GO THE **DISTANCE**

Multi–Sensor Inspection: 2D LIDAR & 3D LIDAR

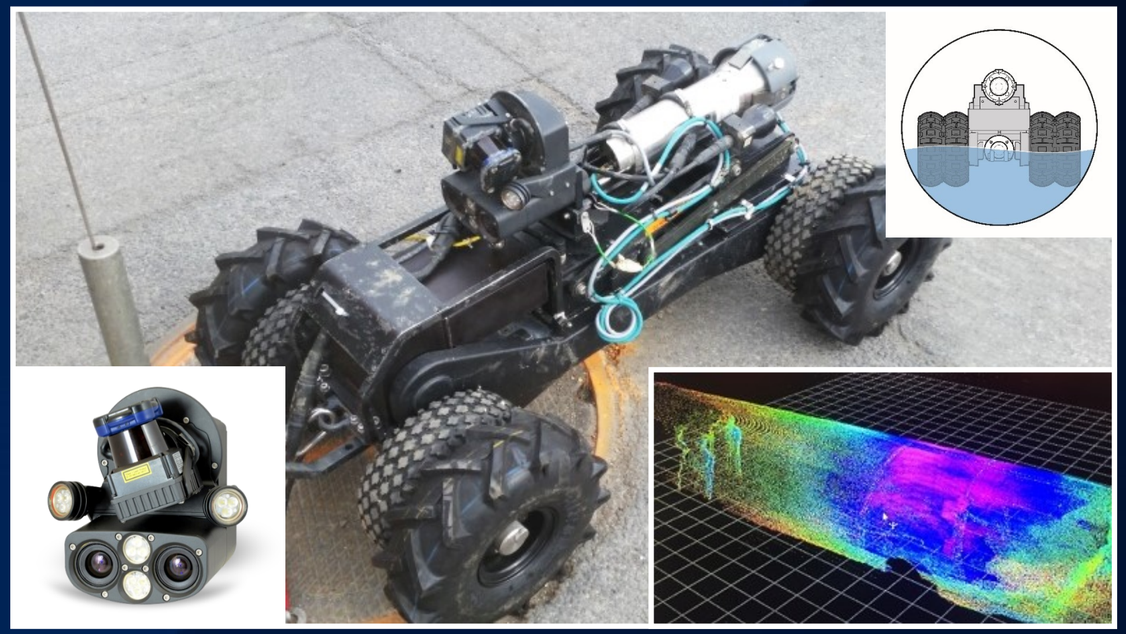
Adam Slifko

CUES / Pipeline Inspection Partners Corp.
Business Development Manager

Current Role: Manages the Multi-Sensor Inspection (MSI) line of business, with an emphasis on 2D and 3D LIDAR applications. Plans and coordinates multi-sensor jobs from field data collection to processing and report submittal.

Background: Mechanical Engineering and Robotics

Multi–Sensor Inspection: 2D LIDAR & 3D LIDAR

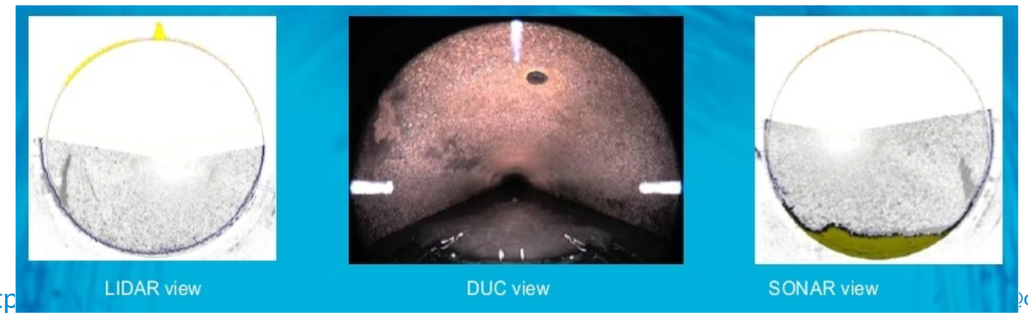


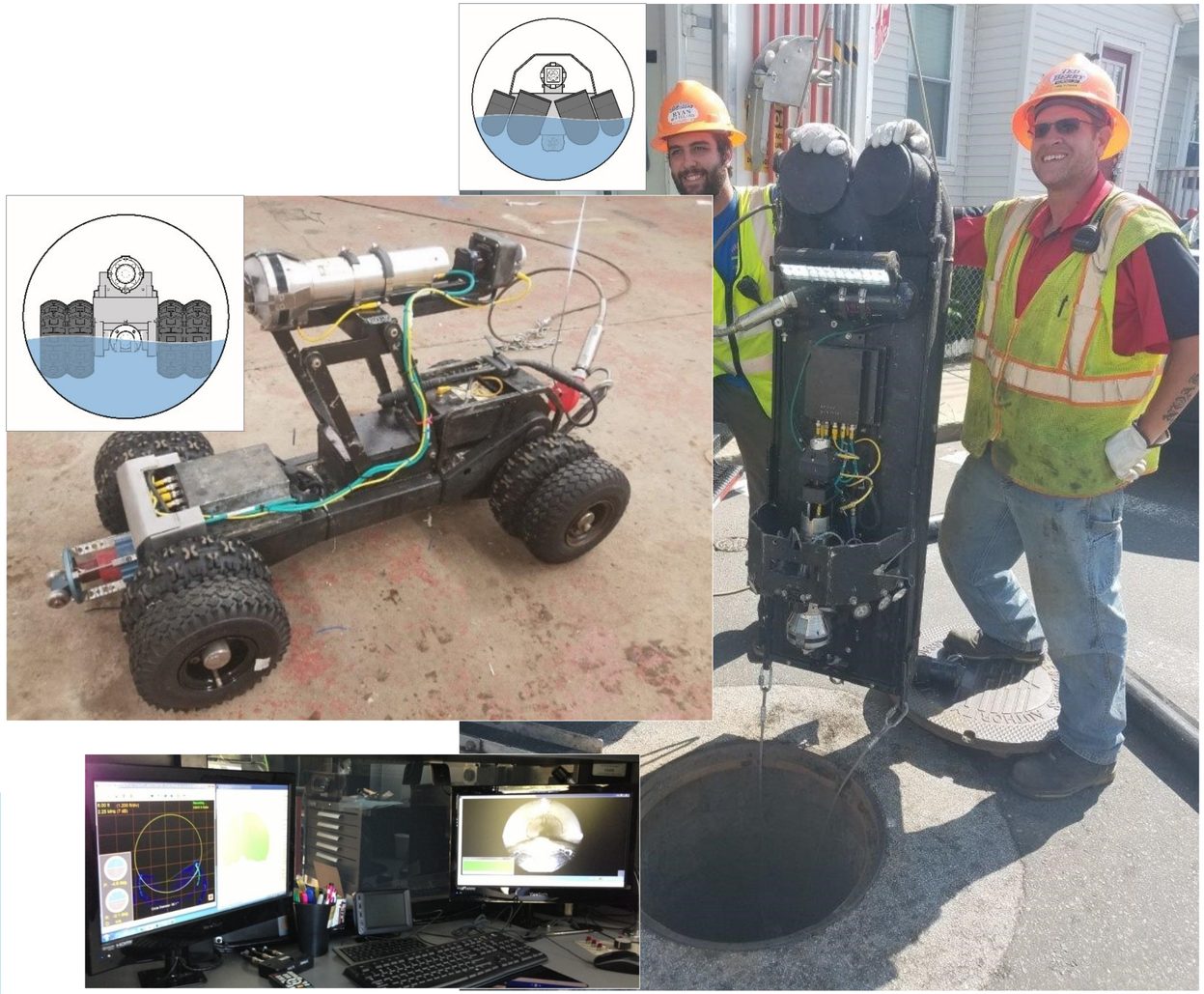
What Is MSI?

- Multiple Sensors
  - LIDAR
  - SONAR
  - Fisheye Video
  - H2S Gas & Temp - OPTIONAL
- 2D LIDAR
- 3D LIDAR
- Quantitative measureable data

SolidFX MSI Equipment

- State-of-the-Art 2D LIDAR Inspection
- FLOAT for 36” and larger pipe
  - Up to 5400 LF
- SMM for 24” and larger pipe
  - Up to 3000 LF
- View and verify data quality in real time
- Code in back office for QA/QC
- Lens cleaning for I&I

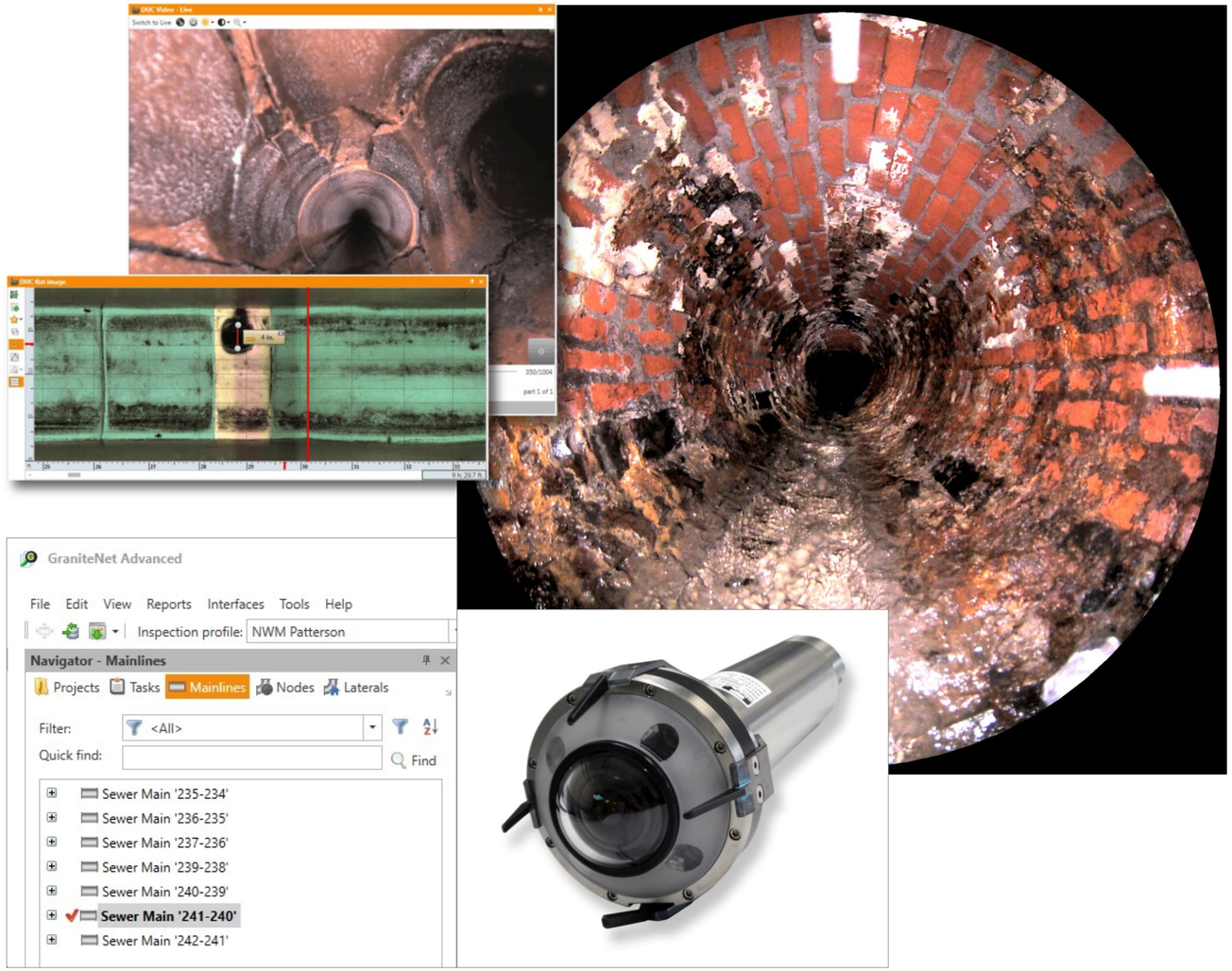




SFX–DUC Camera

Digital Universal Camera (DUC)

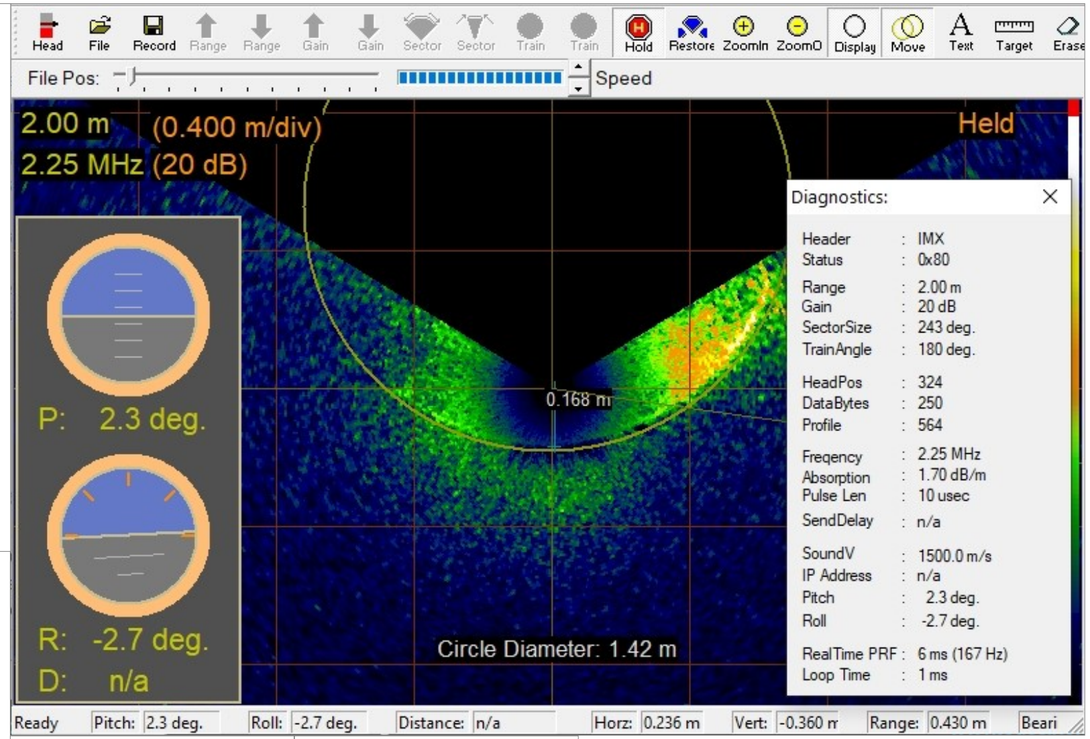
- Live video during inspection
- Digital pan-tilt-zoom
- Never miss a defect
- Integrated with GNet
- Code in truck or in office
- Flat images with measuring capabilities
- No moving parts

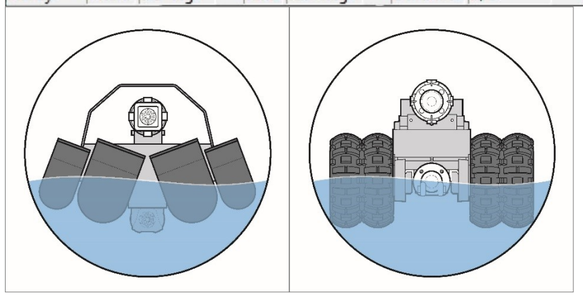


SFX–SONAR

Profiling SONAR

- Frequency = 2.25 MHz
- Beam = 1.4-deg conical
- RPM = 1 rev/sec
- Range = 6” – 180” (15 ft.)
- Pitch & Roll
- Debris level
- Water level
- Capacity Analysis
- On-screen measurements

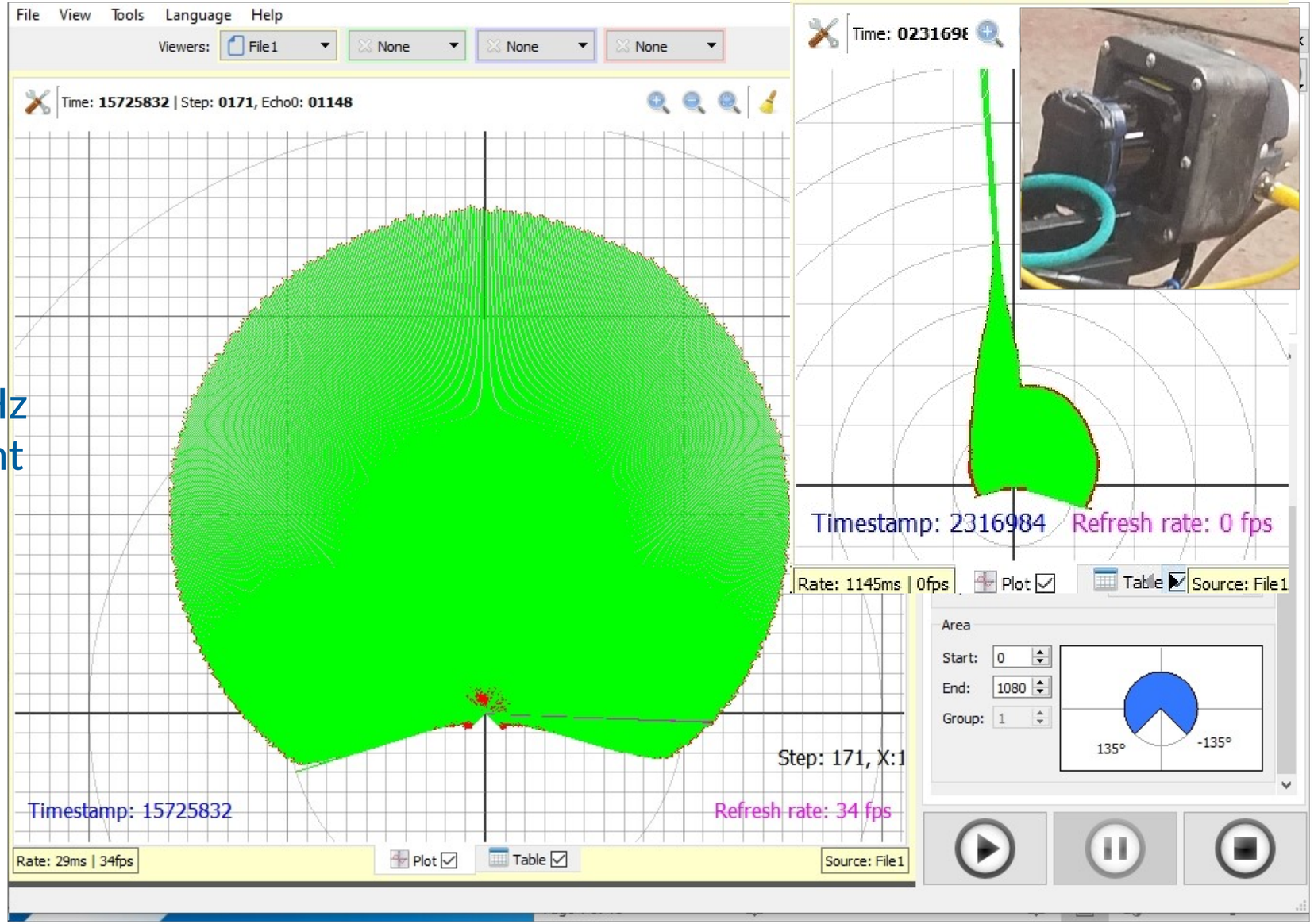




SFX–2D LIDAR

2D Scanning LIDAR

- 2D SCANNING LIDAR
- Live view
- On screen measurements
- 270 degree sweep @ 40 Hz
- 1080 points @ ¼ deg/point
- Height & Width
- Ovality
- Corrosion &Buildup



SFX–H2S Gas/Temp Sensor *(optional)*

H2S/TEMP-data logger

- H2S/TEMP – data logger
- Designed for sewers, manholes, and wet wells
- Wireless Bluetooth download of data
- Time synchronization with other MSI sensors
- Floats and self-righting

H2S Ranges	0-50, 0-200, 0-1000 and 0-2000ppm, Long Deployment (LD) or Short Deployment (SD) sensors available
Gas Accuracy at STP	+/- 2ppm at 20ppm gas (normal temperature and pressure)
Instrument Temp Range	-20C to 50C (-4F to 122F)
Relative Humidity Range	0-100% non-condensing
Ingress Protection	IP68
External Dimensions	Trilateral Diameter 58.3mm x 59.3mm Height 164mm (2.30" x 2.34" x 6.46")
Instrument Weight	300 grams (10.6oz)
Power Supply	3 x AA Alkaline Batteries (in adaptor) Or 1 x 3.6v D Lithium Battery
Logging Interval	1 second to 18 hours
Logging Capacity	3 million data points
Wireless Communication	Data download via *Bluetooth*®
Humidity Accuracy	+/- 5% RH @ 55% RH
Humidity Sensor Range	0-100%
Temperature Accuracy	+/- 0.3 @ 25C (77F)

SFX–Advantages

Live view of video and data
- Code in field or office
- Verify data quality in field
- Reduce re-work

Blow-off system for clearing lens
- No need to pull back
- DUC lens & LIDAR lens

No Shadowing

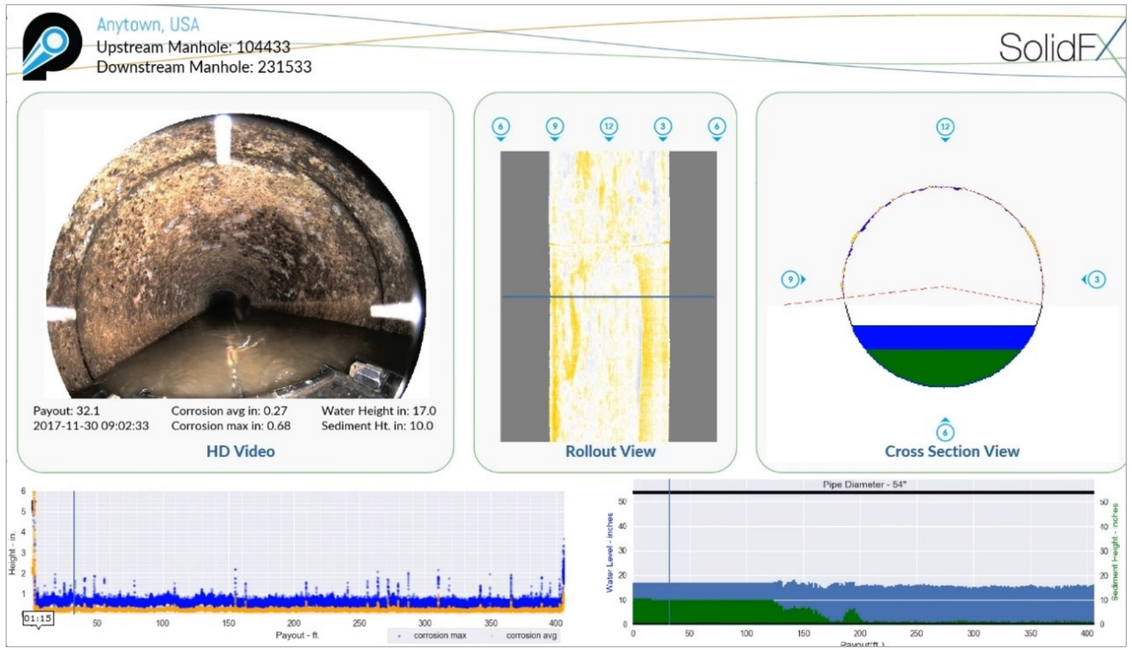
Accuracy is constant as pipe diameter gets larger

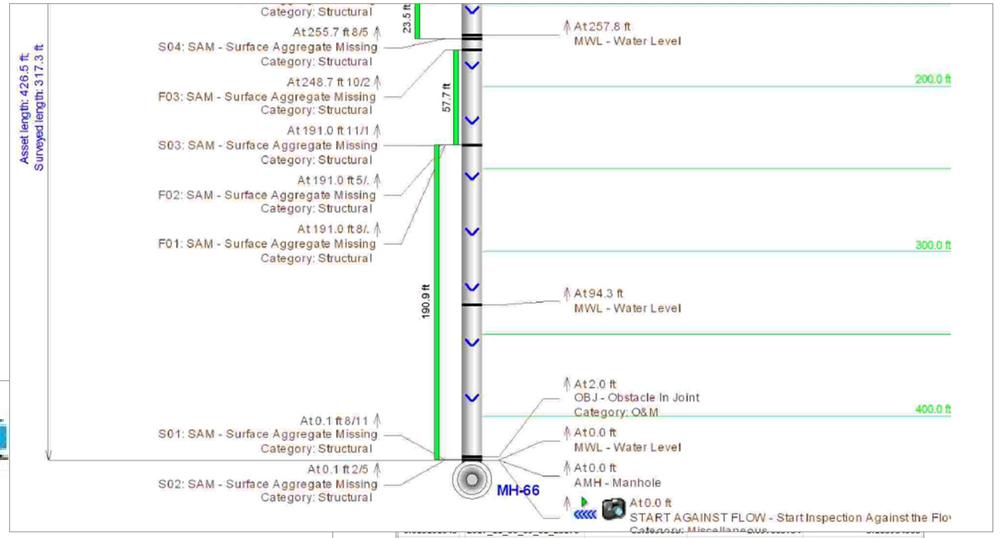
Factory calibration

2D Inspection Technology Comparison			
Feature	**SOLID FX -2D**	**Rauch**	**Fly Eye**
Technology	LiDAR	Spinning Laser Profiling	Laser Profiling with Wand
Cross Sections Scan Rate	45 /second	1.25 /second	12 /second
Cross Section Measurement Density	1080 points	20 -300 points	Function of Pipe diameter
Effective Range	6"- 30 meters	4"-48"	18"-100"
Accuracy	3 mm @ 10m	15mm @ 3m	3 mm @ 3mm
Resolution	1mm (constant)	+/- 0.5% (pipe diameter)	+/-0.1% (pipe diameter)
Calibration	Precision Factory	Automatic	Factory
Limited by Shadowing	No	No	Yes
Requires Wand Change out	No	No	Yes
"Cork Screw" Distortion during Motion	No	Yes	No
Multiple Returns (fog resistance)	Yes	No	No
Sensor Cleaning during Inspection	Yes	No	No
Transport Mechanism	Tractor/Float	Tractor Only	Float Only
3D Option	Yes	No	No
Custom Reporting	Yes	No	No
Live Video	Yes	Yes	No
Sonar Available	Yes	No	Yes
Maximum Deployment Length (m)	2000+	2000	2000+
Data viewable during operations	Yes	Yes	No
Onsite PACP/WRC	Yes	Yes	No

SFX–Reporting Deliverables

- Granite Net database and DUC video file
- 4:1 VIDEO – Synchronized sensor view (MP4)
- Condition Assessment Report (PDF)
- Tabular Data (Summary Info) (CSV)





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0.014773519	2017_11_30_09_01_23224	86.74908718	2.168335546	5.33744858
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0.016515679	2017_11_30_09_01_23274	90.71716059	2.181964199	5.488367359
0.01738676	2017_11_30_09_01_23299	89.73681304	2.147298754	5.33744858
0.01825784	2017_11_30_09_01_23324	78.48615785	2.103991424	4.948263487
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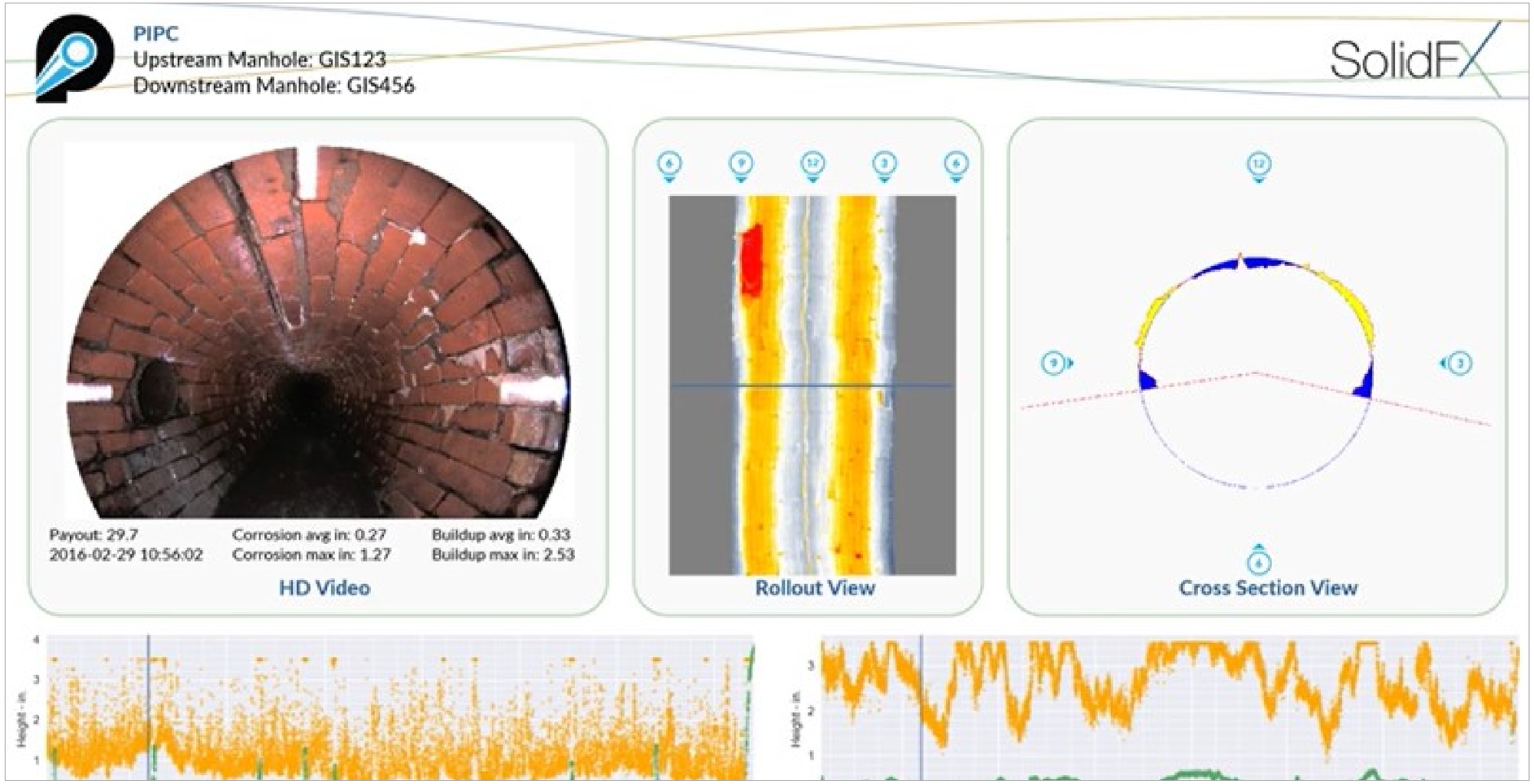
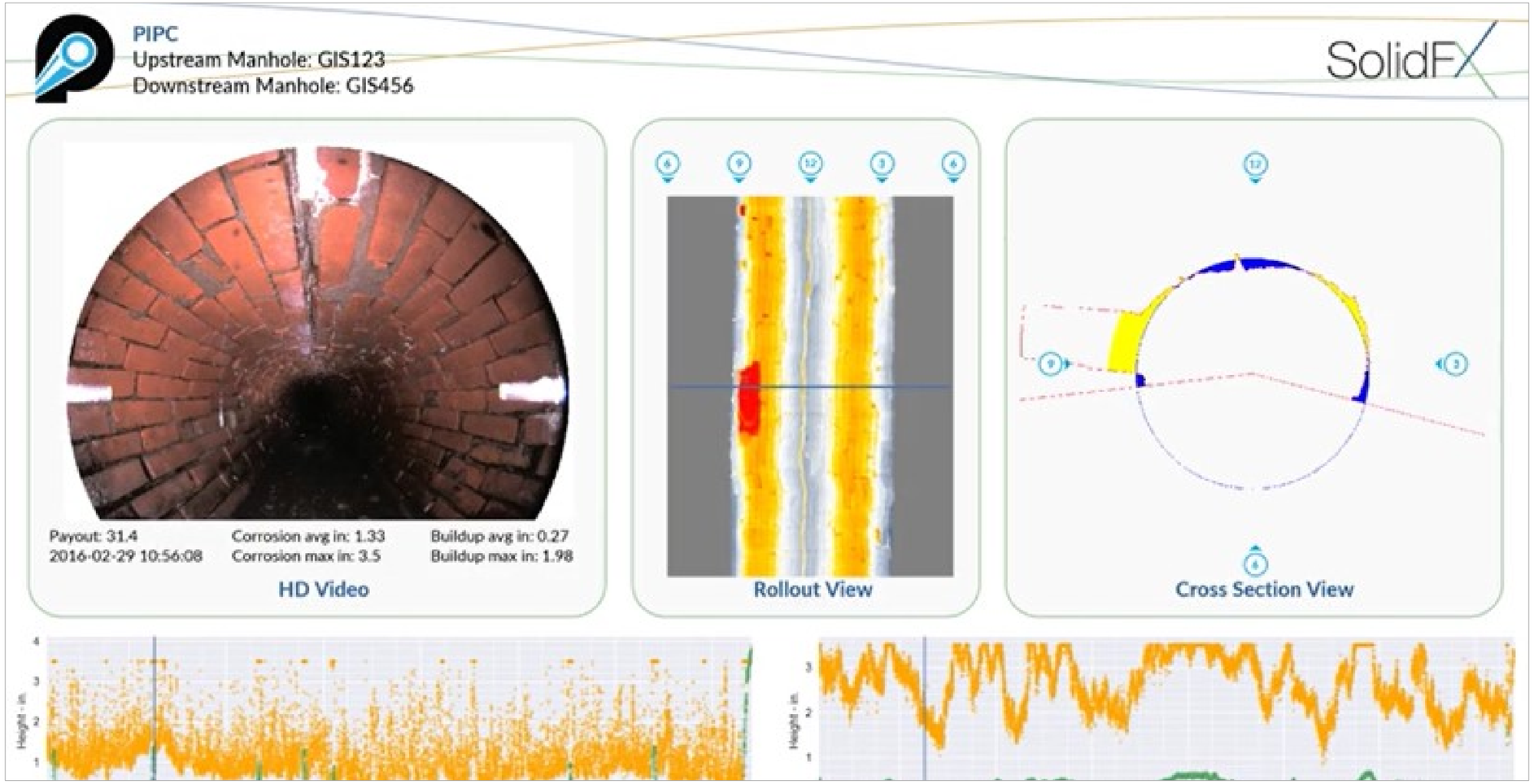
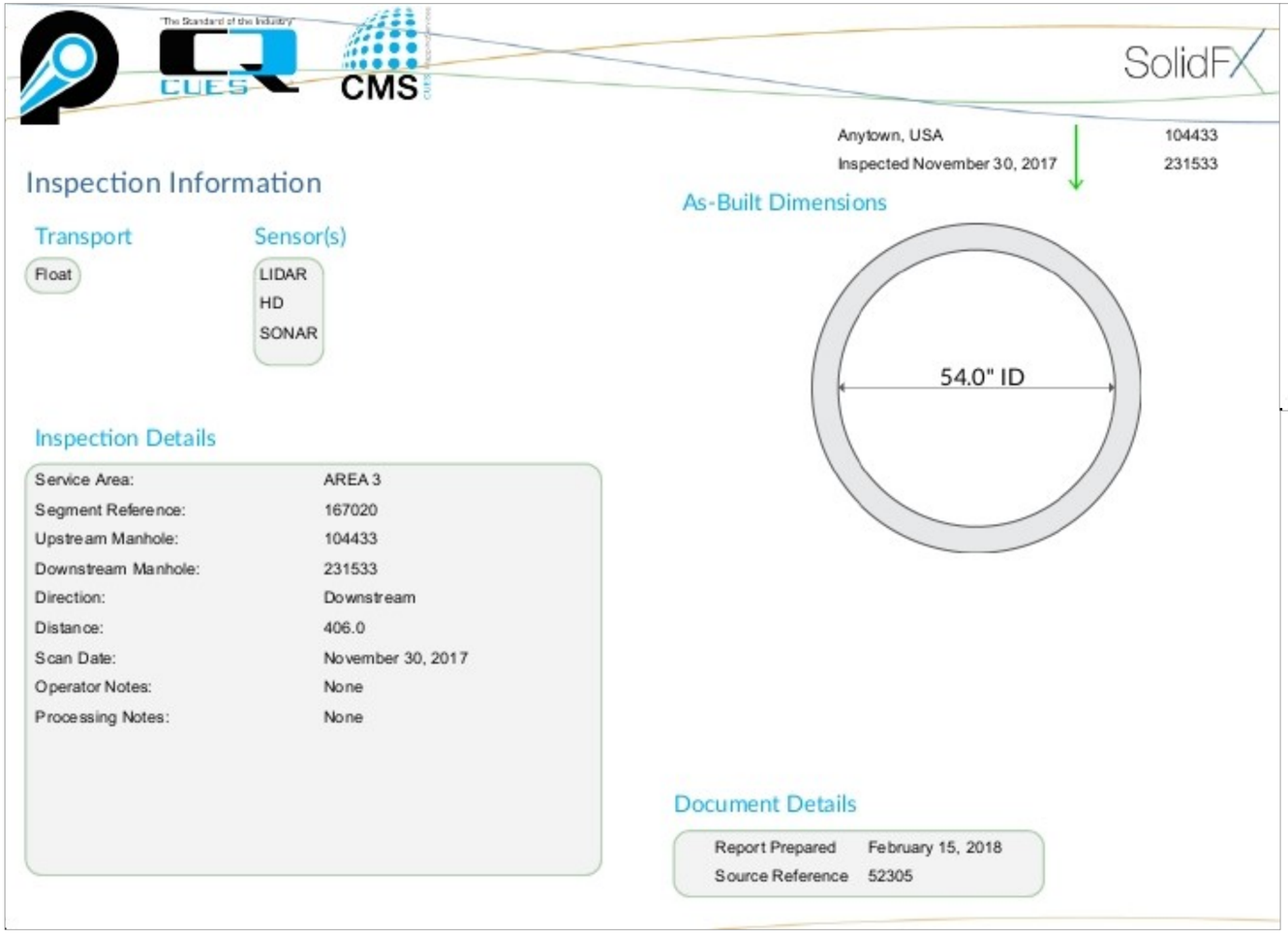
SFX–4:1 Viewer

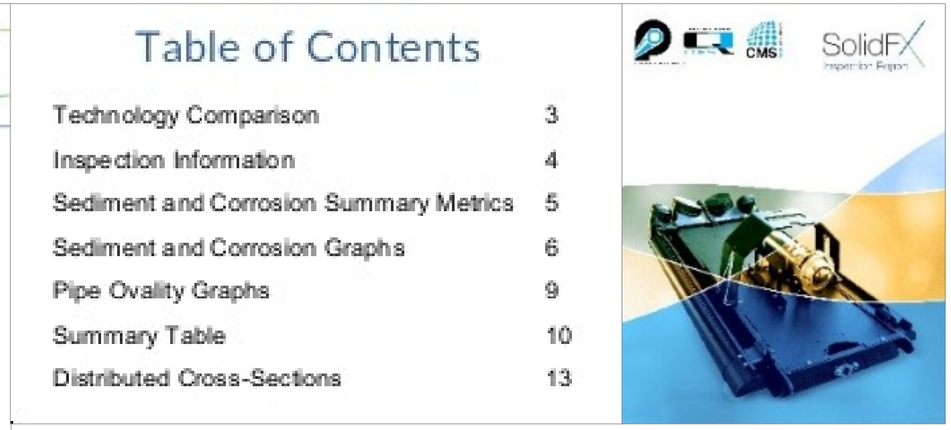


SFX–4:1 Viewer *(cont.)*



SFX–Condition Assessment Report





SFX–Condition Assessment Report *(cont.)*

"The Standard of the Industry"

SolidFX

Anytown, USA 104433

Inspected November 30, 2017 231533

Sediment and Corrosion Summary Metrics

Sediment/Sonar Metrics

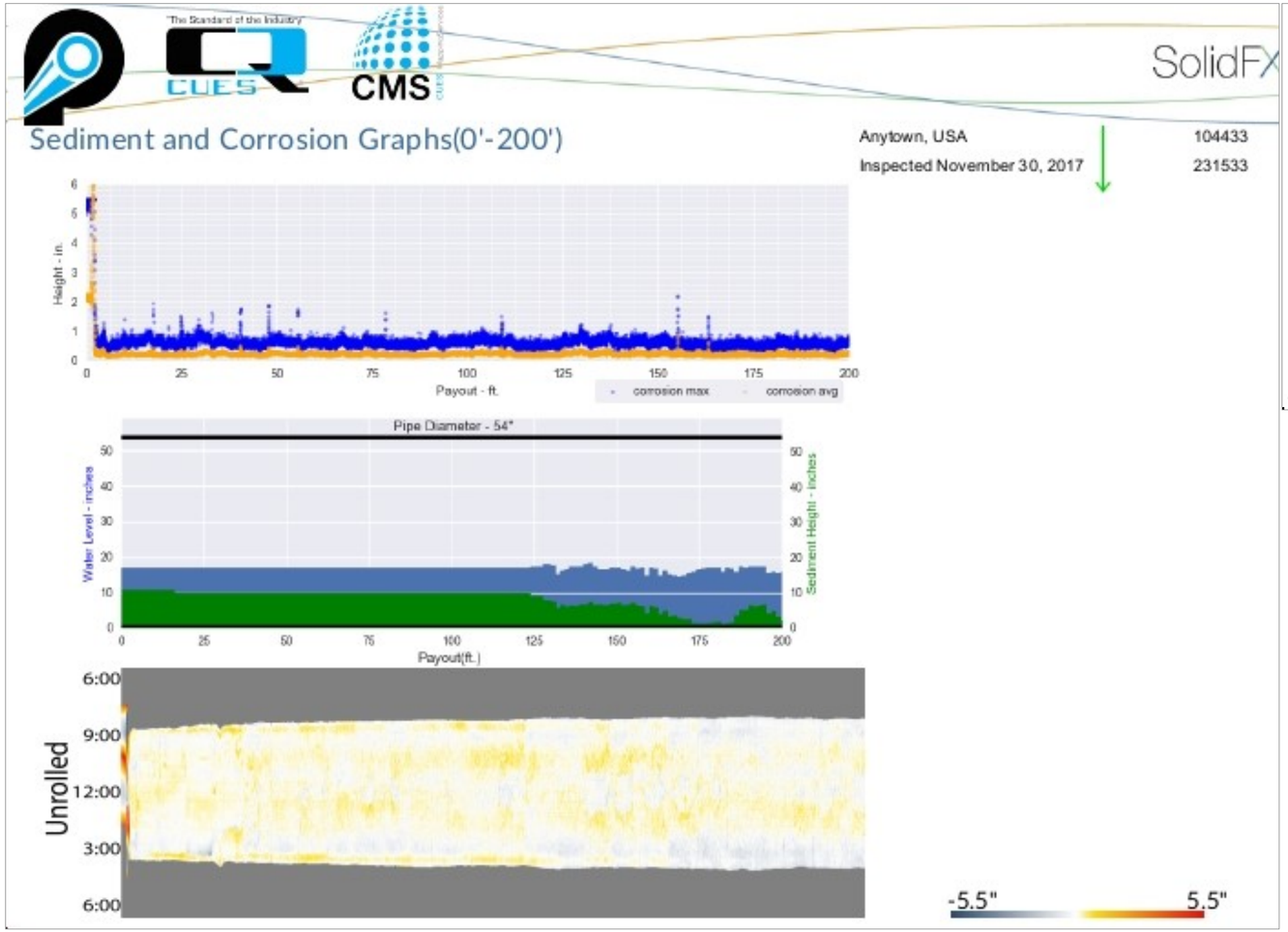
Sediment Volume (cubic yard):	10.1
As-is Capacity/As-built Capacity (%):	95.7
Average cross-sectional restriction (%):	4.3

Corrosion/Lidar Metrics

Corroded Volume (cubic in):	42126.5
Wall/As-built (%):	99.2
Average Wall Loss (%):	0.8

Table of Contents

SFX–Condition Assessment Report *(cont.)*



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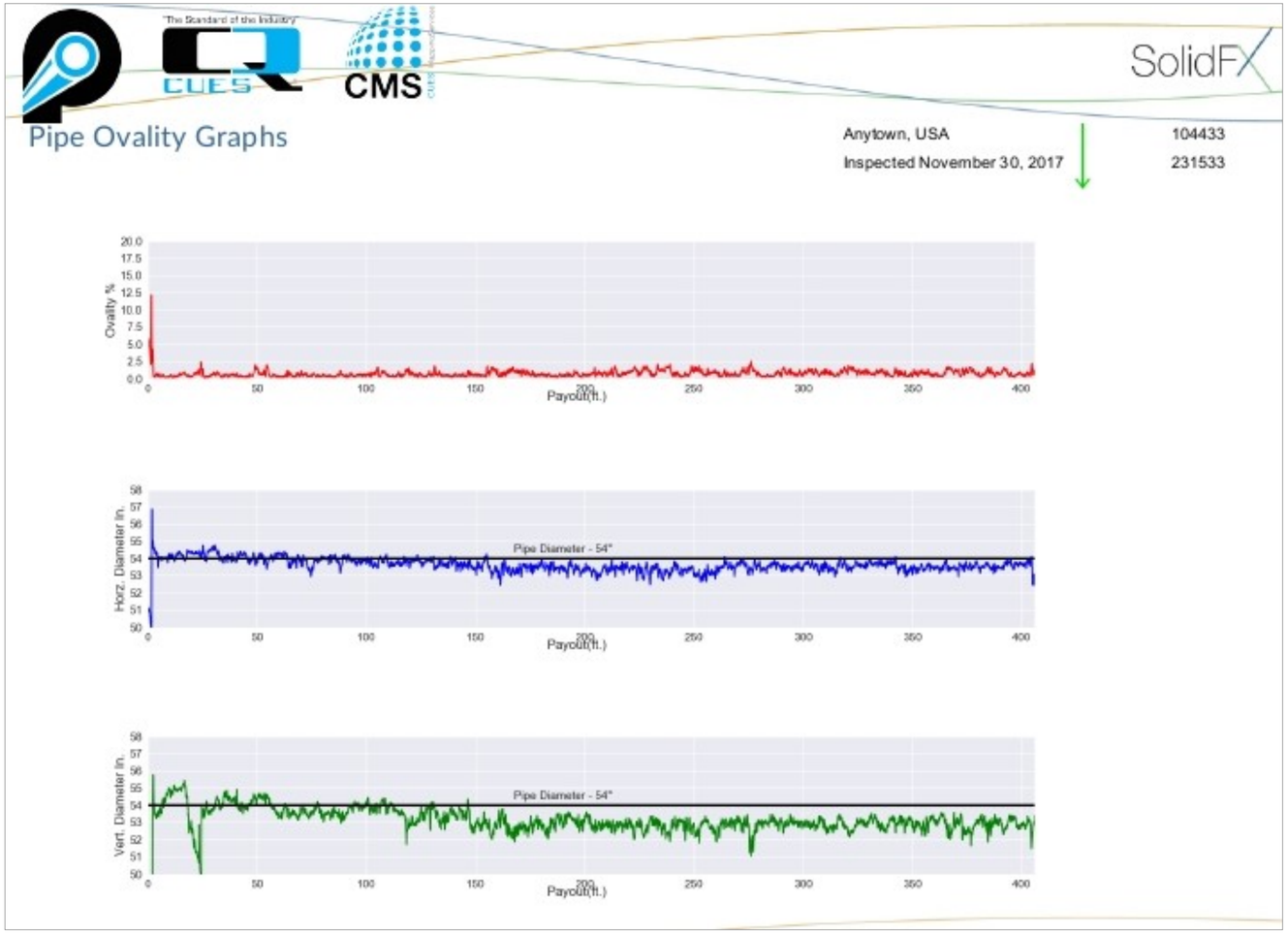
SFX–Condition Assessment Report *(cont.)*



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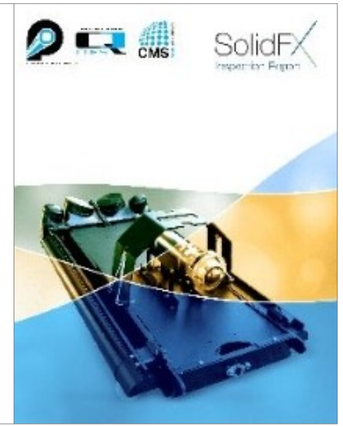

$$\text{Ovality} = \frac{(\text{Horizontal Diameter} - \text{Vertical Diameter})}{(\text{Horizontal Diameter} + \text{Vertical Diameter})}$$

Horizontal Diameter is width at maximum.
Vertical Diameter is 2 * Vertical Radius.
Vertical Radius is vertical distance from center of Horizontal Diameter to peak of circle

SFX–Condition Assessment Report *(cont.)*

The Standard of the Industry

CMS

SolidFX

Anytown, USA 104433

Inspected November 30, 2017 231533

Summary Table

Payout	Type	Note	Av. Corr.	3s Corr.	Max Corr.	Av. Buildup	Max Buildup	Sed. Max Ht.	Sed. Restriction %
0.0'	Start	Start of inspection	2.1"	4.5"	5.5"	0.9"	1.5"	10.8"	9.8%
40.5'	Material Loss	Material Loss at Joint	0.4"	1.3"	1.8"	0.2"	0.7"	10.0"	9.4%
47.8'	Material Loss	Material Loss at Joint	0.4"	1.3"	1.6"	0.2"	0.5"	10.0"	9.4%
50.0'	Regular Interval		0.3"	0.4"	0.7"	0.3"	0.8"	10.0"	9.4%
55.5'	Material Loss	Material Loss at Joint	0.5"	1.5"	1.8"	0.2"	0.6"	10.0"	9.4%
100.0'	Regular Interval		0.2"	0.4"	0.6"	0.3"	0.8"	10.0"	9.4%
145.7'	Sediment	Sediment (0-205 lf.)	0.3"	0.4"	0.8"	0.3"	0.9"	6.7"	5.9%
150.0'	Regular Interval		0.3"	0.5"	0.7"	0.3"	0.9"	7.2"	7.3%
155.0'	Material Loss	Material Loss at Joint	0.7"	1.8"	2.2"	0.4"	1.4"	7.2"	7.5%
200.0'	Regular Interval		0.3"	0.5"	0.8"	0.3"	0.9"	2.2"	1.2%

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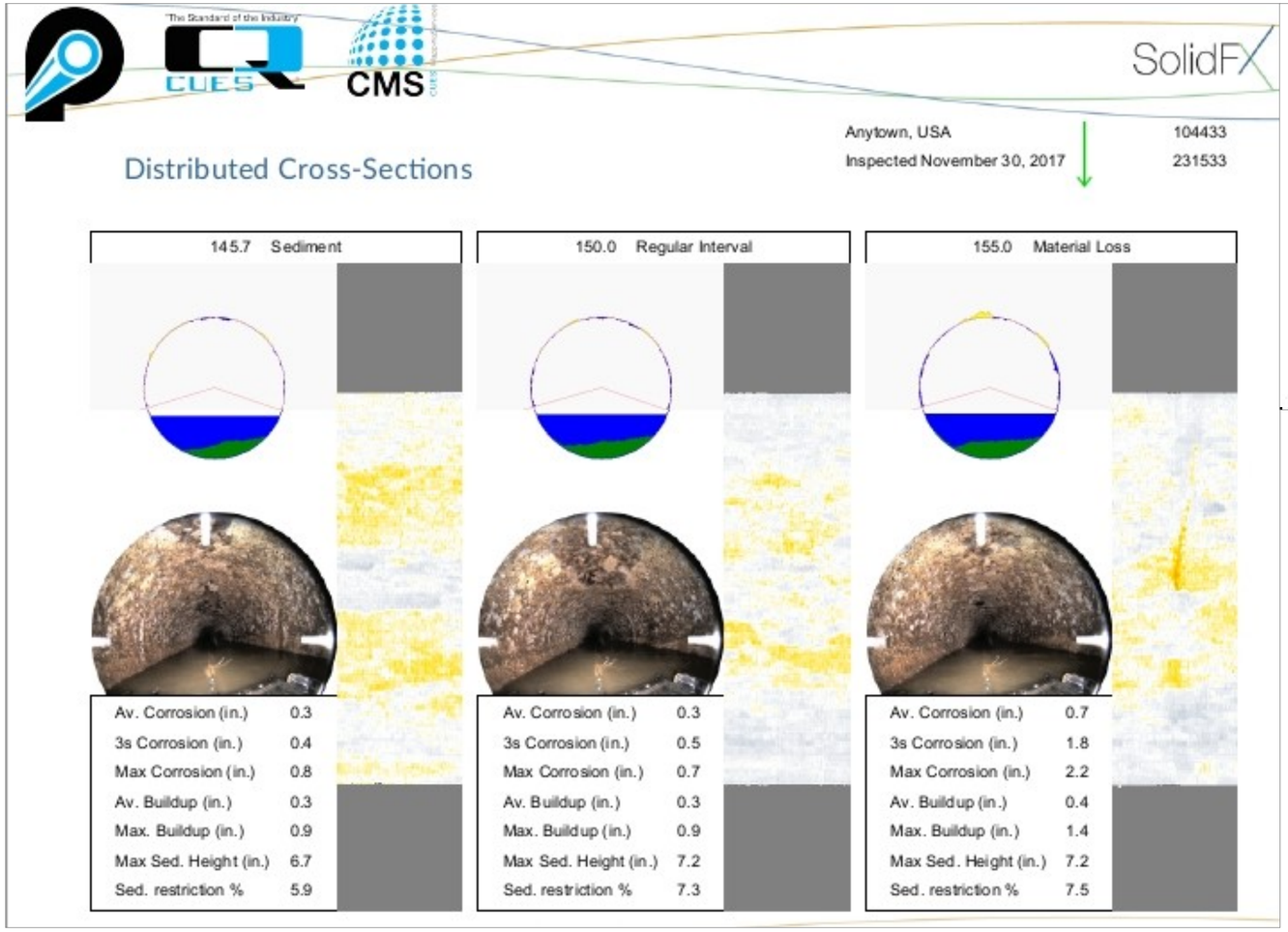
SFX–Condition Assessment Report *(cont.)*



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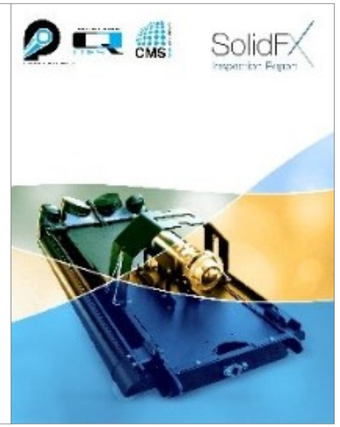
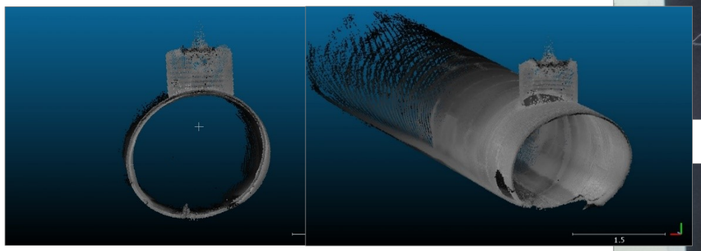
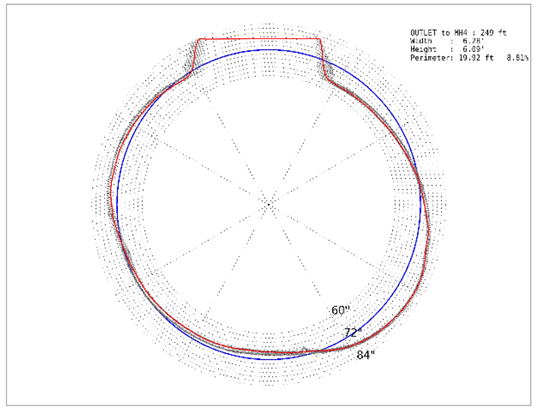


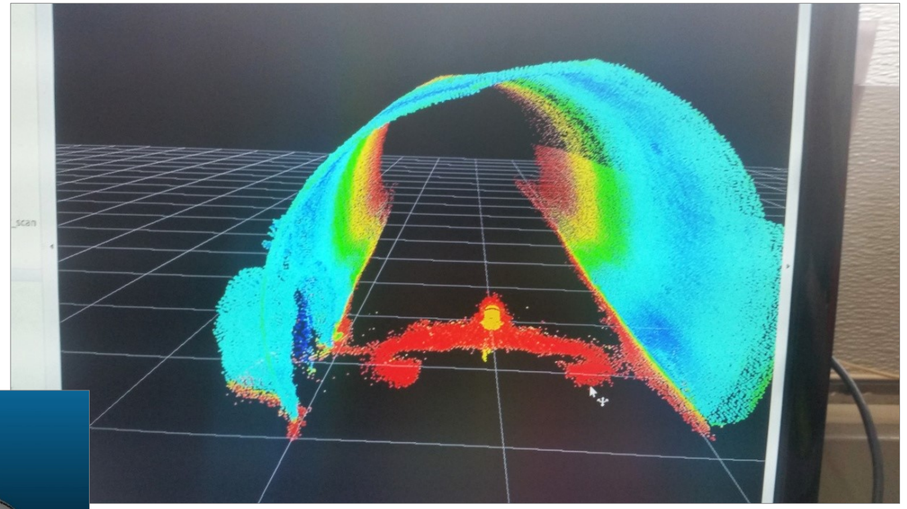
SFX–3D
Multi-Sensor Inspection

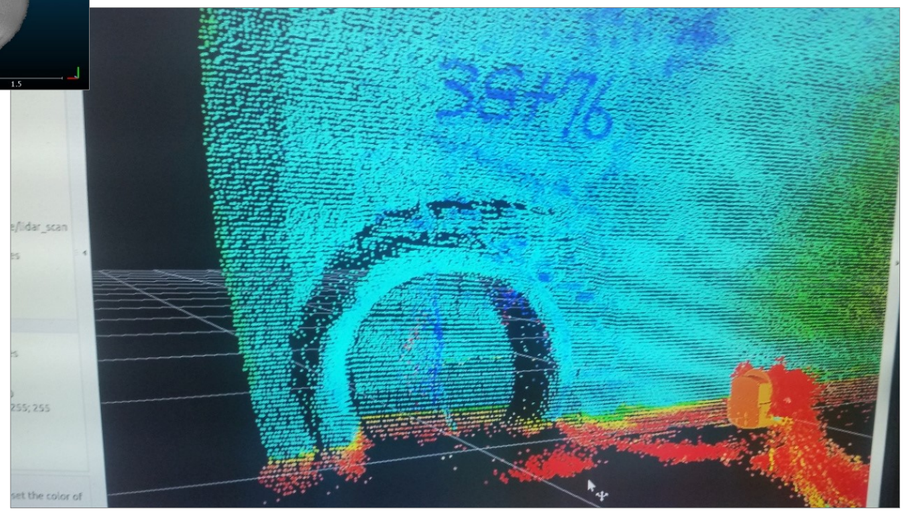
SFX–3D

Condition Assessment Rehab Planning Geo-Location





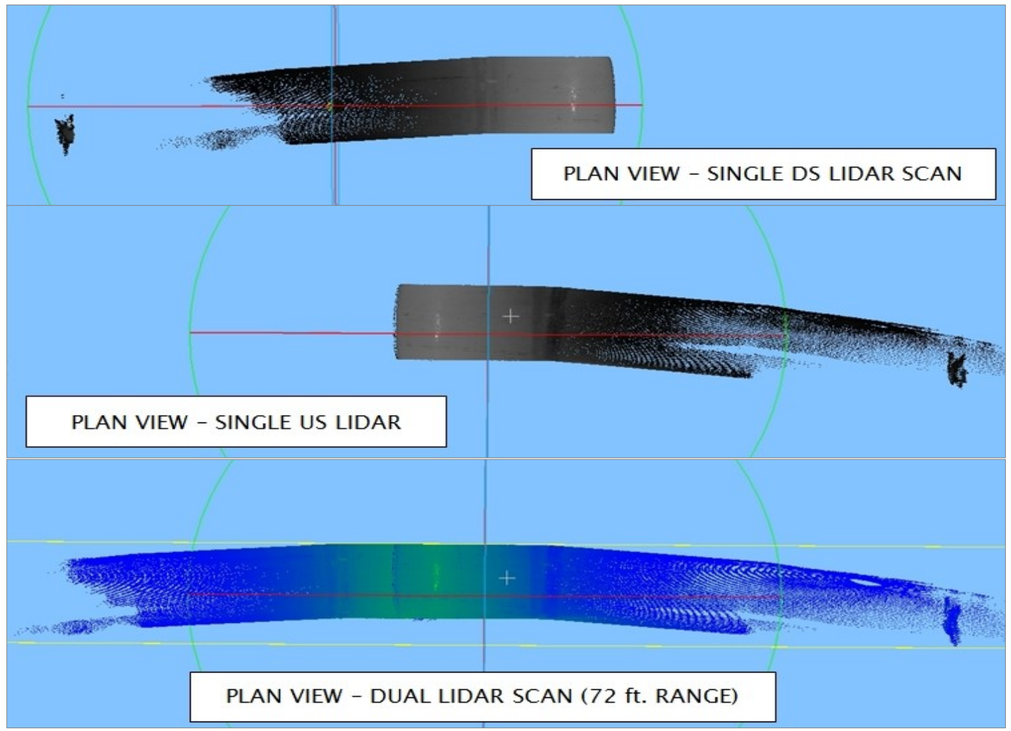




Dual LIDAR Technology

Combine Data From Two Sensors

One SCAN Covers 40–70 Feet



DUAL LIDAR Technology

Longer Point Cloud
More Accurate Measurements

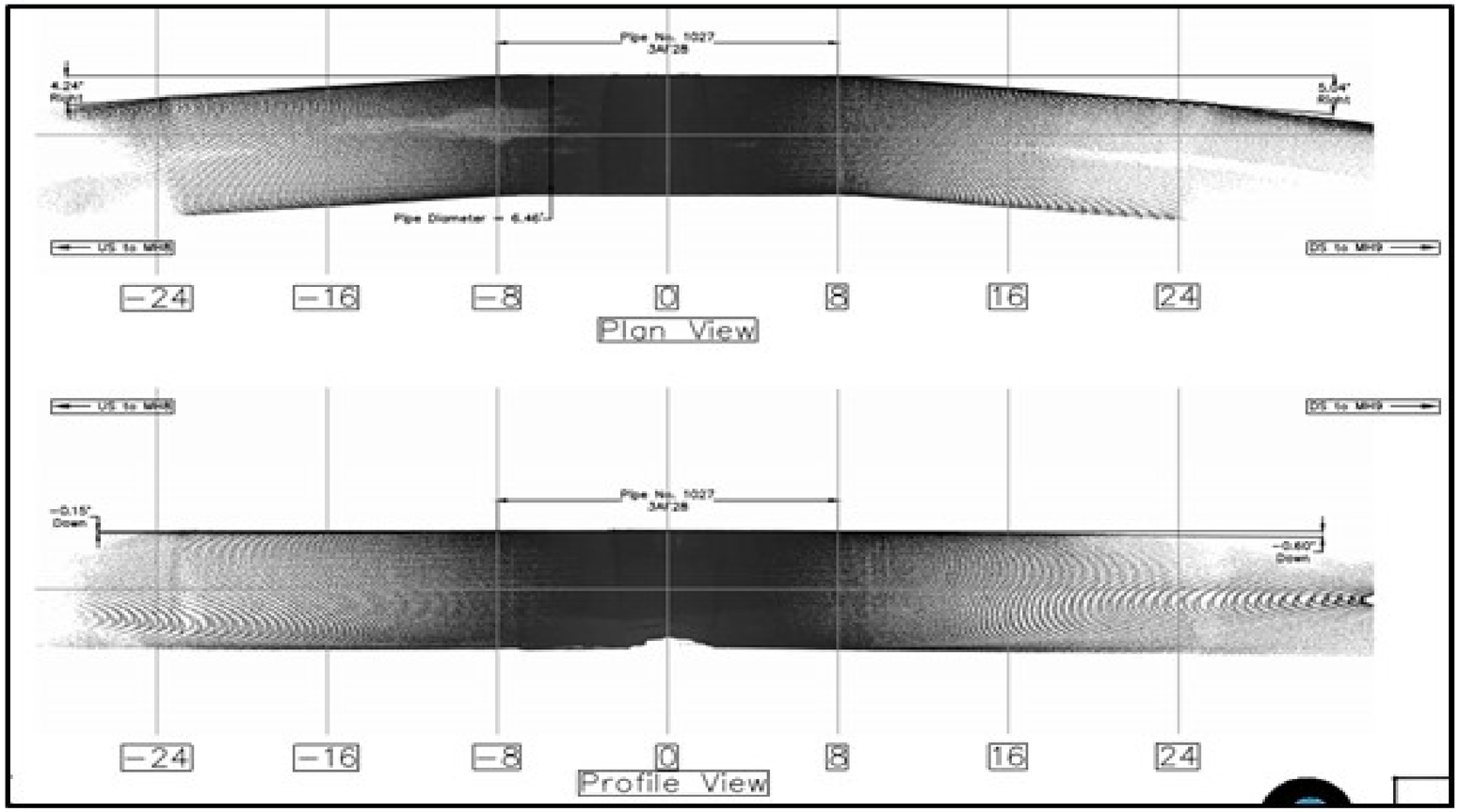


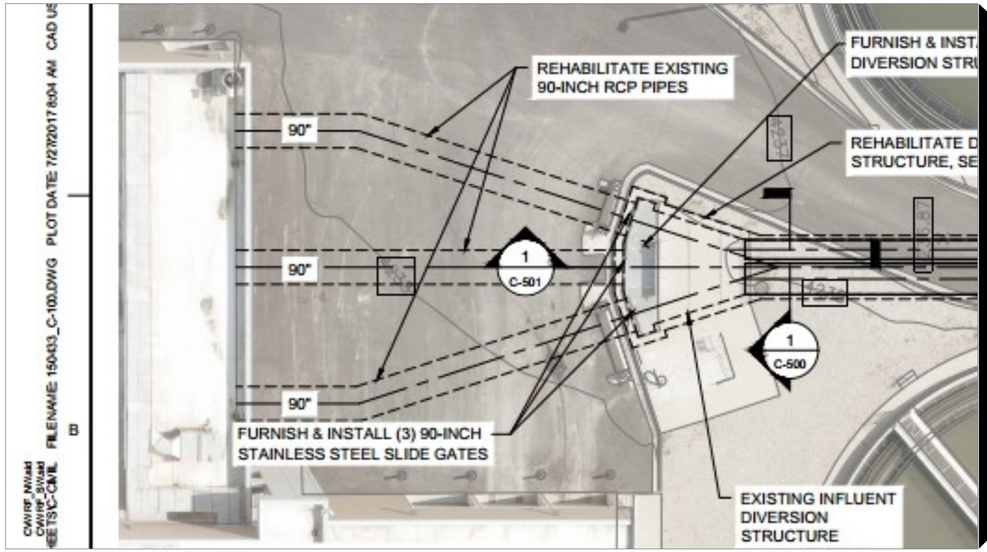
FIGURE 14: CAD ANGLES MEASURED @ 3AF28 [1027]

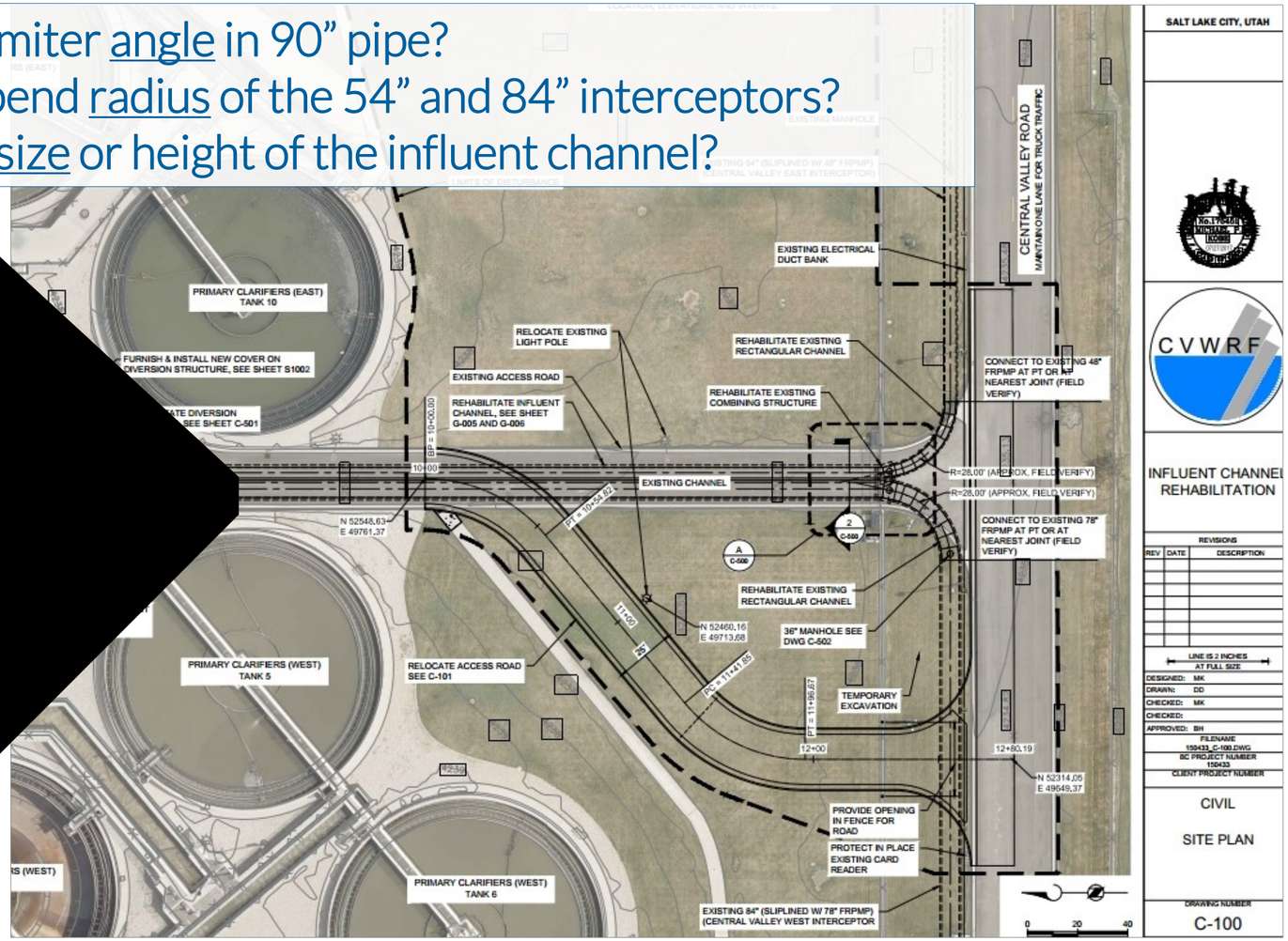
Salt Lake, UT

Influent Structure Rehab

Size and Bend Analysis

What is the miter angle in 90” pipe?
Wait is the bend radius of the 54” and 84” interceptors?
What is the size or height of the influent channel?



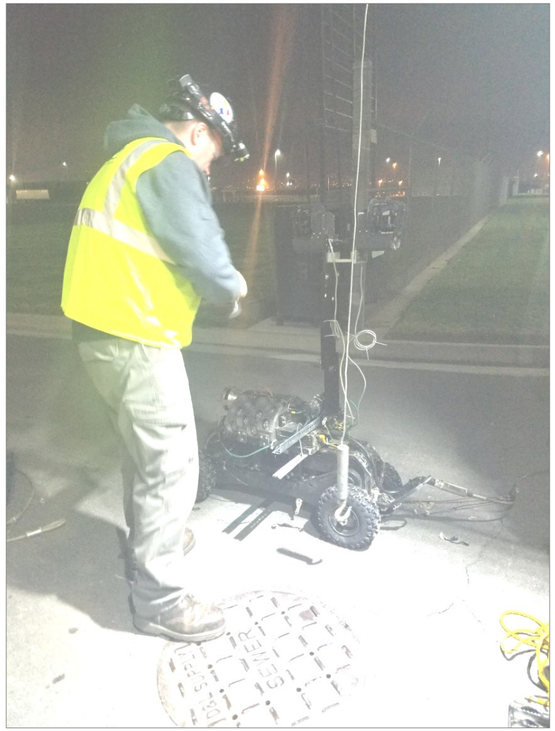


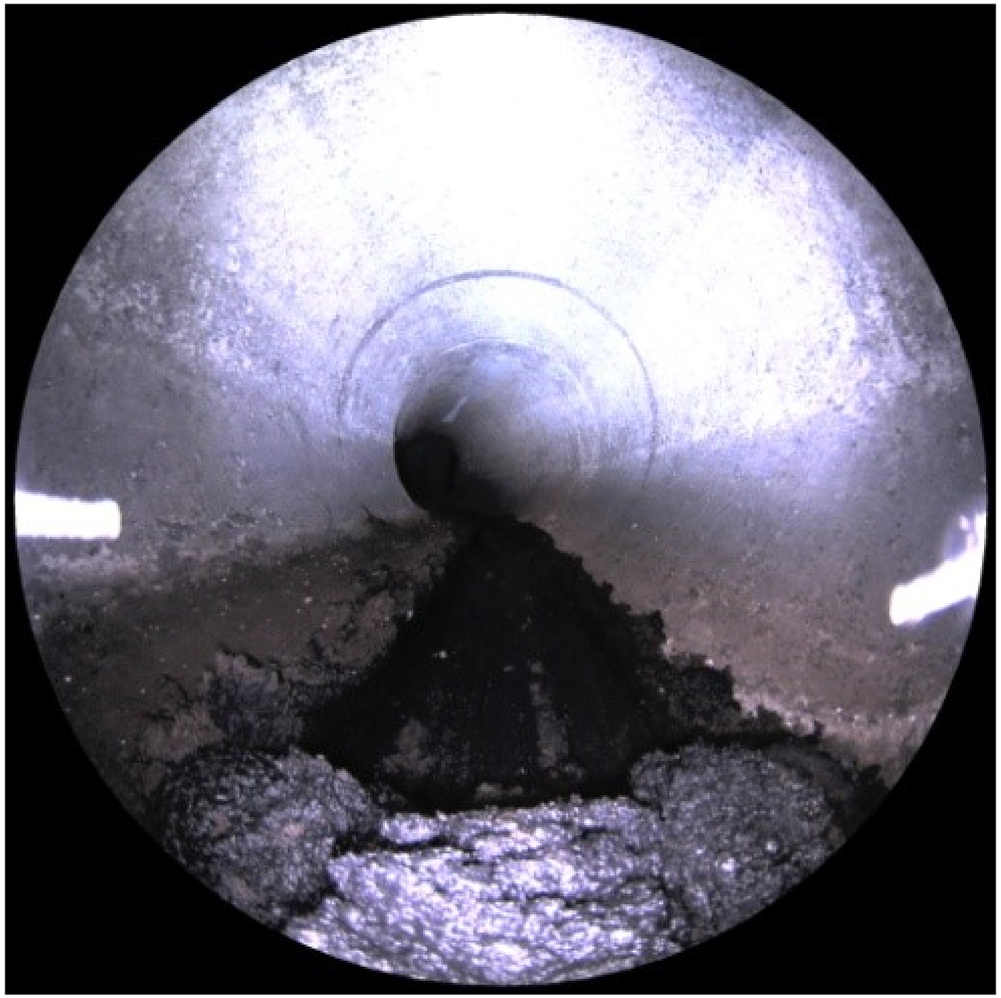
Salt Lake, UT *(cont.)*

Influent Structure Rehab

SMM Setup

90” Diversion Pipe



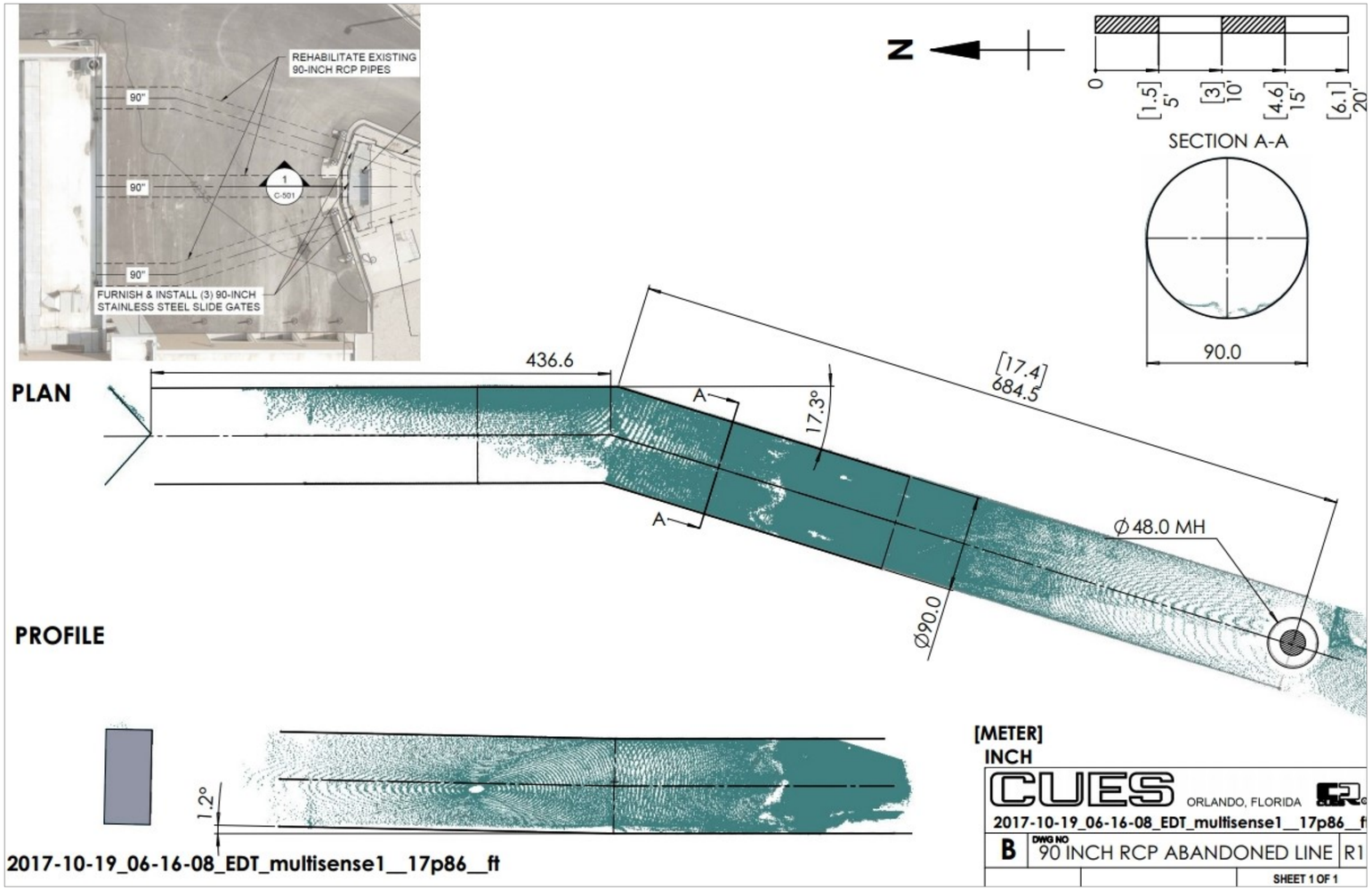


Salt Lake, UT *(cont.)*

Influent Structure Rehab

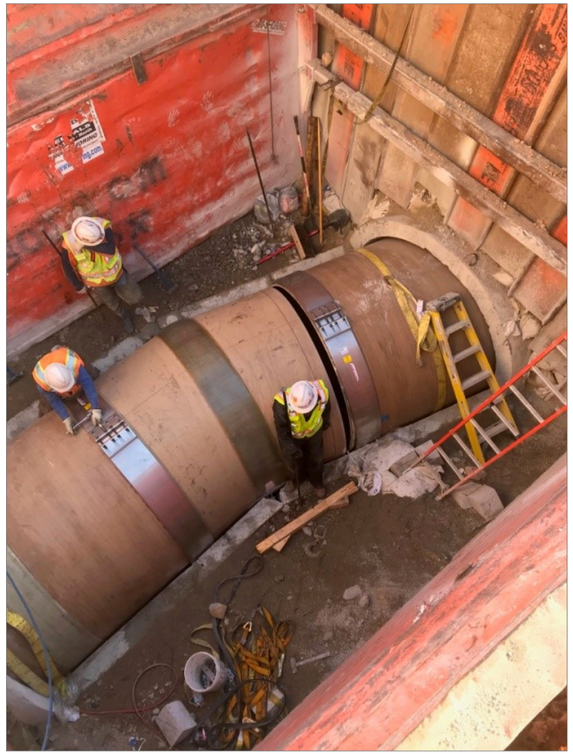
90” Diversion Pipe

CAD Drawing



Salt Lake, UT *(cont.)*

Influent Structure Rehab
Custom Liner Installation

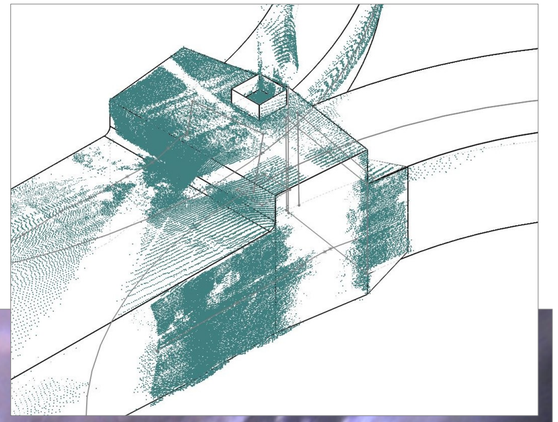


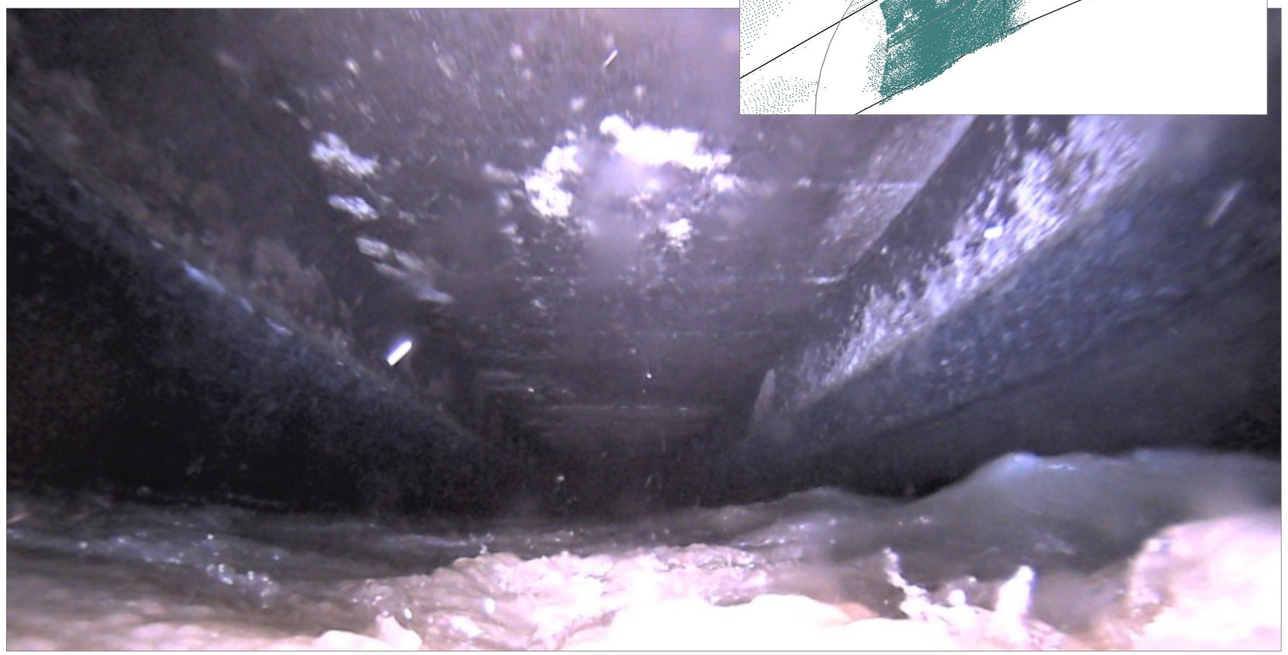
Salt Lake, UT *(cont.)*

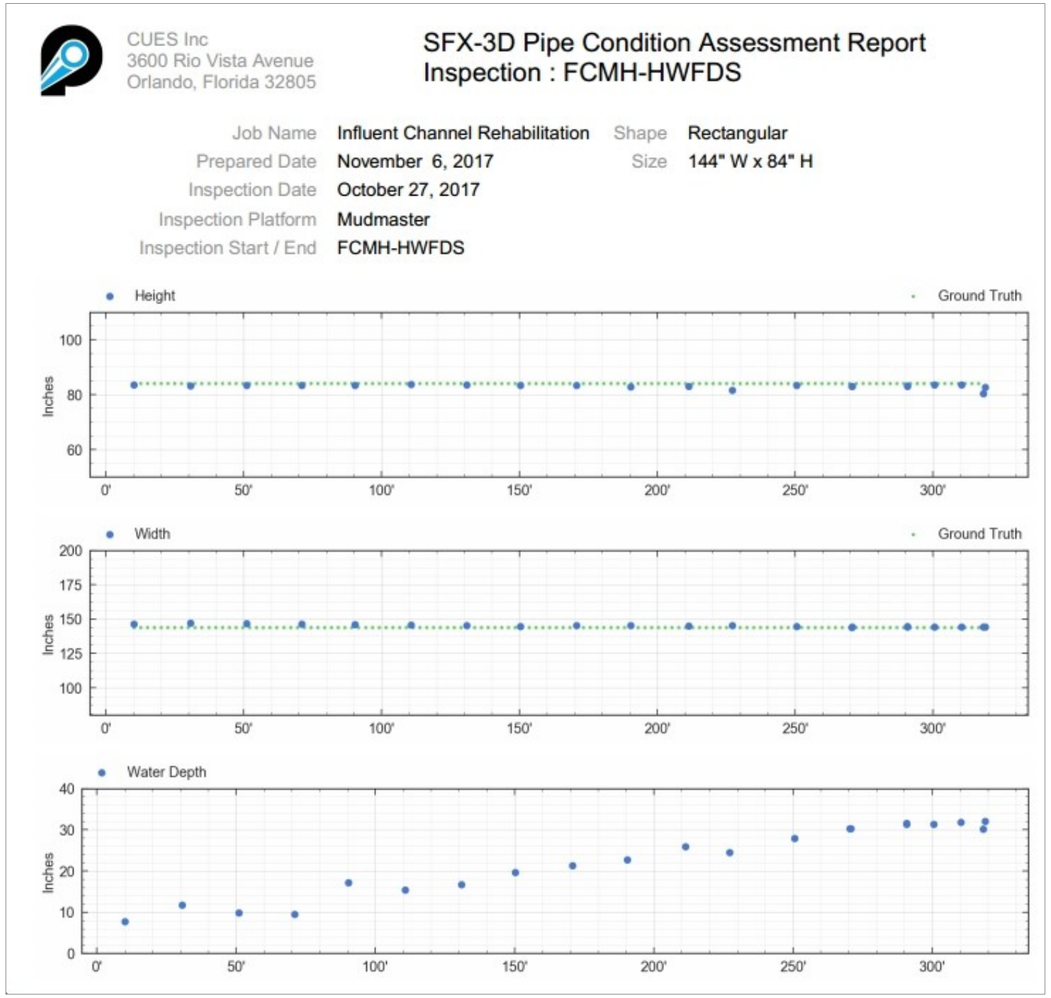
Influent Structure Rehab

Influent Channel Size?

Does the height change?



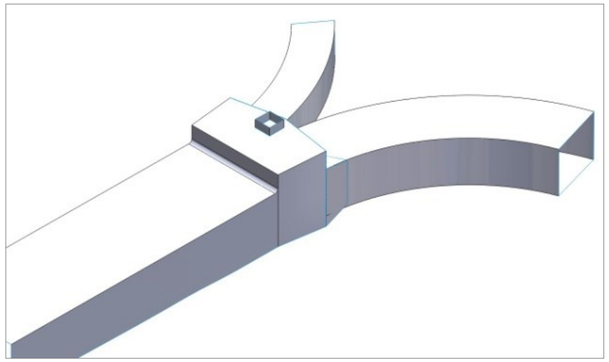


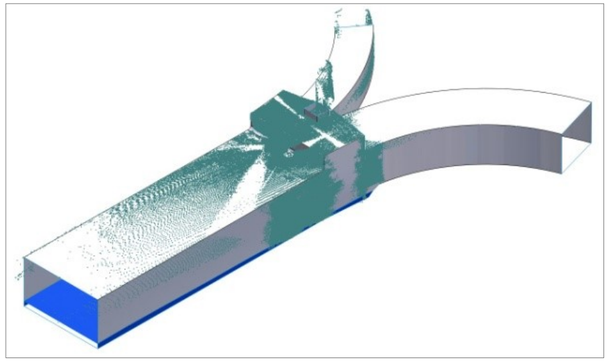


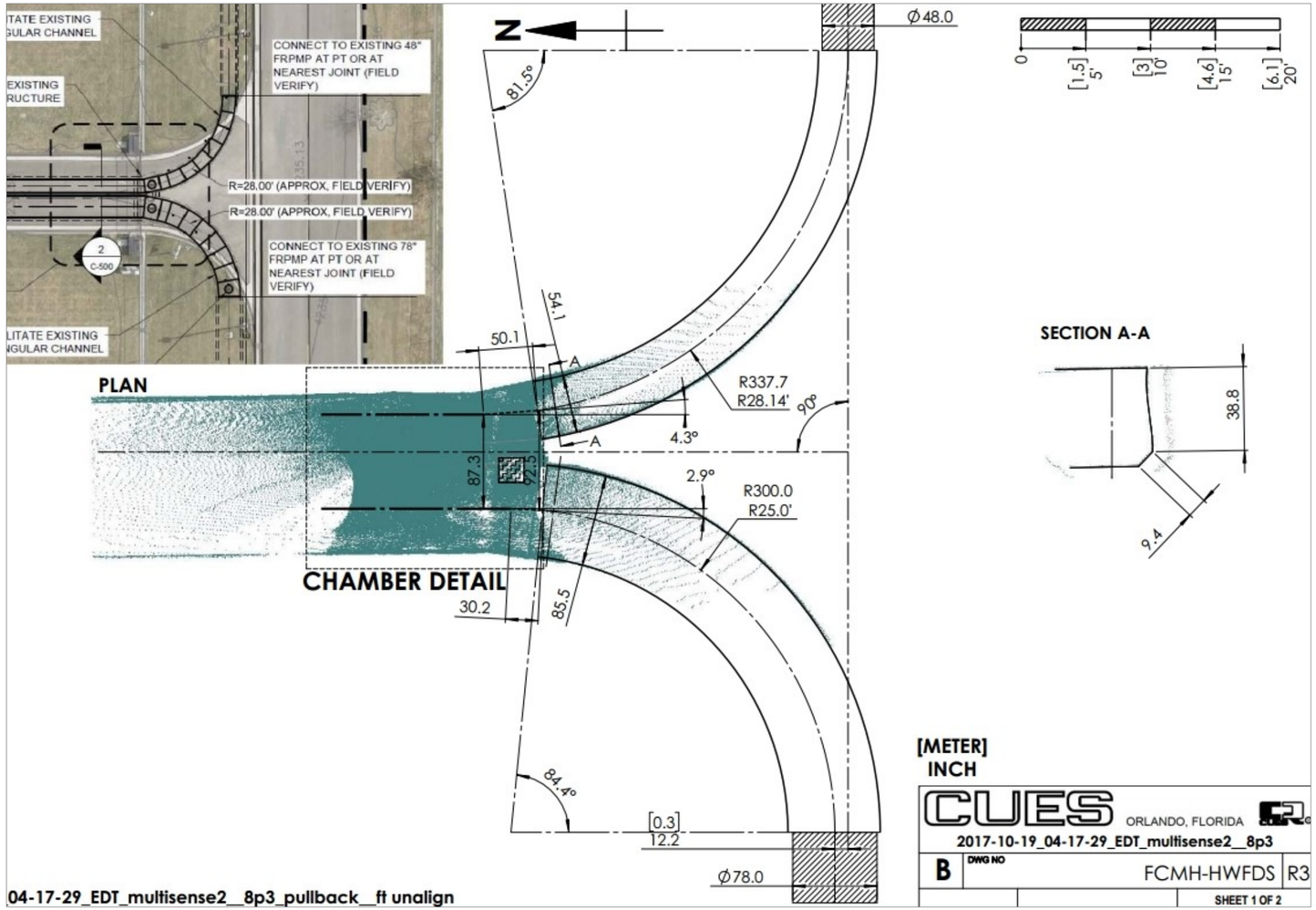
Salt Lake, UT *(cont.)*

Influent Structure Rehab

Combining Structure – Radii?

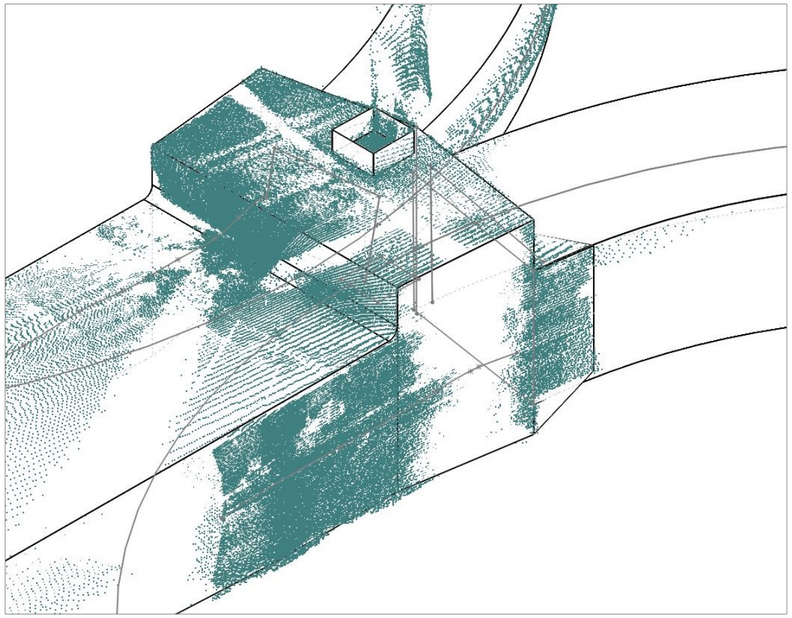


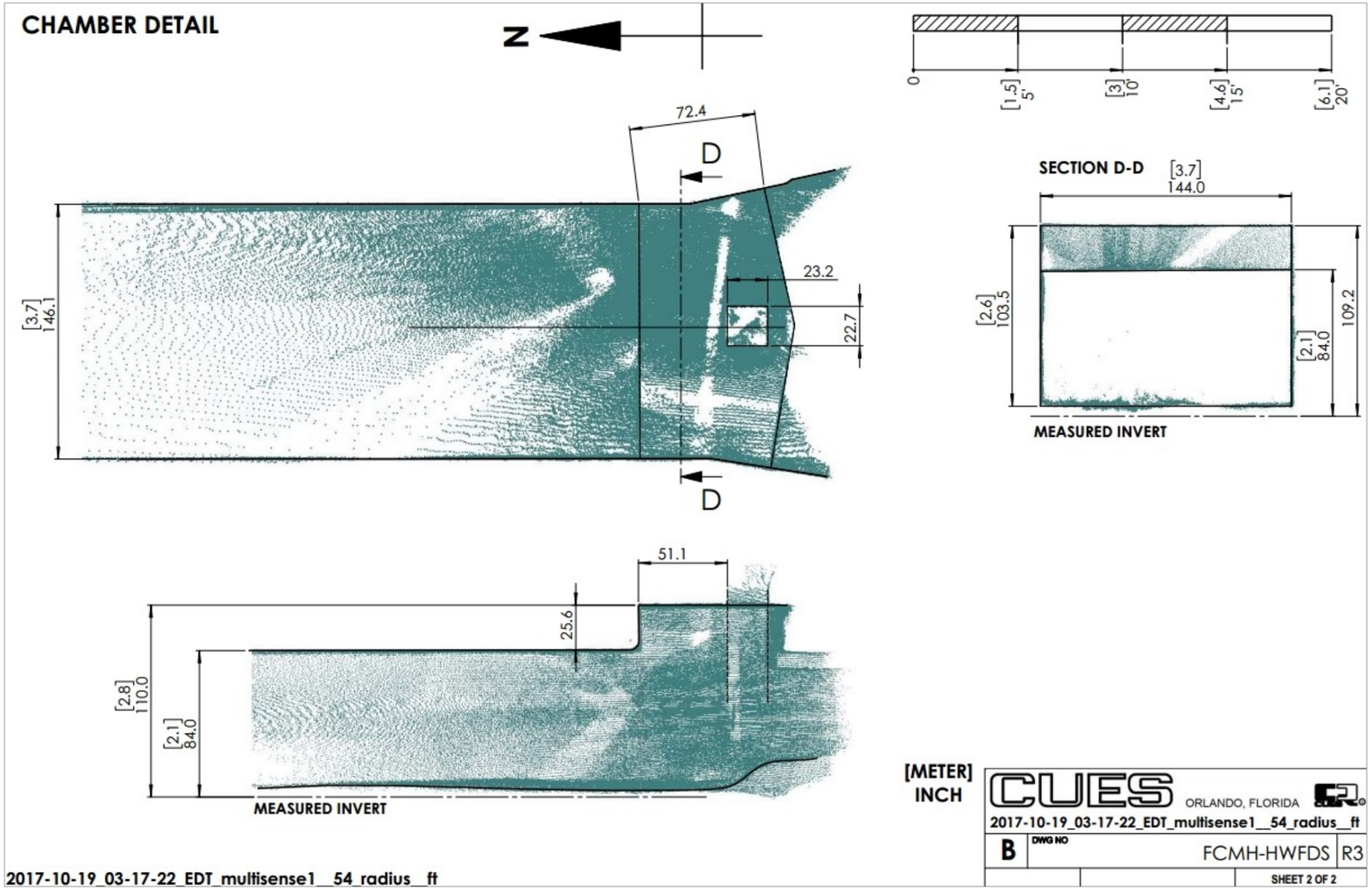




Salt Lake, UT *(cont.)*

Influent Structure Rehab
Chamber Detail



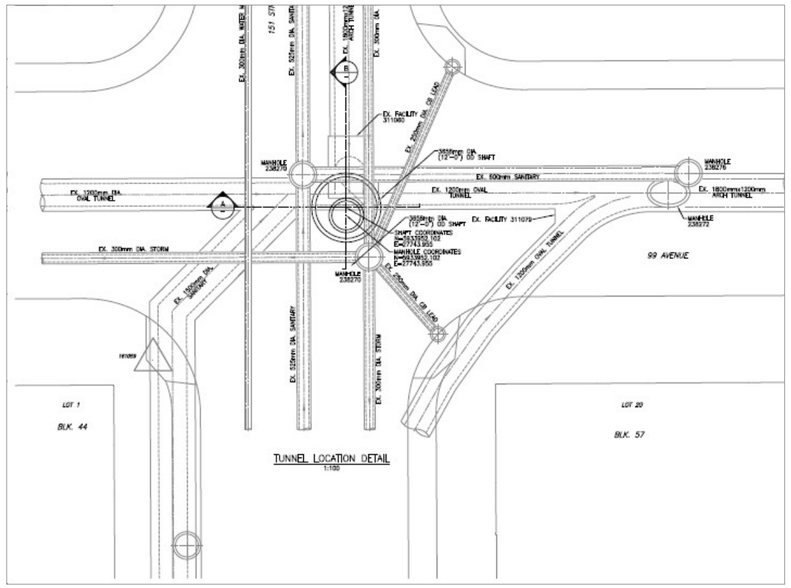


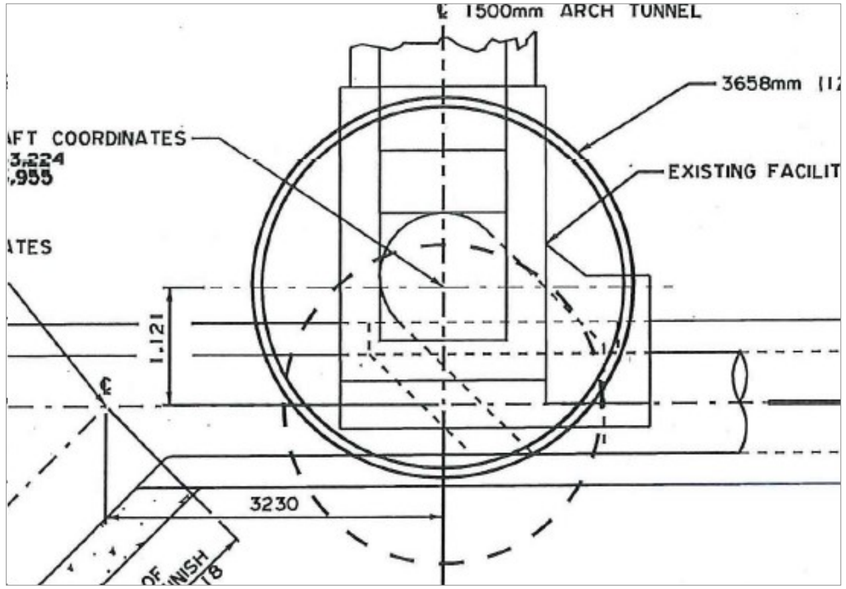
Edmonton Alberta, CA

Drill and Rehab Project

Geo Location & Cross Section Report

- What is smallest cross section of the E-W tunnel?
- Where should be dig our 10’ diameter, 100 ft. deep rehab/maintenance shaft?





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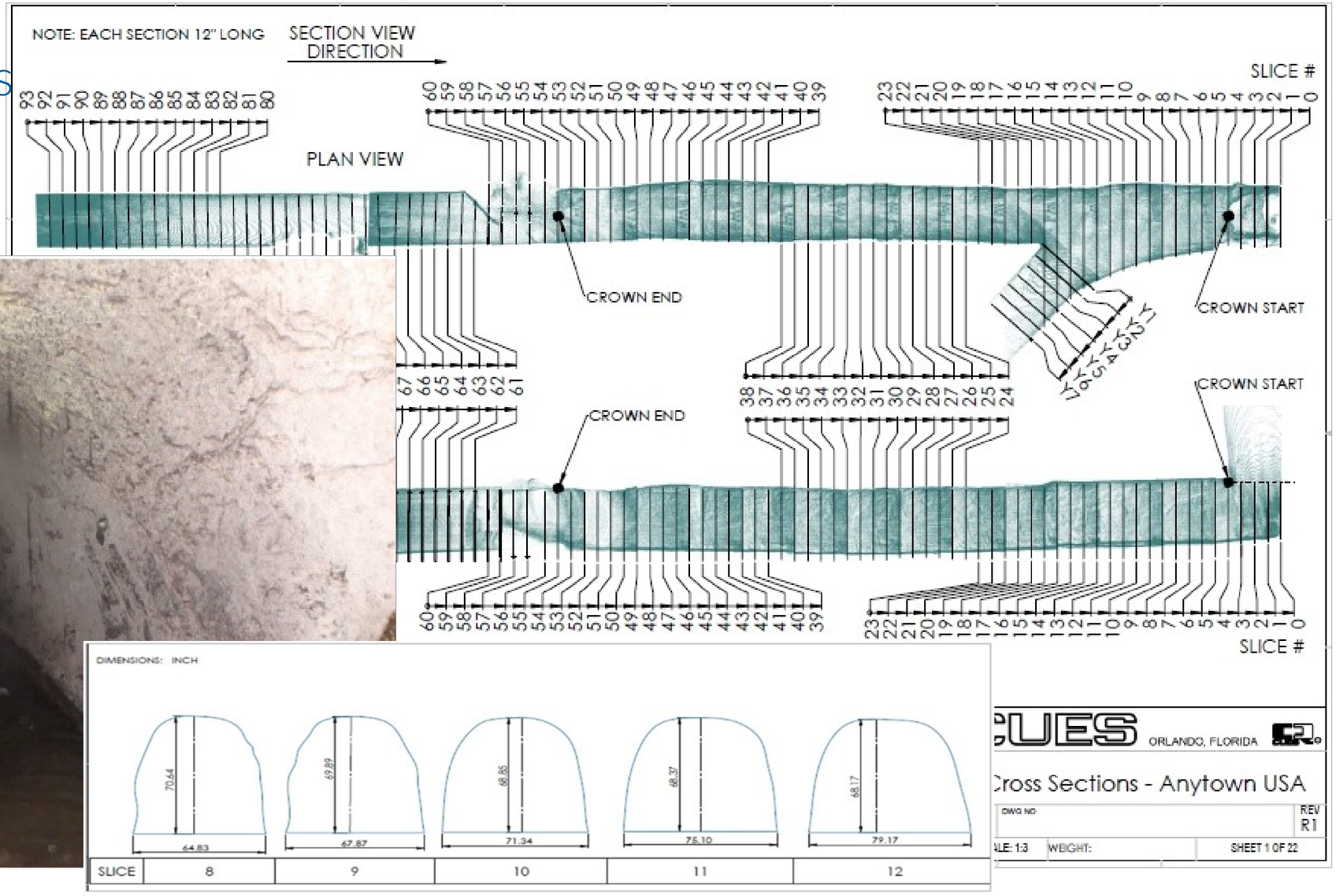
Drill and Rehab Project

Deliverable -Cross Sections

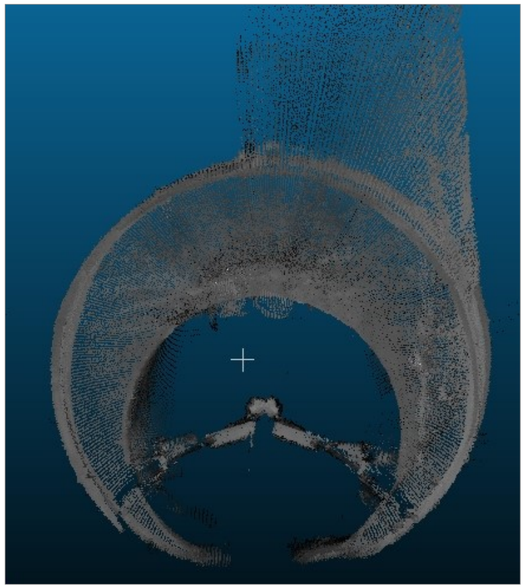


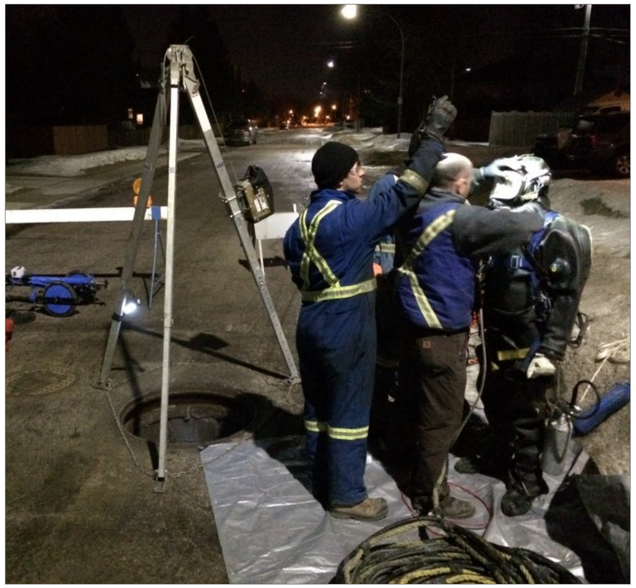
Edmonton Alberta, CA *(cont.)*

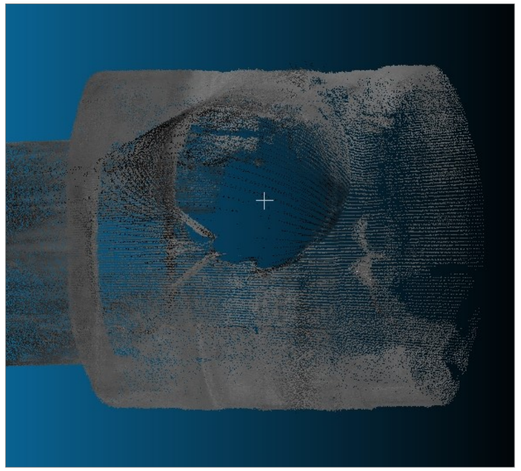
Drill and Rehab Project

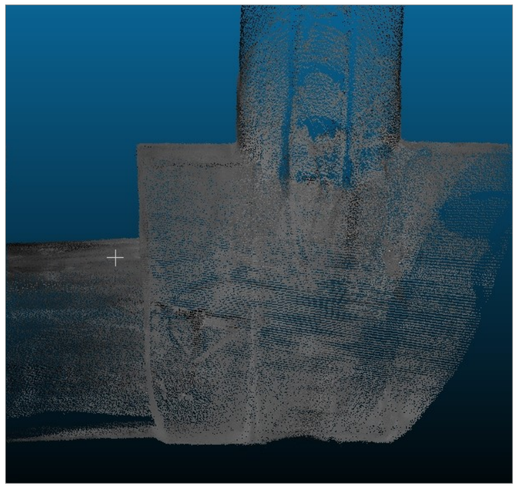
Deployment Into N–S Bypass Pipe

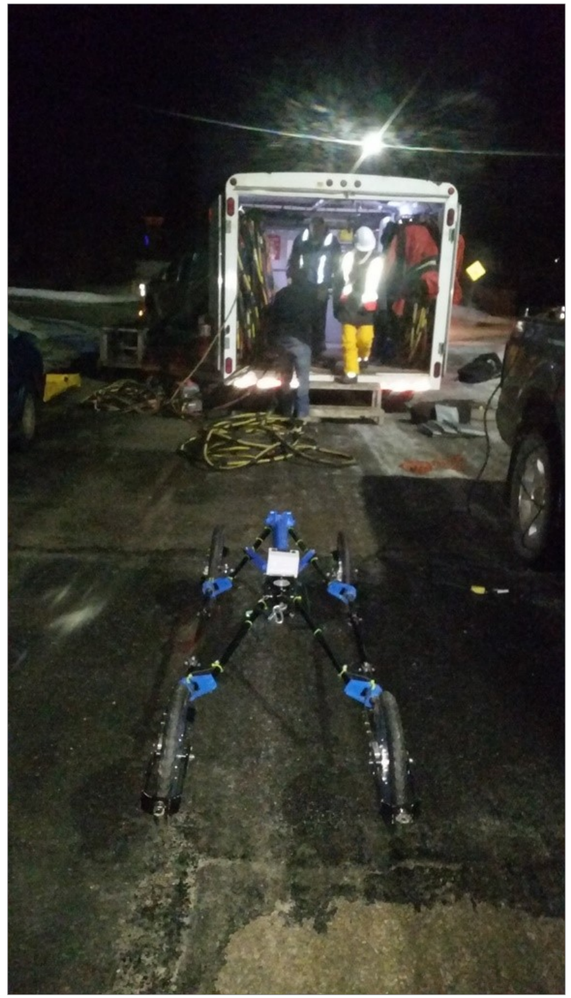
Scans At Bottom of 100’ Deep MH









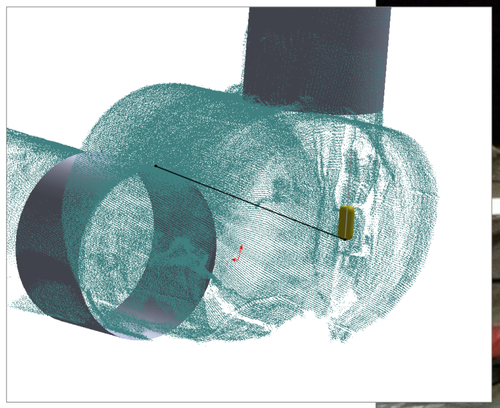


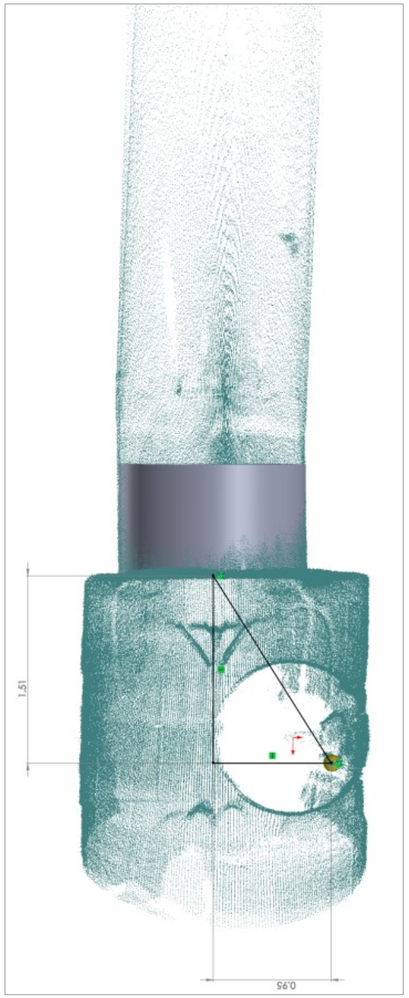
Edmonton Alberta, CA *(cont.)*

Drill and Rehab Project

Offset MH

- Drop plumb line
- GPS coordinate transfer



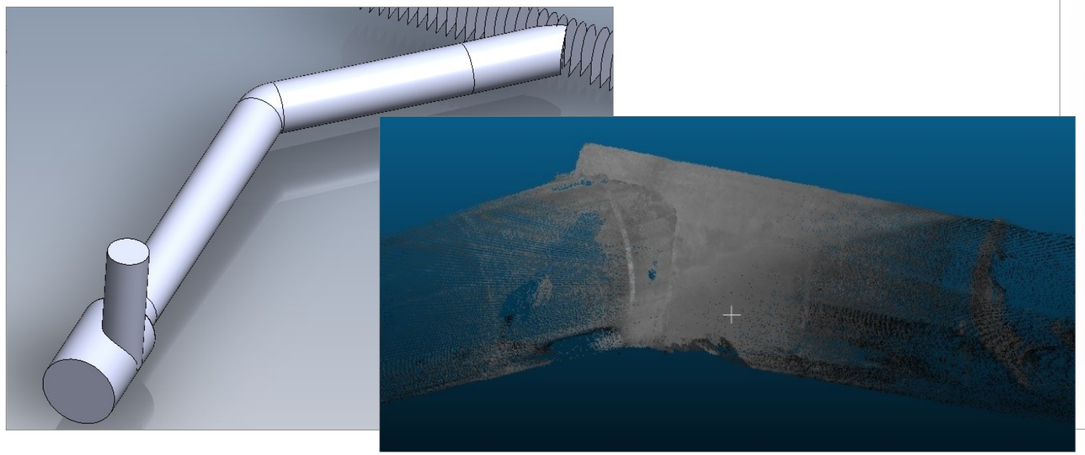


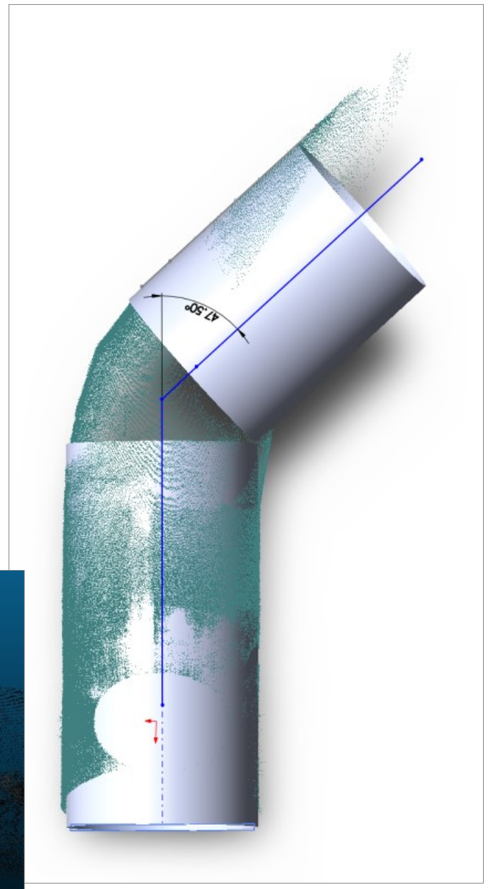
Edmonton Alberta, CA *(cont.)*

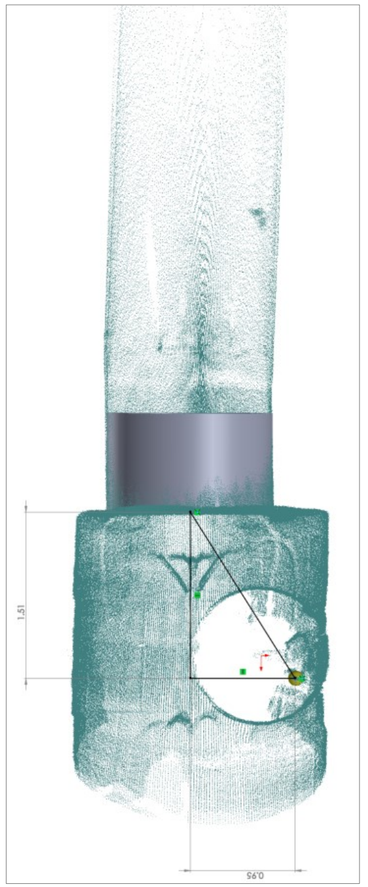
Drill and Rehab Project

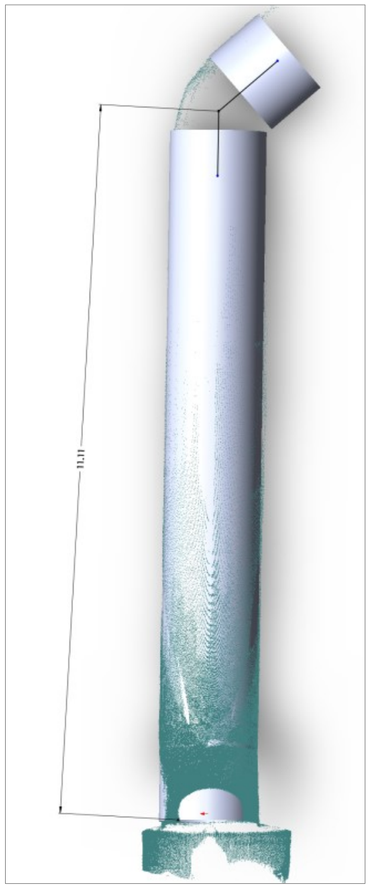
N-S Bypass Pipe – Bend Analysis

- Import point clouds into CAD
- Define pipe wall and CL
- Measure angles
- Update 3D model









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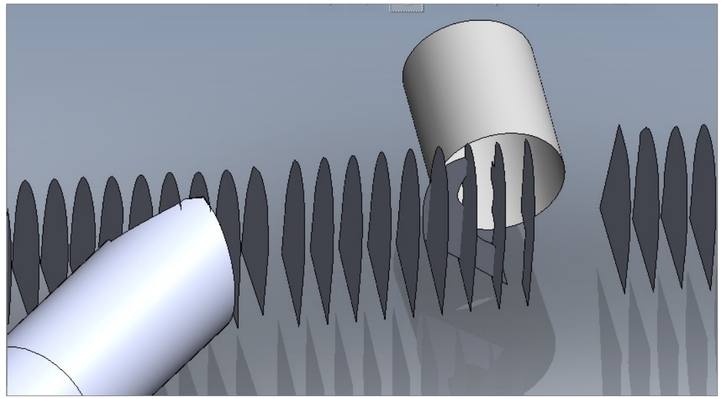
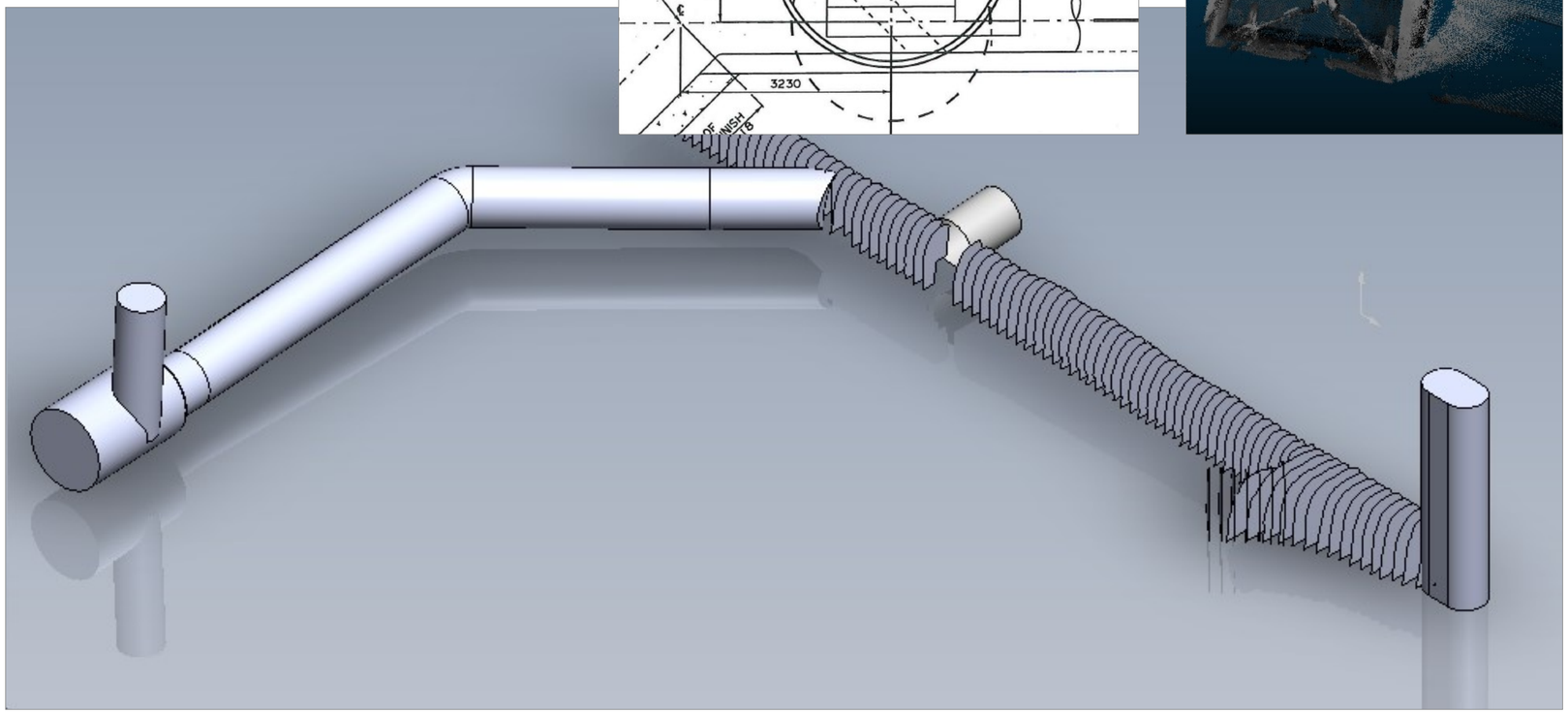
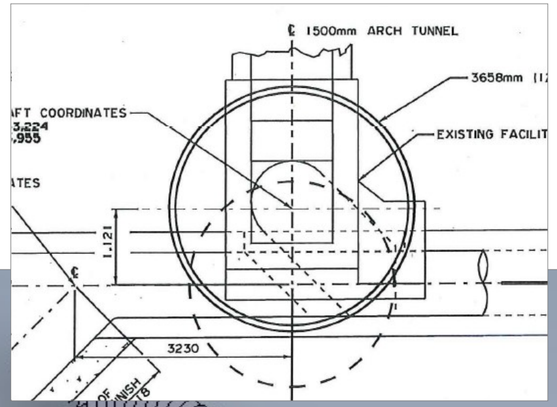
Drill and Rehab Project

Tie The Pipe And Tunnel Together







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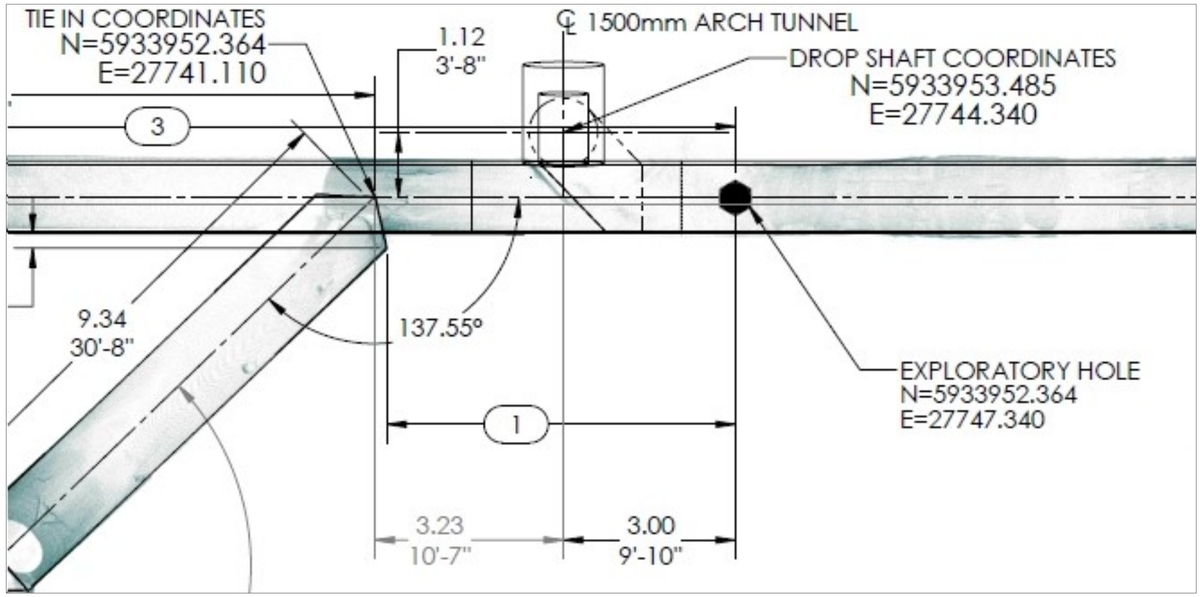
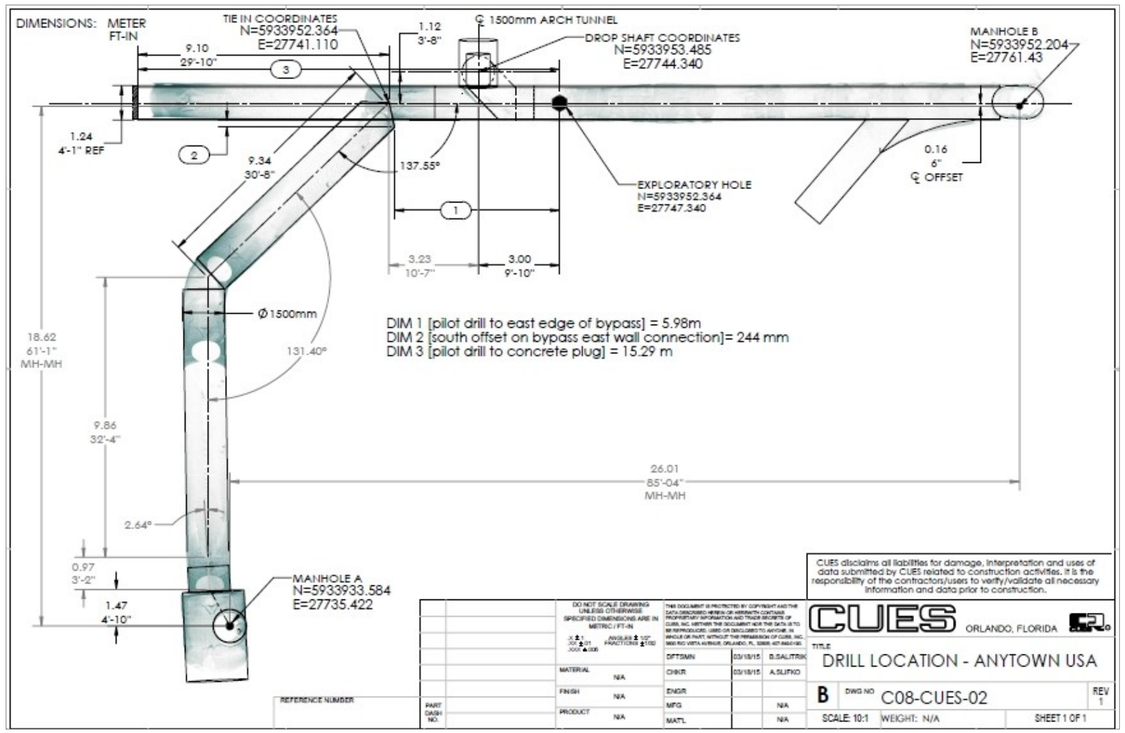
Drill and Rehab Project

Deliverable – Access Shaft Dig Coordinates





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Drill and Rehab Project

Results – Exploratory Hole For Shaft

- String line to South wall – 500mm
- String line to North wall – 490 mm