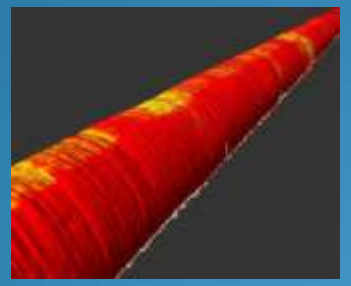
TECHNOLOGIES FOR ASSET MANAGEMENT OF COLLECTION SYSTEMS



ORWEF WATER ENVIRONMENT SCHOOL

3-29-17

Michelle Beason, PE
Regional Manager
National Plant Services, Inc., a Carylon Company

NATIONAL PLANT SERVICES, INC.

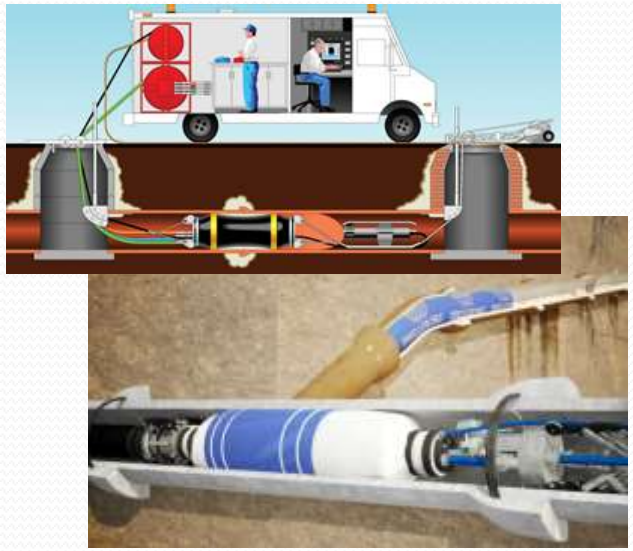
- New Service yard in Hayward, CA.
- Headquarters in Long Beach, CA, since 1981.
- The Carylon Corporation has been in business since 1949 and is comprised of 18 wholly-owned subsidiaries located in 33 locations throughout the United States.

CLEANING

- LARGE AND SMALL DIAMETER PIPE CLEANING
- ROOT REMOVAL
- WWTP CLEANING SERVICES

INSPECTION

- LATERAL AND MAINLINE CCTV INSPECTION
- MULTI-SENSOR INSPECTIONS
- MANHOLE INSPECTIONS



REPAIR

- LATERAL LINING
- CENTRIFUGALLY CAST STRUCTURAL COATINGS
- GROUTING
- CIPP POINT REPAIRS

PRESENTATION TOPICS:

- **WHAT IS ASSET MANAGEMENT?**
  - 14 STEPS TO CREATING A PLAN
- **CLEANING TECHNOLOGY INNOVATIONS**
  - RECYCLED WATER JET VAC TRUCKS
- **INSPECTION TECHNOLOGIES**
  - ADVANCED INSPECTIONS USING LASER/SONAR ROBOTS
  - SL RAT – SEWER LINE RAPID ASSESSMENT TOOL
- **TRENCHLESS REPAIR SOLUTIONS**
  - GROUTING
  - LATERAL LINING
  - CENTRIFUGALLY CAST CONCRETE COATING

What is Asset Management?

What is “Asset Management”?

A <u>continuous</u> process that guides the acquisition, use, maintenance, and disposal of infrastructure assets to optimize level of service, at the lowest life cycle cost.

Level of service: providing reliable and efficient service to customers.

Lowest Life Cycle Cost: Lowest cost for repairing and/or rehabilitating an asset over the assets entire life.

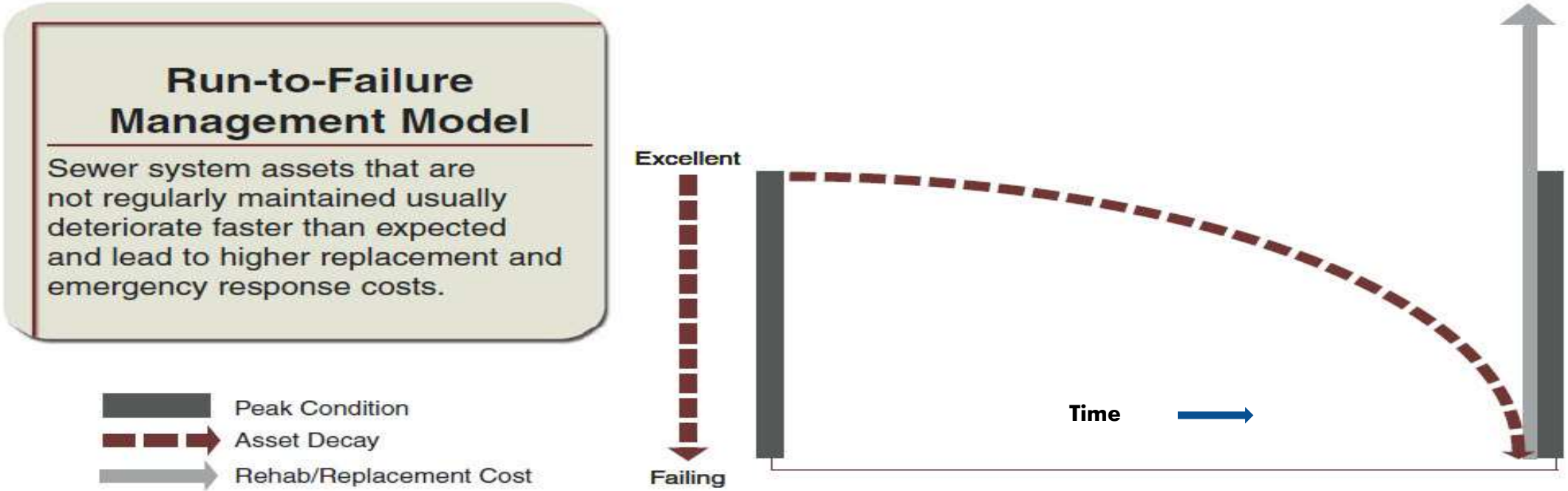
What is "Asset Management"?

What is asset management?

Asset management is a continuous process that guides the acquisition, use, and disposal of infrastructure assets to optimize service delivery and minimize costs over the asset's entire life. Among public utility agencies in the U.S., infrastructure asset management is used most extensively in the transportation sector to protect and maximize investments in highway, rail, and airport infrastructure assets.

Reference: "SSO Fact Sheet – Asset Management for Sewer Collection Systems", USEPA, April 2002

Run to Failure Method



Copied From "SSO Fact Sheet – Asset Management for Sewer Collection Systems", USEPA, April 2002

Benefits of Asset Management

- Prolonging asset life and aiding in rehabilitation/repair/ replacement decisions
- Saving money by preventing unnecessary maintenance activities.
- Meeting service expectations and regulatory requirements.
- Reducing need for expansions and additions through demand management (I/I reduction, flow balancing, etc)
- Setting rates based on sound operational and financial planning.

The main goal of Asset Management is to MAXIMIZE Planned Maintenance and MINIMIZE Unplanned Maintenance.

DEVELOPING AND MAINTAINING AN ASSET MANAGEMENT PLAN

1. What are our Assets
2. Current State and Valuation of Assets
3. Service Activities on the Assets
4. Desired Level of Service
5. Performance goals/Indicators
6. Condition Assessment
7. Capacity Assurance Planning
8. Backbone and Critical Facilities – Emergency Response
9. GIS Based Information system
10. Failure impact evaluation and risk management
11. Maintenance analysis and frequency planning
12. Rehabilitation and replacement Planning
13. Financial Management
14. Maintain and continuously improve your new AM system.

References

"**Asset Management: A Best Practices Guide**", US EPA, April 2008

"**SSO Fact Sheet – Asset Management for Sewer Collection Systems**", USEPA, Office of Wastewater Management, April 2002

"**The O&M in CMOM: Operation & Maintenance**", Water Environment Federation, O&M Version 2.3a

CLEANING TECHNOLOGY INNOVATIONS

RECYCLED WATER JET VACS

Saves Water AND More Efficient

WHAT DO I CLEAN FIRST? HOW OFTEN?

- Establish a regular cleaning frequency depending on the age, material, use, condition of your assets.
- As you clean, record what you find and adjust frequency as needed.
- Have a “Hot Spot” list for those frequent problem areas
  - But then make a plan to FIX those problems!!!!!

RECycler 315 Recycling Jet Vac

- Continuously recycles the wastewater and reuses it to clean the sewer
- Can save over 10,000 gallons per day of drinking water
- 80 to 124 gpm jetting capacity
- Bypass pumping system on board
- Higher efficiency as crews don't have to stop and relocate to fill the water tanks throughout the day
- Automatic filter cleaning operations
- Remote control panel for ease of operation
- Made in Denmark


J.Hvidtved Larsen US
Jesper Hyt, Service Manager
J. Hvidtved Larsen, Denmark

INSPECTION TECHNOLOGIES

Wastewater Inspection Tools

- CCTV Cameras
  - CCTV with Defect Coding
  - Pan Tilt Zoom, or 360




- Multi – Sensor Inspection (MSI) Cameras
  - CCTV
  - Laser
  - Sonar


THE BASICS OF CCTV

- CCTV inspections should be done on a regular frequency to monitor pipe condition.
- It's important to code using a standardized system, either PACP, or your own unique system.
  - What is PACP (Pipeline Assessment and Certification Program)?
    - NASSCO (National Association of Sewer Service Companies) developed the Pipeline Assessment and Certification Program.
    - The objective: consistency between people observing pipe defects, and to be as detailed as possible.
    - Track changes in pipe condition over time
    - 2-day PACP certification class.

PACP – PIPELINE ASSESSMENT AND CERTIFICATION PROGRAM

- Guidelines established in 2002
- Standardized codes and ratings for inspection defects
- Training and certification of operators
- Certification of software vendors (IT Pipes, Wincan, GraniteXP, POSM, etc)
- Guidelines for mapping of data results
  - Structural defects (cracks, manufacture, etc)
  - O&M defects (roots, cleaning, etc)
  - Construction features (manholes, taps, laterals, etc)

PACP GRADES: 1-5

General Assignment of Pipe Condition Grades

Grade 5	Collapsed or collapse imminent
Grade 4	Collapse likely in foreseeable future
Grade 3	Collapse unlikely in near future
Grade 2	Minimal collapse risk
Grade 1	Acceptable structural condition
Grade 0	**An observation only (lateral, manhole, etc)**

PACP Code Example 1

CODE	
PACP	DESCRIPTIONS
Constructional	
BSV	Broken Soil Visible
BVV	Broken Void Visible
H	Hole
HSV	Hole Soil Visible
HVV	Hole Void Visible
D	Deformed
DV	Deformed Vertically
DH	Deformed Horizontally
XP	Collapse
	Joint Displaced
JOM	Joint Displaced/Joint Offset Medium (1 to 1.5)
JOL	Joint Displaced Large /Joint Offset Large (>1.5)
	Open Joint
JSM	Joint Open Medium
JSL	Joint Open Large
JAM	Joint Angular Medium
JAL	Joint Angular Large
SSS	Surface Spalling slight
	Surface Spalling Medium
	Surface Spalling Large
SSSC	Surface Spalling Chemical
SSSM	Surface Spalling Mechanical
SSSZ	Surface Spalling Unknown
SRI	Surface Wear Slight/Roughness Increased
SRIC	Roughness Increased Chemical
SRIM	Roughness Increased Mechanical
SRIZ	Roughness Increased Unknown
SAV	Surface Damage Aggregate Visible
SAVC	Surface Damage Aggregate Visible Chemical

PACP Code Example 2

CODE	
PACP	DESCRIPTIONS
Constructional	
SRV	Surface Wear Large/Aggregate is missing reinforcement visible
SRVC	Aggregate is missing reinforcement visible chemical
SRVM	Aggregate is missing reinforcement visible mechanical
SRVZ	Aggregate is missing reinforcement visible unknown
SRP	aggregate missing and reinforcement is projecting
SRPC	aggregate missing and reinforcement is projecting chemical
SRPM	aggregate missing and reinforcement is projecting mechanical
SRPZ	aggregate missing and reinforcement is unknown
SRC	Reinforcement Corroded
SRCC	Reinforcement Corroded Chemical
SRCM	Reinforcement Corroded Mechanical
SRCZ	Reinforcement Corroded Unknown
SMW	Missing Wall
SMWC	Missing Wall Chemical
SMWM	Missing Wall Mechanical
SMWZ	Missing Wall Unknown
SZ	Surface Damage Other
SZC	Surface Damage Other Chemical
SZM	Surface Damage Other Mechanical
SZZ	Surface Damage Other Unknown
SCP	Surface Damage Corrosion
	Lining Defect
LFD	Lining Detached
LFDE	Lining Defective End
LFB	Lining blistered
	Lining discoloration
LFCS	Lining Service Cut shifted
LFAC	Lining Abandoned Connection
LFOC	Lining Overcut Service

Observed Cracks

Back | Next | Refresh Results | Filter Results | Export Results | Send to GIS | Send to O&M Planner | Send to CIP Project

CCTV Inspection

Line Segment	Up Stream MH	Dn Stream MH	PipeMaterial	System Type	PipeSizeHeight	Line Length	Structural Quick	OM Quick
D11MH1734_D11MH	D11MH1734	D11MH2638	Vitrified Clay Pipe	PipeTech	8.00	481.00	5111	0000
D13MH481_D13MH4	D13MH481	D13MH482	Vitrified Clay Pipe	PipeTech	6.00	390.29	4123	3100
D14MH1983_E14MH	D14MH1983	E14MH1982	Vitrified Clay Pipe	PipeTech	6.00	260.00	5131	4138
D14MH1984_E14MH	D14MH1984	E14MH1981	Vitrified Clay Pipe	PipeTech	6.00	300.00	3423	2718
D14MH1986_E14MH	D14MH1986	E14MH1977	Vitrified Clay Pipe	PipeTech	6.00	500.00	5231	4122
D14MH2805_D14MH	D14MH2805	D14MH1987	Vitrified Clay Pipe	PipeTech	6.00	694.40	5231	4231
D14SF564_D14MH1	D14SF564	D14MH1985	Vitrified Clay Pipe	PipeTech	6.00	220.00	332E	1A00
D7MH773_D7MH768	D7MH773	D7MH768	Vitrified Clay Pipe	PipeTech	12.00	245.90	2111	2Z13
D8MH2700_D8MH26	D8MH2700	D8MH2656	Vitrified Clay Pipe	PipeTech	8.00	100.00	3100	2100
E10MH947_E10MH9	E10MH947	E10MH948	Vitrified Clay Pipe	PipeTech	10.00	82.86	5111	0000
E10MH949_E10MH9	E10MH949	E10MH951	Vitrified Clay Pipe	PipeTech	12.00	325.43	2100	0000
E10MH950_E10MH9	E10MH950	E10MH948	Vitrified Clay Pipe	PipeTech	10.00	181.67	2100	0000
	E10SF592	E10MH944	Vitrified Clay Pipe	PipeTech	6.00	0.00	3100	5100
	E10SF592	E10MH944	Vitrified Clay Pipe	PipeTech	6.00	36.70	2100	0000
E10SF798_E10MH9	E10SF798	E10MH954	Vitrified Clay Pipe	PipeTech	6.00	179.38	2100	2700
E11MH1568_E11MH	E11MH1568	E11MH1566	Vitrified Clay Pipe	PipeTech	10.00	244.00	1300	2100
E11MH1573_E11MH	E11MH1573	E11MH408	Vitrified Clay Pipe	PipeTech	15.00	319.00	211C	3500
E12MH1875_E12MH	E12MH1875	E12MH2425	Vitrified Clay Pipe	PipeTech	6.00	85.51	3521	4100
E12MH2424_E12MH	E12MH2424	E12MH1875	Vitrified Clay Pipe	PipeTech	6.00	77.23	5231	2100
E12MH2425_D12MH	E12MH2425	D12MH311	Vitrified Clay Pipe	PipeTech	6.00	537.92	2111	0000
E12MH2425_D12MH	E12MH2425	D12MH311	Vitrified Clay Pipe	PipeTech	6.00	537.92	3627	4132
E12MH2426_E12MH	E12MH2426	E12MH1875	Vitrified Clay Pipe	PipeTech	8.00	170.95	1100	0000
E12MH480_E13MH2	E12MH480	E13MH2236	Vitrified Clay Pipe	PipeTech	6.00	232.71	3111	2100

Observed Cracks

Back | Next | Refresh Results | Filter Results | Export Results | Send to GIS | Send to O&M Planner | Send to CIP Project

CCTV Inspection

Line Segment	Up Stream MH	Dn Stream MH	PipeMaterial	System Type	PipeSizeHeight	Line Length	Structural Quick	OM Quick
D14SF564_D14MH1	D14SF564	D14MH1985	Vitrified Clay Pipe	PipeTech	6.00	220.00	332E	1A00

CCTV Observations

AcuteDefect	R3Category	Score	DefectType	CodeCategory	SubCategory	Description	Distance	Remarks
NO	No Action		AMH	Configuration	Structure	Manhole	0.00	START OF INSP
NO	No Action		MWL	Inspection	Water Level	Water Level	0.00	
NO	No Action		TFA	Configuration	Side Sewer Locatio	Tap Factory Activ	8.40	
NO	No Action		TFA	Configuration	Side Sewer Locatio	Tap Factory Activ	9.60	
NO	No Action		SSS	Structural	Pipe Deterioration	Surface Spalling	13.30	
NO	No Action		SSS	Structural	Pipe Deterioration	Surface Spalling	18.00	
NO	No Action		RFJ	Operational	Roots	Roots Fine Joint	21.10	
NO	No Action		RFJ	Operational	Roots	Roots Fine Joint	25.20	
NO	No Action		TFC	Configuration	Side Sewer Locatio	Tap Factory Capp	46.60	
NO	No Action		TFC	Configuration	Side Sewer Locatio	Tap Factory Capp	48.30	
NO	No Action		CM	Structural	Crack	Crack Multiple	49.30	
NO	No Action		CC	Structural	Crack	Crack Circumfere	55.70	
NO	No Action		CL	Structural	Crack	Crack Longitudina	70.10	
NO	No Action		TFC	Configuration	Side Sewer Locatio	Tap Factory Capp	71.20	
NO	No Action		TFC	Configuration	Side Sewer Locatio	Tap Factory Capp	73.30	
NO	No Action		RFJ	Operational	Roots	Roots Fine Joint	77.30	
NO	No Action		TFC	Configuration	Side Sewer Locatio	Tap Factory Capp	95.60	
NO	No Action		TFC	Configuration	Side Sewer Locatio	Tap Factory Capp	97.60	
NO	No Action		LR	Structural	Alignment	Alignment Right	111.00	
NO	No Action		TBA	Configuration	Side Sewer Locatio	Tap Break-in Acti	114.70	
NO	No Action		TFC	Configuration	Side Sewer Locatio	Tap Factory Capp	120.60	

Starting access point: Easting: Northing: Elevation: Coordinate system: GPS accuracy:

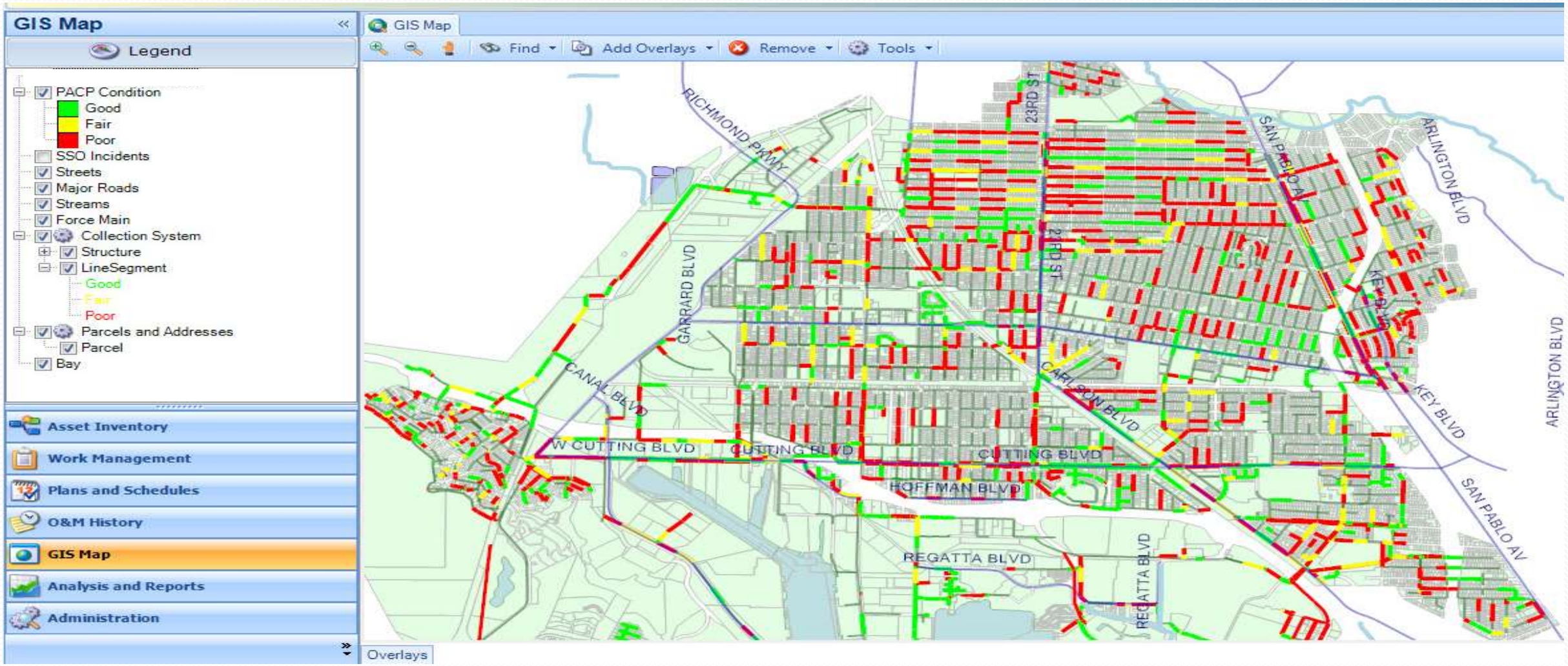
Grade	Amount of Structural Defects	Structural Segment Grade	Structural Pipe Rating	Structural Quick Rating	Structural Pipe Rating Index	Amount of O&M Defects	O&M Segment Grade	O&M Pipe Rating	O&M Quick Rating	O&M Pipe Rating Index	Overall Pipe Rating	Overall Pipe Rating Index
1	0	0	845	563Z	2.584098	0	0	4	4100	4	849	2.588415
2	148	296				0	0					
3	173	519				0	0					
4	0	0				1	4					
5	6	30				0	0					

National Plant Services Inc.
1461 Harbor Ave
Long Beach, CA 90813-2741
Phone: 562-436-7600
Fax: 562-495-1528

GRANITE XP

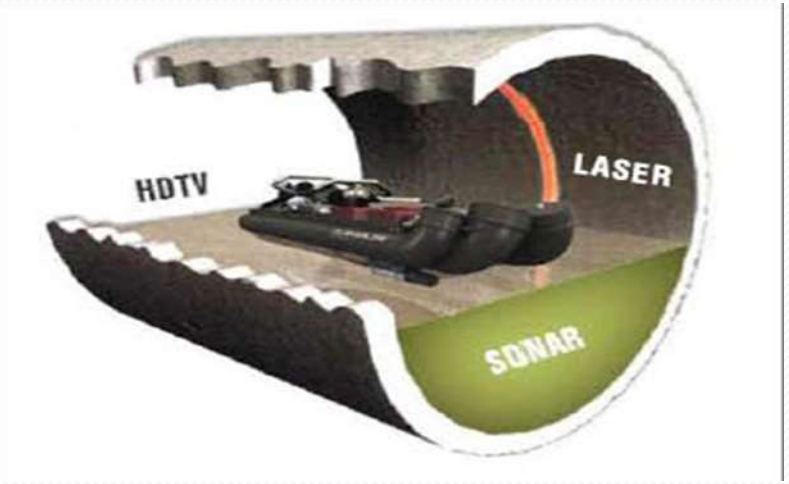
Surveyed by:	Owner:	Start date/time:	Upstream manhole No:	Pipeline segment ref:	Sheet number:
MORENO NPS		2016/11/02	N21-MH0036A	N21-MH0036A_N21-MH0035A	

Distance (Feet) (Meters)	Video Ref.	Group/ Descriptor	Modifier/ Severity	Continuous Defect	S/M/L	Value Inches (mm) 1st	Value Inches (mm) 2nd	%	Joint	Circumferential Location At/From	Circumferential Location to	Image Ref.	Family	Rating	Remarks
0.0	1	AMH										SACRAMENTO REGIONAL-N21-MH0036A-N21-MH0035A AMH at 0.0 ft (D).jpg			N21-MH0036A
0.0	25	MWL						5							
0.0	32	MWM						50					O&M	4	
0.0	88	SAV		S01					J	12	12	SACRAMENTO REGIONAL-N21-MH0036A-N21-MH0035A SAV at 0.0 ft (D).jpg	S	3	
0.0	127	SSS		S02						10	2	SACRAMENTO REGIONAL-N21-MH0036A-N21-MH0035A SSS at 0.0 ft (D).jpg	S	2	
764.3	1460	SAV		F01					J	12	12	SACRAMENTO REGIONAL-N21-MH0036A-N21-MH0035A SAV at 764.3 ft (D).jpg	S	3	
764.3	1475	SSS		F02					J	10	2	SACRAMENTO REGIONAL-N21-MH0036A-N21-MH0035A SSS at 764.3 ft (D).jpg	S	2	
764.3	1505	AMH										SACRAMENTO REGIONAL-N21-MH0036A-N21-MH0035A AMH at 764.3 ft (D).jpg			N21-MH0035A


GIS Map
Legend
PACP Condition
Good
Fair
Poor
SSO Incidents
Streets
Major Roads
Streams
Force Main
Collection System
Structure
LineSegment
Good
Fair
Poor
Parcels and Addresses
Parcel
Bay
Asset Inventory
Work Management
Plans and Schedules
O&M History
GIS Map
Analysis and Reports
Administration
GIS Map
Find
Add Overlays
Remove
Tools
RICHMOND PKWY
23RD ST
SAN PABLO AV
ARLINGTON BLVD
GARRARD BLVD
CANAL BLVD
W CUTTING BLVD
CUTTING BLVD
CARLSON BLVD
KEY BLVD
HOFFMAN BLVD
REGATTA BLVD
Overlays

LATERAL LAUNCH CAMERAS

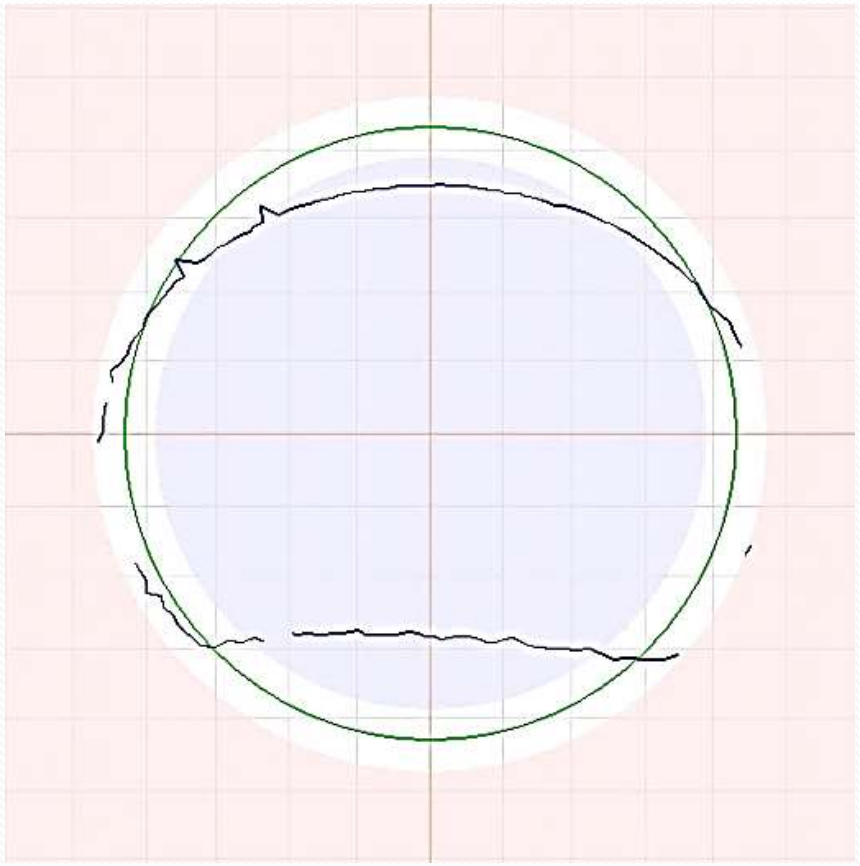
MULTI-SENSOR INSPECTIONS: Why Laser and Sonar?



- **LASER**
  - Measure Ovality
  - Measure Corrosion
  - Measure large defects/cracks
  - Help design rehab projects – size of lining needed, etc
- **SONAR**
  - Prioritize and Direct Cleaning
  - Determine large defects in the pipe under water

Example of Findings: Ovality

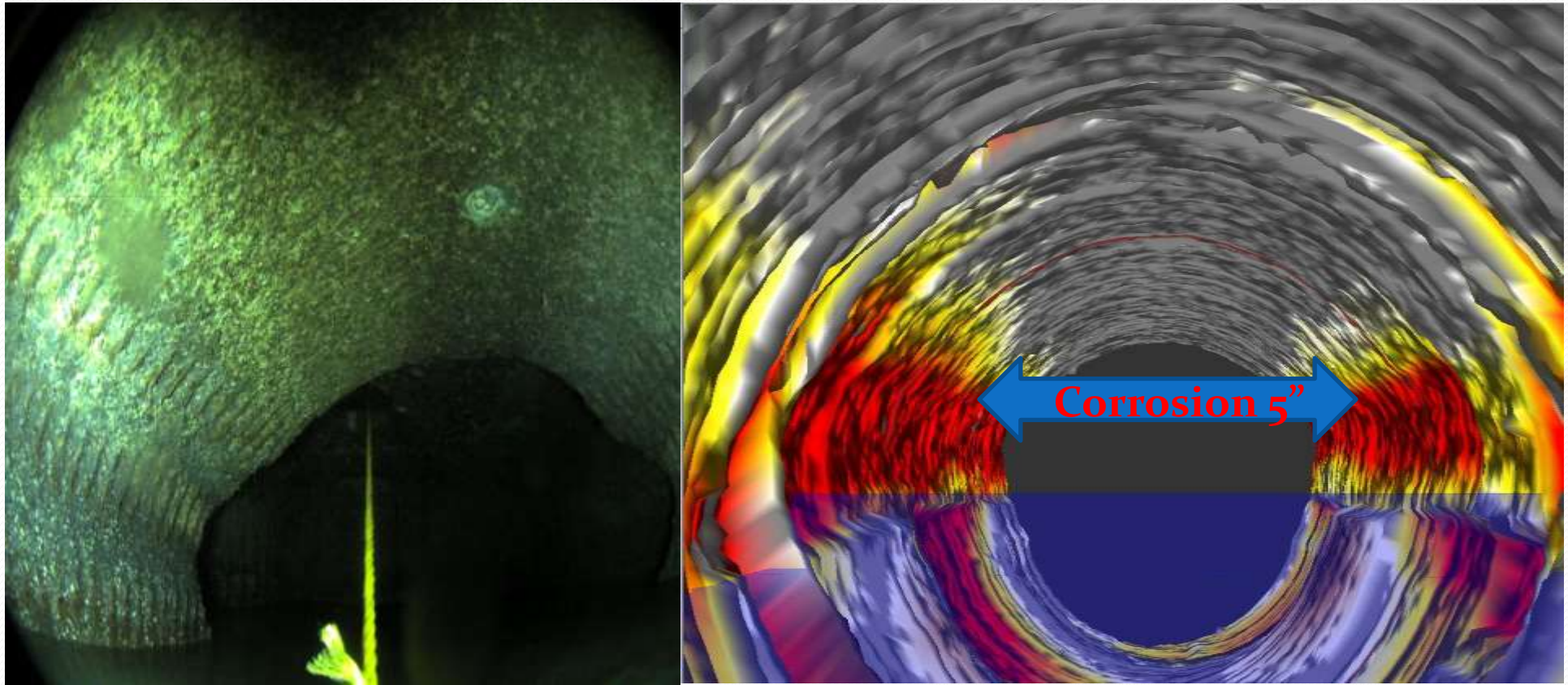
Observed Maximum Ovality: 21.2%



Example of Findings: Corrosion

Conventional CCTV

Laser Profiling



CORROSION IN CONCRETE PIPES

H_2S GAS IS PRODUCED BY THE SLIME LAYER UNDER THE WATER LINE. IT IS THEN OXIDIZED TO SULFURIC ACID BY THIOBACILLUS BACTERIA LIVING ON THE NON-SUBMERGED SURFACES, WHICH THEN 'EATS' THE CONCRETE, EXPOSING THE REBAR REINFORCEMENT, AND CAN LEAD TO COLLAPSE OF THE PIPE.

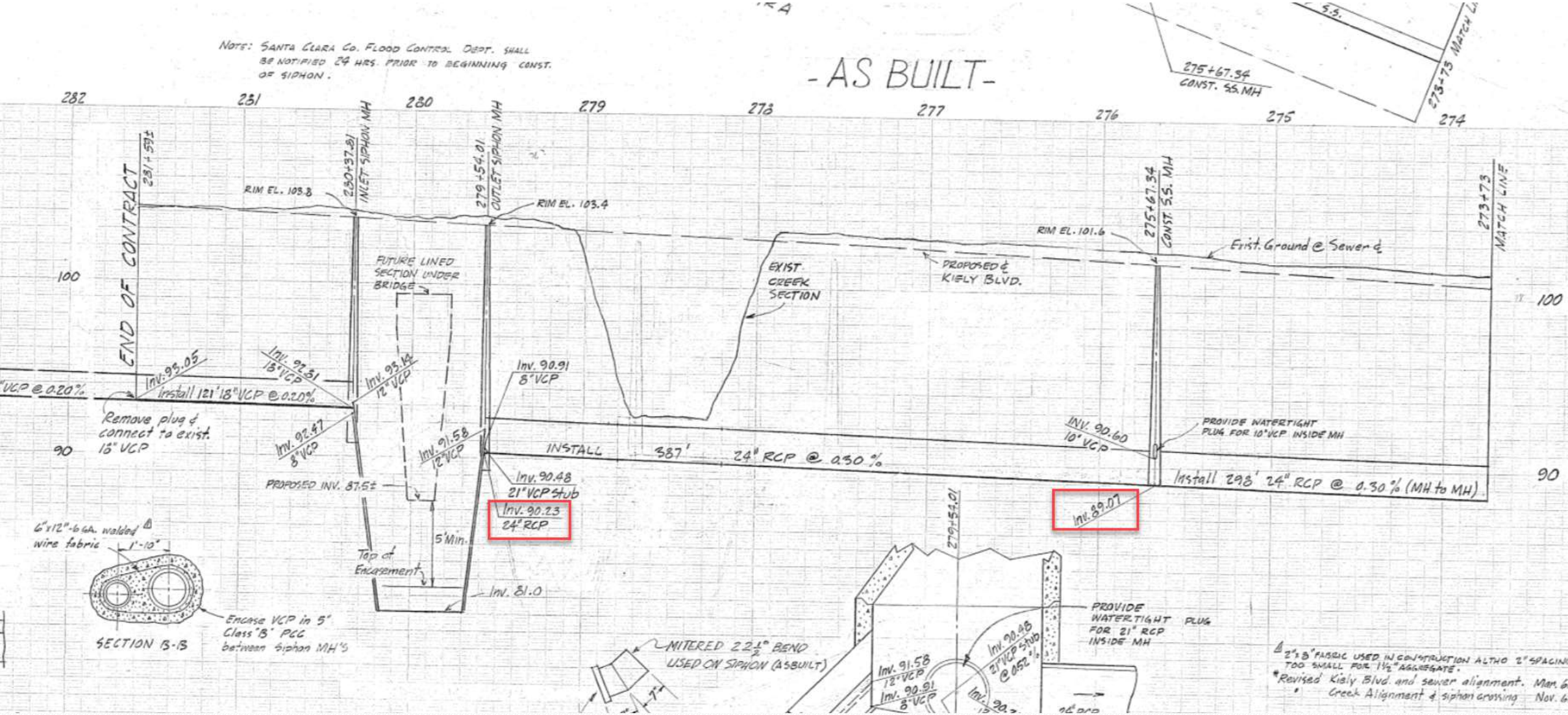
A Note about Hydrogen Sulfide (H2S) Gas

Flows greater than 2 fps will greatly reduce this. New sewers should be designed to take into consideration these necessary flows.

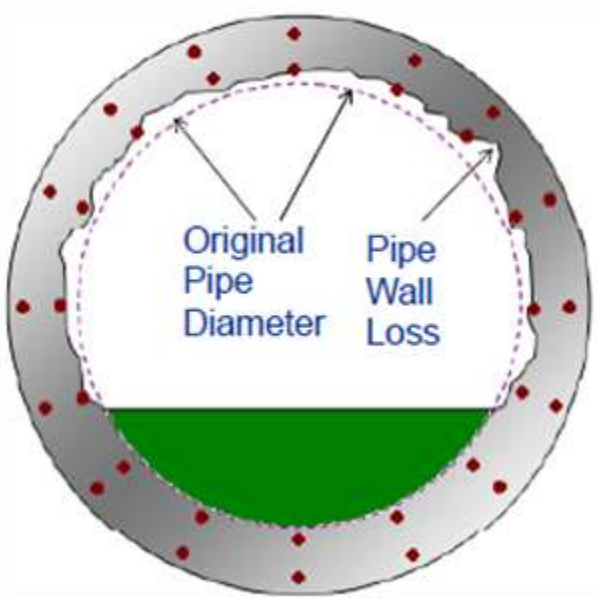
For older sewers without the necessary velocity, monitoring and routing flushing of the pipes can help reduce the amount of H2S gas.

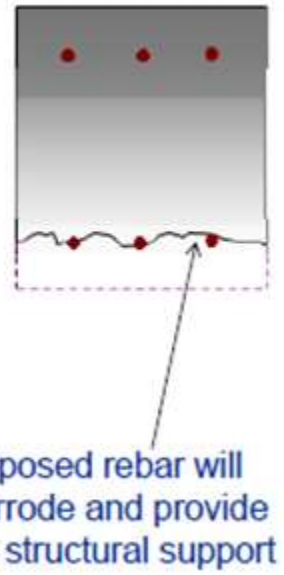
Purchase an aeration system that adds oxygen and changes the chemistry of H2S Gas into harmless sulfates.

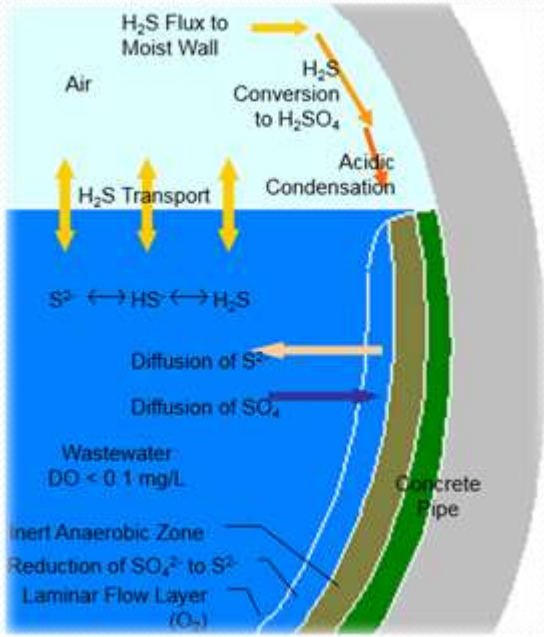
Fall: 90.23' – 89.07' = 1.16 feet elevation difference
Distance between MHs = 380 feet
So, slope is 1.16 feet of fall/380 feet of run = 0.003 x 100 = 0.3% slope



What Happens with Large Wastewater Pipelines: A Quick Primer on Corrosion (example of RCP)







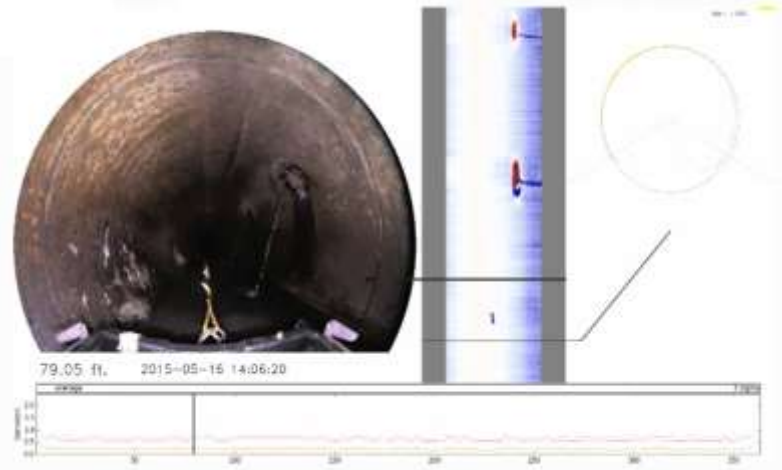
NATIONAL PLANT SERVICES, CARYLON CORPORATION - ADVANCED PIPE INSPECTION TECHNOLOGIES									
TECHNOLOGY PHOTOS	NAME	PURPOSE	MIN SIZE (INCH)	MAX SIZE (INCH)	DEPLOY LENGTH (LF)	CCTV	HD CCTV	LASER	SONAR
	Pole Camera	Pole mounted zoom cameras make it quick and easy to inspect pipes from the topside of a manhole	6"	120"	From Manhole opening only	X			
 CUES GEN OPTICAL ZOOM CAMERA	Conventional CCTV Cameras	We have a large fleet of CCTV cameras including CUES, Envirosight, and Aries that fit on multiple small and large powered tractor platforms	2"	120"	2,000	X			
	National Plant Services TV/Sonar/Laser Float	Float that is configurable with live CCTV cameras, sonar, laser sensors	21"	240"	2,000	X		X	X
	Carylon Collapsible TV/Sonar Float	Collapsible float that is configurable with live CCTV cameras, sonar, laser sensors	21"	240"	2,000	X		X	X
	LIDAR Scanners/3D Laser	Highly accurate LIDAR laser scanners that can be mounted to tractor or float, and used in conjunction with CCTV and sonar. Used to determine corrosion and ovality changes.	30"	35'	2,000			X	
	Diode Laser Profiler	CCTV camera and laser head in one. Creates a profile of the interior diameter to determine corrosion and ovality of pipelines. Tractor and Floating platform.	6"	54"	2,000	X		X	
	Fly Eye MSI Float (Small)	Sonar, Ring Laser, and "fish eye" HDCCTV Assessment in pipelines - Autonomous/ Battery Operated	18"	33"	4,200		X	X	X
	Fly Eye MSI Float (Large)	Sonar, Ring Laser, and "fish eye" HDCCTV Assessment in pipelines - Autonomous/ Battery Operated	36"	118"	6,000		X	X	X
	Sonar Submarine	Sonar of siphons, and full or partially full pipelines - Autonomous/Battery Operated	16"	118"	6,000				X
	Sonar	Live Feed Sonar used to inspect siphons or pipelines. This is the same sonar that is used on the Carylon Collapsible Float.	8"	30'	2,000				X
	Laser Skid	Laser Profiling in dry to partially full pipelines - used with conventional CCTV Camera	12"	48"	2,500	X		X	

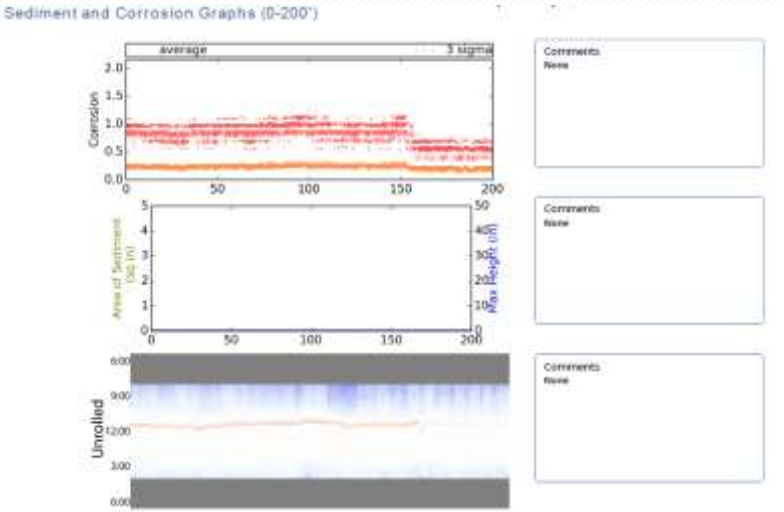
Types of Lasers

- 3D Laser – data in xyz planes
- 2D Laser – data in xy planes
- Ring Laser – ring of light projected inside pipe, measured with camera
- Diode Laser – two very accurate point lasers that spin to create a spiral scan

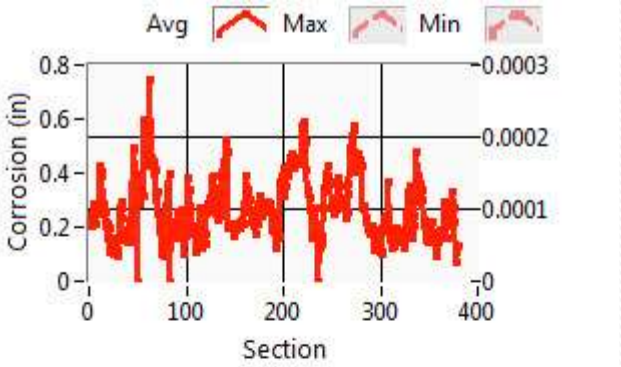
3D Laser

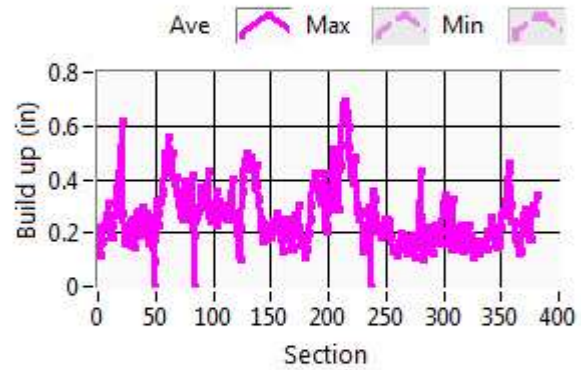
- Several hundred thousand measurements in every direction (X,Y,Z) as the platform moves throughout the pipe.
- Measures corrosion levels, ovality, deflection, and large defects.
- Accuracy from 1/16” to ¼”

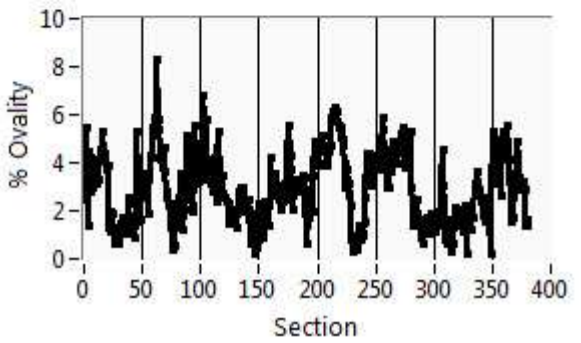


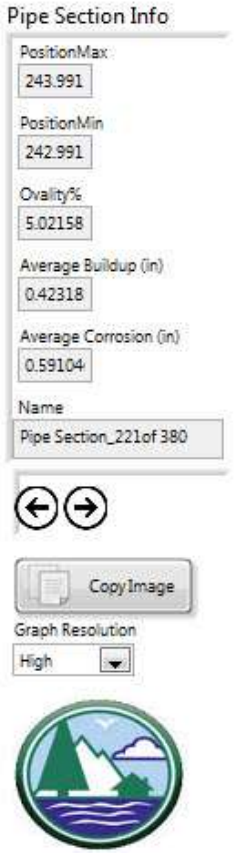


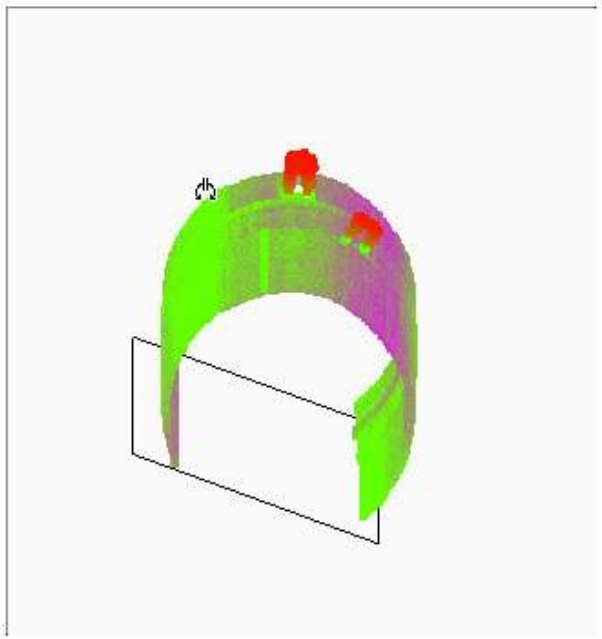
3D Laser

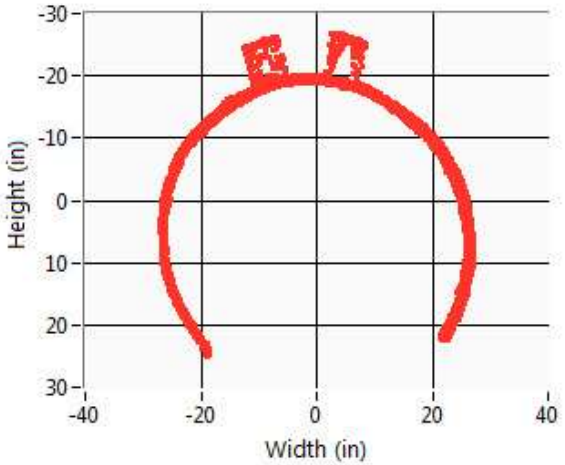

Avg
Max
Min
Corrosion (in)
0.8
0.6
0.4
0.2
0
0.0003
0.0002
0.0001
0
0
100
200
300
400
Section


Ave
Max
Min
Build up (in)
0.8
0.6
0.4
0.2
0
0
50
100
150
200
250
300
350
400
Section

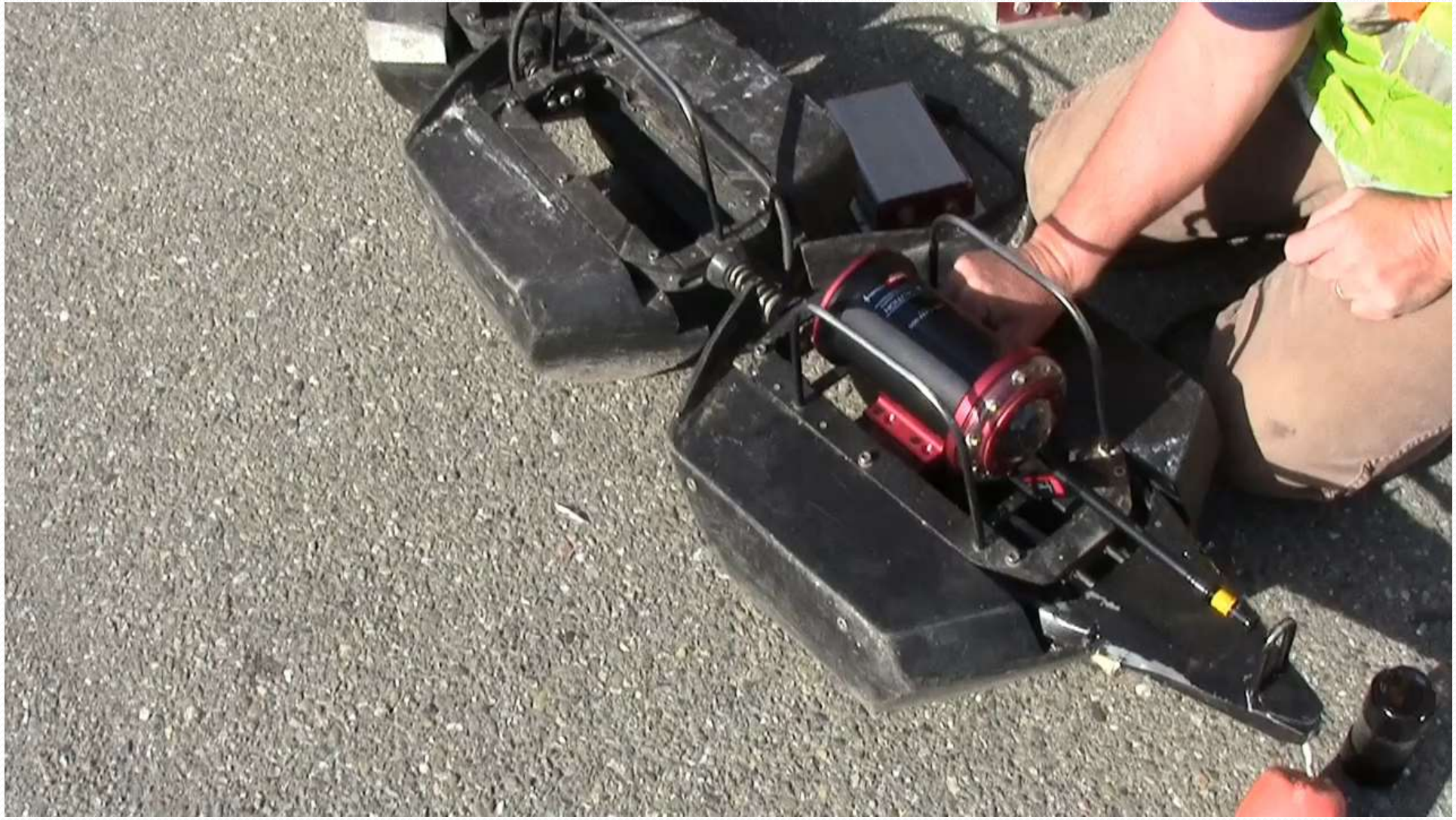

% Ovality
10
8
6
4
2
0
0
50
100
150
200
250
300
350
400
Section


Pipe Section Info
PositionMax
243.991
PositionMin
242.991
Ovality%
5.02158
Average Buildup (in)
0.42318
Average Corrosion (in)
0.59104
Name
Pipe Section_221of 380
Copy Image
Graph Resolution
High




Height (in)
-30
-20
-10
0
10
20
30
-40
-20
0
20
40
Width (in)

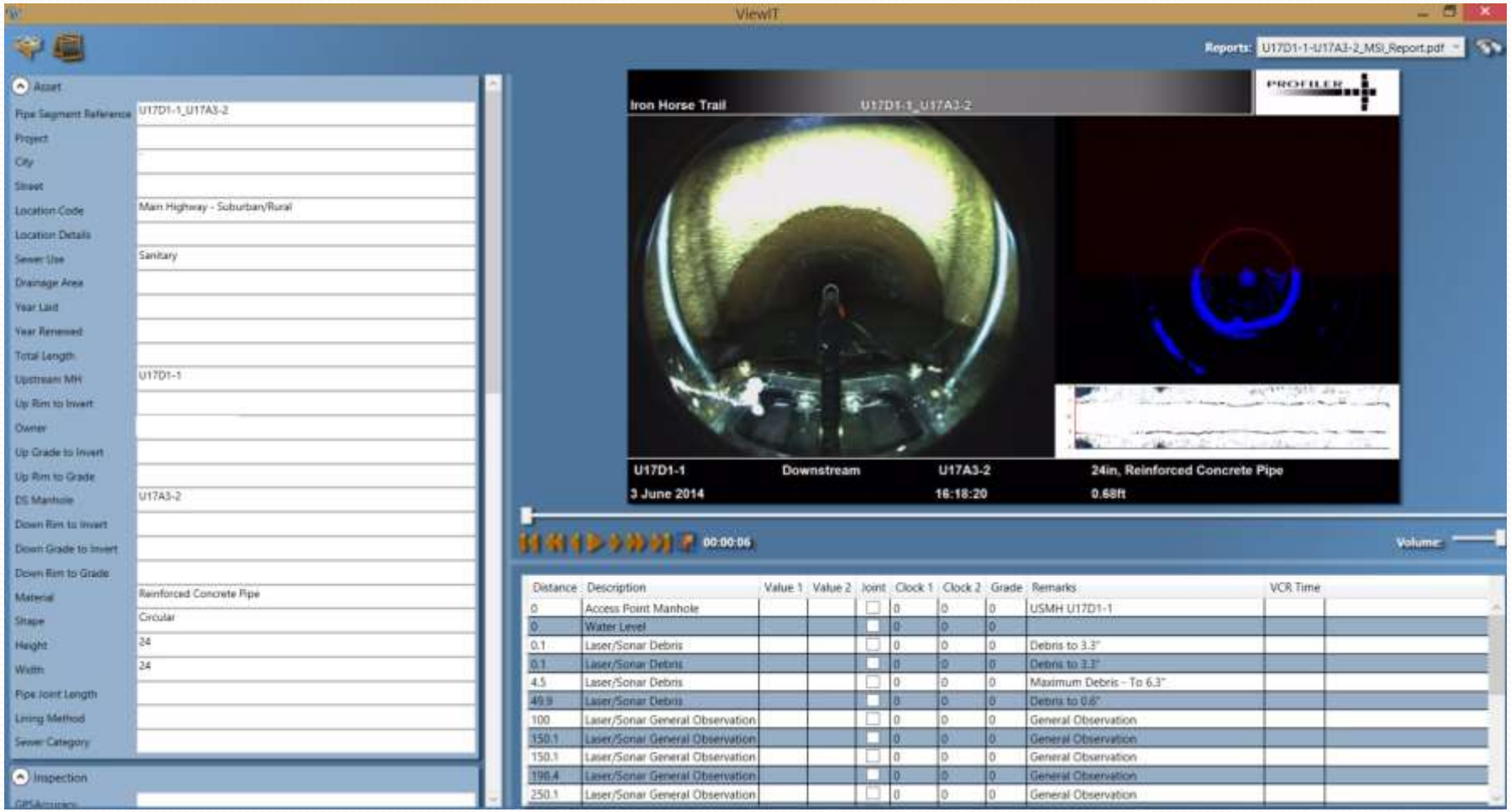
Field Deployment of Ring Laser Technology



When to Crawl…When to Float

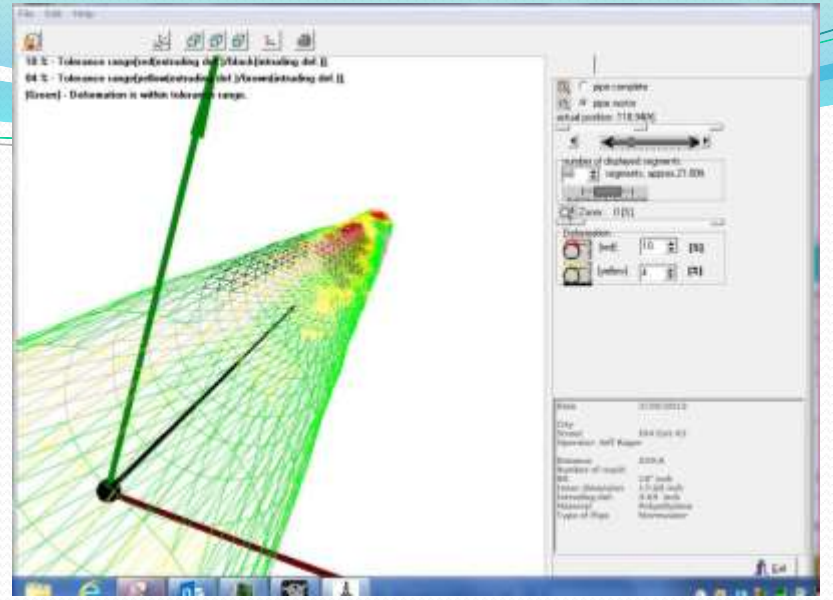
- **Level and velocity of flow;**
- **Restrictions or options available for flow control;**
- **Diameter or dimensions of the conveyance asset;**
- **Access to the pipeline;**
- **Available head space during high and low flow conditions;**
- **Anticipated debris that will remain in the pipeline during inspection;**
- **Depth of asset.**

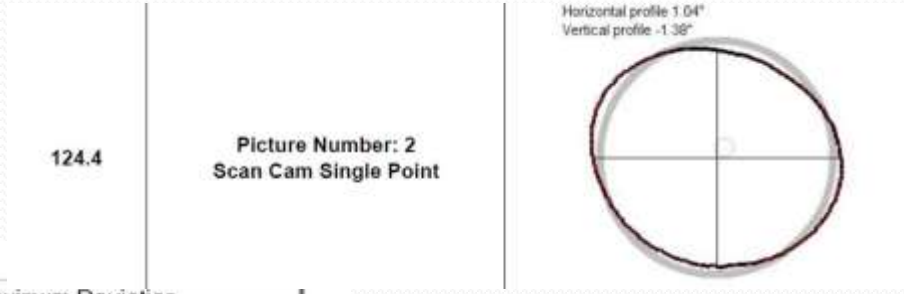
Centralized Data Viewer

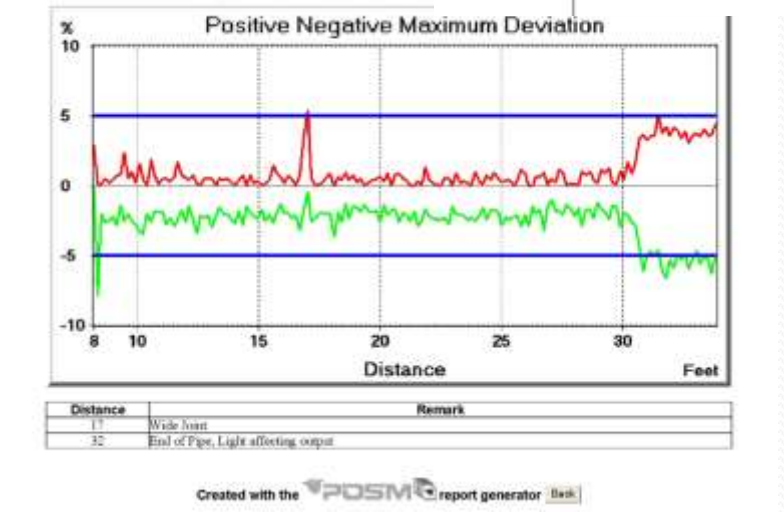


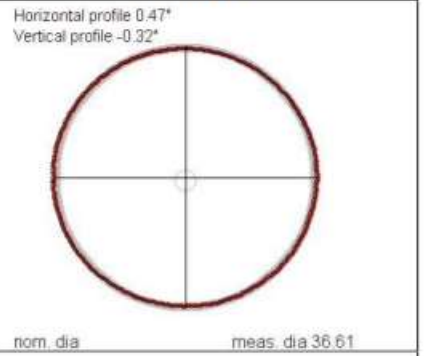
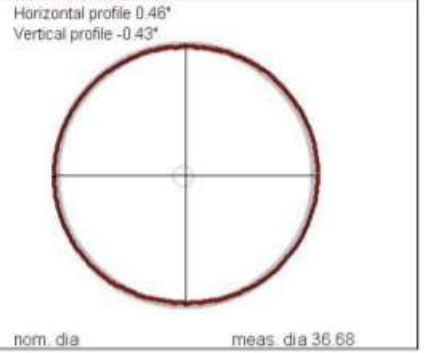
Laser Diode

- Two precise lasers spin on the end of the camera head to create a spiral 3D image of the inside of the pipe with accuracy of 0.5% of pipe diameter
- Good for 6” to 54”



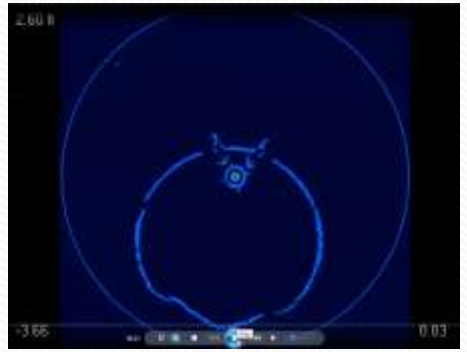




Distance	Fault Observation	Time	Picture
200.2	Picture Number: 2 General Observation	0	
251.1	General Observation Severity: None 3rd Dimension: 0.46" 4th Dimension: -0.43" 5th Dimension: 37.14 6th Dimension: 36.68 Remarks: SINGLE POINT SCAN	09:15	
251.1	Picture Number: 2 General Observation	0	

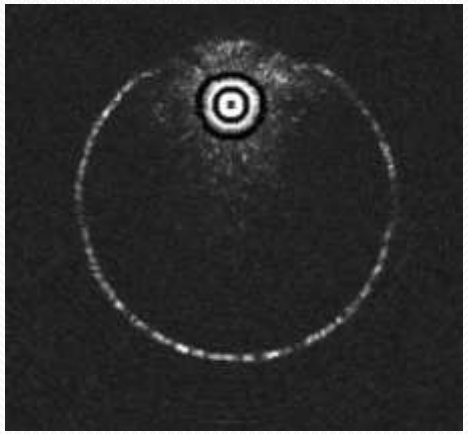
Sonar

- Continuous Acoustic scanning
- 360 degrees per second.
- Used to determine inside dimensions and changes in pipe shape and size, and to quantify the amount of debris in the pipe.
- Accuracy from ¼” to ½”
- Inspects pipelines from 8” to 108” diameter.

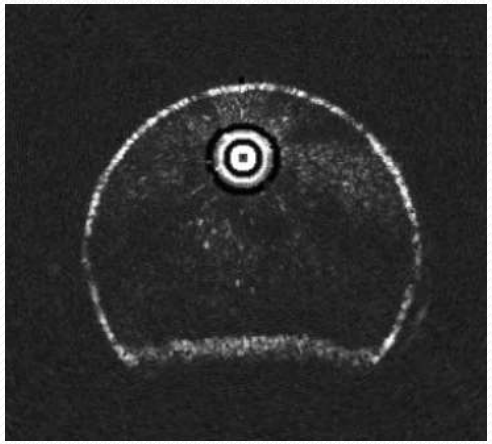


ACTUAL SONAR SCAN
MPEG

RELATIVELY CLEAN SIPHON

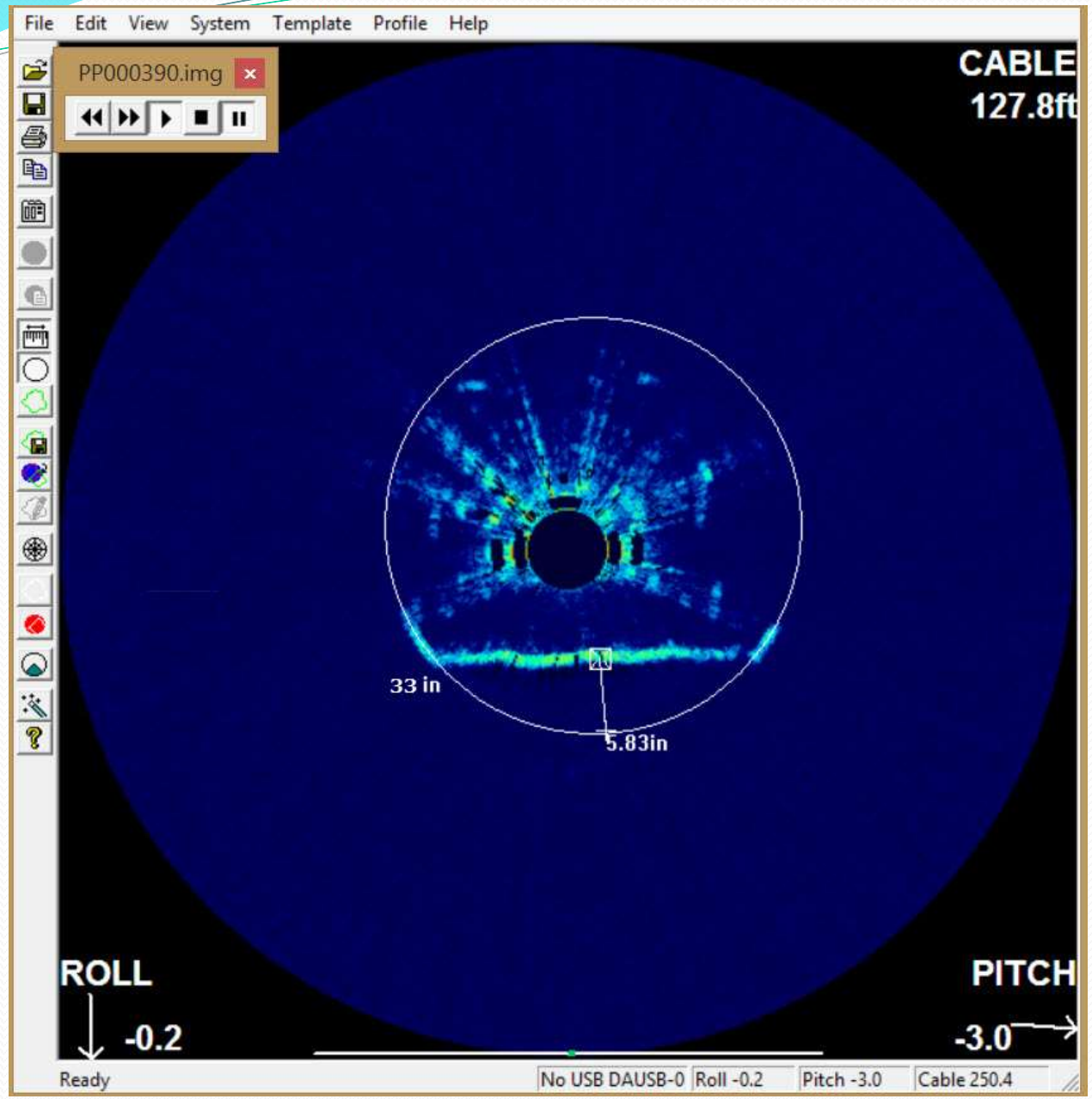


SIPHON WITH DEBRIS

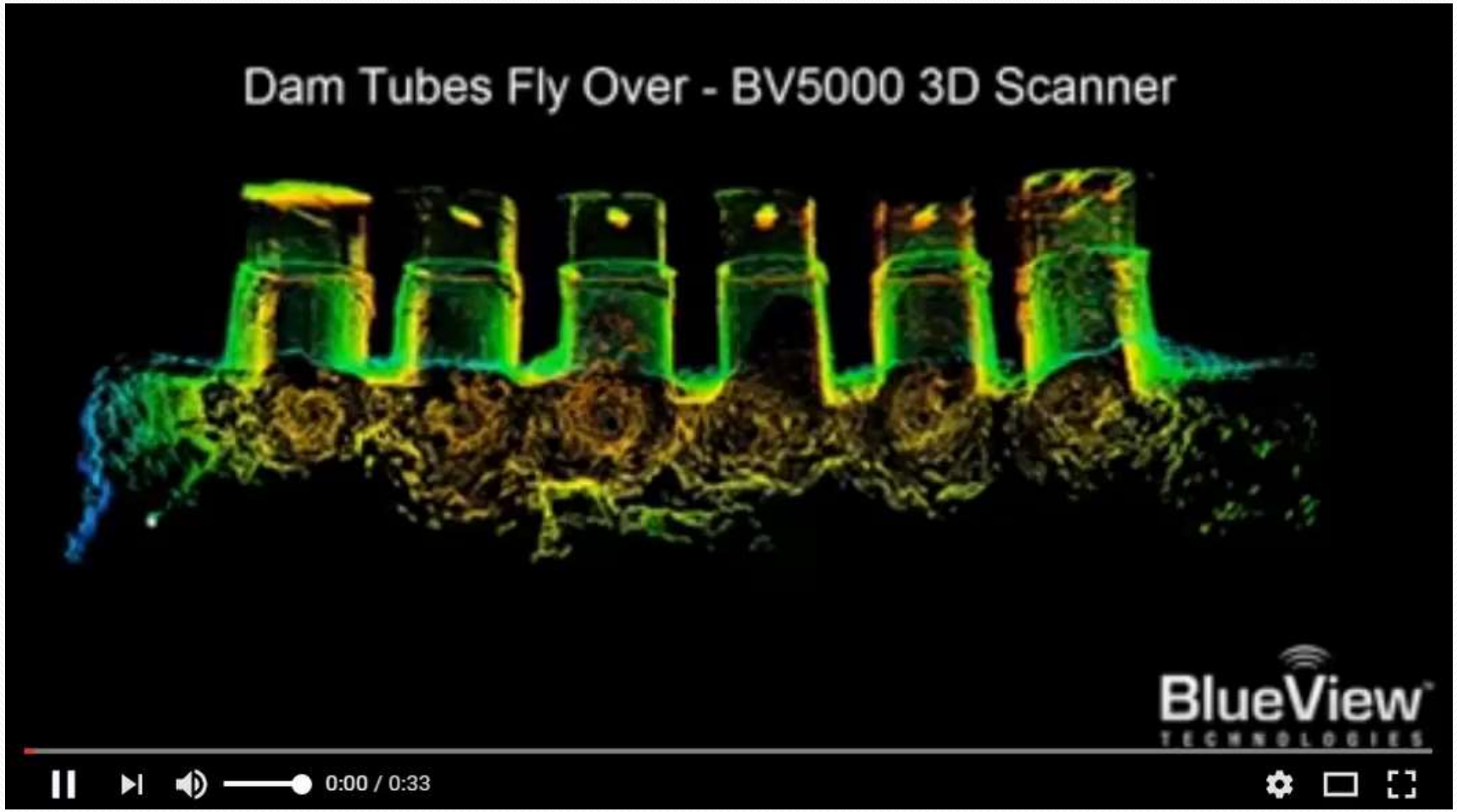


We process this sonar data and provide debris quantities at each location. MPEG sonar movies are also provided for import into your asset management system.

SONAR PROCESSING

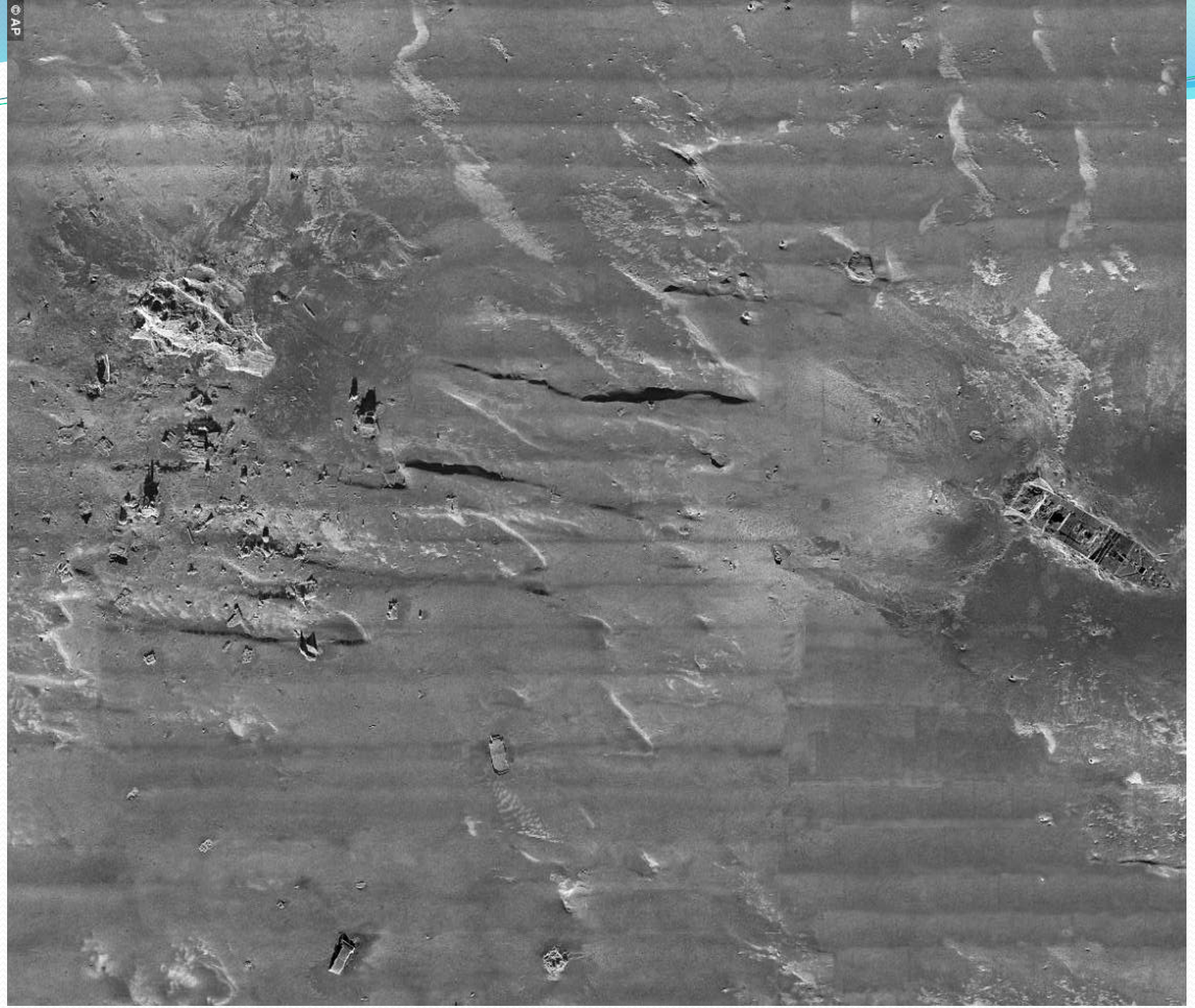


New Multi-Beam Sonar Technology



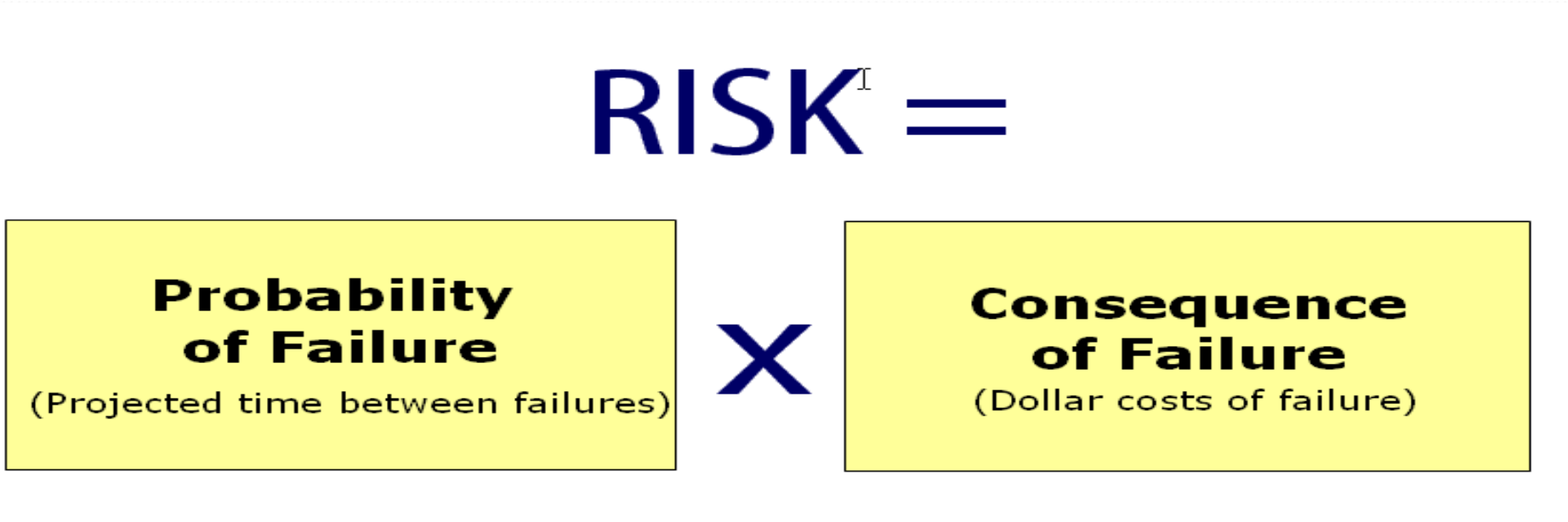
Titanic – New Sonar Images Reveal Much


© AP


© AP

So now what do we do with all this CCTV and Laser Data?

Implementing a Risk Based, Criticality Assessment Program



Probability

How do we Estimate Probability of Failure?

- Assess pipe physical properties and in-situ conditions (system inventory)
  - Age
  - Material
  - Construction Methods
  - Depth of Cover
  - Traffic Loading
  - Soils Conditions
- Condition Assessment –
  - Calculate Damage Severity Index (DSI) or PACP score
  - Project historical records of failure allowing for degradation
- Capacity Analysis -
  - Evaluate system for hydraulic inadequacies
- Engineering Analysis

Probability = In-Situ Factor x DSI or PACP Rating

AGE DOES NOT CORRELATE TO CONDITION

Regular Inspections are Key!

Pipe Material	Pipeline Length (ft)	Pipe Diam (in)	Estimated Wall Tickness Installed (in)	CCTV Data	Laser Data	Sonar Data	PACP Quick Rating	Maximum Corrosion (in)	Install Year
RCP	384	45	4.5	<10%	No	No	4100	2.50	1940
RCP	277	42	4.5	50-75%	Yes	No	3Q00	2.24	1942
RCP	312	42	4.5	100%	Yes	No	3M25	2.16	1916
RCP	240	42	4.5	<10%	Yes	No	5136	2.12	1942
RCP	23	36	4.0	<10%	No	No	3100	2.00	1915
RCP	189	42	4.5	<10%	No	No	4131	2.00	1908
RCP	197	45	4.5	<10%	No	No	5100	2.00	1908
RCP	37	45	4.5	<10%	No	No	3300	2.00	1908
RCP	159	42	4.5	100%	Yes	No	4F3F	1.97	1923
RCP	567	42	4.5	100%	Yes	No	3Z00	1.93	1942
RCP	387	42	4.5	100%	Yes	No	3Z00	1.88	1942
RCP	77	36	4.0	100%	No	No	3B2B	1.80	1938
RCP	146	42	4.5	100%	Yes	No	4A2F	1.79	1923
RCP	130	42	4.5	100%	Yes	No	4D3D	1.79	1923
RCP	108	42	4.5	100%	Yes	No	3H00	1.78	1942
RCP	502	42	4.5	100%	Yes	No	3W2W	1.76	1942
RCP	139	42	4.5	100%	Yes	No	3E00	1.73	1942
RCP	296	45	4.5	100%	Yes	Yes	413J	1.70	1940
RCP	350	60	6.0	100%	Yes	Yes	2A1I	1.70	2000
RCP	230	42	4.5	100%	Yes	No	3T00	1.69	1942
RCP	436	42	4.5	100%	Yes	No	3T2S	1.69	1942
RCP	82	42	4.5	100%	Yes	No	413B	1.66	1923
RCP	189	45	4.5	100%	Yes	No	453Q	1.64	1908
RCP	398	42	4.5	100%	Yes	No	3S00	1.62	1942
RCP	168	42	4.5	100%	Yes	No	3O21	1.61	1942
RCP	1498	42	4.5	75-100%	Yes	No	3Z00	1.60	1938
PVC	304	42	4.5	<10%	No	No	3400	1.60	1969
CMP	19	36	4.0	100%	Yes	No	5434	1.57	1978

BROKEN, FRACTURES, AND CRACKS

NT_NUMBER	NT_USMAN	NT_DSMAN	NT_DIA	NT_MAT_TY	Map Length	Cleaned?	Inspected	Street	STRUCTURAL QUICK SCORE	O&M QUICK SCORE	OVERALL PACP RATING	PACP 1	PACP 2	PACP 3	PACP 4	PACP 5	PACP 6	PACP 7	PACP 8	PACP 9	PACP 10
NTG_1692	U17D2-21	U17D2-20	8	VCP-Vitrified	157	Y	153.1	CHERRY HILLS	4100	0000	4	FM									
NTG_1181	T20D1-7	T20D1-6	8	VCP-Vitrified	77	Y	82.4	SILVERGATE	5121	0000	3.5	MWLS ©	B								
NTG_1014	U17A2-22	U17A2-21	8	VCP-Vitrified	303	Y	331.5	HAVEN	3100	0000	3	FS									
NTG_2252	T20D1-59	T20D1-60	8	VCP-Vitrified	60.0	Y	191.5	Betlen	3121	3700	2.7	RPP	FS	JOM	MWLS	RMJ ©					
NTG_2352	T19D1-19	T19D1-13	8	PVC	299.7303608	Y	286.9	Rolling Hills	3111	4100	2.7	JSM	B	IR							
NTG_2771	U20C1-21	U20C1-20	8	VCP-Vitrified	20	Y	21.4	Betlen	4122	0000	2.7	MWLS ©	FM								
NTG_1182	T20D1-11	T20D1-7	8	VCP-Vitrified	66	Y	60.1	SILVERGATE	5131	3312	2.5	FL	RFI X 2	RMJ ©	JOM	B					
NTG_901	U16A1-14	U16A1-13	8	VCP-Vitrified	187	Y	174.4	LORETO	4100	2300	2.5	FM	DAE ©								
NTG_4717	U19A2-1	U19C6-20	8	VCP-Vitrified	217.0	Y	206.6	VOMAC	5135	4111	2.47	RFI	MWLS © X 3	B							
NTG_1051	T16D2-7	T16D2-6	6	VCP-Vitrified	244.9307394	Y	243.8	FOXCROFT	312C	5141	2.15	FS	MWLS © X 2	RMJ	RML	DAE ©	IG	IR			
NTG_1016	T17B1-17	T17B1-16	8	VCP-Vitrified	178.2769104	Y	140.6	Davona	3128	0000	2.1	MWLS ©	FS								
NTG_1707	U18B2-38	U18B2-37	8	VCP-Vitrified	226	Y	211.9	WINGED FOOT	3111	3128	2.1	FS	DAE ©	JOM	ISSR						
NTG_2499	T19D2-33	T19D2-32	8	VCP-Vitrified	308.7914945	Y	301.9	PADRE	4100	2711	2.1	DAE ©	FH2	RFI							
NTG_4794	U19C3-22	U19C3-21	8	VCP-Vitrified	182	Y	170.4	LANDALE	3129	0000	2.1	MWLS © X 3	FS								
NTG_663	T20D1-26	T20D1-25	8	VCP-Vitrified	131	Y	128.1	Betlen	3100	2A00	2.1	FS	DAE	DAE © X 2							
NTG_1080	U17B1-2	U17B1-1	8	VCP-Vitrified	160	Y	157.1	THUNDERBIRD	312E	512E	2.06	FS	MWLS ©	DAE ©	DSF ©	IG					
NTG_1951	U16A1-13	U16A1-12	8	VCP-Vitrified	475	Y	489.3	LORETO	5134	2100	2.06	MWLS © x 6	JOM	DAE ©	JSM	SCP ©	JOM	B			
NTG_2457	U18A1-8	U18A1-7	8	VCP-Vitrified	346	Y	314.8	MADORA	312B	0000	2.05	MWLS © X 2	FS								
NTG_2467	U18A1-29	U18A1-28	8	VCP-Vitrified	193	Y	207.0	CASSANDRA	412G	0000	2.05	MWLS © X 3	FM								
NTG_1096	U17B1-12	U17B1-11	8	VCP-Vitrified	355	Y	354.7	ALCOSTA	412A	312L	2.04	FM	DAE ©	MWLS X 2	MWLS © X 2	RMJ					
NTG_1687	U17D2-3	U17D2-2	8	VCP-Vitrified	325	Y	336.1	OLYMPIA FIELDS	312I	2F11	2	MWLS © X 3	DAE X 2	DAE ©	IS	RFI	FS				
NTG_1833	T17B1-7	T17B1-5	8	VCP-Vitrified	250.9329403	Y	256.1	TAREYTON	412I	0000	2	FC	MWLS ©								
NTG_2887	U20C2-21	U20C2-20	8	VCP-Vitrified	128	Y	122.0	CIRCLE	085'1100	312B	2	ISSR	DAE	DAE ©	CC						
NTG_4401	T17B2-8	T17B2-5	8	VCP-Vitrified	340.5391243	Y	344.3	KITTERY	2L00	2L00	2	DAE ©	MWLS ©	IW	FC						
NTG_4625	U17C3-12	U17C3-11	8	VCP-Vitrified	472	Y	449.2	BROADMOOR	2900	2A00	2	FC	DAE ©	MWLS ©							
NTG_4627	U17C3-10	U17C3-9	8	VCP-Vitrified	350	Y	358.3	ALMOND	2600	0000	2	FC	MWLS © X 2								
NTG_657	U17D1-23	U17D1-16	8	VCP-Vitrified	260	Y	259.4	PEBBLE	2200	2I00	2	FC	DAE ©	MWLS							
NTG_665	T20D1-33	T20D1-27	8	VCP-Vitrified	144	Y	141.8	Betlen	3100	2A11	2	FS	RFI	DAE ©							
NTG_416	U20D1-35	U20D1-34	8	VCP-Vitrified	287	Y	372.2	REGIONAL	412M	1300	1.96	MWLS ©	FM	RFI X 3	JOM X 2						
NTG_632	U17C1-10	U17C1-9	8	VCP-Vitrified	215	Y	232.6	INVERNESS	312B	1200	1.95	FS	RFI X 2	MWLS © X 2							
NTG_2461	U18A1-5	U18A1-4	8	VCP-Vitrified	368	Y	329.0	ERNWOOD	322D	3216	1.94	FS	MWLS © X 4	RFI	RFI ©	RMJ	RML	RFL	FS		
NTG_1773	U17C3-24	U17C3-23	8	VCP-Vitrified	69	Y	82.2	ASHBY	312A	1200	1.93	MWLS © X 2	FS	RFI X 2							
NTG_2465	U18A1-31	U18A1-28	8	VCP-Vitrified	227	Y	219.4	BROCKTON	312D	2114	1.9	FS	MWLS © X 5	RFI X 3	DSF ©	RFI©					
NTG_2398	U19C1-5	U19C1-4	8	VCP-Vitrified	251	Y	251.9	CORTO	3111	2511	1.875	RFI	FS	JOM	DAE ©						
NTG_4668	U19C3-12	U19C3-11	8	VCP-Vitrified	115	Y	112.2	OXBOW	3321	4136	1.8	FL	RFI	RFI ©	MMC	SCP ©	MWLS ©	JOM	HEAVY STEAM	RBC	RMJ ©
NTG_4523	U17C2-28	U17C2-25	8	VCP-Vitrified	368	Y	348.1	Sedgefield	312B	1G00	1.33	RFI ©	RFL X 2	FS	MWLS © X 2						
NTG_1305	T19D2-34	T19D2-33	8	VCP-Vitrified	279.3580609	Y	284.1	PADRE	4100	311C	1.2	FM	RFI X 2	RMJ	RFI ©						
				TOTAL FOOTAGE			8,726.40														

SEGMENTS EXHIBITING INFILTRATION

NT_NUMBER	NT_USMAN	NT_DSMAN	NT_DIA	NT_MAT_TY	Map Length	Cleaned?	Inspected	Street	STRUCTURAL QUICK SCORE	O&M QUICK SCORE	OVERALL PACP RATING	PACP 1	PACP 2	PACP 3	PACP 4	PACP 5	PACP 6	PACP 7	PACP 8	PACP 9	PACP 10	PACP 11
NTG_2352	T19D1-19	T19D1-13	8	PVC	299.730360E	Y	286.9	Rolling Hills	3111	4100	2.7	JSM	B	IR								
NTG_119E	T16D4-17	T16D4-15	8	VCP-Vitrified	345.489365E	Y	187.5	MILLBRIDGE	3D25	4231	2.45	DAE ©	MWLS © X 3	IW	IR X 2	ID						
NTG_1335	U17C2-8	U17C2-7	8	VCP-Vitrified	177	Y	215.6	BELLE MEADE	4534	4133	2.22	MWLS © X 3	DAE ©	IS X 4	IW	DAE X 3	IR					
NTG_4367	U16C1-8	U16C1-7	8	VCP-Vitrified	89	Y	57.5	KITTERY	2600	4131	2.2	IW	MWLS ©	DAE ©	ID	DAE						
NTG_1051	T16D2-7	T16D2-6	6	VCP-Vitrified	244.9307394	Y	243.8	FOXCROFT	312C	5141	2.15	FS	MWLS © X 2	RMI	RML	DAE ©	IG	IR				
NTG_1910	U17A2-4	U17A2-3	8	VCP-Vitrified	269	Y	269.7	GOSHEN	2D00	4132	2.13	MWLS © X 3	DAE X 2	IR								
NTG_783	U17C2-11	U17C2-10	8	VCP-Vitrified	165	Y	154.6	BELLE MEADE	2D00	5142	2.11	MWLS © X 2	DAE ©	IG	IR X 2	IW	IS					
NTG_638	U17D1-8	U17D1-7	8	VCP-Vitrified	132	Y	136.7	THUNDERBIRD	2D00	5121	2.1	IG	DAE	MWLS ©								
NTG_183E	T16D2-1E	T16D2-17	6	VCP-Vitrified	227.0747149	Y	254.5	SHAW	0000	512C	2.1	IG	DAE ©									
NTG_1697	U17D2-5	U17D2-4	8	VCP-Vitrified	117	Y	135.9	BRYN MAWR	0000	412B	2.1	DAE ©	IR									
NTG_1831	T17B1-3	T17B1-2	10	VCP-Vitrified	309.8681379	Y	294.2	Davona	2J00	4231	2.1	MWLS ©	IR X 2	DAE ©								
NTG_1280	U16A1-6	U16A1-4	8	VCP-Vitrified	248	Y	251.0	ENSENADA	2G00	422B	2.07	MWLS © x 2	MWL	IR	DSF ©							
NTG_1080	U17B1-2	U17B1-1	8	VCP-Vitrified	160	Y	157.1	THUNDERBIRD	312E	512E	2.06	FS	MWLS ©	DAE ©	DSF ©	IG						
NTG_1699	U17D2-2	U17D2-1	8	VCP-Vitrified	265	Y	251.6	OLYMPIA FIELDS	2G00	422B	2.06	MWLS © X 2	DSF ©	IR	DAE X 2	DAE ©						
NTG_510	T17B2-5	T17B2-4	8	VCP-Vitrified	176.9907621	Y	155.4	KITTERY	2D00	2E00	2	IW	DAE	MWLS ©	IW							
NTG_169E	U17D2-7	U17D2-6	8	VCP-Vitrified	139	Y	148.9	BOCA RATON	312A	2A00	2	CM	IS X 2	DAE © X 3	MWLS © X 2	MWLS						
NTG_1681	U18B2-33	U18B2-32	8	VCP-Vitrified	313	Y	308.5	FIRCREST	2D00	312F	2	DAE	IS	MWLS © X 2	DAE ©	OBZ						
NTG_1179	T20D1-22	T20D1-21	8	VCP-Vitrified	191	Y	193.7	DILLON	0000	2B00	2	DAE	DAE © X 2	IS								
NTG_119E	T16D4-17	T16D4-15	8	VCP-Vitrified	345.489365E	Y	63.3	MILLBRIDGE	2500	312A	2	DAE ©	IS	MWLS ©	IW	ID	MSA					
NTG_1190	T16D2-11	T16D2-10	8	VCP-Vitrified	193.95965	Y	178.2	BIDDLEFORD	2B00	2F00	2	DAE ©	IS	MWLS © X 3								
NTG_3536	U19C2-13	U19C2-12	8	VCP-Vitrified	250	Y	227.9	ST RAYMOND	0000	2B00	2	DAE ©	IS									
NTG_1201	T16D4-1E	T16D4-17	6	VCP-Vitrified	278.2744157	Y	261.2	LUDLOW	1100	512I	2	DAE ©	IW	JOM	IG							
NTG_2401	U19C1-2	U19C1-1	8	VCP-Vitrified	266	Y	120.5	PEPPERTREE	0000	312D	2	DAE ©	IW	MSA								
NTG_1826	T16D2-14	T16D2-13	6	VCP-Vitrified	171.1554211	Y	177.1	BIDDLEFORD	2D00	2F00	2	DAE ©	IW	MWLS ©								
NTG_4377	T16D3-6	T16D3-2	15	VCP-Vitrified	306.2150345	Y	288.5	BERNARD	312F	2J00	2	DAE ©	IW	MWLS ©								
NTG_1176	T20D1-19	T20D1-18	8	VCP-Vitrified	142	Y	141.8	TINA	0000	2C00	2	DAE ©	IW									
NTG_4844	U19C1-20	U19C1-19	8	VCP-Vitrified	354	Y	352.7	SERRA	2B00	312L	2	DAE ©	ID	MWLS ©								
NTG_4611	U19C2-36	U19C2-35	6	VCP-Vitrified	236	Y	230.1	CALLE VERDE	2C00	512H	2	DAE ©	IG	MWLS ©								
NTG_1839	T16D2-20	T16D2-19	8	VCP-Vitrified	343.3831974	Y	207.2	MENNET	2B00	422I	2	DAE ©	IR	DAE	MWLS © X 3	DSF © X 2	IW					
NTG_1192	T16D2-13	T16D2-11	8	VCP-Vitrified	185.8646925	Y	188.5	BIDDLEFORD	2B00	412F	2	DAE ©	IR	MWLS ©								
NTG_1053	T16D1-5	T16D1-4	6	VCP-Vitrified	257.6567395	Y	265.2	SCARBORO	0000	2J00	2	DAE ©	IS X 2									
NTG_1083	U17D1-10	U17D1-9	8	VCP-Vitrified	166	Y	165.0	COLONIAL	2400	2E00	2	DAE ©	MWLS X 2	IW	MWLS ©							
NTG_1050	T16D2-E	T16D2-6	8	VCP-Vitrified	260.638893	Y	260.0	BIDDLEFORD	2J00	2J00	2	DAE ©	MWLS ©	IS	IW							
NTG_1189	T16D2-10	T16D2-8	8	VCP-Vitrified	278.8369727	Y	283.9	BIDDLEFORD	2J00	412L	2	DAE ©	MWLS ©	IS	IR							
NTG_4842	U19C1-22	U19C1-21	8	VCP-Vitrified	340	Y	342.2	REGIO	2K00	2L00	2	DAE ©	MWLS ©	IS								
NTG_4401	T17B2-8	T17B2-5	8	VCP-Vitrified	340.5391243	Y	344.3	KITTERY	2L00	2L00	2	DAE ©	MWLS ©	IW	FC							
NTG_2399	U19C1-4	U19C1-2	8	VCP-Vitrified	249	Y	230.6	PEPPERTREE	2200	412H	2	DAE ©	MWLS ©	IR								
NTG_1199	T16D4-20	T16D4-17	8	VCP-Vitrified	259.7450805	Y	251.6	MILLBRIDGE	2G00	412I	2	DAE ©	MWLS ©	IS X 3	IW X 3	IR						
NTG_2489	U16C2-6	U16C2-5	10	VCP-Vitrified	182	Y	163.4	MANGOS	2D00	412G	2	DAE ©	MWLS © X 2	DSF	DSF ©	IR	DAE					
NTG_439E	T16D2-17	T16D2-15	8	VCP-Vitrified	256.8979537	Y	224.6	SHAW	2C00	422G	2	DAE ©	MWLS © X 2	IR	DAE							
NTG_1045	T16D2-5	T16D2-3	8	VCP-Vitrified	196.2142597	Y	190.7	BIDDLEFORD	2E00	422F	2	DAE ©	MWLS © X 2	IR X 2								
NTG_133E	U17C2-9	U17C2-8	8	VCP-Vitrified	416	Y	361.0	BELLE MEADE	2K00	2M00	2	DAE ©	MWLS © X 3	IS	IW							
NTG_1054	T16D1-6	T16D1-4	8	VCP-Vitrified	226.6928933	Y	213.4	MILLBRIDGE	2E00	2J00	2	DAE ©	MWLS © X 3	IW X 2	IS	IW ©						
NTG_2450	U18B1-30	U18B1-28	8	VCP-Vitrified	389	Y	372.0	SANDPOINT	2300	2B00	2	DAE X 2	DAE ©	IS	MWLS ©	MWLS						
NTG_1703	U18B2-43	U18B2-41	8	VCP-Vitrified	145	Y	139.0	WINGED FOOT	2D00	2C00	2	DAE X 2	IS X 2	MWLS ©	DAE ©							
NTG_131E	U18B2-37	U18B2-36	8	VCP-Vitrified	211	Y	196.3	WINGED FOOT	2F11	322C	2	ISSR	MWLS ©	ID	DAE	DAE ©	JOM					
NTG_4843	U19C1-21	U19C1-19	8	VCP-Vitrified	269	Y	273.6	PEPPERTREE	2311	332I	2	JSM	DAE ©	ID ©	MWLS ©	DSF ©						
NTG_4841	U19C1-24	U19C1-21	8	VCP-Vitrified	242	Y	243.8	PEPPERTREE	3321	2F00	2	MWLS ©	DAE ©	IW								
NTG_1086	U17D2-16	U17D2-15	8	VCP-Vitrified	204	Y	168.9	OLYMPIA FIELDS	2E00	412E	2	MWLS ©	DAE ©	IR								
NTG_1319	U18B2-32	U18B2-31	8	VCP-Vitrified	311	Y	335.6	FIRCREST	2200	322F	2	MWLS ©	DAE © X 2	ID	IW	DAE						
NTG_1322	U17D2-15	U17D2-13	8	VCP-Vitrified	181	Y	191.9	OLYMPIA FIELDS	2A00	3129	2	MWLS © X 2	IW	DAE ©	DSF ©	RMJ						
NTG_1202	T16D4-19	T16D4-18	6	VCP-Vitrified	249.4566229	Y	257.5	LUDLOW	2E00	2F00	2	MWLS © X 2	DAE ©	IS								

Consequence

- **Proximity to Water Bodies and Sensitive Environmental Areas**
- **Impacts on adjoining land uses (park or school playground)**
- **Installed mitigation measures (backflow prevention)**
- **Volume of spill**
- **Containment capability**
- **Mitigation Costs**
- **Regulatory fines**
- **Lawsuits and liability exposures**
- **Loss of production and other**

Consequences are categorized in terms of dollar exposures $$$$$$

Create a weighted matrix

- Soil type
  - Fill = 5, Clay Soil = 4….. Bedrock = 0
- Pipe Material
  - Clay = 5…… PVC = 1
- Waterways
  - Under a creek = 5….. Far from any water = 0

Implementing a Risk Based, Criticality Assessment Program

RISK =

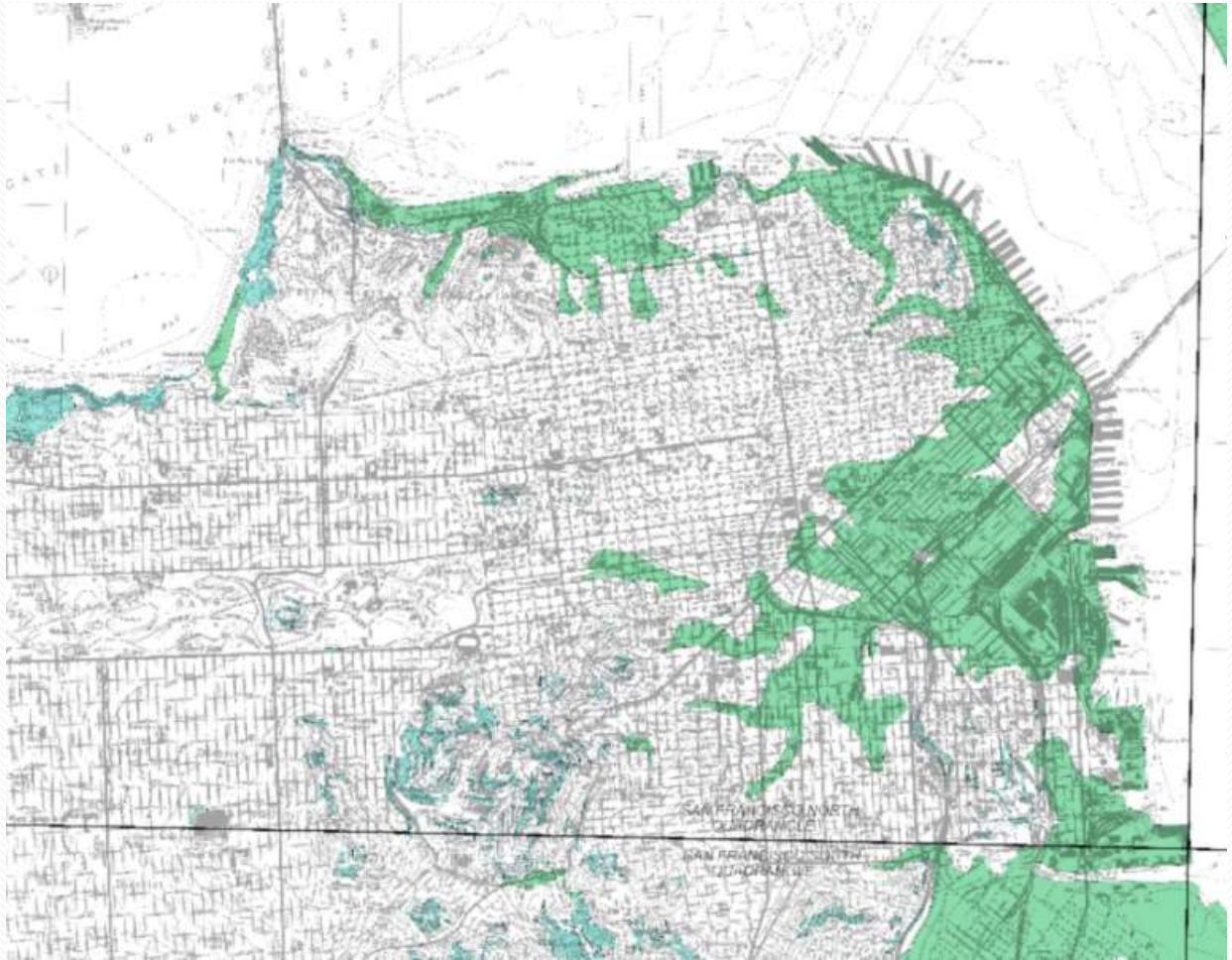
Probability of Failure
(Projected time between failures)

X

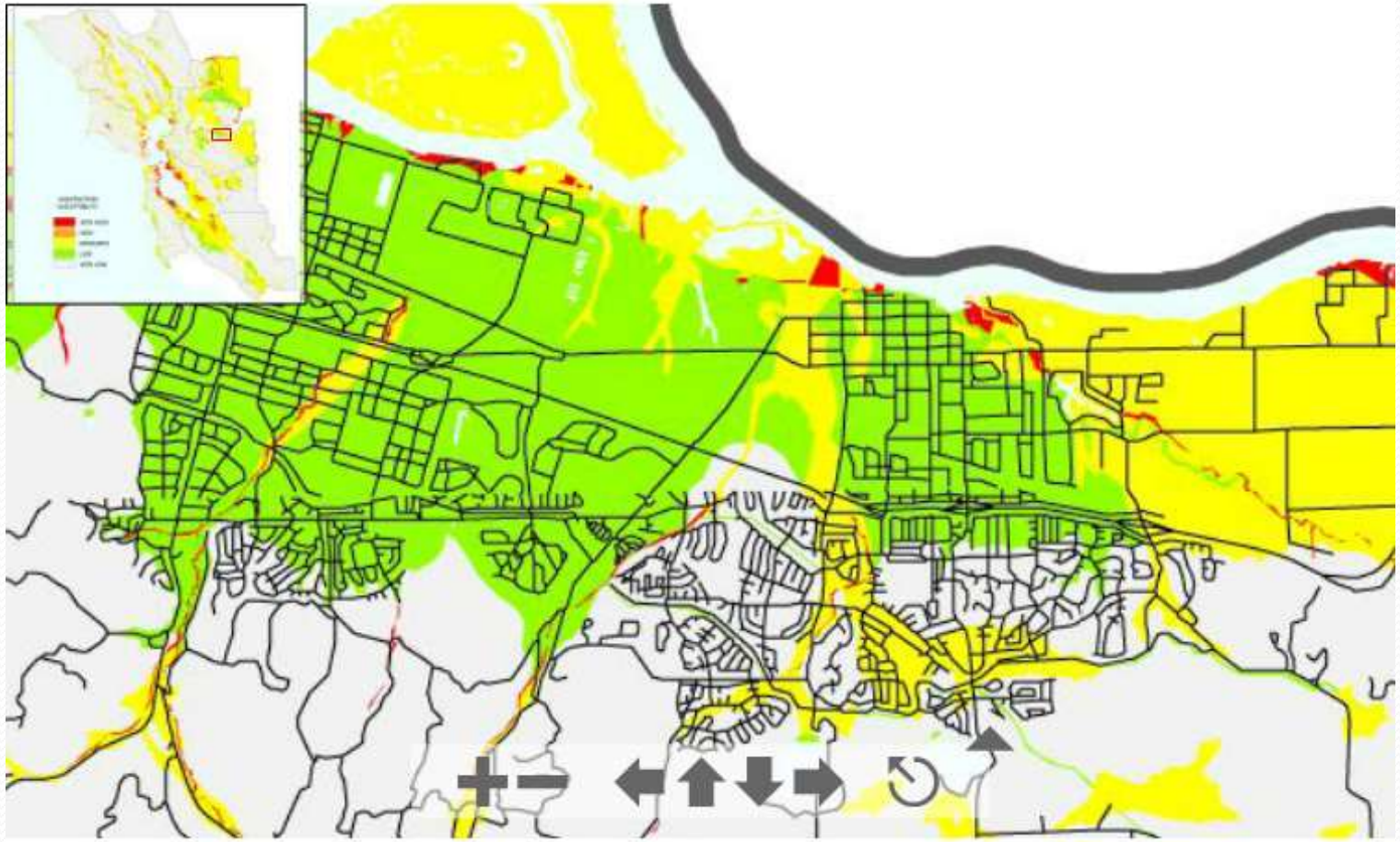
Consequence of Failure
(Dollar costs of failure)

PACP SCORE	3.5		
Material?	CLAY (5)		
Construction Methods?	NO BACKFILL	X	15 FEET FROM A CREEK
Depth of Cover?	SHALLOW – 6 FEET		VOLUME IS HIGH – 24" LINE
Traffic Loading?	UNDER EXPRESSWAY		
Soils Conditions?	FILL OR BAY MUD (5)		

LANDFILL ZONES IN SAN FRANCISCO



LIQUEFACTION POTENTIAL – ANTIOCH/PITTSBURGH



Very High
High
Moderate
Low
Very Low

Example of a Criticality and Risk Calculation

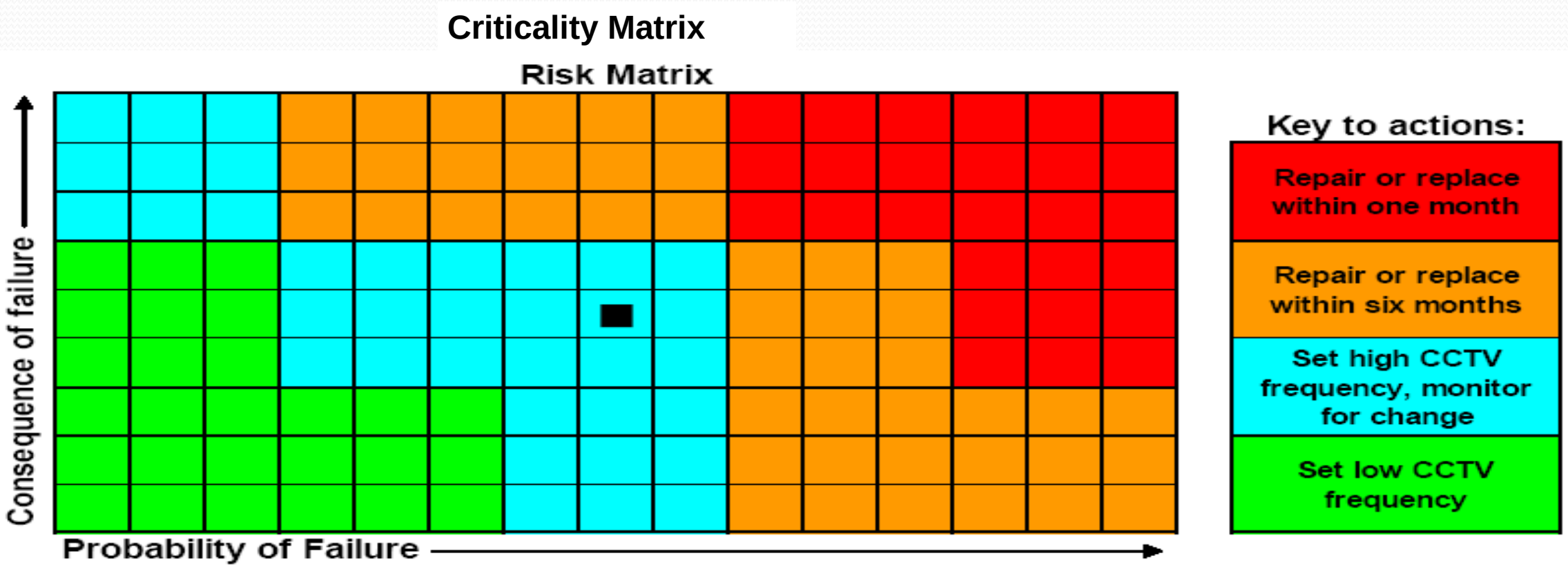
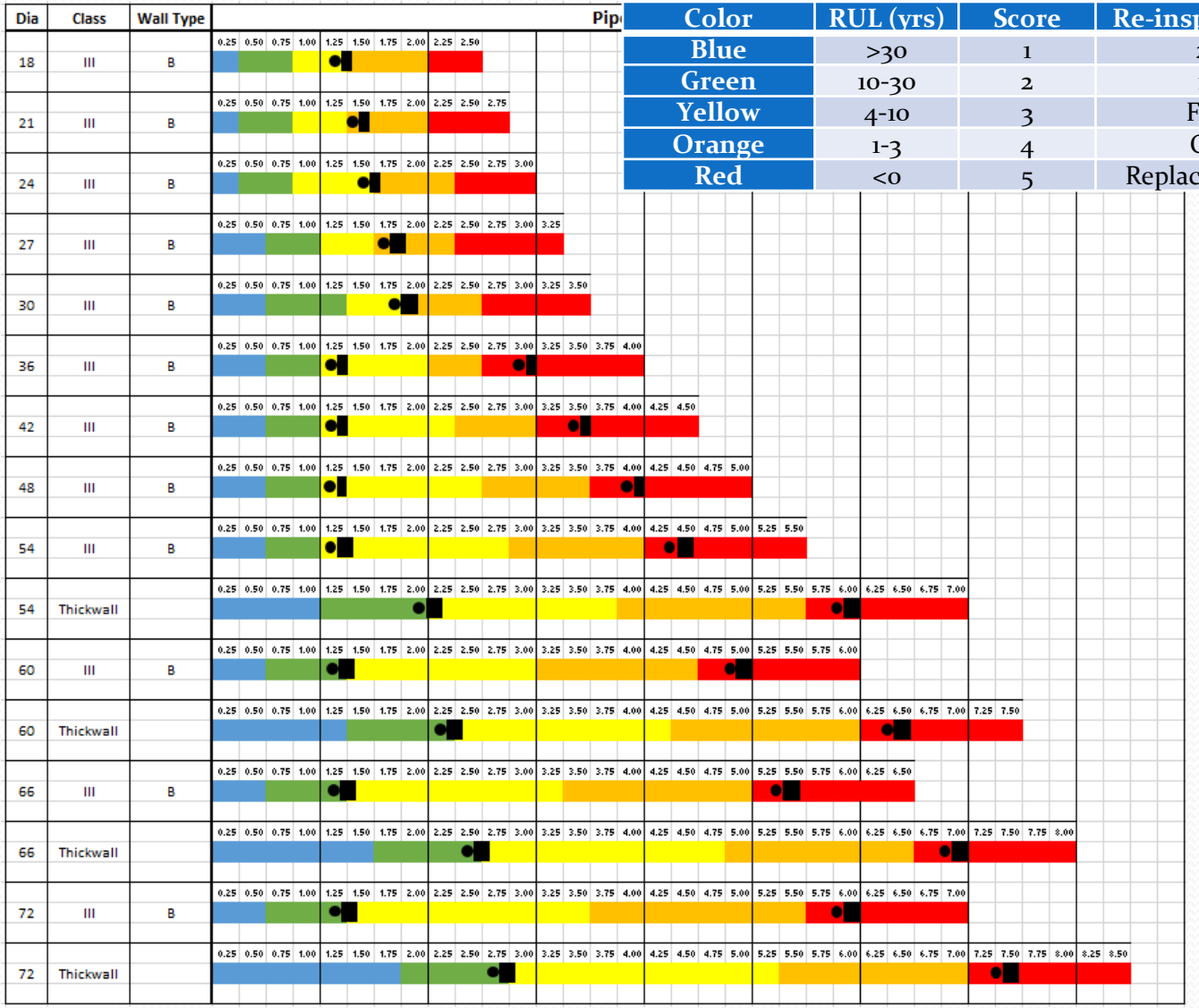


Figure 1: Typical risk probability/consequence matrix, sewer pipe

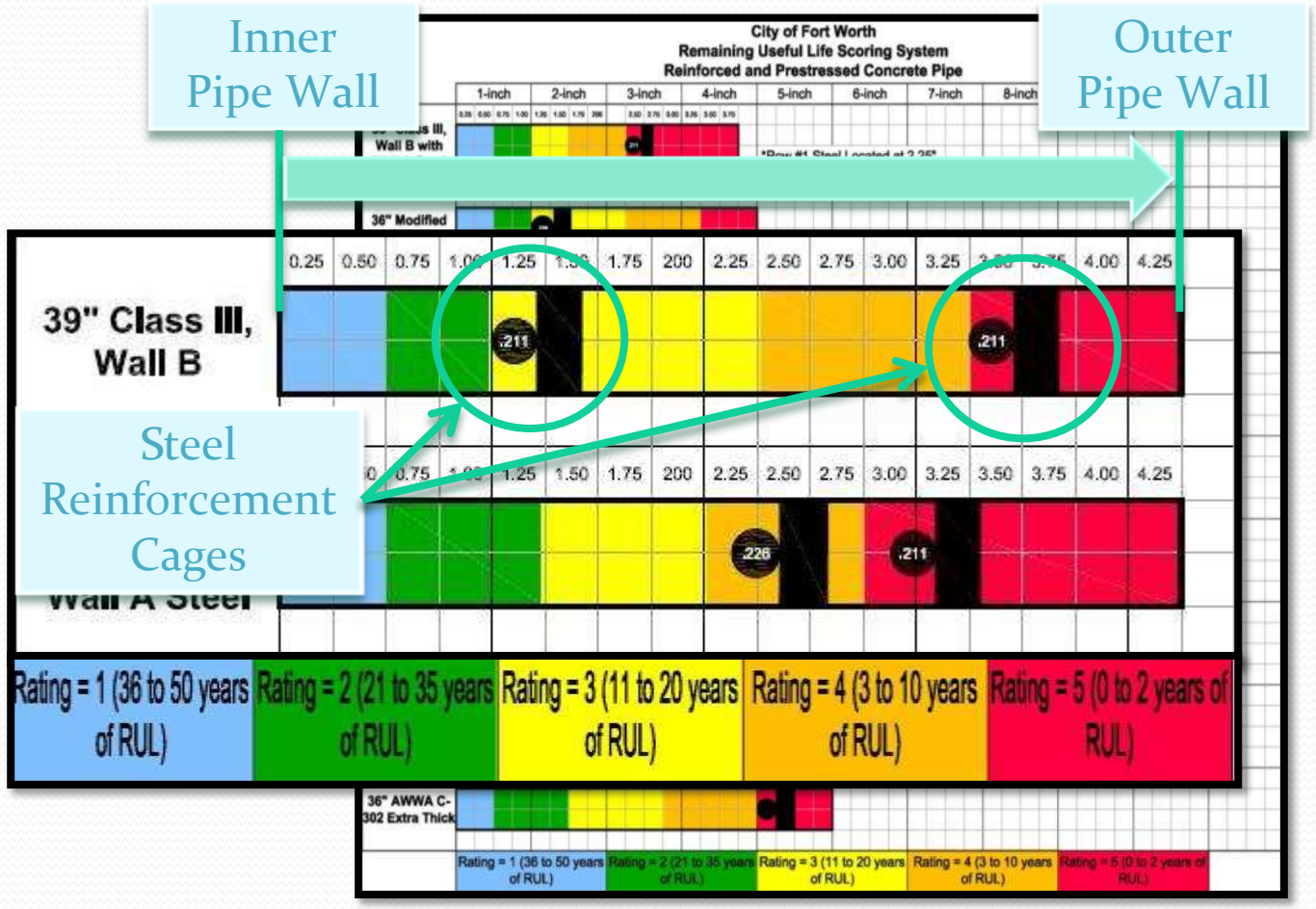
Example Chart to Estimate RUL for RCP



Color	RUL (yrs)	Score	Re-inspection Metric
Blue	>30	1	20 Years
Green	10-30	2	10 Years
Yellow	4-10	3	Five Years
Orange	1-3	4	One Year
Red	<0	5	Replace/Rehabilitate

Remaining Useful Life

- Remaining Useful Life developed for each concrete pipe wall specification
- Condition Score for concrete pipes based on location of steel reinforcement cage
- Developed in AutoCAD to maintain a 1:1 scale



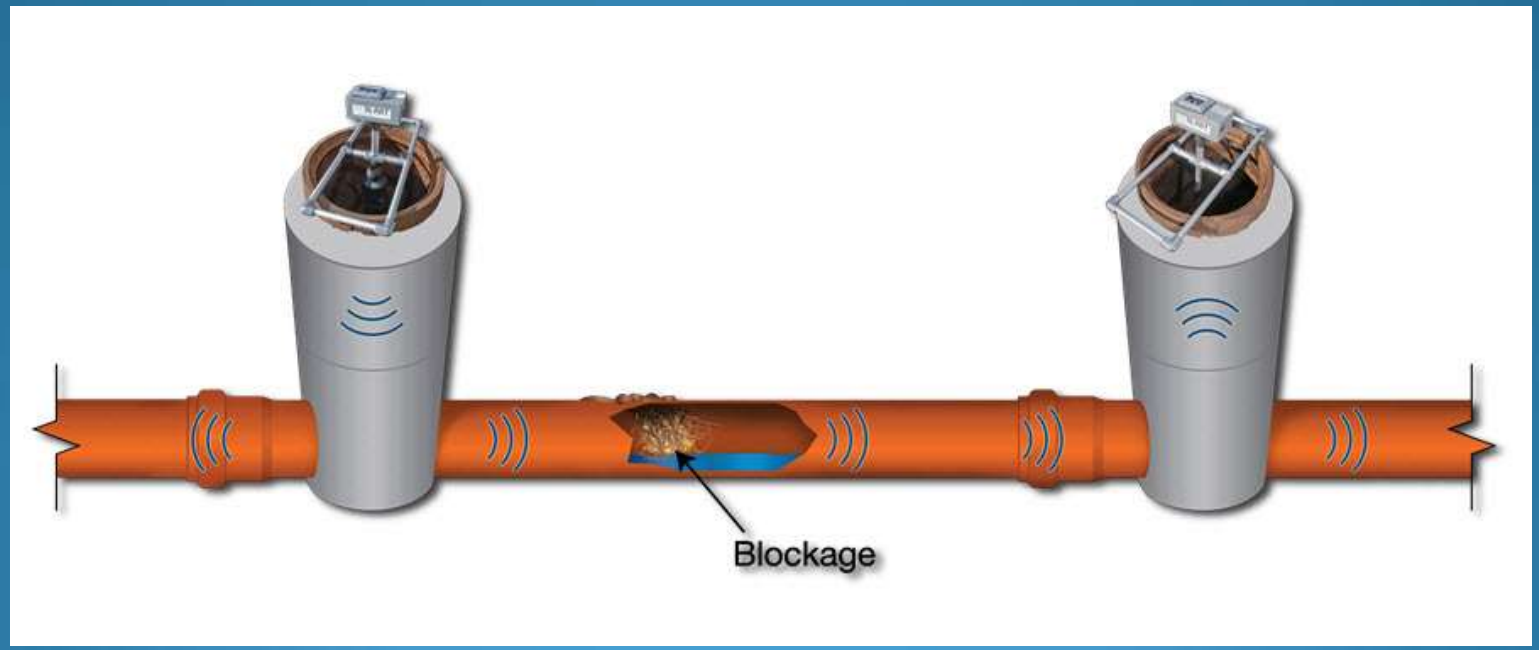
Remaining Useful Life: Example of Matrix Criteria

- **Rating 1: 0 to 0.5 inch from inner pipe wall. Action: Re-Inspect in 10-15 Years**
- **Rating 2: 0.5 to face of first row of steel. Action: Re-Inspect every 5-7 years.**
- **Rating 3: Face of 1st row of steel to half distance to 2nd row of steel. Action: Re-Inspect every 2-3 Years**
- **Rating 4: Half the distance to 2nd row of steel to face of 2nd row of steel. Action: Re-inspect in One year**
- **Rating 5: Face of 2nd row of steel to outer pipe wall surface. Action: Immediate Rehabilitation or Replacement**

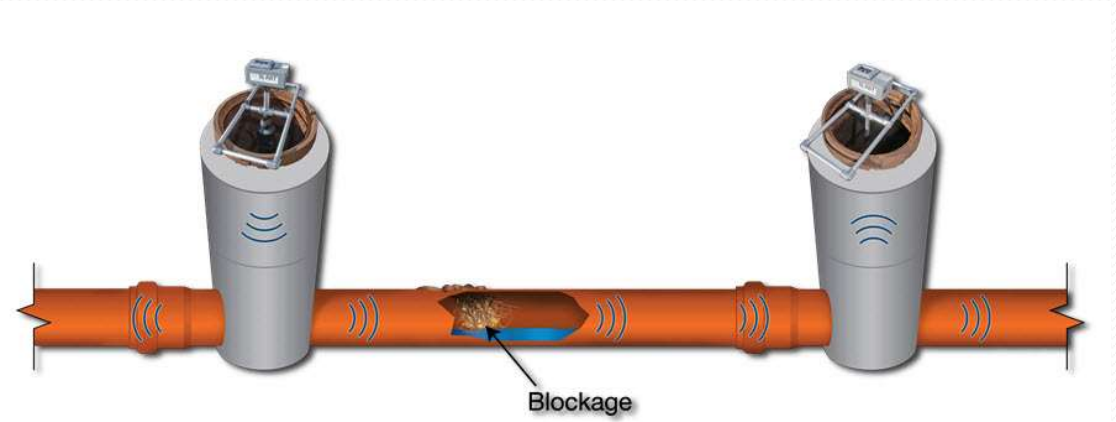
Combine these with Consequence of Failure factors, and it's easy to prioritize what you do when!

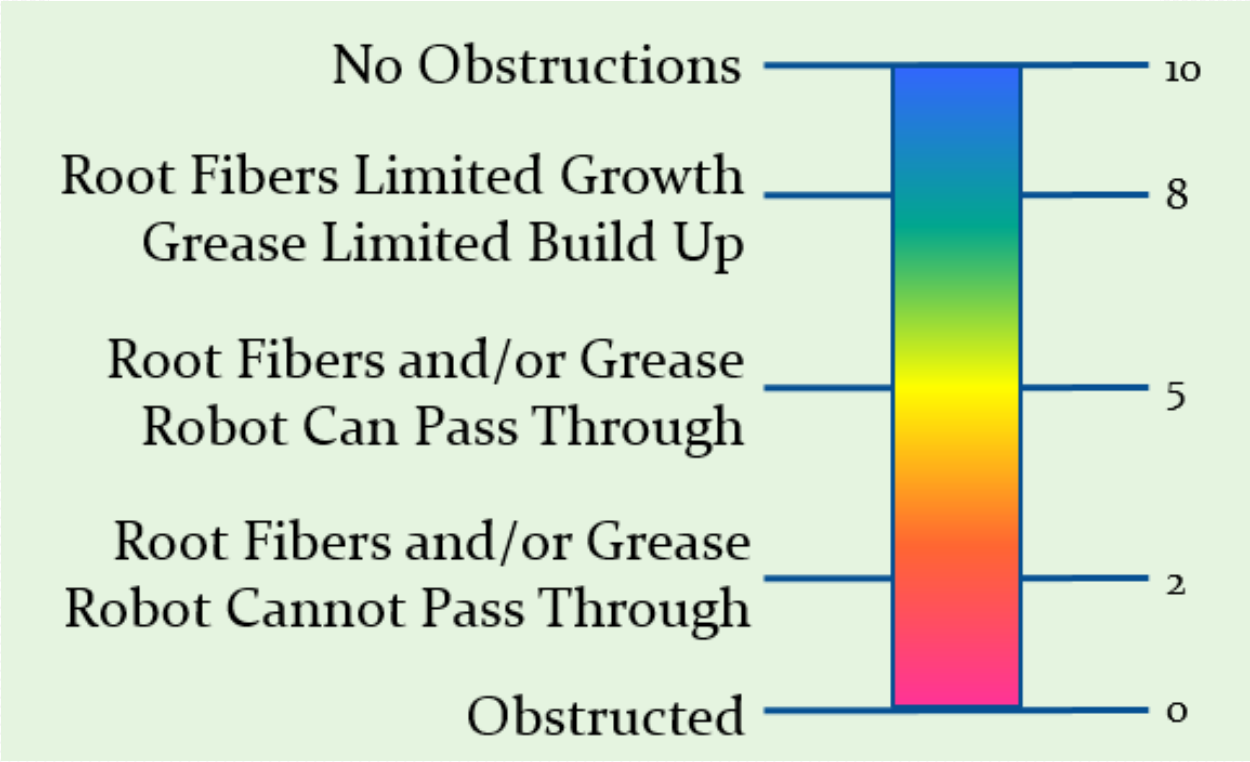
ACOUSTIC ASSESSMENT TOOL

Transmitter **Receiver**



So, How Does it Work?



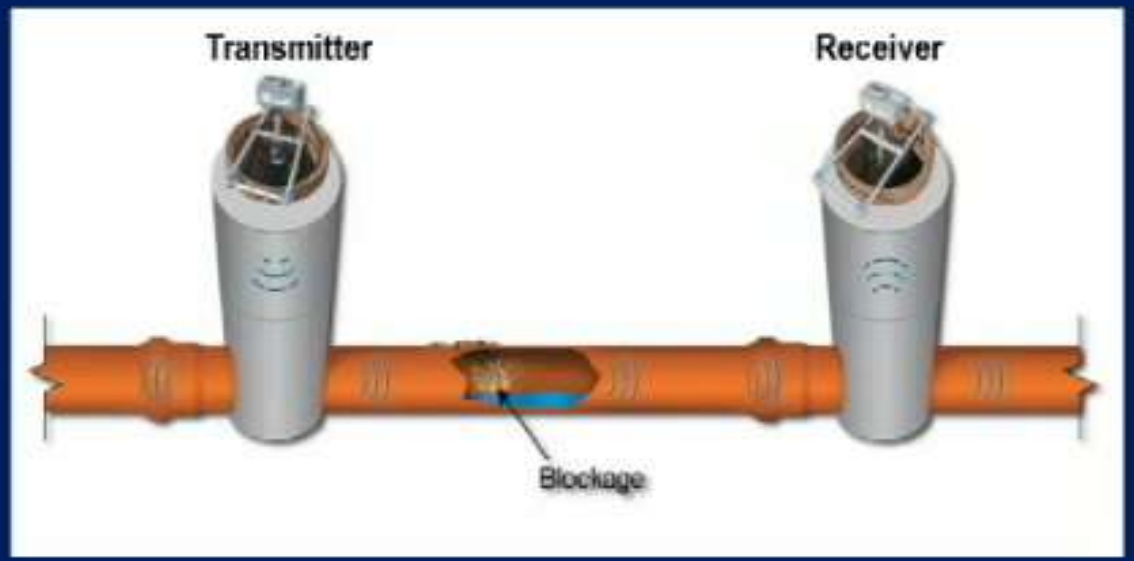


Features of Acoustic Testing

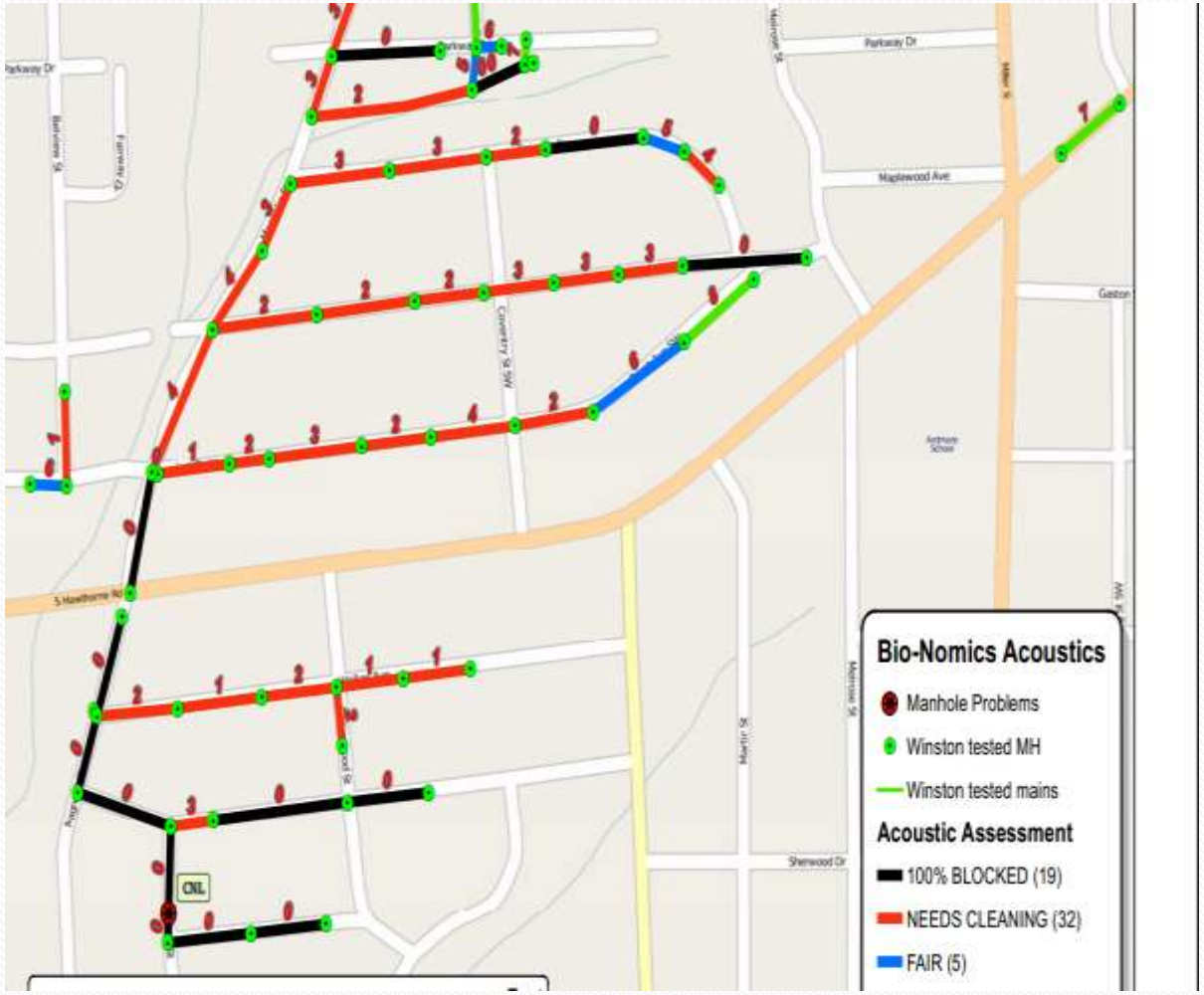
- No Manhole Entry required
- 3 min. test duration
- Real time results of blockage assessment
  - Blockage rating index
- GPS Enabled
- Low Cost- $0.15-0.30 (average) per L.F.

Acoustic Assessment Services

Carylon Corporation



How do we use this information?



Severely Blocked (0)

Poor (1– 4)

Automatic clean and/or CCTV

Monitor (5– 6)

No Action (7– 10)

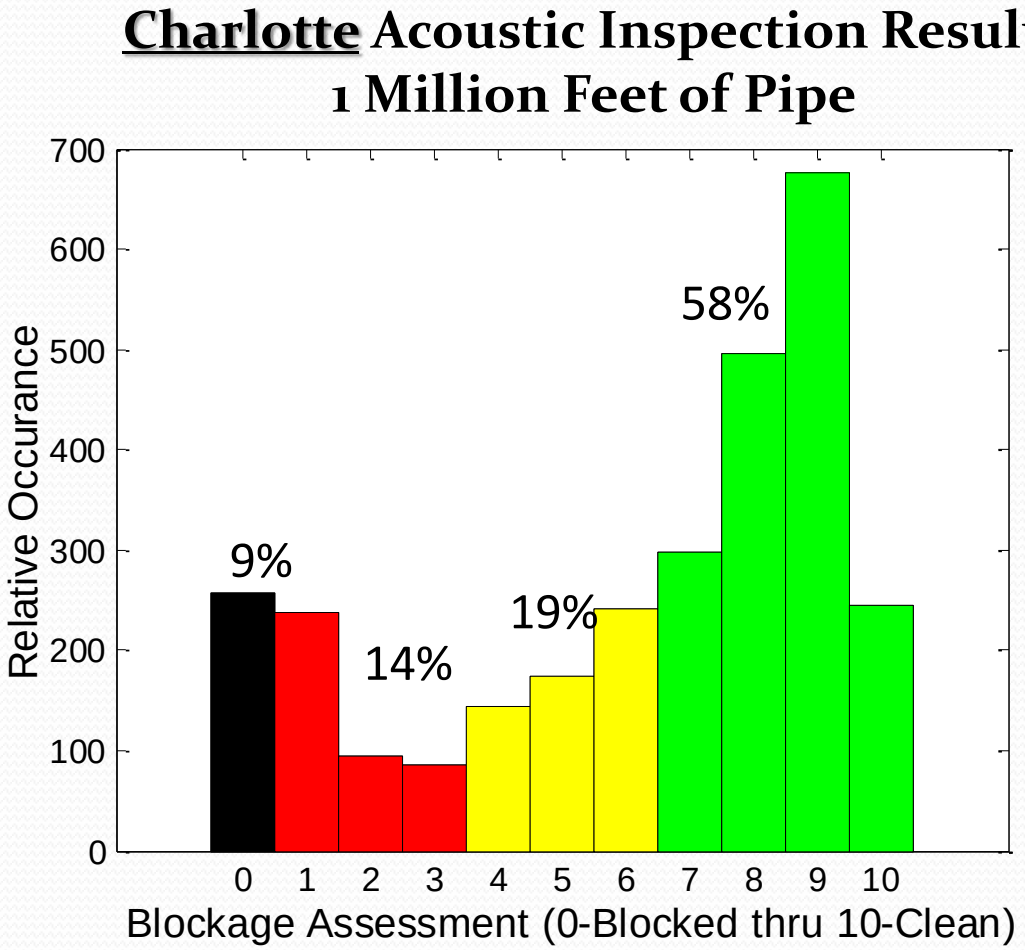
Limitations of Acoustic Inspection

- **Currently does not indicate what is causing the blockage**
  - **FOG, Root balls, Non-dispersible, etc.**
- **Generally does not assess condition of pipe walls**
  - **Hole Void Visible**
- **Does not pinpoint the blockage - Gives an aggregated score for a line segment**
- **Does not measure debris level- only aggregated blockage level.**
- **Under high flow conditions a segment can be assessed with a lower score**

Applications

- Focus cleaning crews in correct locations.
- Eliminate downstream overflows caused by upstream cleaning.
- Avoid repeat overflows in known "Hot Spots" locations.
- Quality Assurance of Post Cleaning.

How Much Cleaning is Wasted?



- Target Historical Problematic Areas
  - **>50% Pipes Essentially Clean**
  - **<10% Need Immediate Action**
- Cleaning a Clean Pipe ⇒ Wastes Resources
- Not Cleaning a Dirty Pipe ⇒ SSO

Case Study II: Targeted Cleaning

"You can see immediately what needs to be cleaned, so it takes the guesswork out and focuses your efforts." – CharMeck Engineer

- **Goal:** Prep Downtown Charlotte, North Carolina prior to DNC
- **Approach:** Use SL-RAT to quickly identify/prioritize cleaning needs for crews
- **Effectiveness:**
  - 2 SL-RAT crews inspected 143k ft of pipe in ~ 2 weeks
  - Saved **$100k** + versus traditional approach
  - Focused on 10-15% of pipes that are the most blocked & prioritized the remainder

Applications Enabled By Acoustics

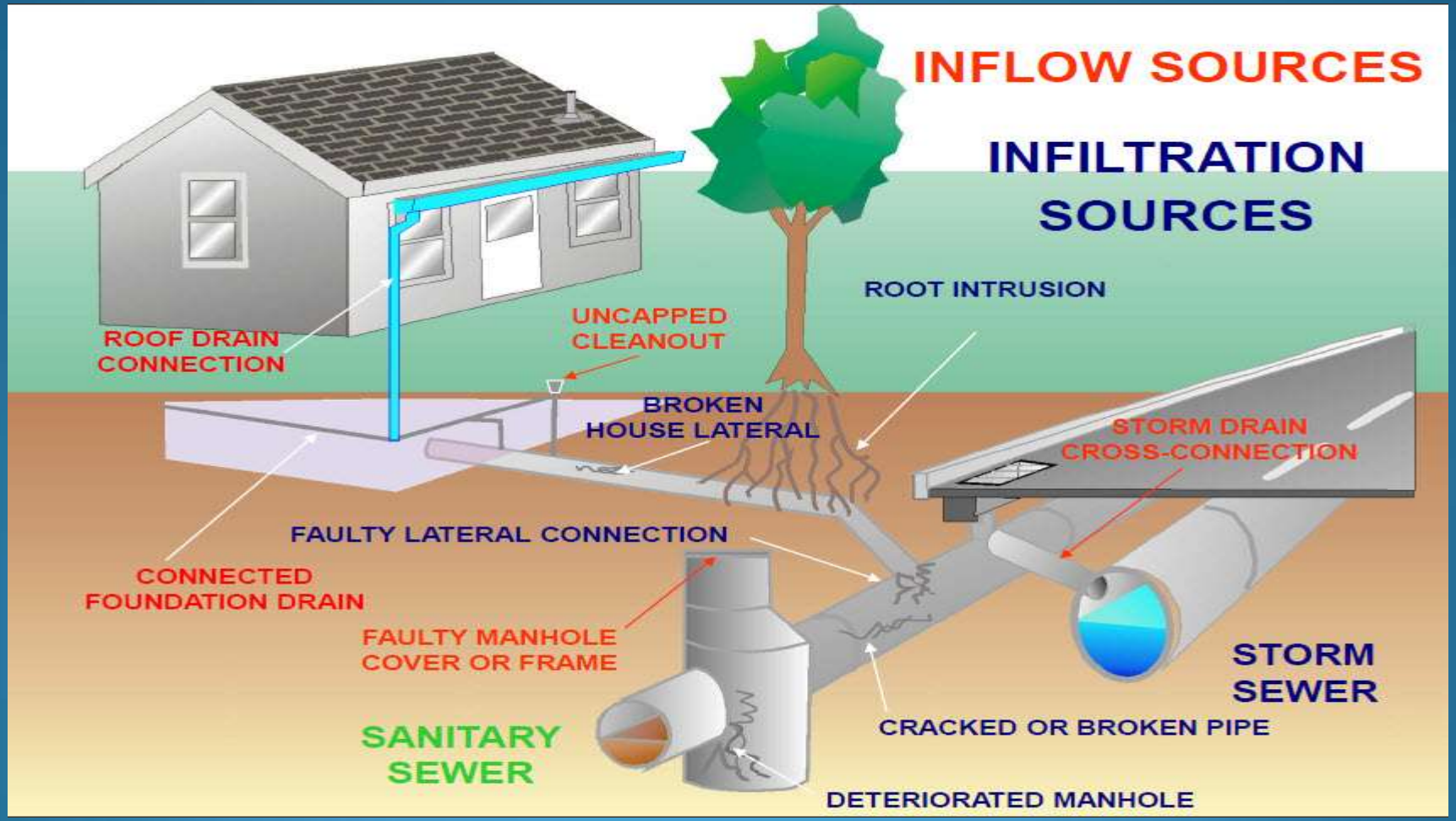
Application Area	How to Use Acoustics	
Pre-Cleaning Assessment	Prioritize/focus cleaning often see >50% cleaning reduction – "focus on cleaning the dirtiest pipes"	QUICK HITS
Condition Surveys	Quickly & economically assess large areas for asset management & planning	
Cleaning Interval Determination	Only clean specific segments when below blockage threshold	
Post-cleaning QA	Low-cost method to check cleaning effectiveness and prevent downstream SSO's	
Optimize SSES Contract Resources	Use acoustics to prioritize pre-cleaning & camera resources for contract advantage	
Performance-Based Contracting	Use acoustic inspection to enable SSO targets in cleaning/inspection contracts	FULL POTENTIAL
Condition Based Maintenance Program	The "holy grail" – economics of acoustics enables a CBM strategy to focus maintenance activity	

TRENCHLESS REPAIR SOLUTIONS

WHAT IS INFILTRATION AND INFLOW (I&I)

Infiltration and Inflow is often referred to as I/I and is the occurrence of storm water or ground water entering into municipal wastewater systems.

INFILTRATION PROBLEMS ARE COMMON

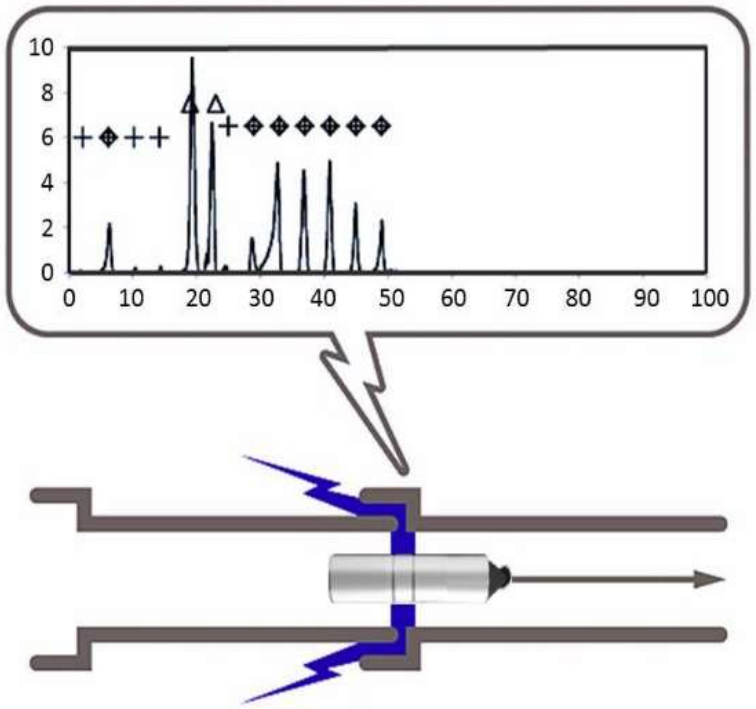


SAMPLE SOURCES OF I/I

How do we find infiltration?

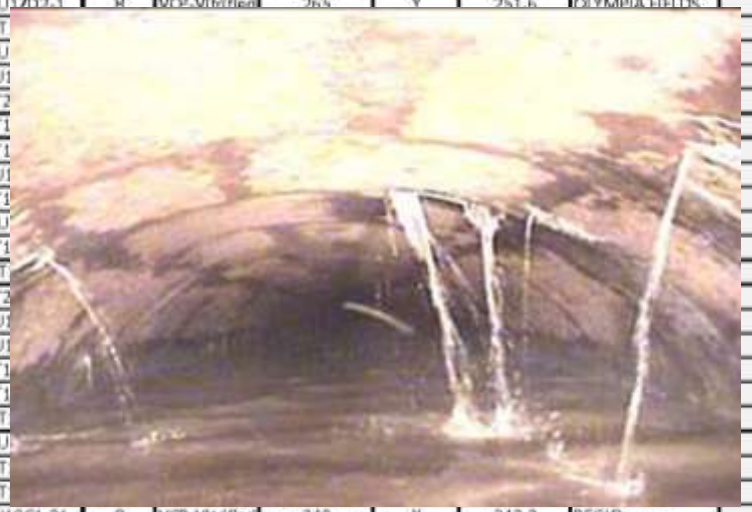
- CCTV Inspections (staining, weeper, gusher)
- Electroscan Inspection
- Air test joints with a grouting packer
- Smoke testing
- Dye Testing

Leaks in sewer pipes are located by measuring the electricity flowing from a probe. As the probe is pulled through a pipe, electricity is used to scan the pipe indicating all defects - hence the term 'Electro Scan.'

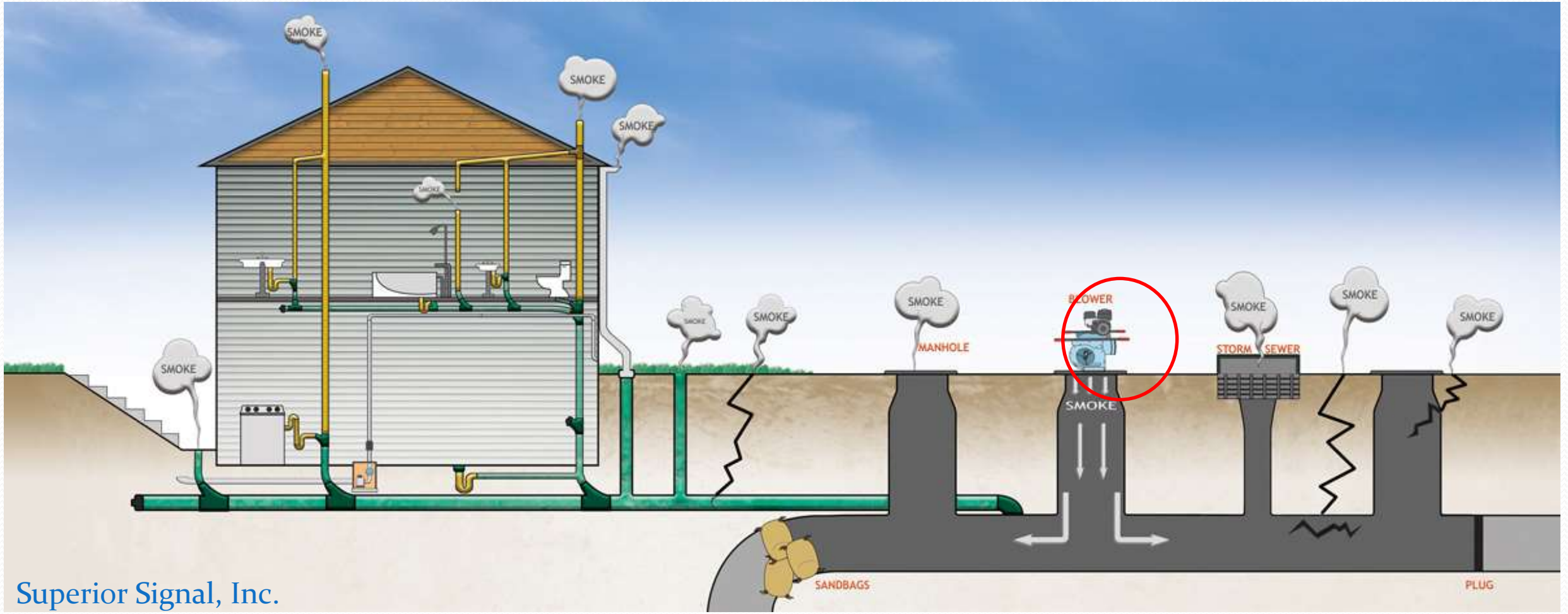


SEGMENTS EXHIBITING INFILTRATION

NT_NUMBER	NT_USMAN	NT_DSMAN	NT_DIA	NT_MAT_TY	Map Length	Cleaned?	Inspected	Street	STRUCTURAL QUICK SCORE	O&M QUICK SCORE	OVERALL PACP RATING	PACP 1	PACP 2	PACP 3	PACP 4	PACP 5	PACP 6	PACP 7	PACP 8	PACP 9	PACP 10	PACP 11
NTG_2352	T19D1-19	T19D1-13	8	PVC	299.730360E	Y	286.9	Rolling Hills	3111	4100	2.7	JSM	B	IR								
NTG_119E	T16D4-17	T16D4-15	8	VCP-Vitrified	345.48965E	Y	187.5	MILLBRIDGE	3D25	4231	2.45	DAE ©	MWLS © X 3	IW	IR X 2	ID						
NTG_1335	U17C2-8	U17C2-7	8	VCP-Vitrified	177	Y	215.6	BELLE MEADE	4534	4133	2.22	MWLS © X 3	DAE ©	IS X 4	IW	DAE X 3	IR					
NTG_4367	U16C1-8	U16C1-7	8	VCP-Vitrified	89	Y	57.5	KITTERY	2600	4131	2.2	IW	MWLS ©	DAE ©	ID	DAE						
NTG_1051	T16D2-7	T16D2-6	6	VCP-Vitrified	244.9307394	Y	243.8	FOXCROFT	312C	5141	2.15	FS	MWLS © X 2	RMI	RML	DAE ©	IG	IR				
NTG_1910	U17A2-4	U17A2-3	8	VCP-Vitrified	269	Y	269.7	GOSHEN	2D00	4132	2.13	MWLS © X 3	DAE X 2	IR								
NTG_783	U17C2-11	U17C2-10	8	VCP-Vitrified	165	Y	154.6	BELLE MEADE	2D00	5142	2.11	MWLS © X 2	DAE ©	IG	IR X 2	IW	IS					
NTG_638	U17D1-8	U17D1-7	8	VCP-Vitrified	132	Y	136.7	THUNDERBIRD	2D00	5121	2.1	IG	DAE	MWLS ©								
NTG_183E	T16D2-1E	T16D2-17	6	VCP-Vitrified	227.0747149	Y	254.5	SHAW	0000	512C	2.1	IG	DAE ©									
NTG_1697	U17D2-5	U17D2-4	8	VCP-Vitrified	117	Y	135.9	BRYN MAWR	0000	412B	2.1	DAE ©	IR									
NTG_1831	T17B1-3	T17B1-2	10	VCP-Vitrified	309.8681379	Y	294.2	Davona	2J00	4231	2.1	MWLS ©	IR X 2	DAE ©								
NTG_1280	U16A1-6	U16A1-4	8	VCP-Vitrified	248	Y	251.0	ENSENADA	2G00	422B	2.07	MWLS © x 2	MWL	IR	DSF ©							
NTG_1080	U17B1-2	U17B1-1	8	VCP-Vitrified	160	Y	157.1	THUNDERBIRD	312E	512E	2.06	FS	MWLS ©	DAE ©	DSF ©	IG						
NTG_1699	U17D2-2	U17D2-1	8	VCP-Vitrified	265	Y	251.6	OLYMPIA FIELDS	2G00	422B	2.06	MWLS © X 2	DSF ©	IR	DAE X 2	DAE ©						
NTG_510	T17B2-5	T							2D00	2E00	2	IW	DAE	MWLS ©	IW							
NTG_169E	U17D2-7	U							312A	2A00	2	CM	IS X 2	DAE © X 3	MWLS © X 2	MWLS						
NTG_1681	U18B2-33	U1							2D00	312F	2	DAE	IS	MWLS © X 2	DAE ©	OBZ						
NTG_1179	T20D1-22	T2							0000	2B00	2	DAE	DAE © X 2	IS								
NTG_119E	T16D4-17	T1							2500	312A	2	DAE ©	IS	MWLS ©	IW	ID	MSA					
NTG_1190	T16D2-11	T1							2B00	2F00	2	DAE ©	IS	MWLS © X 3								
NTG_3536	U19C2-13	U1							0000	2B00	2	DAE ©	IS									
NTG_1201	T16D4-1E	T1							1100	512I	2	DAE ©	IW	JOM	IG							
NTG_2401	U19C1-2	U							0000	312D	2	DAE ©	IW	MSA								
NTG_1826	T16D2-14	T1							2D00	2F00	2	DAE ©	IW	MWLS ©								
NTG_4377	T16D3-6	T							312F	2I00	2	DAE ©	IW	MWLS ©								
NTG_1176	T20D1-19	T2							0000	2C00	2	DAE ©	IW									
NTG_4844	U19C1-20	U1							2B00	312L	2	DAE ©	ID	MWLS ©								
NTG_4611	U19C2-36	U1							2C00	512H	2	DAE ©	IG	MWLS ©								
NTG_1839	T16D2-20	T1							2B00	422I	2	DAE ©	IR	DAE	MWLS © X 3	DSF © X 2	IW					
NTG_1192	T16D2-13	T1							2B00	412F	2	DAE ©	IR	MWLS ©								
NTG_1053	T16D1-5	T							0000	2I00	2	DAE ©	IS X 2									
NTG_1083	U17D1-10	U							2400	2E00	2	DAE ©	MWLS X 2	IW	MWLS ©							
NTG_1050	T16D2-E	T							2I00	2I00	2	DAE ©	MWLS ©	IS	IW							
NTG_1189	T16D2-10	T							2I00	412L	2	DAE ©	MWLS ©	IS	IR							
NTG_4842	U19C1-22	U19C1-21	8	VCP-Vitrified	340	Y	342.2	REGIO	2K00	2L00	2	DAE ©	MWLS ©	IS								
NTG_4401	T17B2-8	T17B2-5	8	VCP-Vitrified	340.5391243	Y	344.3	KITTERY	2L00	2L00	2	DAE ©	MWLS ©	IW	FC							
NTG_2399	U19C1-4	U19C1-2	8	VCP-Vitrified	249	Y	230.6	PEPPERTREE	2200	412H	2	DAE ©	MWLS ©	IR								
NTG_1199	T16D4-20	T16D4-17	8	VCP-Vitrified	259.7450805	Y	251.6	MILLBRIDGE	2G00	412I	2	DAE ©	MWLS ©	IS X 3	IW X 3	IR						
NTG_2489	U16C2-6	U16C2-5	10	VCP-Vitrified	182	Y	163.4	MANGOS	2D00	412G	2	DAE ©	MWLS © X 2	DSF	DSF ©	IR	DAE					
NTG_439E	T16D2-17	T16D2-15	8	VCP-Vitrified	256.8979537	Y	224.6	SHAW	2C00	422G	2	DAE ©	MWLS © X 2	IR	DAE							
NTG_1045	T16D2-5	T16D2-3	8	VCP-Vitrified	196.2142597	Y	190.7	BIDDLEFORD	2E00	422F	2	DAE ©	MWLS © X 2	IR X 2								
NTG_133E	U17C2-9	U17C2-8	8	VCP-Vitrified	416	Y	361.0	BELLE MEADE	2K00	2M00	2	DAE ©	MWLS © X 3	IS	IW							
NTG_1054	T16D1-6	T16D1-4	8	VCP-Vitrified	226.6928933	Y	213.4	MILLBRIDGE	2E00	2I00	2	DAE ©	MWLS © X 3	IW X 2	IS	IW ©						
NTG_2450	U18B1-30	U18B1-28	8	VCP-Vitrified	389	Y	372.0	SANDPOINT	2300	2B00	2	DAE X 2	DAE ©	IS	MWLS ©	MWLS						
NTG_1703	U18B2-43	U18B2-41	8	VCP-Vitrified	145	Y	139.0	WINGED FOOT	2D00	2C00	2	DAE X 2	IS X 2	MWLS ©	DAE ©							
NTG_131E	U18B2-37	U18B2-36	8	VCP-Vitrified	211	Y	196.3	WINGED FOOT	2F11	322C	2	ISSR	MWLS ©	ID	DAE	DAE ©	JOM					
NTG_4843	U19C1-21	U19C1-19	8	VCP-Vitrified	269	Y	273.6	PEPPERTREE	2311	332I	2	JSM	DAE ©	ID ©	MWLS ©	DSF ©						
NTG_4841	U19C1-24	U19C1-21	8	VCP-Vitrified	242	Y	243.8	PEPPERTREE	3321	2F00	2	MWLS ©	DAE ©	IW								
NTG_1086	U17D2-16	U17D2-15	8	VCP-Vitrified	204	Y	168.9	OLYMPIA FIELDS	2E00	412E	2	MWLS ©	DAE ©	IR								
NTG_1319	U18B2-32	U18B2-31	8	VCP-Vitrified	311	Y	335.6	FIRCREST	2200	322F	2	MWLS ©	DAE © X 2	ID	IW	DAE						
NTG_1322	U17D2-15	U17D2-13	8	VCP-Vitrified	181	Y	191.9	OLYMPIA FIELDS	2A00	3129	2	MWLS © X 2	IW	DAE ©	DSF ©	RMJ						
NTG_1202	T16D4-19	T16D4-18	6	VCP-Vitrified	249.4566229	Y	257.5	LUDLOW	2E00	2F00	2	MWLS © X 2	DAE ©	IS								

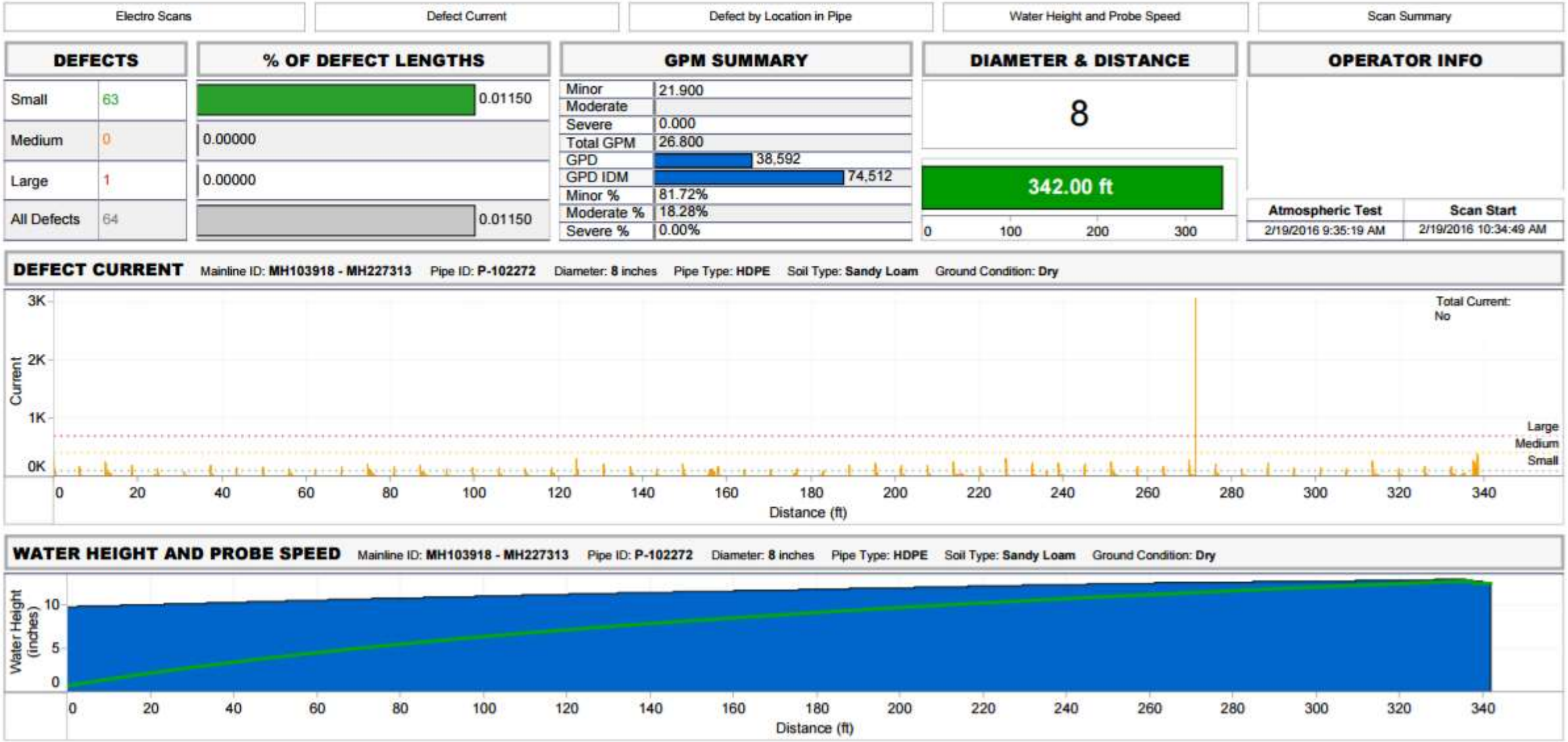


Smoke Testing



Superior Signal, Inc.

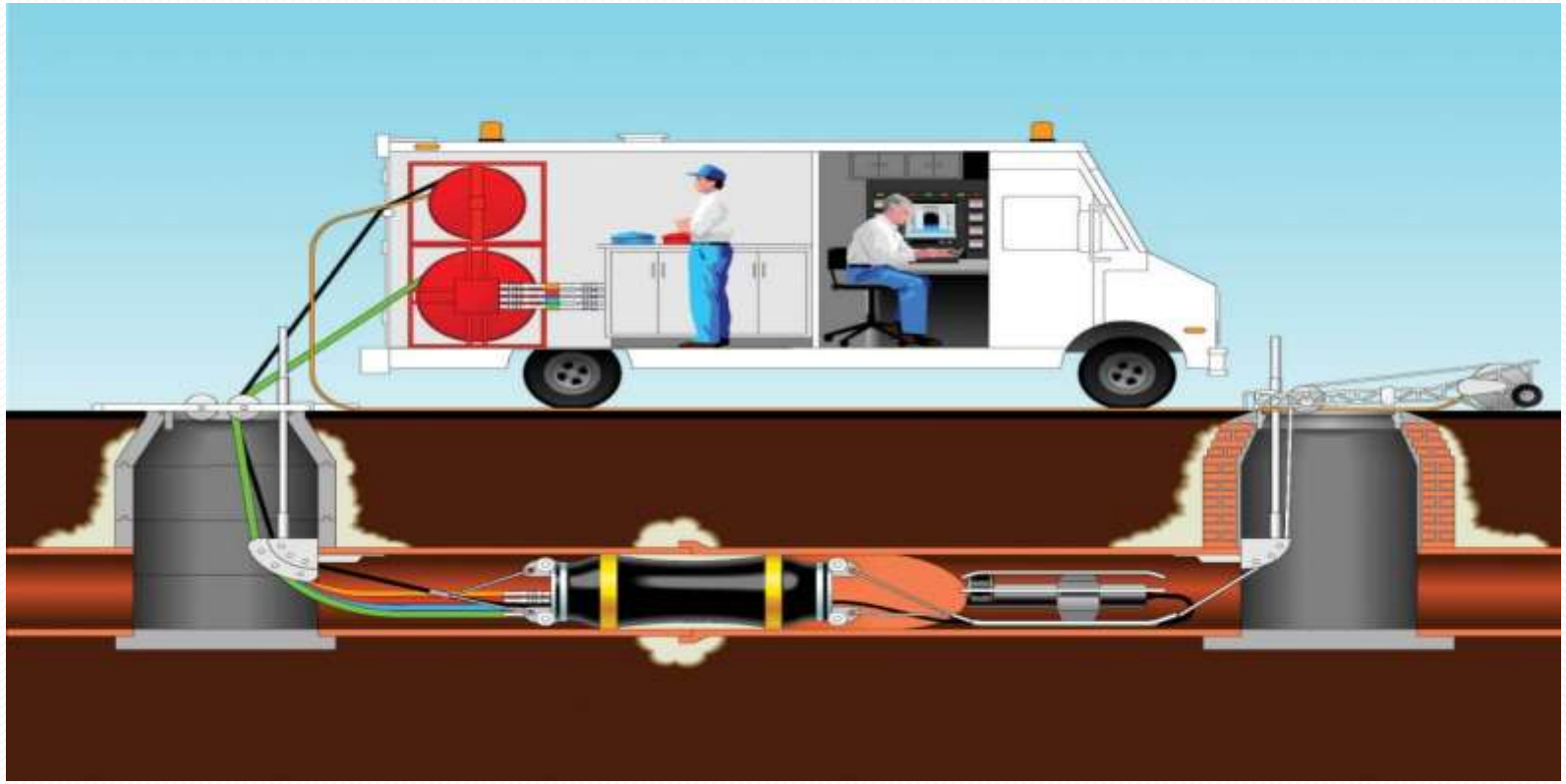
Electroscan



What can I use to Fix……?

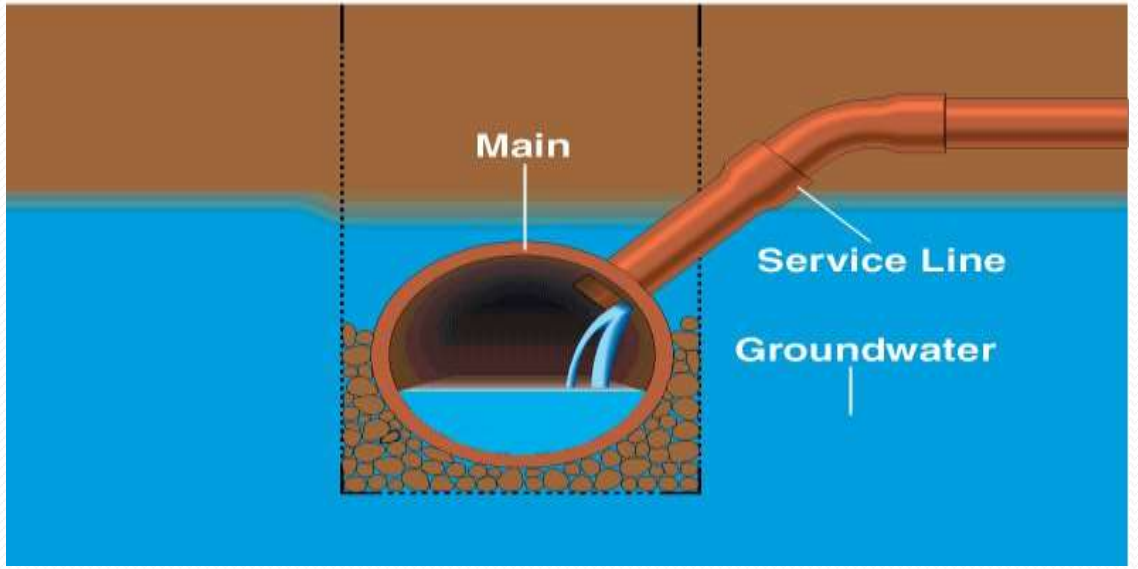
- Water Infiltration
  - Through a joint: grouting
  - Through a broken pipe or lateral: point repair
  - Through a manhole: grouting
- Broken pipe/Hole/Fractures
  - Point Repair in a mainline
  - Lateral lining for a lateral
- Roots
  - Root Foaming
  - Point repair (main line)
  - Lateral Lining (lateral)
- Corrosion in a mainline
  - CIPP lining/sliplining
  - Replace
  - Structural Coatings

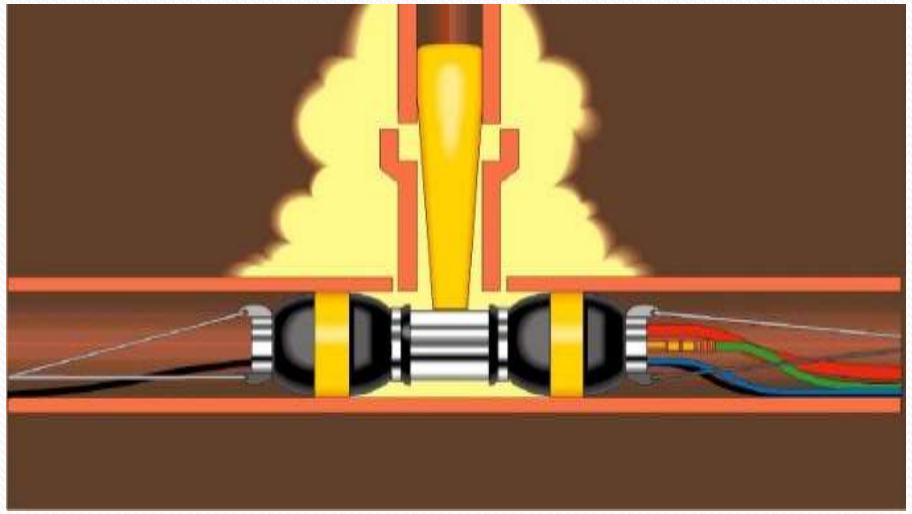
Testing & Sealing of Joints (Via Injection Grouting)

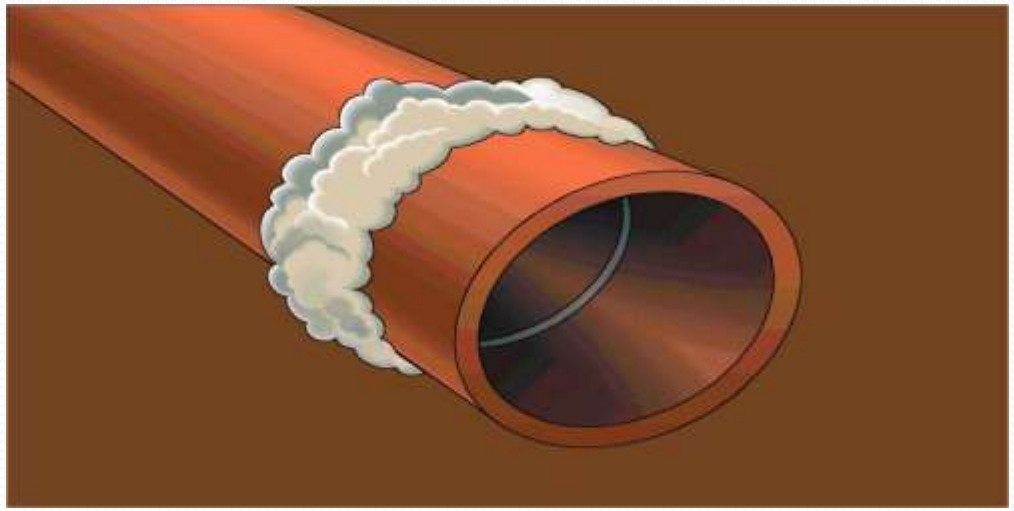


Testing and grouting of pipe joints

Injection Grouting







CHEMICAL GROUTING STOPS INFILTRATION

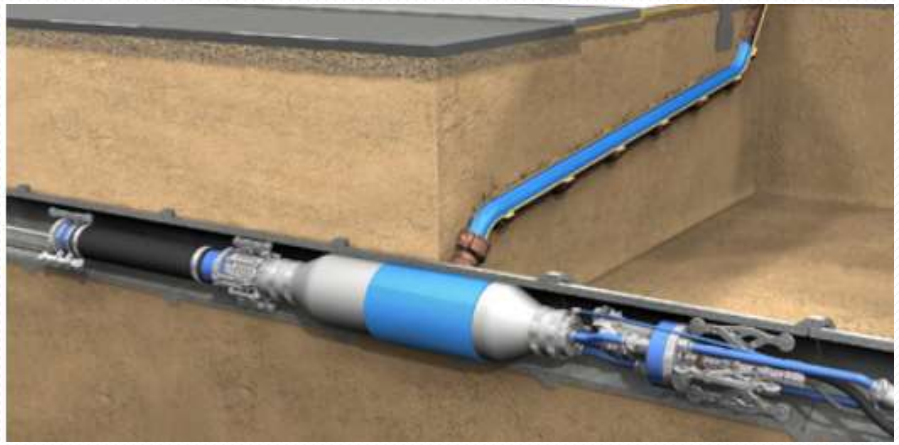
ANOTHER ALTERNATIVE TO STOP I&I
Service Connection Lining

Before

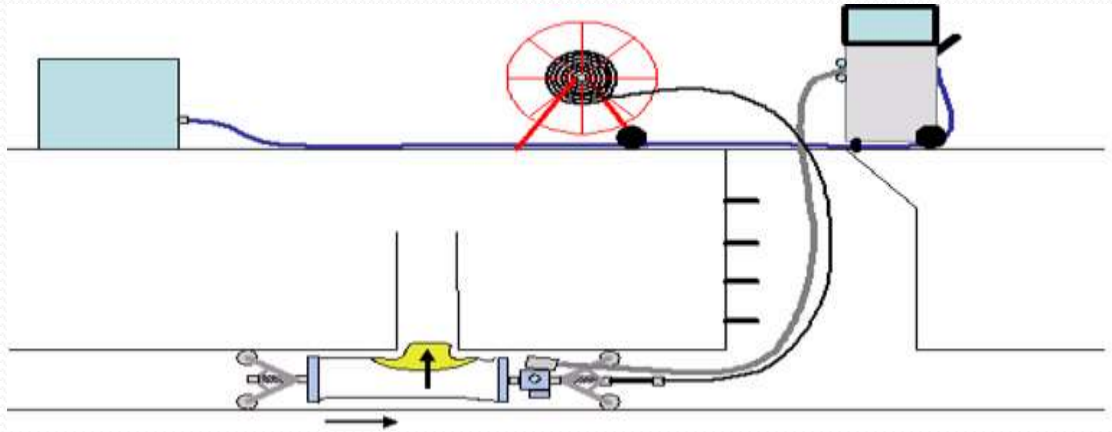
After

LCR
(Lateral Connection Repair)

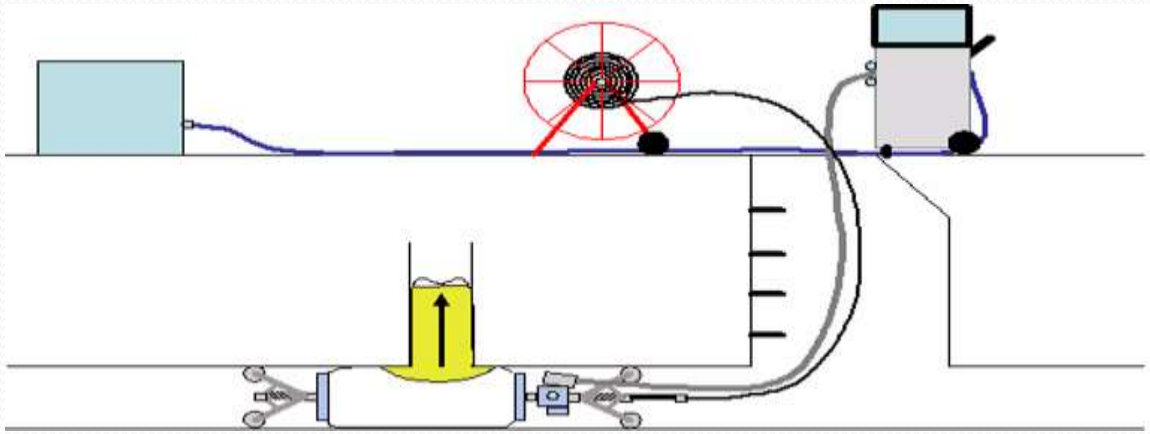
MTH
(Main to House)



INVERSION PROCESS



Position the packer until the pathfinder engages into the opening of the lateral connection. Make sure the LCR packer takes a center position with the lateral opening.

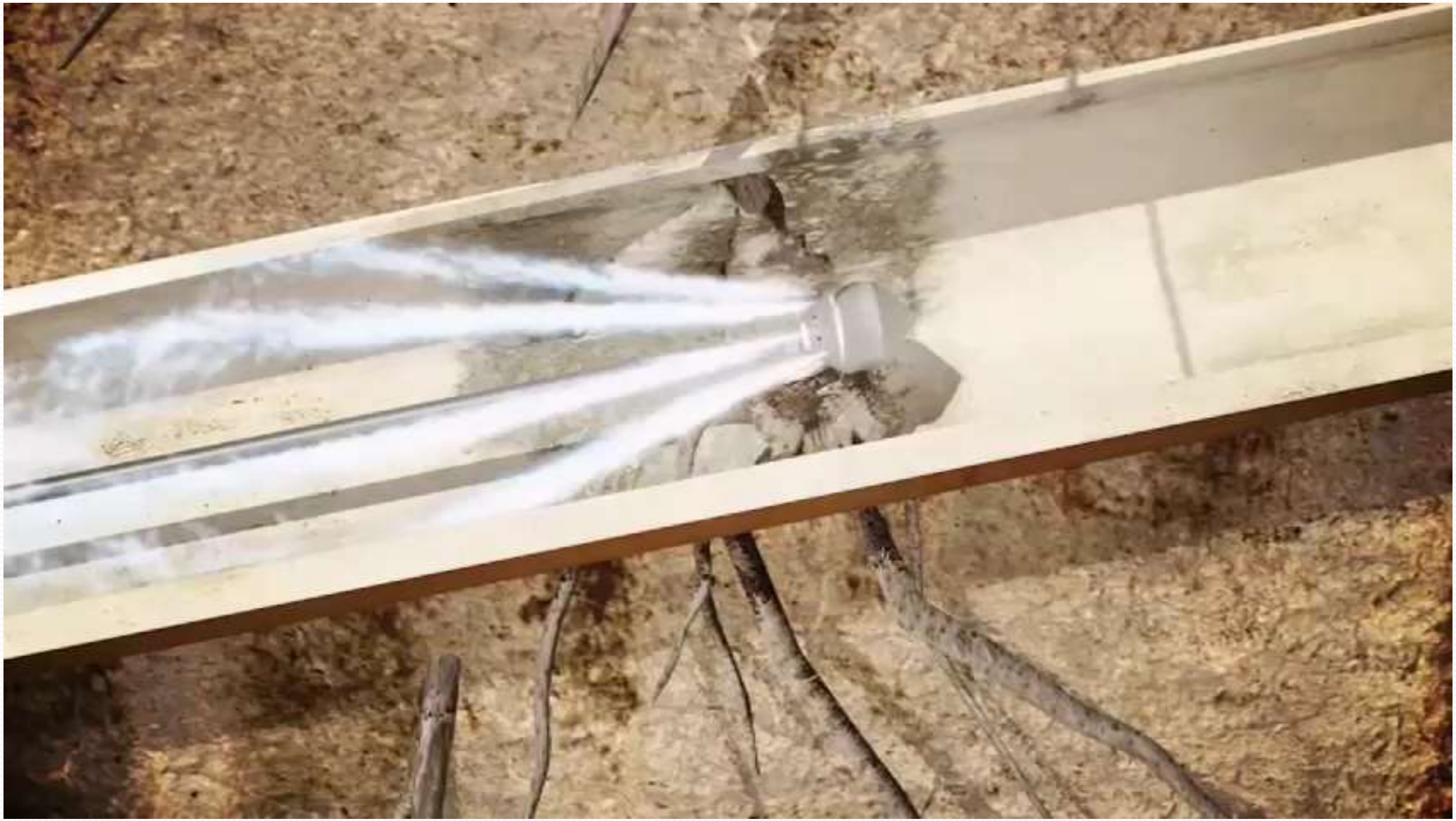


Set the pressure regulator to an inflation pressure of 10 psi. At first, the pressure is built up in the main pipe. Then pressure will be built up in the lateral connection thereby causing the inversion process to start.

LATERAL SERVICE LINE INSPECTION & REPAIR

Carylon Corporation

The Environmental Protection Specialists



CIPP

CURED-IN-PLACE PIPE

Trenchless CIPP Short Liners

- Short liner spot repairs to rehabilitate holes, cracks and eliminate sources of heavy infiltration.

Trenchless CIPP Spot Repair

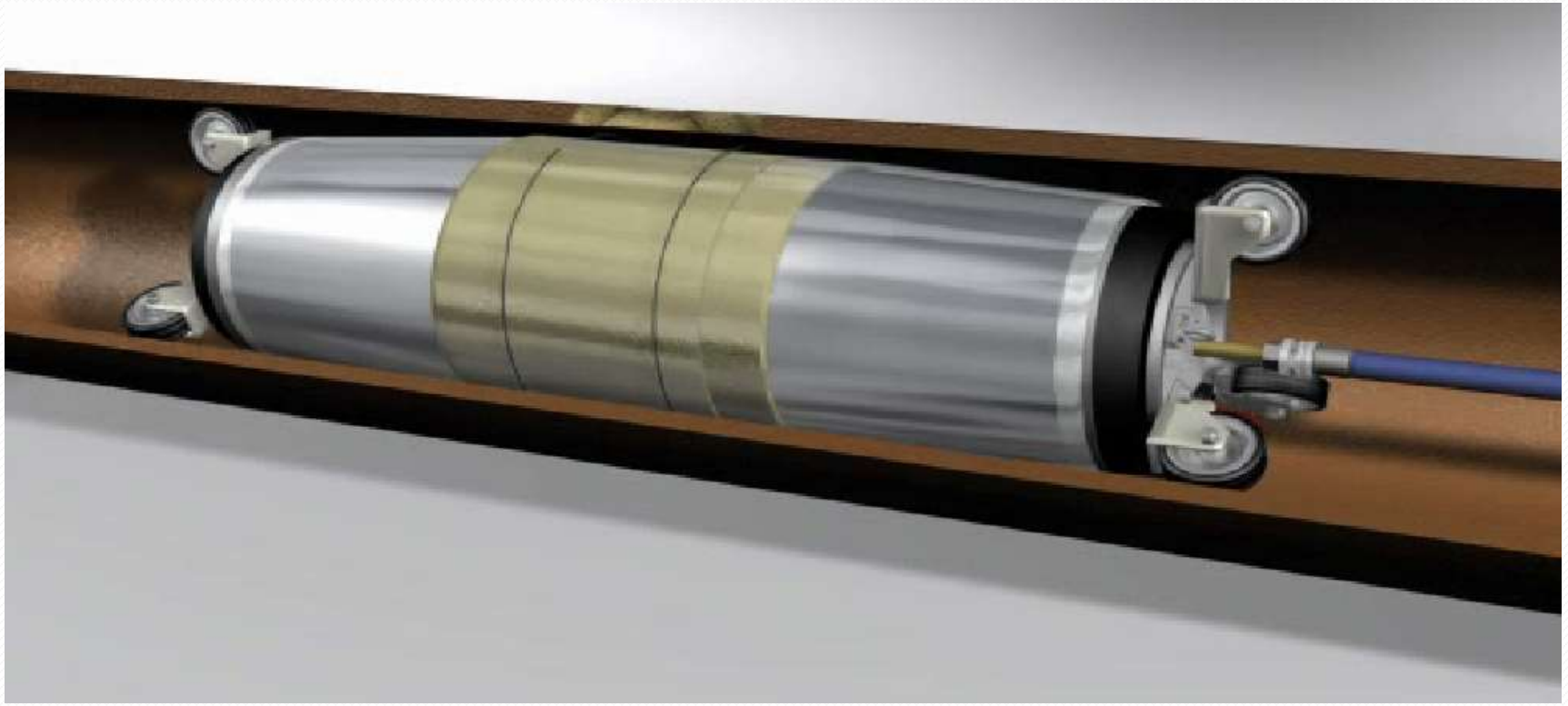
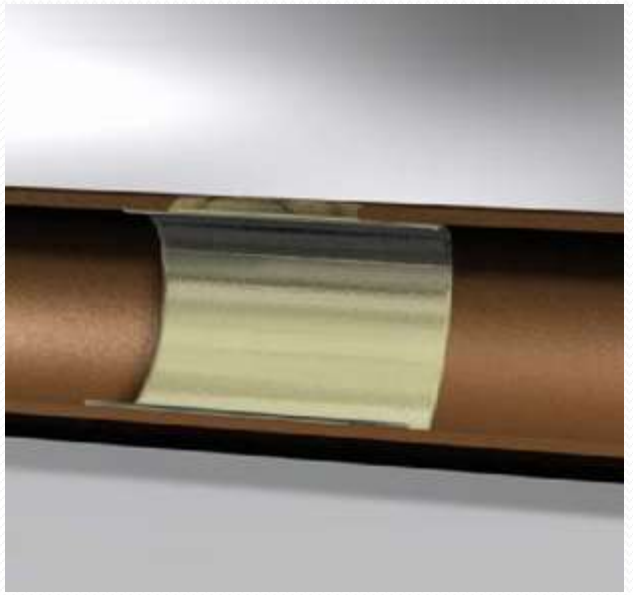


Diagram showing a pipe that has been sectionally repaired.



Spin Cast Pipe Rehab with Corrosion Inhibitor

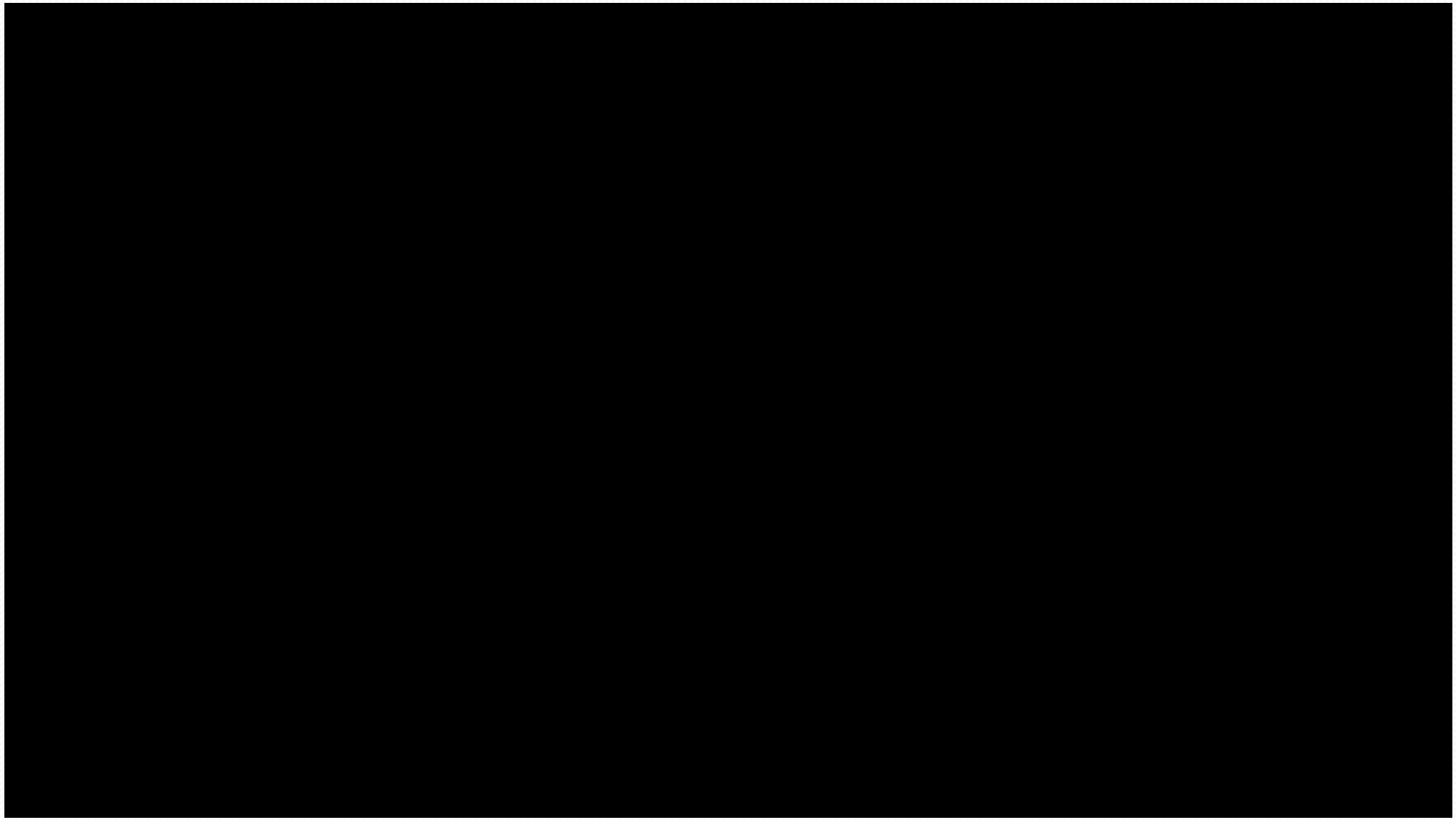
Deterioration of wastewater systems created by the effects of *"Concrete Corrosion"* is causing premature failure of structures resulting in expensive and disruptive repairs.

Who Wants to Chemically Grout this Section?

USED TO REHAB STORM AND WASTEWATER PIPELINES

- CENTRIFUGALLY CAST CONCRETE COATING IS APPLIED WITH A ROTATING SPIN CAST NOZZLE
- USED VERTICALLY OR HORIZONTAL
- CONSHIELD® ANTIMICROBIAL ADDITIVE IS DOSED INTO THE MIX TO RENDER THE COATING UNINHABITABLE FOR BACTERIA GROWTH, WHICH STOPS THE CORROSION.

96” Centrifugally Cast Spin Cast Pipe Rehab Before and After



Small Equipment Footprint

Report Graphics Sample

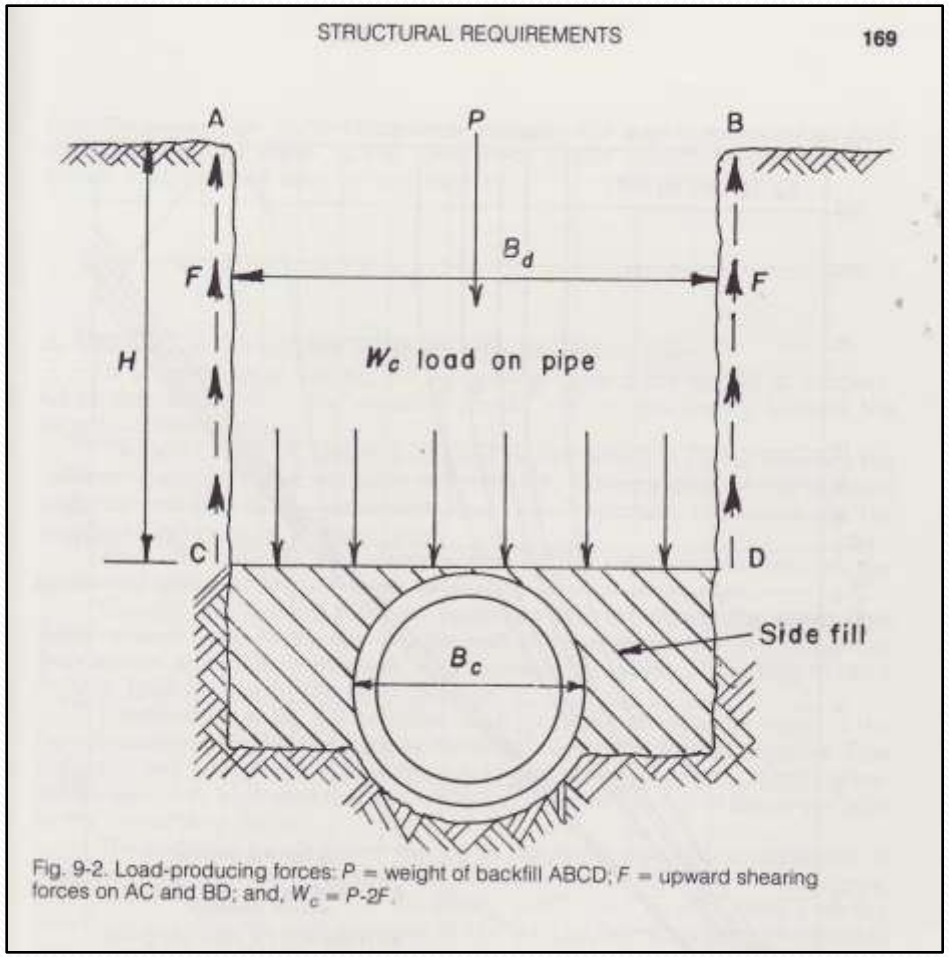


Fig. 9-2. Load-producing forces: P = weight of backfill ABCD; F = upward shearing forces on AC and BD; and, $W_c = P\text{-}2F$.

Minnesota DOT 80 feet of 36 in pipe

SR 16, Florida 80feet of 13ft pipe

Questions?

MICHELLE BEASON, PE

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