

# Integrating Lessons Learned in Specifications Development

Track IV – Pressure Pipe

January 28, 2020

Matthew Coleman, City of Toronto

Paul Pasko, SEH



# PRESENTATION OVERVIEW:

## 1) **Replace? Repair? Rehab?**

Making Effective Renewal Decisions

## 2) **Developing a Water Main Lining Project**

Design Criteria

Defining Project Scope

Servicing

Bidder Proof

Community Impacts

QA/QC Recommendations

## 3) **Lessons Learned**

ROW/Easements

What Ifs?

Approval Agency

Ongoing Maintenance

Independent lab testing of material properties

Mitigating Future Failures

# Why do we need watermain rehabilitation?



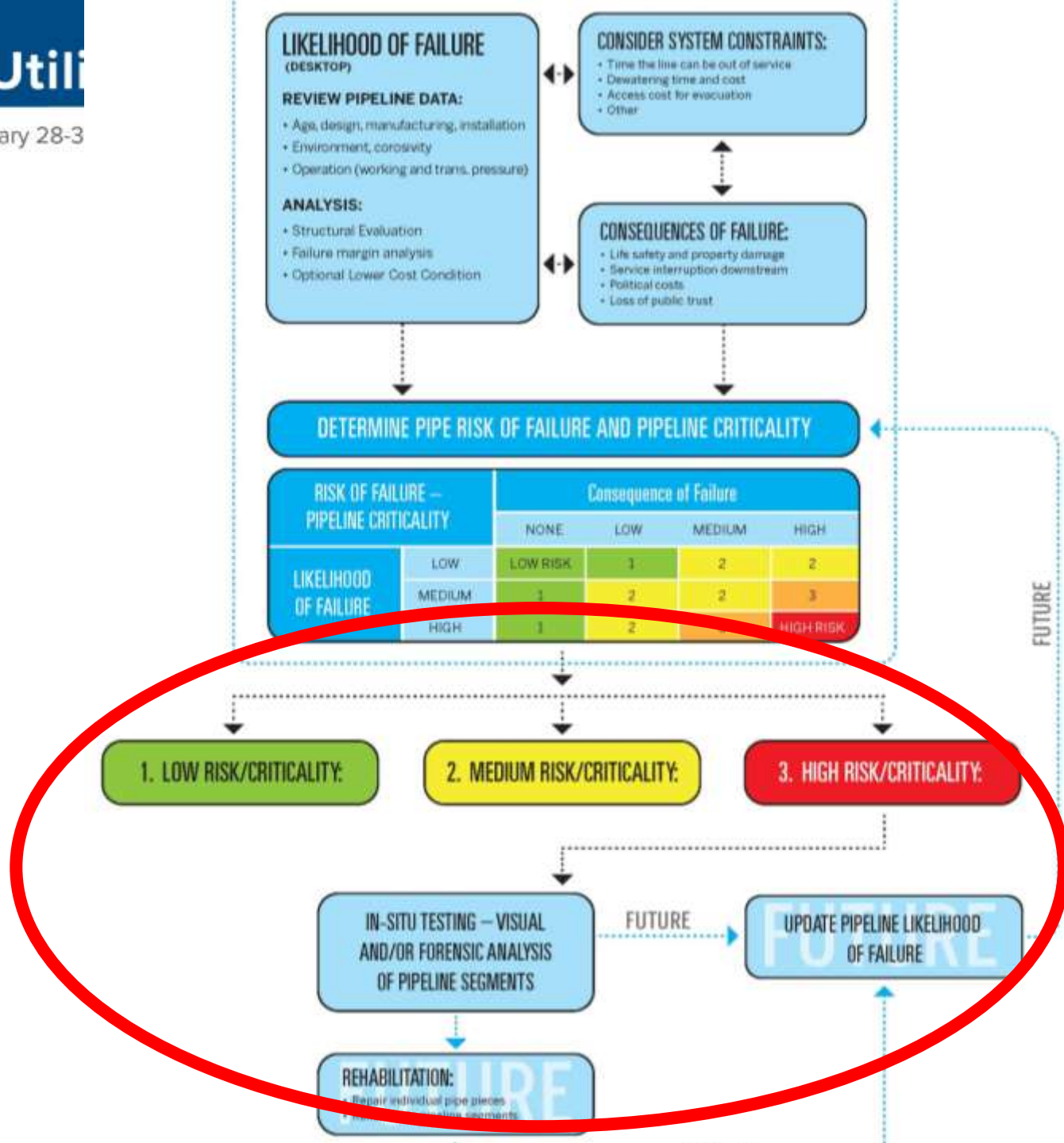
## DETERMINE CORE RISK:

*Probability X  
Consequence*

- Maintain Asset Data
- Build Rating Criteria
- Prioritize on Risk
- Alternatives Analysis

Invest in your  
**CRITICAL ASSETS**

Maximize ratio of  
**RISK REDUCED / COST**



# Traditional Measurement of Pressure Pipe Condition

## Direct

- Visual inspection (CCTV or manned entry)
- Sampling
- Nondestructive testing
- Age and material

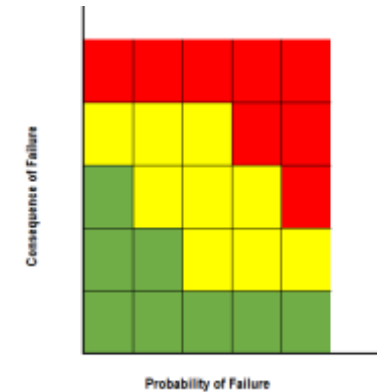
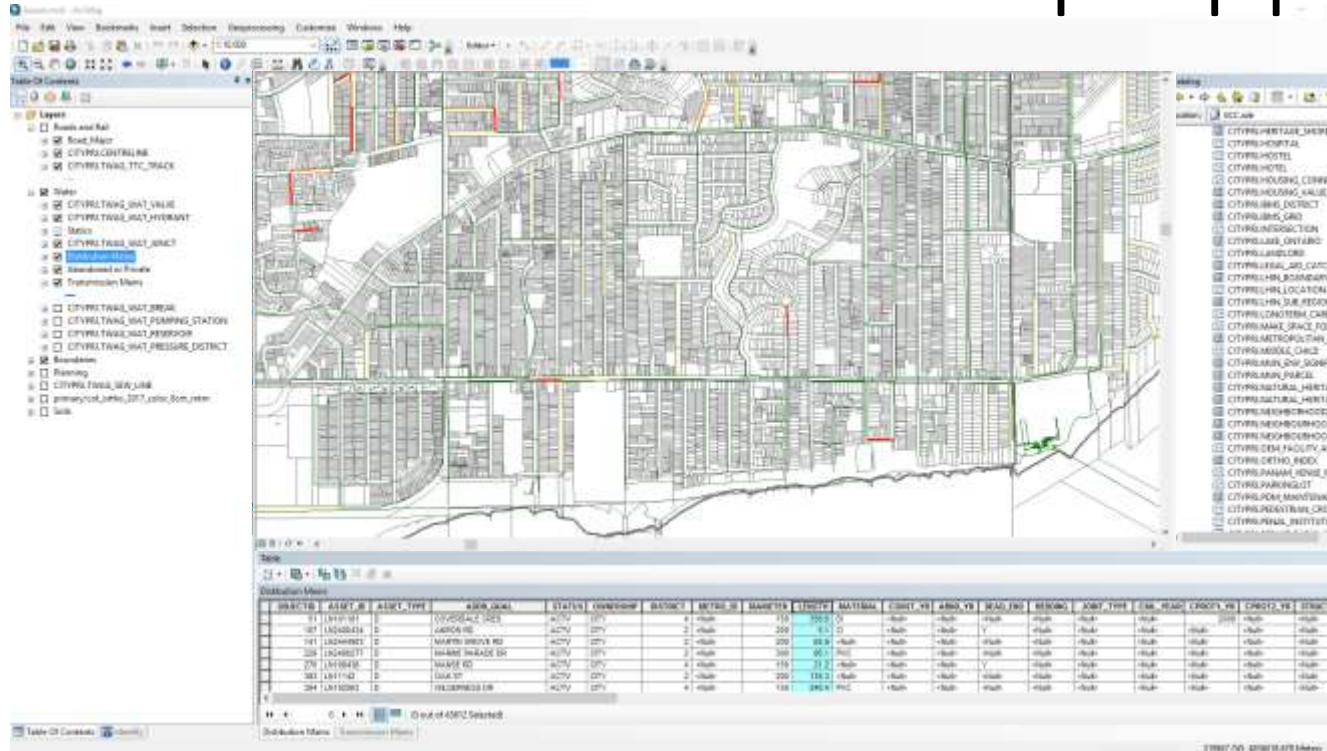
## Indirect

- Failure history
- Leakage level
- Flow testing
- Soil resistivity





# Toronto Water: Desktop Approach



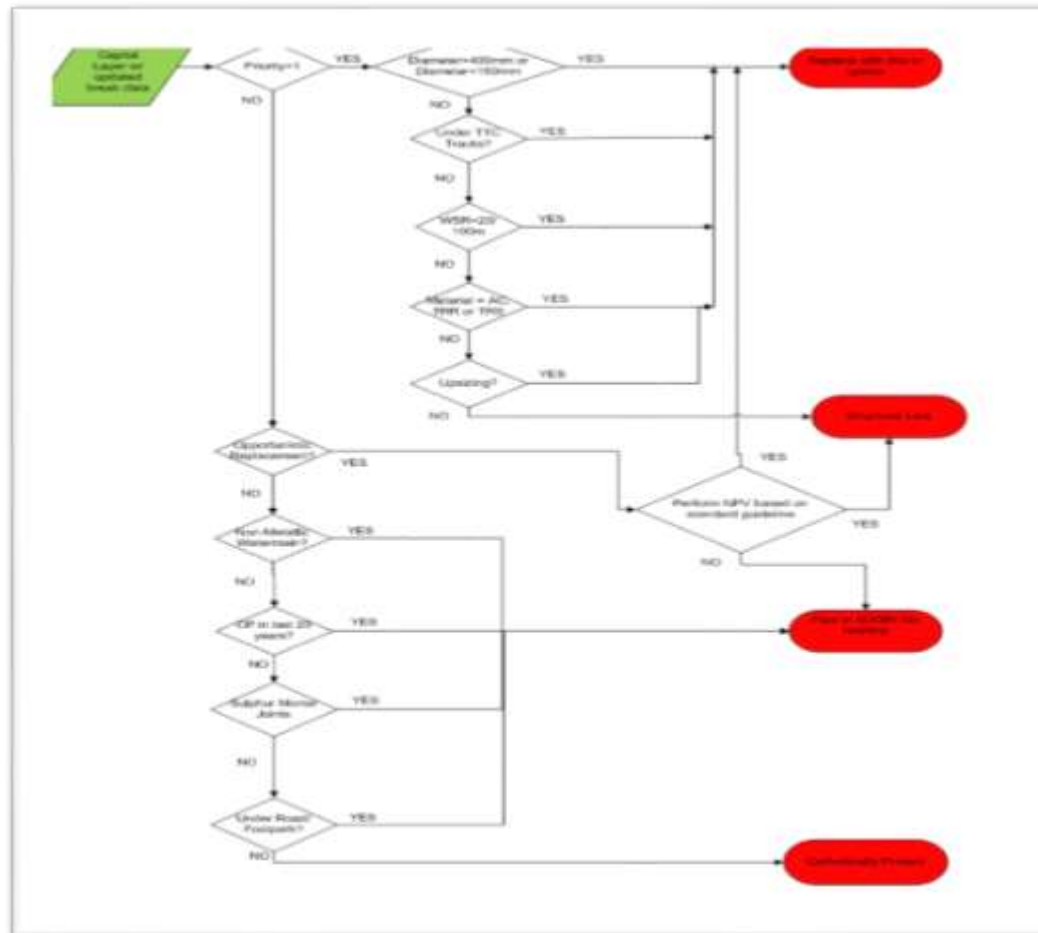
## Replace? Repair? Rehab?

... Effective Renewal Decisions





# Replace vs Reline vs Slipline



## SQL Query on GIS

"OWNERSHIP" = 'CITY' AND "STATUS" = 'ACTV'  
 AND "CONST\_YR" < 2000 AND "WS\_PER\_100"  
 < 0.1 AND "DIAMETER" > 149 AND  
 "DIAMETER" <= 400 AND "MATERIAL" <> 'AC'  
 AND "MATERIAL" <> 'TRR' AND P\_Priority > 1

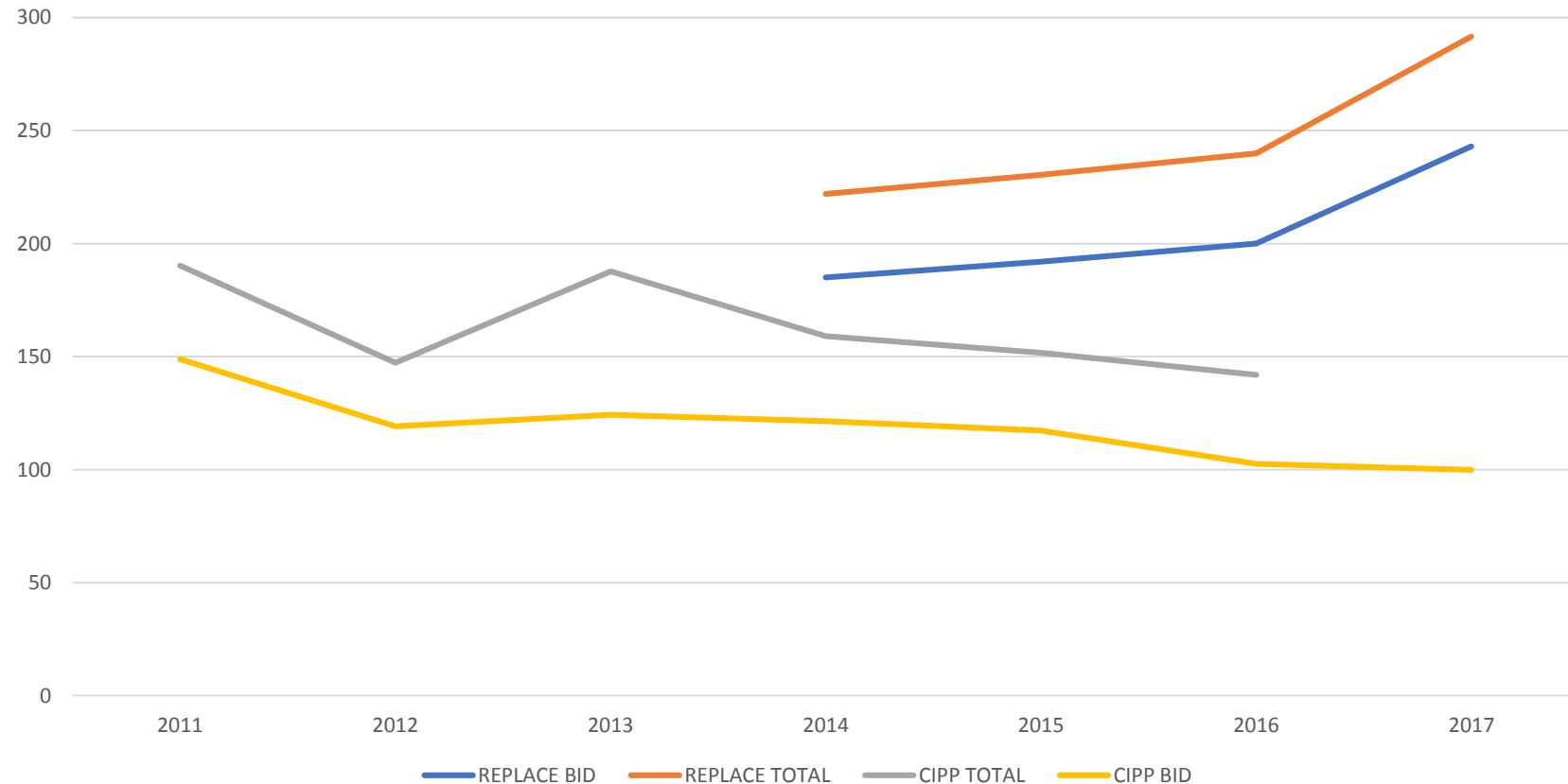




Bidding a Water Main Lining Project:

# Budgeting/Estimating CIPP Rehab

**RECENT CIPP WATER MAIN REHABILITATION  
vs. OPEN TRENCH REPLACEMENT COSTS**  
(Madison, WI) \* Price Per Foot



# PRESENTATION OVERVIEW:

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Bidder Proof

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QA/QC Recommendations

## 3) Lessons Learned

ROW/Easements

What Ifs?

Approval Agency

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## Developing a Water Main Lining Project

### Design Criteria

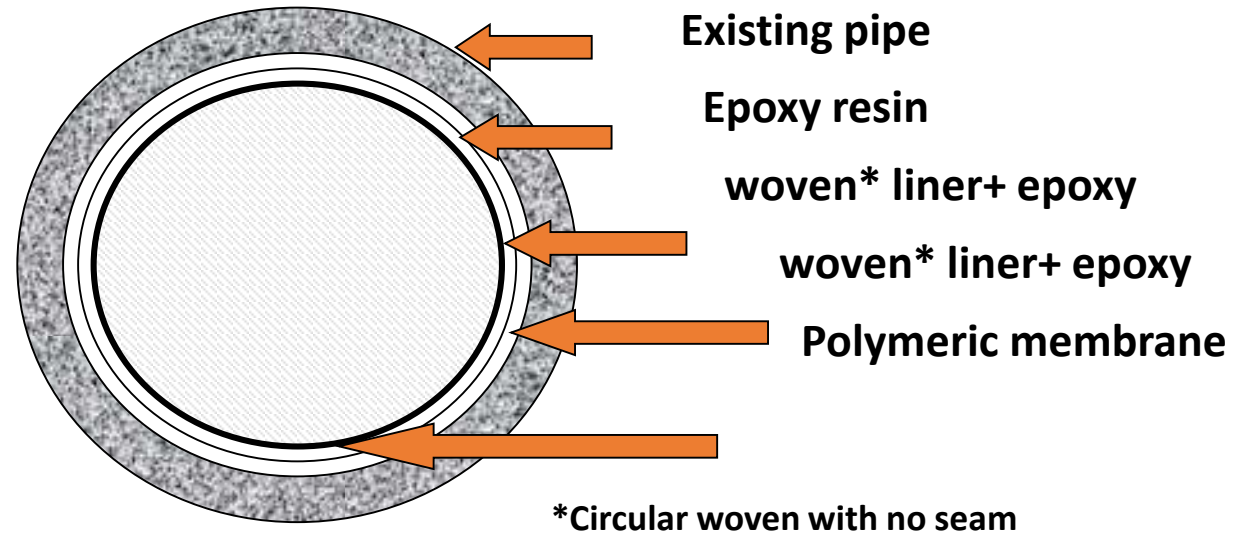
Defining Project Scope

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Note: not to scale

<b>Installed diameters</b>	6 to 24 in
<b>Installed lengths</b>	up to 500 feet
<b>Hazen Williams Coefficient</b>	>120
<b>Maximum Working Pressure</b>	150 psi



# UCT The Underground Utilities Event



Underground Construction Technology | January 28-30, 2020 | Fort Worth, TX



Designation: F1

## Standard Practice for Rehabilitation of Existing Pipes by Inversion and CIPP

This standard is issued under the original adoption or, in the case of subsequent revision, superscript epsilon ( $\epsilon$ ) indicating the year of revision.

## Developing a Water Main Lining Project

Design Criteria

Defining Project Scope

Servicing

Bidder Proof

Community Impacts

QA/QC Recommendations



### RS BlueLine® Inversion Liner CIPP Wall Thickness Design

Designed in Accordance with ASTM F1216-07a

Project: Water Line Rehabilitation  
Location: Toronto, Ontario CANADA  
Designed By: Phil Kerridge  
Date: Jan 29, 2019

Owner: City of Toronto  
Contractor: Robert B. Somerville Co. Limited  
Line Segment(s): 300 mm  
Additional Information: 7.3 psi Vacuum

#### Design Assumptions:

- Condition of host pipe
- Inside diameter of host pipe (in)
- Ovality of host pipe (%)
- Constrained soil modulus of native soil in the pipe zone (psi)

D =	11.8	in
q =	2.0%	
M <sub>so</sub> =	1,000	psi

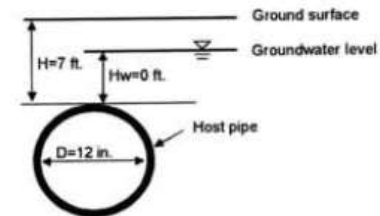
- Shaded cells are user-defined

- See ASTM F1216, Appendix X1 for definitions

- Default value is 2%; range = 0.1%-10%

- See table below for recommended values

Granular Native Soils		Unconfined compressive strength (q <sub>u</sub> )		Description	M <sub>so</sub>	
Blows/ft (per ASTM D1586)	Description	tons/sf	kPa		psi	kPa
> 0 - 1	very, very loose	> 0 - 0.125	0 - 13	very, very soft	50	0.3
1 - 2	very loose	0.125 - 0.25	13 - 25	very soft	200	1.4
2 - 4		0.25 - 0.50	25 - 50	soft	700	4.8
4 - 8	loose	0.50 - 1.0	50 - 100	medium	1,500	10.3
8 - 15	slightly compact	1.0 - 2.0	100 - 200	stiff	3,000	20.7
15 - 30	compact	2.0 - 4.0	200 - 400	very stiff	5,000	34.5
30 - 50	dense	4.0 - 6.0	400 - 600	hard	10,000	69.0
> 50	very dense	> 6.0	> 600	very hard	20,000	138.0



- Flexural modulus of Elasticity of CIPP, initial (psi)
- Long-term retention of tensile properties (%)
- Long-term retention of flexural properties (%)
- Flex modulus of elasticity of CIPP, long-term (psi)
- Design safety factor
- Unit weight of soil (pcf)
- Unit weight of water (pcf)
- Depth of cover (ft)
- Height of groundwater (ft)
- Is this an above ground installation?
- Internal pressure (psi)
- Internal vacuum pressure (psi)
- Diameter of hole or opening in original pipe wall (in)
- Poisson's ratio of CIPP
- Flexural strength of CIPP, initial (psi)
- Flexural strength of CIPP, long-term (psi)
- Tensile strength of CIPP, initial (psi)
- Tensile strength of CIPP, long-term (psi)
- Enhancement factor (dimensionless)
- Surface live loading condition

E =	400,000	psi
E <sub>t</sub> =	50%	
N =	2.0	
δ <sub>t</sub> =	120	lb/ft <sup>2</sup>
δ <sub>w</sub> =	62.4	lb/ft <sup>3</sup>
H =	6.6	ft
H <sub>w</sub> =	0.0	ft
P =	No	
P <sub>v</sub> =	125.0	psi
d =	7.3	psi
v =	0.50	in
σ <sub>t</sub> =	0.30	
σ <sub>1</sub> =	10,000	psi
σ <sub>2</sub> =	10,000	psi
σ <sub>3</sub> =	13,000	psi
σ <sub>4</sub> =	6,500	psi
K =	7.0	
	HS-20	

- Minimum value is 250,000 psi per ASTM F1216

- Default value is 50%

- Determined from long-term retention %

- Default value is 2.0

- Applies to fully deteriorated designs only

- Measured from ground surface to top of pipe

- Measured from top of pipe

- Pressure pipe applications only

- Pressure pipe applications only; if no pressure, input 0

- Default value is 0

- Pressure pipe applications only! If no pressure, input 0

- Average value for CIPP per ASTM F1216

- Minimum value is 4,500 psi per ASTM F1216

- Determined from long-term retention %

- Pressure pipe applications only

- Determined from long-term retention %

- Minimum value recommended per ASTM F1216

- AASHTO HS-20 or HS-25; Cooper E80 railway or airport loading



- Getting on the same page with contractors on what we expect as a finished product
- Toronto Specification 7.60: Cured-in Place Pipe Lining of Watermains
- [https://www.toronto.ca/wp-content/uploads/2017/11/8fac-ecs-specs-pipespecs-TS\\_7.60\\_Jan2015.pdf](https://www.toronto.ca/wp-content/uploads/2017/11/8fac-ecs-specs-pipespecs-TS_7.60_Jan2015.pdf)
- [Google: Toronto TS7.60 CIPP](#)

## Developing a Water Main Lining Project Design Criteria Defining Project Scope

City of Toronto Trenchless Rehabilitation of Existing Watermains  
SCP, CIPP Defect Classification

### 5.4.3.4 Example 4 - Moderate Type 3



**Root Cause:** Different than standard lumps, its shape is caused by instantaneous depressurization or rapidly pushed up air during lining due to an adjacent valve.  
**Description:** Tall-thin medium size ovoid lump along the side of the liner. Width at the lump base is ~15% of the circumference of the liner. Height of the lump is ~25% of the diameter of the liner. Lump may pose a problem to the liner by reducing hydraulic carrying capacity and providing a stress concentration point that can reduce the pressure class of the liner.  
**Recommendation:** Dig and replace at the moment but further testing could validate leaving as it is depending on the severity (see Section 6 Testing).

### 5.4.3.6 Example 5 - Severe



**Root Cause:** Bump due to external pressure (water or air) during the forming of the liner.  
**Description:** Large size ovoid lump along the bottom of the liner. Width at the lump base is 15%-25% of the circumference of the liner. Height of the lump is >30% of the diameter of the liner. Lump poses a problem to the liner by reducing hydraulic carrying capacity and providing a stress concentration point that can reduce the pressure class of the liner.  
**Recommendation:** Dig and replace.



# Project Scope Considerations

- **Multi-Location vs. Concentrated Area**
- Joint-Municipality Agreement
- Ongoing Service Agreement (Multi-Year)
- Civil/Site Work Options





# Establishing Project Limits

## Developing a Water Main Lining Project

Design Criteria

Defining Project Scope

Servicing

Bidder Proof

Community Impacts

QA/QC Recommendations

- Valve Locations
- Locating Access Pits
  - Hydrant Feeds for Temp. Water Supply
  - Typical Max Spacing 600-800-FT
- **Staging and Storage Areas**
  - offer alternative location if site can't accommodate



## Maintaining Service

- **Temporary Bypass Water Systems**
- Pressure / Source
- Fire Protection
- Water Quality
- Metering
- 24-hr on-call
- Access & Ramps
- House Connections
- Freezing

### Developing a Water Main Lining Project

Design Criteria

Defining Project Scope

Planning

Water Proof

Community Impacts

QC Recommendations

TYPICAL BYPASS SET-UP







## Developing a Water Main Lining Project

Design Criteria

Defining Project Scope

**Servicing**

Bidder Proof

Community Impacts

QA/QC Recommendations



## Developing a Water Main Lining Project

Design Criteria

Defining Project Scope

**Servicing**

Bidder Proof

Community Impacts

QA/QC Recommendations



## Bidders Proof of Responsibility

A Bidder will not be considered as a qualified contractor for this project unless the Bidder receives a rating of at least 10 points, as determined by the Owner, using the following system for assigning or deducting points:

1.0 CIPP Work	
Experience in installation of CIPP trunk water main pipe lining and similar to this project in terms of lineal footage within the last three years, to the satisfaction of the Owner	5 points
➤ For each additional project qualifying under the above category	1 point each
Experience of the assigned job superintendent in supervising CIPP trunk water main pipe lining projects while under traffic similar in size and functions within the last three years, to the satisfaction of the Owner	5 points
➤ For each additional CIPP project supervised that qualifies under the above category	1 point each
History of initiating change orders (not at the owner's request) that total more than 5% of the original bid within the last five years	Deduct 2 points for each confirmed project
History of complaints regarding completion deadlines or the quality of the work of projects within the last five years	Deduct 2 points for each confirmed project
2.0 Site Work	
Experience in street reconstruction/utility projects entailing aspects of open cut excavations, installations of temporary water systems, paving operations, restoration and traffic control similar in scope to this project within the last three years	0 points for three (3) or more projects Deduct 2 points for each project less than three (3)
Experience of the assigned job superintendent in supervising street reconstruction/utility projects entailing aspects of open cut excavations, installations of temporary water systems, paving operations, restoration and traffic control similar in scope to this project within the last three years	0 points for three (3) or more projects Deduct 2 points for each project less than three (3)
History of initiating change orders (not at the owner's request) that total more than 5% of the original bid within the last three years	Deduct 2 points for each confirmed project
History of complaints regarding completion deadlines or the quality of the work of projects within the last three years	Deduct 2 points for each confirmed project

*The Owner may give partial credit for points or deducts depending upon the nature of the projects.*

The object of the request for the Bidder's qualifications is to make it possible for the Owner to have exact information of the financial ability, equipment and personnel available and past performance and experience of the Bidder, in order to reduce the hazards involved in awarding a Contract to a party apparently not qualified to perform it, and to select only those Bidders qualified to properly complete the work.

## Developing a Water Main Lining Project

Design Criteria  
Defining Project Scope  
Servicing  
**Bidder Proof**  
Community Impacts  
QA/QC Recommendations

Bid Award Letter  
April 14, 2014  
Page 6

Paragraph	Qualifications of Bidder			
	Pember <sup>1</sup>		Fer-Pal <sup>2</sup>	
	Points	Comment	Points	Comment
control similar in scope to this project within the last three years				
Experience of the assigned job superintendent in supervising street reconstruction/utility projects entailing aspects of open cut excavations, installations of temporary water systems, paving operations, restoration and traffic control similar in scope to this project within the last three years	-5	Pember did not identify a superintendent in Section 2.3.1. Therefore score -2 points for each of up to 3 projects not identified for an unidentified superintendent	-	
History of initiating change orders (not at the owner's request) that total more than 5% of the original bid within the last three years	0		-	
History of complaints regarding completion deadlines or the quality of the work of projects within the last three years	0		-	
<b>Total Points</b>	<b>5</b>		<b>34</b>	

<sup>1</sup> Scored both sections 1.0 and 2.0 because Pember will complete paragraph 2.0 Site Work themselves, while subcontracting with Michels Corporation to complete paragraph 1.0 CIPP Work.

<sup>2</sup> Scored only section 1.0 because Fer-Pal will complete both paragraphs 1.0 CIPP and 2.0 Site Work themselves.

### Conclusions

Based on our review of submitted proposal forms and Proofs, Fer-Pal gives the City its best chance to realize the value in its choice to use CIPP method to rehabilitate its water main thus receiving our recommendation of award in the amount of \$818,885.80. Fer-Pal is a very able Contractor with both the experience and leadership necessary to execute this project's very demanding schedule in a historic downtown while not impacting key downtown activities.

Please contact me with questions and comments at 952.912.2611 or [ppasko@sehinc.com](mailto:ppasko@sehinc.com). We look forward to assisting the City with construction phase activities.

Sincerely,

SHORT ELLIOTT HENDRICKSON INC.



Paul J. Pasko III, PE  
Project Manager

Enclosure  
pip3



## Bidders Proof of Responsibility - continued

### Developing a Water Main Lining Project

Design Criteria

Defining Project Scope

Servicing

**Bidder Proof**

Community Impacts

QA/QC Recommendations



#### Re: Post-Bid Proof of Responsibility Review & Contract Award Recommendations - Hastings Downtown Watermain Lining

Nick Egger, P.E. to: Brent Pember

04/15/2014 05:21 PM

"epember@pembercompanies.com",

Cc: "nbowman@pembercompanies.com", Thomas Montgomery, Curt

Wmpee, Paul Pasko III, Mark Peine

Thank you for the response Brent. I understand that you are frustrated and disappointed in the outcome and the direction we intend to take.

We will honor your request for a meeting, and we are available late morning on Thursday. Would the time of 11am work for you? We would be gathering at our Public Works Building rather than at City Hall.

Eric - Please let me know if 11am on Thursday is workable from your end.

Regards,

Nick Egger, P.E.  
City Engineer

City of Hastings

Sent from my iPad

On Apr 15, 2014, at 12:16 PM, "Brent Pember" <bpember@pembercompanies.com> wrote:

Nick,

Obviously we disagree very strongly with the Proof of Responsibility summary provided by SEH. There were things that could have easily been clarified by SEH with a simple follow-up call to us (no product information, supervisor qualifications, etc..) but we didn't hear anything from them until this letter.

For SEH to grade Pember Companies at negative 6 points is an insult and quite frankly a joke. We have done many projects similar in scope in the City of Hastings alone. It wasn't too many years ago that the City of Hastings paid close to an extra \$100,000 to use Pember Companies over one of our competitors.

Michels has similar objections to their score. We would like to setup a meeting at City Hall this week to discuss the scores. Eric Pember will be attending from our office. Please let Eric know when that meeting can take place and we will coordinate with Michels.

Thanks,

Brent

Brent Pember, P.E.  
President  
Pember Companies, Inc.  
N4449 469th Street  
Menomonie, WI 54751  
Phone: 715.235.0316 ext. 30





## Developing a Water Main Lining Project

Design Criteria  
Defining Project Scope  
Servicing  
Bidder Proof  
Community Impacts  
QA/QC Recommendations



## Construction Update

September 19, 2019

### Watermain Cleaning and Relining on Finch Avenue East from Alamosa Drive to east of Page Avenue OVERNIGHT WORK

Contract: 18TW-CTS-07CWD  
Start Date: March 2019  
End Date: November 2019  
*\*Timeline is subject to change.*

The City of Toronto will be cleaning and structurally relining the watermain in your area starting in the month of March through November. During this process, the City will also replace the City-owned portion of any substandard water service pipes.

Phase 1 of this project on Linus Road and two sections of Finch Avenue East (Gaspé Road to Page Avenue and Leslie Street to Linus Road) was completed in January 2019. Restorations followed in Spring 2019. Phase 2 began in March 2019 on Finch Avenue East from Alamosa Drive to east of Page Avenue.

Beginning September 23, overnight work will commence in the area. Overnight work is required to complete the project and minimize disruption.

A map of the work area can be found on page 3 of this notice.

This project is part of the Council-approved Capital Works Program to renew our aging infrastructure, improve water distribution and reduce the risk of watermain breaks.

#### IMPORTANT INFORMATION ABOUT LEAD WATER SERVICES

If you live in a house/building that was built before the mid-1950s, your water service may be made of lead. Please read the attached fact sheet with important information about the risks of lead in drinking water, especially if someone in your house/building is pregnant, there are children under six years old, or there is an infant drinking formula made from tap water.

Please note: Lead pipes were not used in apartment buildings or other multi-residential buildings with more than six units.

#### WORK DETAILS

In the first few weeks, the City's contractor will move equipment on-site and prepare the work area before construction begins. Construction crews will then:

- Excavate pits in the road to access the watermain
- Install a temporary water supply system and attach your building to the supply
- Clean and structurally reline the existing watermain
- Replace any City-owned water service pipes that do not meet City standards (from the watermain to the private property line)
- Remove the temporary water supply and restore all work areas with asphalt, concrete or grass

#### WHAT TO EXPECT DURING CONSTRUCTION

- You may experience dust, noise and other inconveniences. The City will make efforts to reduce the impacts. We appreciate your patience
- Property owners should remove items located within City property limits (boulevard), such as landscaping and / or decorative objects
- The City will not be responsible for damage to any privately owned items on City property

## CIPP Liner Verification:

### PRECONSTRUCTION

- Design/Submittals
- Confirm Plans

### CONSTRUCTION

- Installation logs
  - NSF 61
  - Pressure Tests

### POST-CONSTRUCTION

- Physical Properties
- Water Quality
  - Bacteriological
  - VOC/BPA

## Developing a Water Main Lining Project

- Design Criteria
- Defining Project Scope
- Servicing
- Bidder Proof
- Community Impacts
- QA/QC Recommendations

REVISION # 26, April 2015, 2015

Site: Madison St Street Pit # 6 to 7

Contract # \_\_\_\_\_ Site Superintendent: \_\_\_\_\_

1. Host pipe and cleaning Date: 9-26-2014

Host pipe address: 114 - 117 Most fully open hydrant valves: ✓ initial

Pipe Material: \_\_\_\_\_ Pipe Diameter: I.D. 54"

Pipe Length: 190 ft Pipe Diameter: O.D. 54"

# of passes (surge): 0 # of passes (flusher jet): 3

Special conditions, observations & notes: \_\_\_\_\_

Flusher truck # 163-HU Winch truck # W38-05 Operator Name: Luis Hernandez

Other Liner(s) any: Excess

2. Initial inspection and cutting of service connections Date: 7/17/2014

Record the # of times needed to remove water: \_\_\_\_\_ Verified by laser profiler: ✓ on 7/17/2014

Size of services: 3/4" Largest available pipe ID: 11 1/2"

Camera Direction: PG to PT Pipe length (ft. per camera): 35'

# of non-instructing services: \_\_\_\_\_ # of cuts installed: 10

# of old or obsolete services: \_\_\_\_\_ # of material cuts used: \_\_\_\_\_

Record location & description of significant features (bends in pipe, low spots, head in pipe, hydrants): \_\_\_\_\_

Obstructions: 22.5' Observation: Hydrant Distance: \_\_\_\_\_ Observation: \_\_\_\_\_

Notes: Final Hydrant at 112.5'

Used 1" SPHAR for a new installation Operator's name: Emma Deng

Installed at 112.5' Assistant's name: Yunhui

Camera truck # 541-84

3. Flushing - Insert pressure to flush pipe to remove all gas, oil, concrete residue or debris for 8 inch pipe:

For 12" pipe & larger, water - unless other liquid, acceptable pressure of flusher jet to be below 15 psi.

30 min cold water cycle at 25 psi starts when pipe reversed

Circle grade description: FLAT

Start, record time pipe first: 7:30 SIGNIFICANT STEEP: 1

Record time pipe reversed: 7:35 Record # of pipe shut: 1

Record time pipe completed: 7:45 Direction pipe shut: to 7

Record pressure pipe shut at: 25 Pipe shut towards center: to 7

Record pressure pipe shut at: 25 C&G water temperature: 55 No

Circle empty water: None 30 40 50 >50

Comments / Notes: See Preconstruction Drawing Reinforce Pipe

4. Cure for 1.5 hours at 60-65 degree Celsius (2 hours for 12in and 2.5 hours for 18in & 24in)

Curing time: 1.5 hrs at entry: 75 Temp (C): 65

(+0:15) 75 (+0:30) 75 (+1:00) 75 (+1:30) 75 (+2:00) 75

Post cure water pressure: psi Operator name: Emma Deng

Comments / Notes: 24 hr. High speed Baker truck #: 540-340

on 10-14-2014 per email on 10-15-2014 per spec

5. Final inspection & cutting of service connections Date: 10-10-2014

Direction: PG to PT # of services observed: 1 to

Distance: \_\_\_\_\_ Observation: \_\_\_\_\_

PARAGON SYSTEMS

LABORATORY REPORT

Paragon Systems  
1641 Langstaff Rd. Bldg. B, Unit 14-17  
Concord, Ontario, Canada, L4K 5X8  
Tel (905) 738 - 0447  
Fax (905) 738 - 5659






Figure1: Representative photographs of the as received sample.

WRITTEN BY: Yunhui Deng REVIEWED BY: Po-Szu Yao

Yunhui (Emma) Deng Materials Analyst - Sr Po-Szu (Bruce) Yao Test Manager

DATE: January 12, 2015 DATE: January 12, 2015



Certified to  
NSF/ANSI 61

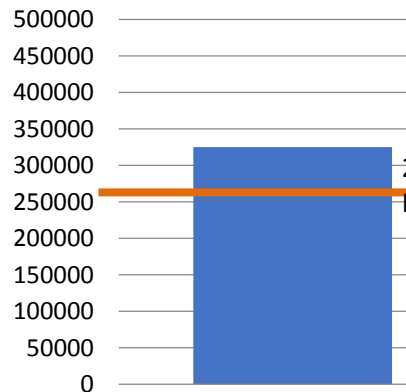


## Physical Properties Testing Analysis

### Confirm Design Performance

- Tensile
- Flexural (b)
- Thickness

### Flexural M



2011 ■ Flexural Modulus (psi) 2012

**RS BlueLine® Inversion Liner CIPP Wall Thickness Design**  
*Designed in Accordance with ASTM F1216-07a*

**Project:** Water Line Rehabilitation  
**Location:** Toronto, Ontario CANADA  
**Designed By:** Phil Kerridge  
**Date:** Jan 29, 2019

**Owner:** City of Toronto  
**Contractor:** Robert B. Somerville Co. Limited  
**Line Segment(s):** 300 mm  
**Additional Information:** 7.3 psi Vacuum

**Design Assumptions:**

- Condition of host pipe
- Inside diameter of host pipe (in)
- Ovality of host pipe (%)
- Constrained soil modulus of native soil in the pipe zone (psi)

Fully Deteriorated  
D = 11.8 in  
q = 2.0%  
M<sub>so</sub> = 1,000 psi

- Shaded cells are user-defined  
- See ASTM F1216, Appendix X1 for definitions  
- Default value is 2%; range = 0.1%-10%  
- See table below for recommended values

From Table 5.6 of AWWA Manual of Water Practices M45, Second Edition

Granular Native Soils		Unconfined compressive strength (q <sub>u</sub> )		Description	M <sub>so</sub>	
Blows/ft (per ASTM D1586)	Description	tons/sf	kPa		psi	kPa
> 0 - 1	very, very loose	> 0 - 0.125	0 - 13	very, very soft	50	0.3
1 - 2	very loose	0.125 - 0.25	13 - 25	very soft	200	1.4
2 - 4		0.25 - 0.50	25 - 50	soft	700	4.8
4 - 8	loose	0.50 - 1.0	50 - 100	medium	1,500	10.3
8 - 15	slightly compact	1.0 - 2.0	100 - 200	stiff	3,000	20.7
15 - 30	compact	2.0 - 4.0	200 - 400	very stiff	5,000	34.5
30 - 50	dense	4.0 - 6.0	400 - 600	hard	10,000	69.0
> 50	very dense	> 6.0	> 600	very hard	20,000	138.0

H=7 ft  
H<sub>w</sub>=0 ft  
Ground surface  
Groundwater level  
Host pipe  
D=12 in.

- Flexural modulus of Elasticity of CIPP, initial (psi)
- Long-term retention of tensile properties (%)
- Long-term retention of flexural properties (%)
- Flex modulus of elasticity of CIPP, long-term (psi)
- Design safety factor
- Unit weight of soil (pcf)
- Unit weight of water (pcf)
- Depth of cover (ft)
- Height of groundwater (ft)
- Is this an above ground installation?
- Internal pressure (psi)
- Internal vacuum pressure (psi)
- Diameter of hole or opening in original pipe wall (in)
- Poisson's ratio of CIPP
- Flexural strength of CIPP, initial (psi)
- Flexural strength of CIPP, long-term (psi)
- Tensile strength of CIPP, initial (psi)
- Tensile strength of CIPP, long-term (psi)
- Enhancement factor (dimensionless)
- Surface live loading condition

E = 400,000 psi  
50%  
100%  
E<sub>t</sub> = 400,000 psi  
N = 2.0  
δ<sub>1</sub> = 120 lb/ft<sup>2</sup>  
δ<sub>2</sub> = 62.4 lb/ft<sup>2</sup>  
H = 6.6 ft  
H<sub>w</sub> = 0.0 ft  
P = 125.0 psi  
P<sub>v</sub> = 7.3 psi  
d = 0.50 in  
v = 0.30  
σ<sub>1</sub> = 10,000 psi  
σ<sub>2</sub> = 10,000 psi  
σ<sub>3</sub> = 13,000 psi  
σ<sub>4</sub> = 6,500 psi  
K = 7.0  
HS-20

- Minimum value is 250,000 psi per ASTM F1216
- Default value is 50%
- Determined from long-term retention %
- Default value is 2.0
- Applies to fully deteriorated designs only
- Measured from ground surface to top of pipe
- Measured from top of pipe
- Pressure pipe applications only
- Pressure pipe applications only; if no pressure, input 0
- Default value is 0
- Pressure pipe applications only! If no pressure, input 0
- Average value for CIPP per ASTM F1216
- Minimum value is 4,500 psi per ASTM F1216
- Determined from long-term retention %
- Pressure pipe applications only
- Determined from long-term retention %
- Minimum value recommended per ASTM F1216
- AASHTO HS-20 or HS-25; Cooper E80 railway or airport loading



2011 ■ Flexural Strength (psi) 2012

**Developing a Water Main Lining Project**

Design Criteria  
Defining Project Scope  
Servicing  
Bidder Proof  
Community Impacts  
QA/QC Recommendations

# Defect Remediation

## Benign



TORONTO\_GERRARD ST.EAST\_P10-P6\_V3.mpg



## Cause for Remediation



TORONTO\_PRINCESS ST\_P5\_P2\_V3.mpg





# Defect Remediation

## Mis-drilled Service Reinstatement

### Developing a Water Main Lining Project

Design Criteria

Defining Project Scope

Servicing

Bidder Proof

Community Impacts

QA/QC Recommendations



# PRESENTATION OVERVIEW:

## 1) Replace? Repair? Rehab?

Making Effective Renewal Decisions

## 2) Developing a Water Main Lining Project

Design Criteria

Defining Project Scope

Servicing

Bidder Proof

Community Impacts

QA/QC Recommendations

## 3) Lessons Learned

ROW/Easements

What ifs?

Approval Agency

Ongoing Maintenance

Independent lab testing of material properties

Mitigating Future Failures

# Easements:



## Lessons Learned

### ROW/Easements

What Ifs?

Approval Agency

Ongoing Maintenance

Independent lab testing

Mitigating Future Failures



# Easements:

## Lessons Learned

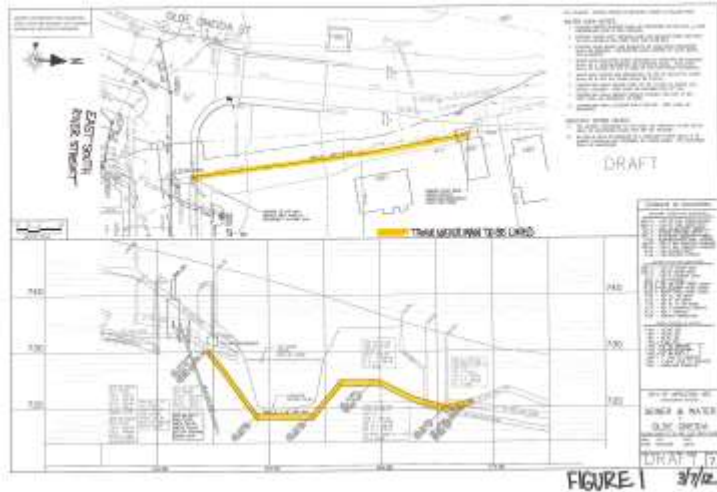
ROW/Easements  
What Ifs?  
Approval Agency  
Ongoing Maintenance  
Independent lab testing  
Mitigating Future Failures





# UCT The Underground Utilities Event

Underground Construction Technology | January 28-30, 2020 | Fort Worth, TX



## Lessons Learned

ROW/Easements

What Ifs?

Approval Agency

Ongoing Maintenance

Independent lab testing

Mitigating Future Failures

- “Experimental Basis” Approvals
- Communicate early intent to proceed with CIPP rehab
- Discuss intended scope
- Confirm design criteria
  - All WM pipe = AWWA Pressure Class 150
  - 100 psi working pressure
  - 2.5 x safety factor,
  - 50-year life
- Confirm required testing
- Notice of Install/Reports
  - Primary Contacts:
    - Marvin Hansen, PE
    - Norm Hahn, PE



## Lessons Learned

ROW/Easements  
What Ifs?  
**Approval Agency**  
Ongoing Maintenance  
Independent lab testing  
Mitigating Future Failures

SUBJECT: WATER SYSTEM FACILITIES PLAN AND SPECIFICATION APPROVAL

Dear Ms. Witzel-Behl:

The Wisconsin Department of Natural Resources, Division of Water, Bureau of Drinking Water and Groundwater, is conditionally approving on an “Experimental Basis”, plans, specifications and special provisions for the following project. Information of sufficient detail to meet the requirements of s. NR 811.09 Wis. Adm. Code, was submitted for review.

**Water system name:** City of Madison

**Date received:** 08/15/2012

**Engineering firm:** City of Madison Water Utility



## Receiving Data

### Lessons Learned

ROW/Easements  
What Ifs?  
Approval Agency  
**Ongoing Maintenance**  
Independent lab testing  
Mitigating Future Failures

OBJECTID	ASSET ID	ASSET TYPE	ASSET NAME	STATUS	OWNERSHIP	DISTRICT	RETRO ID	DIAMETER	LENGTH	MATERIAL	CONCT. YR	ASMT. YR	DEAD END
81	UH101181	D	COVINGDALE CREEK	ACTV	DTV	4	4	150	100.0	DI	chub	chub	chub
187	UH040434	D	JACKSON RD	ACTV	DTV	2	4	200	6.1	CI	chub	chub	Y
141	UH044003	D	MARTIN GROVE RD	ACTV	DTV	2	4	200	65.9	chub	chub	chub	chub
229	UH040077	D	BAIRNIE PARKWAY DR	ACTV	DTV	2	4	200	98.1	PVC	chub	chub	chub
270	UH101431	D	BARRETT RD	ACTV	DTV	4	4	150	27.2	chub	chub	chub	Y
385	UH111142	D	DAK ST	ACTV	DTV	2	4	200	100.0	chub	chub	chub	chub
384	UH120363	D	VILDERHORN DR	ACTV	DTV	4	4	150	348.4	PVC	chub	chub	chub
491	UH0423678	D	ARBOA DELL RD	ACTV	DTV	2	4	150	51.9	chub	chub	chub	Y
412	UH102365	D	STRAWBERRY HILLS DR	ACTV	DTV	4	4	200	121.0	PVC	chub	chub	chub
432	UH101014	D	GORDON ST E	ACTV	DTV	1	4	200	8.7	chub	chub	chub	chub
891	UH101123	D	LEWISDALE TRL	ACTV	DTV	4	4	150	34.5	DI	chub	chub	Y
978	UH000211	D	SEVEN VALLEY DR	ACTV	DTV	2	4	200	98.4	chub	chub	chub	chub
579	UH00042	D	KIRLING AVE	ACTV	DTV	2	4	200	66.9	CI	chub	chub	chub
618	UH102344	D	BREARLINGTON RD	ACTV	DTV	4	4	200	6.5	CI	chub	chub	chub
744	UH0447441	D	MCARTHUR ST	ACTV	DTV	2	4	200	107.0	chub	chub	chub	chub
753	UH100491	D	ROSLAN AVE	ACTV	DTV	3	4	150	12.5	CI	chub	chub	chub
821	UH110084	D	BRUNSWICK ST	ACTV	DTV	2	4	150	298.2	chub	chub	chub	chub
840	UH100044	D	LANGDON AVE	ACTV	DTV	1	4	200	11	CI	chub	chub	chub
880	UH101207	D	COLLEGE ST	ACTV	DTV	1	4	150	125.3	CI	chub	chub	chub
884	UH047646	D	BARNES AVE	ACTV	DTV	2	4	150	127.4	chub	chub	chub	Y
954	UH040428	D	BERKUSA AVE	ACTV	DTV	2	4	150	202.0	CI	chub	chub	chub
986	UH040843	D	WYFORD DR	ACTV	DTV	3	4	200	19.3	PVC	chub	chub	Y
1017	UH100020	D	ROTARY DR	ACTV	DTV	4	4	200	15.8	DI	chub	chub	chub
1018	UH100017	D	QUEENSLAND AVE	ACTV	DTV	1	4	150	90.1	CI	chub	chub	chub
1121	UH100016	D	OLD PARK RD	ACTV	DTV	1	4	150	88.2	CI	chub	chub	chub
1131	UH100043	D	AVENUE RD	ACTV	DTV	3	4	150	13.1	DC	chub	chub	chub
1211	UH100048	D	BEWA RD	ACTV	DTV	1	4	150	81.4	CI	chub	chub	chub
1480	UH100006	D	ROSEVIEW RD	ACTV	DTV	1	4	150	38.4	PVC	chub	chub	chub
1680	UH040037	D	ALDERIDGE AVE	ACTV	DTV	2	4	150	299	CI	chub	chub	chub
1679	UH100066	D	DAVISVILLE AVE	ACTV	DTV	1	4	150	28.1	CI	chub	chub	chub
1680	UH12308	D	ELLIS AVE	ACTV	DTV	2	4	150	248.1	chub	chub	chub	chub
1684	UH100001	D	BOUNT PLAZA RD	ACTV	DTV	3	4	150	8.7	CI	chub	chub	chub
1644	UH10721	D	PORTLAND ST	ACTV	DTV	2	4	200	108.2	CI	chub	chub	chub
1718	UH101028	D	ELLSWORTH AVE	ACTV	DTV	1	4	150	8.2	CI	chub	chub	chub
1875	UH100045	D	STEELES AVE E	ACTV	DTV	4	4	200	84.9	PVC	chub	chub	chub
1980	UH100411	D	QUEENSLAND AVE	ACTV	DTV	1	4	150	6.1	chub	chub	chub	Y
2189	UH101011	D	STRAFMORE BLVD	ACTV	DTV	1	4	200	9.2	CI	chub	chub	chub
2213	UH100045	D	SEWELLS RD	ACTV	DTV	4	4	200	250	DI	chub	chub	chub
2423	UH044708	D	NEPUNG AVE	ACTV	DTV	2	4	200	6.2	chub	chub	chub	Y
2588	UH040008	D	SELBYTON AVE	ACTV	DTV	2	4	200	8.9	chub	chub	chub	chub
2634	UH000072	D	HAMER COLLEGE BLVD	ACTV	DTV	2	4	200	56.2	chub	chub	chub	chub
2647	UH000061	D	FOURTEENTH ST	ACTV	DTV	2	4	150	7.9	chub	chub	chub	chub
2655	UH100065	D	FAUCETT TRL	ACTV	DTV	4	4	200	84.3	DI	chub	chub	chub
2672	UH040208	D	BEUFIELD RD	ACTV	DTV	2	4	200	28.9	chub	chub	chub	chub
2884	UH100038	D	FAIRFIELD RD	ACTV	DTV	3	4	150	164.7	CI	chub	chub	Y
2717	UH100066	D	MCQUAY-CASLE ST	ACTV	DTV	4	4	200	87	DI	chub	chub	chub
2838	UH000179	D	BARON AVE	ACTV	DTV	1	4	150	7	CI	chub	chub	Y
2885	UH040475	D	SLINGTON AVE	ACTV	DTV	2	4	150	77.7	chub	chub	chub	Y
2896	UH100019	D	HURON ST	ACTV	DTV	1	4	200	108.0	CI	chub	chub	chub
3028	UH100053	D	LARK SHORE BLVD W	ACTV	DTV	1	4	200	203.7	CI	chub	chub	chub
3030	UH100021	D	LOGAN AVE	ACTV	DTV	1	4	200	84.1	CI	chub	chub	chub
3111	UH100008	D	WILKINSON DR	ACTV	DTV	2	4	150	44.6	CI	chub	chub	chub
3225	UH040002	D	ROYAL YORK RD	ACTV	DTV	2	4	250	6.1	chub	chub	chub	chub
3297	UH100034	D	PERMYNELL DR	ACTV	DTV	4	4	200	91.9	PVC	chub	chub	chub
3318	UH101006	D	REDWOOD AVE	ACTV	DTV	1	4	150	98.0	CI	chub	chub	chub
3336	UH100021	D	WILLOW AVE	ACTV	DTV	1	4	150	5.7	CI	chub	chub	chub
3297	UH100178	D	PROCT ST E	ACTV	DTV	1	4	200	82.4	CI	chub	chub	chub
3361	UH100007	D	PROCT ST E	ACTV	DTV	1	4	150	11.7	chub	chub	chub	chub

- New geospatial data
- New assets
- Rehabilitation information
- Avoid duplication of entry by receiving information in the format required
- NO PAPER



# New tooling for tapping

## Lessons Learned

ROW/Easements  
What Ifs?  
Approval Agency  
**Ongoing Maintenance**  
Independent lab testing  
Mitigating Future Failures





## Lessons Learned

ROW/Easements

What Ifs?

Approval Agency







## Lessons Learned

ROW/Easements

What Ifs?

Approval Agency

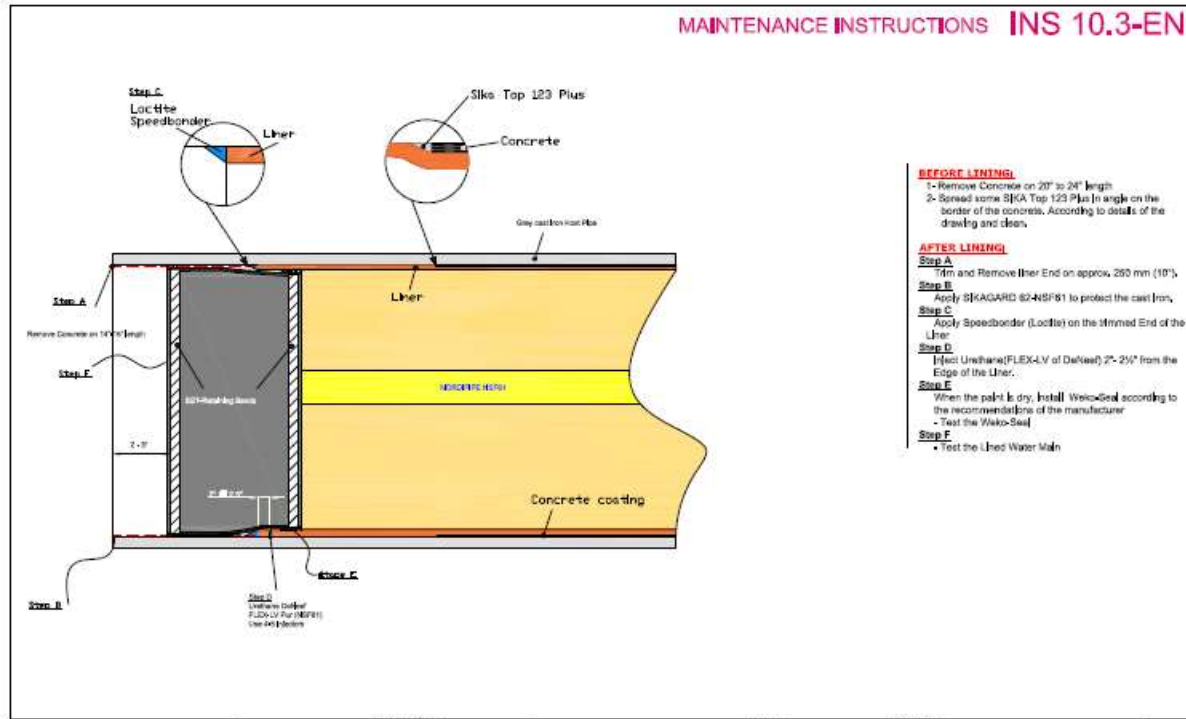
**Ongoing Maintenance**

Independent lab testing

Mitigating Future Failures

## Lessons Learned

ROW/Easements  
What Ifs?  
Approval Agency  
**Ongoing Maintenance**  
Independent lab testing  
Mitigating Future Failures



• Different materials prescribe different methods and materials to repair liners

• Need to consolidate to avoid confusion

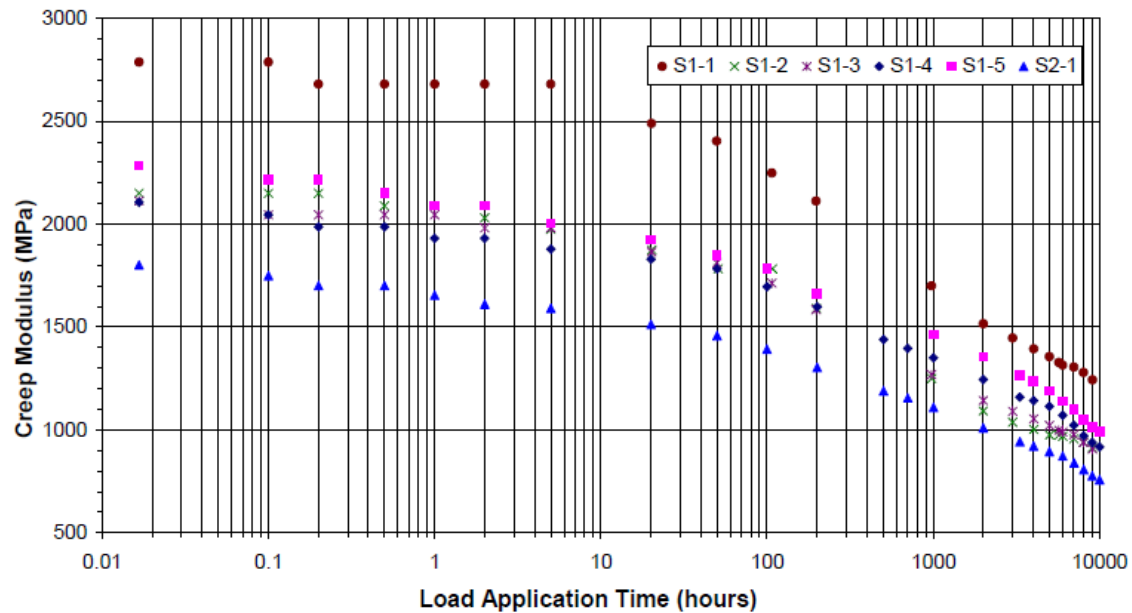
Thanks for making this easy engineers....



- ASTM D2990, Standard Test Methods for Tensile Compressive and Flexural Creep and Creep-Rupture of Plastics

## Lessons Learned

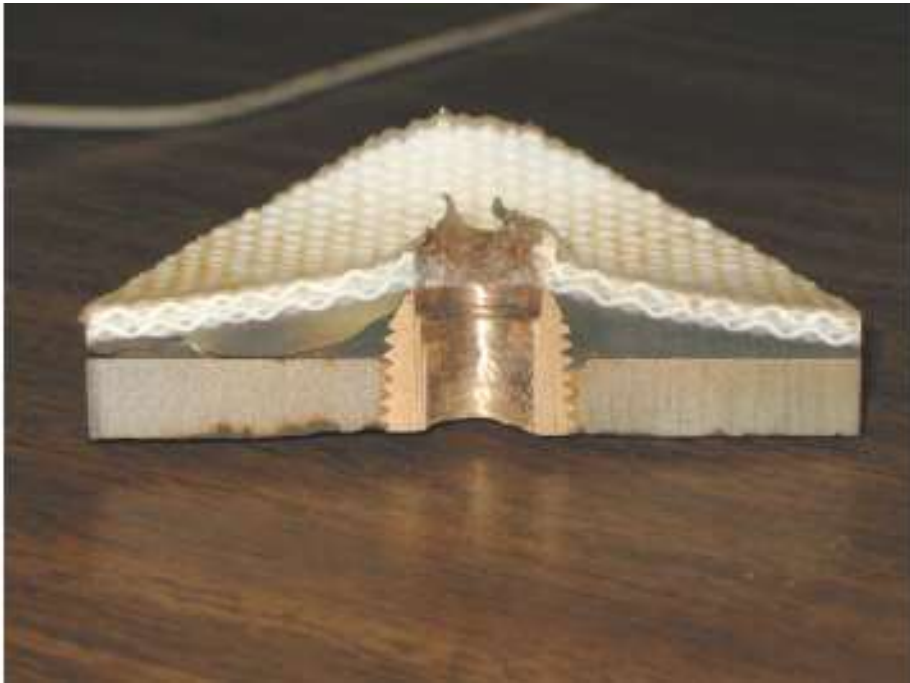
ROW/Easements  
What Ifs?  
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Independent lab testing  
Mitigating Future Failures





## Lessons Learned

ROW/Easements  
What Ifs?  
Approval Agency  
Ongoing Maintenance  
Independent lab testing  
Mitigating Future Failures



- Service connections might fail, lets go look!

**Lessons Learned**

ROW/Easements  
What Ifs?  
Approval Agency  
Ongoing Maintenance  
Independent lab testing  
Mitigating Future Failures

# Testing deflection properties



## Documenting findings and improvements, circulate and communicate

Item	Location	Proposed by	Existing	Change
1 7.60.21		Randy Cooper		add in "Sharp edges", "around services" and "the pipeline shall also be dried and left free of visible moisture (free standing water) in both the pipe and pipe joints", and "pipe repairs approved by contract admin"
2 7.60.21		Mark Knight		"remove All rust, tuberculation" is over the top, you won't get all rust off. Use NACE cleaning level
3 7.60.21		Mark Knight		better define what we mean by bonding to the watermain surface
4 7.60.02.4b		Mark Knight	Third party verification that the material proposed meets ASTM D1599, ASTM D2990...	Vague, there is no minimum. Change wording
5 7.60.02.4b		Sadesh Mahalingham	Third party verification that the material proposed meets ASTM D1599, ASTM D2990...	In addition to this, the contractor should also submit the ASTM D2990- Creep testing for BOTH tensile and flexural. Just providing the flexural creep data is not sufficient as a tensile creep modulus result can be used to estimate the behavior of the material that is exposed to long term sustained and fluctuating internal pressure. Though no benchmark currently exist, I believe it would be prudent for the City to have the bidder supply third party studies relating to the liners performance under shear, bending and adhesion.
6 various		Sadesh Mahalingham	ASTM D1216-07 are being used.	Change all ASTM specifications to the current ones. ASTM F1216-16, ASTM F1743-17, ASTM F2019-11
7 7.60.28		Sadesh Mahalingham	bending up to 4% at the joints	Added in language to deflection, settlement or rotation that better predicts the CIPP liners threshold.
8 NEW		Sadesh Mahalingham		Rationality of the ASTM D2290
9 7.60.02.4b		Martin Bureau	ASTM D2990 testing	ASTM D2990 is a very broad standard. The Specification Document should clearly refer to creep modulus data (as opposed to creep-rupture) to be provided. Relevant stress levels for creep testing should be provided (e.g., between x% and y% of yield or maximum strength...). Also, long term properties are important both in a context to top load (liner bending) and internal pressure (positive or negative). Since the design guidelines employed in ASTM F1216 are based on flexural modulus for the former and tensile strength for the latter, it should be mandatory to provide long-term creep factor in both flexural and tensile modes.