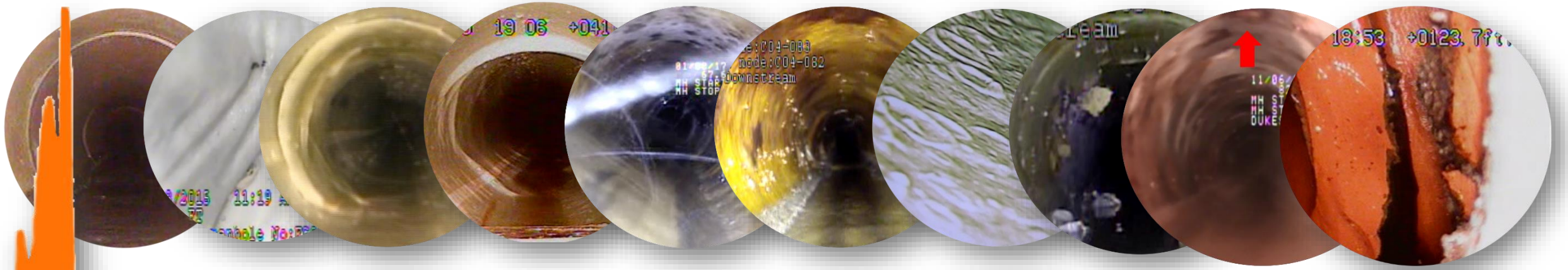
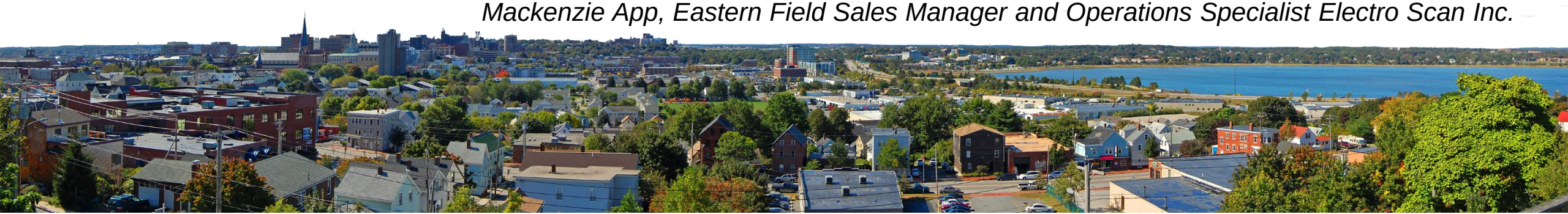


New Standards to Find & Measure Infiltration and Test & Certify Cured-In-Place Pipe (CIPP)

Mackenzie App, Eastern Field Sales Manager and Operations Specialist Electro Scan Inc.



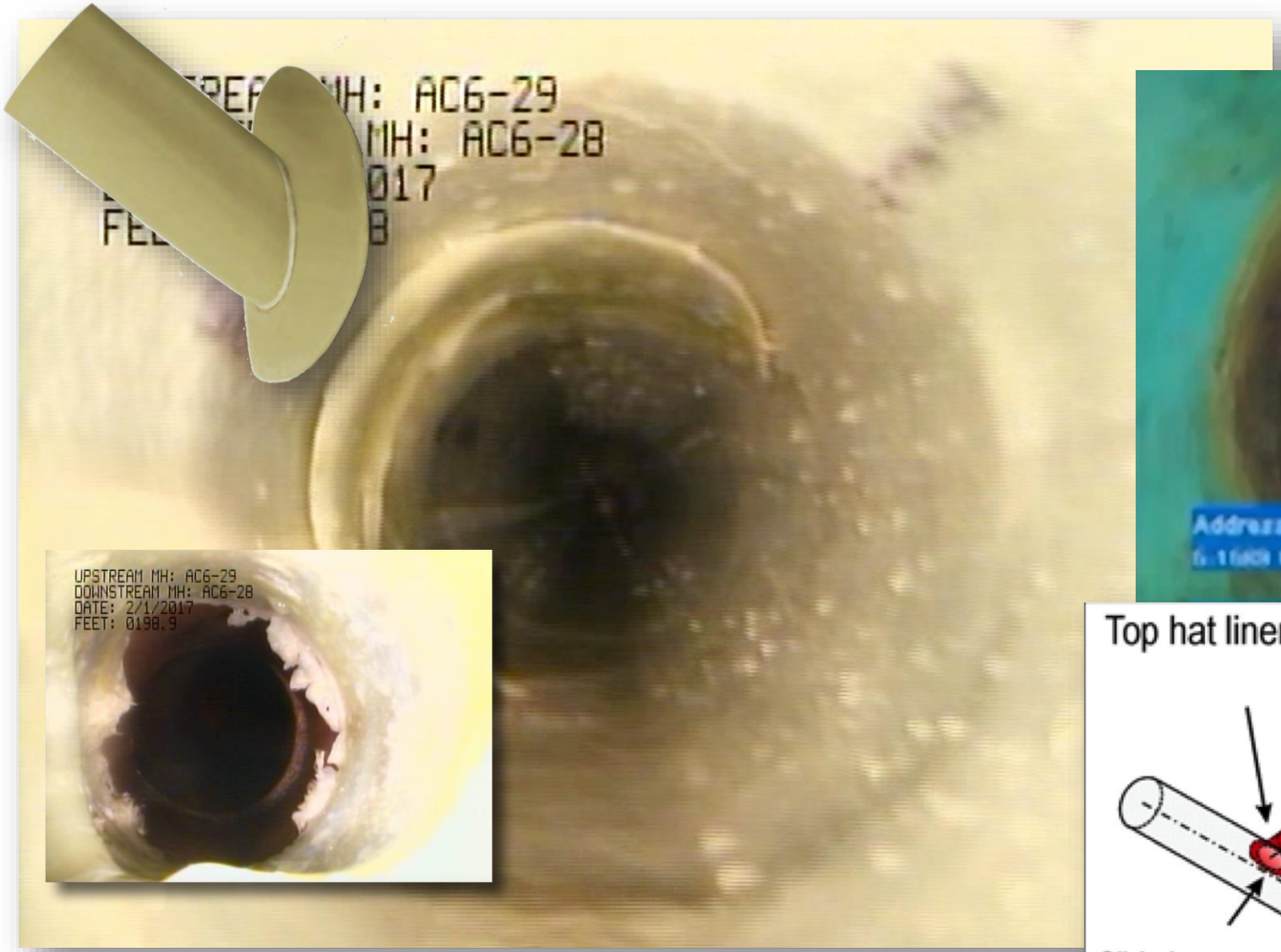
New Standards for Testing & Certifying Cured-In-Place Pipe (CIPP) As Watertight

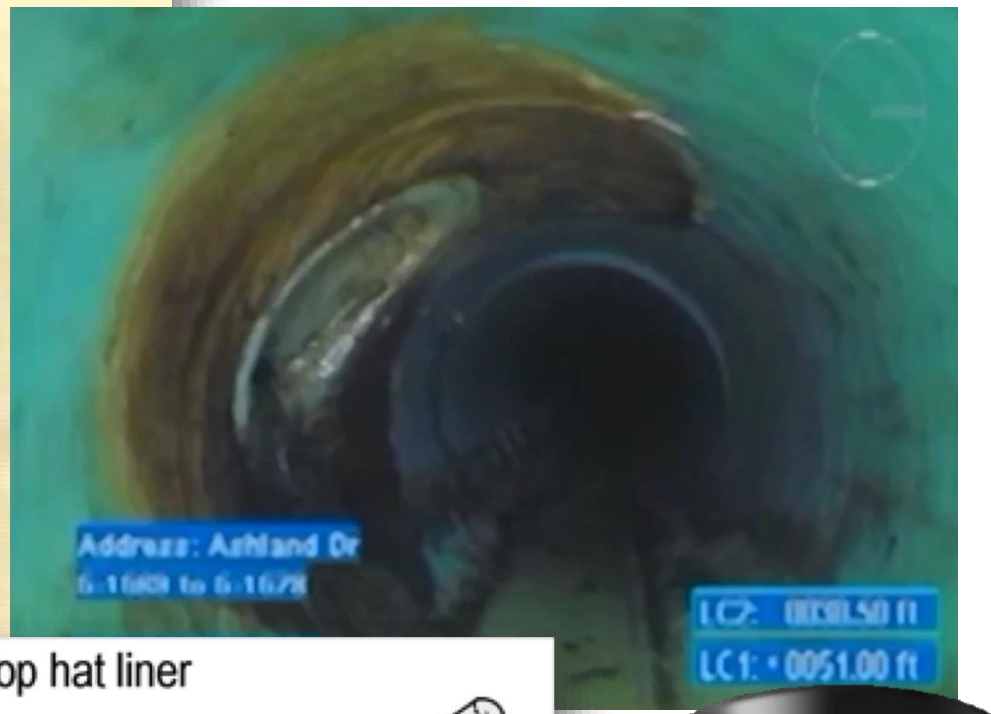
1. Introduction
2. What the FELL?
3. Case Studies
4. Wrap-Up

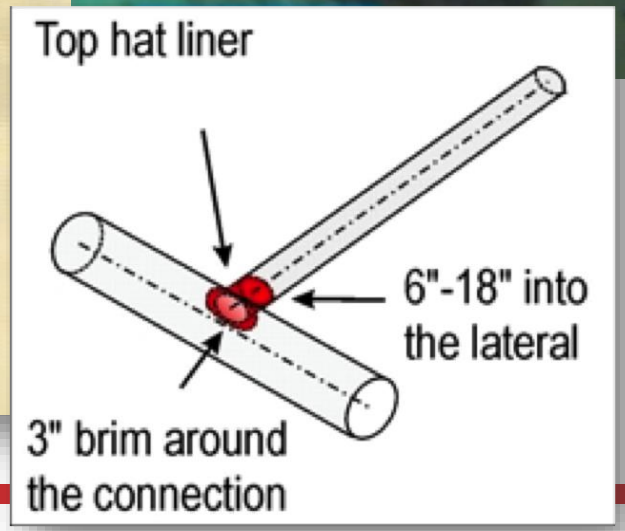
Part 1

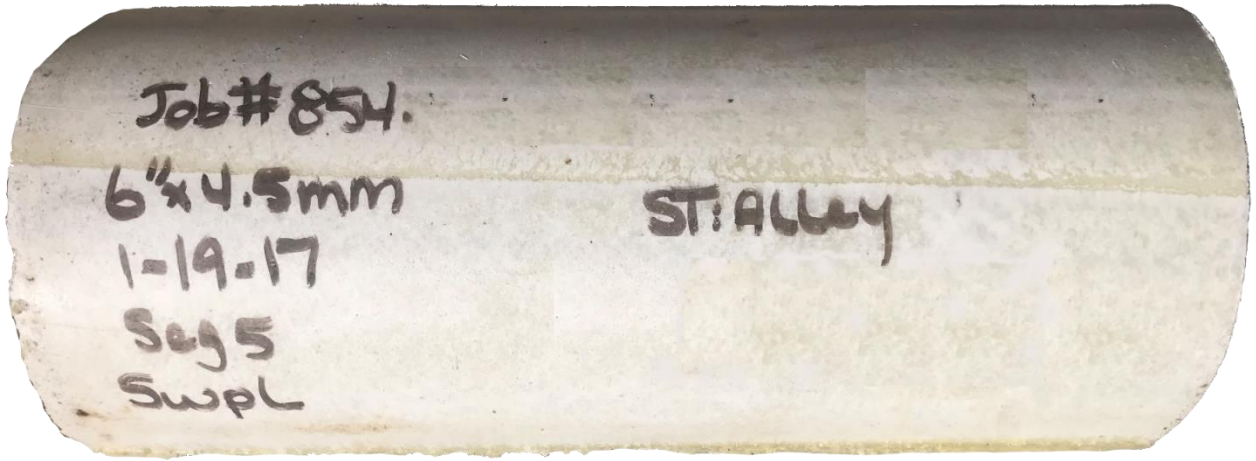

LIVE
BREAKING
NEWS
BREAKING NEWS
Failed Trenchless UV-Liner Causes Massive Flooding
Homeowners Evacuated as Contractor to be Held Responsible
LIVE
BRK
Heavy Rain Cause 50ft Section of Newly Installed Sewer to Backup Into Million Dollar Homes

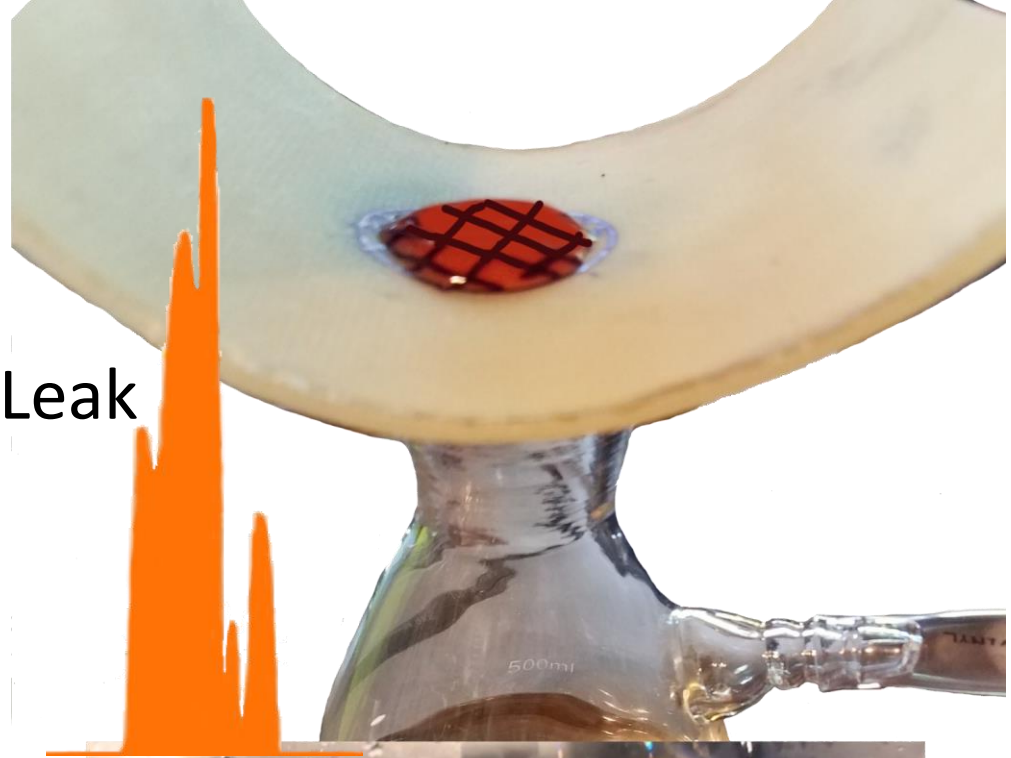
Defective Sewer Lateral Connections









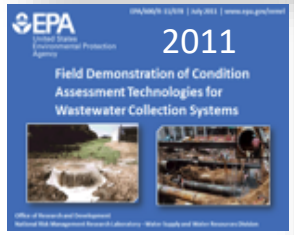


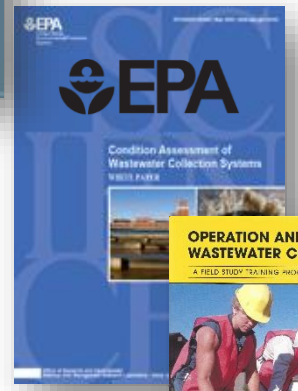
Leak

Soakage

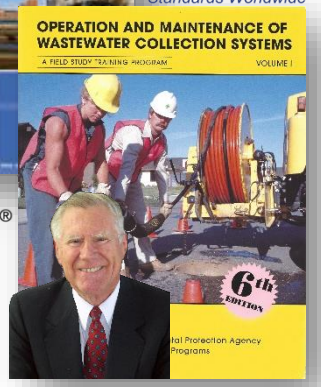
Milestones of New Acceptance Standards

2004	**WERF Study** – An Examination of Innovative Methods Used in the Inspection of Wastewater Systems, Focused Electrode Leak Location System (Fell-41).
2006	**ASTM F2550-06 Approved** – First Presentations at ASCE Pipeline Conference.
2009	**Condition Assessment of Wastewater Collection Systems** EPA/600/R-09/049, 4.3.1 Electrical Leak Location Method, published.
2010	**State of Technology for Rehabilitation of Wastewater Collection Systems –** EPA/600R-10/078, including FELL is published. Ken Kerri contacts Chuck Hansen.
2011	**USEPA Field Demonstration** – Condition Assessment Technologies for Wastewater Collection Systems. First benchmarking CCTV and FELL.
2013	**ASTM F2550-13 Approved** – Added recommendation for scanning all Pre- and Post-Rehabilitation, including Cured-In-Place Pipe. **NASTT Best New Product Award; WEF Best Innovation Award**
2014	Ken Kerri, PhD, PE Updates **O&M Wastewater Collection Systems** manual. FELL added to first EPA Consent Decree (EBMUD).
2015	**Adoption by UK-basedWRc** – Developers of NASSCO CCTVV Codes.
2017	Japan Sewer Collection System Maintenance Association (**JASCOMA**), Certification for Water Tightness.
2018	**AWWA M77 Standard & ASTM F2550-13 (2018) Reapproved.** Condition Assessment of Water Mains, Includes FELL.
2019	**IKT** (Germany) expected to publish CIPP research study that utilizes FELL.





ASTM INTERNATIONAL
Standards Worldwide



NASTT 2013 wef®

EPA 2014
United States Environmental Protection Agency

2015
wrc
United Kingdom

WATER ENVIRONMENT & REUSE FOUNDATION
WE&RF

JASCOMA
Japan

AWWA

IKT
Germany

Designation: ASTM F2550-13 (2018)

Standard Practice for Locating Leaks in Sewer Pipes By Measuring the Variation of Electric Current Flow Through the Pipe Wall[1]

This standard is issued under the fixed designation F2550; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

Infiltration of groundwater into a sewer through defects in the pipe can considerably increase the operation and capital costs of a sewer system. Exfiltration of sewage out of a sewer pipe may cause degradation of aquifers and shoreline waters. Accurate location, measurement, and characterization of all potential pipe leak defects are essential inputs for cost-effective design, testing, and certification of pipe repairs, renewal, and new construction. While commonly used sewer leak assessment methods, such as air and water pressure testing, represent cost effective methods to provide overall Pass/Fail pipe assessments, their inability to provide accurate location and size of leaks, particularly at individual joints and service connection, limit their use in remediation and rehabilitation decision support.

M77 Manual of Practice: Condition Assessment of Water Mains

Chapter **7**

Leak Detection

Low Voltage Conductivity Testing

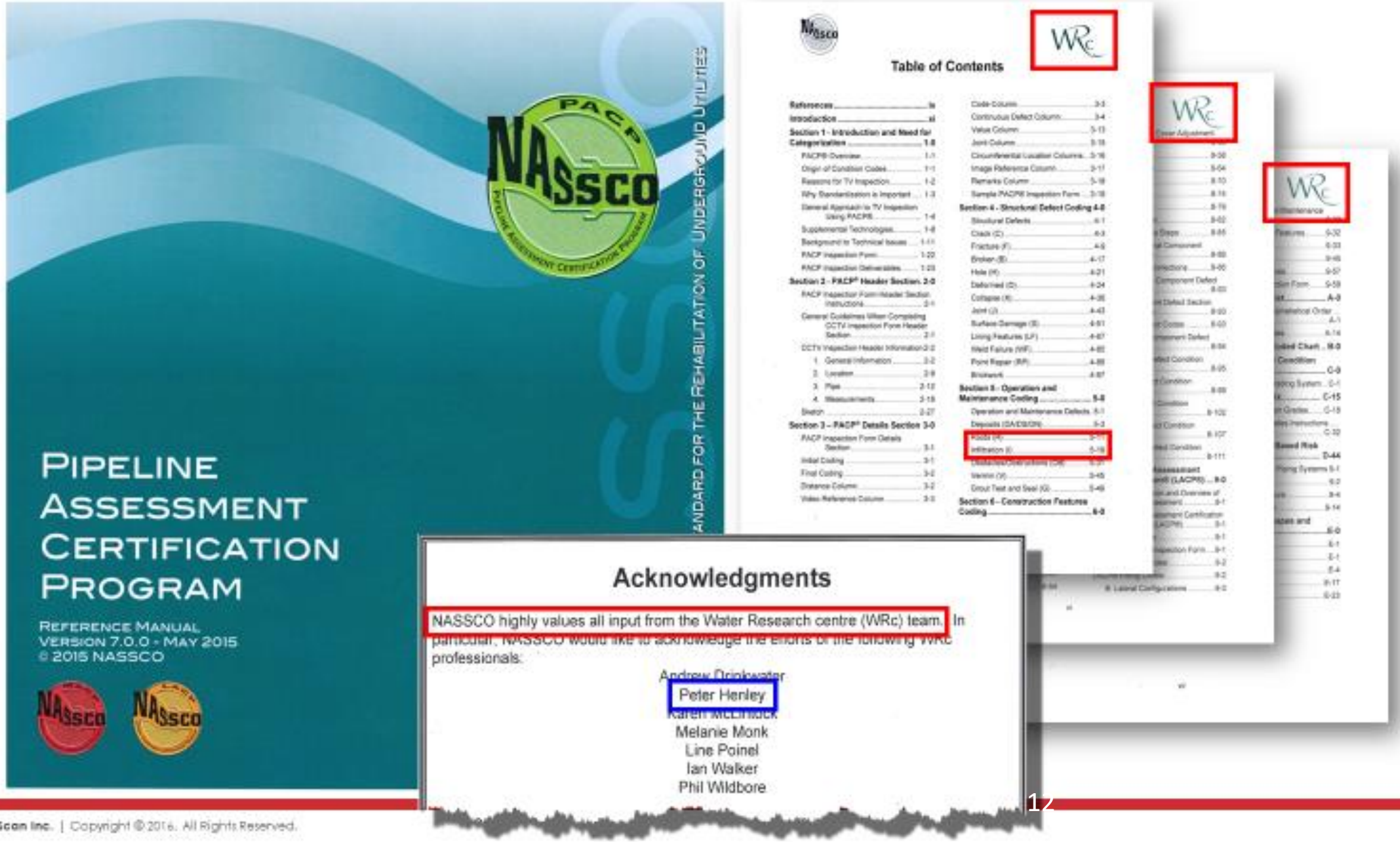
Pipe materials. Since low voltage conductivity testing is based on the difference of the high electrical resistivity properties of the pipe walls (i.e., non-conductive) vs. the low electrical resistivity of the earth surrounding the pipe, non-conductive pipe materials work best with this testing method, including asbestos cement (AC), cured-in-place pipe (CIPP), fiberglass-reinforced pipe (FRP), high-density polyethylene (HDPE), polyvinyl chloride (PVC), and reinforced concrete pipe (RCP).

2018

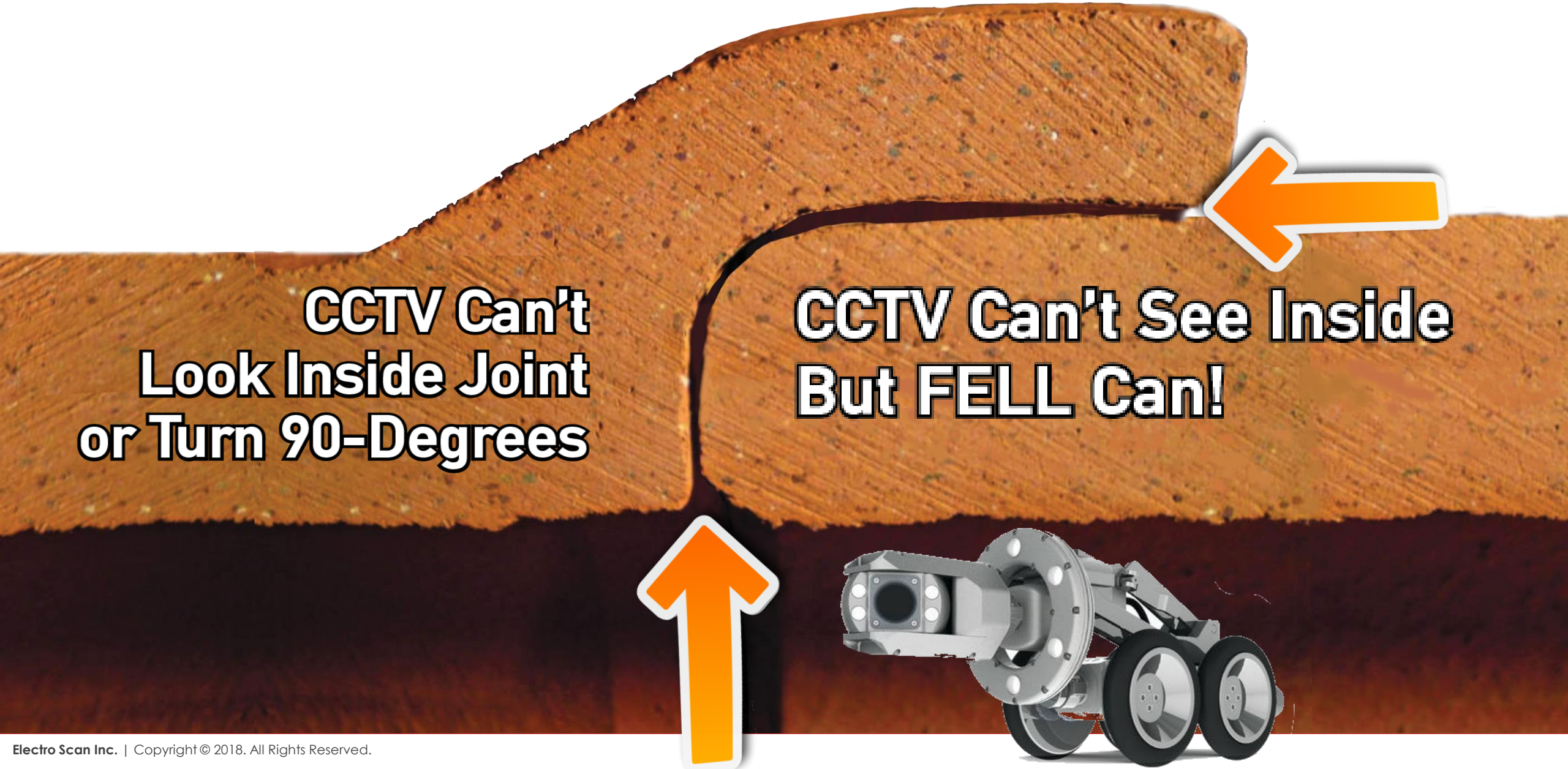
wrc infrastructure developers of NASSCO standards.

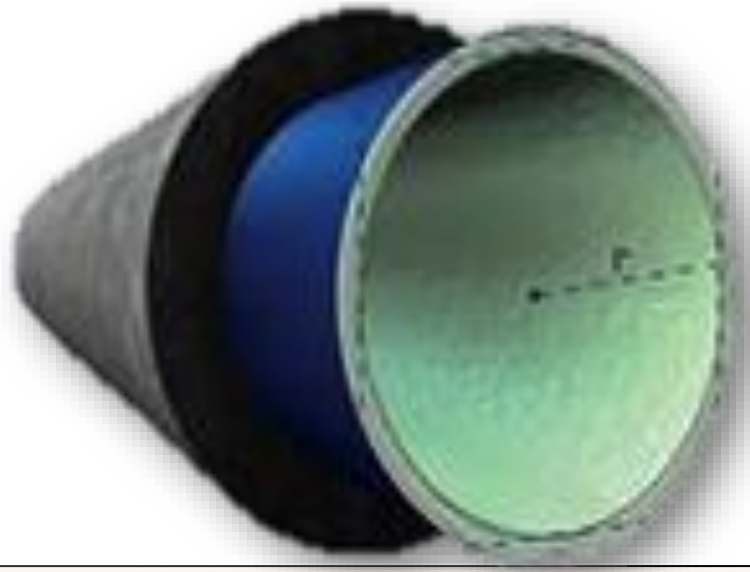
Case Study - Sewer Infiltration Identified and Quantified

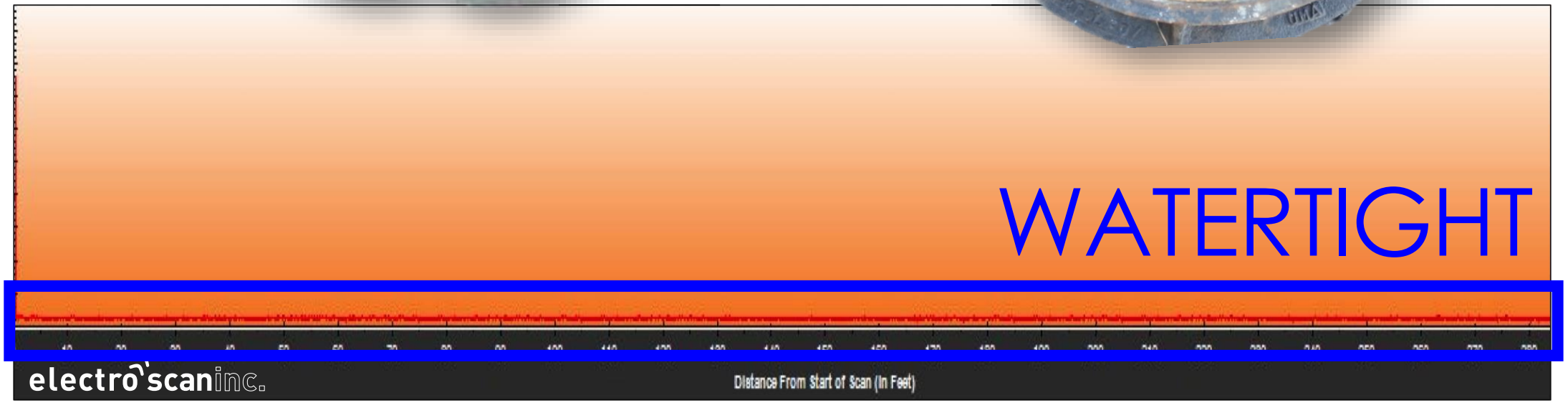
https://www.wrc-infrastructure.co.uk/resources/case-study-sewer-pipe-infiltration-identified-and-quantified/

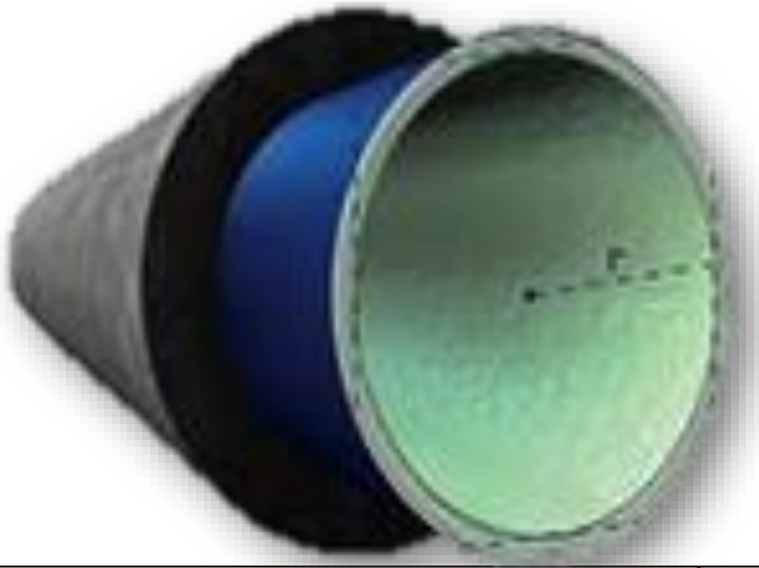


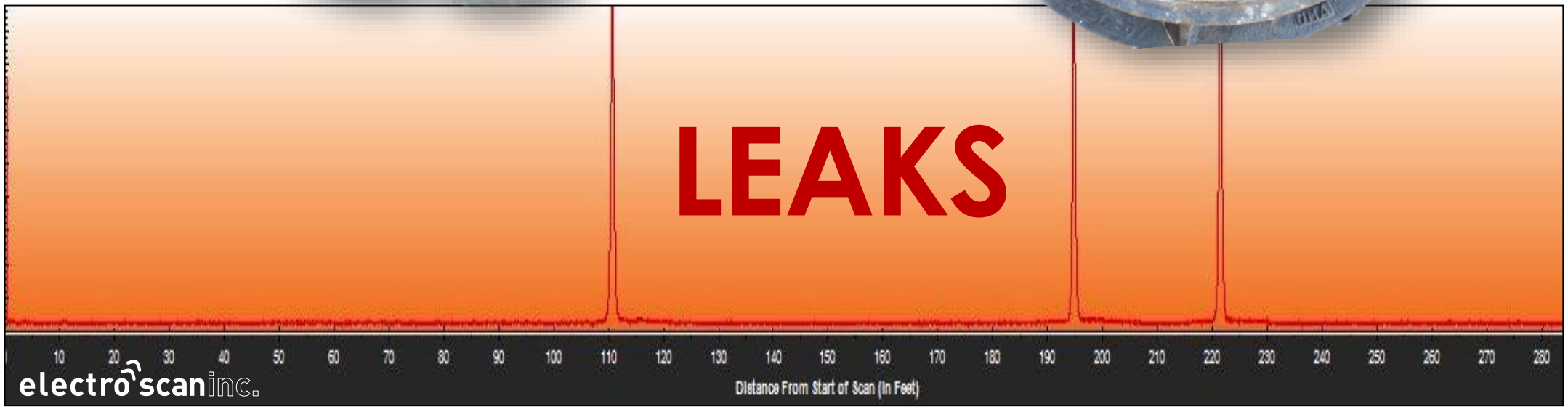
CAMERAS MISS 80-100% OF LEAKS.











Focused Electrode Leak Location (FELL)

Selected Cured-In-Place Pipe Assessments – By CIPP Supplier

+150 CIPP FELL Assessment Projects Over 1 Million Feet

1. **Ace Pipe Cleaning, Inc., Kansas City, MO**
   City of Springfield, MO

2. **ADS-Pipe, Hilliard, OH**
   City of Sacramento, CA (Tiechert Construction)

3. **Advanced Pipe Repair, Inc.**
   Town of Cromwell, CT (Installed 2008)

4. **AM Liner East, Inc., Berryville, VA**
   Bucks County, PA
   New Castle County, DE

5. **Aarsleff Rohrsanierung G**
   Formerly Insituform Ger
   Stuttgart, Germany
   Stadtentwässerung Dres

6. **CIPP Corp., Hudson, IA**
   City of El Segundo, CA (Sancon Engineer
   City of Goldsboro, NC (Tri-State Utilities)
   City of Grand Mound, IA (Municipal Pipe
   City of Hagerstown, MD (Mr. Rehab)
   City of Manassas, VA (Tri-State Utilities)
   City of Newport News, VA (Tri-State Utilit
   City of Oceanside, CA (Sancon Engineering)
   City of San Luis Obispo, CA (Sancon Engineering)
   Iowa Great Lakes Sanitary Dist., IA (Municipal Pip
   Jurupa Community Service District, CA (Sancon
   Spotsylvania County, VA (Tri-State Utilities)
   Village of Lombard, IL (Hoerr Construction)

7. **Danby North America, Inc., Cary, NC**
   Town of Groton, CT (Green Mountain Pipeline S

8. **Granite Construction, Watsonville, CA**
   Formerly Layne Inliner, Liquiforce
   City of Akron, OH
   City of Beachw
   City of Haver
   James City Ser
   Town of Wallin

9. **I Ch**
   City of Columbi
   City of Crystal Lake, IL (2018 Lining Project)
   City of Fayetteville, AR
   City of Grass Valley, CA (Nor Cal / MTC)
   City of North Las Vegas, NV
   Johnston County
   Miami-Dade Water and Sewer Department, FL
   MSD of Buncombe County, NC
   Nashville Metro Water, TN
   istrict, C
   CA (Express Se

10. **R, C A**
    City of Bossier City, LA (PM Construction)

11. **LMK, Ottawa, IL**
    City of Fort Lauderdale, FL
    Harpeth Valley Utility District, TN
    Iowa Great Lakes Sanitary District, IA
    Louisville MSD, KY
    Upper Montgomery Joint Authority, PA

12. **Masterliner, Hammond, LA**
    East Baton Rouge Parish, LA (S&P Liner, LLC)

13. **Michels Corporation, Brownsville, WI**
    City of Madison, WI
    City of Oshkosh, WI (2011 Lining Project)
    ck, NJ

14. **peline, anapolis, IN**
    le, FL

15. **National Lin LLC, Dela**
    OH (Inla habilitation, IPR)
    WI (Visu
    IA (Visu
    WI (Visu- -2014 g Proj
    l (Visu-Se
    (Sout t Pipeli
    City of San Jose, CA (Southwest Pipeline)
    Inland Empire Utilities Agency, CA (RePipe CA. IPR West)
    ity Service District, CA (Southwest ne)
    L

17. **P**
    City of Peoria, AZ

18. **Reline America, Saltville, VA**
    City of Chandler, AZ (Achen Gardner)
    City of Manteca, CA (DownStream Services, Inc.)
    City of Kansas City, MO (Blue Nile)
    Harpeth Valley Utility District, TN (Portland Utility)
    Lower Paxton Township Authority, PA (Abel Recon)
    New Castle County, DE (Abel Recon)

19. **SAK Construction, LLC, O'Fallen, MO**
    City of Manhattan, KS
    City of Monterey, CA
    City of Roseville, CA
    City of Sacramento, CA (PIPEology Inc.)
    City of Santa Barbara, CA
    Pima County, AZ
    Santa Cruz County, CA

20. **Sanipor Vertriegs GmbH, Baden, Austria**
    of Seattle, WA

21. **SAERTEX multiCom, GmbH, Saerbeck, Germany**
    Upper Montgomery J Authority, PA (Precision)

    GA
    Ho

    Terra Contracting, Kalamazoo, MI
    City of East Brunswick, NJ

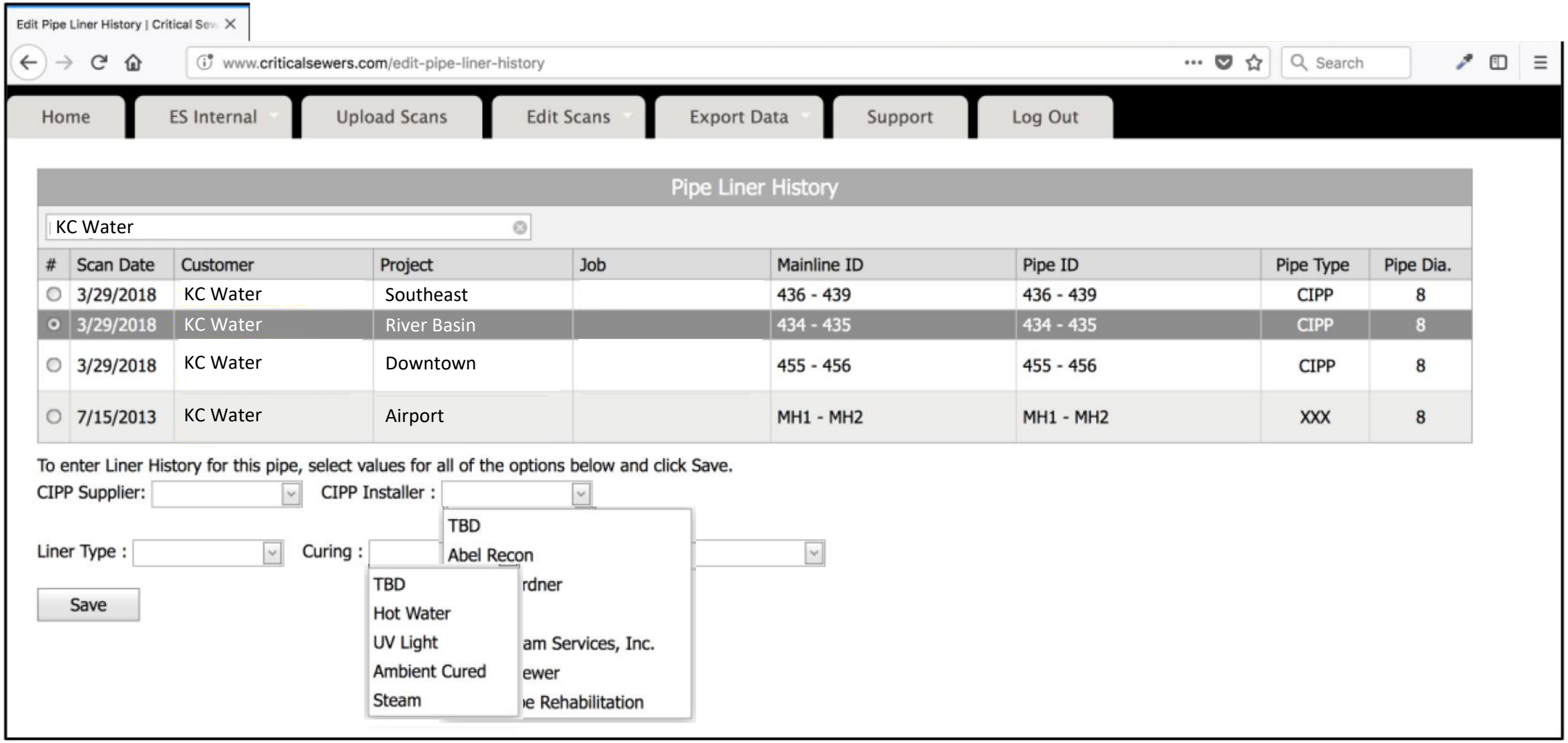
    eden
    River, NJ (National Water Main Co.)

    c., Burnet, TX

    (A division of Suez), Atlanta, GA
    Township of East Brunswick, NJ (Spray-In-Place Pipe, LLC / Warren)

28. **Wildcat Construction, Inc., Colorado Springs, CO**
    City of Aurora, CO (Utility Maintenance Contractors)

CIPP Reporting By Contractor

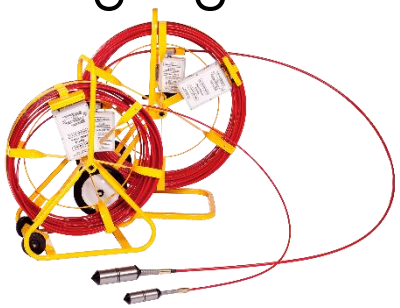


Part 2

What the FELL?

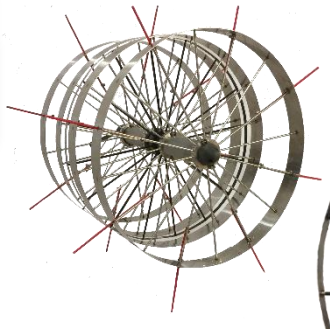
BY PIPE DIAMETER

3''- 8''



6''- 36''

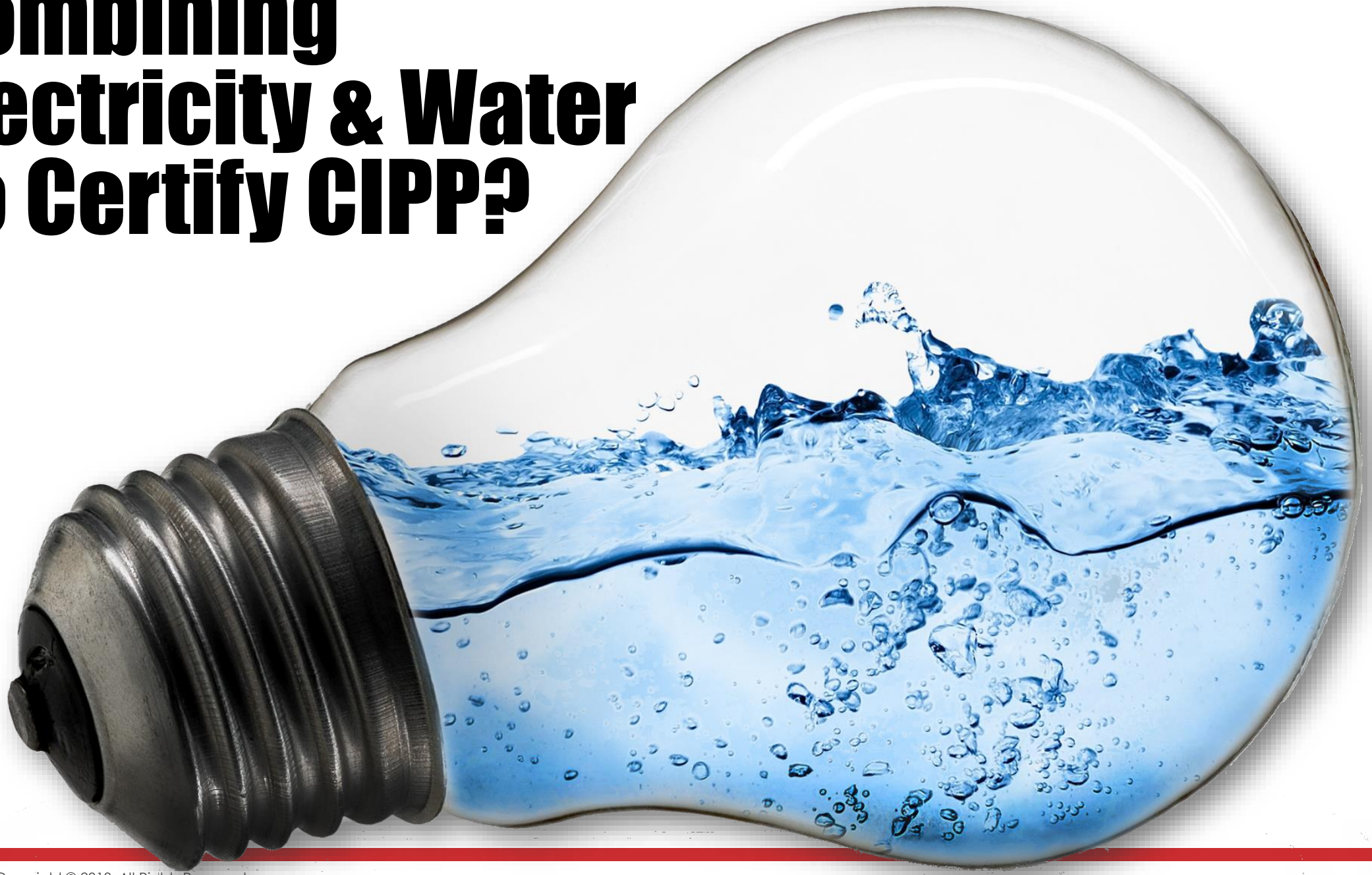
36''- 54''



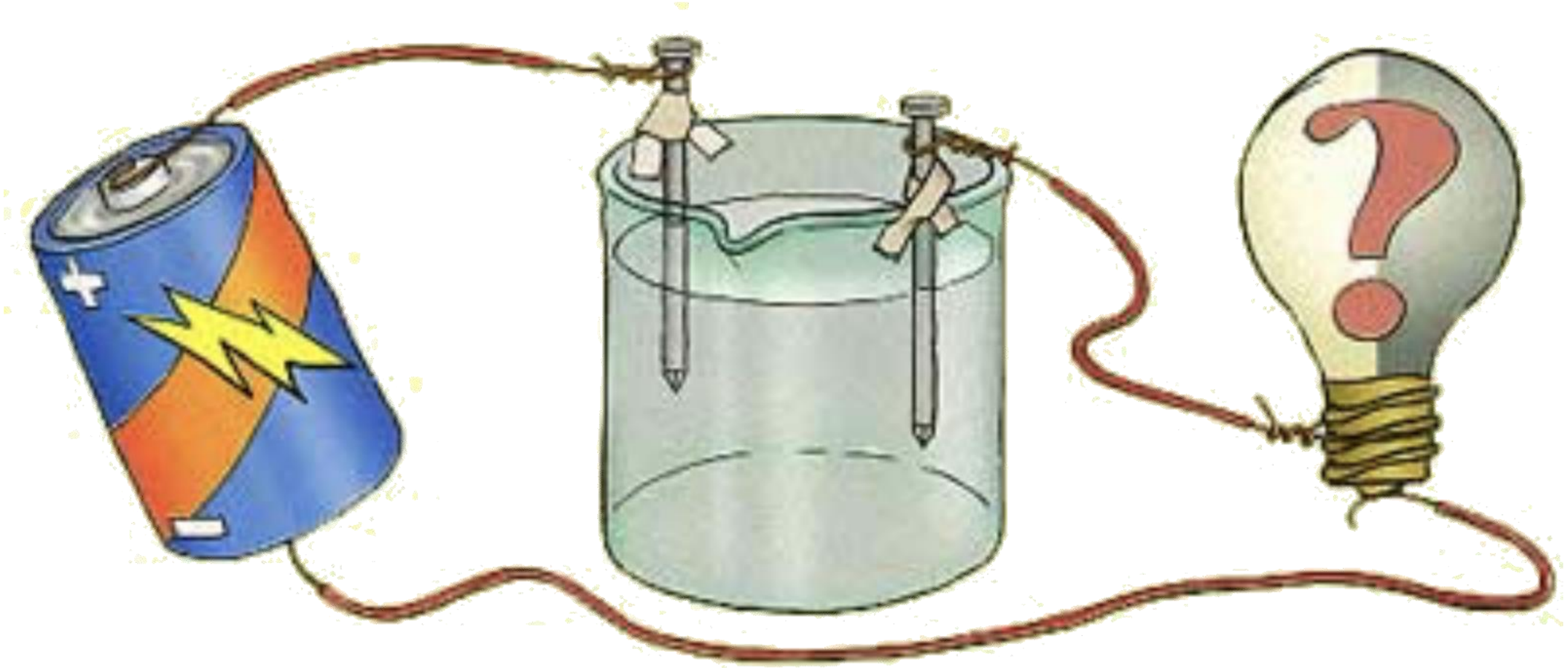
Over 60''

Mobile Unit

Combining Electricity & Water To Certify CIPP?

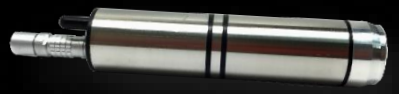


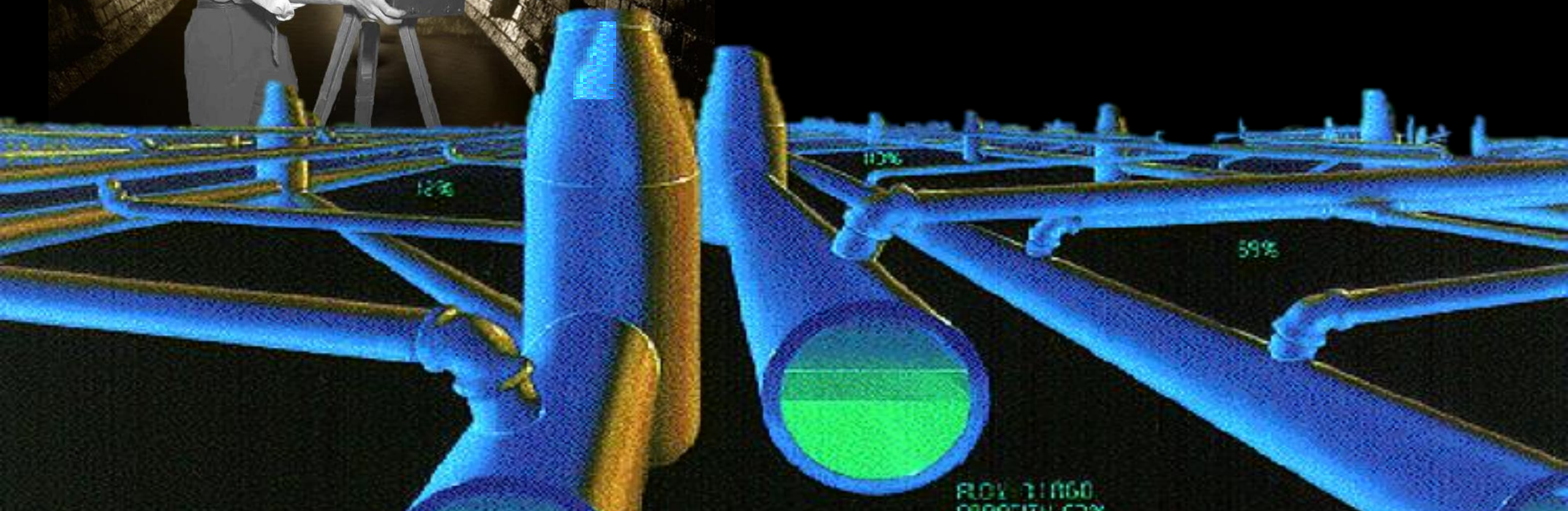
Elementary School



CCTV

FELL

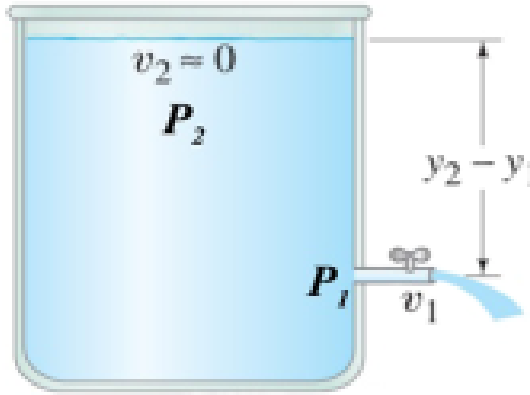




"If a Pipe Leaks Electricity, It Leaks Water."

- Elementary Geophysics

Torricelli's Law



$$v_1 = \sqrt{2g(y_2 - y_1)}$$

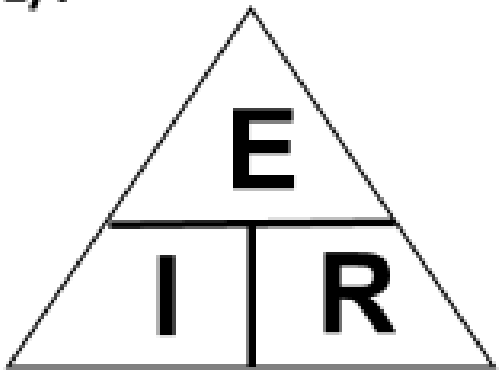
$$P_1 = P_2$$

$$P_1 + (\tfrac{1}{2})\rho(v_1)^2 + \rho g y_1 = P_2 + (\tfrac{1}{2})\rho(v_2)^2 + \rho g y_2$$

Ohm's Law

E = IR ; I = E/R ; R = E/I

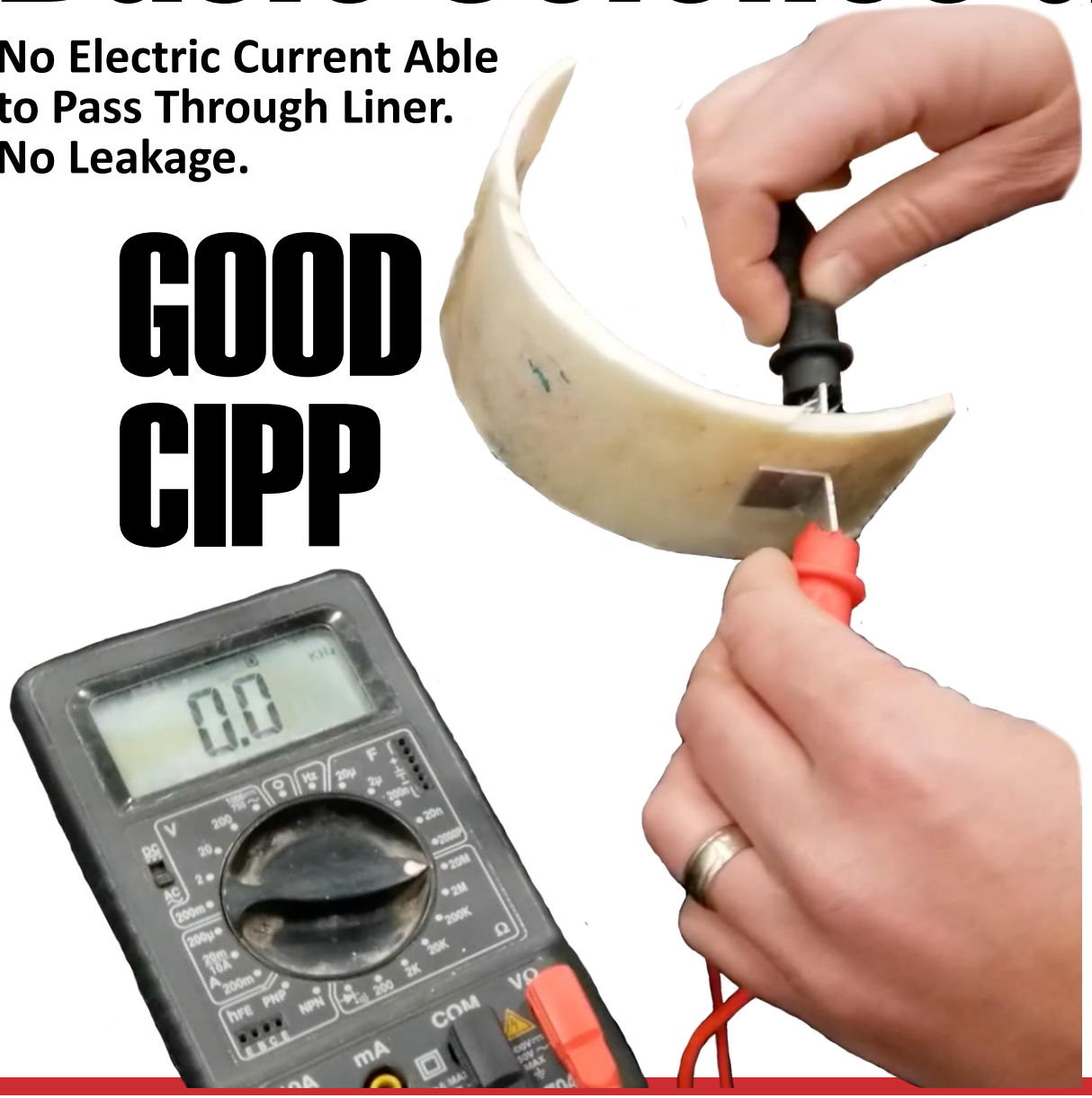
Where:
"E" *volts*
"I" *amps*
"R" *ohms*



Basic Science Ohm's Law

No Electric Current Able to Pass Through Liner. No Leakage.

GOOD CIPP



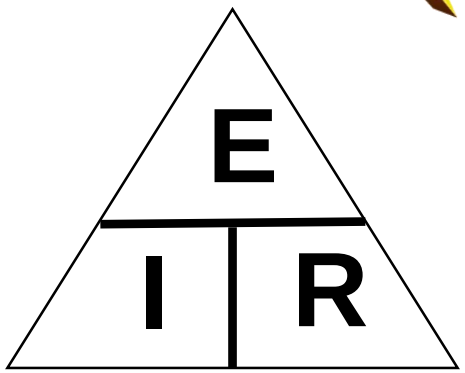
$$E = IR \; ; \; I = E/R \; ; \; R = E/I$$

Where:

"E" ***volts***

"I" ***amps***

"R" ***ohms***



Basic Science Ohms Law

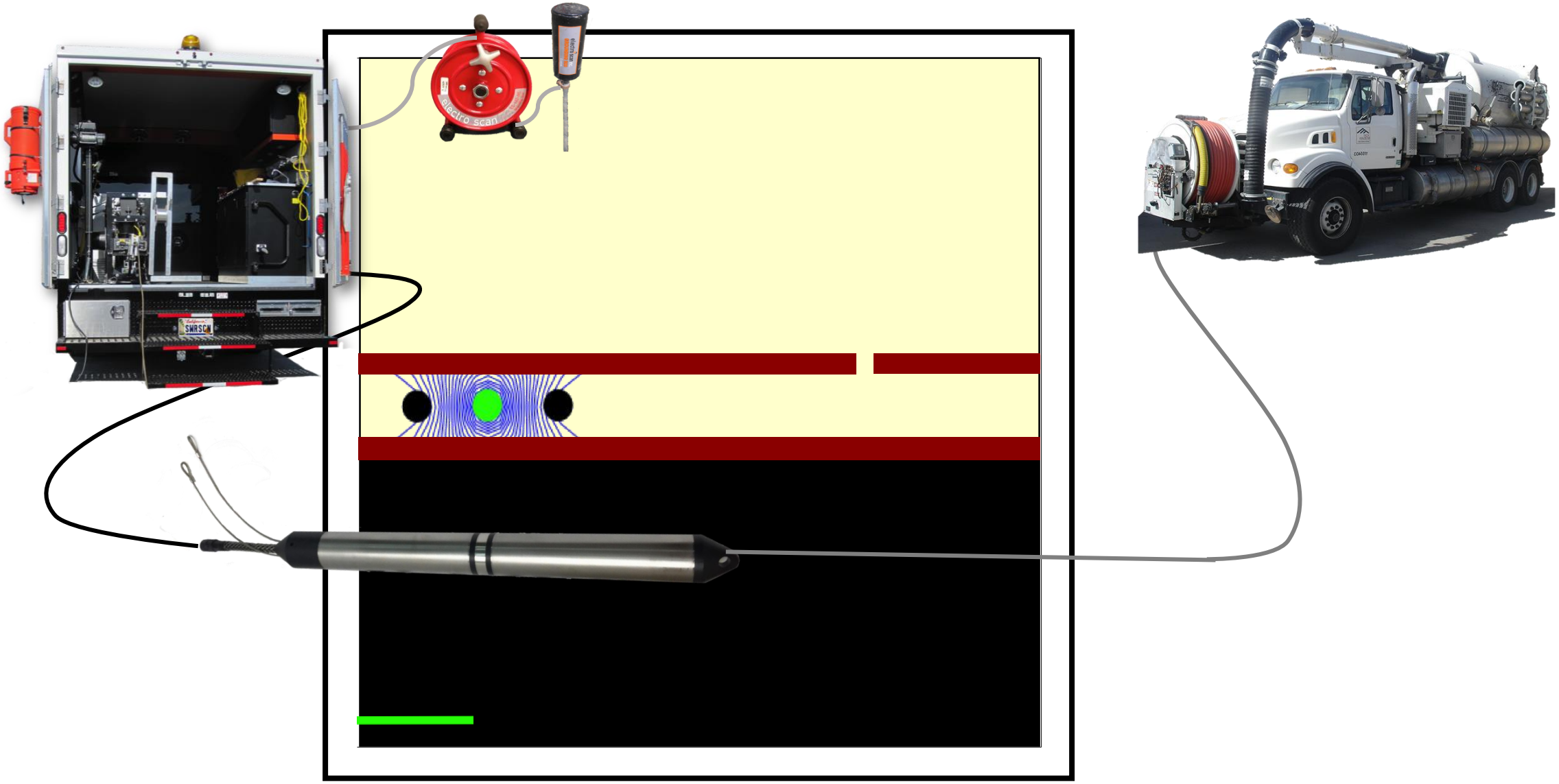
Electric Current Able to Pass
Through Liner Wall.
Leak Located & Measured.

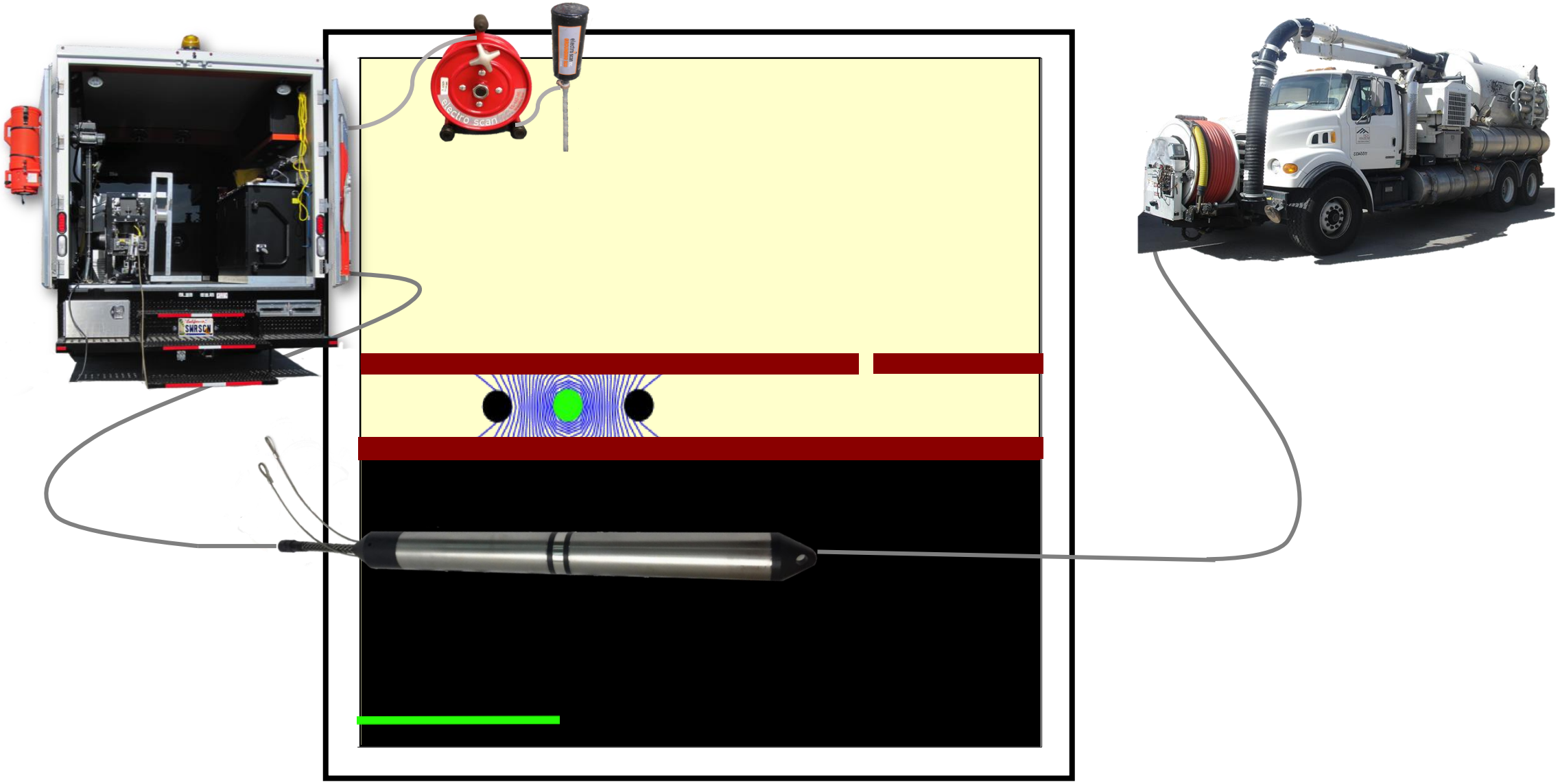
BAD CIPP

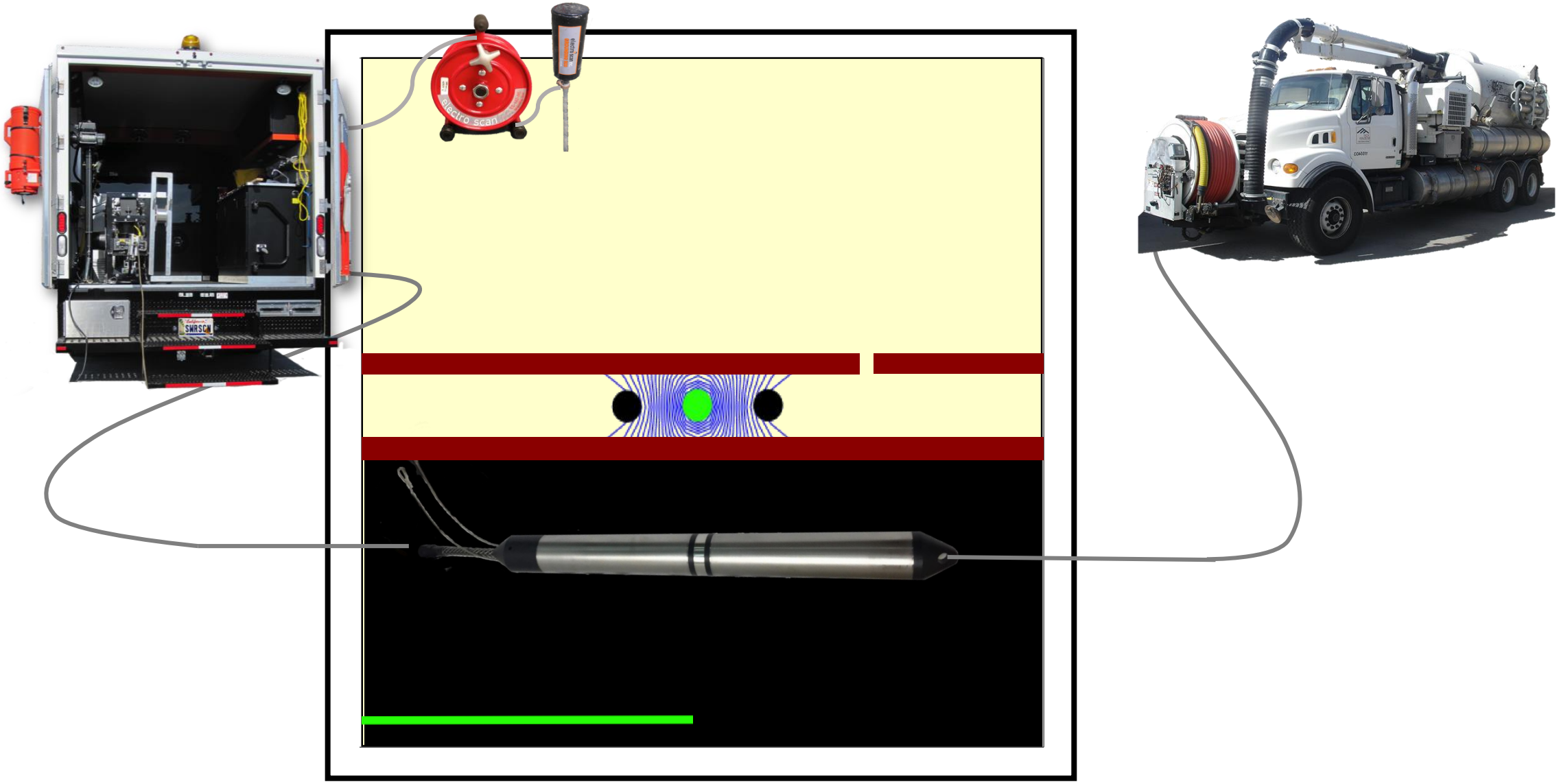
FELL is a 'Holiday' Test...

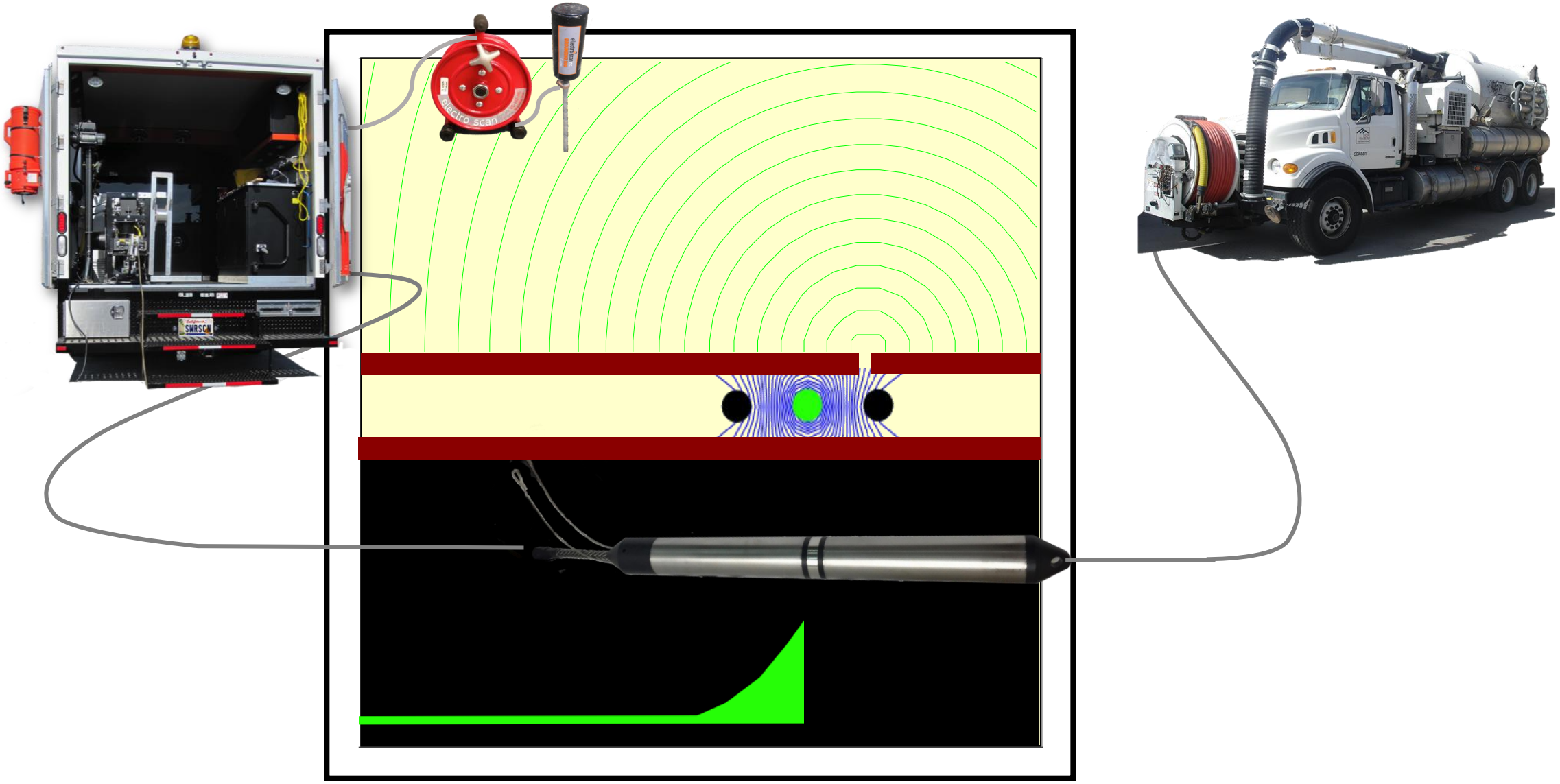
ASTM D5162
ASTM D4787
NACE RP01-88

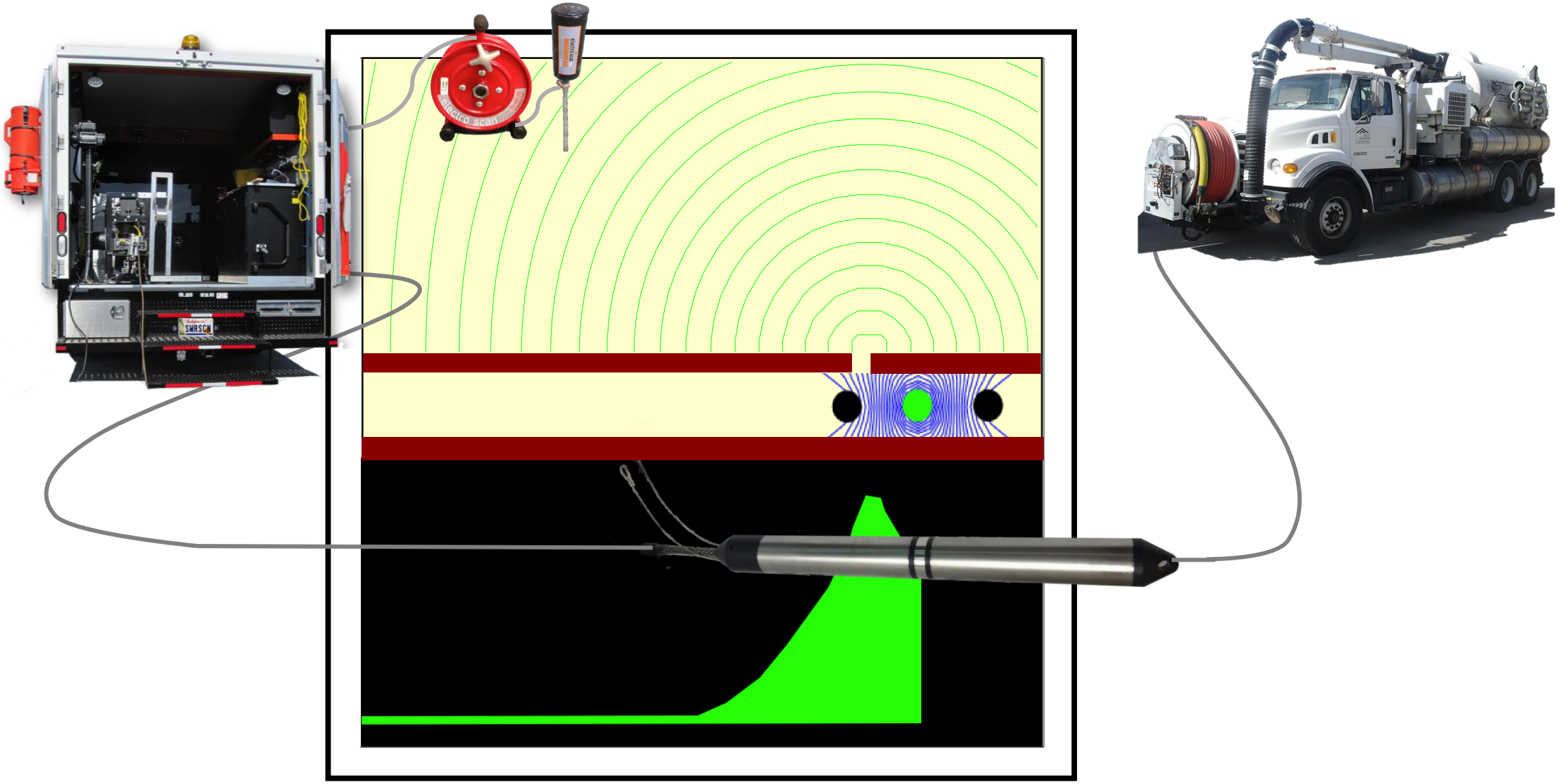
...For Full-Length Pipes.

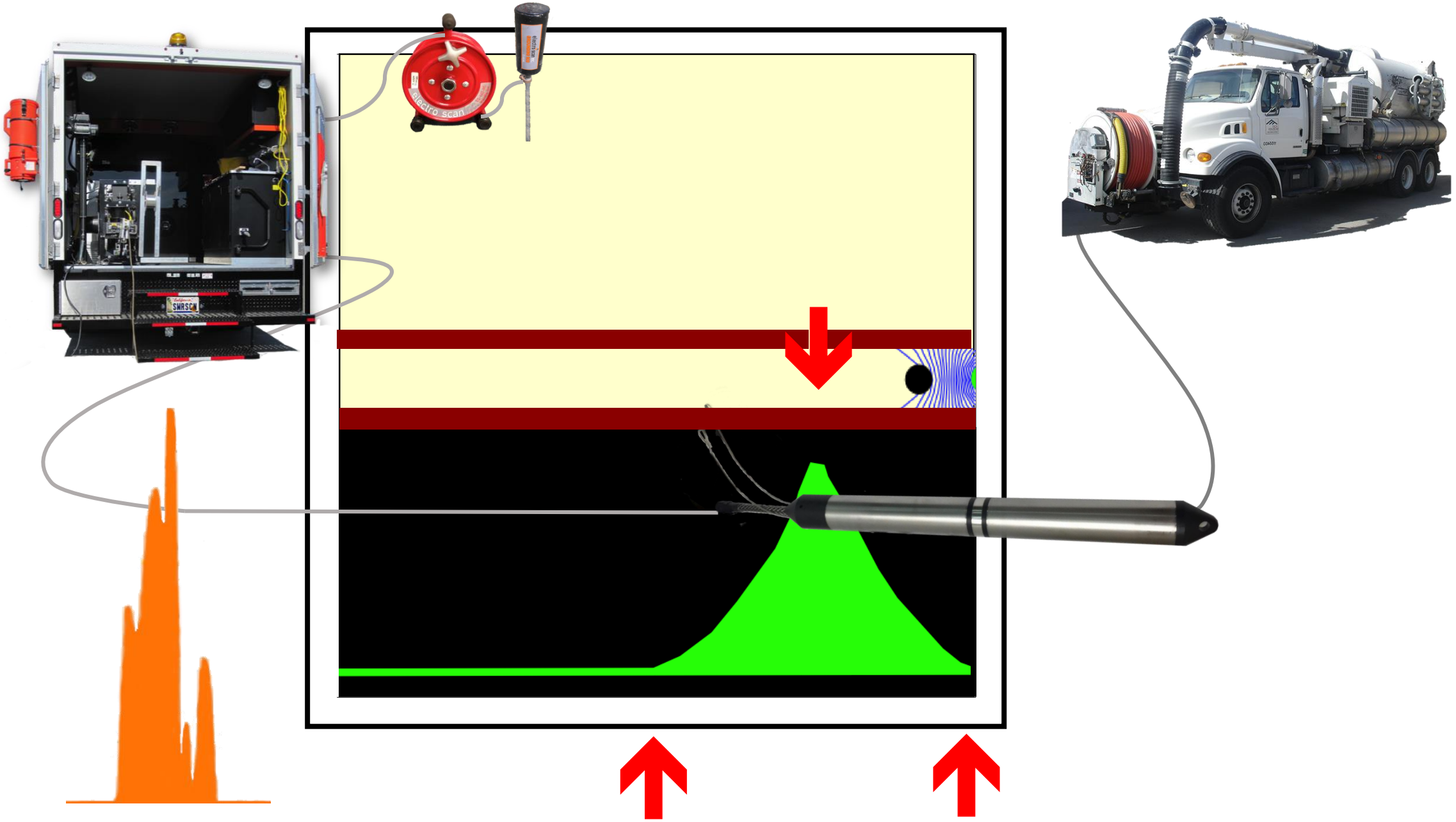




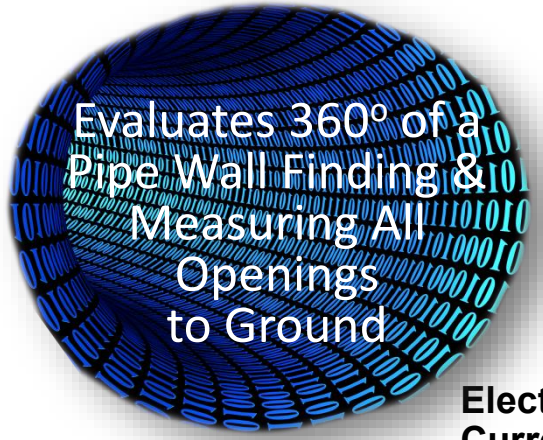








FELL Survey - Field Operation



Electro Scan Inspection Van

Jet Truck

Electric Current Meter

Grounding Source

Voltage Source

Water = Conductor

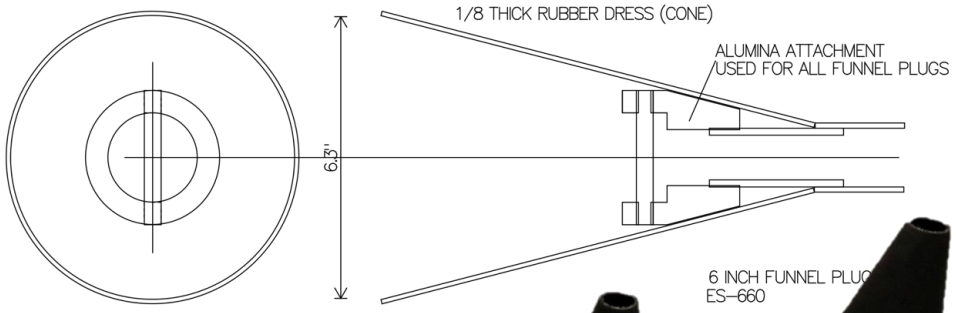
Probe Cable

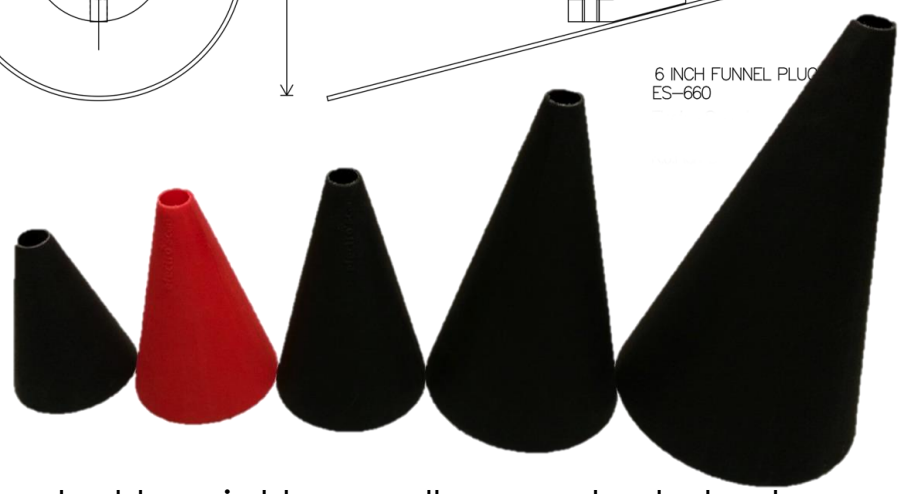
Electro Scan Probe

Sliding Funnel Plug

Water – Must Surround The Probe To Allow Electrical Current To Assess The Wall of the Pipe.

Funnel Cone Recommended For Pipe Diameters Up To 15”

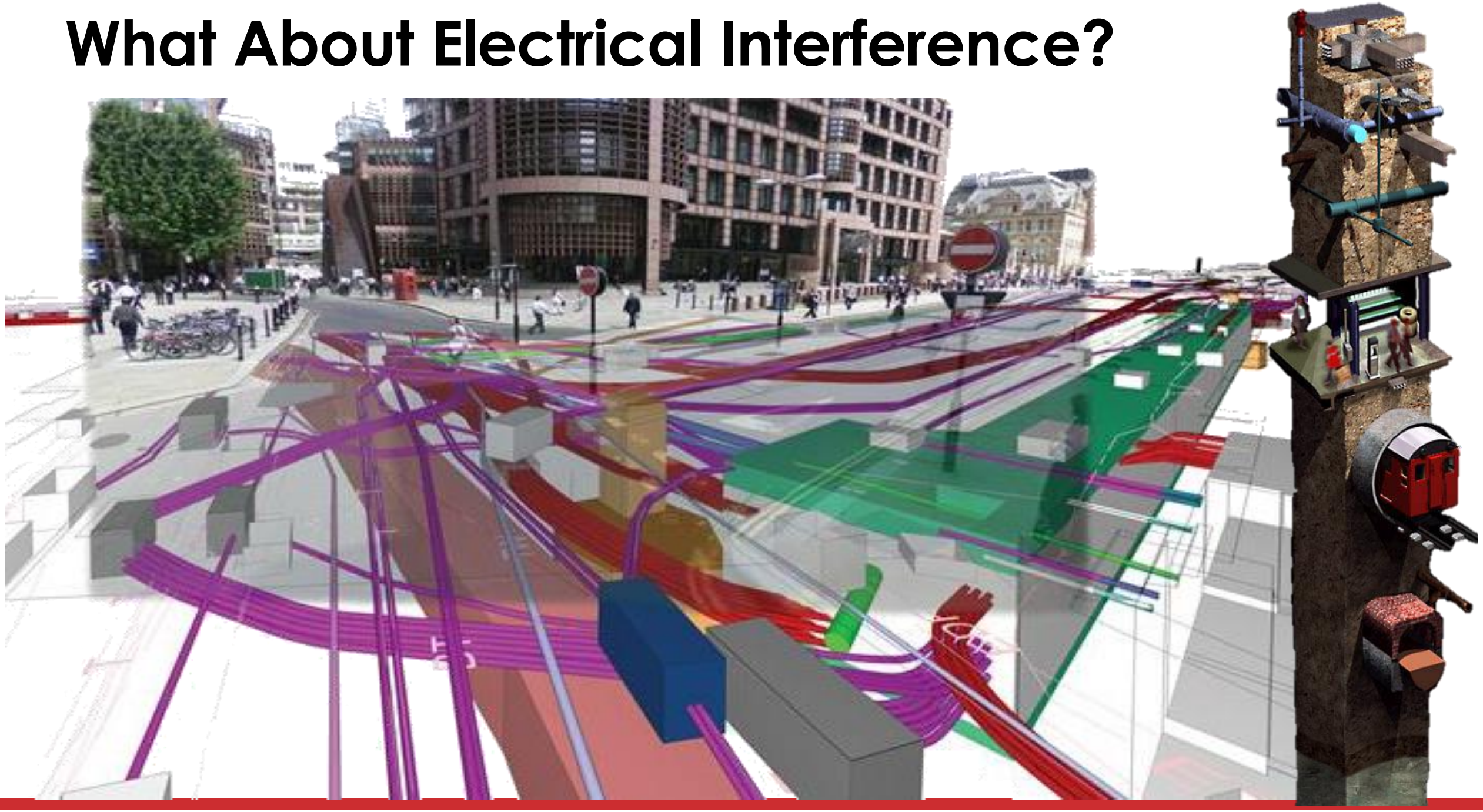




Connected to a jet hose, allows water to be temporarily held back to create a moving reservoir around probe.

For Larger Diameters, Pipe Wall Assessed at Water Line & Below

What About Electrical Interference?



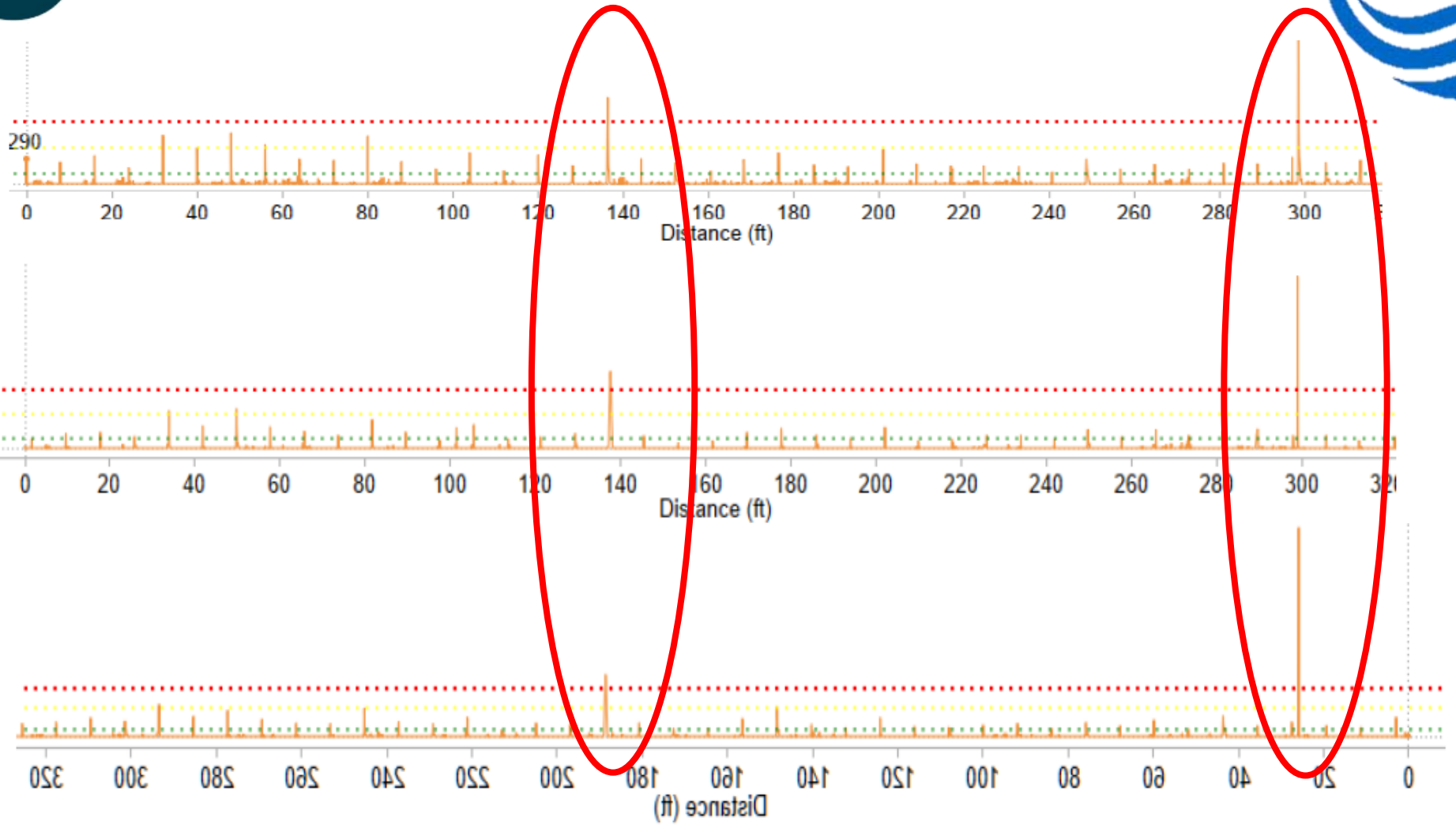
Repeatability Test

Same Pipe & Same Equipment

Scan 1

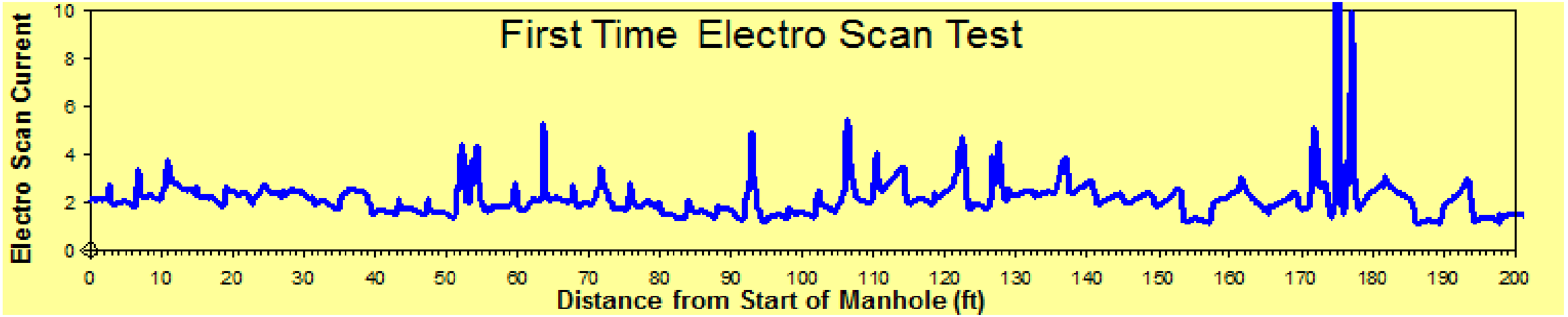
Scan 10

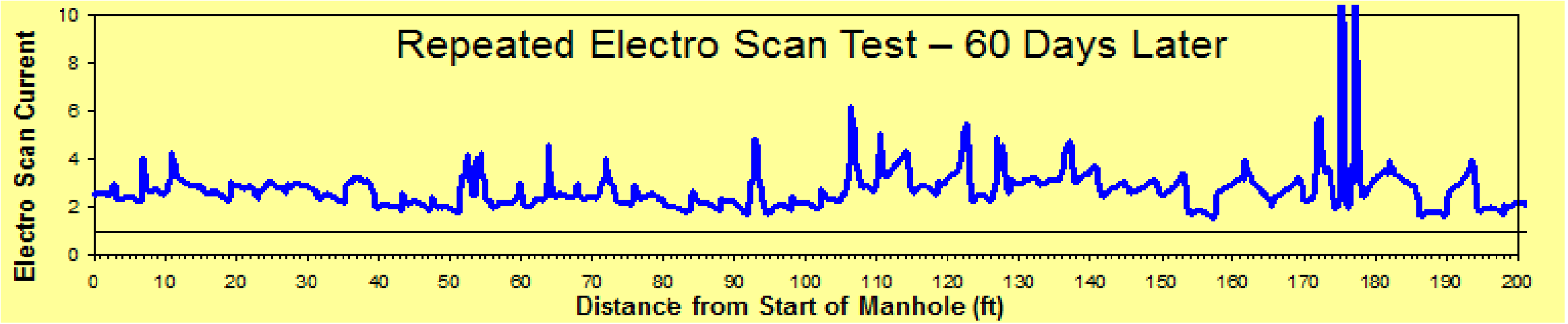
Scan 15



60-Days

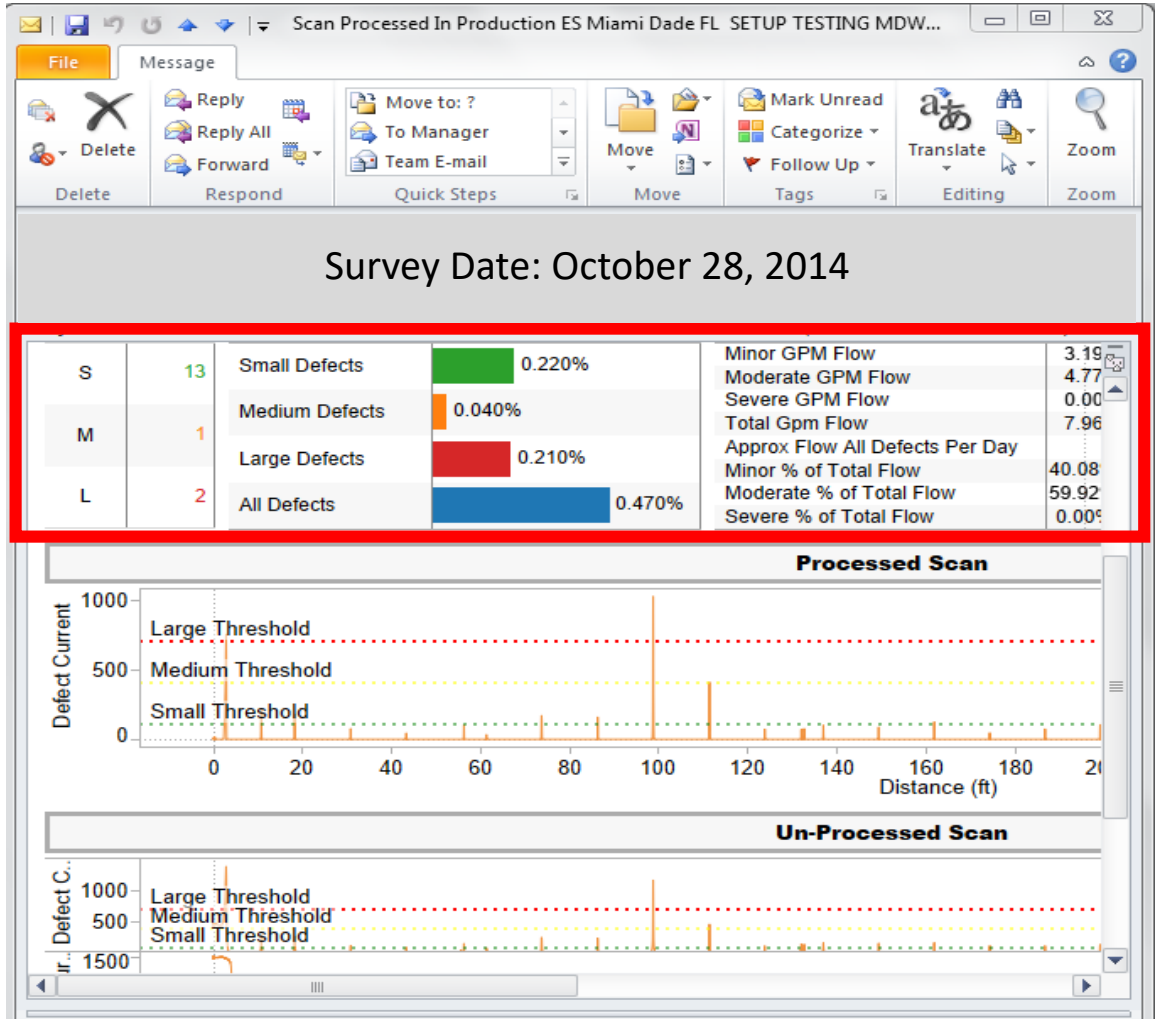
EPA Repeatability Example – Same Pipe, Same Equipment, Same Field Crew

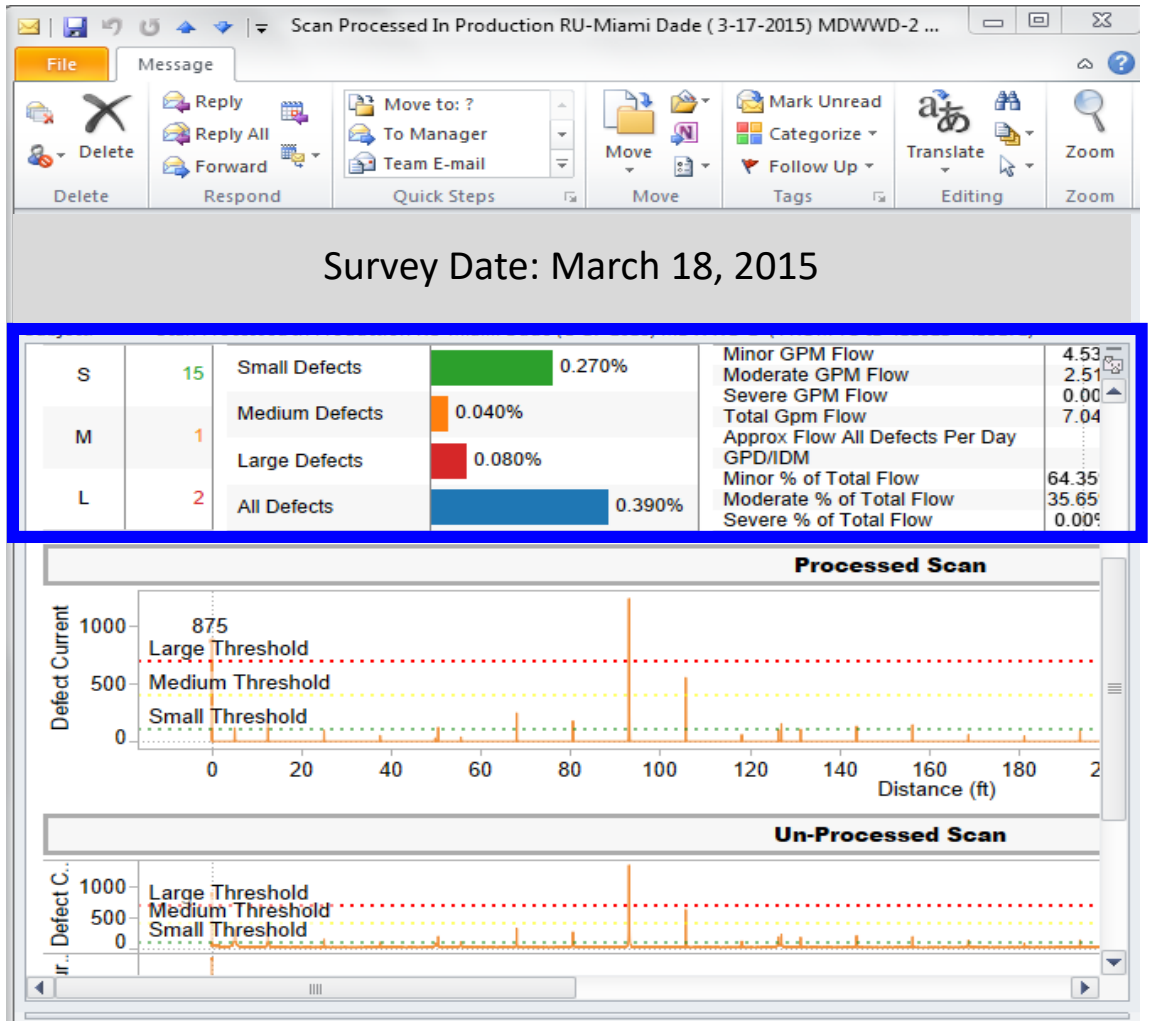




140-Days

MDWASD Example – Different CCTV Cables/Reels, FELL Probes, Crews, Software Version

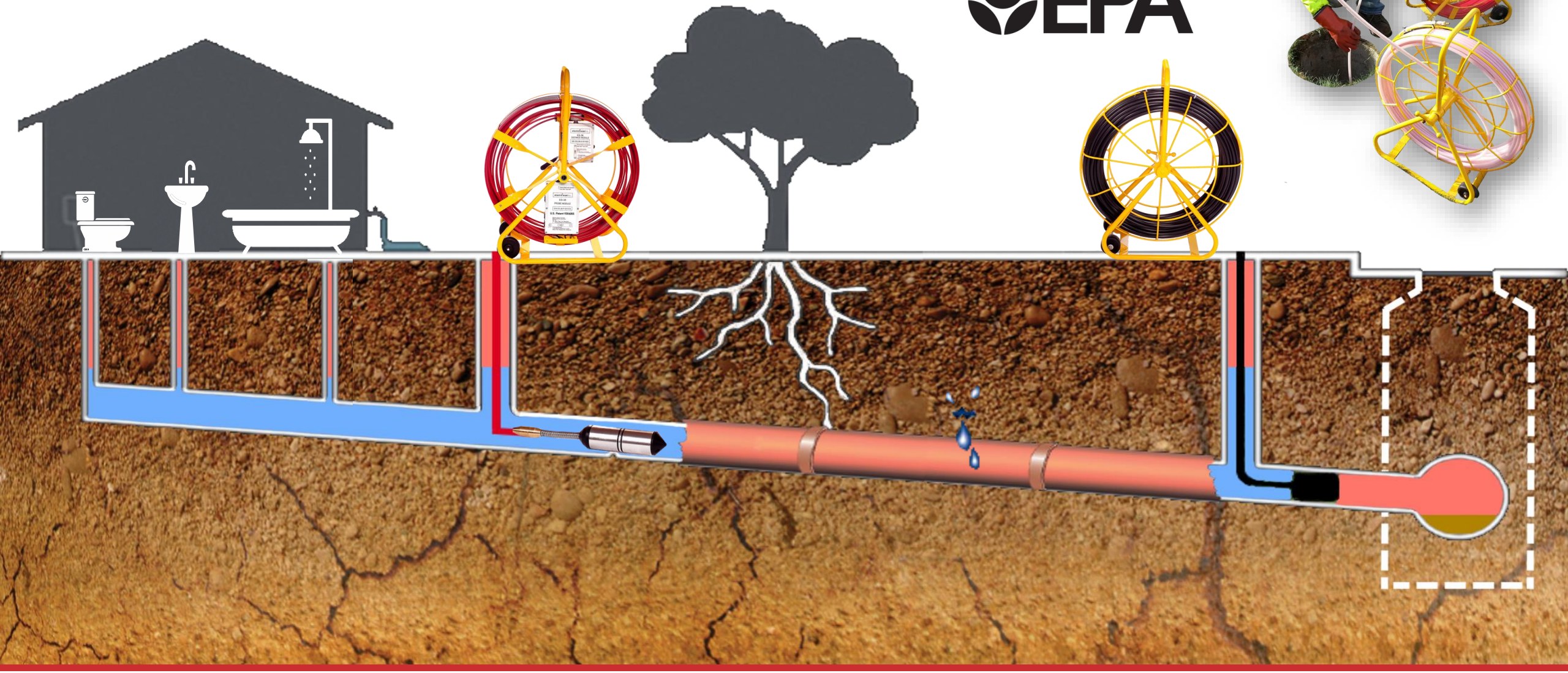




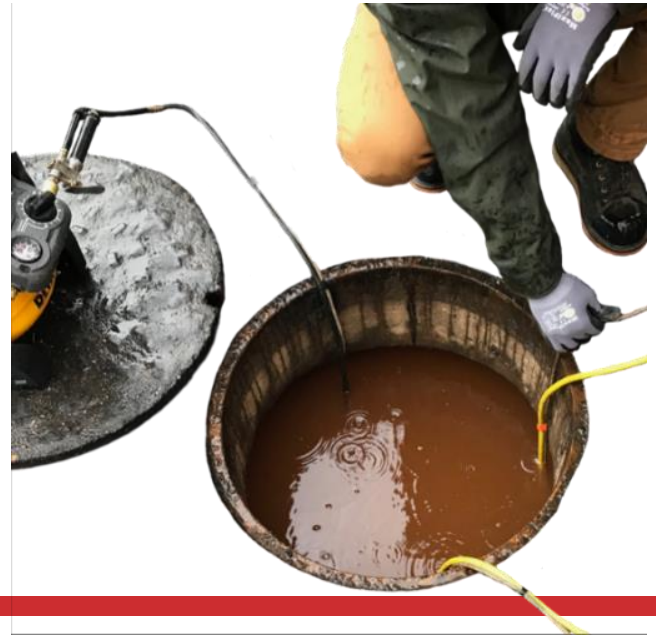
How Are Laterals Tested?

3-6” Diameter Pipes Up To 200 LF

WATER ENVIRONMENT & REUSE FOUNDATION
WE&RF
EPA



How Are Manholes Tested?



amazon web services™

FIRE WALL

criticalsewers®

FIRE WALL

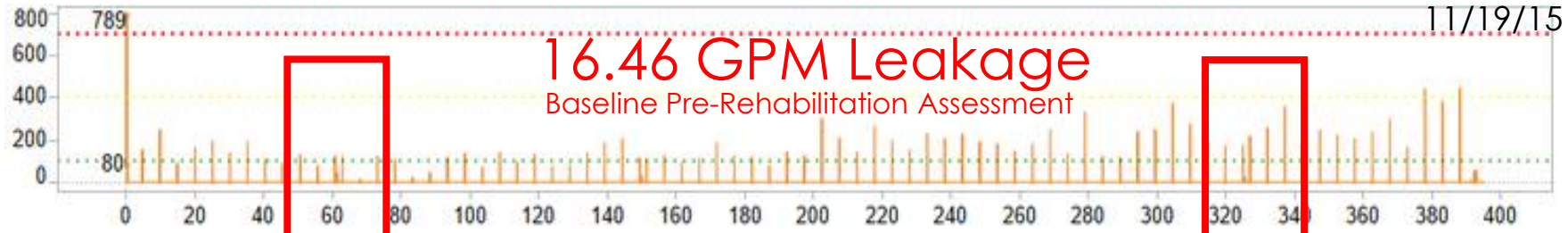
Results In Minutes

SAP HANA infor Innovyze® WinCan ORACLE®

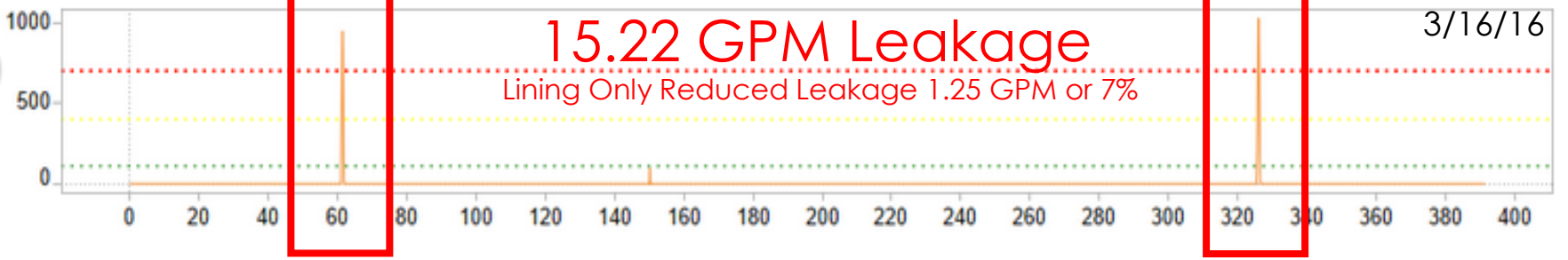
Measuring Reduction In Flows

	Date	Pipe ID	Diameter	Pipe Type	Distance (ft)	Small Defects	Medium Defects	Large Defects	GPM	GPD	GPD/IDM
A	11/19/2015	1-35 - 1-34	8	VCP	395.1	64	2	1	16.46	23,702	39,592
B	3/16/2016	1-35 - 1-34	8	CIPP	391.3	0	0	2	15.22	21,917	36,968
C	6/29/2016	1-35 - 1-34	8	CIPP	394.8	1	0	0	0.20	288	481

Test A



Inspect B



Accept C

Warren Township, NJ

WARREN TOWNSHIP SEWERAGE AUTHORITY
STAGE I/II SEWER SERVICE AREA – COLLECTION SYSTEM REHABILITATION
CONTRACT NO. 60
WARREN TOWNSHIP, NJ

SECTION 33 01 12.11

LEAKAGE DETECTION – FOCUSED ELECTRODE LEAK LOCATION (FELL) INSPECTION AND TESTING

PART 1 - GENERAL

1.01 REFERENCE STANDARDS

A. Comply with applicable provisions and recommendations pursuant to the following standards:
1. ASTM F2550 – Standard Practice for Locating Leaks in Sewer Pipes by Measuring the Variation of Electric Current Flow Through the Pipe Wall.

B. Acceptance Testing:
1. General
a. Lined pipes shall be FELL tested as described in this section.
b. Any damage caused to properties due to wastewater handling and/or wastewater backup while FELL testing shall be the responsibility of the Contractor.
2. Testing Equipment
a. FELL Testing shall be performed utilizing a low-voltage, tri-electrode array inspection probe, approved by the manufacturer for the respective pipe diameter. This equipment and process will be in full compliance with ASTM F2550 with capabilities as outlined in this Standard. For pipes with diameters below 16", a Sliding Funnel Plug should be used, so as to limit the amount of water used and prevent against backups. All equipment should be calibrated daily to verify that electrodes are operating within manufacturer's specified current range.
3. Focused Electrode Leak Locating (FELL) Procedure

FELL TESTING & ACCEPTANCE SPECIFICATION

Bid Item 60-16 FELL Inspection and Testing: The Bidder hereby proposes the following unit price per LF price for all FELL Inspection and Testing (post liner installation), including submittals, and any other Division 1 requirements; Work covered by Divisions 2 through 33 as applicable; testing, warranties, guarantees, and all other work incidental to the full completion of the Project as set forth in the Contract Documents; excepting that covered by Allowance Items. The total estimated linear footage of FELL Inspection and Testing is 12,407 LF.

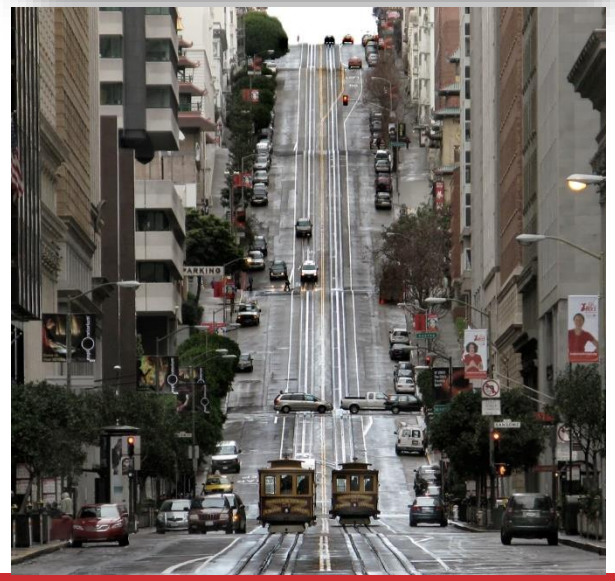
Unit Price per linear foot, Bid Item 60-16

_____ $_____ per L.F.
(Words) (Numbers)

60-16	FELL Inspection and Testing	12,407	LF

San Francisco, CA

San Francisco Water Power Sewer
Services of the San Francisco Public Utilities Commission



+30 Construction Bids Since January 2017

	AGENCY	CONTRACT	PROJECT NAME	ENGINEERS ESTIMATE	TOTAL FOOTAGE
1	SFPUC	WW-633	Various Locations Sewer Replacement No. 2	$ 7,300,000	8,770
2	SFDPW	2501J	University St and Sunnydale Ave Pavement Renovation and Sewer Replacement	2,456,344	444
3	SFDPW	2657J	Octavia Blvd and Oak Street Enhancement	1,008,481	373
4	SFPUC	WW-649	Paul Avenue Sewer Replacement	770,000	912
5	SFPUC	WW-629	Various Locations Sewer Replacement No. 1	8,000,000	9,403
6	SFPUC	WW-636	Various Locations Sewer Replacement No. 4	5,500,000	5,319
7	SFPUC	TBD	Mariposa Avenue	2,000,000	450
8	SFDPW	2781J	Proposition K Curb Ramps FY 15-16	540,000	100
9	SFDPW	2731J	Filbert St and Leavenworth Street Pavement Renovation and Sewer Replacement	7,300,000	6,447
10	SFDPW	2300J	California Laurel Village Improvement Project	3,500,000	1,322
11	SFPUC	[illegible]	[illegible]	[illegible]	7,101
12	SFDPW	[illegible]	[illegible]	[illegible]	1,340
13	SFDPW	[illegible]	[illegible]	[illegible]	7,172
14	SFDPW	[illegible]	[illegible]	[illegible]	4,128
15	SFDPW	5826	Clayton, Clipper, & Portola Pavement/Sewer/Water Renovation	12,900,000	4,282
16	MTA	1303	SF MTA 22 Fillmore Transit Priority Project	67,000,000	3,195
17	SFPUC	WW-637	Various Locations Sewer Replacement and Pavement Renovation No. 5	4,400,000	4,367
18	SFDPW	[illegible]	[illegible]	[illegible]	1,068
19	SFDPW	[illegible]	[illegible]	10,[illegible]75	2,564
20	SFDPW	[illegible]	[illegible]	3,[illegible]00	1,300
21	SFDPW	[illegible]	[illegible]	18,[illegible]0	2,906
22	SFPUC	WD-2692	Sewer Replacement on Geary Boulevard From 32nd to 48th Avenues	8,000,000	1,538
23	SFPUC	WW-674	Geary Boulevard Sewer & Water Improvements	14,500,000	8
24	SFPUC	WW-611	Cutler Ave, Lower Great Hwy, Sloat Blvd, & Wawona Street Sewer Replacement	2,300,000	1,412
25	SFPUC	WW-627	Baker Beach Green Streets	6,000,000	192
26	SFDPW	8473	San Bruno Avenue Multimodal Improvement Project	1,500,000	600
27	SFPUC	TBD	Hunters Point Shipyard Development	NA	17,563
28	SFDPW	8792	Various Locations Pavement Renovation No. 37 and Sewer Replacement	11,700,000	7,092
29	SFDPW	1032	Various Locations Pavement Renovation No. 39 and Sewer Replacement	10,400,000	3,976
30	SFDPW	7417	Parkmerced/Twin Peaks/Mt Davidson Manor Residential Street Resurfacing	5,100,000	1,671
TOTAL SFPUC & SFDPW PROJECTS				**$ 242,599,576**	**107,015**

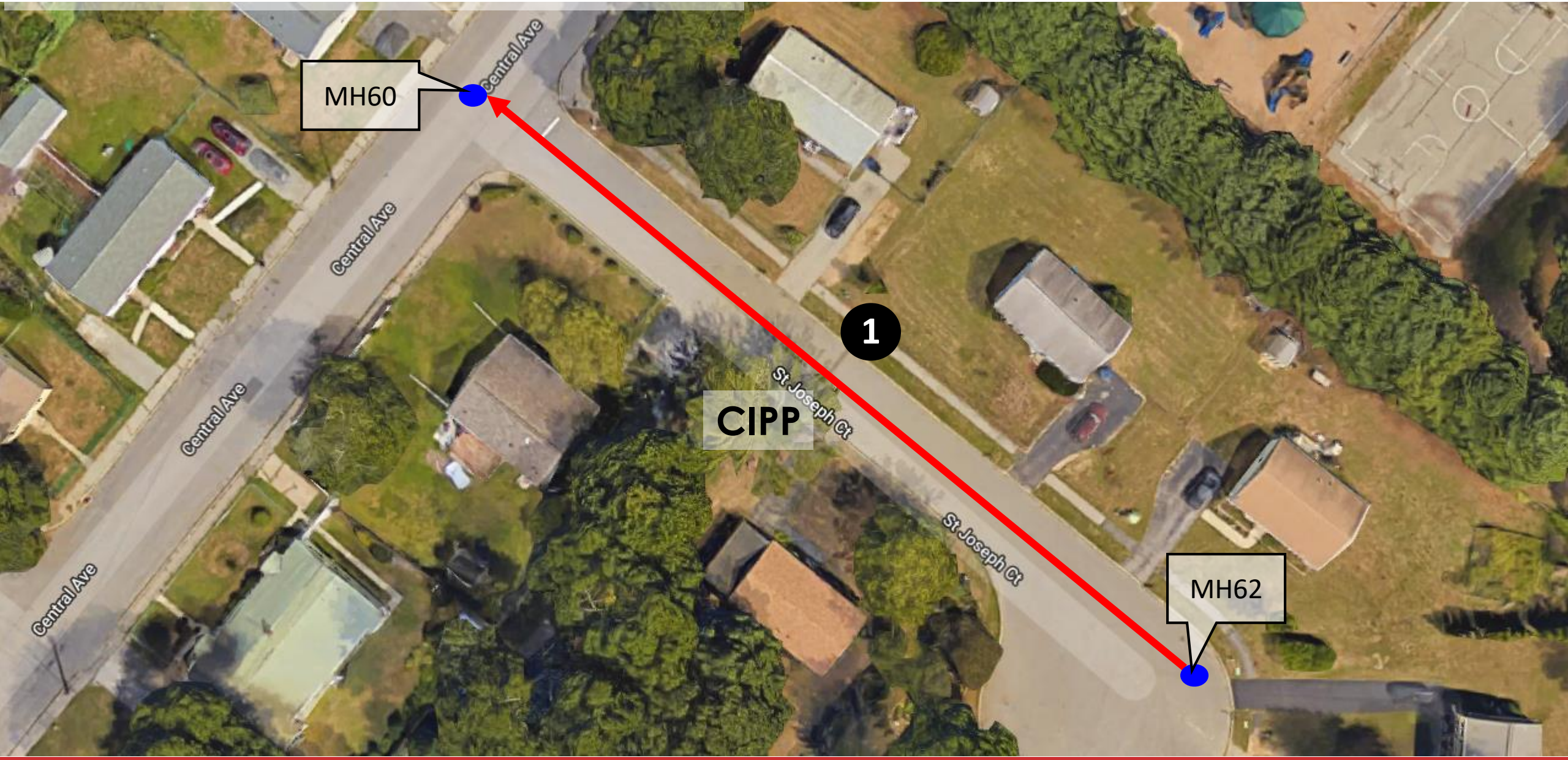
Part 3

CASE STUDIES

electro scan inc.

EPA Regions

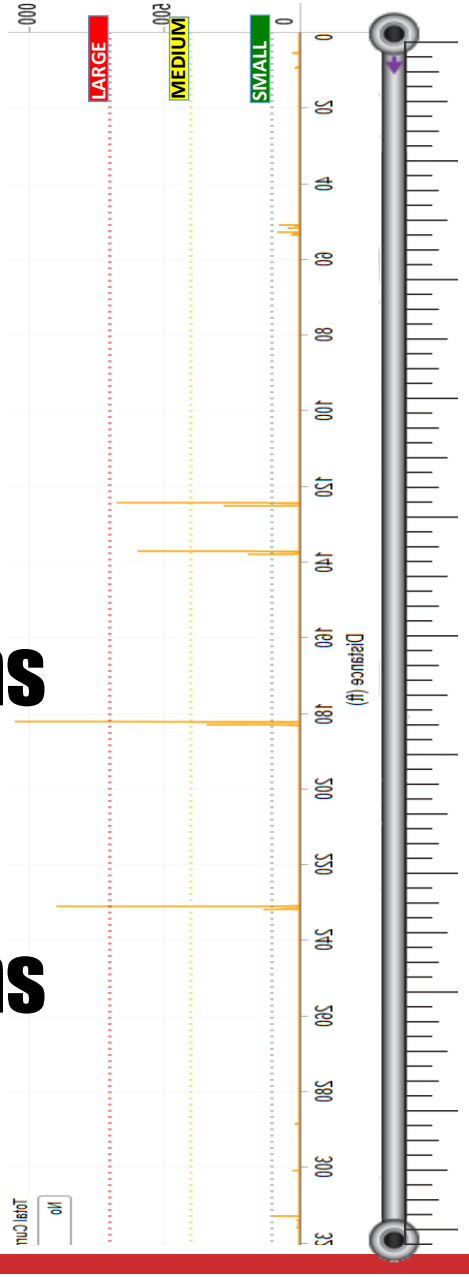
1. CIPP ASSESSMENT



FELL

Electro Scan
8 Defects
6.19 GPM

4 Service Connections
Leak-Free
&
4 Service Connections
Defects



0’	Upstream Manhole
6’	Lateral @ 10 o’clock
10’	Lateral @ 3 o’clock
55.2’	Lateral @ 9 o’clock
56.8’	Lateral @ 9 o’clock
127.7’	Lateral @ 3 o’clock
141.3’	Lateral @ 10 o’clock
186.7’	Lateral @ 9 o’clock
234.4’	Lateral @ 2 o’clock
326.4’	Downstream Manhole

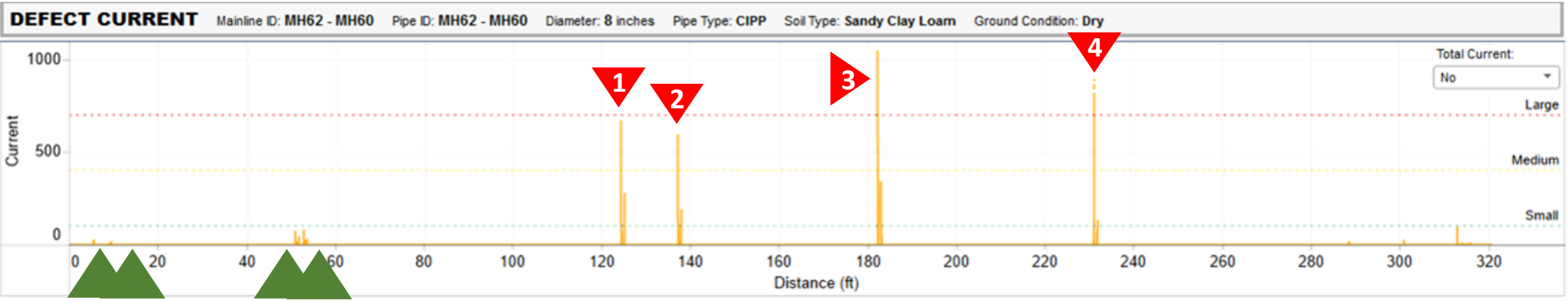
CCTV

CCTV Date
06/21/2018

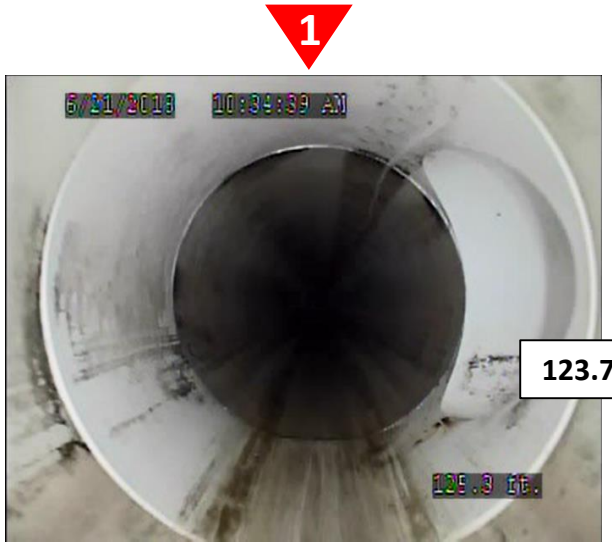
CCTV
ZERO Callouts Contributing to Infiltration

FELL & CCTV

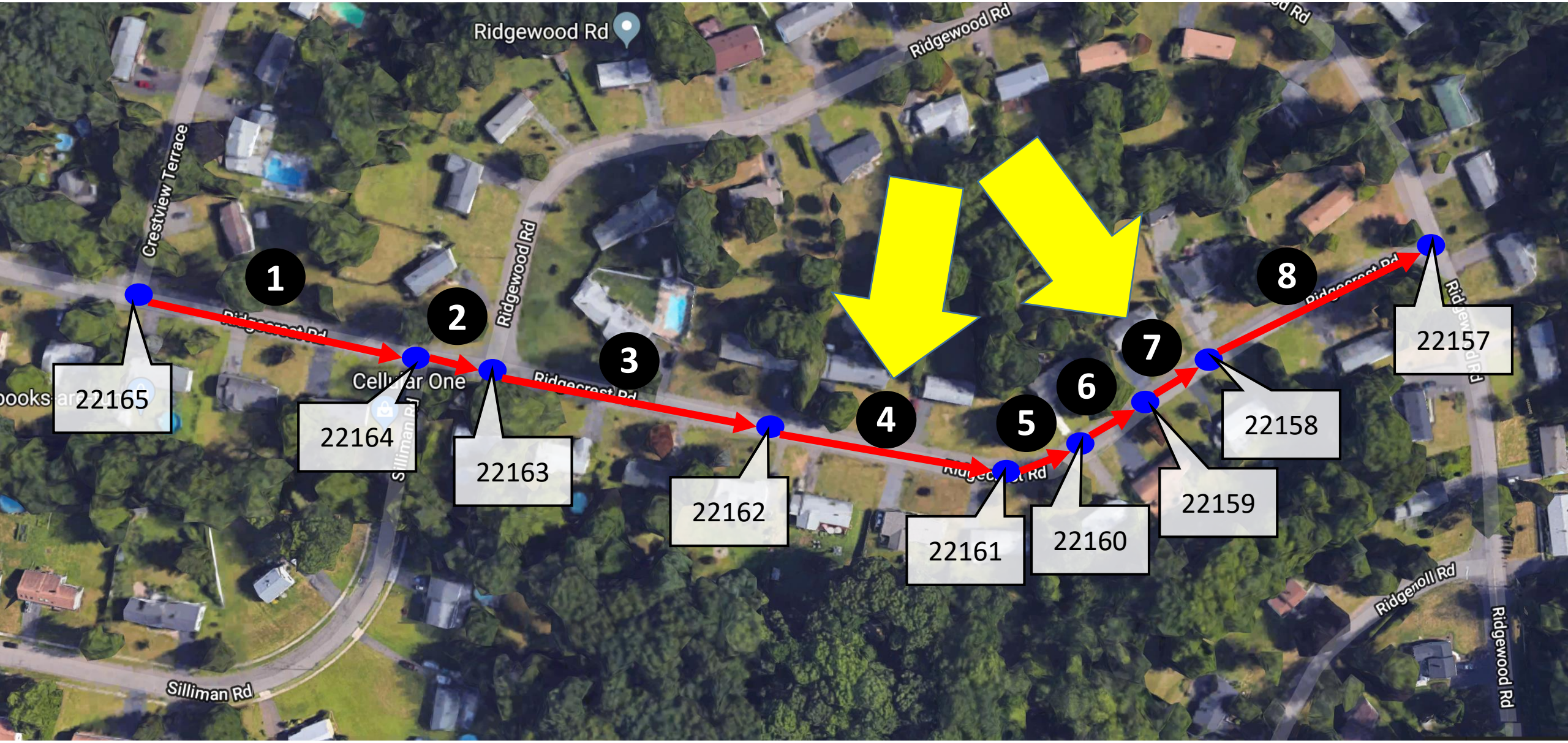
CCTV Date:
06/21/2018



Significant Leaks at 4 Service Connections!



2. VCP & CIPP ASSESSMENT



2. VCP & CIPP ASSESSMENT

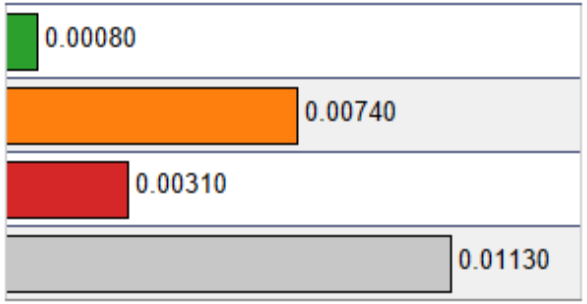
	Scans	Footage	Total Defects	GPM	GPD
Total:	**8**	**1,529**	**52**	**166.6**	**239,904**

Date	Mainline ID	Pipe ID	Pipe Type	Diameter	Distance (ft)	Small	Medium	Large	GPM	GPD	GPD IDM
1/19/2018	22165 - 22164	22165 - 22164	VCP	10	322.7	18	7	11	112.07	161,381	264,072
	22164 - 22163	22164 - 22163	VCP	10	86.2	0	1	1	1.27	1,829	11,199
	22163 - 22162	22163 - 22162	CIPP	10	305.5	0	2	1	23.85	34,344	59,357
4	22162 - 22161	22162 - 22161	CIPP	10	291.0	1	2	1	21.17	30,485	55,322
	22161 - 22160	22161 - 22160	CIPP	10	49.4	0	0	0	0.00	0	0
	22160 - 22159	22160 - 22159	CIPP	10	93.0	0	0	0	0.00	0	0
7	22159 - 22158	22159 - 22158	CIPP	10	100.7	5	0	0	0.76	1,094	5,737
	22158 - 22157	22158 - 22157	CIPP	10	280.2	1	1	0	7.48	10,771	21,119

❹ Defects at Lateral v. Liner Defects

DEFECTS	
Small	1
Medium	2
Large	1
All Defects	4

% OF DEFECT LENGTHS



GPM SUMMARY	
Minor	0.600
Moderate	0.000
Severe	20.570
Total GPM	21.170
GPD	30,485
GPD IDM	55,322
Minor %	2.83%
Moderate %	0.00%
Severe %	97.17%

DIAMETER & DISTANCE

10

291.00 ft

0 100 200 300

OPERATOR INFO

Tech Electroscan

Project

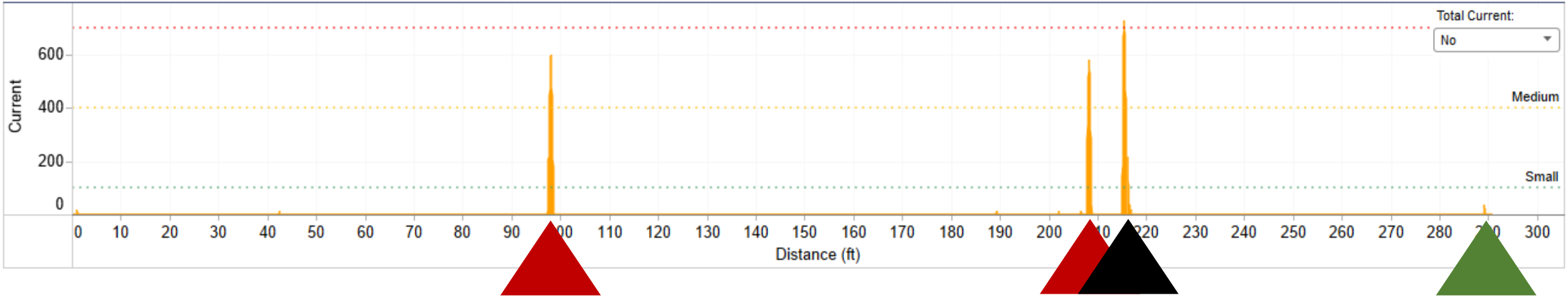
Demo

Job

Demo

Atmospheric Test	Scan Start
1/19/2018 6:13:51 AM	1/19/2018 7:08:36 AM

DEFECT CURRENT Mainline ID: **22162 - 22161** Pipe ID: **22162 - 22161** Diameter: **10** inches Pipe Type: **CIPP** Soil Type: **Sandy Clay Loam** Ground Condition: **Snow**



❹ Defects at Lateral v. Liner Defects

DEFECTS	
Small	1
Medium	2
Large	1
All Defects	4

% OF DEFECT LENGTHS

0.00080
0.00740
0.00310
0.01130

GPM SUMMARY	
Minor	0.600
Moderate	0.000
Severe	20.570
Total GPM	21.170
GPD	30,485
GPD IDM	55,322
Minor %	2.83%
Moderate %	0.00%
Severe %	97.17%

DIAMETER & DISTANCE

10

291.00 ft

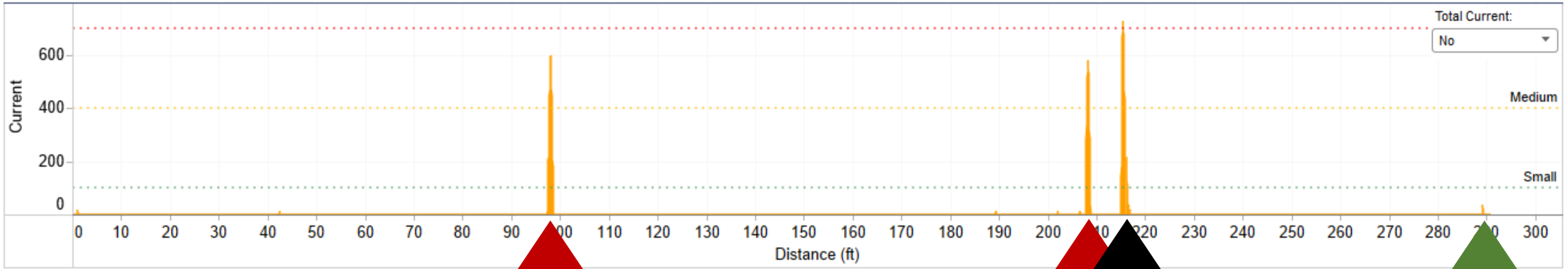
0 100 200 300

OPERATOR INFO

Tech Electroscan
Project
Demo
Job
Demo

Atmospheric Test	Scan Start
1/19/2018 6:13:51 AM	1/19/2018 7:08:36 AM

DEFECT CURRENT Mainline ID: **22162 - 22161** Pipe ID: **22162 - 22161** Diameter: **10** inches Pipe Type: **CIPP** Soil Type: **Sandy Clay Loam** Ground Condition: **Snow**



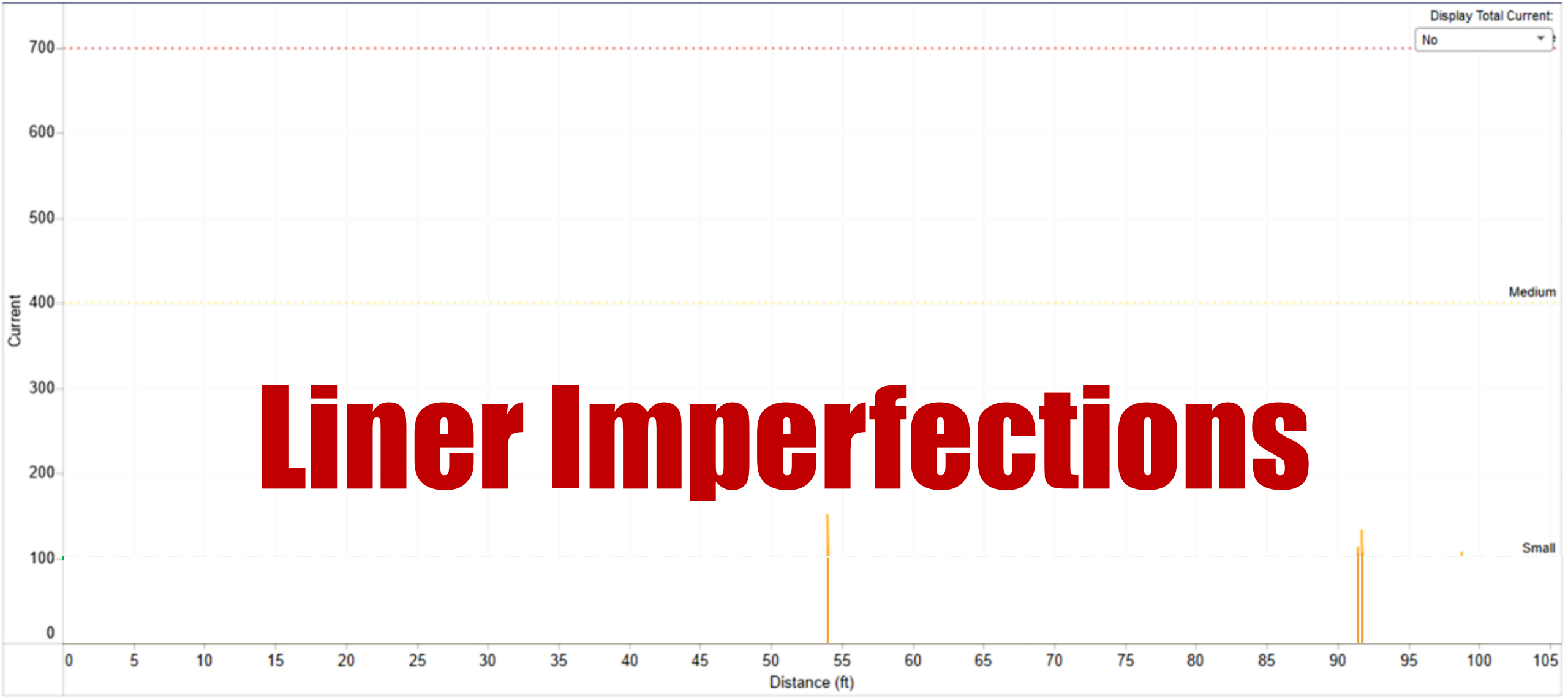
Bad Lateral

Bad Lateral

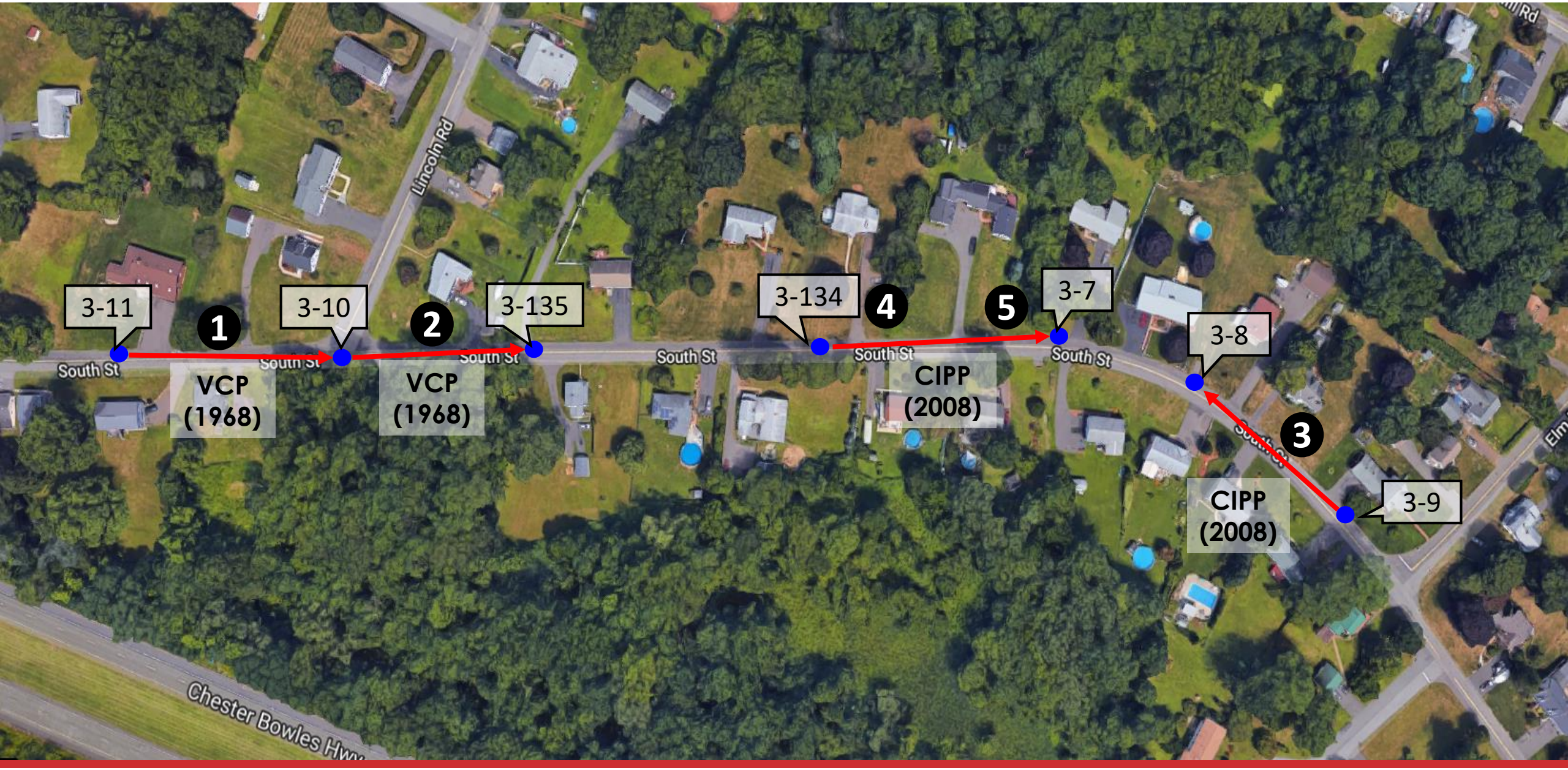
Bad Liner

Good Lateral

7 CIPP Pinhole Leaks & Liner Soakage



3. VCP & CIPP Assessment



3. VCP & CIPP Assessment

	Scans	Footage	Total Defects	GPM	GPD
Total:	**5**	**993**	**85**	**72.55**	**104,472**

Listed In Inspection Order

Date	Mainline ID	Pipe ID	Pipe Type	Diameter							
6/20/2018	3-11 - 3-10	3-11 - 3-10	VCP	8	234.2	22	1	0	9.19	13,234	37,297
	3-10 - 3-135	3-10 - 3-135	VCP	8	237.6	33	1	0	7.81	11,246	31,243
	3-9 - 3-8	3-9 - 3-8	CIPP	8	234.0	17	3	2	33.40	48,096	135,669
	3-134 - 3-134.5	3-134 - 3-134.5	CIPP	8	93.3	3	0	2	14.42	20,765	146,852
	3-134.5 - 3-7	3-134.5 - 3-7	CIPP	8	193.5	0	0	1	7.73	11,131	37,957

Ranked By GPM

Date	Mainline ID	P	Pipe Type	Diameter							
6/20/2018	3-9 - 3-8	3	CIPP	8	234.0	17	3	2	33.40	48,096	135,669
	3-134 - 3-134.5	3	CIPP	8	93.3	3	0	2	14.42	20,765	146,852
	3-11 - 3-10	3-11	VCP	8	234.2	22	1	0	9.19	13,234	37,297
	3-10 - 3-135	3-10 - 3-135	VCP	8	237.6	33	1	0	7.81	11,246	31,243
	3-134.5 - 3-7	3-134.5 - 3-7	CIPP	8	193.5	0	0	1	7.73	11,131	37,957

10 Yr-Old CIPP Worse Than 50 Yr-Old VCP

A. 2008 CIPP Worse Than 1968 VCP

DEFECTS	
Small	17
Medium	3
Large	2
All Defects	22

% OF DEFECT LENGTHS

Small	0.01290
Medium	0.00340
Large	0.01080
All Defects	0.02710

GPM SUMMARY	
Minor	6.350
Moderate	7.050
Severe	20.000
Total GPM	33.400
GPD	48,096
GPD IDM	135,669
Minor %	14.47%
Moderate %	16.07%
Severe %	69.46%

DIAMETER & DISTANCE

8

234.00 ft

0 50 100 150 200

OPERATOR INFO

Tech Electroscan

Project

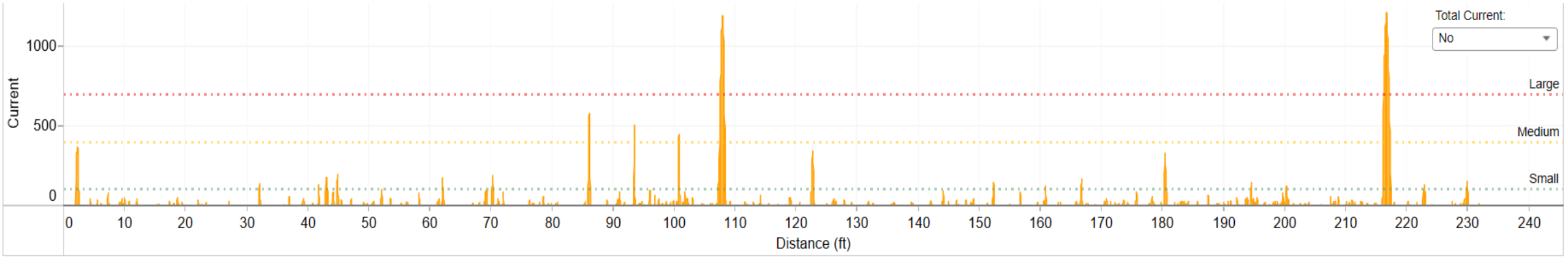
DEMO

Job

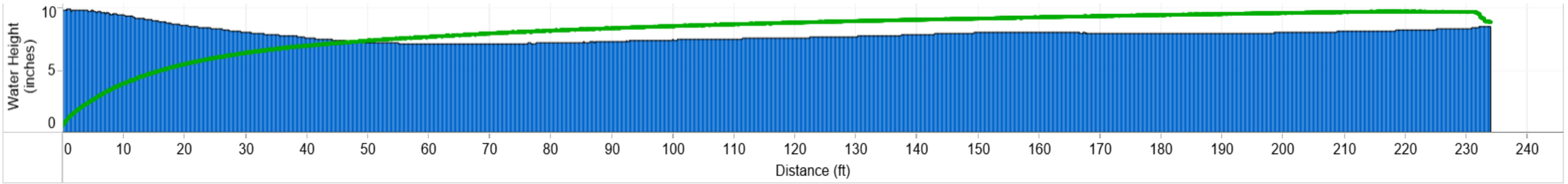
DEMO

Atmospheric Test	Scan Start
6/20/2018 9:13:51 AM	6/20/2018 11:02:00 AM

DEFECT CURRENT Mainline ID: **3-9 - 3-8** Pipe ID: **3-9 - 3-8** Diameter: **8** inches Pipe Type: **CIPP** Soil Type: **Clay Loam** Ground Condition: **Dry**

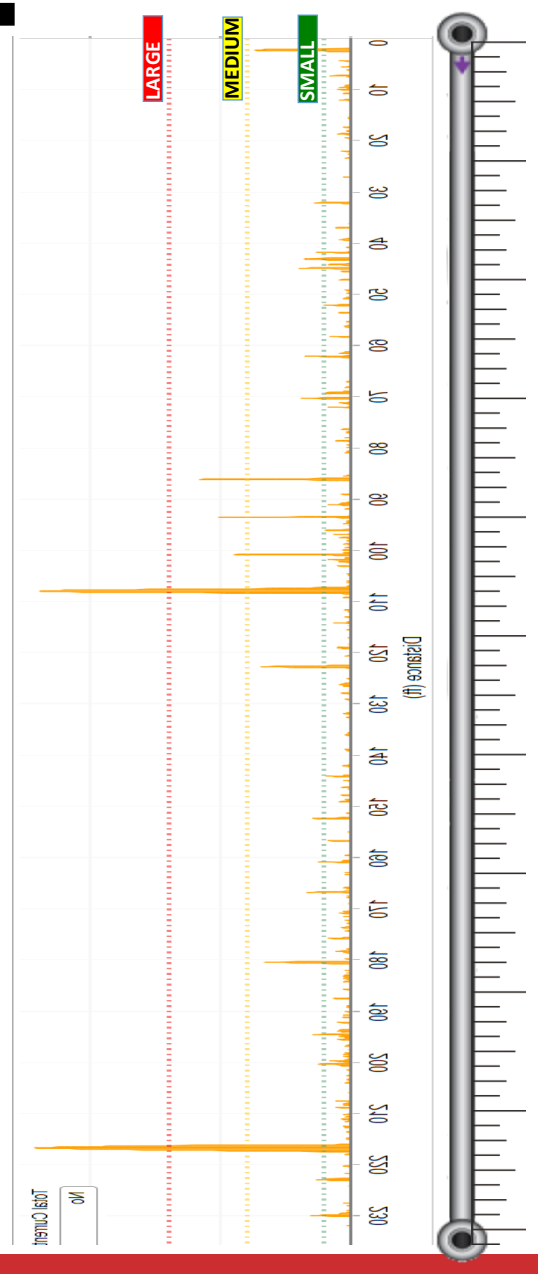


WATER HEIGHT AND PROBE SPEED Mainline ID: **3-9 - 3-8** Pipe ID: **3-9 - 3-8** Diameter: **8** inches Pipe Type: **CIPP** Soil Type: **Clay Loam** Ground Condition: **Dry**



FELL

Electro Scan
22 Defects
33.4 GPM



CCTV

16.8’	L3 – Lateral 3
73.6’	L3 – Lateral 3
125.1’	L9 – Lateral 9
189.8’	L3 – Lateral 3
233.9’	Downstream Manhole MH#3-8

CCTV
ZERO (0) Structural Defects

B. CIPP Assessment: Liner Leaks at Most Host Pipe Joints

DEFECTS	
Small	25
Medium	0
Large	1
All Defects	26

% OF DEFECT LENGTHS

Small	0.02560
Medium	0.00000
Large	0.00660
All Defects	0.03220

GPM SUMMARY	
Minor	9.400
Moderate	2.880
Severe	8.580
Total GPM	20.860
GPD	30,038
GPD IDM	81,678
Minor %	45.06%
Moderate %	13.81%
Severe %	41.13%

DIAMETER & DISTANCE

10

194.00 ft

0 50 100 150 200

OPERATOR INFO

Tech Electroscan

Project

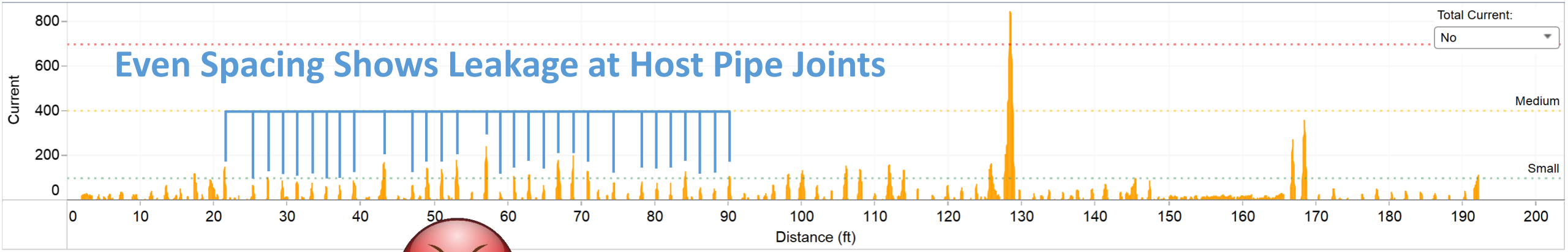
DEMO

Job

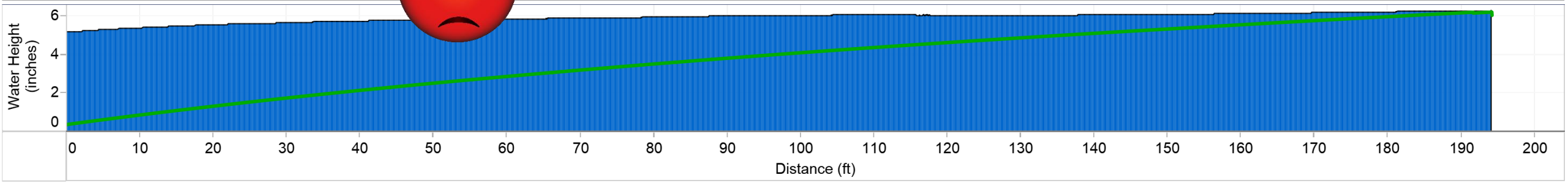
DEMO

Atmospheric Test	Scan Start
10/12/2018 10:05:25 AM	10/12/2018 10:05:44 AM

DEFECT CURRENT Mainline ID: **307887 - 307878** Pipe ID: **307887 - 307878** Diameter: **10** inches Pipe Type: **CIPP** Soil Type: Ground Condition: **Dry**



WATER HEIGHT AND PROBE SPEED Mainli 878 Pipe ID: **307887 - 307878** Diameter: **10** inches Pipe Type: **CIPP** Soil Type: Ground Condition: **Dry**

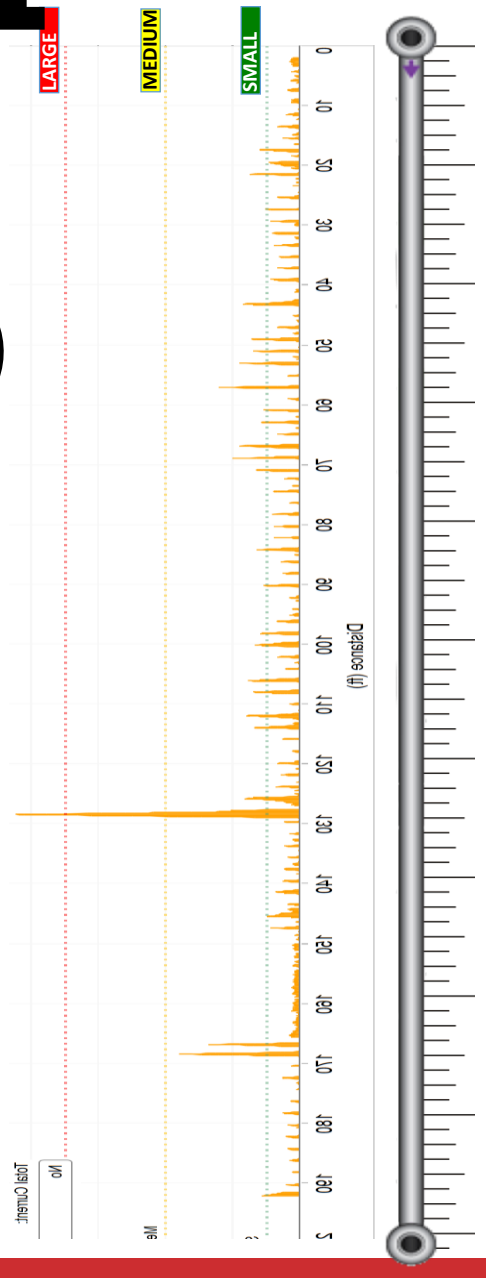


FELL

CCTV

CCTV Date
08/03/2017

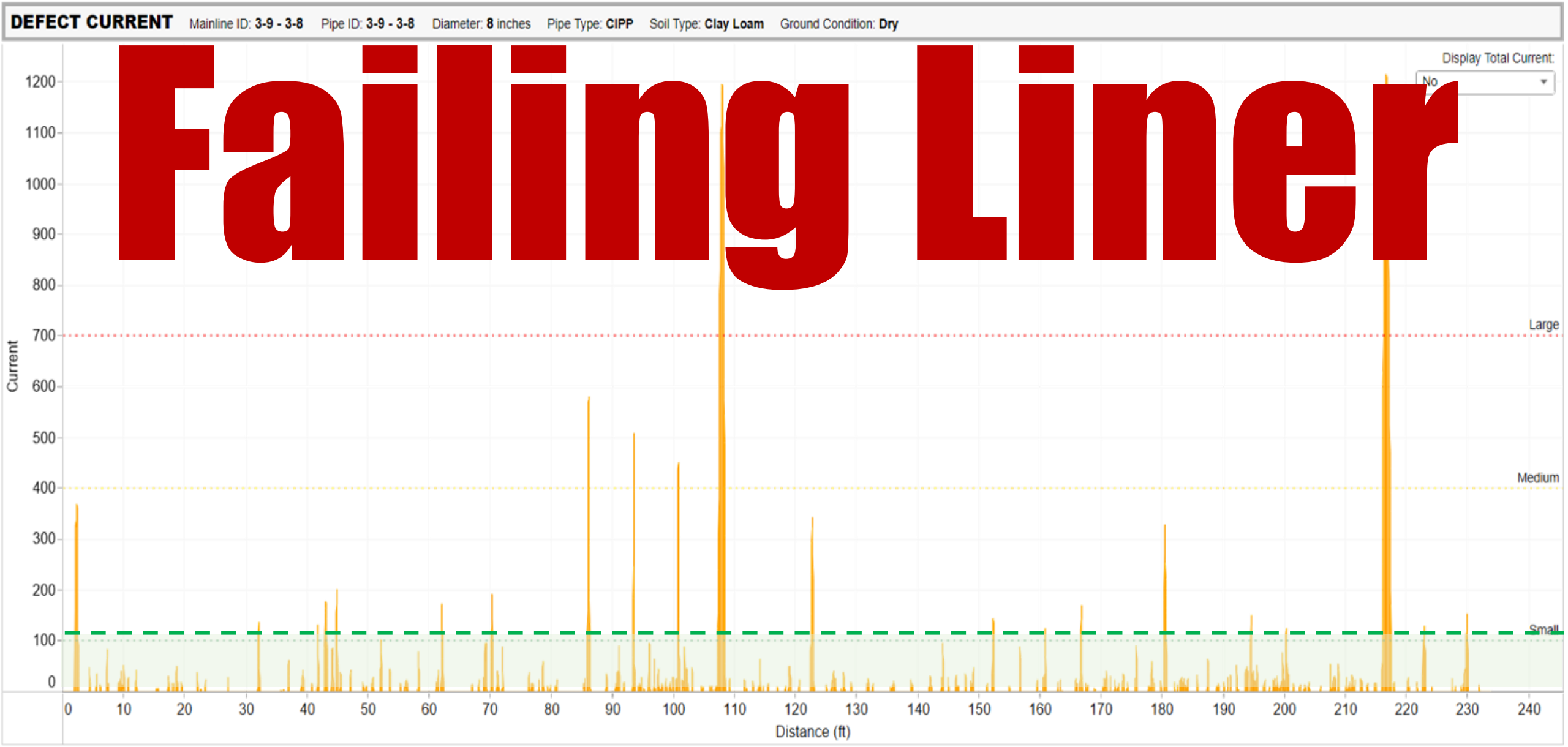
Electro Scan
26 Defects
20.8 GPM



0’	Upstream Manhole 307887
100.8	Tap Factory Made Active
134.6	Tap Factory Made Active
170.7	Tap Factory Made Active
209.5’	Downstream Manhole 307878

CCTV
ZERO (0)
Structural
Defects

C. CIPP Lateral, Liner, and Pinhole Defects



Electro Scan Field Results

	Scans	Footage	Total Defects	GPM	GPD
Total:	**5**	**1,037**	**220**	**112.89**	**162,562**

	Date	Mainline ID	Pipe ID	Pipe Type	Diameter	Distance (ft)	Small	Medium	Large	GPM	GPD	GPD IDM
	10/9/2018	1916 - 2787	1916 - 2787	VCP	8	206.13	53	4	1	41.87	60,293	193,048
		2787 - 2789	2787 - 2789	VCP	8	223.67	86	5	1	36.23	52,171	153,942
		2789 - 1915	2789 - 1915	VCP	8	216.23	19	1	0	7.03	10,123	30,899
4		1915 - 2788	1915 - 2788	VCP	8	215.06	19	1	1	14.94	21,514	66,024
5		2788 - 5156	2788 - 5156	VCP	8	176.40	27	2	0	12.82	18,461	69,072
												0K 400K

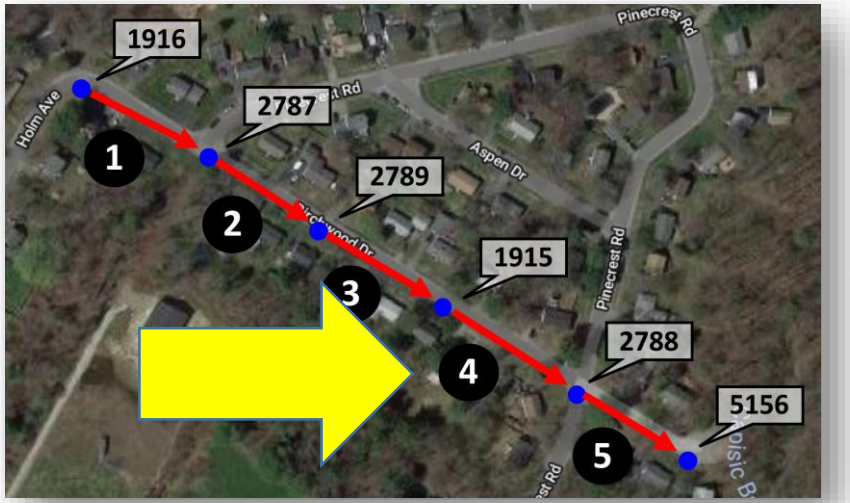
4

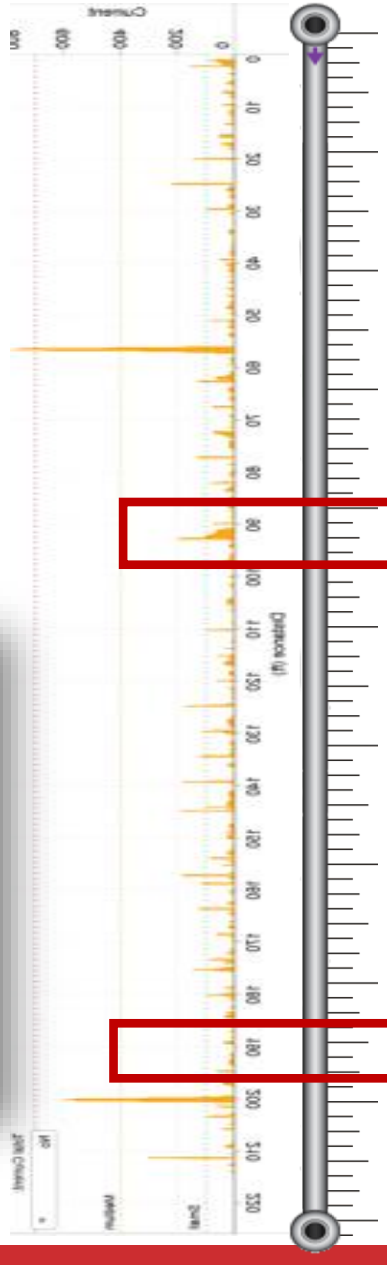
FELL

CCTV

CCTV Date
10/10/2018

Electro Scan
21 Defects
14.9 GPM





55.2’ Tap Factory Made Active

67.4’ Tap Factory Made Intruding

93.2’ Infiltration Runner

106.9’ Water Level S

111.8’ Water l

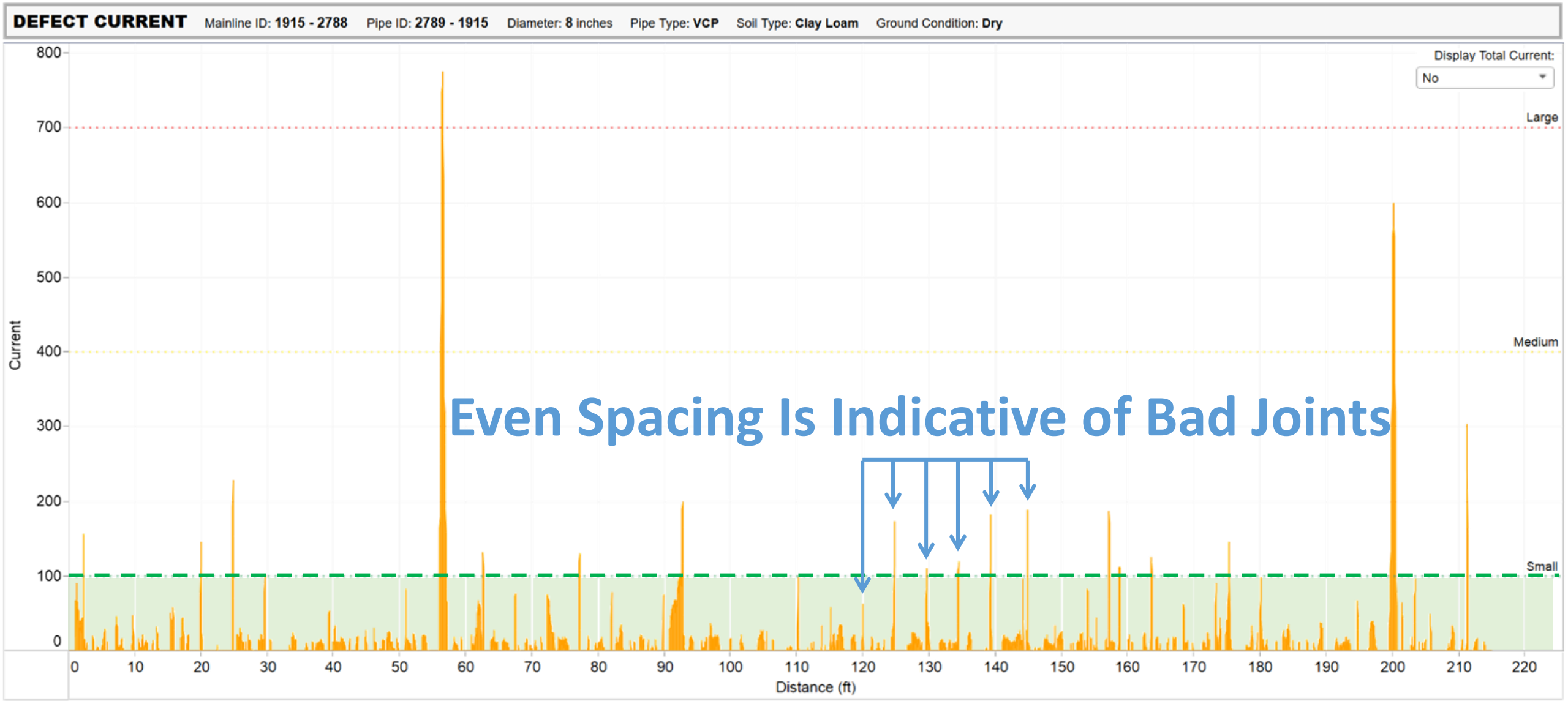
187.9’ Infiltration Runner At Connection

214.6’ Tap Factory Made Intruding

223.5’ Water Level Sag

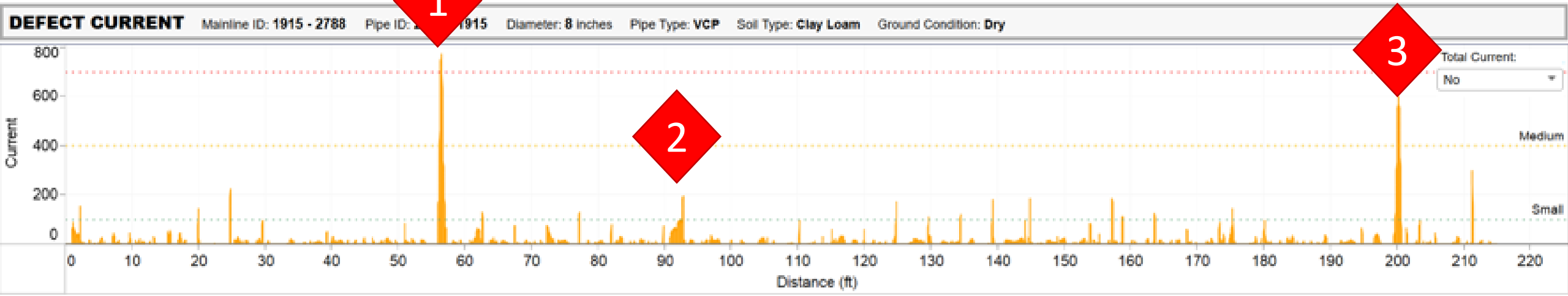
CCTV
2 Callouts Identifying Infiltration

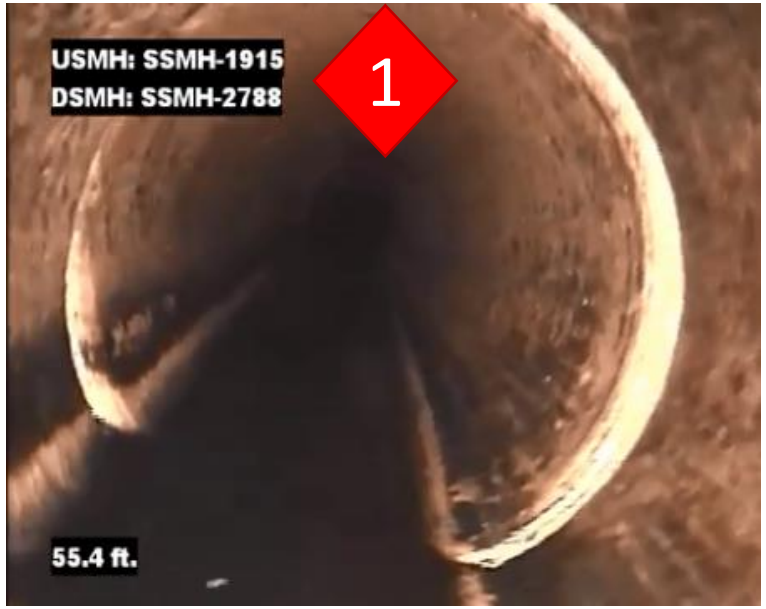
4

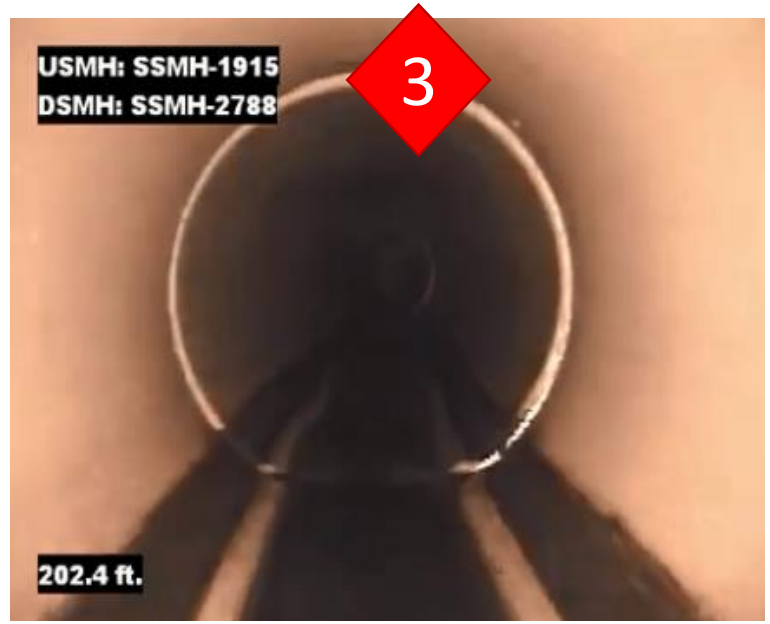


4

CCTV Date
10/10/2018







LARGEST DEFECTS ARE JOINTS!!

4 Worst 2 Defects = 76% of Estimated Defect Flow

	Defects	Length (ft)	GPM	% of GPM	GPD	GPD/IDM
Total:	**21**	**2.956**	**14.920**	**100%**	**21,485**	**65,935**

DEFECT BY LOCATION Mainline ID: **1915 - 2788** Pipe ID: **2789 - 1915** Diameter: **8** inches Pipe Type: **VCP** Soil Type: **Clay Loam** Ground Condition: **None** **Ranked By GPM**

Defect Grade	Defect Start (ft)	Defect End (ft)	Length (ft)	GPM	% of GPM	GPD	GPD/IDM
L	56.50	57.46	0.96	6.39	42.77%	9,202	28,239
M	200.25	201.09	0.84	5.03	33.67%	7,243	22,229
S	211.31	211.46	0.14	0.57	3.82%	821	2,519
S	92.78	92.97	0.19	0.48	3.21%	691	2,121
S	157.24	157.34	0.10	0.30	2.01%	432	1,326
S	139.34	139.44	0.10	0.28	1.87%	403	1,237
S	124.80	124.89	0.10	0.25	1.67%	360	1,105
S	24.82	24.86	0.05	0.21	1.41%	302	928
S	20.04	20.11	0.07	0.19	1.27%	274	840
S	175.34	175.41	0.07	0.19	1.27%	274	840
S	134.47	134.54	0.07	0.16	1.07%	230	707
S	62.64	62.69	0.05	0.13	0.87%	187	575
S	77.21	77.26	0.05	0.13	0.87%	187	575
S	158.78	158.83	0.05	0.12	0.80%	173	530
S	163.65	163.70	0.05	0.12	0.80%	173	530
S	2.28	2.30	0.02	0.10	0.67%	144	442
S	29.66	29.69	0.02	0.07	0.47%	101	309
S	92.32	92.35	0.02	0.07	0.47%	101	309
S	144.91	144.91	0.00	0.06	0.40%	86	265
S	129.64	129.64	0.00	0.04	0.27%	58	177
S	92.47	92.47	0.00	0.03	0.20%	43	133

5

DEFECTS	
Small	27
Medium	2
Large	0
All Defects	29

% OF DEFECT LENGTHS

	0.01870
	0.00330
	0.00000
	0.02200

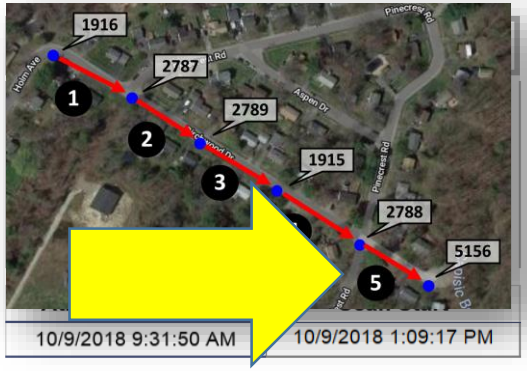
GPM SUMMARY	
Minor	5.800
Moderate	7.020
Severe	0.000
Total GPM	12.820
GPD	18,461
GPD IDM	69,072
Minor %	45.24%
Moderate %	54.76%
Severe %	0.00%

DIAMETER & DISTANCE

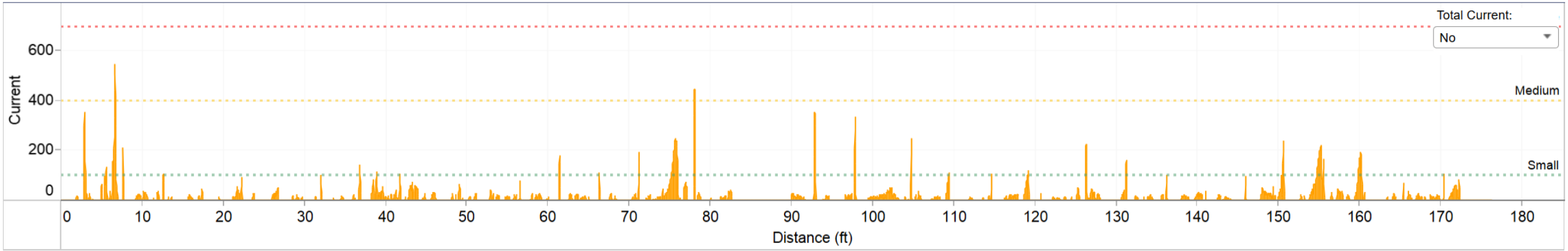
8

176.00 ft

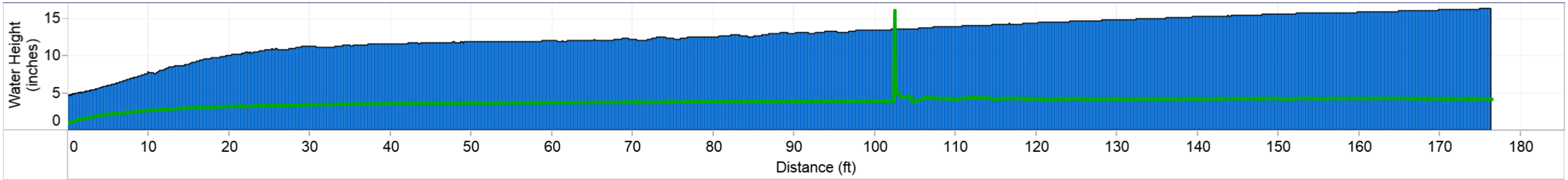
0 50 100 150



DEFECT CURRENT Mainline ID: **2788 - 5156** Pipe ID: **2789 - 1915** Diameter: **8** inches Pipe Type: **VCP** Soil Type: **Clay Loam** Ground Condition: **Dry**



WATER HEIGHT AND PROBE SPEED Mainline ID: **2788 - 5156** Pipe ID: **2789 - 1915** Diameter: **8** inches Pipe Type: **VCP** Soil Type: **Clay Loam** Ground Condition: **Dry**



5

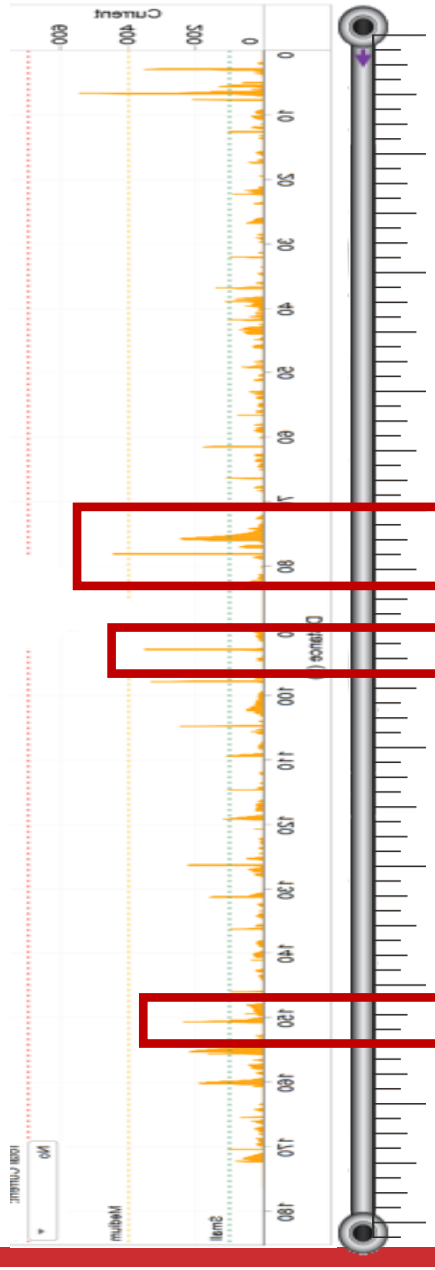
FELL

CCTV

CCTV Date:
10/10/2018

Electro Scan
29 Defects
12.8 GPM

CCTV
3 Callouts Identifying Infiltration



68.5’ Water Level Sag

72.5’ Water Level
73.6’ Tap Factory Made Defective Infiltration

93.2’ Infiltration Weeper At Tap Break In
93.7’ Tap Break-In Intruding

116.3’ Tap Factory Made Capped

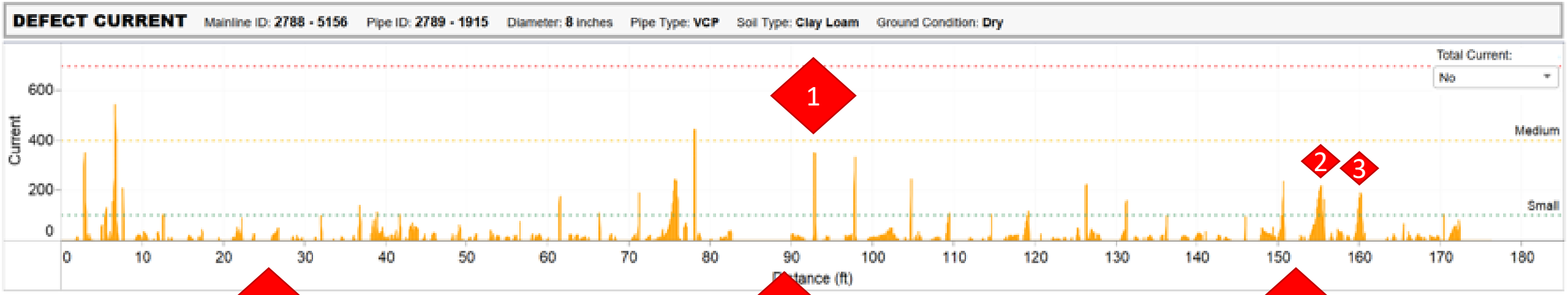
148.6’ Tap Factory Made
148.6’ Infiltration Runner Under Connection

195.3’ Tap Factory Made Capped

5

LEAKING JOINTS AND LATERALS THROUGHOUT.

CCTV Date
10/10/2018

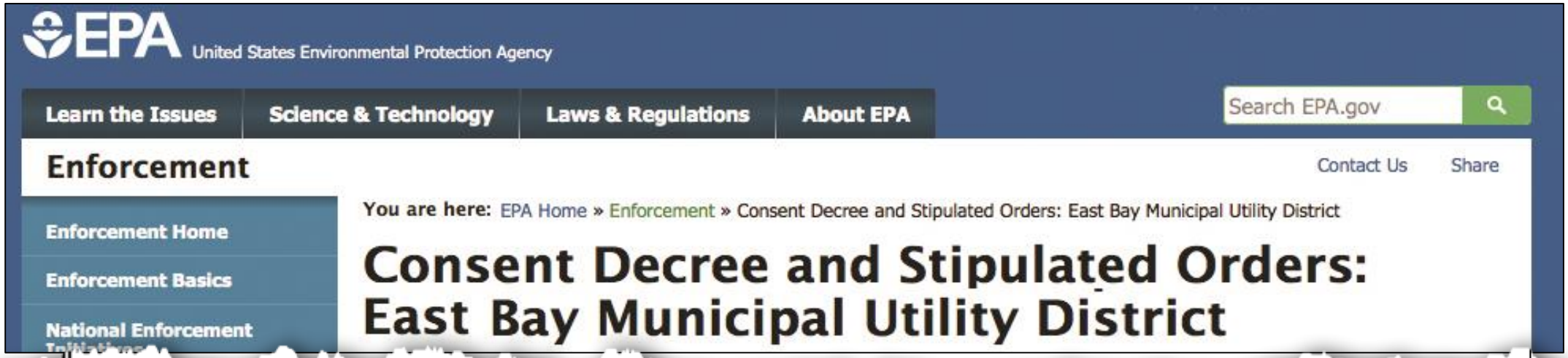


Part 4

Wrap Up

electro scaninc.

Included in EPA Consent Decrees Since 2014

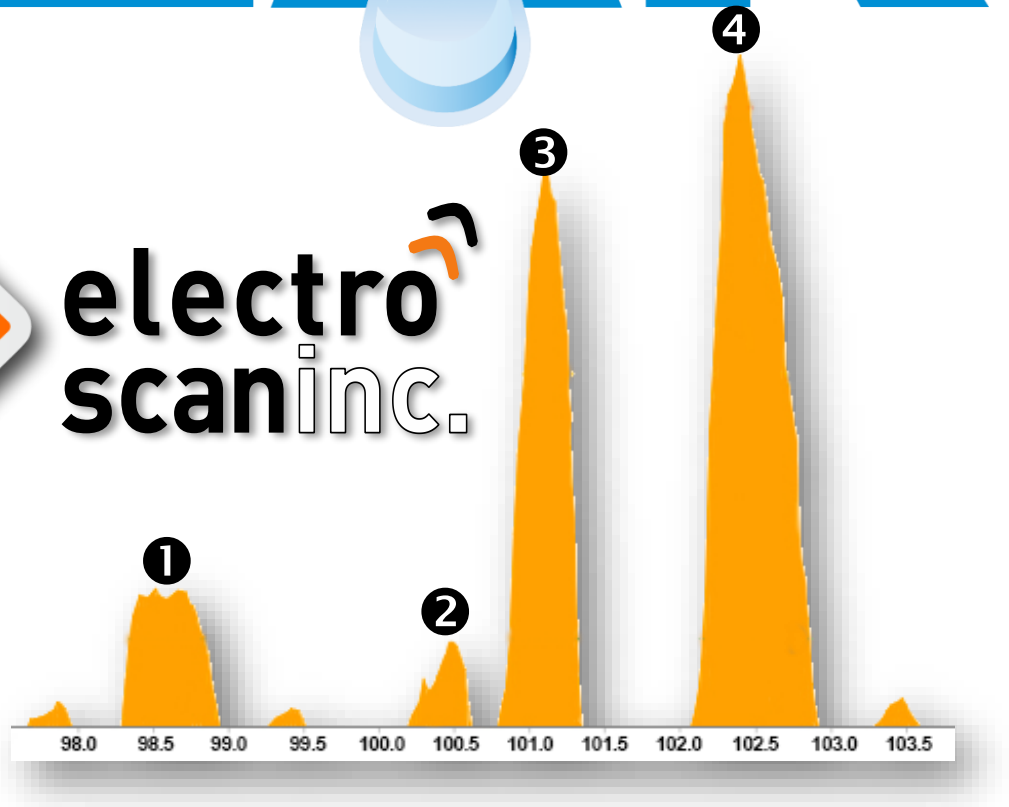


iv. Other field data collection methods such as dye testing; level sensors; CCTV; visual inspection; focused electrode leak location; laser; sonar; field reconnaissance during storm events; and other methods of detecting sources of Inflow and Rapid Infiltration.

d. Identify additional techniques for I&I identification and prioritization. These may include, but are not limited to, analysis of surface maps, rainfall-response data analysis, or hydrologic or hydraulic modeling.

LEAK

electro scan inc.



IMMEDIATELY CHANGE YOUR SPECS

Defect	Repair Method
Wrinkles or ridges exceeding 5% and up to 8% of pipe diameter outside of 120-degree invert arc. Wrinkles or ridges exceeding 2% and up to 8% of pipe diameter inside of 120-degree invert arc (except corrugations in CMP).	Grind to required tolerance. Grind to required tolerance within the lower 120-degrees of pipe to remove and point repair where needed to maintain minimum thickness, or else use procedure in accepted repair plan. If wrinkles or ridges exceed 8% of pipe diameter, you must remove CIPP.
Holes, tears, soft spots, and lifts up to 6 inches in major dimension. Delaminated areas up to 12 inches in major dimension; blistering or bubbling of the coating on CIPP surface present over a maximum of 5% of surface area.	Make point repair under manufacturer's recommendations. If defect covers a larger area, you must remove CIPP.
CIPP thickness less than calculated minimum thickness.	You must remove CIPP. If groundwater conditions allow, you may install a second CIPP within the first CIPP that produces a similar dimension ratio to the first CIPP, or else use procedure in accepted repair plan.
Annular space at lateral connection or at end of CIPP or infiltration at lateral opening.	Seal with quick-set epoxy mortar, high viscosity epoxy or a hydrophilic vulcanized expansive rubber strip.

NEVER GRIND DOWN WRINKLES!

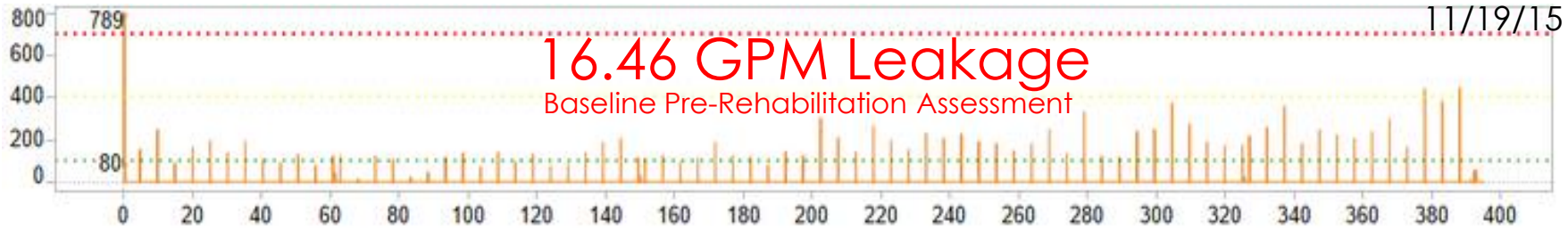
Defect	Repair Method
Wrinkles or ridges exceeding 5% and up to 8% of pipe diameter outside of 120-degree invert arc. Wrinkles or ridges exceeding 2% and up to 8% of pipe diameter inside of 120-degree invert arc (except corrugations in CMP).	Grind to required tolerance. Grind to required tolerance within the lower 120-degrees of pipe to remove and point repair where needed to maintain minimum thickness, or else use procedure in accepted repair plan. If wrinkles or ridges exceed 8% of pipe diameter, you must remove CIPP.
Holes, tears, soft spots, and lifts up to 6 inches in major dimension. Delaminated areas up to 12 inches in major dimension; blistering or bubbling of the coating on CIPP surface present over a maximum of 5% of surface area.	Make point repair under manufacturer's recommendations. If defect covers a larger area, you must remove CIPP.
CIPP thickness less than calculated minimum thickness.	You must remove CIPP. If groundwater conditions allow, you may install a second CIPP within the first CIPP that produces a similar dimension ratio to the first CIPP, or else use procedure in accepted repair plan.
Annular space at lateral connection or at end of CIPP or infiltration at lateral opening.	Seal with quick-set epoxy mortar, high viscosity epoxy or a hydrophilic vulcanized expansive rubber strip.

BEST PRACTICE

THREE STEPS TO ZERO.

Date		Pipe ID	Diameter	Pipe Type	Distance (ft)	Small Defects	Medium Defects	Large Defects	GPM	GPD	GPD/IDM
11/19/2015	A	1-35 - 1-34	8	VCP	395.1	64	2	1	16.46	23,702	39,592

Test A

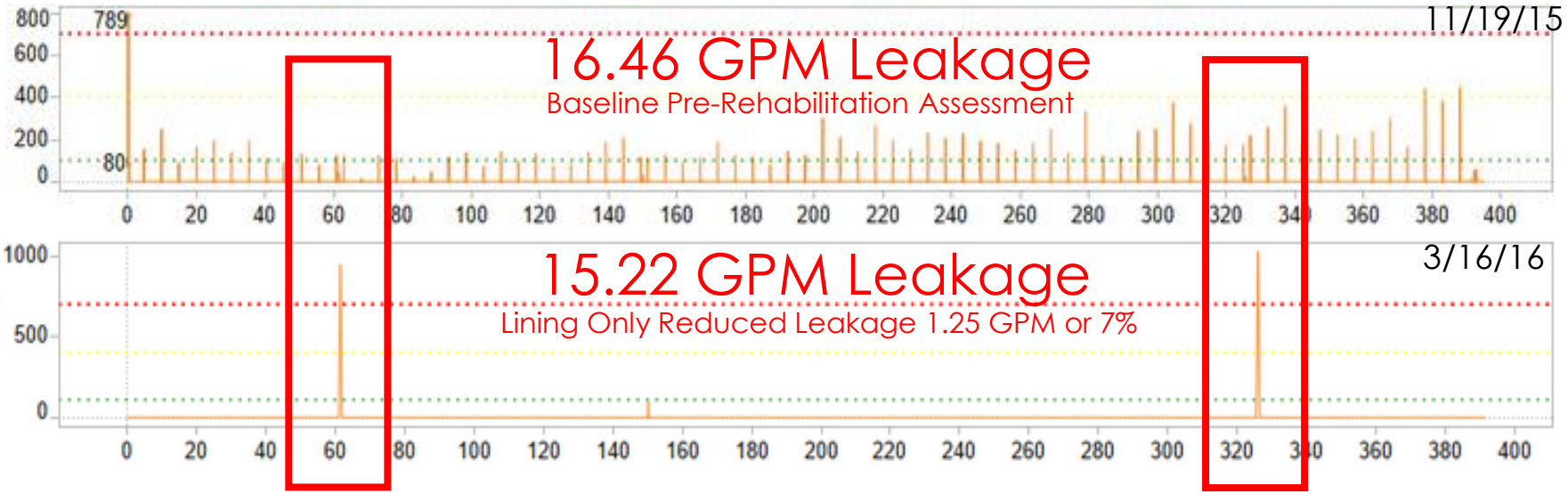


THREE STEPS TO ZERO.

Date		Pipe ID	Diameter	Pipe Type	Distance (ft)	Small Defects	Medium Defects	Large Defects	GPM	GPD	GPD/IDM
11/19/2015	A	1-35 - 1-34	8	VCP	395.1	64	2	1	16.46	23,702	39,592
3/16/2016	B	1-35 - 1-34	8	CIPP	391.3	0	0	2	15.22	21,917	36,968

Test A

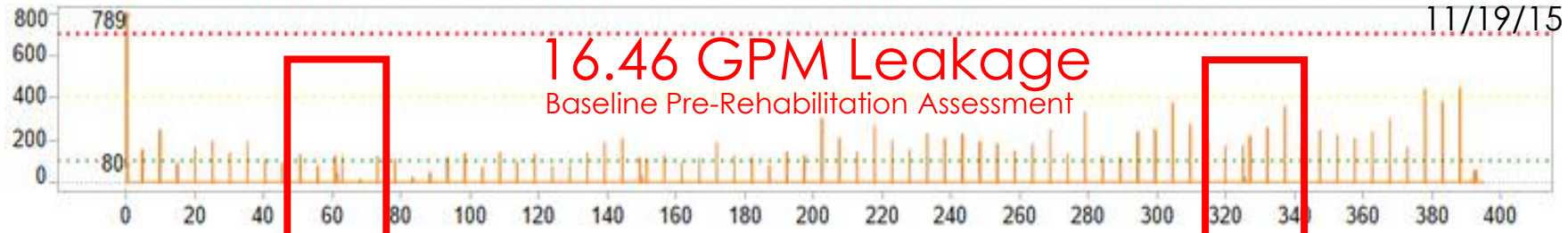
Inspect B



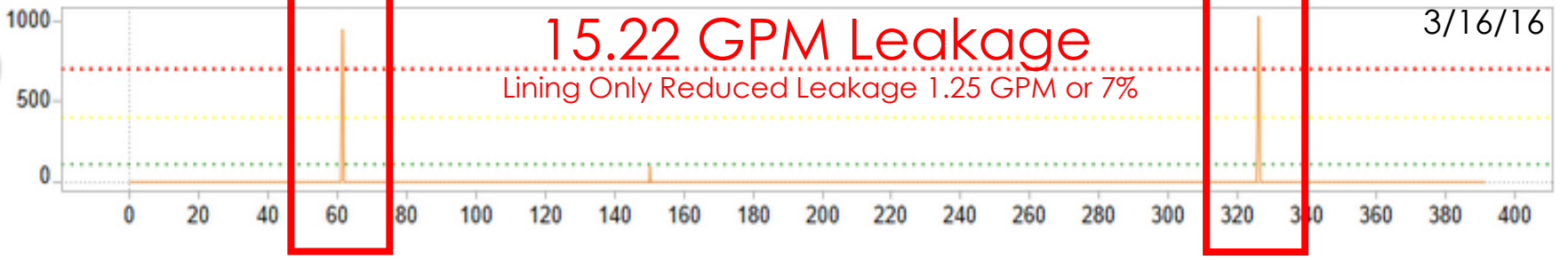
THREE STEPS TO ZERO.

Date		Pipe ID	Diameter	Pipe Type	Distance (ft)	Small Defects	Medium Defects	Large Defects	GPM	GPD	GPD/IDM
11/19/2015	A	1-35 - 1-34	8	VCP	395.1	64	2	1	16.46	23,702	39,592
3/16/2016	B	1-35 - 1-34	8	CIPP	391.3	0	0	2	15.22	21,917	36,968
6/29/2016	C	1-35 - 1-34	8	CIPP	394.8	1	0	0	0.20	288	481

Test A



Inspect B



Accept C

Mackenzie App Mackenzie@Electroscan.com 315-857-8845


ANSWER
QUESTION