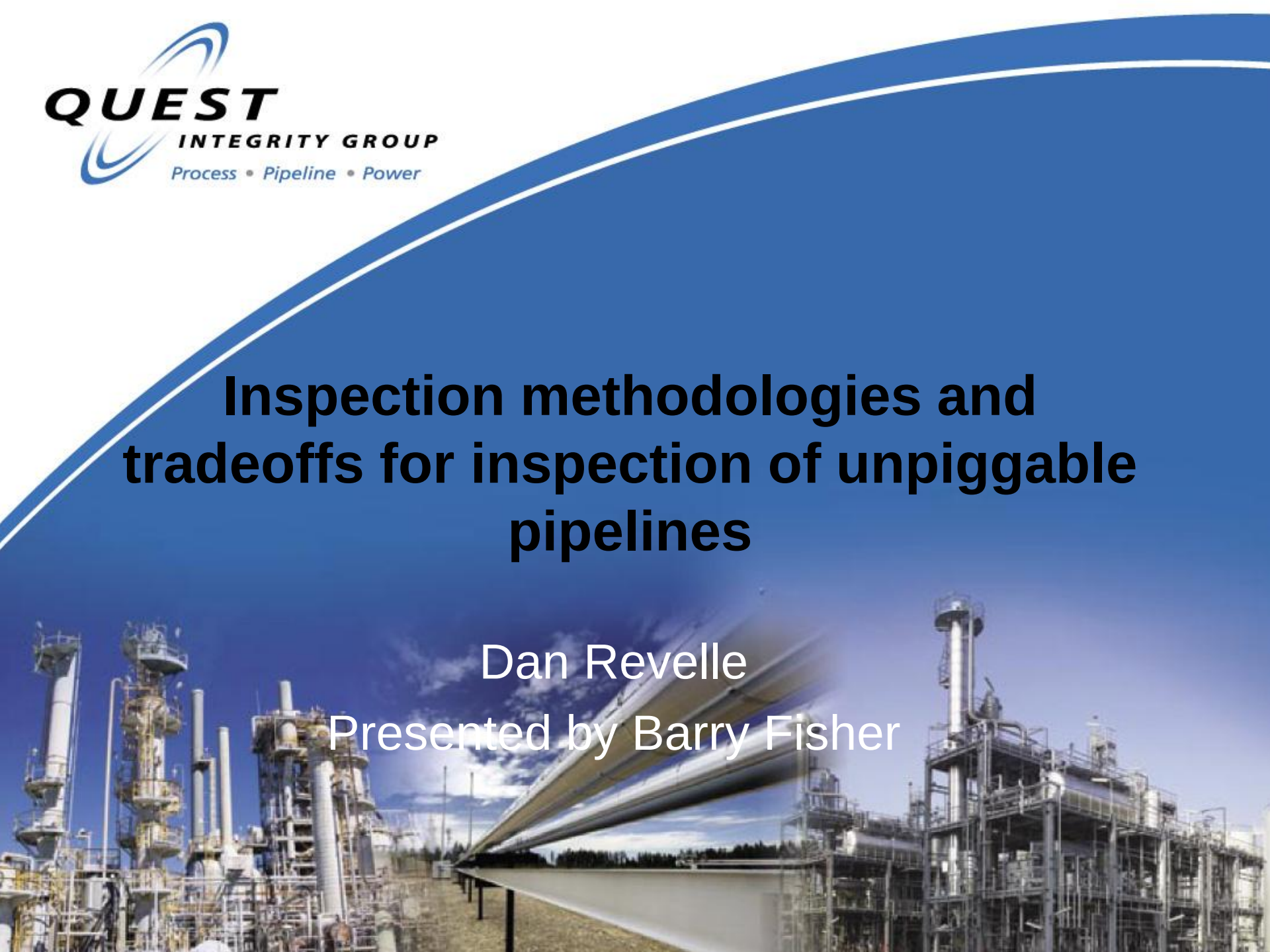
QUEST INTEGRITY GROUP
Process • Pipeline • Power

Inspection methodologies and tradeoffs for inspection of unpiggable pipelines

Dan Revelle
Presented by Barry Fisher



Overview

- Unpiggable Pipelines and Inspection Options
- Inspection Considerations
- Importance of Data Quality
- Case Studies

Unpiggable Pipelines[1]

- Small Diameter
- Bore Restrictions
- Small Radius Bends
- Back-to-Back Bends
- Mitered bends
- Unbarred Tees
- Y Connections
- Diameter Changes
- No Launcher or Receiver
- Steep and Vertical Sections
- Thick or Thin Walled Pipe
- Deadlegs, crossovers and laterals

[1]*Unpiggable Pipelines* presented by Shie, Koch and Bubenik at PPIM 2010

Unpiggable Options

- Direct Assessment (includes guided wave and localized UT)
  - Guided wave is a screening tool with limited range. Not suitable for assessment of defects that exist in the line.
  - In-line inspection can gather many more readings and localized UT or other point measurements.
- Hydrostatic Testing
  - Achieves regulatory compliance, but does not assess features are not at pressure failure threshold.
    - Pinhole leaks
    - Dents, gouges, blisters, sloping laminations
    - Defects with burst pressures above hydrotest pressure
- Modifying Line
  - Still have to run inspection.
  - Integrity management program still benefits from high resolution dataset.

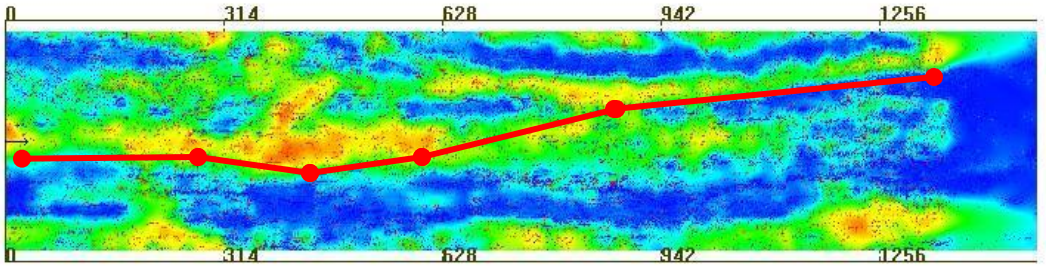
Ease of Inspection

- How to get the best assessment of the integrity of the pipeline?
- Evaluate entire project
  - Line modifications and setup
  - Operational complexity during inspection
    - Launch, receive, pumping requirements, HS&E
  - Which anomalies are and are not detectable
  - Inspection data validation
  - Precision and detail of pipeline features
  - Timing and flexibility of entire process
    - Does action need to be taken while the pipeline is out of service?

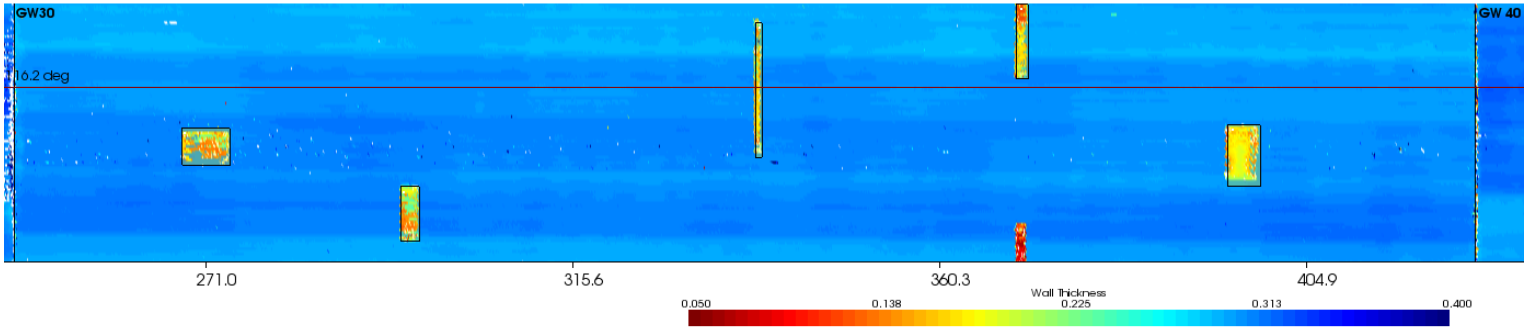
High Resolution Data Set

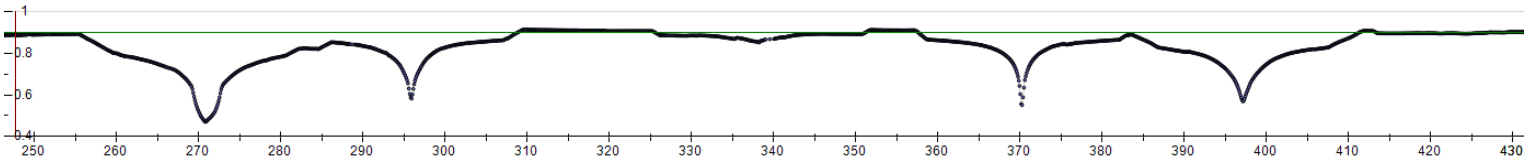
Integrated Level 2 assessment for maximum utilization of high resolution ultrasonic dataset

- Ultrasonic data is very well suited to Level 2 effective area assessment
- Can run an automated effective area assessment independent of any flaw boxing
- Does not reduce a complex corrosion area to just the two parameters of depth and length.



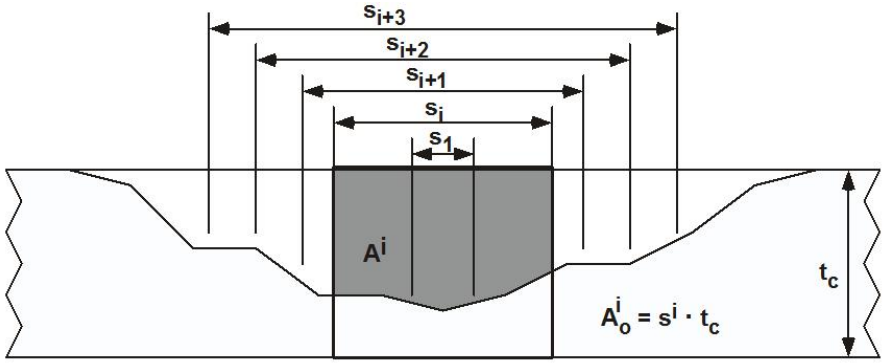
Measured Wall Thickness





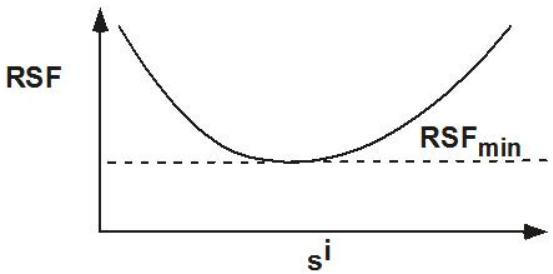
Calculated Remaining Strength Factor (RSF)

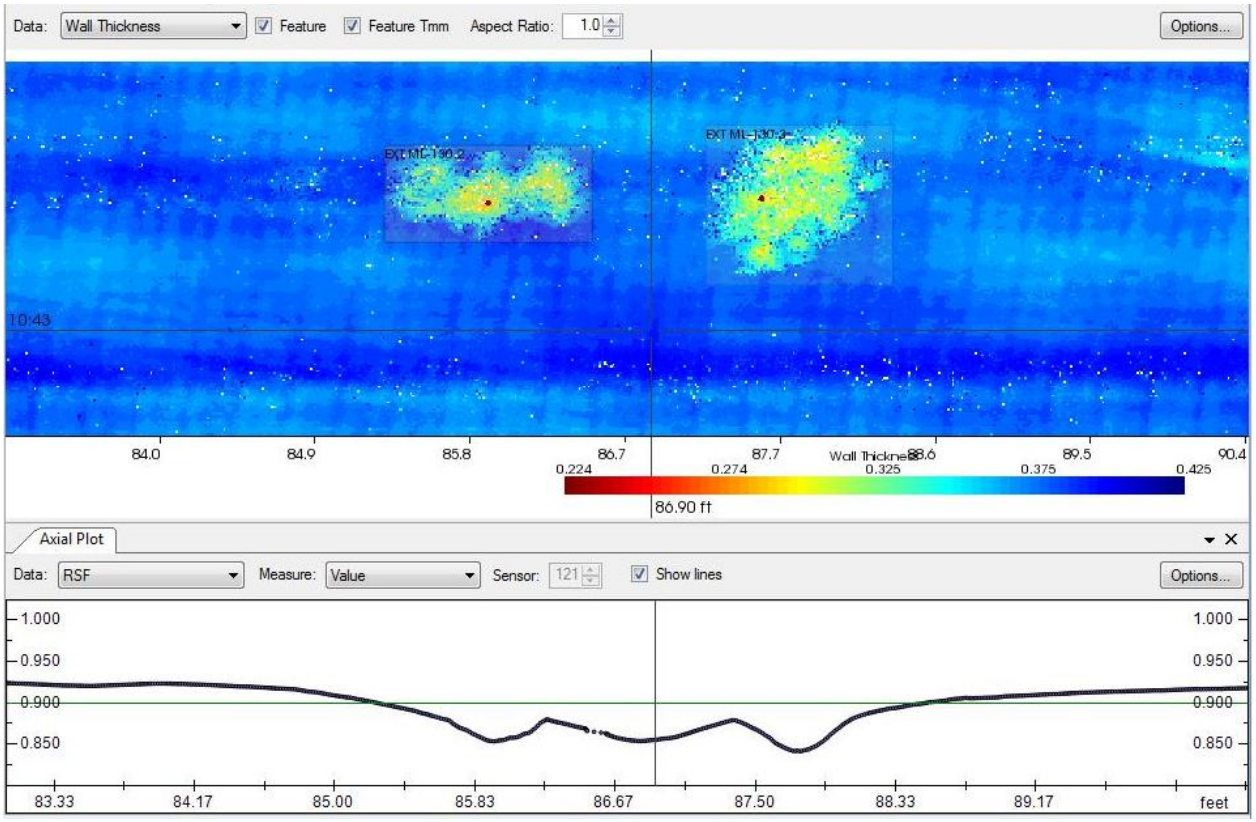
Interaction of Corrosion Areas



- Accurate profiling of corrosion allows for accurate assessment both individual defects and of defect interaction.
- Corrosion modeling can be applied to the individual defect profiles.

•Effective area calculation quantifies load carrying capacity of the specific section of pipe.
•Interaction between defects is calculated according to the individual profile of all defects involved.

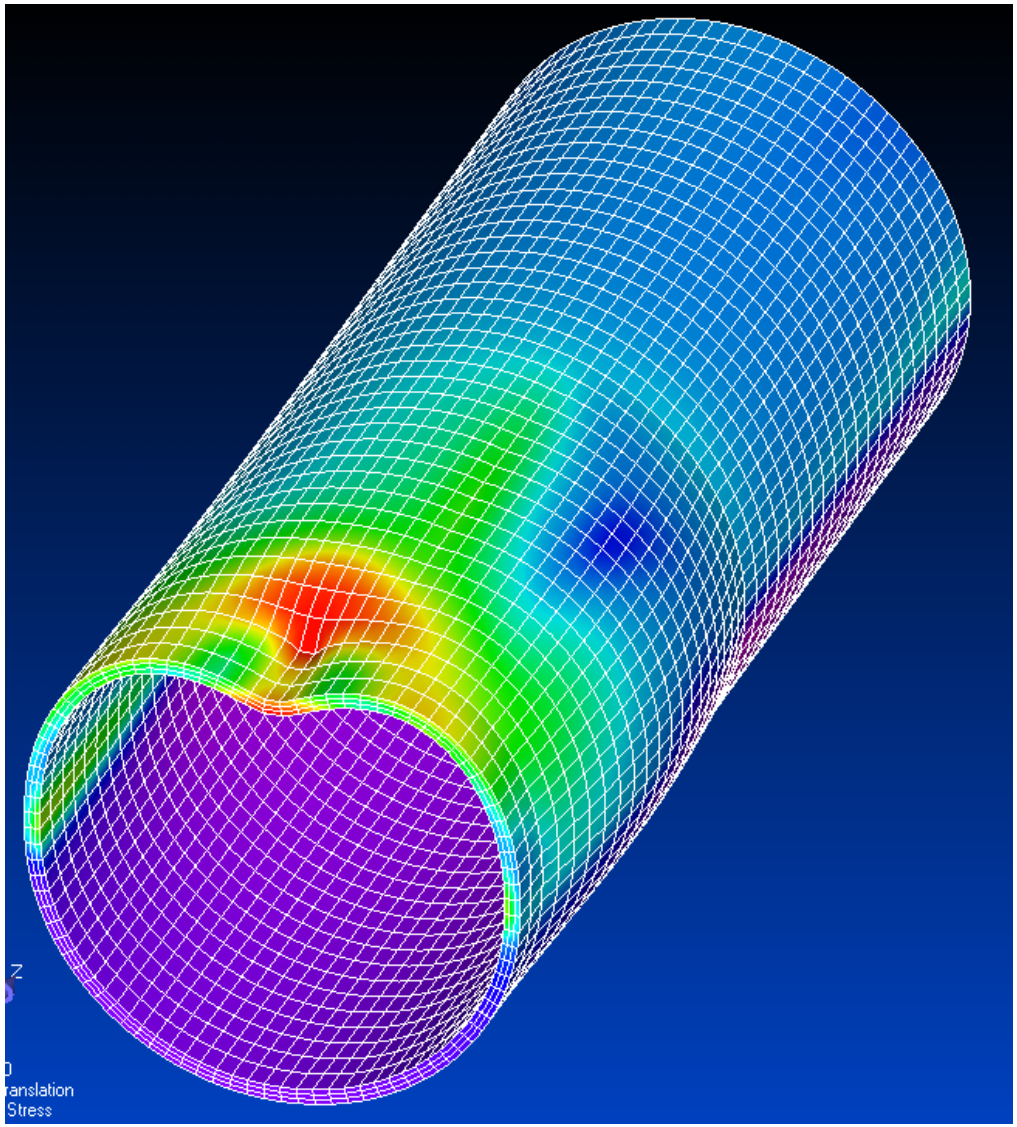




Run Comparison

- Better comparison between runs to get corrosion rates.
  - Not just mapping a single point, able to look at the entire profile of an anomaly
  - Can add a variable corrosion rate to the full defect profile
- Better characterization of defects allows for greater accuracy when comparing datasets.
- Full set of thickness and radius data for all inspections allows for comparison of areas that may have been below a reporting threshold on a prior survey.

High Resolution Data for Dents



- Failures at dents do not always correlate directly with depth
- High resolution profile of dent and surrounding pipe allows for advanced strain assessment
  - B31.8S strain rule
  - Finite Element Assessment
- 3D finite element analysis can simulate the formation of a dent, rerounding and damage that occurs over the subsequent pressure cycles.

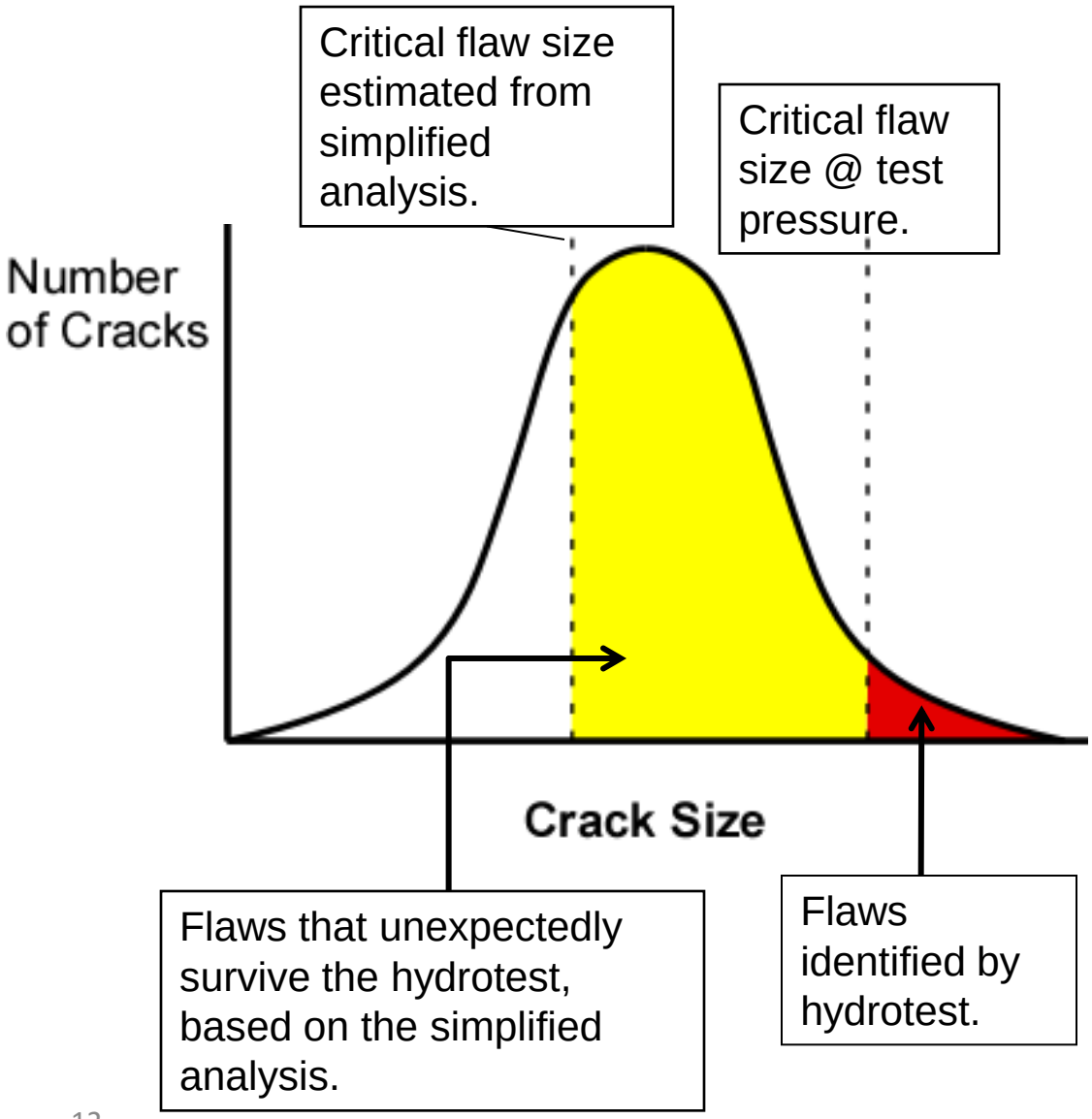
Value of High Resolution Inspection

- Accurate Results
  - Avoid unnecessary field investigations
- Identify Damage Mechanisms
  - Not only can damage be repaired but data can be used to start investigating the root cause of the damage
  - Data can be used to assist in estimating corrosion growth rates
- Multiple Data Sets
  - Compression wave UT gathers both wall thickness and deformation data with the same signal
  - Can be integrated with other data sets to perform further analysis (eg. CP data, GIS databases, future internal inspections)
- Measure Actual Wall Thicknesses
  - Many lines have wall thicknesses are less than manufactured specified tolerances
  - Values are assessed as part of the Level 2 Assessment

What is Conservative?

- Perfect regulatory compliance does not guarantee conservatism.
- Hydrotest gives regulatory compliance, but does not give information beyond ability to hold pressure at a single point in time.
  - Ongoing corrosion – does not provide information about defects that do not fail.
  - Through-wall leak – small areas of corrosion may not fail, even if almost already through-wall.
  - Dents - fail due to cyclic loading
  - Cracks – hydrotest can worsen existing cracks that are not yet large enough to cause a failure.

Why is Accuracy Important?



- Hydrostatic testing has traditionally been used to "detect" cracks. A simplified fracture mechanics analysis is typically used to estimate the largest flaw that survived the test.
- However, the simplified analysis usually underestimates the critical flaw size. Thus significantly larger-than-expected flaws survive the test.

Conservative Integrity Management

- Repairing all anomalies to an arbitrary threshold uses finite resources that could be more effectively spent on other parts of an integrity management program
  - High resolution data can lead to more accurate assessment results and prioritization.
  - Rapid data analysis and assessment can lead to cost savings in remediation of line while it is still out of service.
- Are pipelines not inspected because there is not capacity to perform all of the potential repairs that might be necessary?
- What data can be fed back into risk models to help quantify risk across an entire pipeline system?

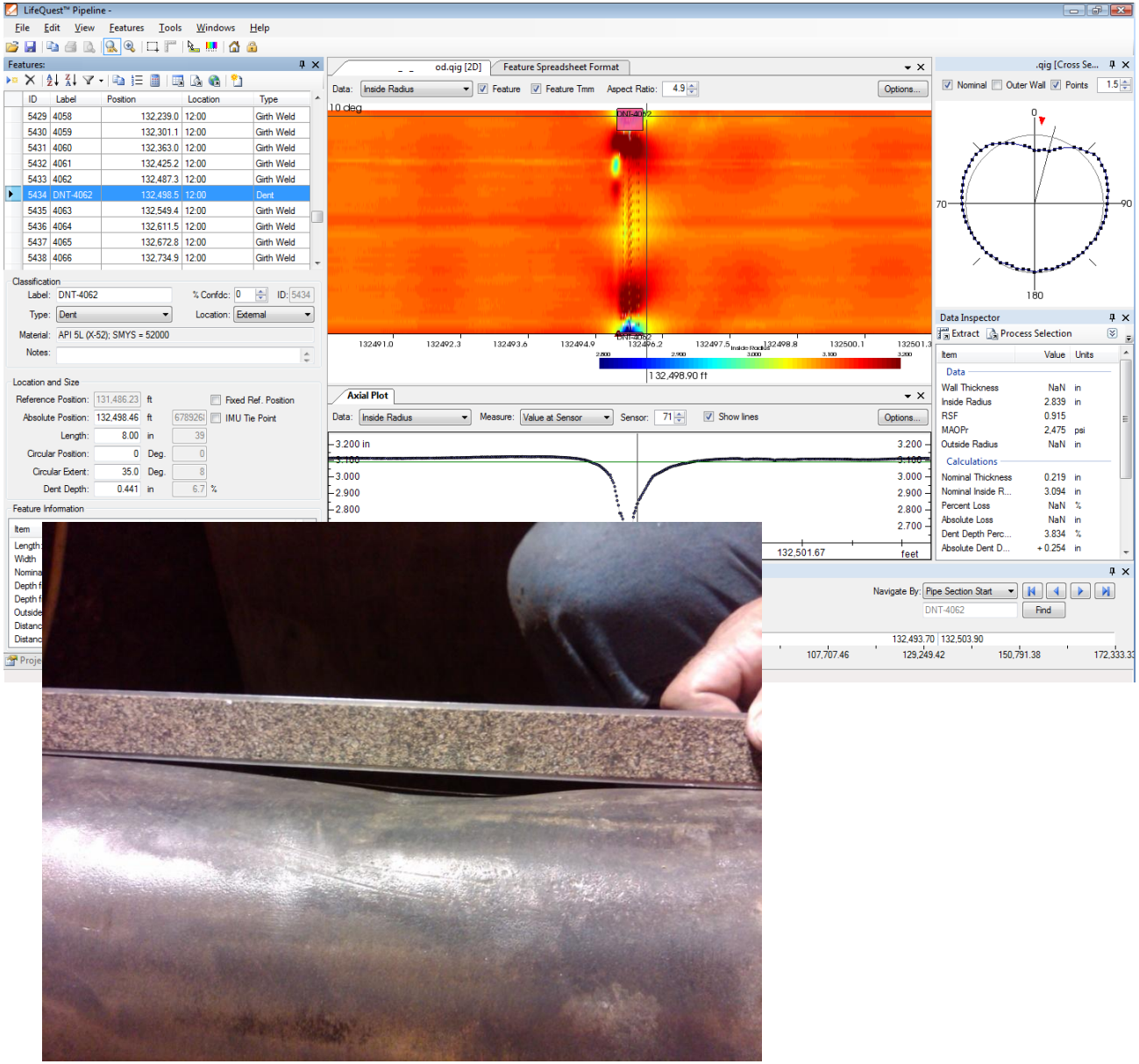
Case Study - 1: Dual Diameter

- Dual diameter pipeline (6”/8”) in a major metropolitan area.
  - Small radius bends
  - Multiple diameter changes. Need to inspect both diameters of pipe in single run
- Using frequent hydrotests to achieve regulatory compliance.
  - Only provide a snapshot of pipeline integrity
  - Not useful for dents of near through-wall failures
- Over 32 miles of pipeline.
- Desirable to inspect in product with standard operational pumps.

Case Study - 1: Successful Inspection

- Quest worked with operator during planning stages to ensure that tool could navigate with their specific pumping configuration
- Ran a sizing tool to validate pumping capabilities and ability of the tool to navigate the line
- Successfully inspected entire line during first inspection attempt. 22 hour inspection gathered over 637 million individual wall thickness and radius measurements.
- Identified hundreds of anomalies including blisters and dents with metal loss.

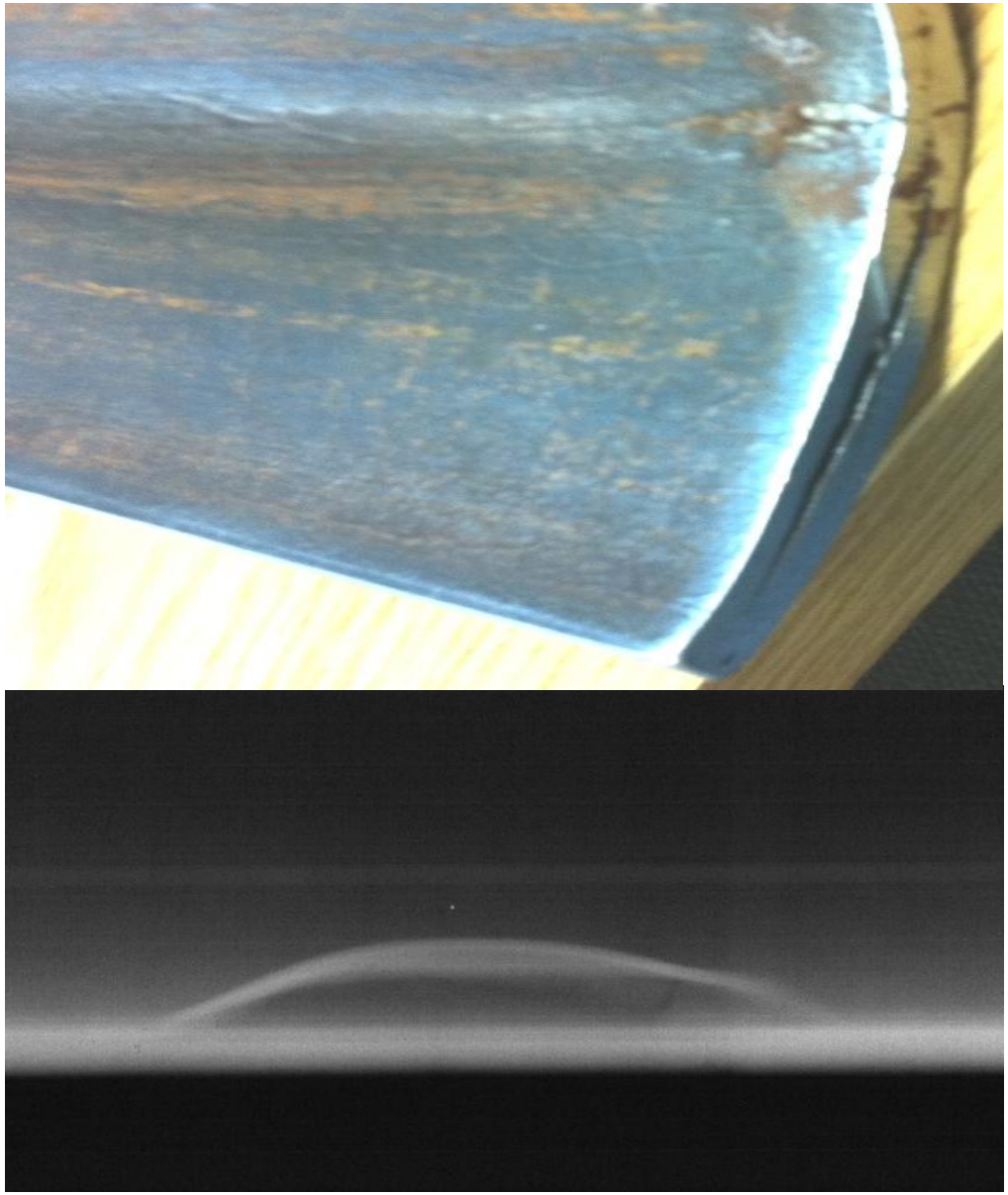
Case Study - 1: Results



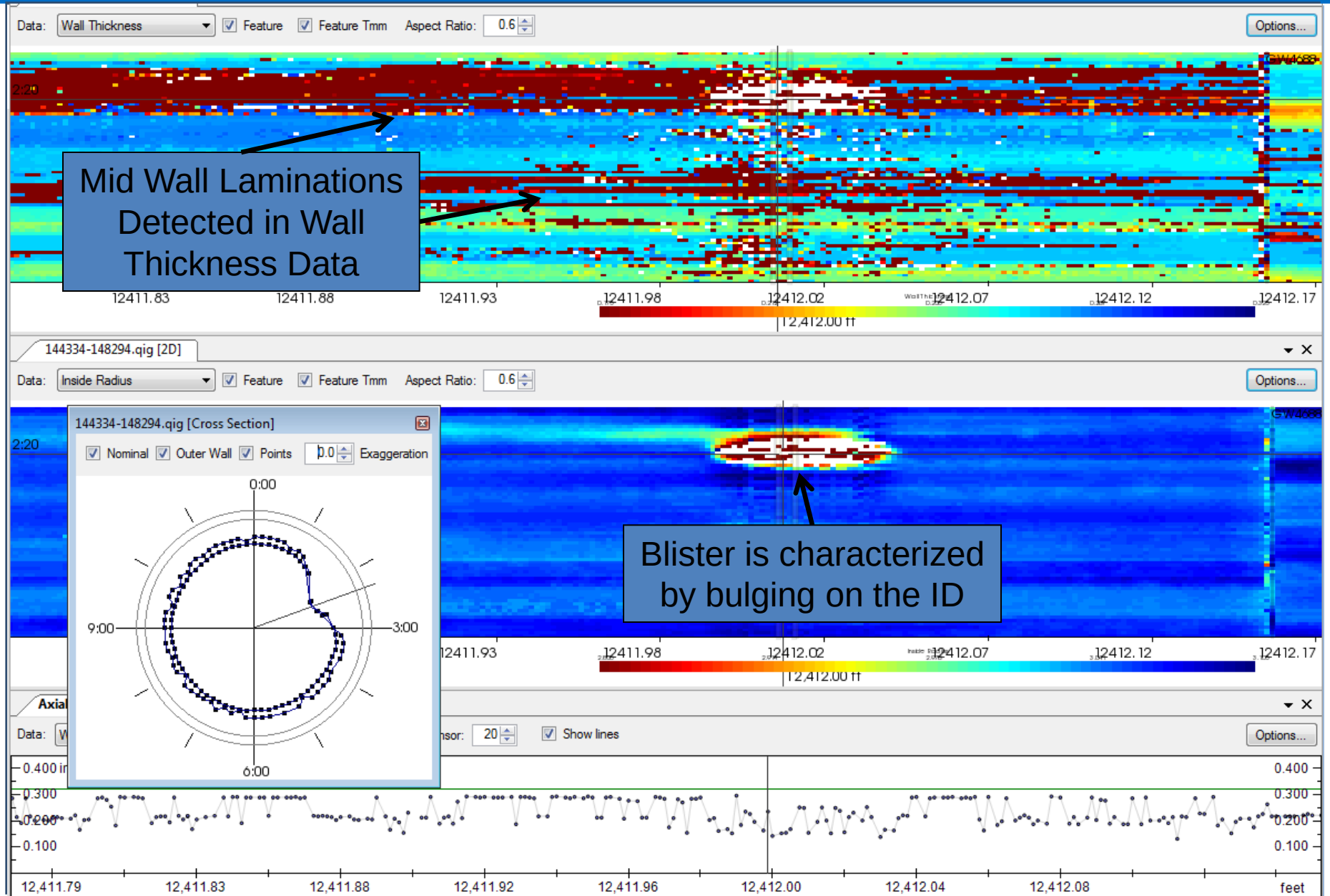
- Quest collected analyzed and performed a full Fitness-For-Service Assessment on nearly 9 GB of data
- Customized reporting to fit client requirements including piping station locations
- Critical defects such as this 6% topside dent were found that would not have been detectable by a hydrotest and could have led to a costly in-service failure

Case Study - 1: Blisters

- Inspection also revealed the presence of large blisters and laminations
- Not visible from an external examination of the pipe. Would not have failed a hydrotest.
- Blisters able to be distinguished from dents by profile of defect as well as presence of laminations in surrounding pipe.
- Treatment of blisters is not proscribed in regulations. Evaluation is helped by detailed profiling data



Case Study - 1: Blisters



Case Study - 2: Parallel Lines

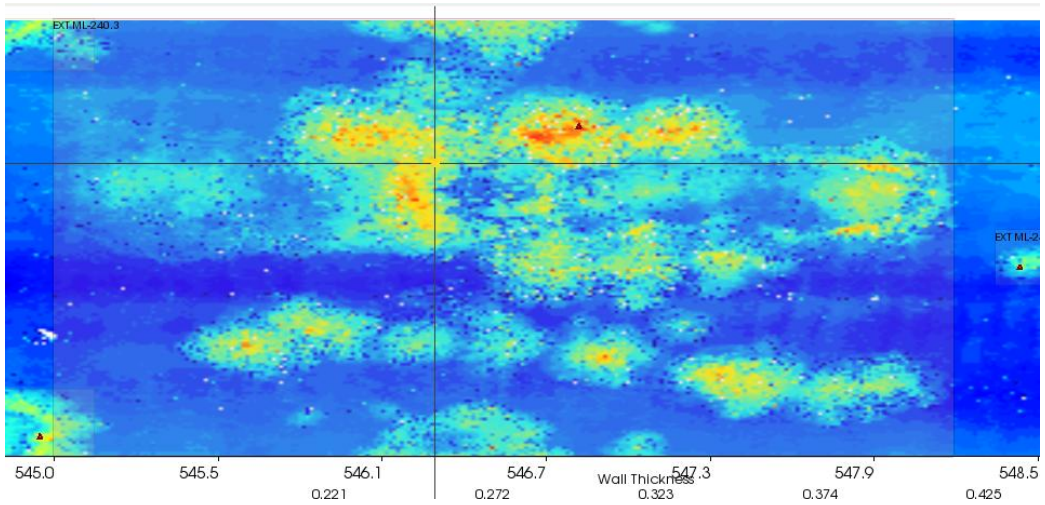
- Multiple 12” parallel pipelines that run under a short span of water.
- No existing launcher or receiver facilities
- Previously had used guided wave ultrasonic inspection (GUL) but wanted more detailed information than GUL was able to deliver.
  - Guided wave better suited as a screening tool. ILI allows for direct anomaly sizing and assessment.
- Considered using a tethered ILI tool, but ease of operation led to InVista.
  - Ease of launch and receive of tool was important because there was not a lot of available workspace on either end.
  - Bidirectional capability allowed for majority of the work to be done on one side
  - Flexibility of tool operation saved operator complexity and cost on the project.
- Quest Integrity provided temporary launch/receive trap, ran gauge plate pig, and performed pipeline cleaning as part of contract

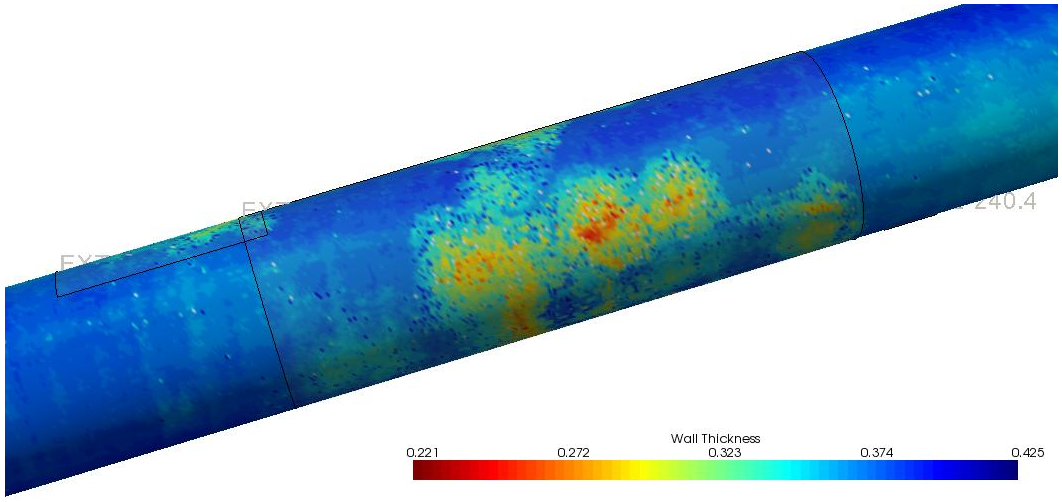
Case Study - 2: Setup

- Greater operational flexibility.
  - Inspector and operator collaborated on overall project plan.
  - Used a single launch and receive location.
  - Used a single launch/receive barrel during the inspection of four parallel lines. Barrel was switched between lines.
  - Able to inspect more than one line per day including cleaning. Entire project completed in under one week.

Case Study - 2: Results

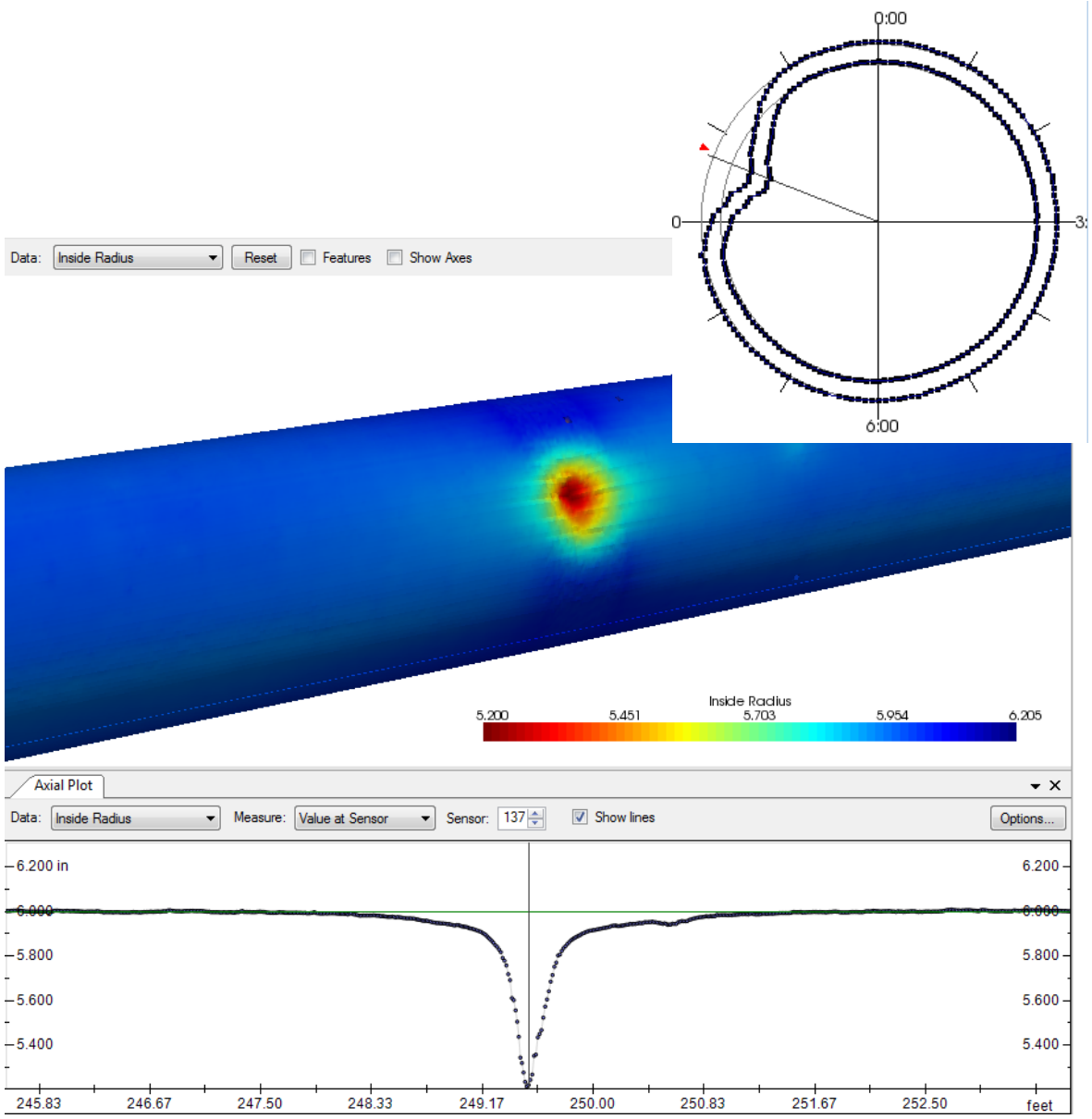
- Quantified external corrosion
- Identified defects in areas that would have been difficult to access for manual inspection
- Full Level 2 assessment done on entire line. Engineering Fitness-For-Service assessment delivered using 100% of the data
- Both Fitness-For-Service report and standard ILI spreadsheet in client format included as part of the final report.





Case Study – 2: Dents

- 6% dent identified in one line.
- High resolution data allows engineers to use strain-based engineering approach as an alternative to standard depth-based method. A variety of Fitness-For-Service assessments are possible.
  - API 579 Level 2
  - ASME B31.8
  - Finite Element Analysis
- Can calculate a remaining life for dents in number of cycles



Case Study - 3: Ease of Operation

- 6” pipeline on a wharf without any existing launch or receive capabilities.
- Prior integrity verifications done with hydrotests.
  - Give snapshot of line condition without any information about corrosion rates
  - Not useful for all defect types
- Location near water meant there is a high consequence for any loss of containment.
- Congested working area made addition of temporary traps difficult
- Inspection team was able to mobilize quickly with little logistical overhead

Case Study - 3: Launch without a Launcher

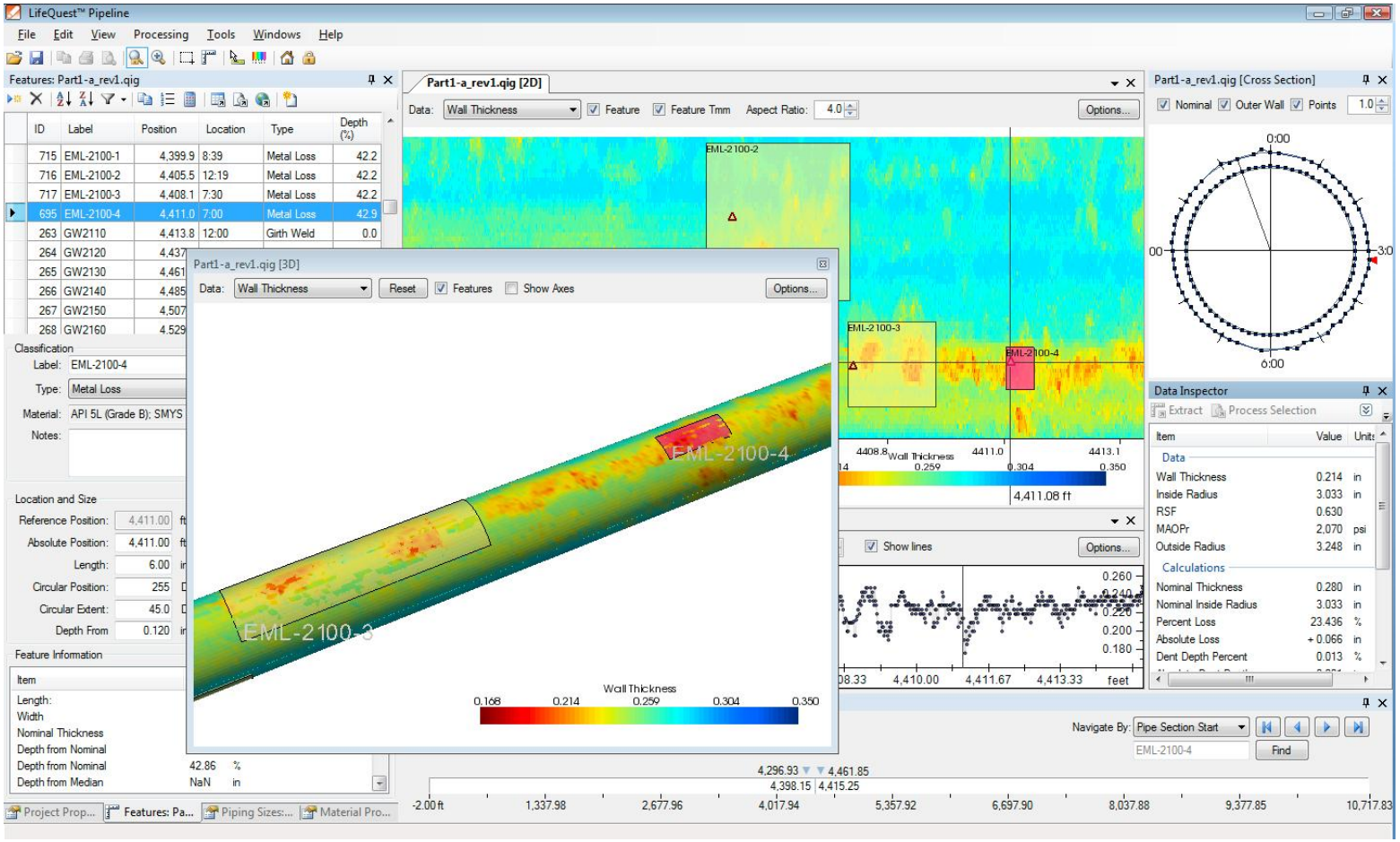
- At launch point a valve was removed and tool was placed by hand into 6” nominal pipe.
- Valve was then reattached, line was filled using plant’s firewater and air vented.
- InVista launched by opening the valve allowing for flow into the section of pipe into which the tool had been placed
- Total launch preparation time was about 90 minutes.

Case Study - 3:
Receive without a Receiver

- Tool was stopped at the far end of the inspection run with an orifice plate.
- Location of the tool was verified from transmitter signal.
- End portion of the line was then drained, flange was unbolted, orifice plate was removed and tool was retrieved by hand.
- Time for tool retrieval was about 15 minutes.

Case Study - 3: Results

- Preliminary review of data done with client on-site
- Full inspection analysis results and Fitness-For-Service engineering assessment delivered with 30 days

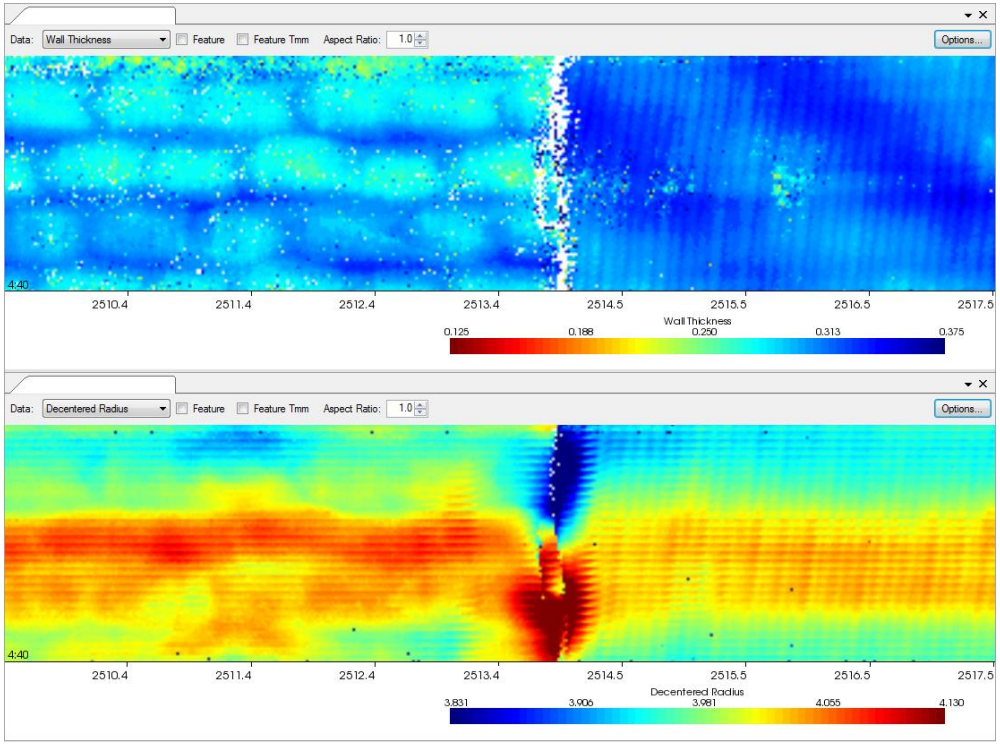


Case Study - 4: Miter Bends

- Operator has a set of pipelines of various diameters in a large urban area.
- Pipelines contain miter bends.
- Bidirectional inspection tool gave the operator confidence in probability for success

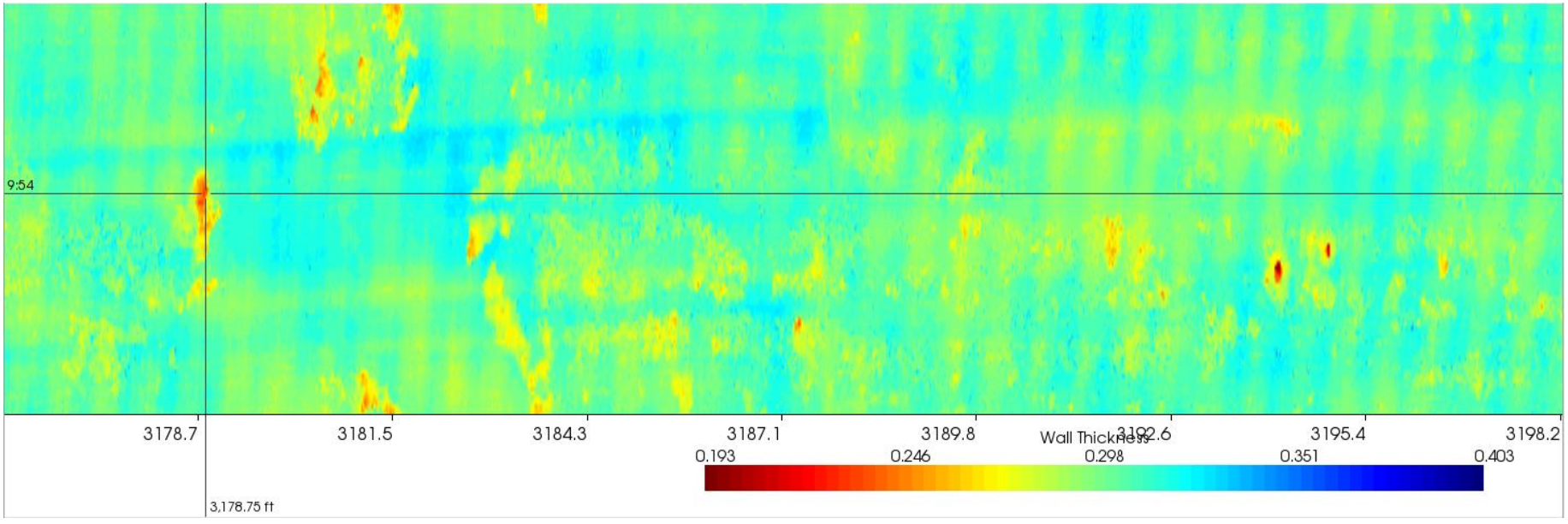
Case Study - 4: Miter Bends

- Quest was able to rapidly mobilize, inspect and report on target lines.
- InVista successfully navigated and inspected all sections of the pipeline, including portions that cleaning pigs had difficulty in navigating.



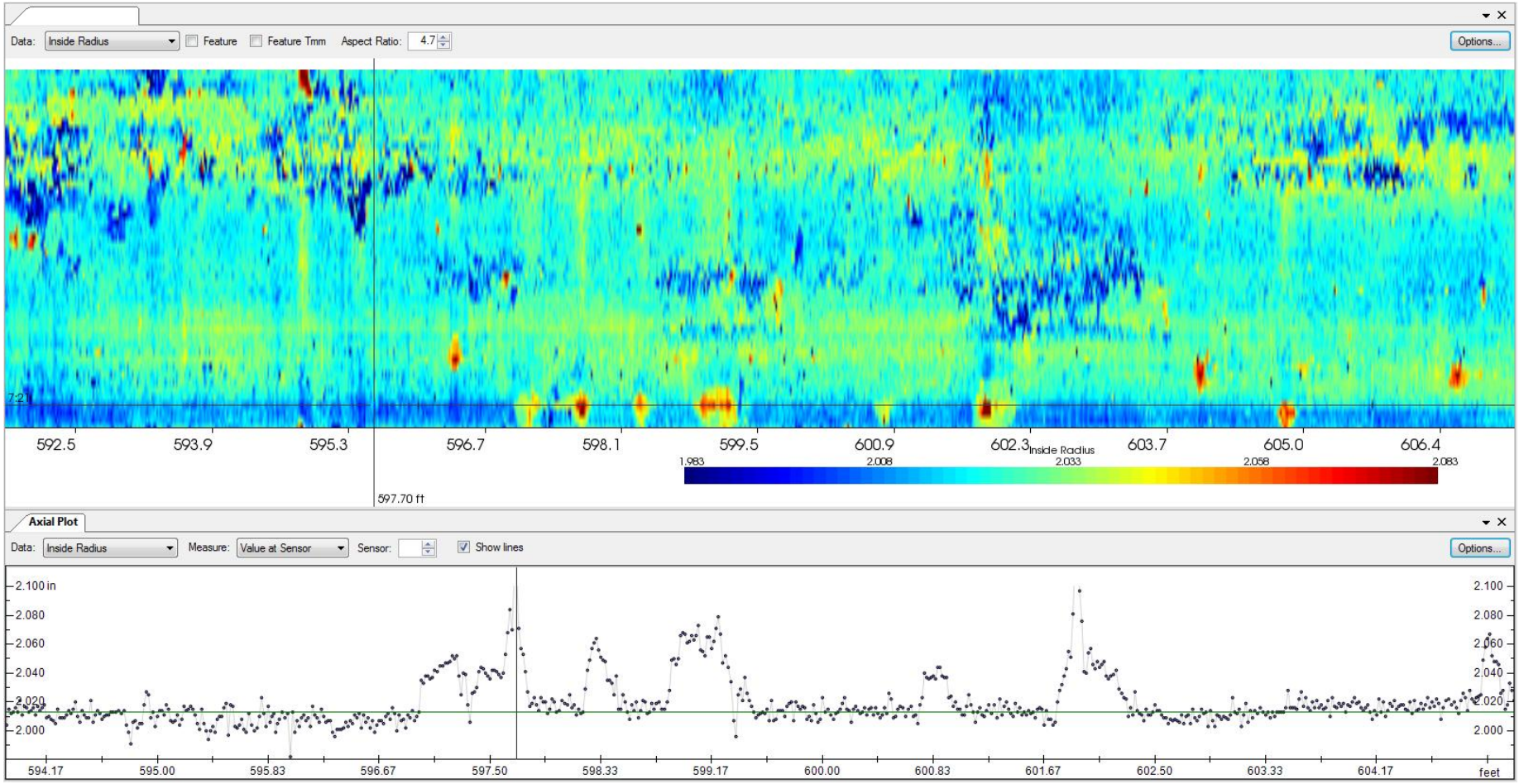
Case Study - 4: Success

- Inspection made more efficient by looping pipelines of the same diameter together.
- Able to manufacture defects in the loop piping for inspection verification
- Preliminary report identified some small diameter deep internal pitting
  - Quest Integrity worked with the operator during the initial prove up to locate and size these anomalies.
  - Results incorporated into final Fitness-For-Service assessment.
- Based on successful inspection and data validation follow up inspections were quickly scheduled and performed on nearby lines.



Case Study - 4: Internal Corrosion

Small diameter internal corrosion
Clear image in inspection data despite problems encountered during cleaning
Onsite support from inspection personnel and high resolution images of corrosion pattern in each pipe joint helped to simplify a potentially difficult prove-up



Conclusions

- Inspection options do exist – often without extensive pipeline modifications
  - Unpiggable lines offer unique challenges and can benefit from creative solutions. Operator and inspection company should work together to help solve a complex inspection puzzle.
    - Operator understands pipeline configuration
    - Inspection company understands tool performance and capabilities
- Inspection is just one piece of the overall integrity management project
- High resolution datasets can be used more efficiently for integrity management.
  - Want to maximize benefit of inspection data to gain more information than a single pass/fail snapshot at a single point in time

Thank You

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Questions?