Wastewater Collection Pipe Rehabilitation (CIPP)

Circular Road Project

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Outline

- Town Infrastructure
- History of Cured-In-Place-Pipe (CIPP)
- Advantages and Disadvantages
- CIPP vs. Traditional Replacement
- Scope of Work
- CIPP Process
- Project Challenges
- Conclusions

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Town Infrastructure

10 Year Capital Spending Avg.

Running Annual Avg. Expenditure		
Roads	$	2,283,624
Water & Sewer	$	3,303,208
Recreation	$	844,703
Buildings	$	816,366
Average:		$7,247,901

70-year replacement timeframe
Own approx. 97 km of sewer mains

Total Asset Replacement Value

Asset Class	Replacement Value ($)	Portion of Total* Replacement Value ($)
Roads	146,725,782	29%
Facilities	135,885,036	27%
Sanitary	73,150,956	14%
Water	61,666,094	12%
Storm	49,024,141	10%
Equipment	26,885,662	5%
Parks and Land Improvements	8,949,725	2%
Fleet	2,560,857	1%
Total*	504,848,253	

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History of CIPP

- Definition – *"Insertion of a resin-impregnated lining tube which is then cured to form a tight fit against the existing sewer."*[1]
- Invented in the early 1970 by Eric Wood
- 1st project – London 1971 (53 yrs.). 1,170 mm x 600 mm brick egg shaped sewer lined 6 mm.
- It is still in use today. Testing completed 20 & 30 years after install. Still in excellent shape.

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1 – WRc Sewerage Rehabilitation Manual, 4th Edition.

History of CIPP

- 1st UK patent (Insituform) – August 21st, 1970
- 1st CIPP lining in NA was 300 mm drain in Fresno, CA in 1976.
- Formal design processes established in 1983.
- Design life = minimum of 50 years.
- Major installation in Winnipeg, MB in 1978
  - Assessed in 2003 and tested 2011 (450 mm liner)
  - Physicals like new

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Advantages & Disadvantages

- Advantages:
  - Less residential disturbance (min. excavation)
  - Cheaper (depending on situation)
  - Thin-walled (flow capacity not compromised)
  - Minimal insertion access required
  - Ability to be pulled through bends
- Disadvantages:
  - Resin smell during steam curing
  - Complexity of installation

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CIPP vs. Traditional Replacement

Traditional (Open Cut)

- 2,420 m of new mains.
- 1,320 m of service lines.
- 165 homes to be serviced.
- Approx. Cost = $800/m
- Total = $1,930,000 (est.)
  - Significant disturbance to the area. Only patching asphalt.
  - Homes serviced from rear.
  - Topography an issue.

CIPP Relining

- 2,347 m of sanitary mains relined.
- 173 m of 100 mm
- 2,074 m of 150 mm
- 100 m of 200 mm
- 106 services reinstated
- Average Cost = $601/m
- Total = $1,410,000

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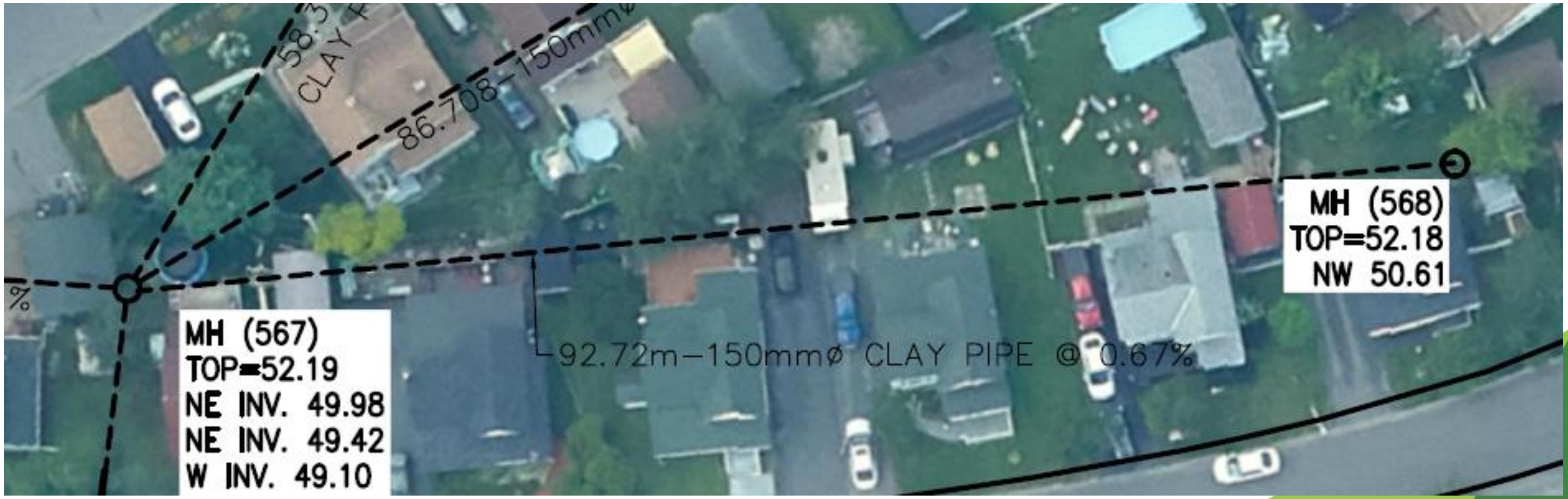
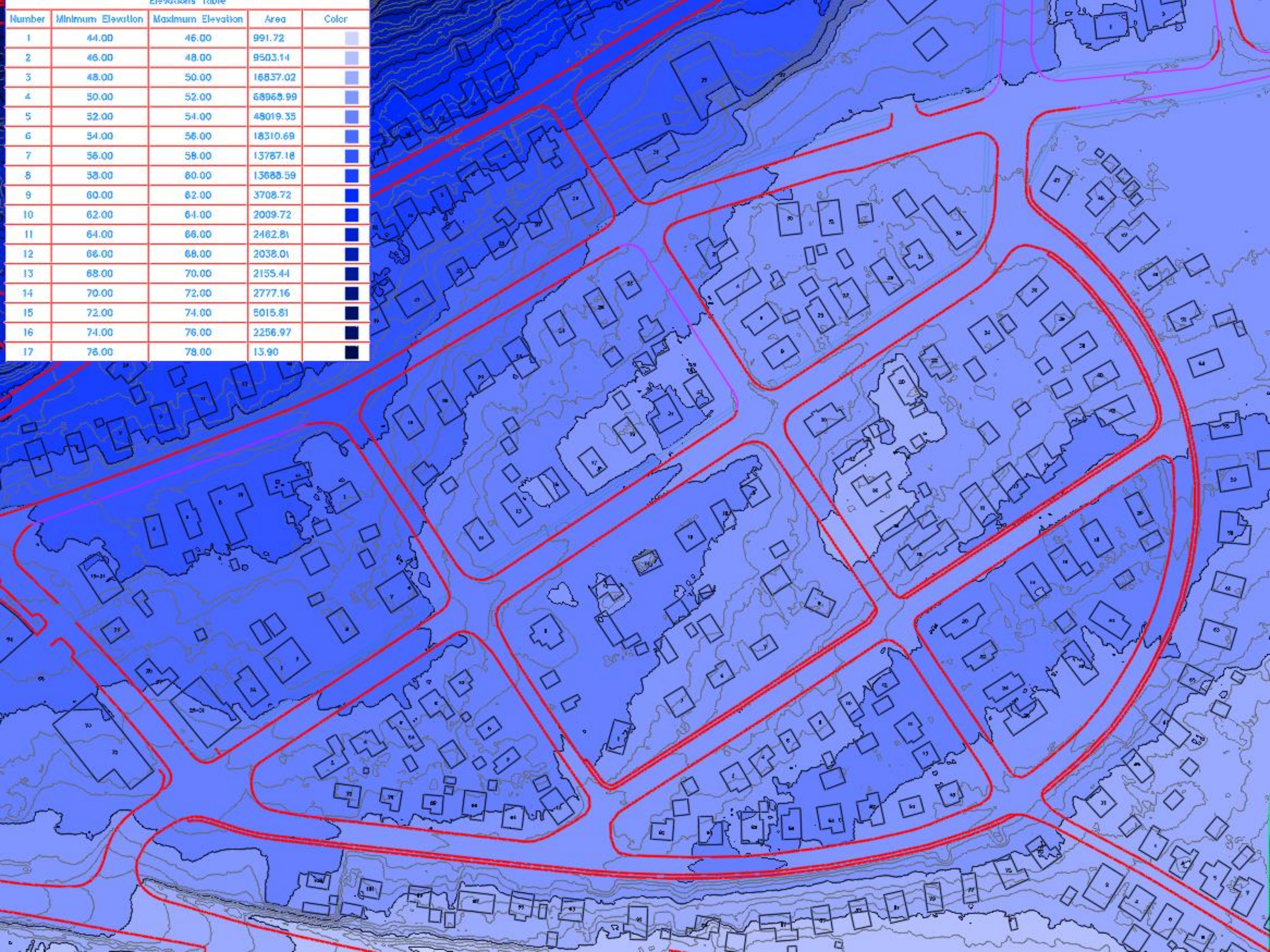
Existing Alignment Example

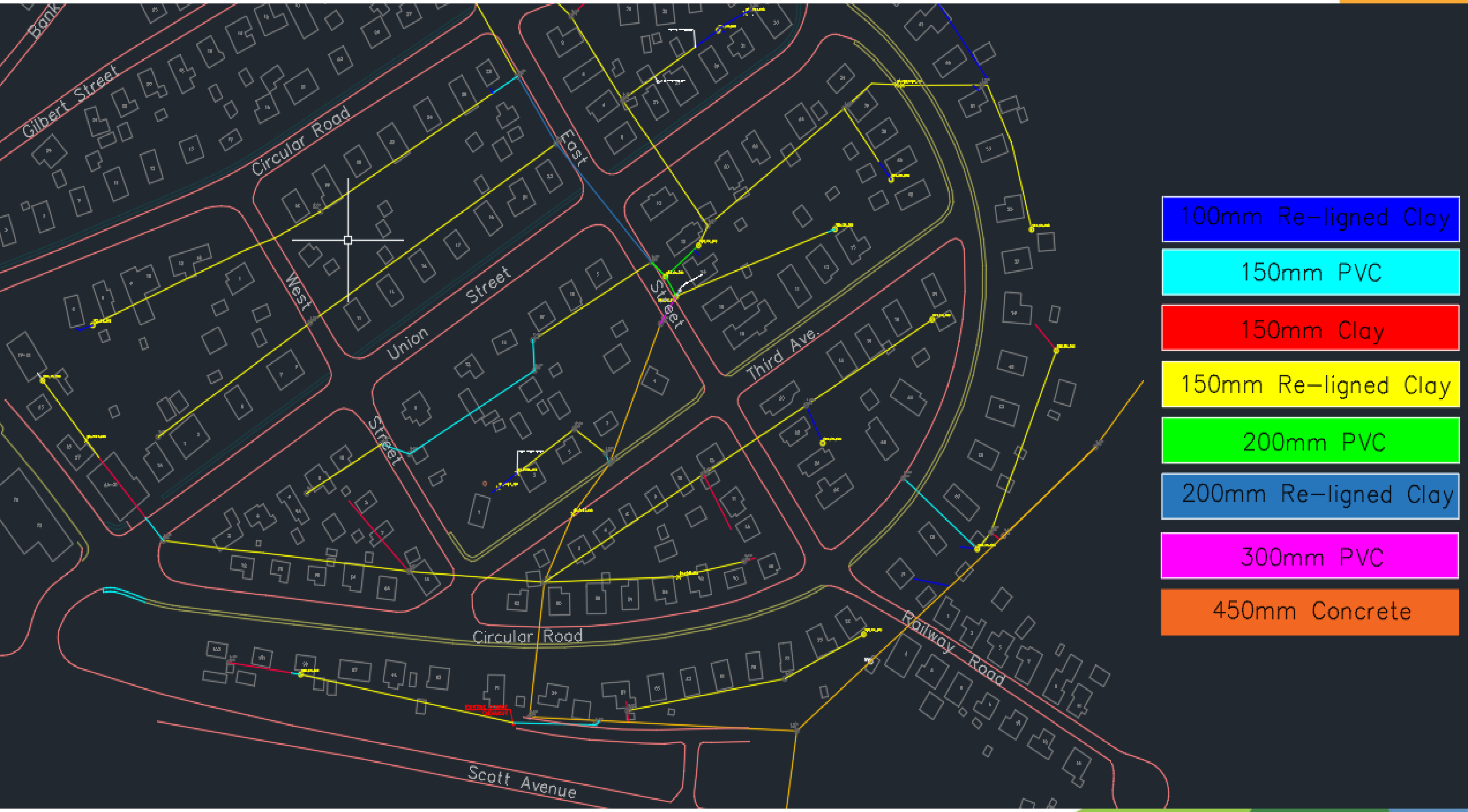


Elevations Table

Number	Minimum Elevation	Maximum Elevation	Area	Color
1	44.00	46.00	991.72	
2	46.00	48.00	9503.14	
3	48.00	50.00	16837.02	
4	50.00	52.00	68968.99	
5	52.00	54.00	48019.35	
6	54.00	56.00	18310.69	
7	56.00	58.00	13787.18	
8	58.00	60.00	13688.59	
9	60.00	62.00	3708.72	
10	62.00	64.00	2009.72	
11	64.00	66.00	2462.81	
12	66.00	68.00	2038.01	
13	68.00	70.00	2155.44	
14	70.00	72.00	2777.16	
15	72.00	74.00	5015.81	
16	74.00	76.00	2256.97	
17	76.00	78.00	13.90	



CIPP Scope of Work



Project Description

- Project funded under ICIP – 17-GI-22-00034
- Total funding was $3,489,067 HST included
  - Water, storm and CIPP sanitary repairs in the Circular Road area. Work remaining for 2024.
  - 90-year-old clay sewer lines
  - Project broken into three separate tenders and a PCA for engineering services.
    - AllNorth Consulting - $83,000
    - Afonso Contracting - $1,410,000
    - ANW Contracting - $1,008,000
    - Paving - $265,000

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CIPP Process

- Clean & complete CCTV of existing pipe
- Clean host pipe – remove root intrusion, grease, debris buildup and trim services.
- Setup bypass for flow & communication
- Install CIPP liner – pull-in-place or inversion
- Cure the CIPP – steam, hot water or UV light
- Reinstate the service connections
- CCTV camera of final product & QA samples
- CCTV 1-year warranty inspection

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Camera Equipment

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CCTV Pre-Inspection

CCTV Pre-Inspection

CCTV Pre-Inspection

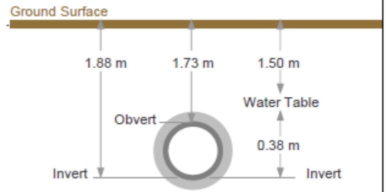
Design – Fully Deteriorated

PROGRESSIVE ENGINEERING & CONSULTING **CIPP-DESIGN**

CIPP Liner Thickness for Non-Pressure Pipes
By ASTM F1216-16 Appendix X1 Design Method

PROJECT INFORMATION **Design Date:** Jul 13, 2023

MH 531 to MH 577
Section 1



Existing Pipe: 150 mm ID; Ovality: 3%
Fully Deteriorated Design
Required Liner Thickness: 2.5 mm

EXISTING PIPE PARAMETERS	ENTERED	CIPP liner design by Appendix X1 method of ASTM F1216-16		
Existing Pipe Condition	Fully Det.	**KEY FACTORS: FULLY DETERIORATED CONDITION DESIGN**		
Inside Diameter, D	150 mm	Flexural Modulus, E, 50 Year Design	862.0 MPa	50% of Es
Depth to Invert	1.88 m	Flexural Strength, σ, 50 Year Design	15.50 MPa	50% of σs
Water Table below Surface	1.5 m	Minimum Dia for host pipe	146 mm	For 3% ovality
Ovality of Existing Pipe, Δ	3%	Maximum Dia for host pipe	155 mm	For 3% ovality
Soil Density, w (2000 Kg/m3)	19.61 KN/m3	Ovality Reduction Factor, C	0.764	For 3% ovality
Soil Modulus, E's	6.9 MPa	Water Buoyancy Factor, Rw	0.956	
Live Load Used	HS-20	Coeff of Elastic Support, B'	0.2654	
Other Load	0 kPa	Water Pressure, Invert	0.0037 MPa	0.380 m Head
CIPP LINER PARAMETERS	ENTERED	**Total Design Pressure, P, Invert**	**0.0037 MPa**	**For X1.1 & X1.2**
Design Life	50 Years	Water Pressure, Obvert	0.0023 MPa	0.230 m Head
Flexural Modulus Short-term Test, Es	1724 MPa	Soil Pressure, Obvert	0.0324 MPa	1.730 m Cover
% of Es used for 50 Year Design E	50%	Live Load Pressure Ws, Obvert	0.0108 MPa	Note 1
Flexural Strength Short-term Test, σs	31 MPa	Other Load Pressure, Obvert	0.0000 MPa	
% of σs used for 50 Year Design σ	50%	**Total Design Pressure, qt, Obvert**	**0.0455 MPa**	**For X1.3**
Enhancement Factor, K	7	NOTES: E and σ correspond with E_L and $σ_L$ in F1216 Appendix X1		
Poisson's Ratio, ν	0.3	Note 1: AASHTO HS-20. Refer AWWA M11, M23, M55.		
Safety Factor, N	2	Note 2: t based on providing DR ≤ 100. See F1216 Note X1.2		
DESIGN BY ASTM F1216 VERSION	F1216-16			

FULLY DETERIORATED DESIGN REQUIRES CIPP THICKNESS SATISFY F1216-X1 EQUATIONS X1.1, X1.2, X1.3 & X1.4

Equation		Required t mm	Required t in	Required DR
X1.1: P = [2KE/(1-v^2)] x [1/(DR-1)^3] x [C/N] For load at invert due to groundwater hydrostatic pressure		1.5 mm Note 2	0.059 in Note 2	100.0 Note 2
X1.2: (1.5Δ/100)(1+Δ/100)(DR)^2-0.5(1+Δ/100)DR=σ/(PN) For minimum thickness for ovality		0.7 mm	0.028 in	214.3
X1.3: qt=[1/N] x [32 x Rw x B' x E's x C x (E x I/D^3)]^(1/2) For load at obvert due to groundwater, soil & live loads		2.1 mm	0.083 in	71.4
X1.4:(Es x I)/D^3 = Es/[12(DR^3)] ≥ 0.00064 For minimum CIPP liner stiffness	Governs	2.5 mm	0.098 in	60.0
Required in Place Liner Thickness - Fully Deteriorated		**2.5 mm**	**0.098 in**	**60.0**

t mm is rounded-up to 1 decimal place; t in = t mm/25.4; DR = (Inside Diameter mm)/(t mm) NA - Not Available/Applicable

Liner Sample Test Requirements Are: Es ≥ 1724 MPa (ASTM D790); σs ≥ 31 MPa (ASTM D790); Thickness ≥ 2.5 mm (ASTM D5813).
If test results are at variance, other combinations of properties and thickness can provide required liner performance. Reconcile design.

PARAMETERS FOR FLOW COMPARISON		FLOW COMPARISON FOR 2.5 mm LINER	
Liner thickness for flow comparison	2.5 mm	Inside Diameter before Lining	150 mm
Manning n used for before lining	0.0120	Inside Diameter after Lining	145 mm
Manning n used for after lining	0.0100	Flow Capacity after Lining	110% of before lining flow

COMMENTS

- Required ASTM F1216-16 Appendix X-1 Design
- Fully Deteriorated
- 50-year design life
- Majority 2.5 mm liners
- Flow capacity
- ~20-30% thicker liner compared to partially deteriorated design.

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Heavy Root Intrusion

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Root Cutting Equipment

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Pull in Place & Inversion

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Hot Water Curing

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Hot Water Curing

- All 100 mm pipes were wetted with epoxy on-site and cured with hot water.
- Epoxy lining designed for shorter runs (~50m)
- 1-3 hour curing time
- Disadvantage is they must be used installed and cured quickly.

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Steam Curing

Steam Curing

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Steam Curing

- Liners were ordered from New Jersey already pre-wetted with resin and kept on ice.
- Kept in refrigeration truck out of sunlight.
- Curing is 90 minutes at 130 degrees Fahrenheit with 30-minute cool down.
- Pressure varies 8 – 12 psi.
- 3 thermocouples in place measuring temps.

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Reinstate Service Connections

REINSTATEMENT CUTTER

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CCTV Camera (Post)

CCTV Camera (Post)

CCTV Camera (Post)

QA Testing

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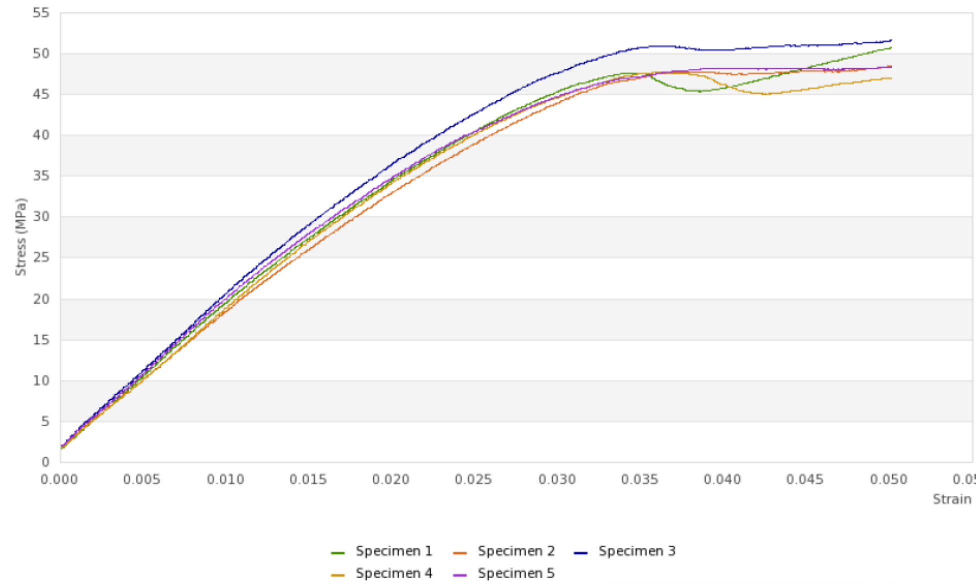
QA Testing


GFW
Section 28
6"Ø
MH 12 - 557
7/31 2023
AFGV5000.0.3
OCT-10, 2023


Stress (MPa)
0
5
10
15
20
25
30
35
40
45
50
55
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
0.055
Strain
Specimen 1
Specimen 2
Specimen 3
Specimen 4
Specimen 5

QA Testing

PARAGON SYSTEMS

LABORATORY REPORT

Paragon Systems Testing
18 Basaltic Road
Concord Ontario, Canada, L4K 1G6
Tel: (905) 738-0447 Fax: (905) 738-565

TS 4.10 Liner Sample Test Results - Reconciliation and Deficiency Evaluation Matrix

Test Results	Units	Test Results (from page 1)	Properties Required per Design (Note 1,3)	Test Results vs Design	Required Thickness At Test Properties (RTATP) (Note 2, 3)	Reconciliation Outcome
Short Term Flexural Modulus	MPa	1,780	1,720	Acceptable	—	None
Short Term Flexural Strength	MPa	48.4	31.0	Acceptable	—	None
Thickness (avg)	mm	3.2	2.5	Acceptable	—	None
Thickness (min)	mm	2.9	2.2	Acceptable	—	None
					Overall Sample Status	NOT DEFICIENT

Project Challenges

- Resin curing - smell complaints (plastic).
- ~2% homes had toilet issue during cleaning.
- 13 pits (distance, size change or joint offsets).
- Small manholes and site access difficult.
- Sags too great in three locations to complete.
- Roots excessive in one line.
- One line with protruding cast iron services.
- One liner failed resulting in sewer backup.

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Conclusion

- Approx. 165 homes with relined sewer main.
- Approx. 2.4 km of rehabilitated infrastructure.
- Challenges encountered but successful project
- QA testing results were satisfactory.
- Experienced gained by Town staff.
- Significantly lower disturbance option.
- Contractor great to work with.

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