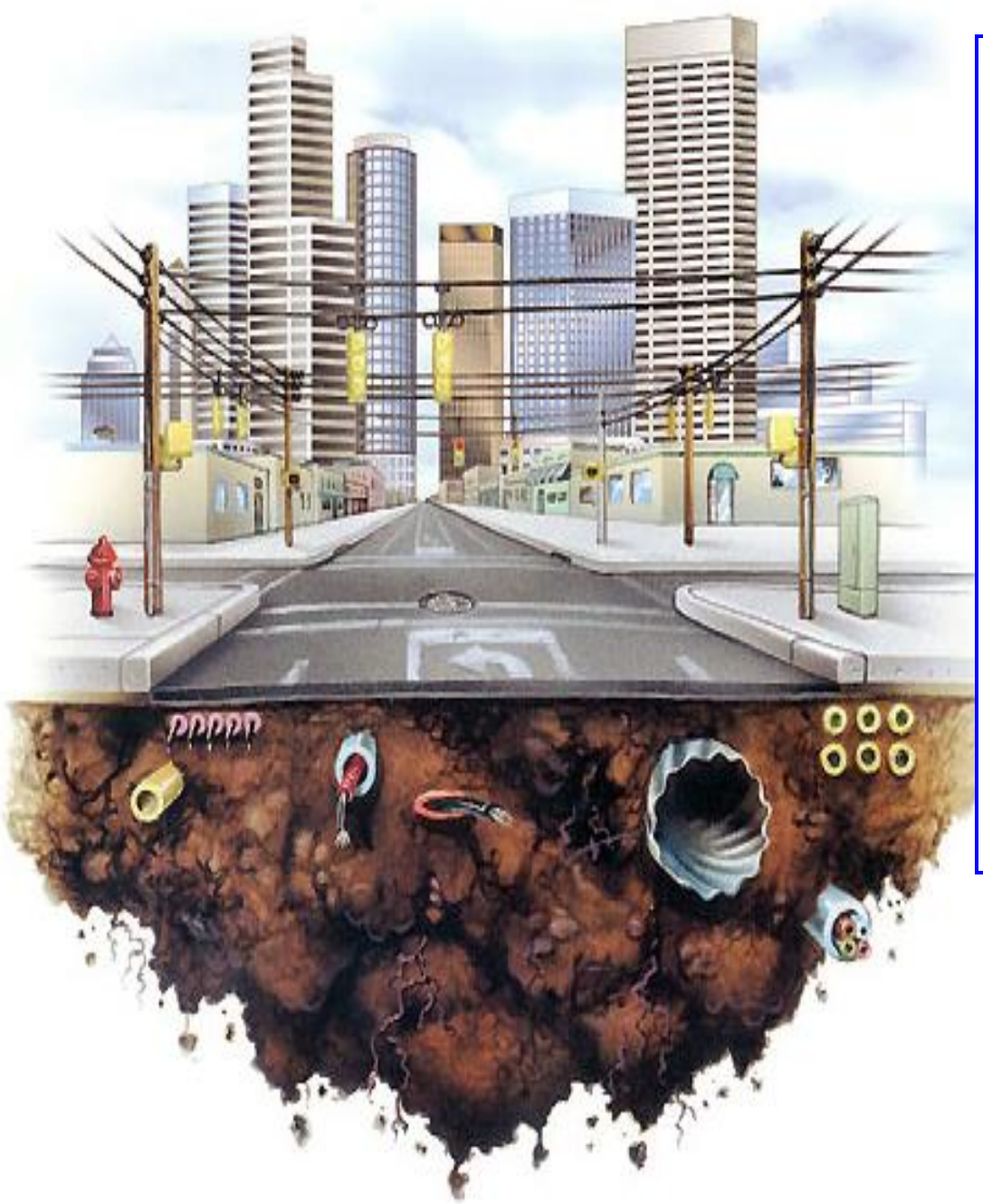
Once flushers had to clear a 150ft (45m) slug of hardened fat from under Leicester Square, using pickaxes. It took them eight weeks. "It has a smell all its own, this wall of rotting fat, generating heat and midge flies. Then mix it up with sewage, contraceptives, nappies, it turns your stomach."

Despite this, the flushers generally do the job for life, for the camaraderie and adventure. Mr Smith had worked previously in mine tunnelling, but boys do grow up dreaming of working in the sewers: of this year's intake of 12 trainees, three are sons of flushers. They must learn a parallel map of London, with tunnels named after the roads above, underground rivers, or just with a romantic whim: Pall Mall, Opera, Savoy.

You also notice the toilet paper. Is that not meant to dissolve? "It should do, but we hate Double Velvet," said Mr Smith. "Or those new wet-wipe things. You might as well put a sleeping bag down."

Human waste is burnt, as a renewable electricity source, but everything else, including cotton buds and nappies, has to be fished out, laundered, and sent to the rubbish tip, where it should have gone in the first place.

Sir Joseph thought that his life-saving sewers would get rid of waste, not bear the brunt of the chronically wasteful. In *Les Misérables*, Victor Hugo describes the Parisian sewers as the "conscience of the city". In London, our conscience is not clean.



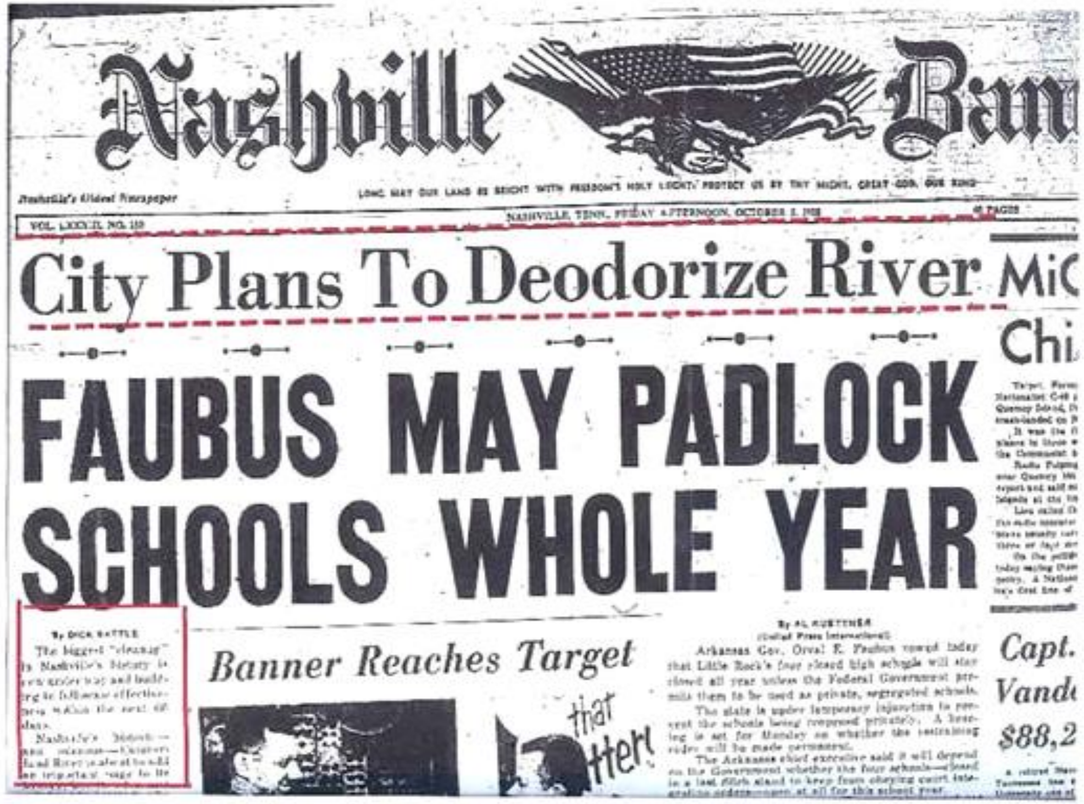
COLOR CODE

FOR MARKING
UNDERGROUND UTILITY LINES

	ELECTRIC
	GAS - OIL - STEAM
	COMMUNICATION CATV
	WATER
	RECLAIMED WATER, IRRIGATION
	SEWER
	TEMPORARY SURVEY MARKINGS
	PROPOSED EXCAVATION

This photo from the early twentieth century shows the bewildering assortment of pipes and tubes that lies underneath most Manhattan streets. Photo courtesy of Con Edison.

Nashville Combined Sewer System



Nashville Banner

City Plans To Deodorize River

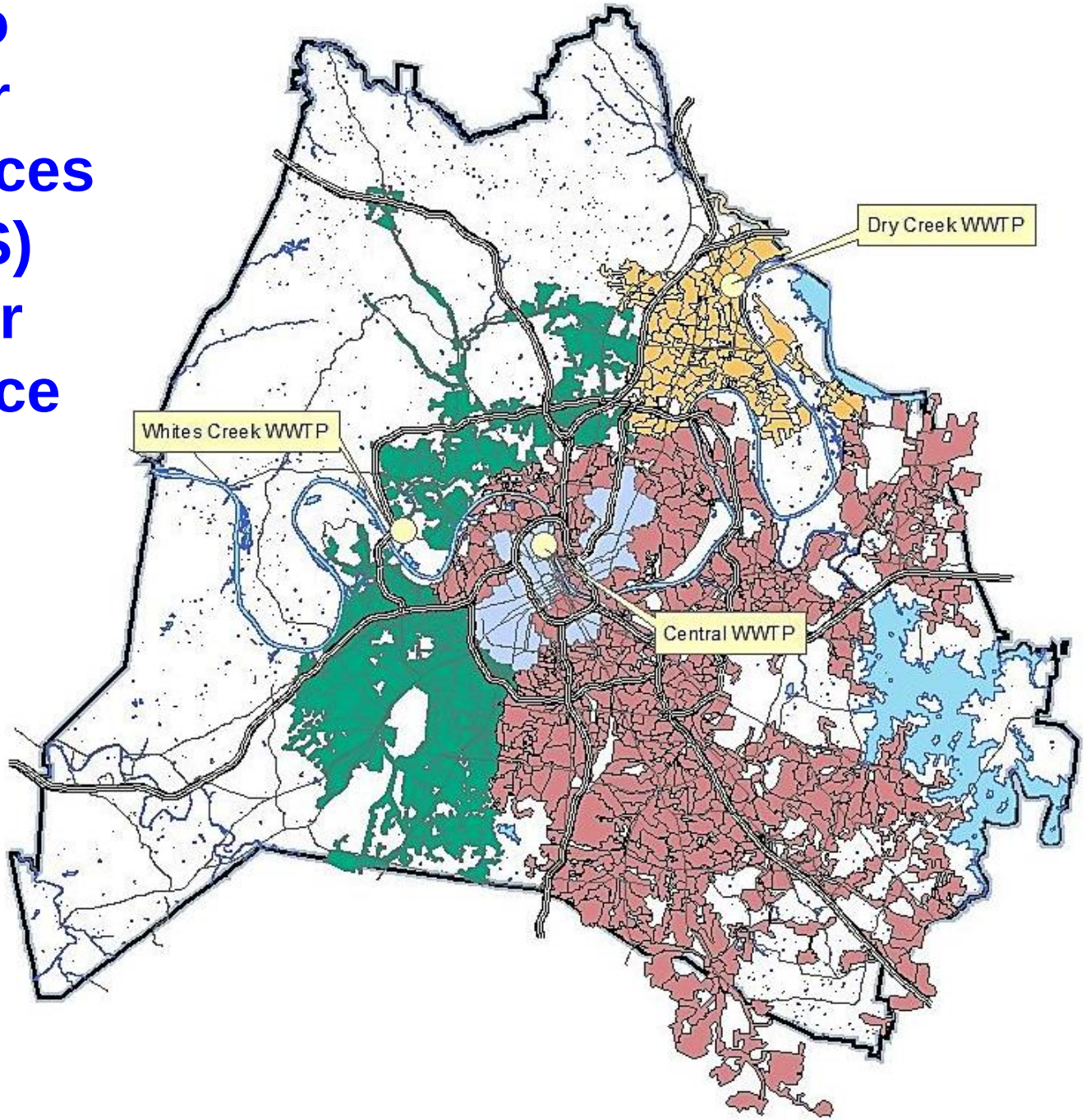
FAUBUS MAY PADLOCK SCHOOLS WHOLE YEAR

Banner Reaches Target

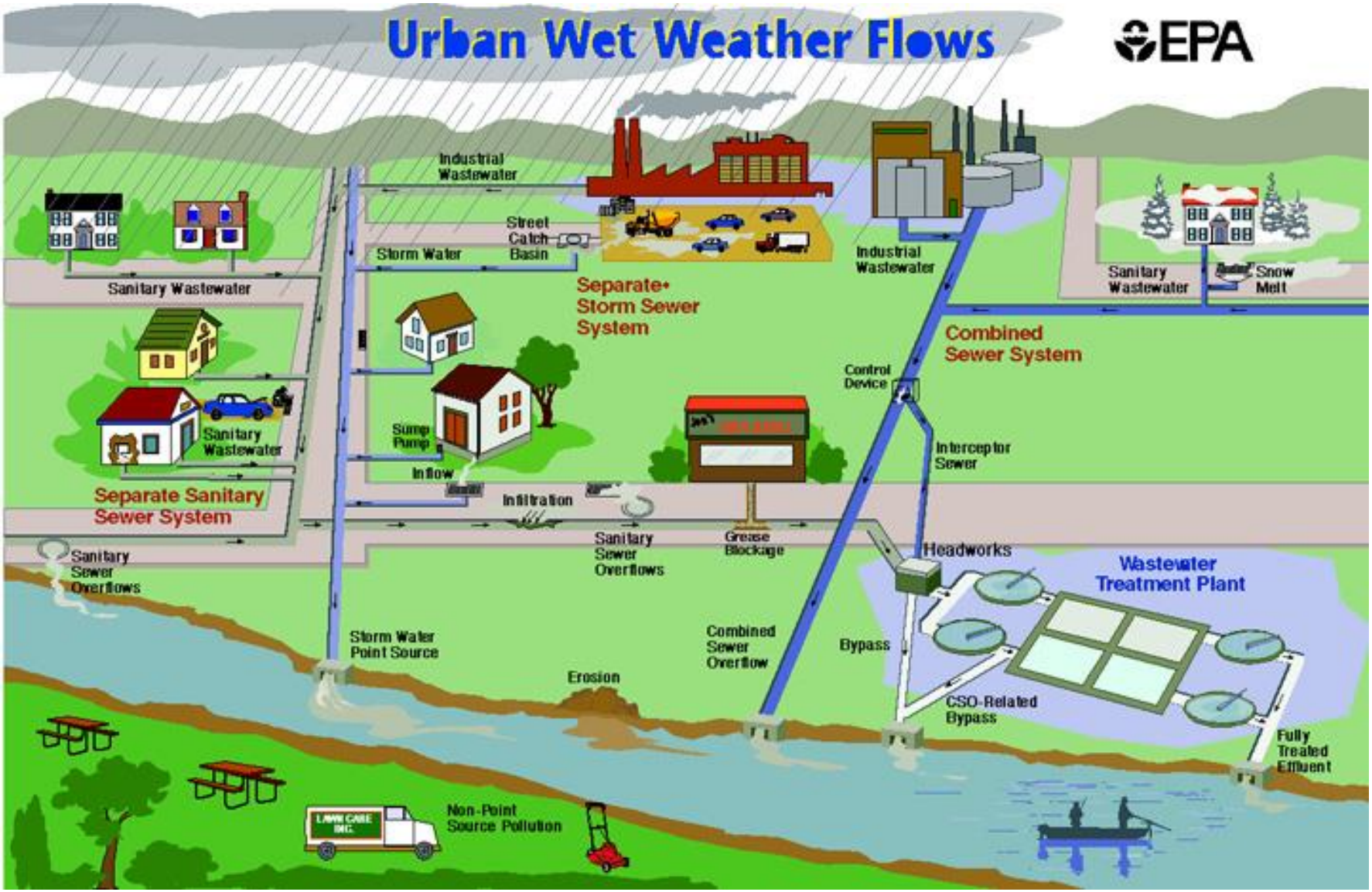
Nashville Banner October 8, 1958 By: Dick Battle

Nashville's original sewer system was built in the late 1800's and carried both storm water and sewage directly to the Cumberland River without treatment. It wasn't until the late 1950s that Nashville constructed the Central Wastewater Treatment Plant the first plant to treat the wastewater before it was released into our rivers and streams. Now routed to a wastewater treatment plant, most of the original system remains in service today.

Metro Water Services (MWS) Sewer Service Area



Combined Sewer Systems



Received

2007 OCT 24 AM 10:18

U.S. DIST. COURT
MIDDLE DIST. OF TN

UNITED STATES DISTRICT COURT
FOR THE MIDDLE DISTRICT OF TENNESSEE
(Nashville Division)

THE UNITED STATES OF AMERICA and
THE STATE OF TENNESSEE,

Plaintiffs,

v.

METROPOLITAN GOVERNMENT
OF NASHVILLE AND
DAVIDSON COUNTY,

Defendant.

CIVIL ACTION
NO. 3 07 1056

JUDGE ECHOLS

CONSENT DECREE

INTRODUCTION

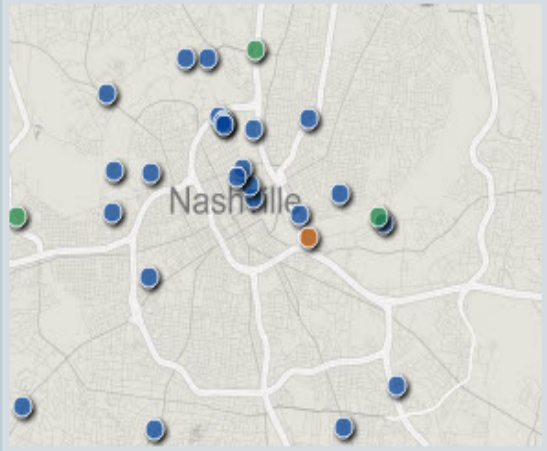
WHEREAS, the United States of America, on behalf of the Administrator of the United States Environmental Protection Agency ("EPA"), filed a Complaint alleging that the Defendant, the Metropolitan Government of Nashville and Davidson County, Tennessee ("Metro"), acting by and through its Department of Water and Sewerage Services, has violated the Clean Water Act, 33 U.S.C. § 1251, *et seq.* ("CWA"); and

WHEREAS, the CWA imposes strict liability based upon any violation of the CWA; and

WHEREAS, on April 30, 2007, the State of Tennessee ("State") issued a sixty (60) day notice of intent to sue Metro pursuant to 33 U.S.C. § 1365, and thereafter filed a Complaint

What is a Consent Decree?

A **consent decree** is a final, binding judicial decree or judgment memorializing a voluntary agreement between parties to a suit, in return for an end to a civil litigation or withdrawal of a criminal charges.



New Project Map

We have released a new Project Map to quickly view up to date information about the Clean Water Nashville projects.

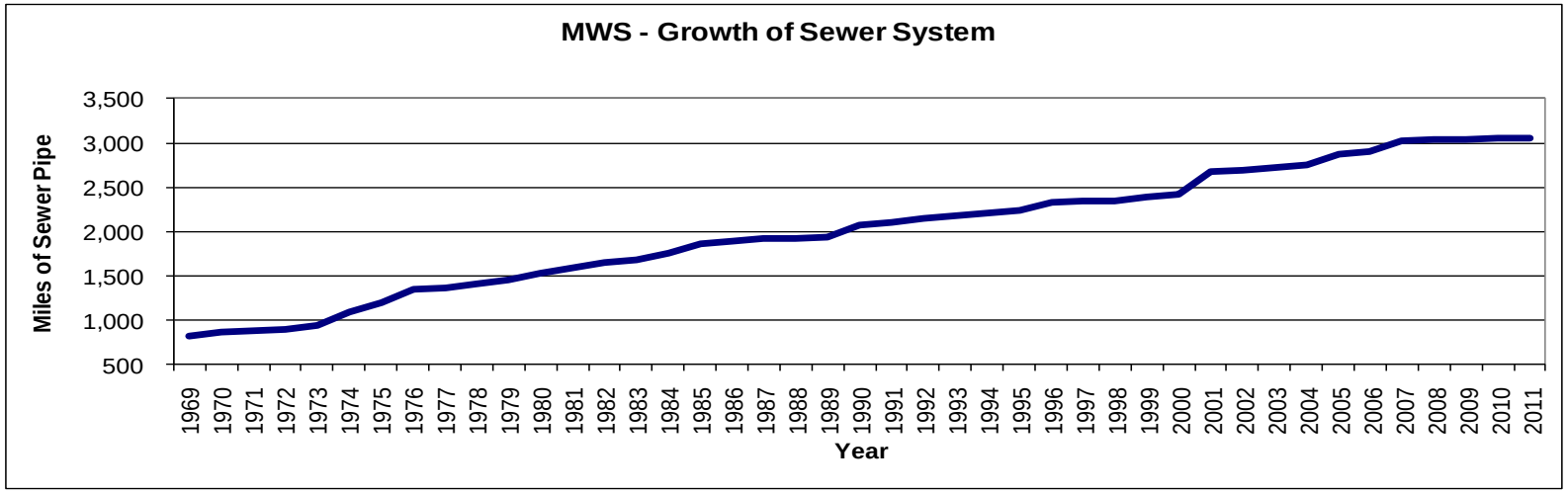
read more

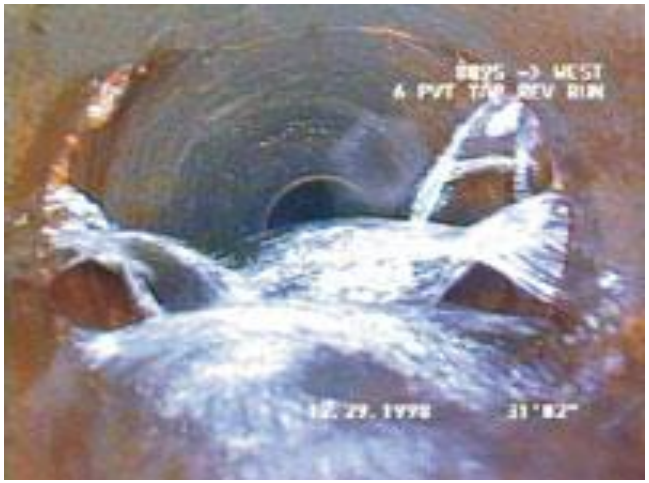
The Clean Water Nashville Overflow Abatement Program is an initiative led by Metro Water Services in coordination with partner agencies including the U.S. Environmental Protection Agency (EPA) and Tennessee Department of Environment and Conservation (TDEC) for the purpose of meeting the Clean Water Act requirements and, in the process, ensuring the environmental health of the Cumberland River for future generations.

This site provides information about:

- the Clean Water Nashville Overflow Abatement Program and the Consent Decree agreement between the Metro Nashville Government, TDEC and EPA that sets the terms for system infrastructure improvements;
- the *Long Term Control Plan* that involved significant community input in the recommendations for Metro's combined sewer system;
- the *Corrective Action Plan/Engineering Report* for addressing sewer overflows from the separate sewer system; and
- the status of current projects in the Clean Water Nashville Overflow Abatement Program of infrastructure renewal to reduce sewer overflows, reduce health risks associated with exposure to bacteria and contaminants, and improve water quality in the Cumberland River and Davidson County's extensive network of streams, creeks, and tributaries.

1960s – 2010s

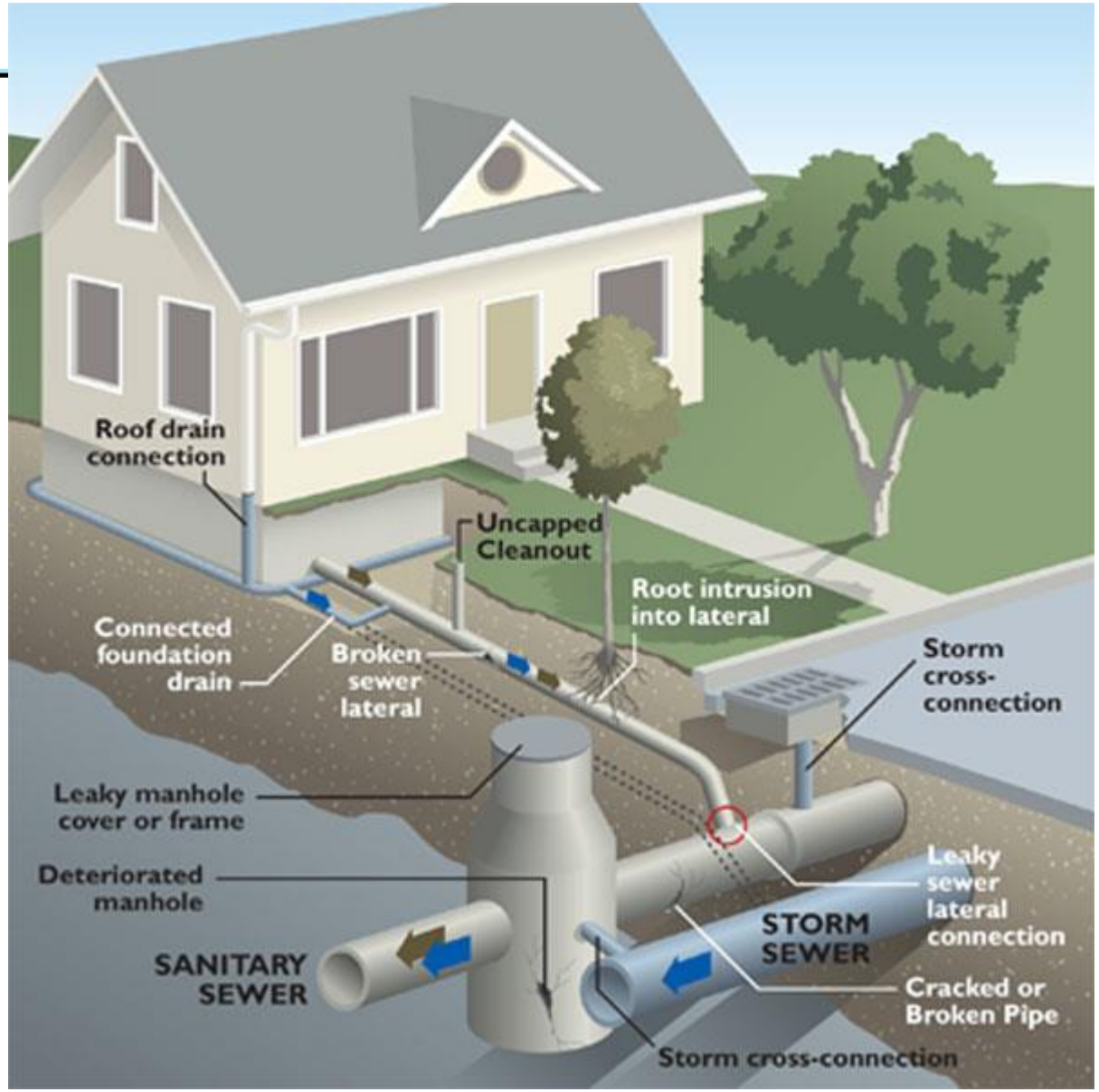

MWS - Growth of Sewer System
Miles of Sewer Pipe
3,500
3,000
2,500
2,000
1,500
1,000
500
1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Year



Infiltration and Defects Identified by Televised Inspection

Defects Identified in MWS Sewers

Sources of Inflow and Infiltration (I / I)



Let the work begin……..


CAT
CAT 345B L
CAT

30th Street Waterline Replacement Project

- Lane restrictions in the work zone on E. Aurora Ave. from Quinn to 30th streets.
- 8:30 a.m. to 4:30 p.m.
- Traffic will be flagged around the work area.
- Some weekend work will occur to accommodate water-dependent businesses.
- Intermittent water outages could occur in the area.
- Information: Barb Kenyon (303) 441-3266

New Technologies

- **The disruption of traffic flow, the need to restore roadway surfaces, difficulty with gaining access to right-of-ways, and the need to deal with inconvenienced users, all add to the already high cost of the traditional open-cut construction.**

- **Consequently, the traditional practice of open-cutting roadways and streets is sometimes impractical or even impossible.**

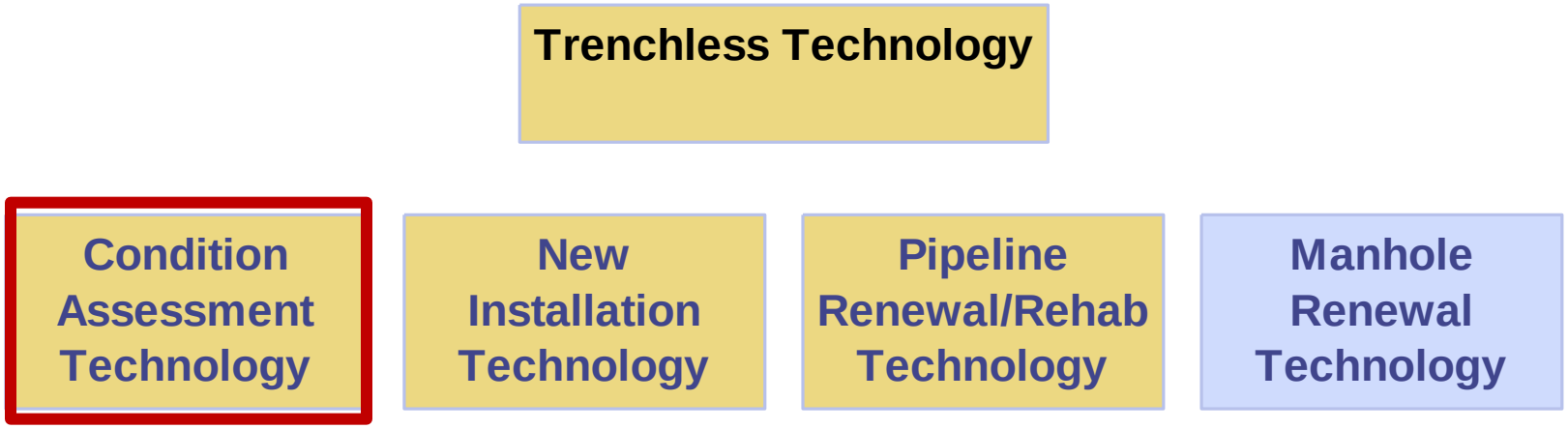
Trenchless Technologies

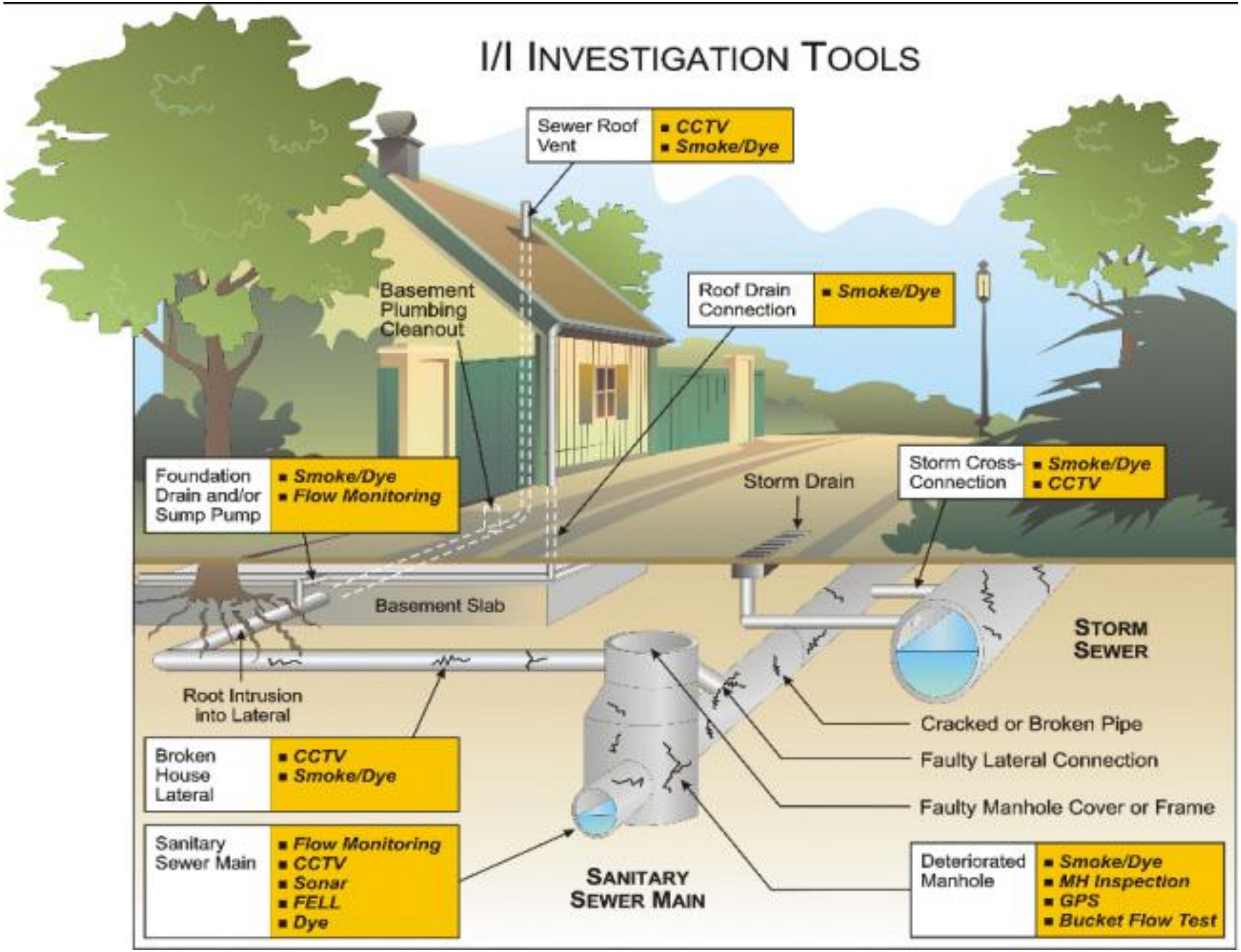
- Non-invasive or Minimally Invasive
- Minimum Disruption - traffic, users, business
- Environmentally Friendly
- Lower Social Cost
- Lower Life-cycle Cost
- Very Often Lower Initial Cost

Trenchless Technology (TT)

- Methods, equipment & materials utilized to install new or renew/repair existing underground utility/ communication systems that minimize the disruption & destruction to society and/or our environment by minimizing excavation.

TT Categories




I/I INVESTIGATION TOOLS
Sewer Roof Vent
CCTV
Smoke/Dye
Basement Plumbing Cleanout
Roof Drain Connection
Smoke/Dye
Foundation Drain and/or Sump Pump
Smoke/Dye
Flow Monitoring
Storm Drain
Storm Cross-Connection
Smoke/Dye
CCTV
Basement Slab
STORM SEWER
Root Intrusion into Lateral
Cracked or Broken Pipe
Faulty Lateral Connection
Faulty Manhole Cover or Frame
Broken House Lateral
CCTV
Smoke/Dye
Sanitary Sewer Main
Flow Monitoring
CCTV
Sonar
FELL
Dye
SANITARY SEWER MAIN
Deteriorated Manhole
Smoke/Dye
MH Inspection
GPS
Bucket Flow Test

- **Infiltration and Inflow in sewers causes two main problems.**

- **The first and probably most apparent cause is unnecessary pumping and treatment costs.**

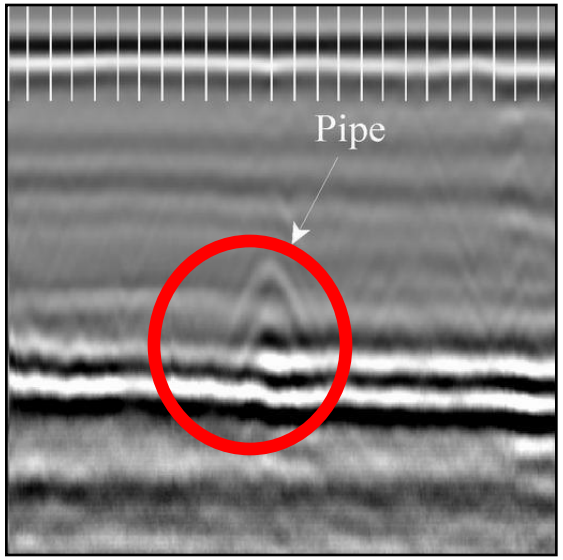
- **The second, and the less obvious is the risk of structural collapse of a sewer line.**

Condition Assessment Technologies

Outside the Pipe

- *GPR-Ground Penetrating Radar*
- Electromagnetics
- Resonant Sonics
- Acoustical
- Pulse indication

Condition Assessment – Outside



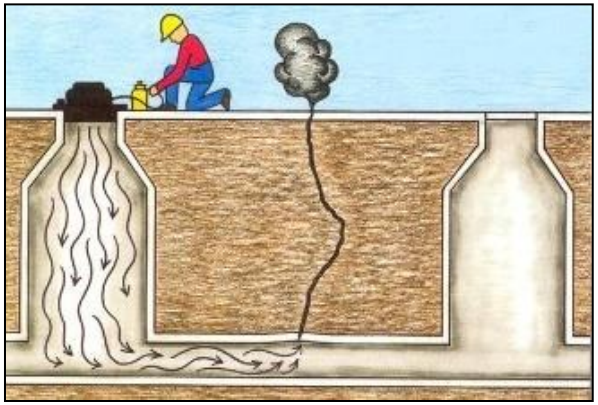
Multisensory Ground Penetration Radar (GPR) Utilized in Locating Underground Pipe

Condition Assessment Technologies

Inside the Pipe

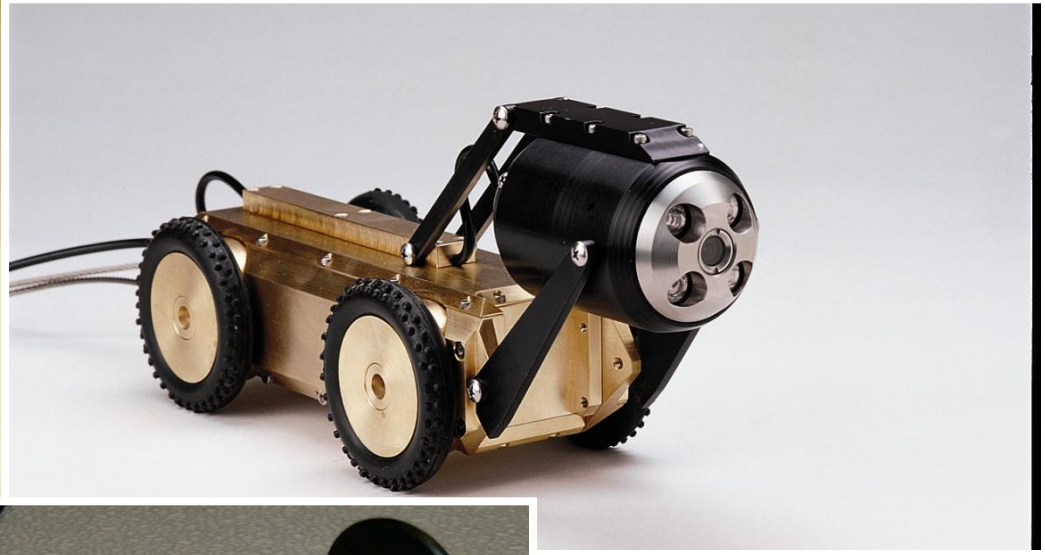
- ***Smoke testing/Dye testing/Flow meter***
- ***CCTV***
- **Hydroscope**
- **Smart Pigs**
- **Sonar**

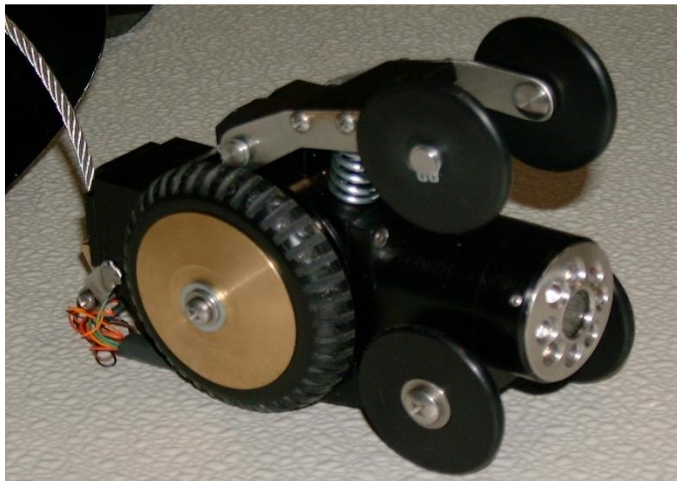
Condition Assessment – Inside



Flow Monitoring Device, Dye Testing, and Smoke Testing in Sewers (clockwise from top left)

INSPECTION EQUIPMENT





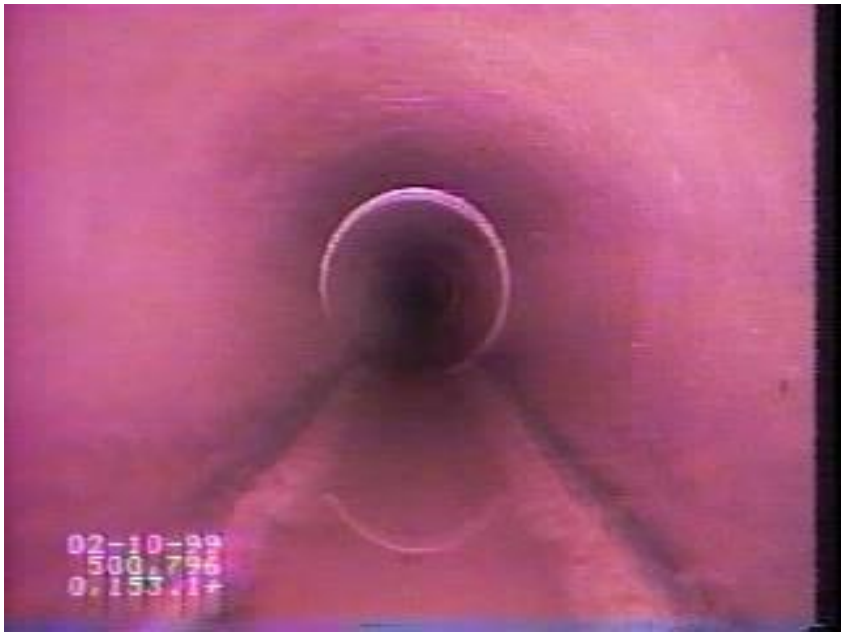
CCTV Data Analysis

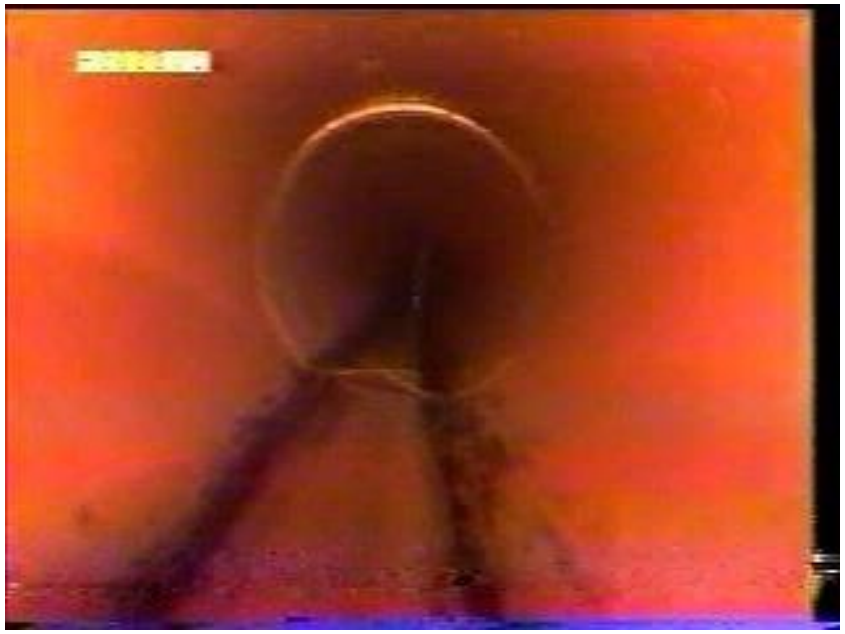
The sewer scanning system allows the entire surface of the pipe wall, from manhole to manhole, to be viewed on *one screen!*

During video inspection of sewers, it is not uncommon to find situations of partial collapse (esp. for the older brick sewers as in this case in Newark, NJ)

Active Leaks are <u>not</u> difficult to Identify

The Challenge of Locating Infiltration!





Snake hiding in sewers is caught

A 10ft (3m) snake thought to have been living in sewage pipes in a block of flats for three months has been caught on a bathroom floor.

The boa constrictor, named Keith, is thought to have been abandoned after the resident was evicted owing £5,500 in rent to his landlord.

It has been slithering out of toilet bowls thoughout the flats in Manchester since August.

In the wild the snake lives close to rivers or swamps.

VIDEO **See the sewer snake**

The creature has been spotted on several occasions and homeowners have put bricks on toilet seats in a bid to keep the beast from popping out of the pan.

Pipes
Clog Over Time

Built on the proven Sahara® platform, the Sahara® Video CCTV system gives utilities the ability to see inside water pipelines without costly shutdown or dewatering.

How Sahara® Video Works

Sahara® Video is easily inserted into a live pipeline through a standard 2 inch or larger tap. Tethered to the surface, the Sahara® CCTV camera is gently pulled by the flow of the water transmitting real-time video data from inside the pipeline. With the ability to travel up to 6,000 feet, Sahara® Video can be used for a number of applications including:

- Locating lost line valves;
- Investigating unexplained flow conditions;
- Locating debris and partial blockages;
- Searching for illegal connections;
- Locating and assessing tuberculation of all types;
- Visually inspecting pipe walls and liners;
- Examining the condition of suspect valves;
- Screening for obstacles or laterals before using a free-swimming inspection tool;
- Assessing internal corrosion on metallic pipes;
- Inspecting pipes near a known leak to help plan repairs;

Fluid

- Potable Water
- Raw Water

Pipe Materials

All

Pipe Diameters

5" (150mm) and larger

http://www.puretechltd.com/

MANHOLE INSPECTION

Manhole Cameras

Section C112-12-001 - Intervention

Summary | Description | Observation

2	ID	P1	P2	Qty	Observation 1	Extent	Observ
1	45	0	4.998	1	Service condition->Debris - gravel	60%	Local
2		0	0	1	Service condition->Infiltration	Runner	At joint

Position
P1 0 ft P2 0 ft

Quantity
1

Observation 1: Service condition->Debris - gravel
Extent: 60%
Intrusion: N/A ft
Observation 2: Local

Clock References
C1 N/A C2 N/A

Diameter / Dimensions
D1 N/A ft D2 N/A ft

Comments
N/D

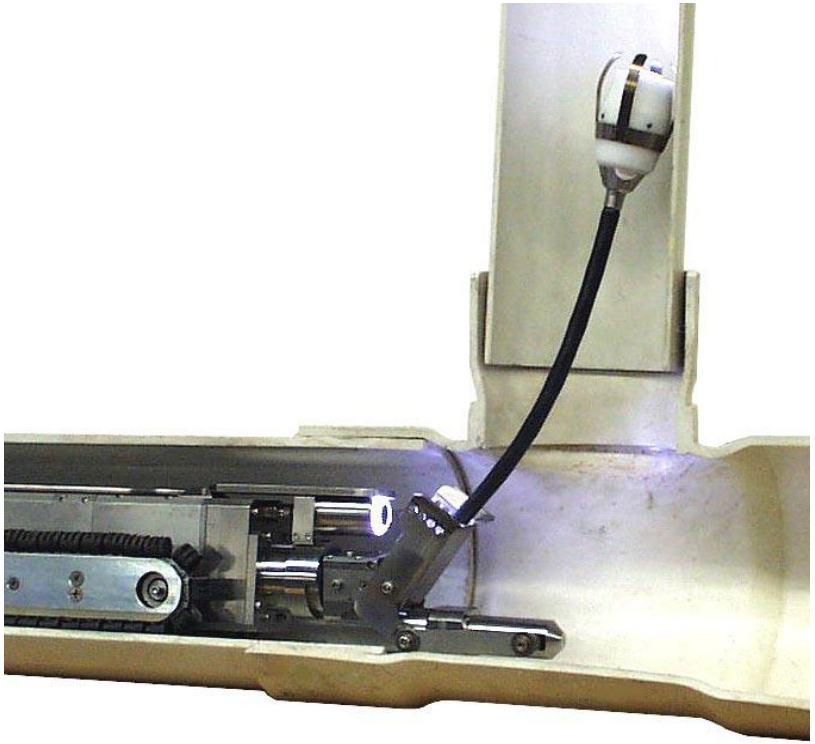
Photo

1	File
1	Bassin 112 tronç.12_C112-12-001_34.j

OK | Close | Apply Now

LATERAL INSPECTION

ProScout II camera
with Connection 1 (CX1)



ProScout System with
ProScout II camera

LAMP shown with a
ProScout III camera

Optional Sonde and
Receiver

WATER WORKS & SANITARY SEWER BOARD
22 BIBB STREET MONTGOMERY, ALABAMA TEL: 334.206.1600 | FAX: 334.240.1689

https://www.mwwssb.com/engineering/private-lateral-programs/#what

Private Lateral Management

What is a "private lateral" and why should one be managed?

How did you determine there is a problem with my private

nent affect me?

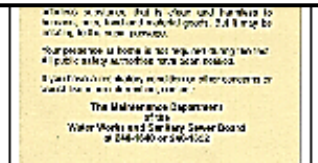
our door?

orhood to execute the
m (PLMS). This program is
your sanitary sewer system
our entire system, one
door hanger describes,
he sewer system to locate
that allow unwanted
his unwanted storm water
sewer system and causes
lse in the system. It is
storm water inflow be
rd's sewer mains,
laterals. Since smoke can
of vents during these
idents concern, we are
mers with additional
ils of the PLMS and its

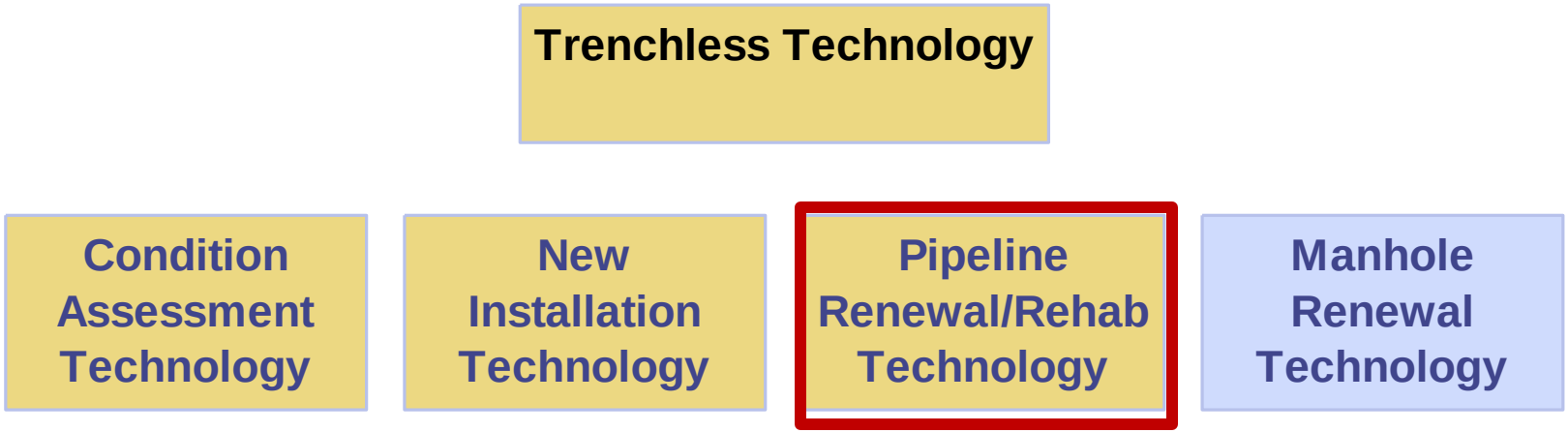
How does Private Lateral Management affect me?

Historically, we placed sole responsibility for private lateral maintenance at the feet of the private property owner. If a problem was discovered in a customer's sewer system between the house or building and our sewer collection mains, we notified the private property owner and directed them to make the repairs. In recent years, however, we adopted what we feel is a more aggressive but cooperative policy. Upon finding a lateral defect, we **notify** the property owner by mail. As before, the property owner is responsible for all repairs on the sewer lateral (upper and lower portions).

Many times, however, all that is required is the replacement of a damaged or missing cleanout cap. We can also handle this for property owners at a nominal cost of $13.00 plus 4% utility tax. If a property owner resolves to have the problem repaired on his own, we will visit the site to inspect the completed repairs. If those repairs do not meet our standards or another defect is located in the process, a **second notice** is sent to the property owner with instructions on how to fix the problem and bring their lateral into compliance with our standards. This notice also advises the property owner that the consequences for non-response or for failing to make the required repairs is termination of water service.



TT Categories



Renewal/Rehab. Techniques

- ***Sliplining***
  - Continuous / Segmental
- ***Cured-in-place pipe (CIPP)***
- **Deformed & reshaped (mod. cross-section)**
  - Fold & Formed (PVC & modified PVC)
  - Deformed & reformed (HDPE)
- **Lining w/ segmental liners**
  - Strips / Panels
- **Point source repairs**
  - Robotic
  - Mechanical bands
  - Grouting

Method	Diameter Range (inches)	Maximum Installation Lengths (ft.)	Liner Material	Application
Sliplining:				
Segmental	12-150	5,000	PE, PP, PVC, GRP	Gravity & Pressure
Continuous	4-60	1,000	PE, PP, PVC, GRP	Gravity & Pressure
Spiral Wound	4-100	1,000	PE, PP, PVC, PVDF	Gravity
CIPP:				
Inverted in Place	4-108	3,000	Thermoset Resin	Gravity & Pressure
Winched in Place	4-54	500	Thermoset Resin	Gravity & Pressure
Close-Fit:				
Swaged	4-15	700	HDPE, PVC	Gravity & Pressure
Folded	3-24	1,000	HDPE, MDPE	Gravity & Pressure
Expanded Spiral	4--36	1,000	HDPE, MDPE	Gravity & Pressure
Spray-on Lining:				
Cement Mortar	4-36	NA	Cement Mortar	Gravity & Pressure
Shotcrete	>42	NA	Cement Mortar	Gravity & Pressure
Epoxy	4-24	NA	Epoxy	Gravity & Pressure
Point Source Repairs:				
Robotic	8-30	NA	Epoxy & Cement Mortar	Gravity
Grouting	NA	NA	Chemical Grouting	Any
Mechanical Sleeve	4-24	NA	Mechanical Sleeves	Any
Point CIPP	4-24	50	Fiberglass/Polyester Resin	Gravity

Definitions of Acronyms

PE-Polyethylene
PP-Polypropylene
PVC-Poly Vinyl Chloride
PVDF-Poly Vinylidene Chloride
GRP-Glassfiber Reinforced Polyester
HDPE-High Density Polyethylene
MDPE- Medium Density Polyethylene

ROOT CONTROL

- Physical Control - lining, grouting, sealing, remove the tree(!), etc.

- Mechanical Control – reaming, jetting, flailing, etc.

- Chemical Control - herbicides

ROOT CONTROL

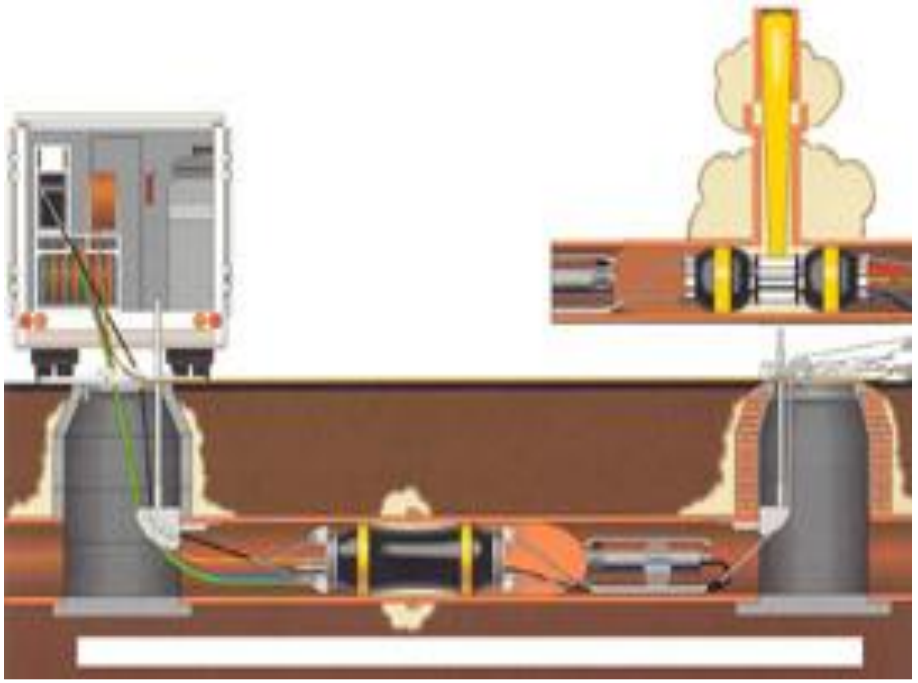
Roots not only restrict flow but can separate and crack the pipe.

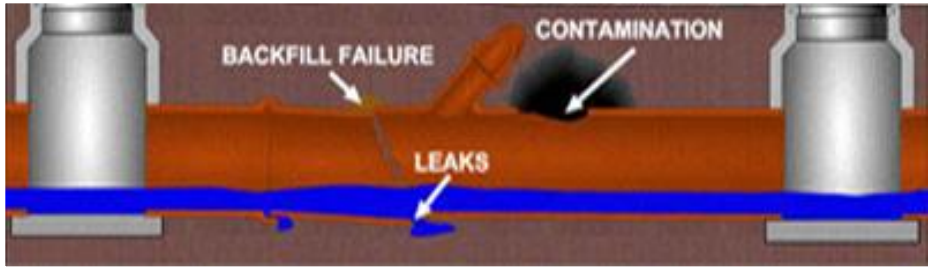
CHEMICAL GROUTING

LEAK CONTROL

CHEMICAL GROUTING

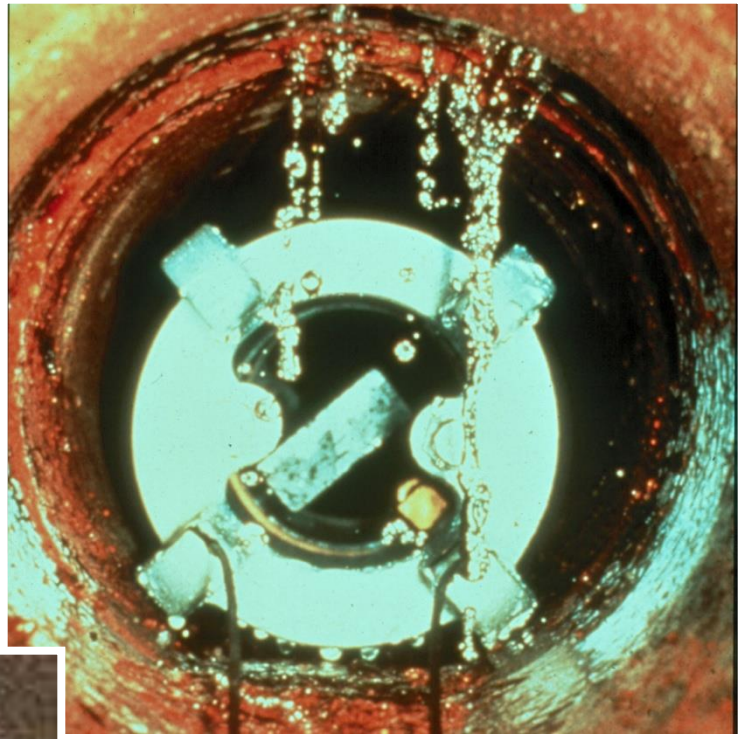
- Typical setup
- Truck positioned over manhole
- Packer (bladder) positioned at leaking joint/defect
- CTV camera monitors the positioning and process.





CHEMICAL GROUTING

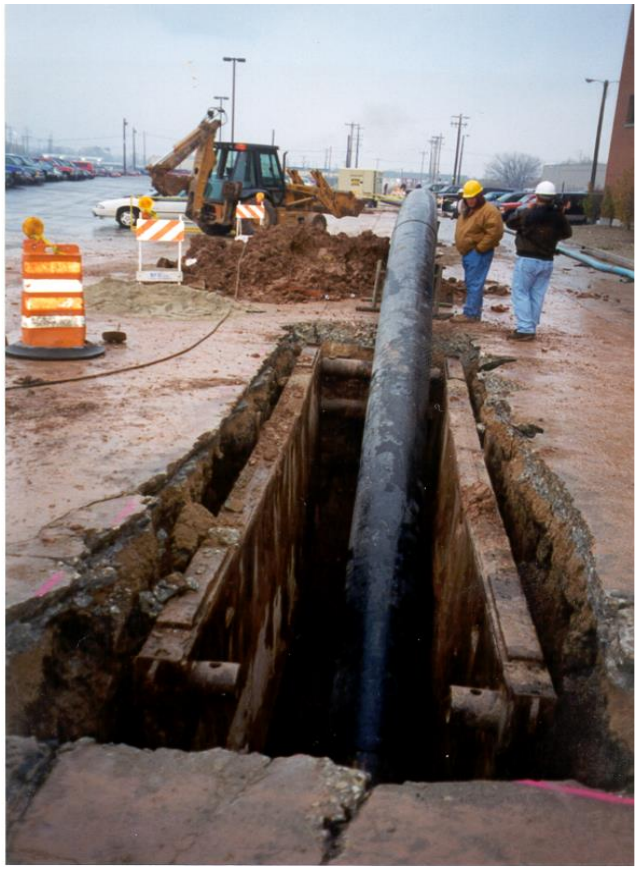
Bladder pulled into position



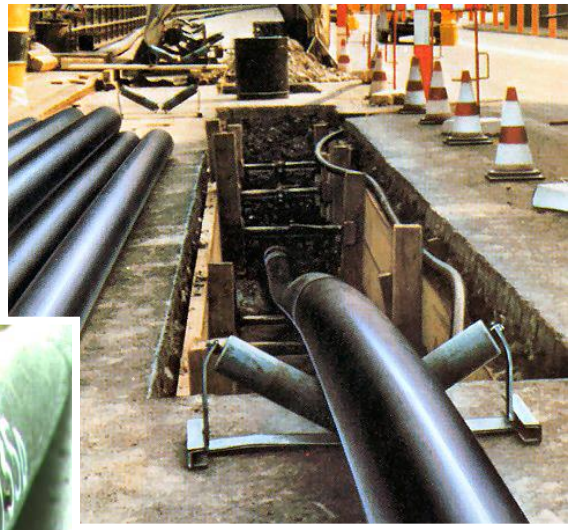
SLIPLINING

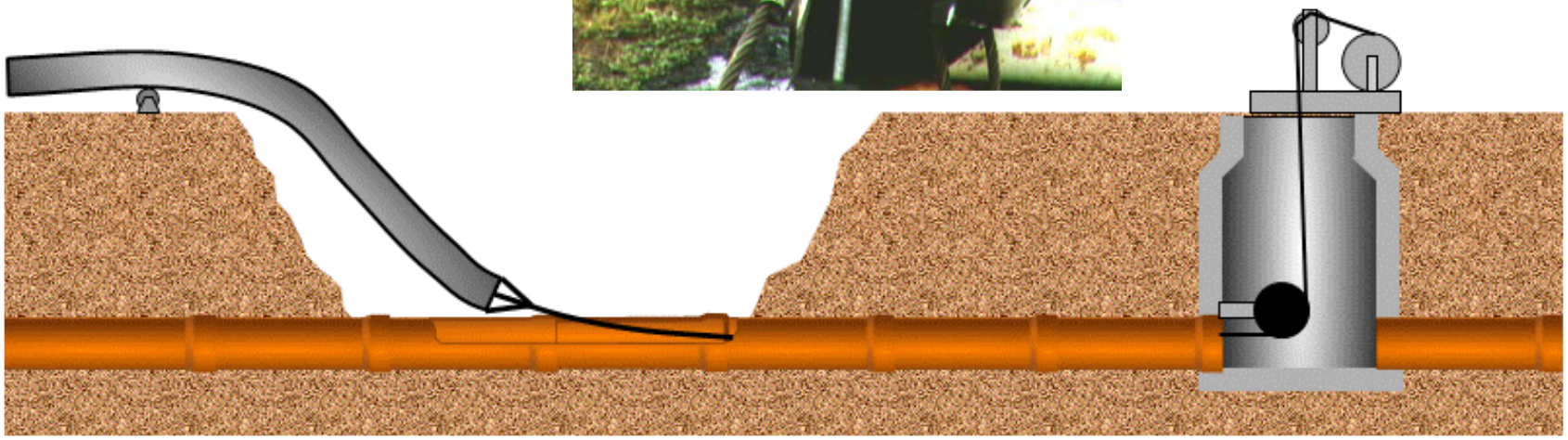
SLIPLINING

- Manhole to Manhole Rehabilitation
- Pipe Type - New
- Pipe Size – Smaller than host pipe
- Structural Support -Partial or full
- Liner Material –HDPE,PVC,CSP, Steel
- Pipe Life - 50+ years
- Site Preparation – Access pits required
- Replacement/Rehab - Cost Medium



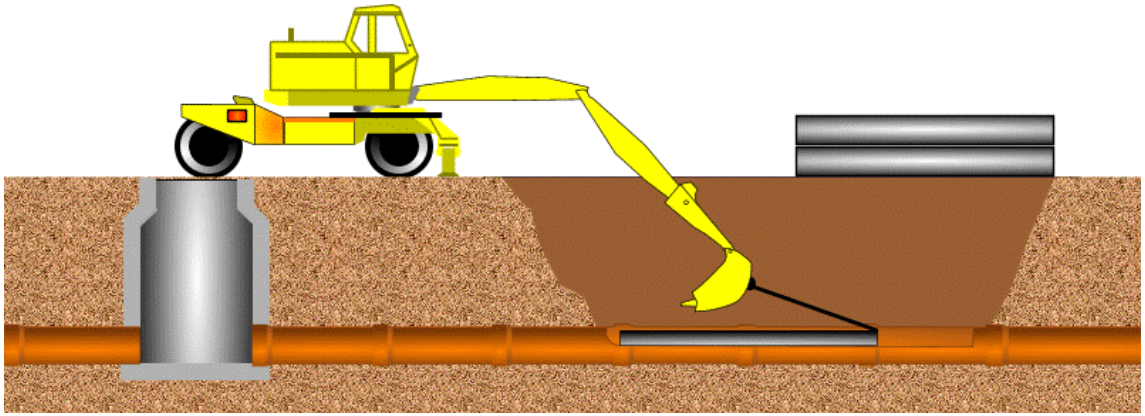
SLIPLINING - CONTINUOUS

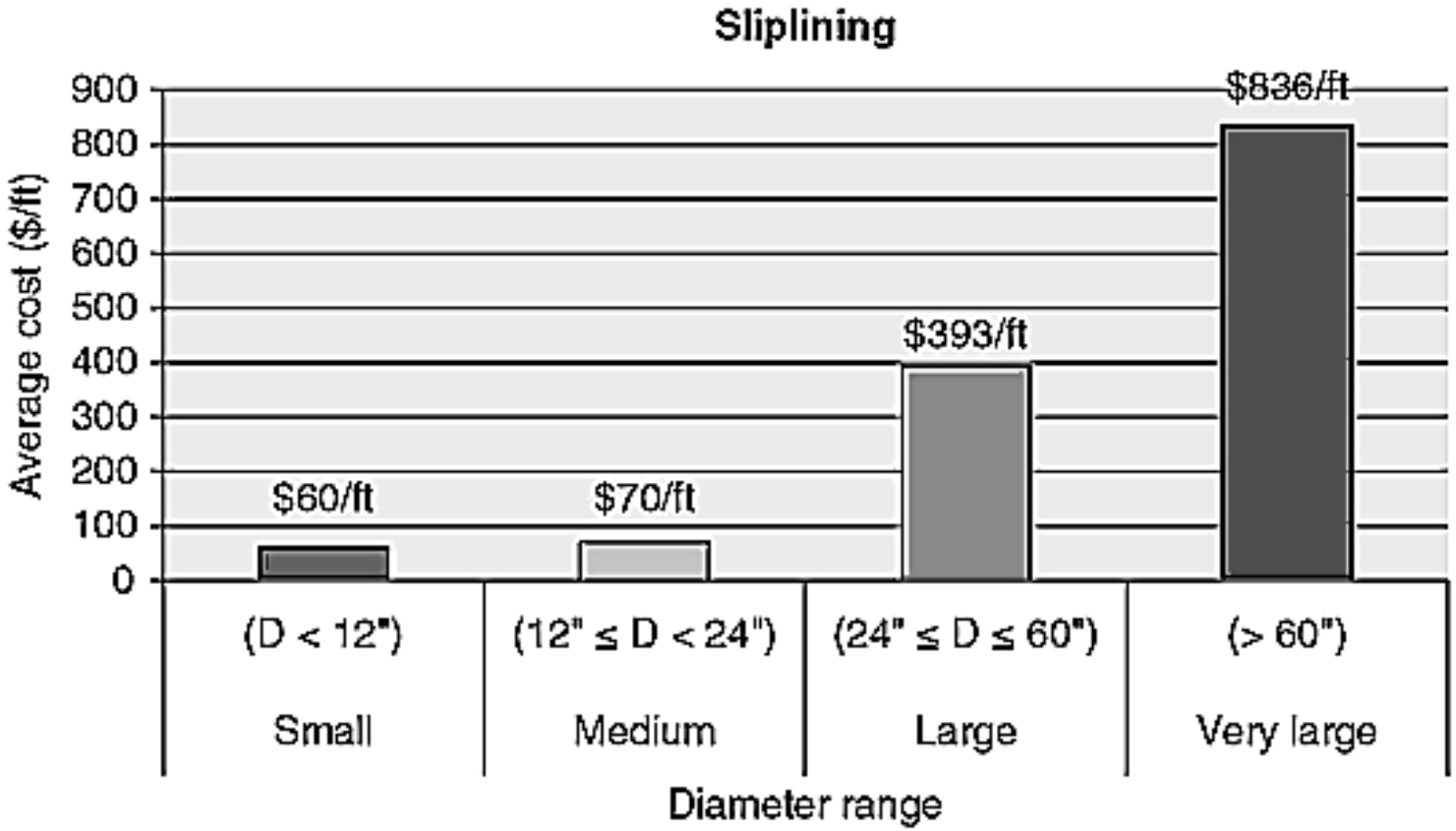




SLIPLINING- SEGMENTAL

Typically accomplished using short lengths of PVC, Composite or GRP (Typically 20 feet). Profile wall PVC is applicable to round pipe restorations while the GRP systems can accommodate round, egg, arch and elliptical shaped host piping. Bends and transitions can also be accommodated by the GRP systems.





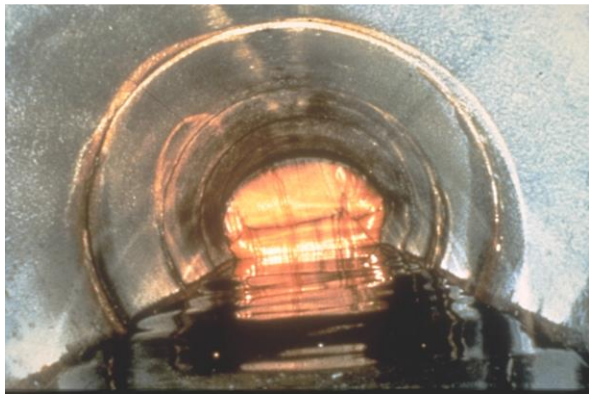
2012 Cost Data (Trenchless Technology, McGraw-Hill, Najafi & Gokhale)

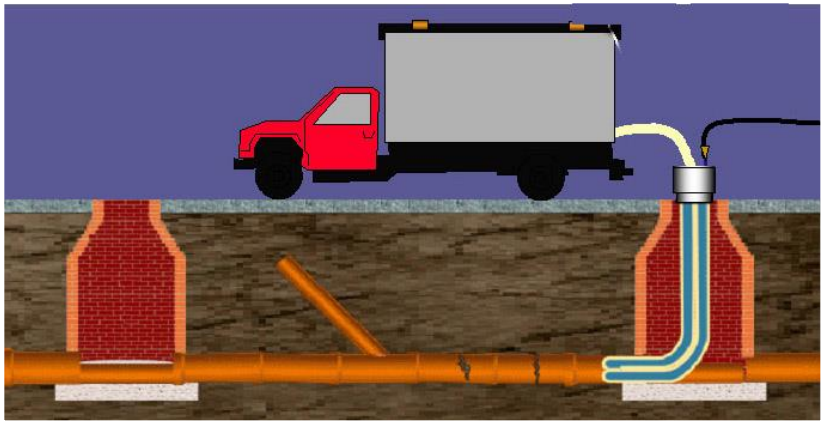
THERMOSET LINING TECHNOLOGIES (CIPP)


335

CIPP – INSTALLATION

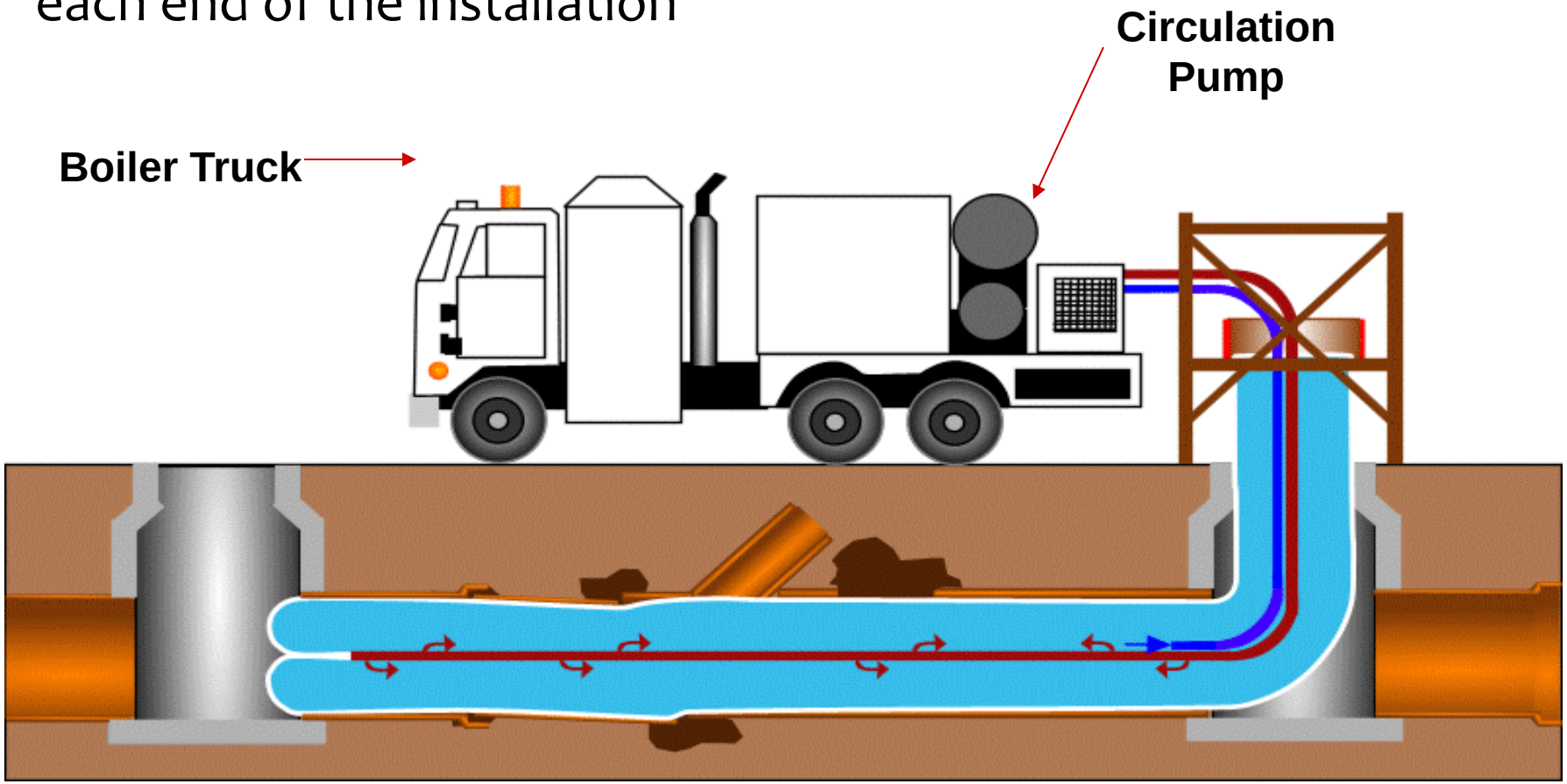
CIPP is a thermoset resin system (polyester, vinyl ester, or epoxy) that is delivered via a felt tube of the thickness specified. The resin saturated tube is installed either by directly inverting the tube into position using water; or by pulling the resin saturated tube into place and inflating the tube with a calibration hose. Once in place and properly inflated the resin system is cured.





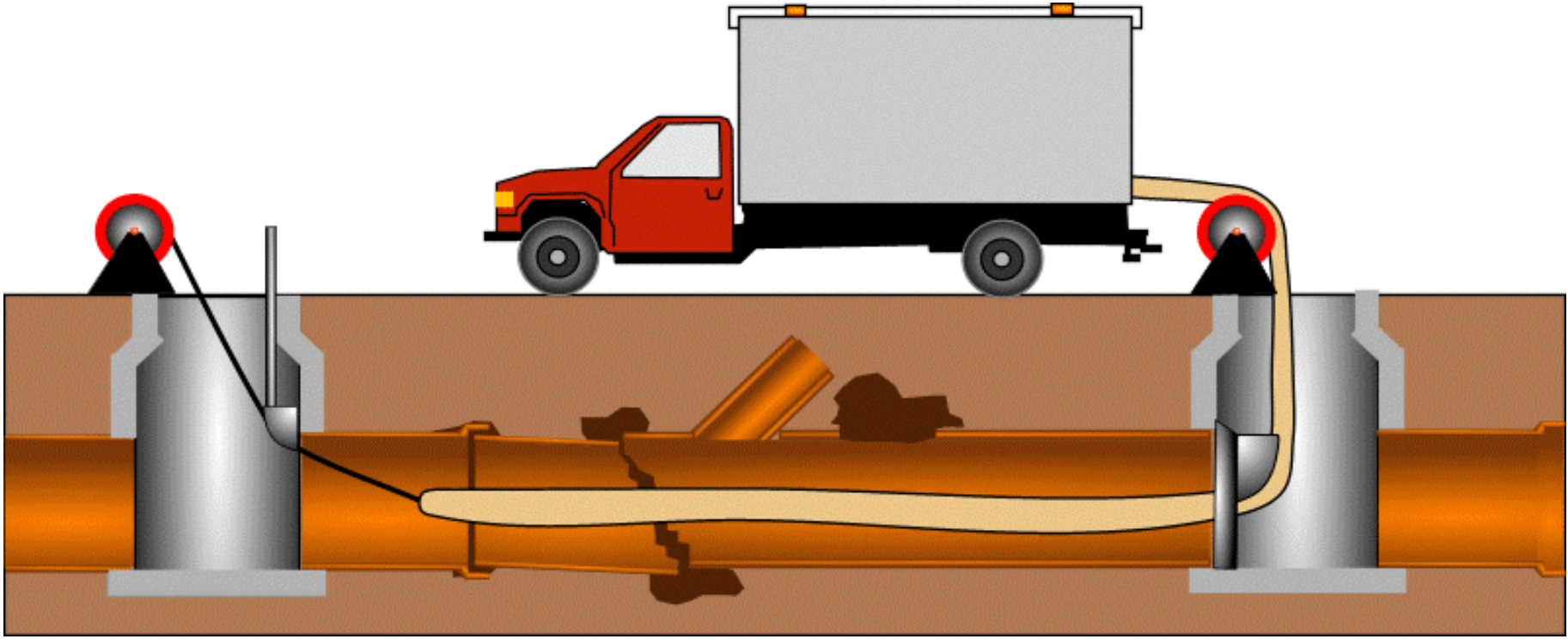
CURING WITH HOT WATER

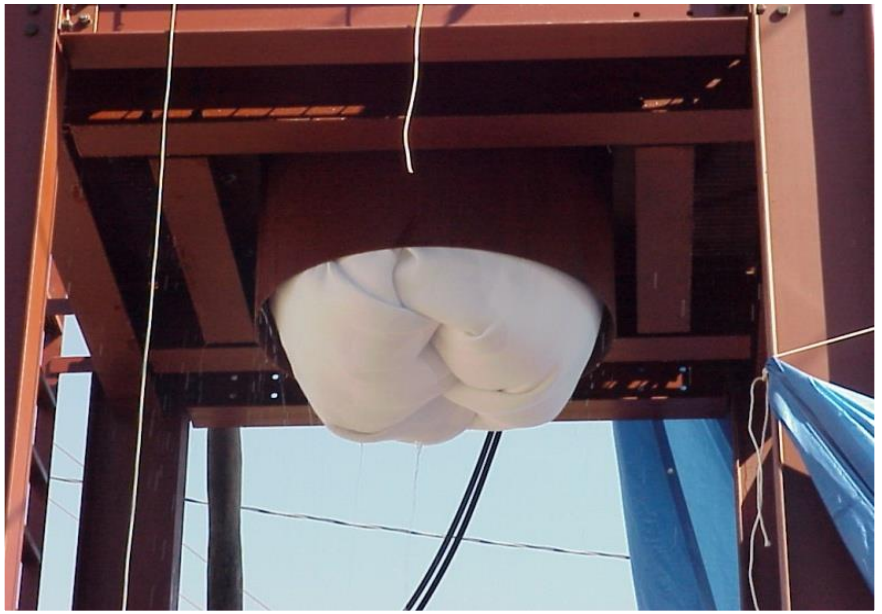
- Once in place and properly inflated, with cold water, the liner is cured by heating the water. Cure temperatures are monitored at access points and at each end of the installation

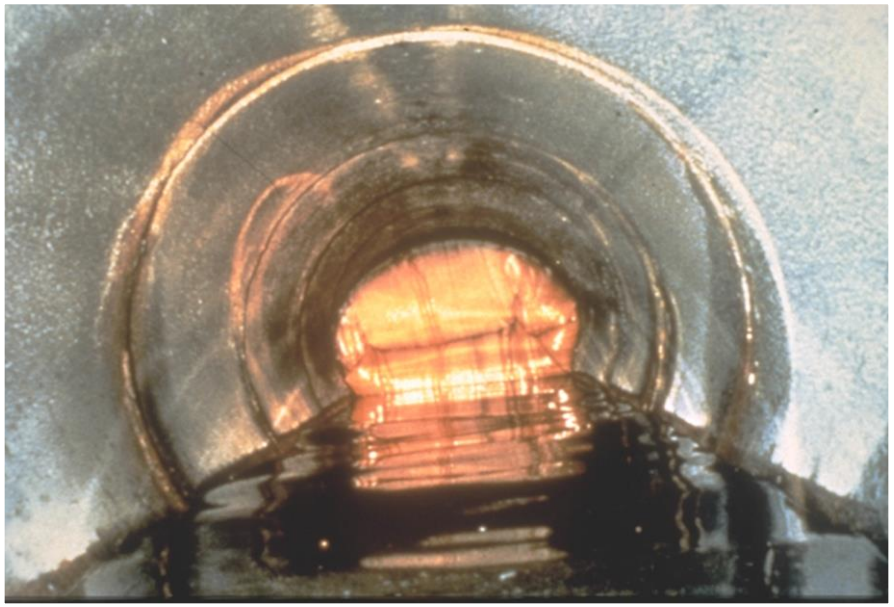


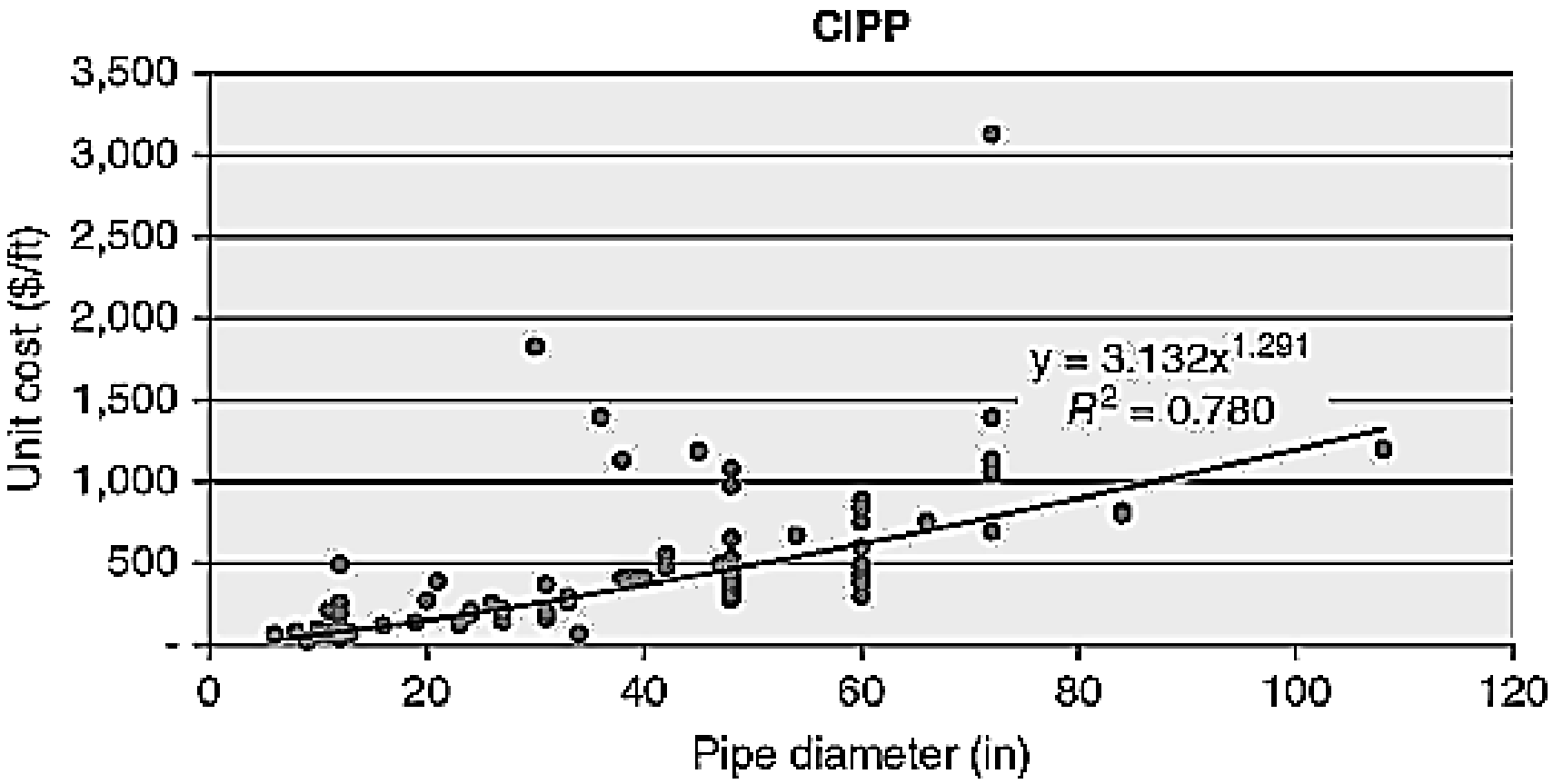
CURING WITH STEAM

Once in place and properly inflated with air the resin system is cured using steam heat. Typically the components must be an integrated system specially designed for steam curing





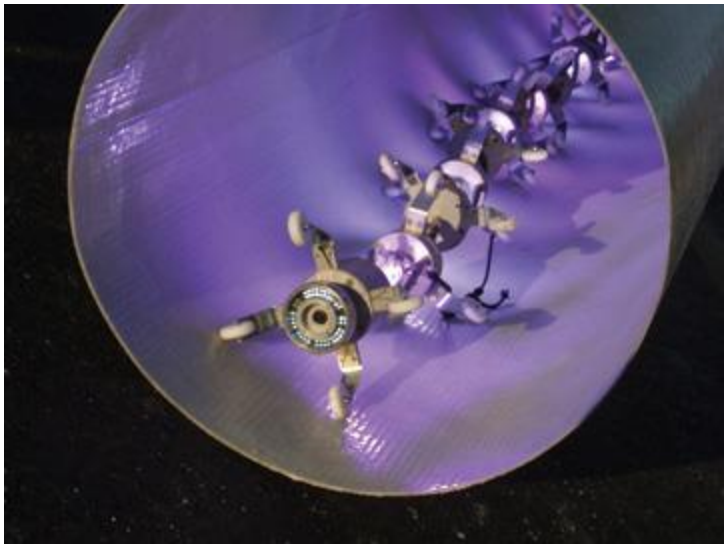




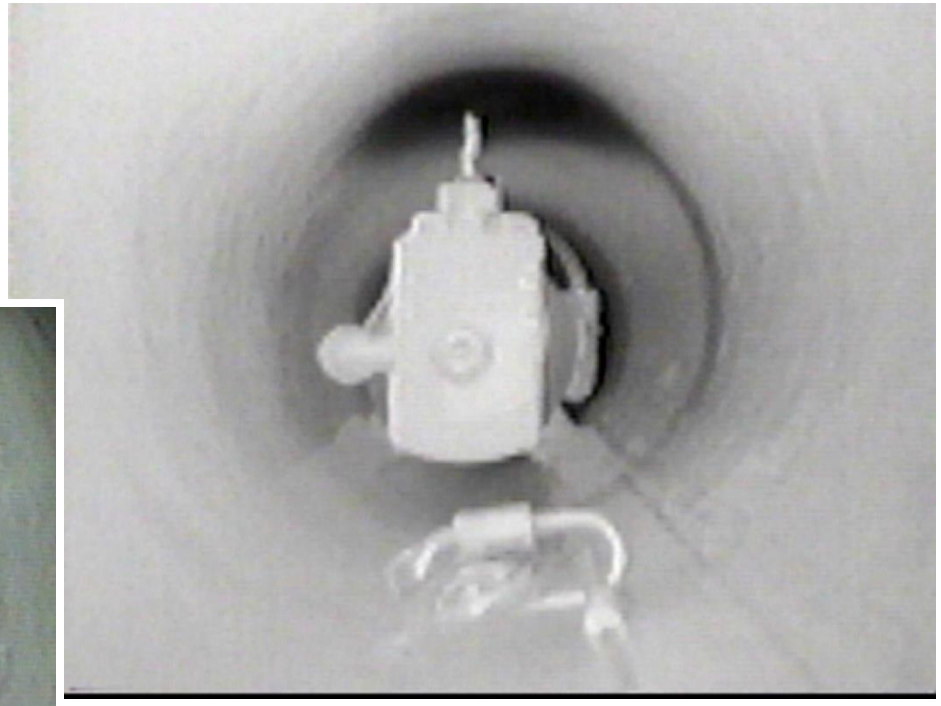
2012 Cost Data (Trenchless Technology, McGraw-Hill, Najafi & Gokhale)

UV LIGHT CURED

A fiberglass liner is usually pulled into the host pipe. A light train & CCTV is inserted in one end and pulled to the opposite end recording the pre-cure condition of the liner. The light train is then pulled back through curing the liner, at a regulated speed, with the CCTV camera recording the actual curing of the liner.



OPEN LATERALS FROM INSIDE WITH ROBOTIC CUTTERS

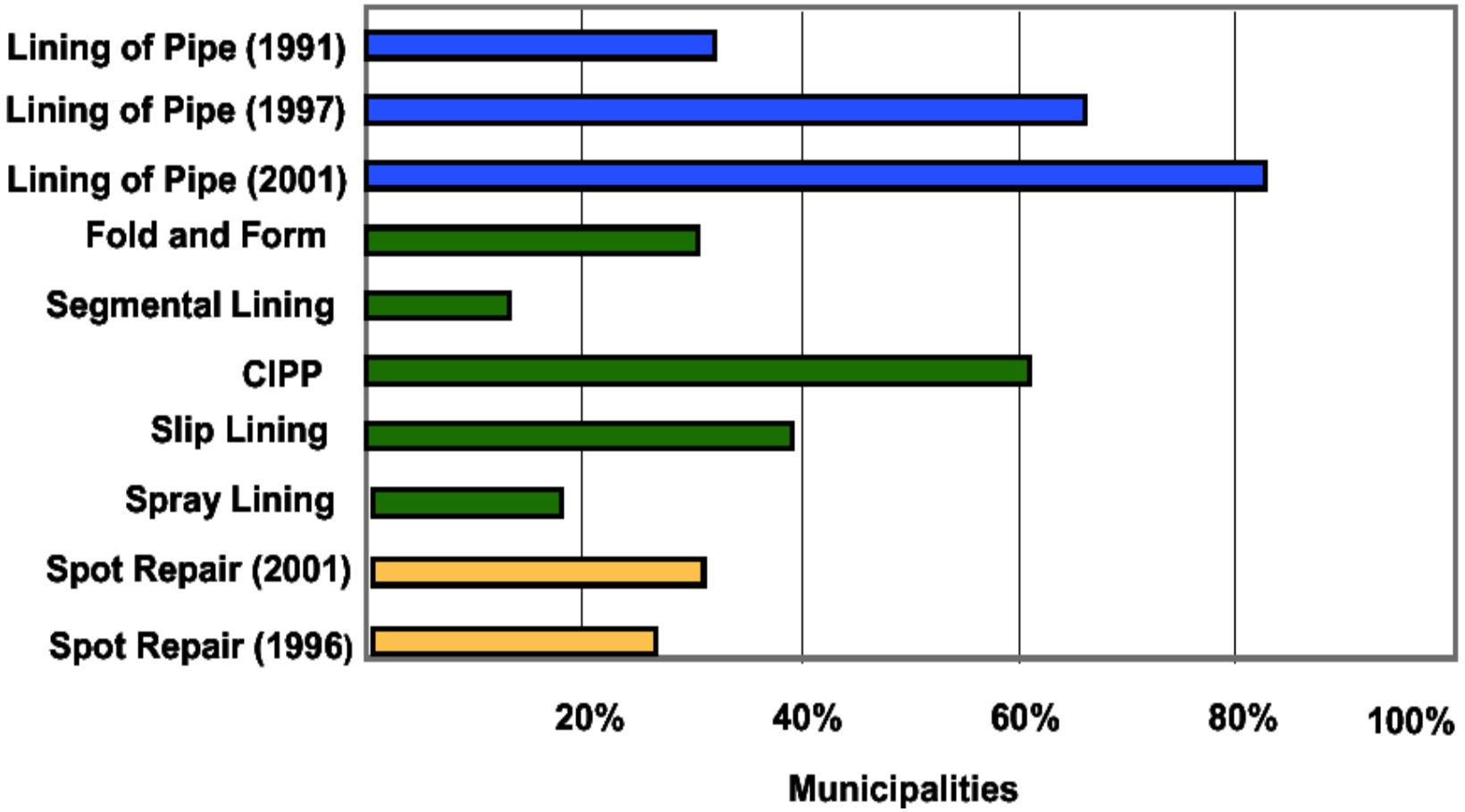


THERMOSET LINING

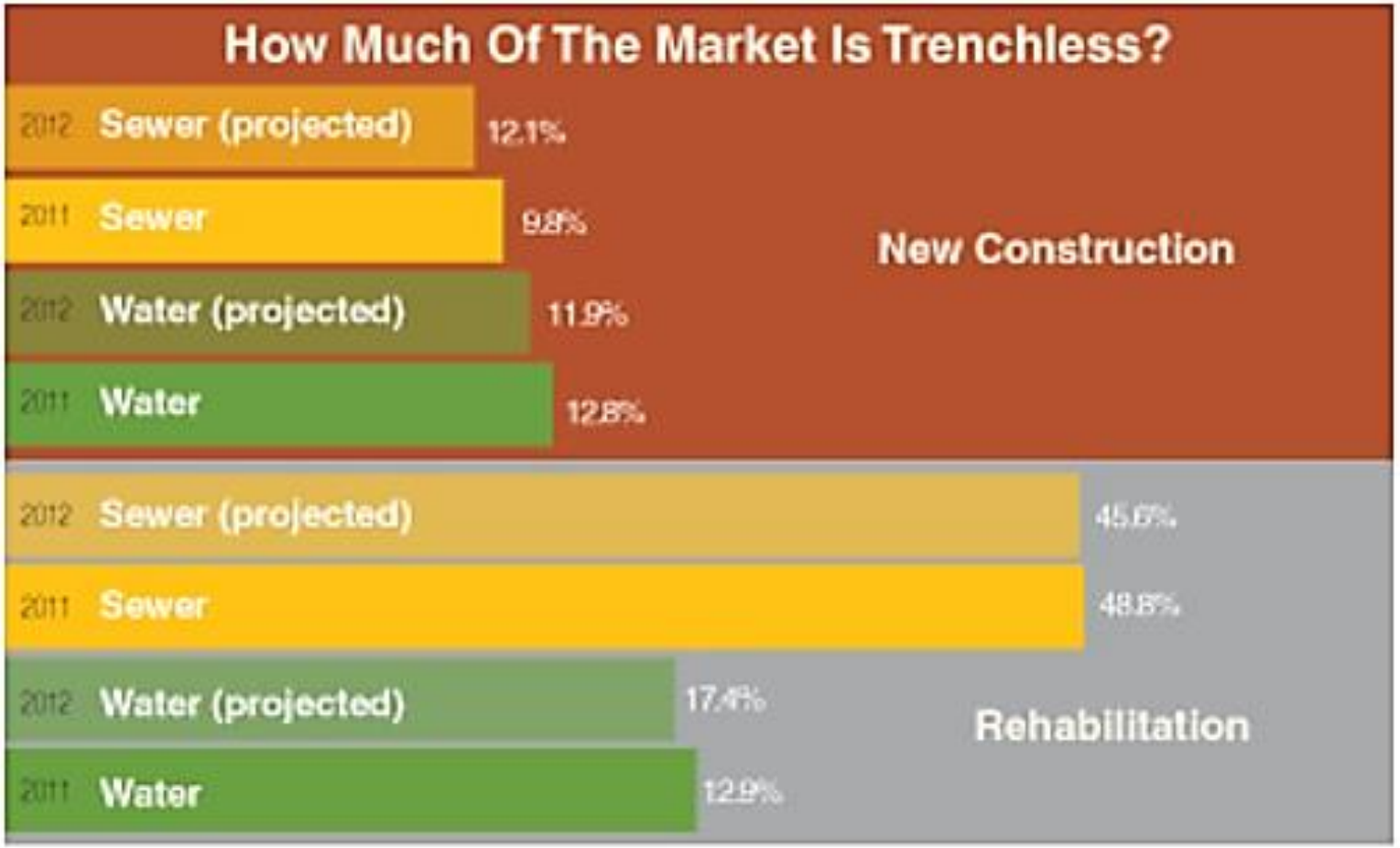
Cured in Place Pipe (CIPP)

Pipe Type - Lining
Pipe Size - Same
Pipe Life - 50+ years
Site Preparation - Typically Non-Disruptive
Replacement/Rehab Cost - Low
Social Impact - Minimum

Utilization of TT Rehab Techniques

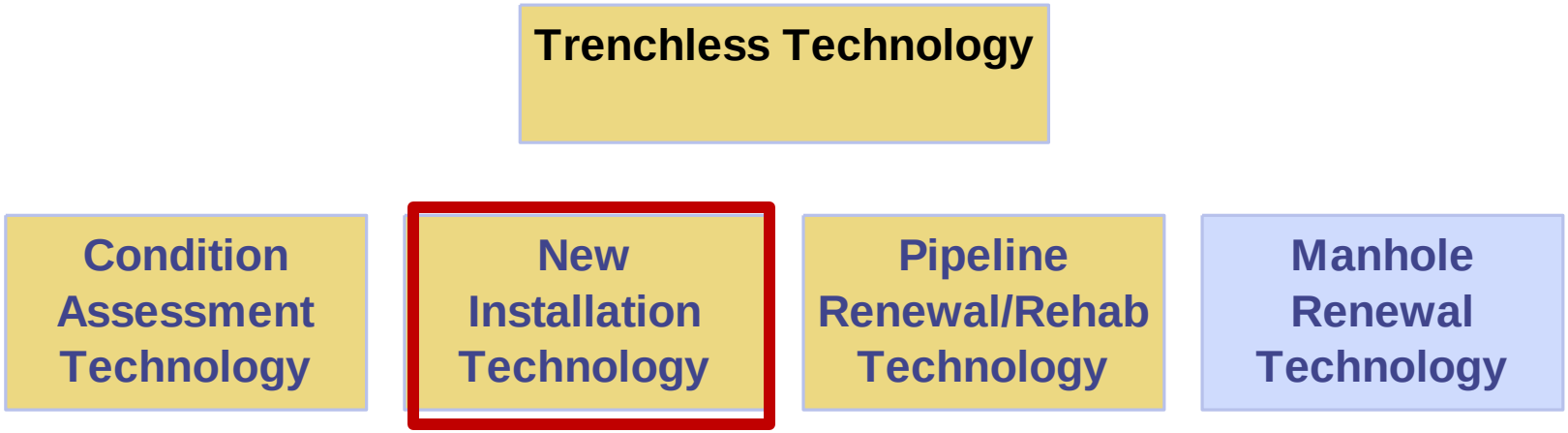


15th Annual Municipal Survey: Underground Construction
By Robert Carpenter, Editor | [February 2012, Vol. 67 No. 2]



http://www.ucononline.com/fingers-crossed-15th-annual-municipal-survey?page=4

TT Categories



New Installation Techniques

- **Non-personnel entry techniques**
  - **Auger boring (AB)**
  - ***Pipe ramming (PR)***
  - **Compaction methods (CM)**
  - ***Microtunneling (MT)***
  - ***Horizontal Directional Drilling (HDD)***
  - ***Pipebursting (PB)***

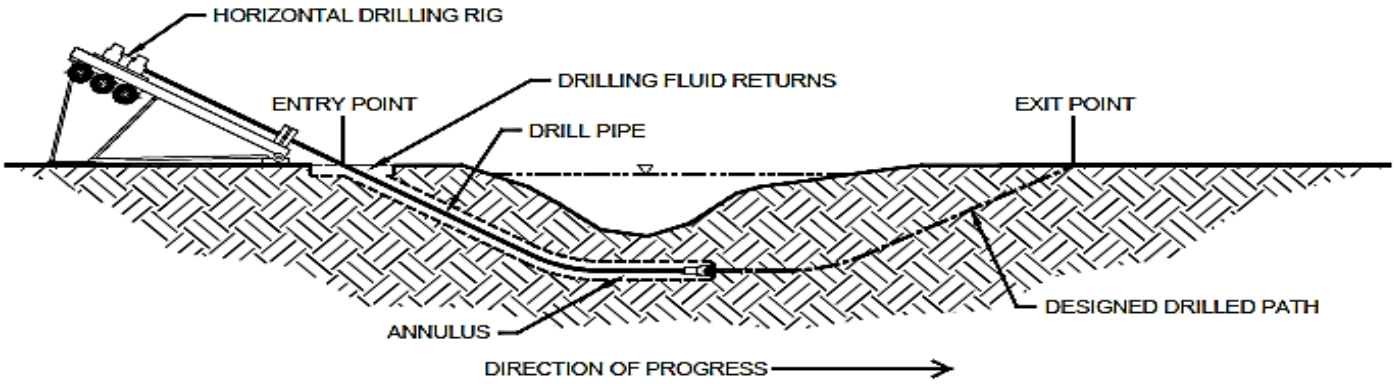
- **Personnel entry techniques**
  - **Pipe jacking (PJ)**
  - **Utility tunneling (UT)**

Horizontal Directional Drilling (HDD)

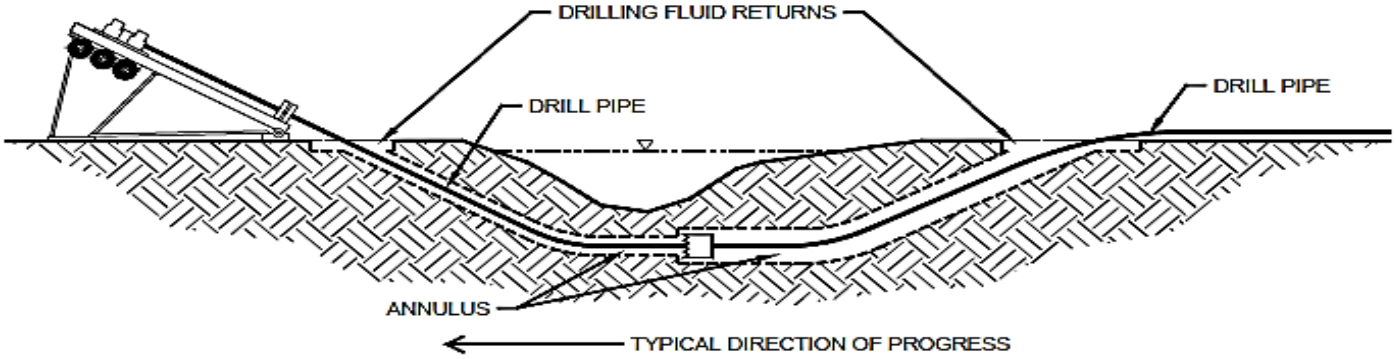
- **Horizontal Directional Drilling (HDD) is defined as: “steerable system for the installation of pipes, conduits, and cables in a shallow arc using a surface launched drilling rig”.**
- **HDD technology originated from the oil fields in the 1970s and evolved by merging technologies used in utilities and water well industries.**
- **In most cases, HDD is a three stage process.**

1. The first stage consists of directionally drilling a small diameter pilot hole along a designed directional path.
2. The second stage involves enlarging this pilot hole to a diameter suitable for installation of the pipeline.
3. The third stage consists of pulling the pipeline back into the enlarged hole.

PILOT HOLE



PREREAMING



PULLBACK

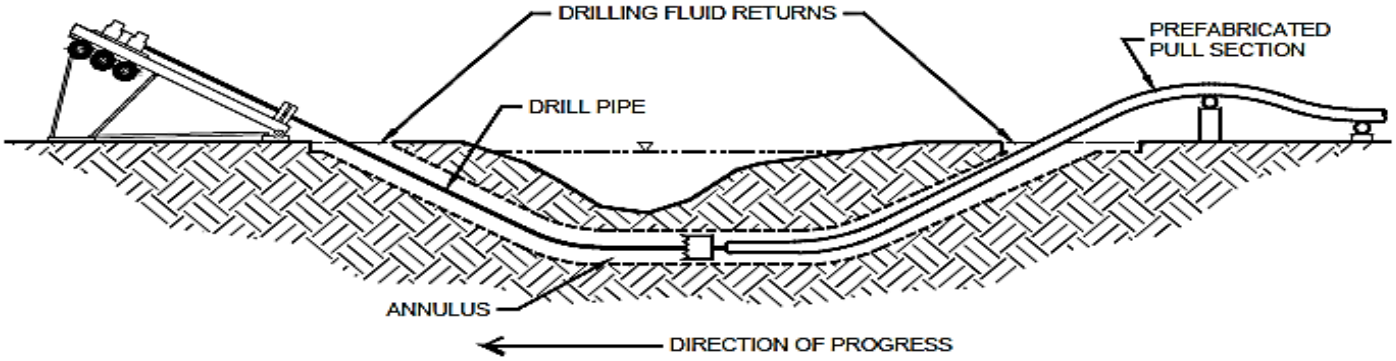
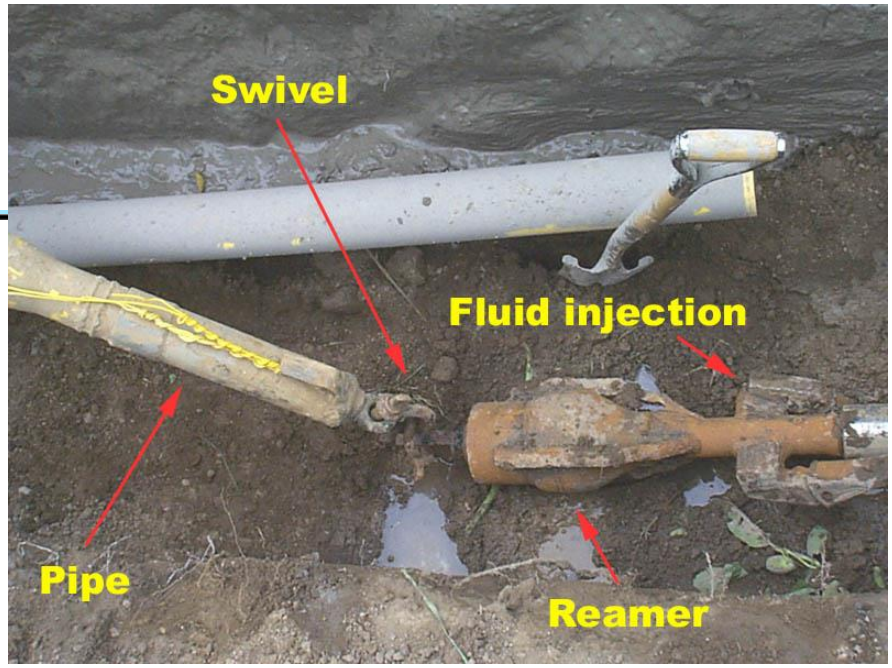


Table 2.1 Comparison of main features of typical HDD methods (Iseley and Gokhale 1997)

Type	Diameter	Depth	Drive Length	Torque	Thrust/ Pullback	Machine Weight	Typical Application
Maxi	600-1,200 mm (24-48 in)	≤ 61 m (200 ft)	≤ 1800 m (6000 ft)	≤ 108.5 KN-m (80,000 ft-lb)	≤ 445 KN (100,000 lb)	≤ 30 ton (267 KN)	River, Highway crossings
Midi	300-600 mm (12-24 in)	≤ 23 m (75 ft)	≤ 270 m (900 ft)	1-9.5 KN-m (900-7000 ft-lb)	89-445 KN (20,000-100,000 lb)	≤ 18 ton (160 KN)	Under rivers and roadways
Mini	50-300 mm (2-12 in)	≤ 4.5 m (15 ft)	≤ 600 ft (180 m)	≤ 1.3 KN-m (950 ft-lb)	≤ 89 KN (20,000 lb)	≤ 9 ton (80 KN)	Telecom and Power cables, and Gas lines


Drilling Rig


Swivel
Fluid injection
Pipe
Reamer


Tracking receiver

Drilling fluids perform several important functions. They cool and lubricate the drill bit, stem and other down hole tools.

The fluid also assists in sealing the sides of the bore, therefore stabilizing the borehole.

Finally, drilling fluids are designed to carry the cuttings out of the hole.

A good drilling fluid should provide all of these functions. The most widely used drilling fluids for HDD applications are based on bentonite.

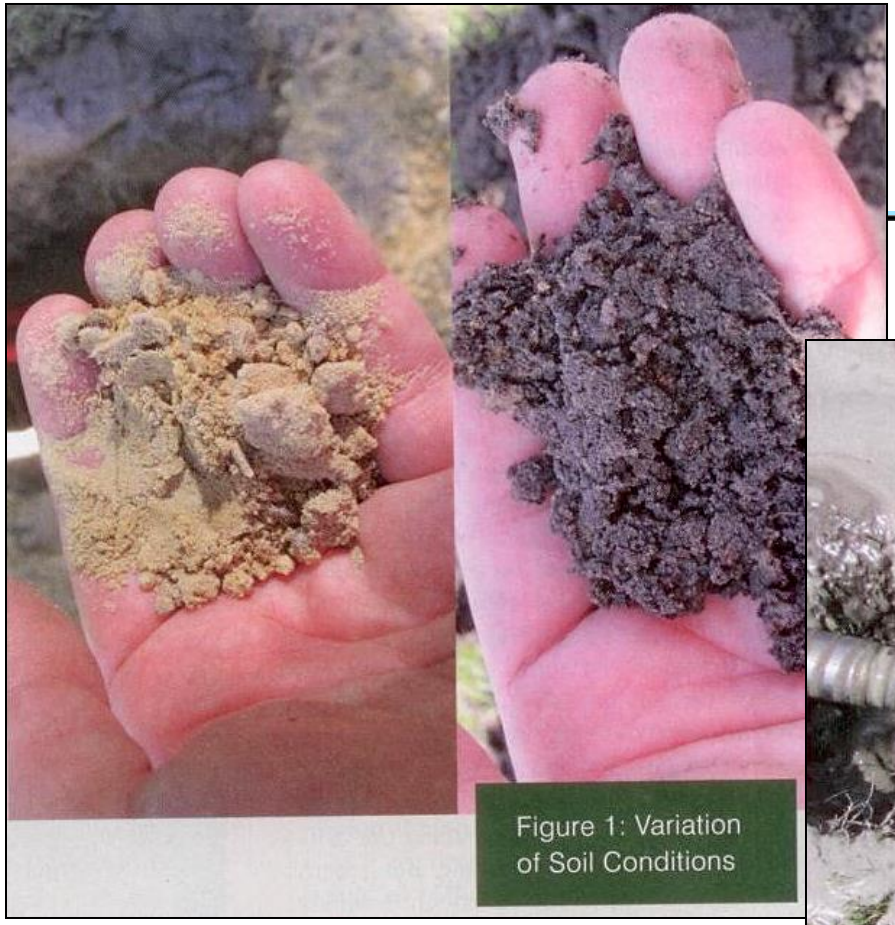


Figure 1: Variation of Soil Conditions

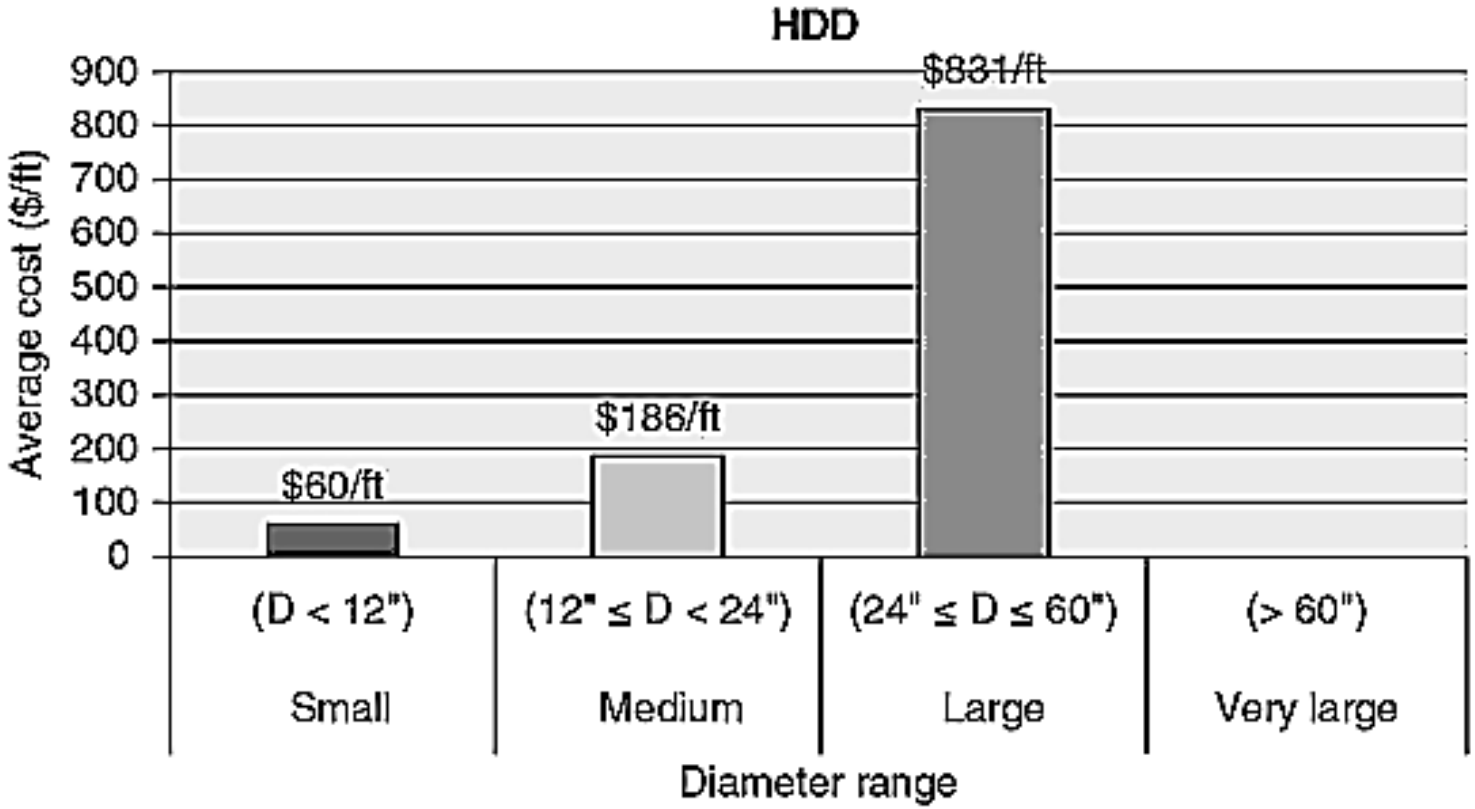
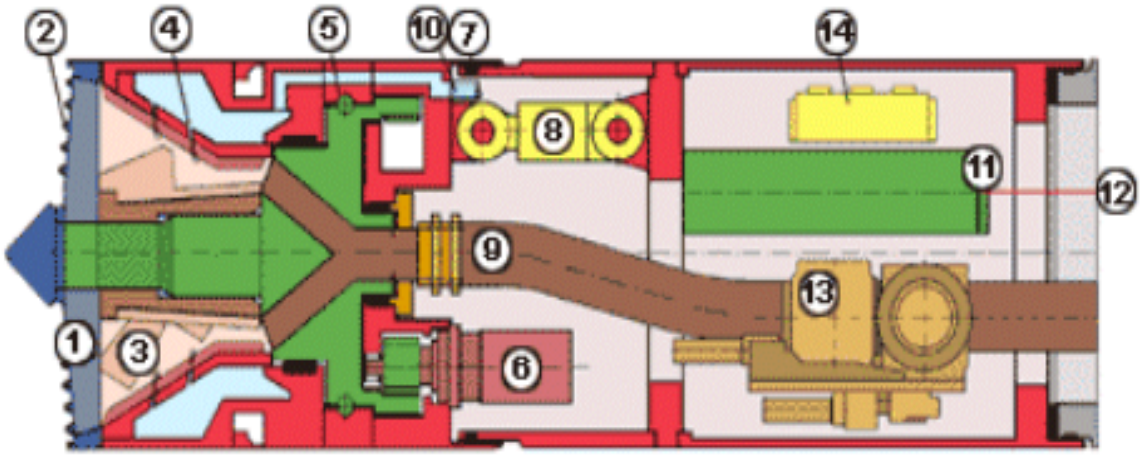


Figure 1.7 Average cost of HDD trenchless method classified by diameter ranges.

2012 Cost Data (Trenchless Technology, McGraw-Hill, Najafi & Gokhale)

Micro Tunneling (MT)

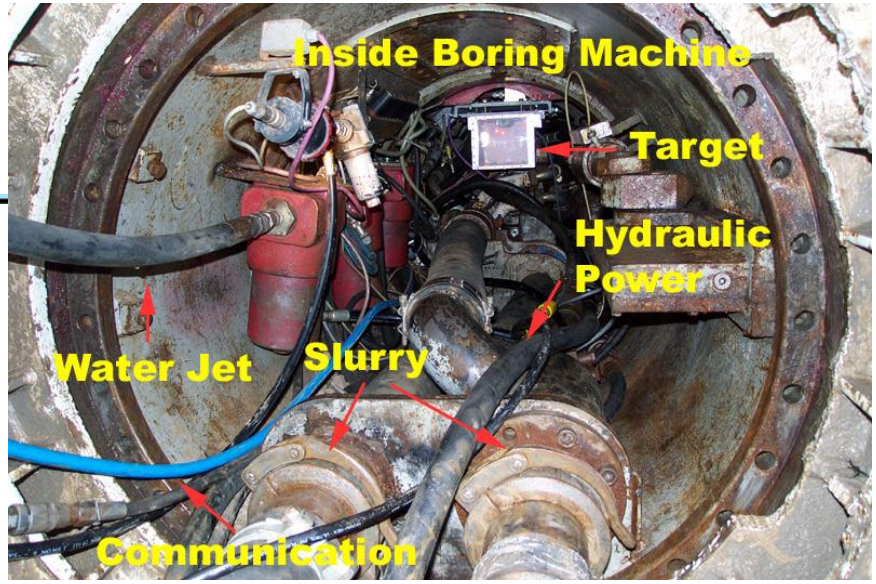
- **MT is defined as “a remotely controlled and guided pipe jacking technique that provides continuous support to the excavation face and does not require personnel entry into the tunnel .”**
- **The MTBM is operated from a control panel, normally located on the surface.**
- **The system simultaneously installs pipe as soil is excavated and removed.**
- **Personal entry is not required for routine operation.**
- **The guidance system uses a laser beam projected onto a target in the MTBM, capable of installing gravity sewers or other types of pipelines to within ± 25 mm of line and grade.**



1. Cutting wheel
2. Extraction tool
3. Crusher space
4. Nozzles
5. Main bearing
6. Rotation drive
7. Shield articulation seal
8. Steering cylinder
9. Conveyor pipe
10. Supply pipe
11. ELS target
12. Laser beam
13. Bypass
14. Valve block

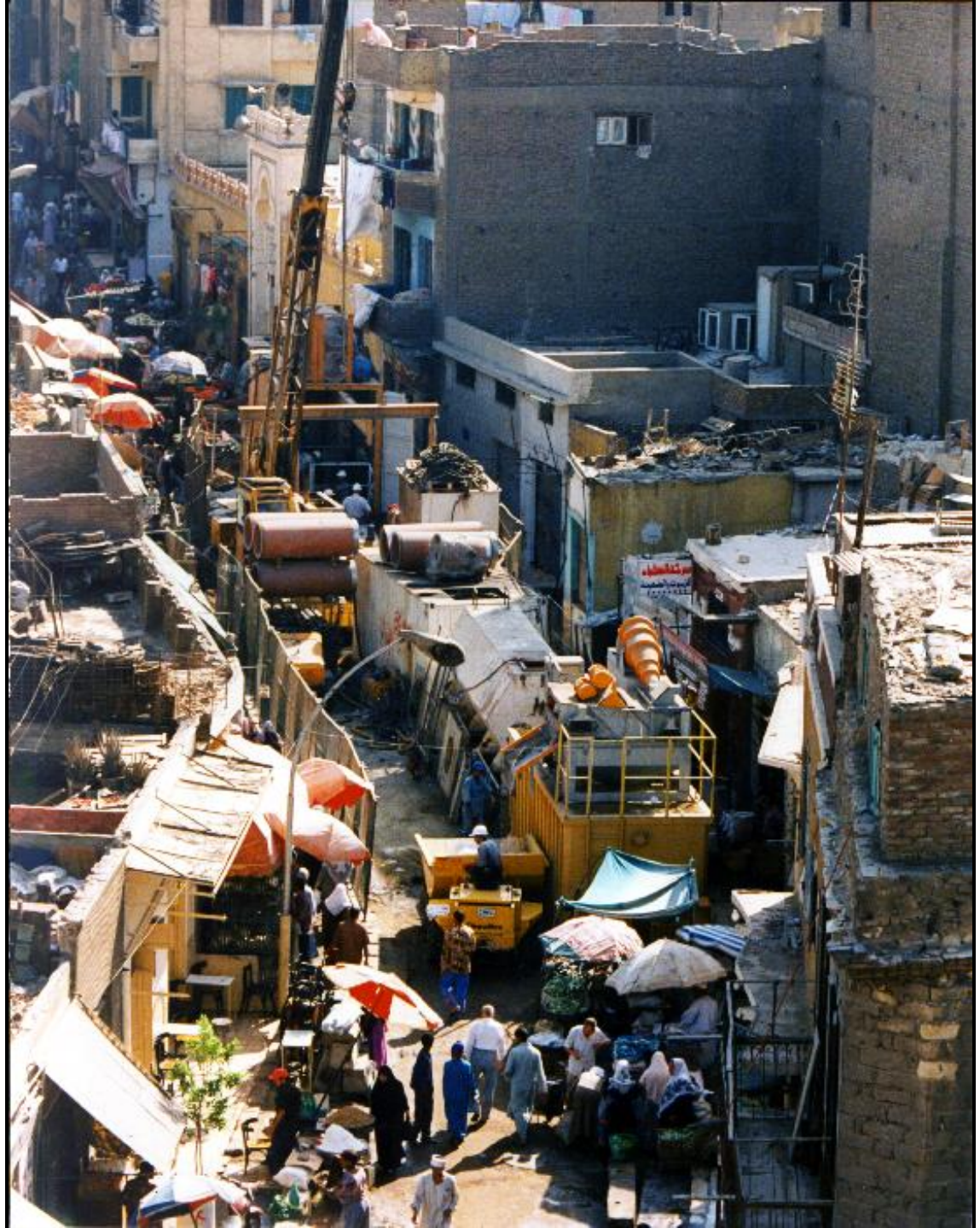
Typical slurry type MTBM (Herrenknecht Inc.)


Microtunneling Boring Machine
Cutting Head
Second Segment


Inside Boring Machine
Target
Hydraulic Power
Water Jet
Slurry
Communication


Laser

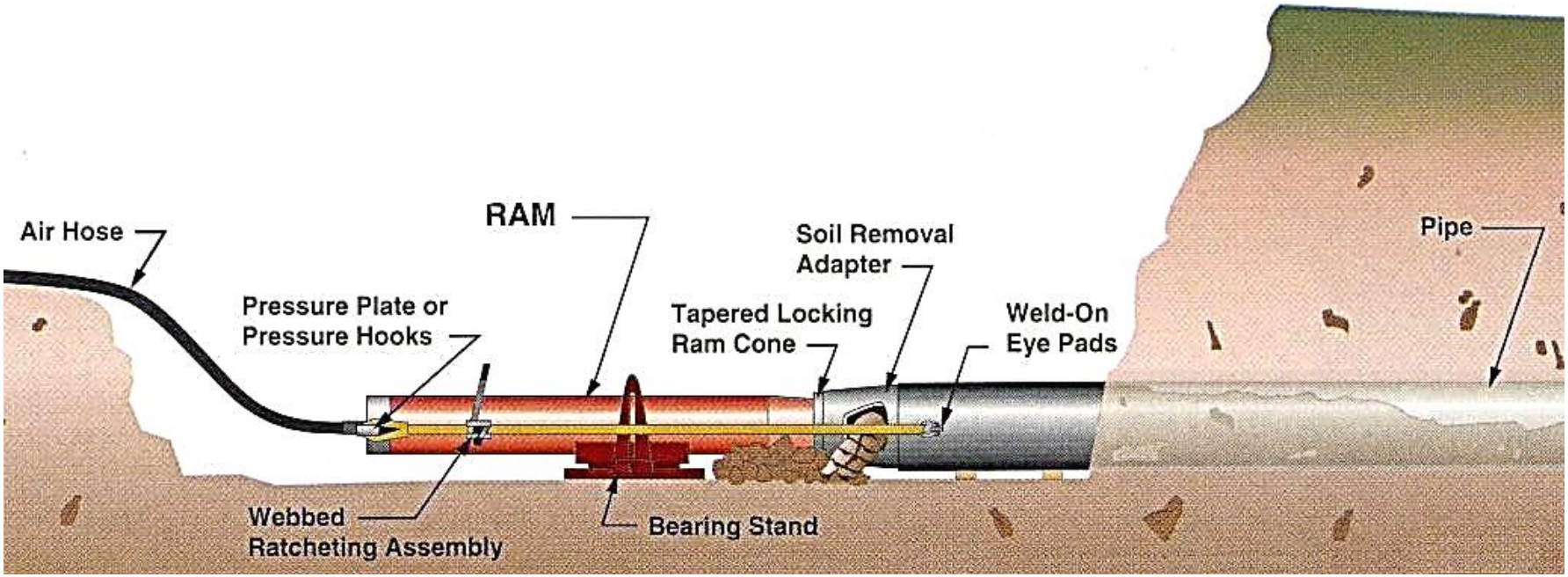
The logistics of handling and launching the microtunnelling machines in Hong Kong's narrow yet very busy streets was not an easy problem to overcome



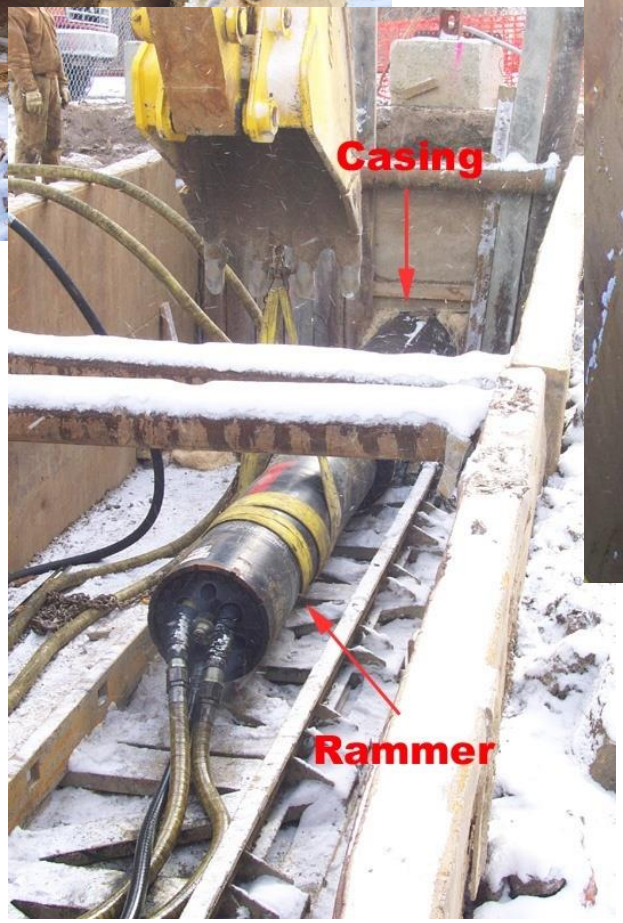
Pipe Ramming (PR)

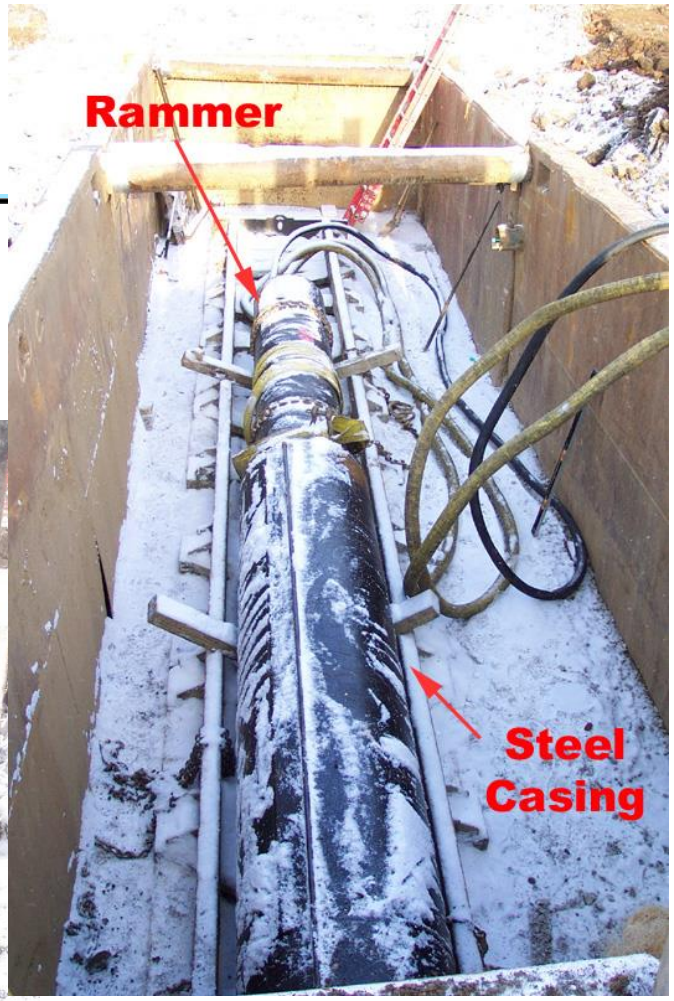
- **Pipe ramming (PR) involves using the dynamic force and energy transmitted by a percussion hammer attached to the end of the pipe.**
- **The basic procedure consists of ramming a steel pipe through the soil by using a device, generally air powered, attached to the end of the pipe.**
- **Pipe ramming permits the installation of larger casings in a wide range of soil conditions.**
- **It provides continuous casing support during the drive with no over excavation.**

Open Faced Pipe Ramming




Casings
Augers


Casing
Rammer


Rammer
Steel
Casing

Pipe Bursting (PB)

- **Pipe bursting was first developed in the United Kingdom in late 1970's**
- **PB is a pipe replacement method for the deteriorated and undersized gas, water or sewer pipelines.**
- **The existing pipes are replaced size-for-size or up-sized with a new pipe in the same location**
- **The bursting head, one of the major components of pipe bursting operation, bursts or splits the existing pipelines and pushes broken fragments into surrounding soil while simultaneously pulling a new pipeline.**

PIPE BURSTING

- Pipe Type – New
- Pipe Size - Same or larger
- Pipe Life - 100+ years
- Site Preparation - Moderately Disruptive
- Replacement/Rehab – Cost Medium
- Social Impact - Moderate

PIPE BURSTING

Existing pipeline is fractured and expanded internally of the replacement pipeline.

Existing pipe upsizing of up to 25% is routine, upsizing between 25% and 50% can be challenging and moderately difficult.

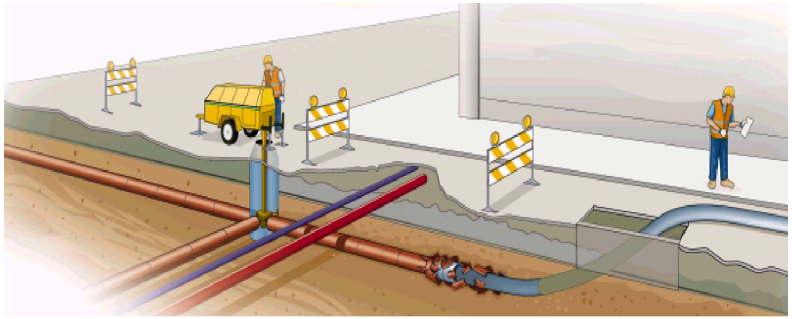
TYPES OF BURSTING SYSTEMS

Mainline

Pneumatic Systems

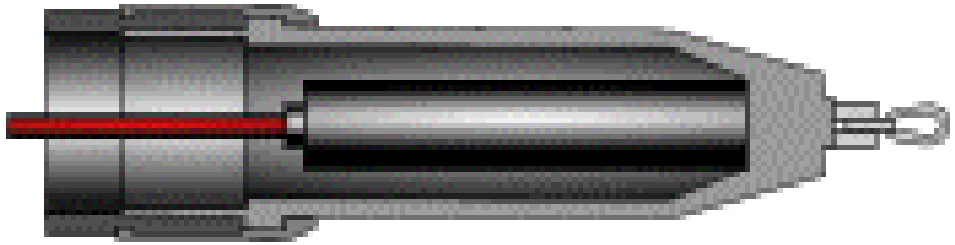
Static Systems

Hydraulic Systems

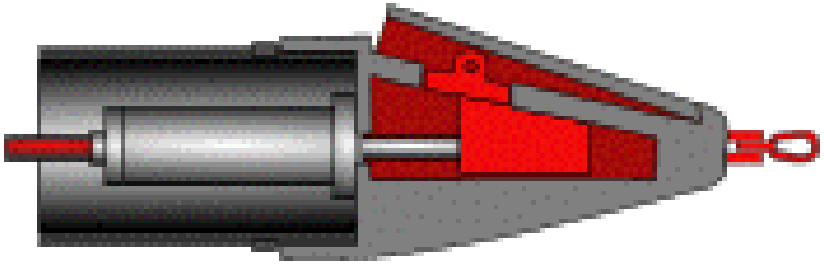


Lateral

Small portable systems



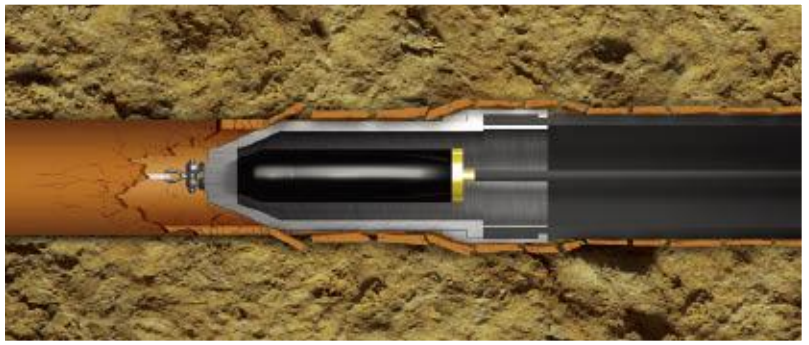
Pneumatic Head



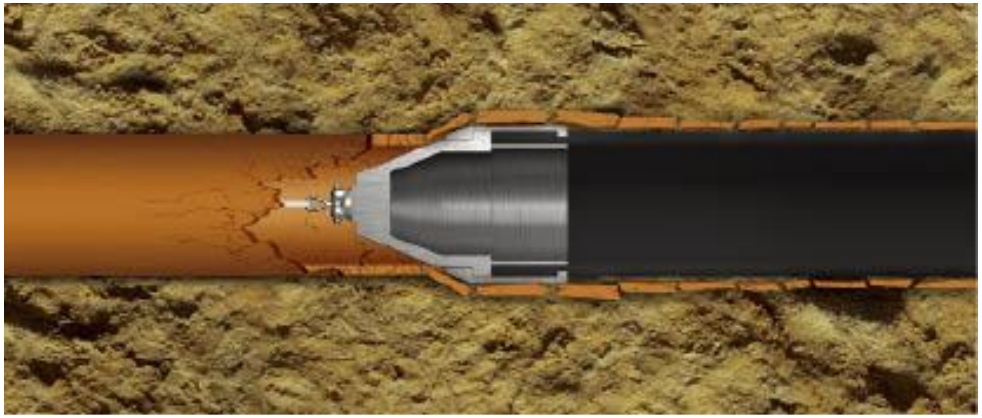
Hydraulic Head

PNEUMATIC PIPE BURSTING

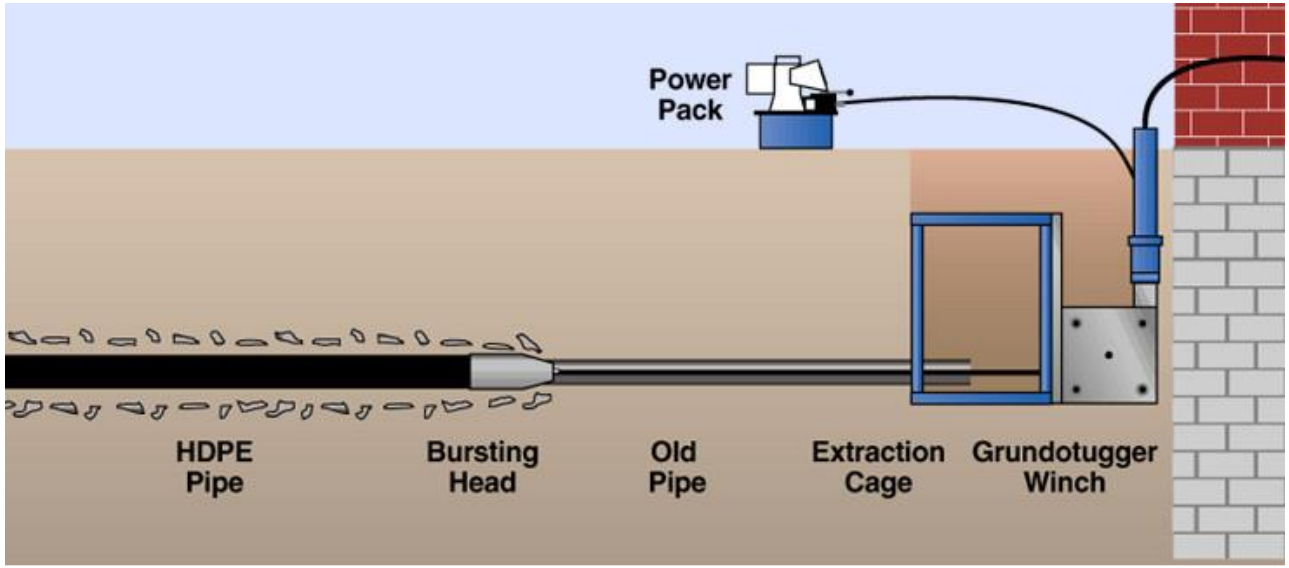
The primary principal in pneumatic pipe bursting systems is percussion. Force is applied by a reciprocating hammer action which is activated by compressed air delivered by a hose that passes through the new pipe being pulled in. This system is ideal for heavily consolidated soils but is less efficient in running sands.



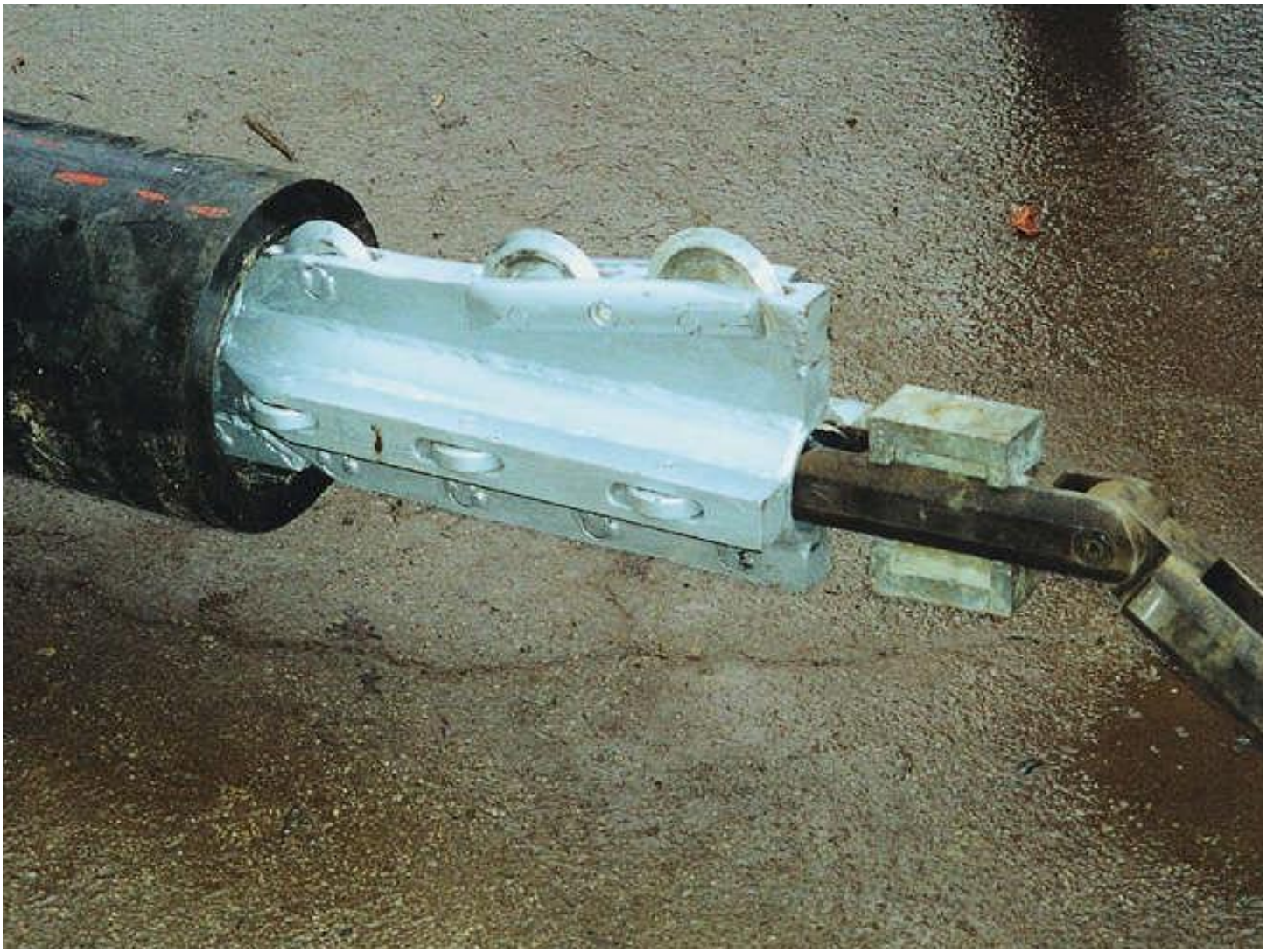
STATIC PIPE BURSTING

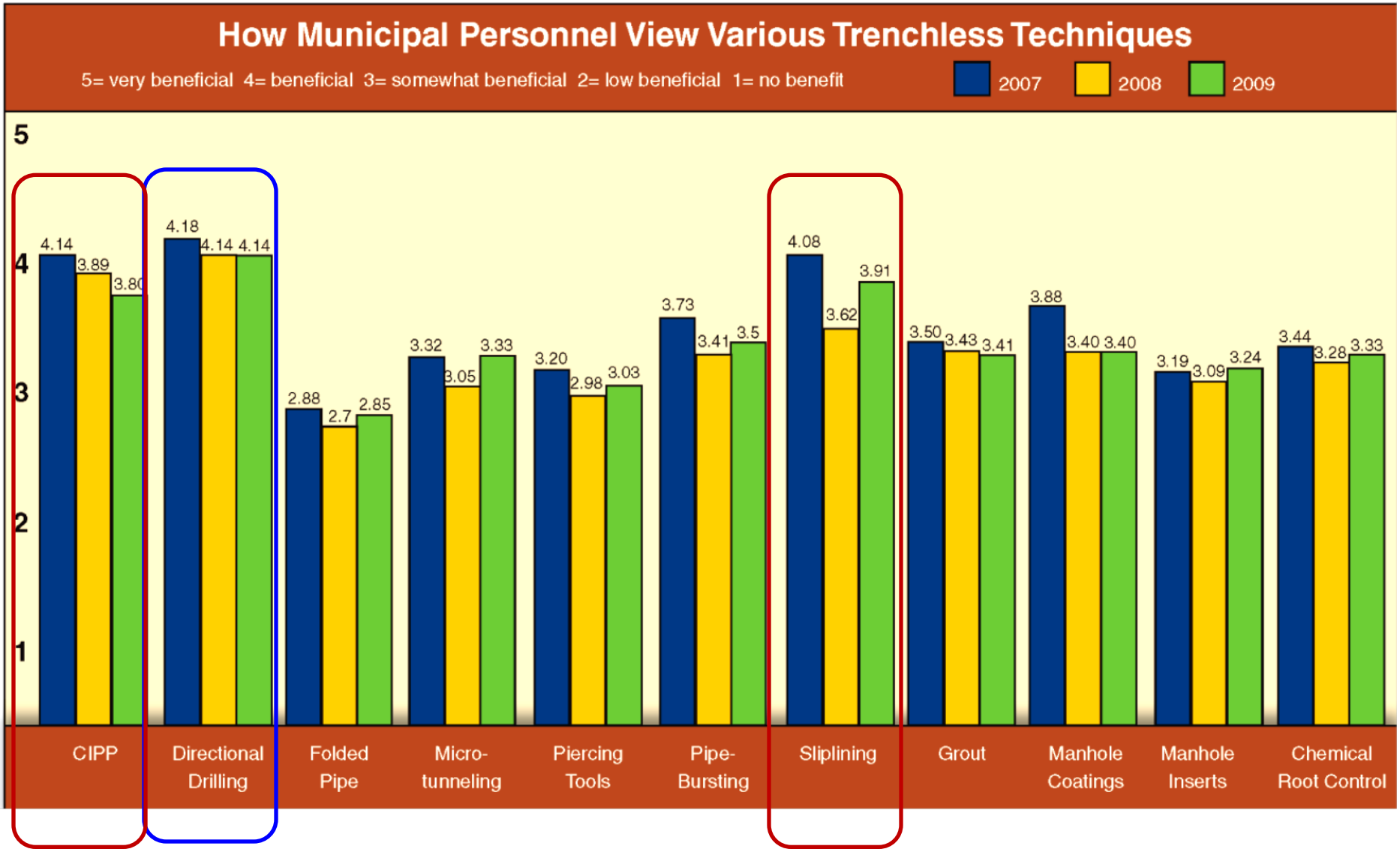


LATERAL BURSTING SYSTEMS



PIPE SPLITTING





http://undergroundconstructionmagazine.com/exclusive-underground-construction%E2%80%99s-12th-annual-municipal-survey-year-hope-and-caution?page=5

CONCLUSIONS

- **“Trenchless” pipeline rehabilitation technologies are not magic pills, merely tools in the arsenal of designers and operators, when used properly can provide effective solutions.**

- **Projects must be evaluated, good engineering practice applied and the ”correct” technology selected to achieve desired results.**

Thank You

2013 Annual Building Inspection Engineering

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