PIPE PENETRATING RADAR

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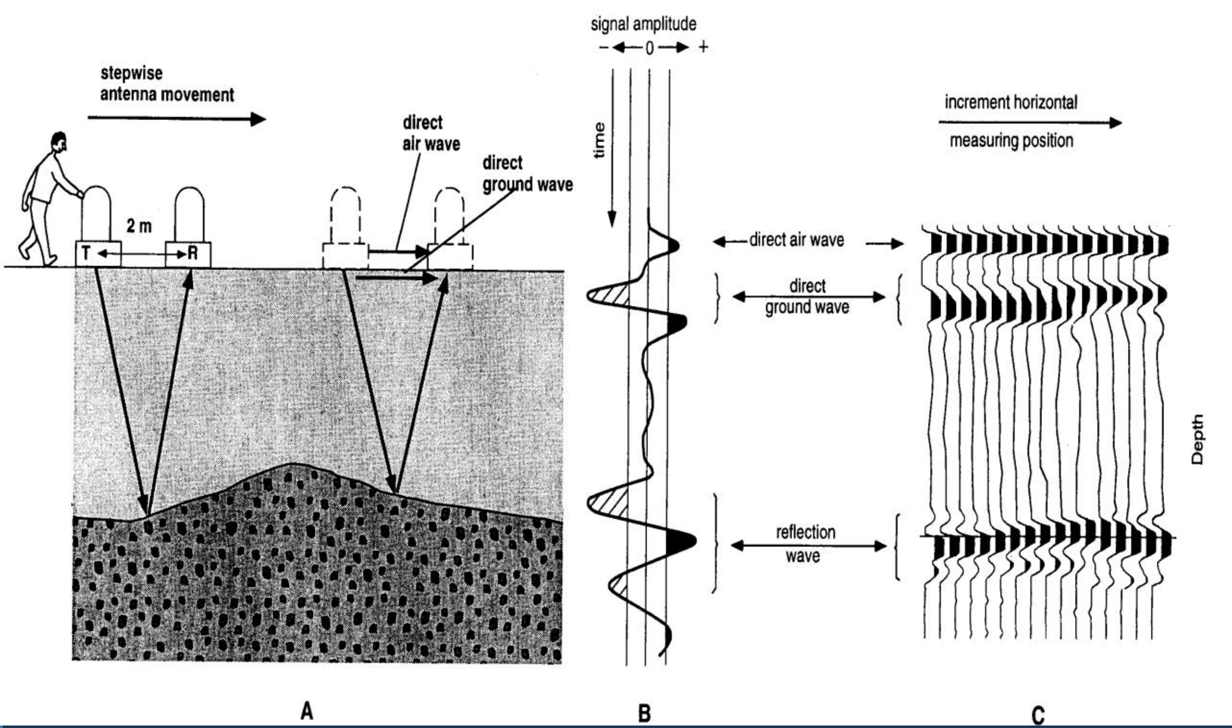
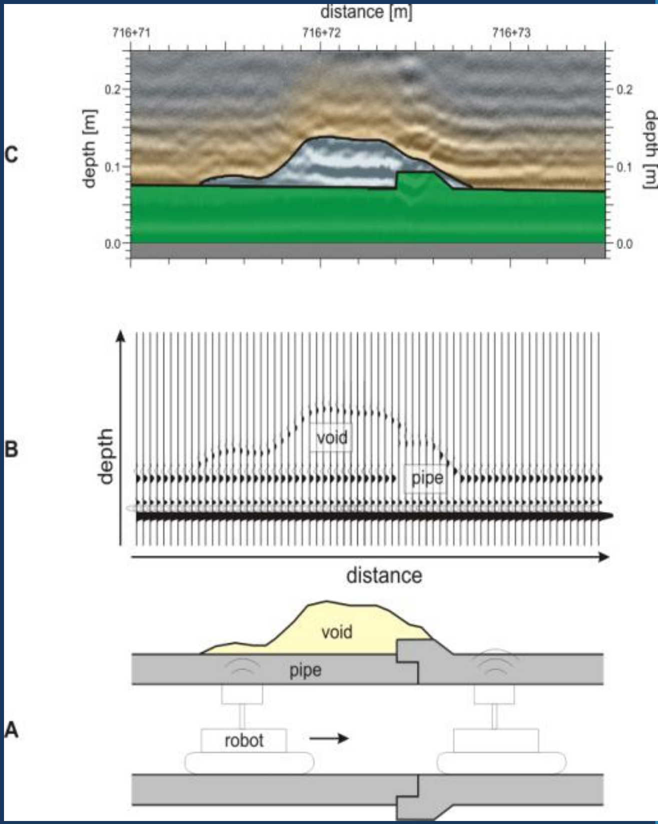
Outline

- GPR 101: why GPR sometimes does not work
- Pipe Penetrating Radar: why PPR always works
- PPR deployment
- Data display
- LIDAR and sonar
- Selected case studies
- Summary

Introduction: GPR

GPR Principle





A high frequency electromagnetic wave, (25 MHz to 2.5 GHz), is emitted via an antenna into the ground or structure under evaluation.

The reflected energy caused by changes in the electromagnetic properties of the material is detected by a receiver antenna and recorded for subsequent analysis.

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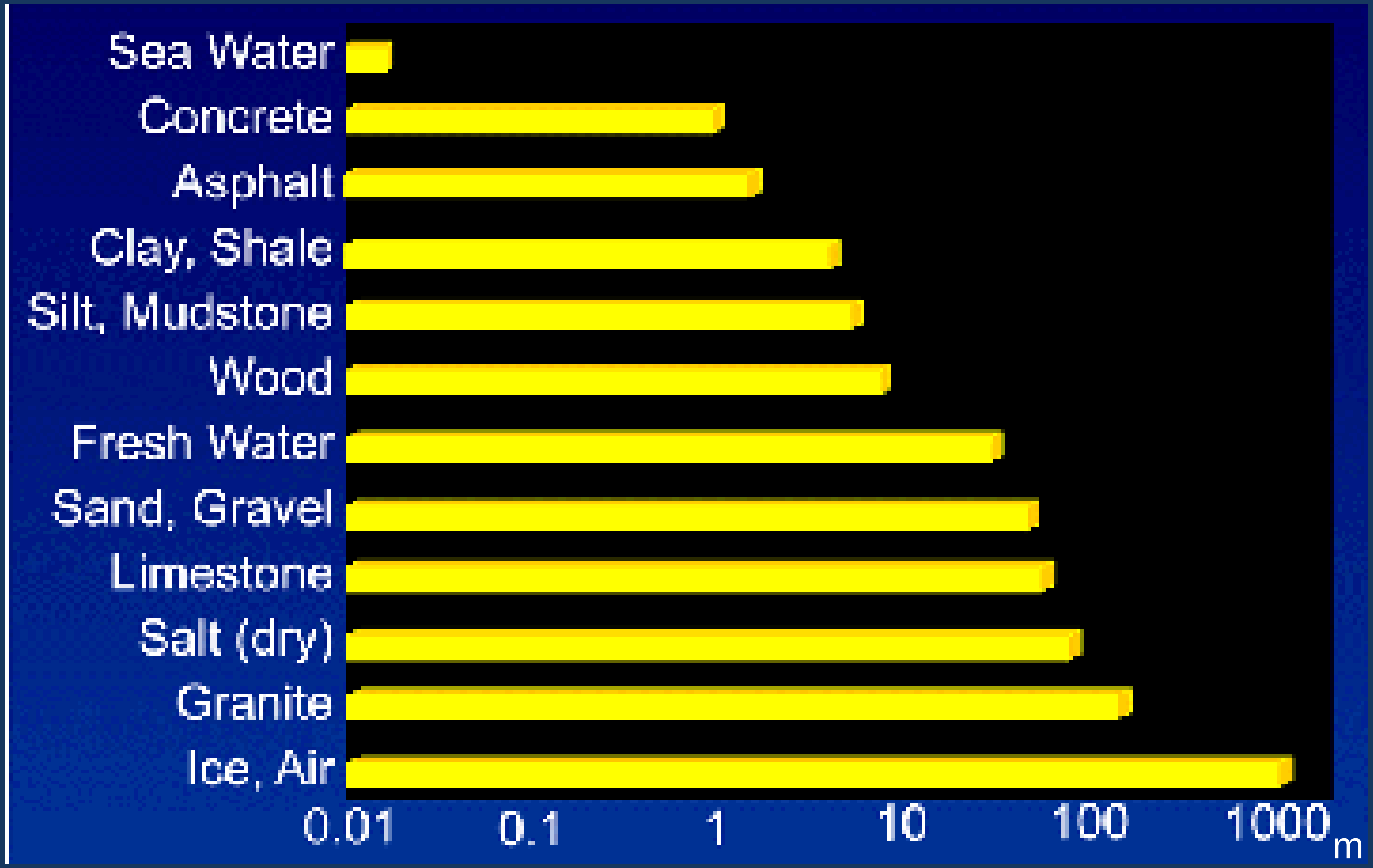
Penetration Depth



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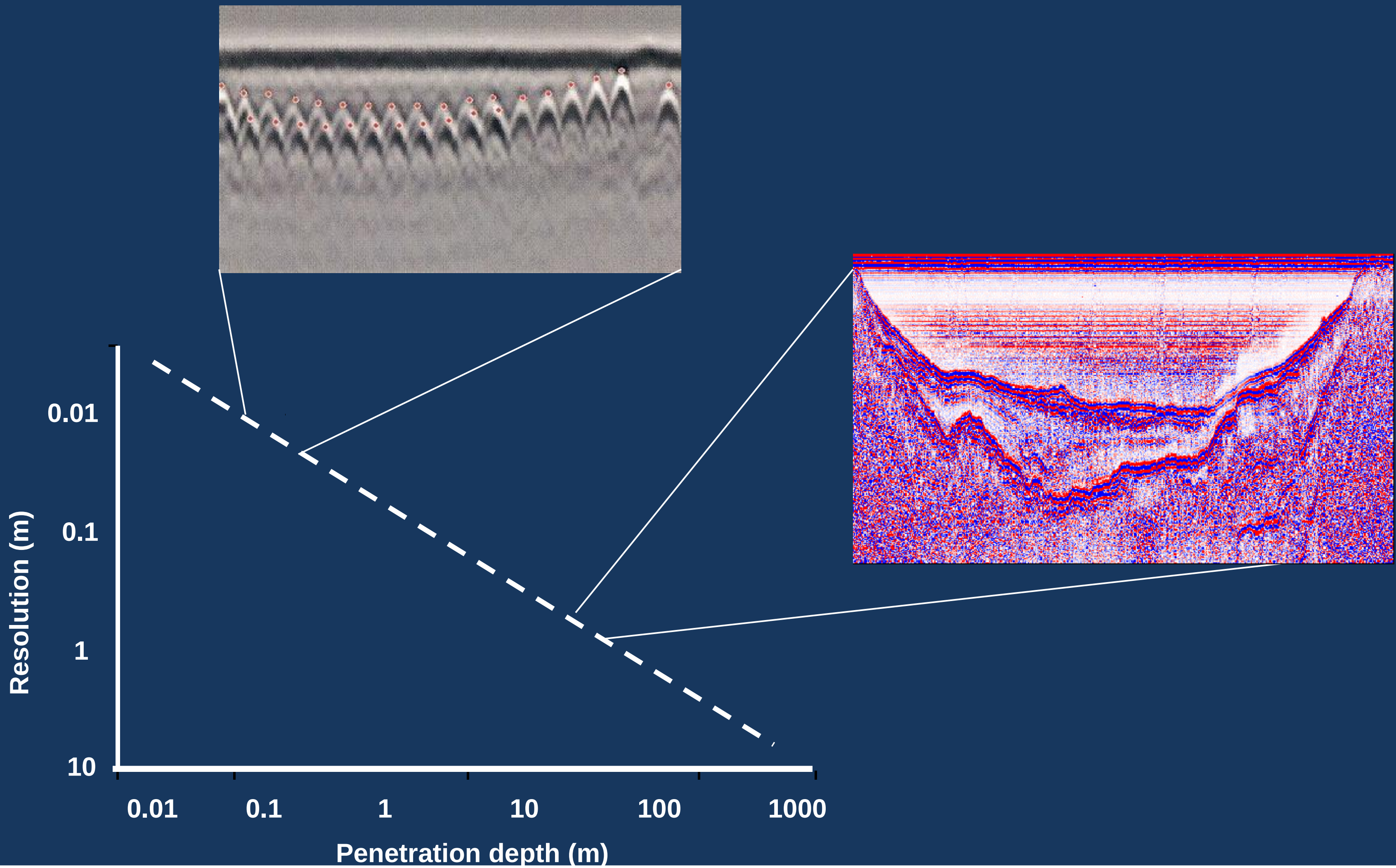
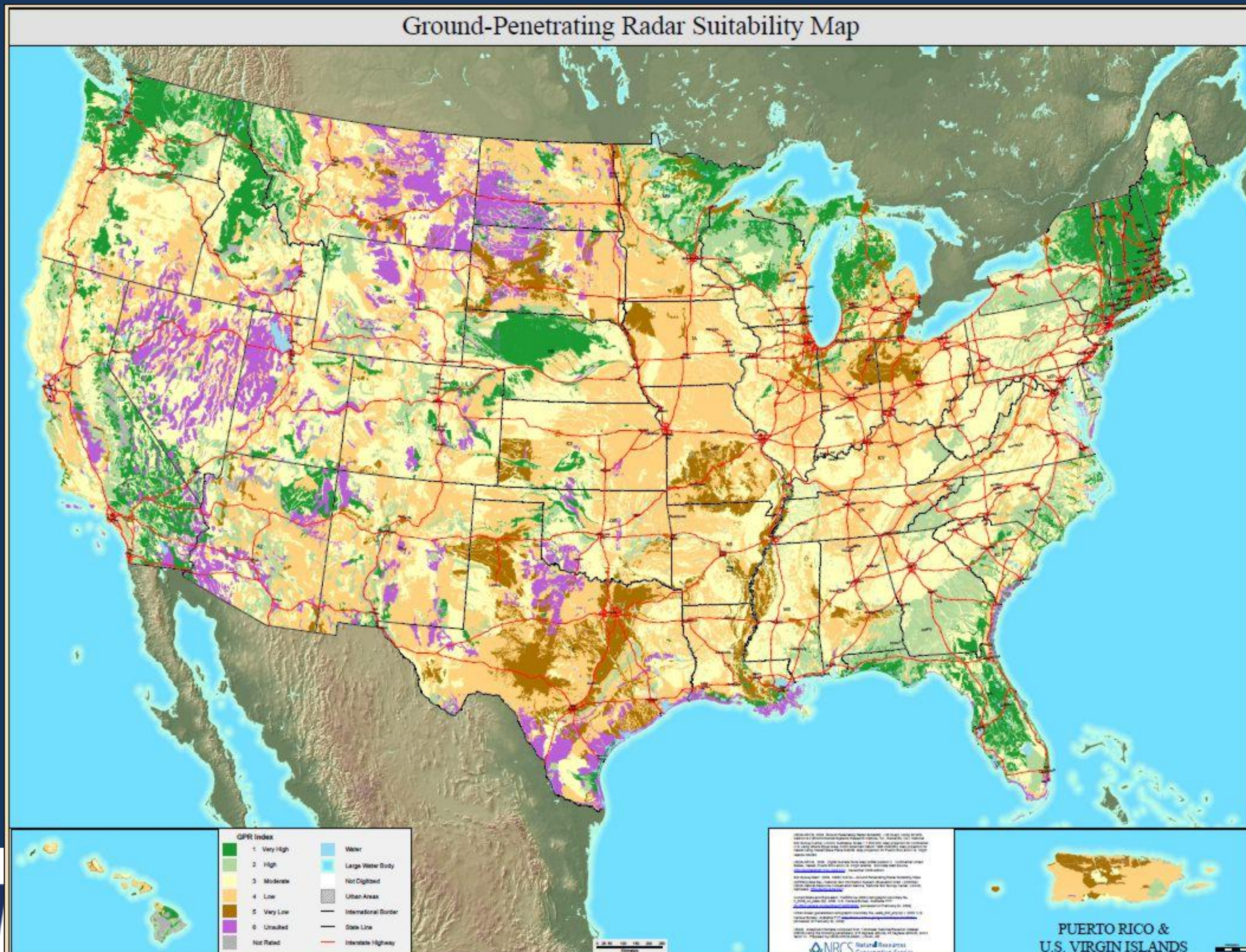
Penetration vs. Resolution



How Come it Doesn't Always Work?



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GPR vs PPR

- GPR "above ground" applications:
  - always works in concrete environments
    - Concrete thickness
    - Locate and map rebar, conduits, voids, etc.
  - limited penetration in conductive soils
  - untrained and inexperienced operators overselling the technology

- PPR: in pipe application of GPR:
  - always works in non-ferrous pipes
  - will measure pipe wall thickness
  - rebar depth
  - voids outside the pipe
  - provides quantitative repeatable structural information

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PPR Deployment

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Exposed Pipe

- Excavation necessary
- Limited but safe access
- No size limitation
- Pipe can be empty or full
- Spot checks
- High points on force mains
- A/C pipes
- No need for confined space entry

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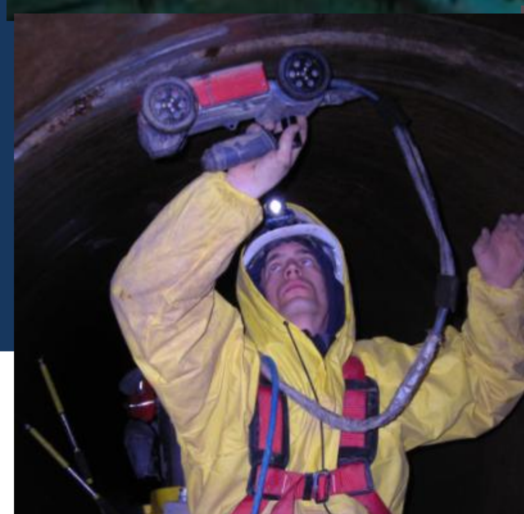
Manned entry

Pros:

- Flexible data collection
    - Frequency
    - Orientation
    - Pipe size
    - 3D data
- Speed

Cons:

- Risk of confined space entry
- Flow
- Pipe size (e.g. < 36”)



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Robotic PPR Inspection

- Remotely operated robot:
- HD CCTV (pan, tilt, zoom)
- 18-36 inch
- 9 to 3 o'clock
- 1500 feet tether (6000 ft optional)
- 2 auxiliary cameras
- 1.6 & 2.6 GHz GPR antennae
- LIDAR scanner
- 3D laser coming soon
- Accurate x,y,z coordinates
- "Swiss army knife"

Robotic PPR Inspection

- PPR can confirm visual defects, map voids
- Measure rebar cover and/or concrete thickness
- Provides structural assessment, allows proactive asset management

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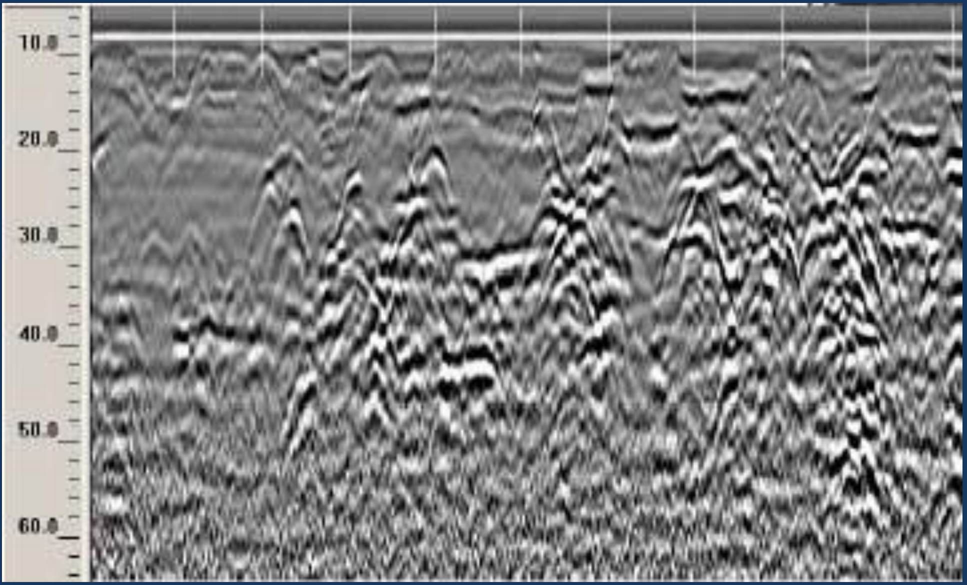
PPR Data Display



Good data display is an integral part of interpretation

Five types of data display

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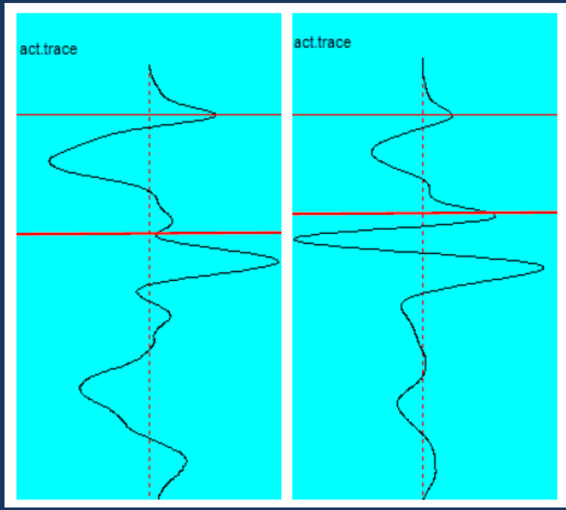
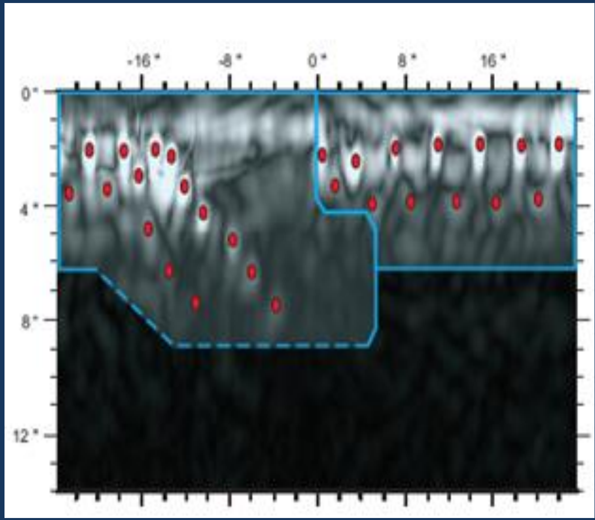
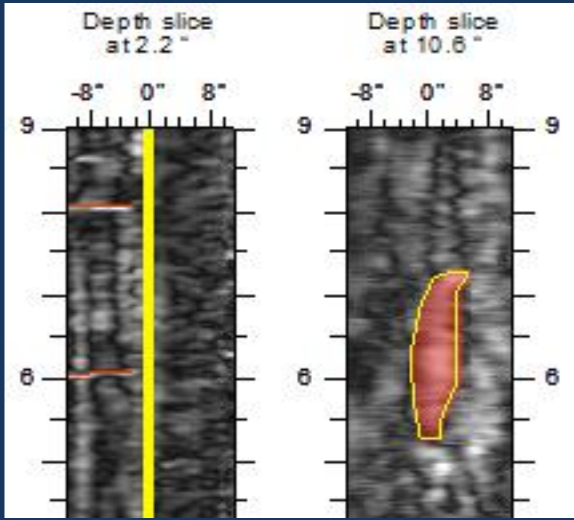
PPR Display and Reporting







A-Scan

One dimensional trace to detect targets & determine their depth below a spot on the pipe

B-Scan

Display is obtained by assigning a color to amplitude ranges on the trace.

C-Scan

aka Grid Scans from combining cross sections and show conductivity contrasts

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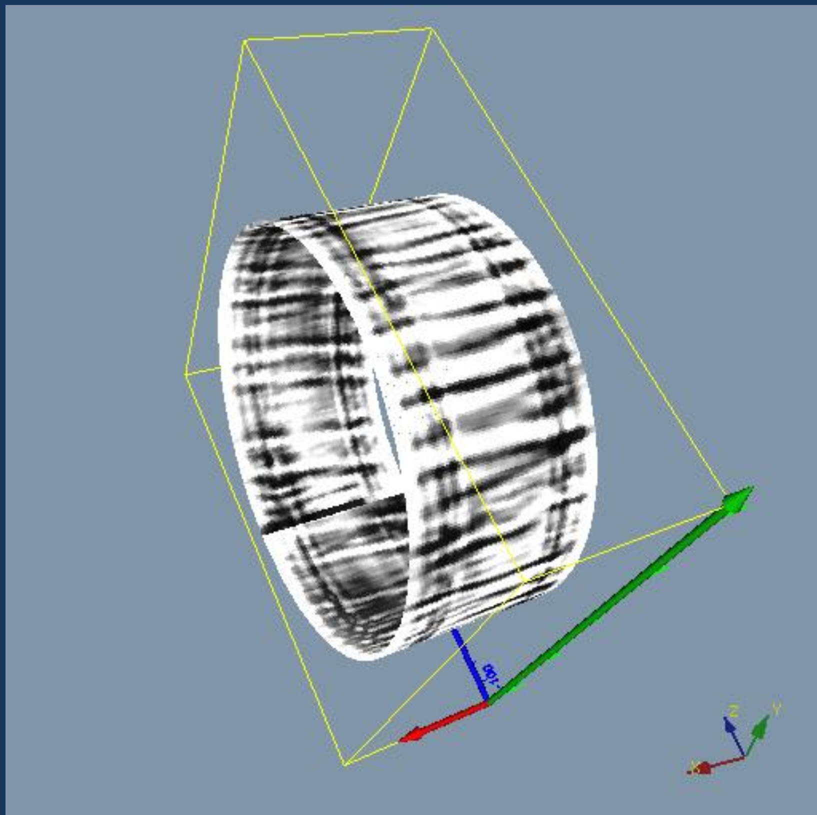
PPR Display and Reporting

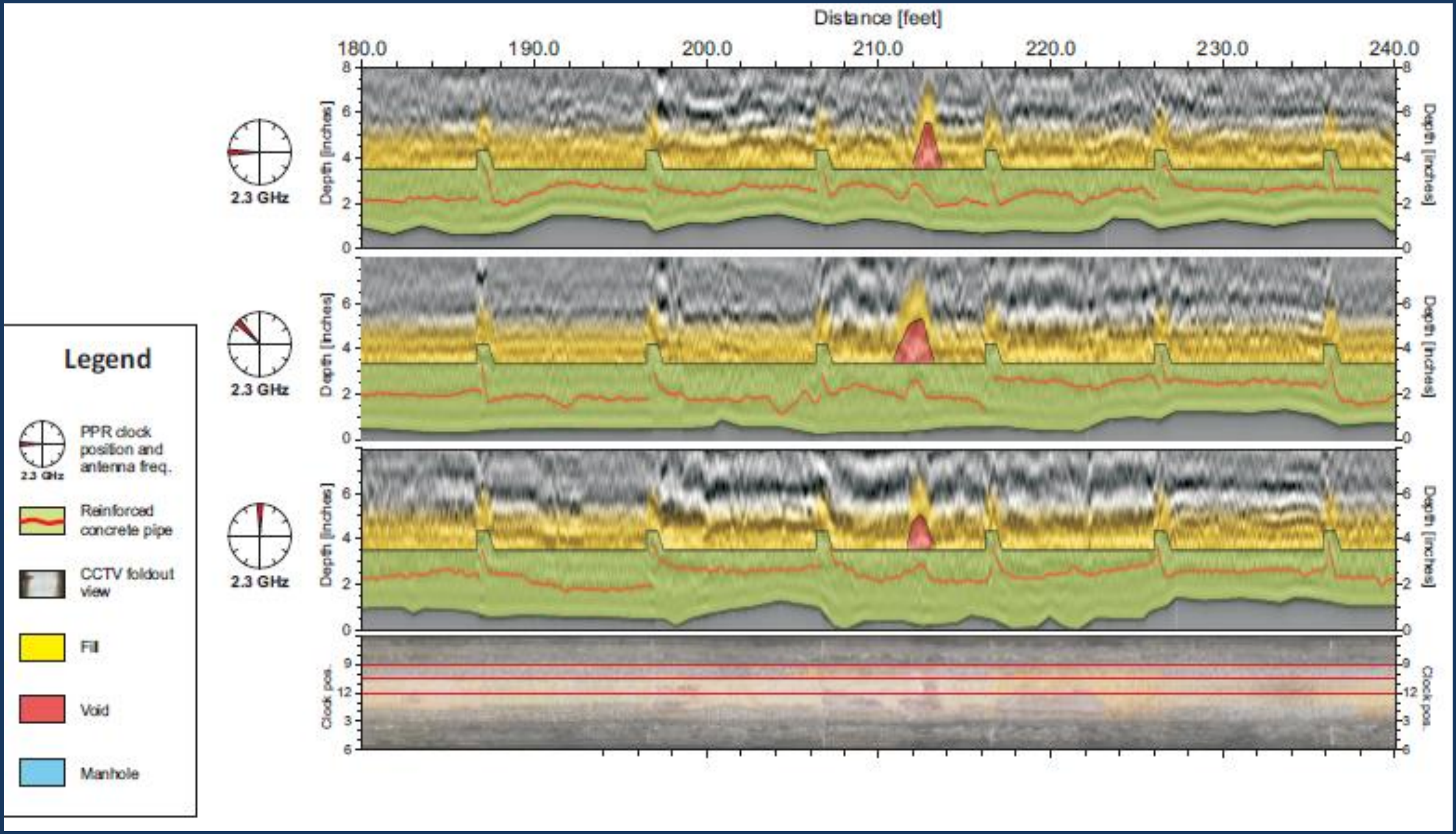


3D Display

Block views of PPR traces that are recorded at different positions on the pipe surface

3D view of a 42” RC pipe joint, white bands and lines represent rebar.

Integrated PPR Data Display (IPPRDD)



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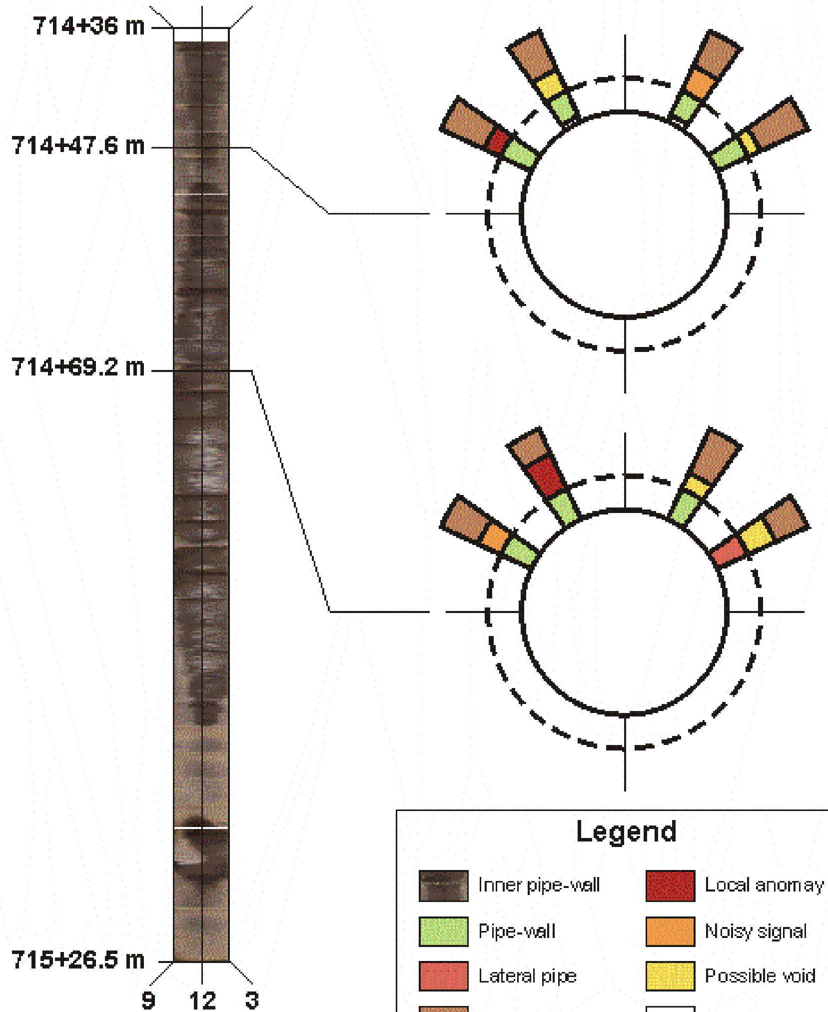
Project #: A0545 / 2010	Asset number: 714 / 36 – 715 / 26 Start position: 714+36 m Final position: 715+26.5 m Total length: 89.5 m	Use: storm sewer Pipe size: 24 inches Pipe shape: circular Pipe material: concrete

Road: Xxxxxxxxxx rd.	City: Xxxxxxxxxxxxx	State/Prov.: Xxxxxxxxxxxx	Country: Xxxxxxxxxxxxx

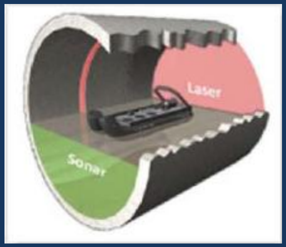
Survey customer: Xxxxxxxxxx Survey owner: Xxxxxxxxxx	Survey date: yy/mm/dd – yy/mm/dd Operator: Xxxxxx Xxxxxxx	Interpret date: yy/mm/dd – yy/mm/dd Operator: Xxxxxx Xxxxxxx

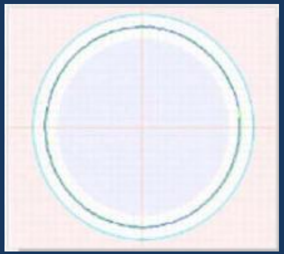


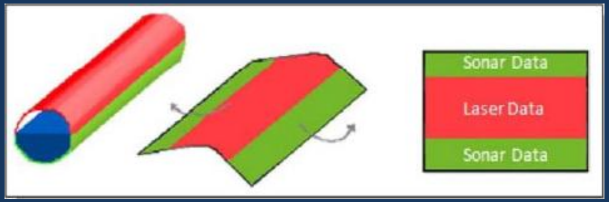
Legend

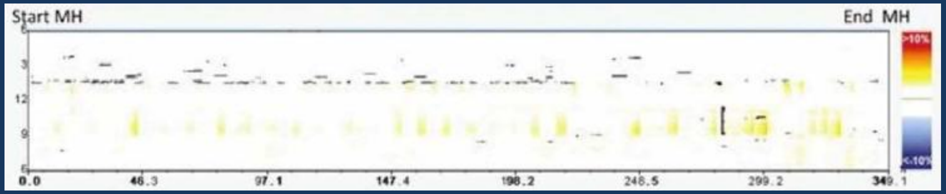
- Inner pipe-wall
- Pipe-wall
- Lateral pipe
- Native soil
- Local anomay
- Noisy signal
- Possible void
- Void

Sonar and LIDAR



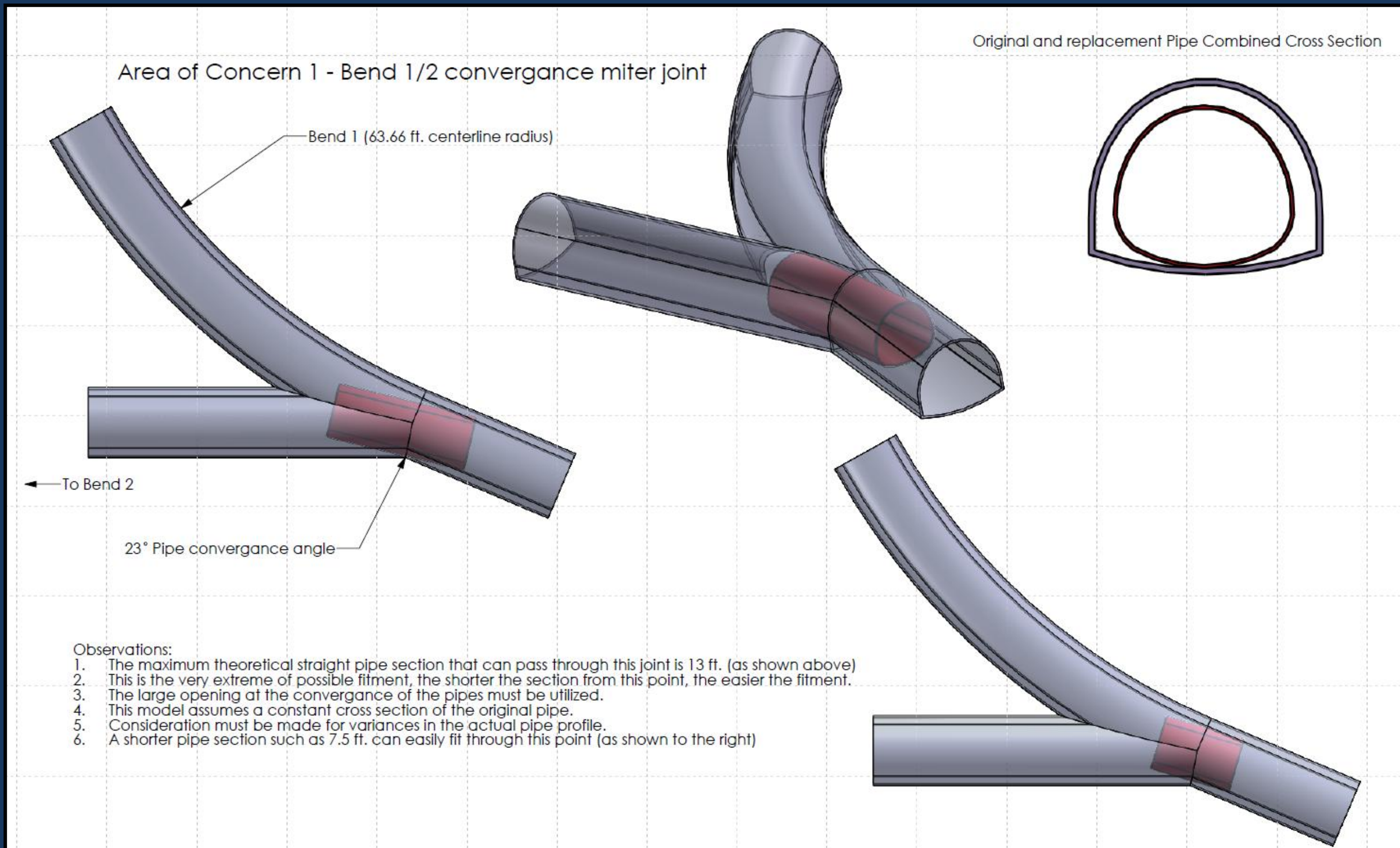






- Combined CCTV / Sonar / Laser
  - Laser Module Attached to Robot or Float
- Pipe Condition Evaluated from
  - Laser
  - Sonar and Video
- Debris Displayed from Sonar

3 D laser



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Case study #1: man entry

Determination of pipe wall thickness and joint condition
Davis Aqueduct
Salt Lake City

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Davis Aqueduct, Salt Lake City

- 60 inch raw water RCP
- Man entry PPR survey

- Objectives:
- Survey leaky joints for:
  - Joint configuration
  - Pipe wall thickness
  - Voids outside pipe
  - Tight deadline

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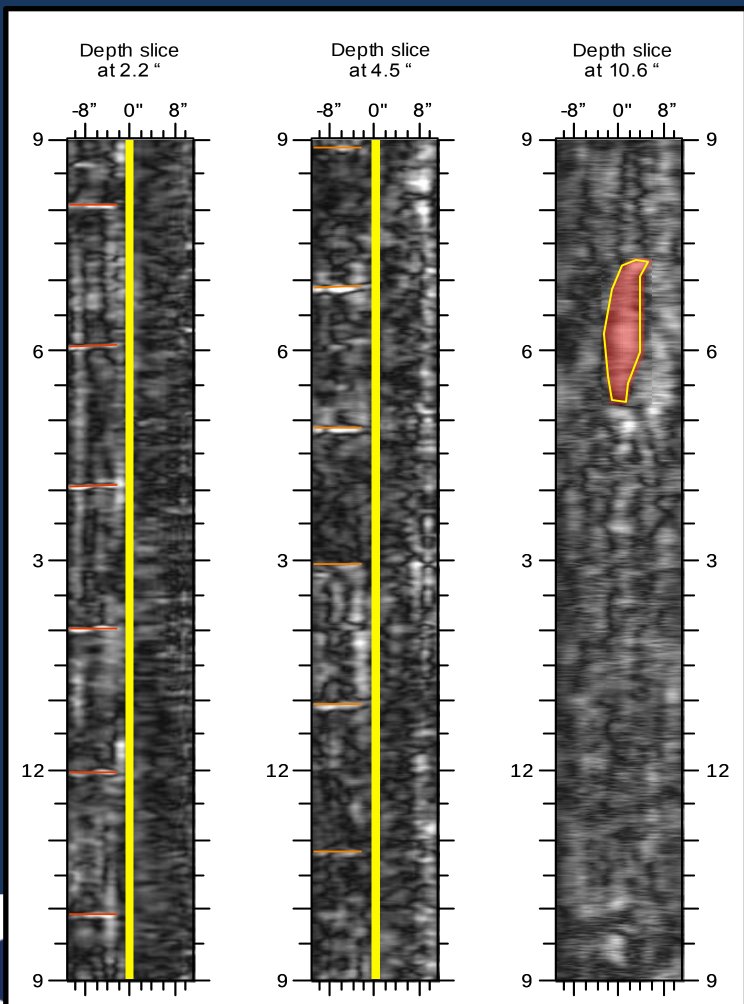
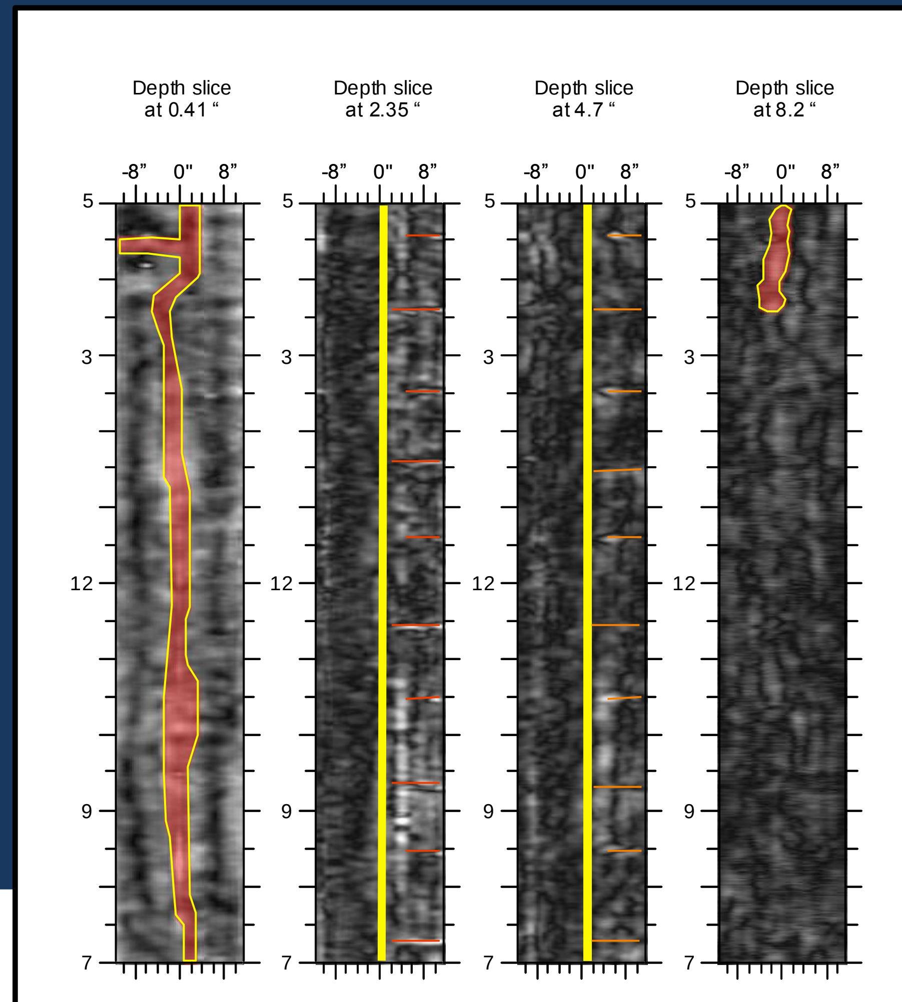
Davis Aqueduct, PPR Setup

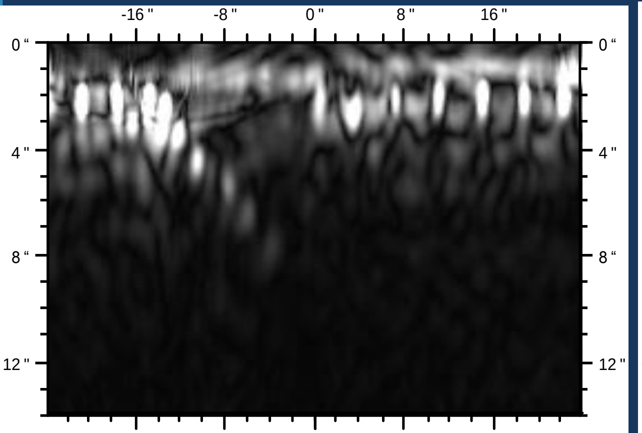
- Three antenna frequencies (1 GHz, 1.6 GHz, 2.6 GHz)
- Longitudinal and circumferential lines
- High resolution large grids (4 ft x 4 ft) at bottom quadrant

Davis Aqueduct, PPR Results

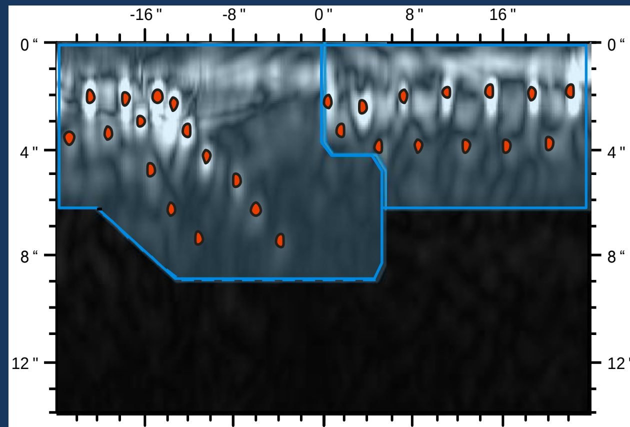




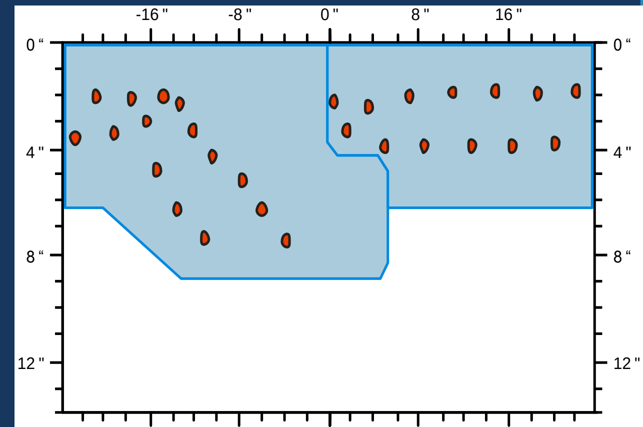
Davis Aqueduct, PPR Summary



Processed GPR data.



Processed GPR data with interpretation.



GPR data interpretation.

- Four joints surveyed (3 leaky, one control)
- Good data quality (2.6 GHz worked best)
- Over 2400 ft line data (in two days)
- 8 High resolution large grids
- Joint types, pipe wall thickness and voids were identified

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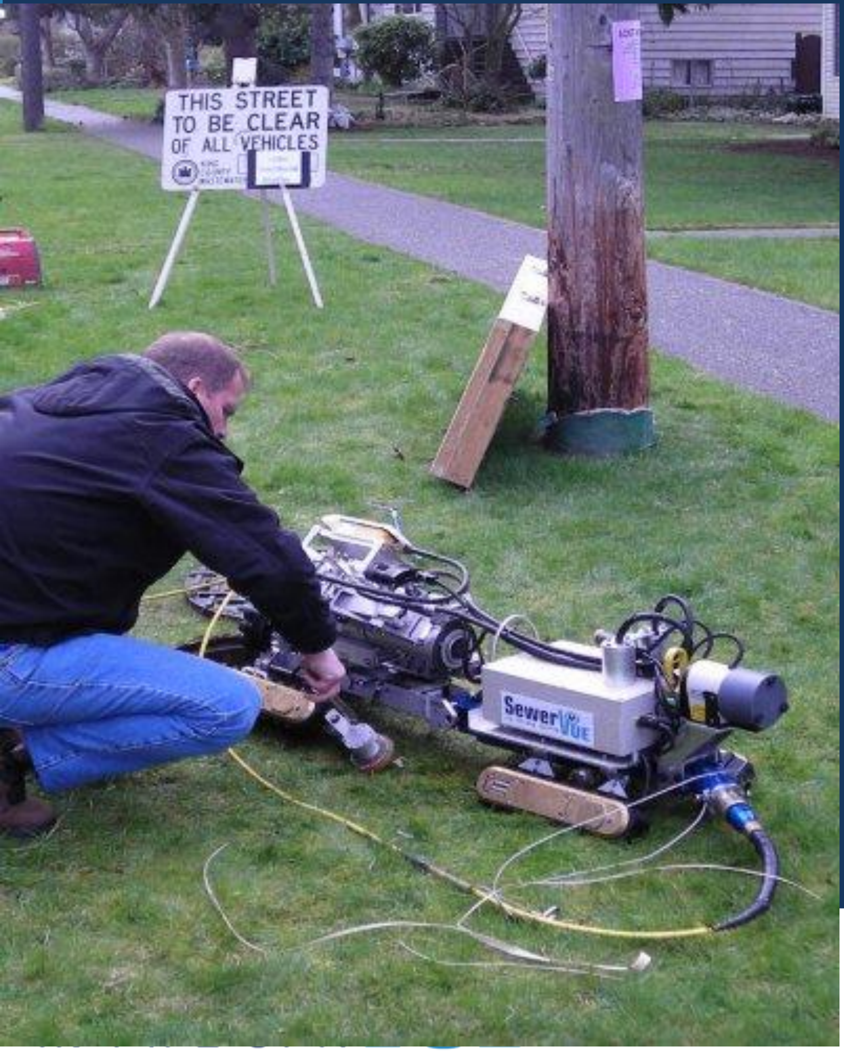
Case study #2: robotic PPR

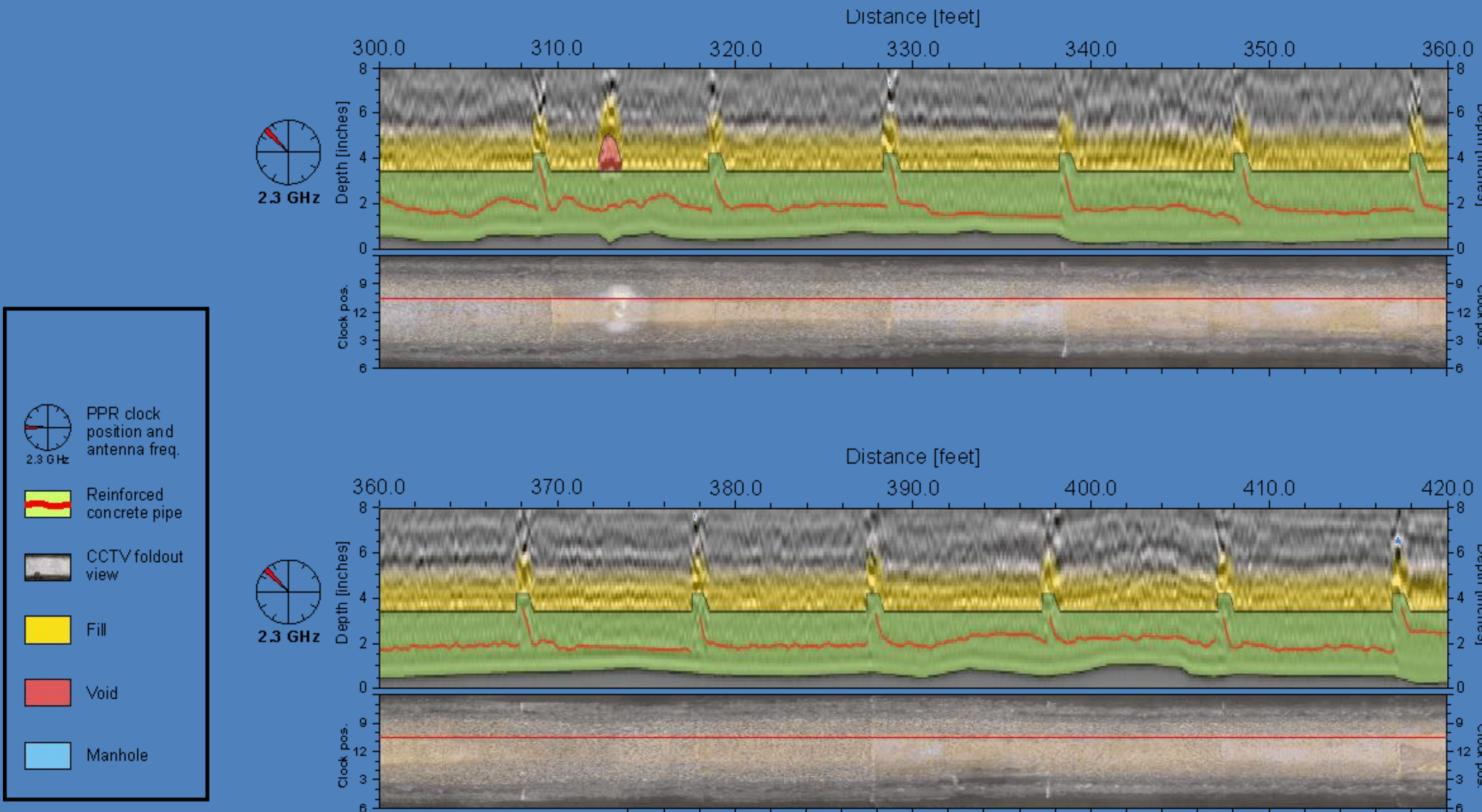
Multisensory robotic pipe condition survey including PPR, laser and CCTV King Co., Washington

King County, WA

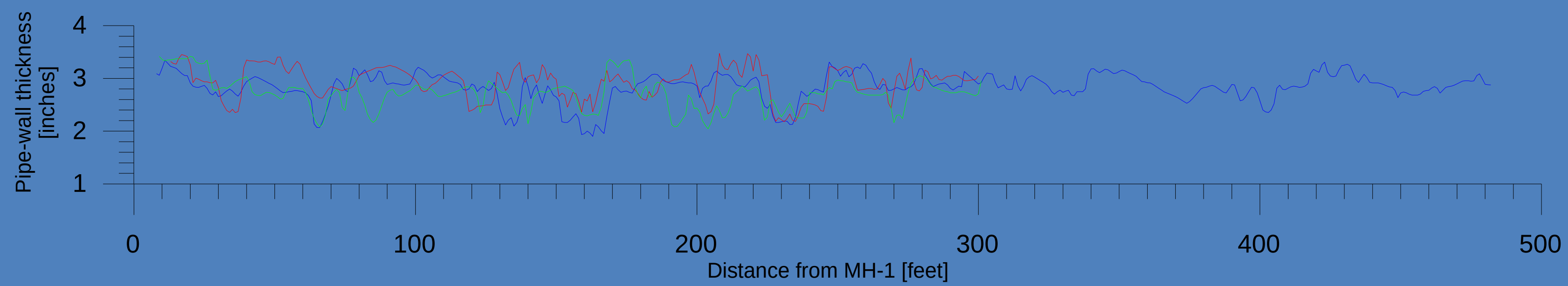
- 62nd Ave. SW - Beach Drive Interceptor-North
- 30” Dia. RCP
- Local Contractor: *Interactive Pipe Inspection*



PPR Data Reporting



Strong anomaly – PPR anomaly visible on CCTV foldout view



Location Rank By % Wall Loss	Pipe Scan Loc (feet from MH)	PPR Scan Location O'clock	PPR Scan Wall Measurement (inch)	Percent Wall Loss (%)	Northing Co-ord (° ' ")	Easting Co-ord (° ' ")
23	64.0	10:30	2.1	40.58	47°34'31.62"	122°24'43.62"
10	65.0	10:30	2.1	42.44	47°34'31.62"	122°24'43.62"
50	84.0	9:00	2.2	38.42	47°34'31.43"	122°24'43.62"
33	85.0	9:00	2.2	39.86	47°34'31.43"	122°24'43.62"
17	132.0	10:30	2.1	41.19	47°34'30.96"	122°24'43.65"
47	133.0	10:30	2.2	38.64	47°34'30.95"	122°24'43.65"
24	140.0	9:00	2.1	40.47	47°34'30.88"	122°24'43.65"
36	152.0	10:30	2.2	39.47	47°34'30.77"	122°24'43.68"
29	153.0	10:30	2.2	39.86	47°34'30.76"	122°24'43.68"
44	155.0	10:30	2.2	38.69	47°34'30.74"	122°24'43.68"
2	159.0	10:30	1.9	46.22	47°34'30.70"	122°24'43.68"
12	192.0	9:00	2.1	42.17	47°34'30.37"	122°24'43.68"

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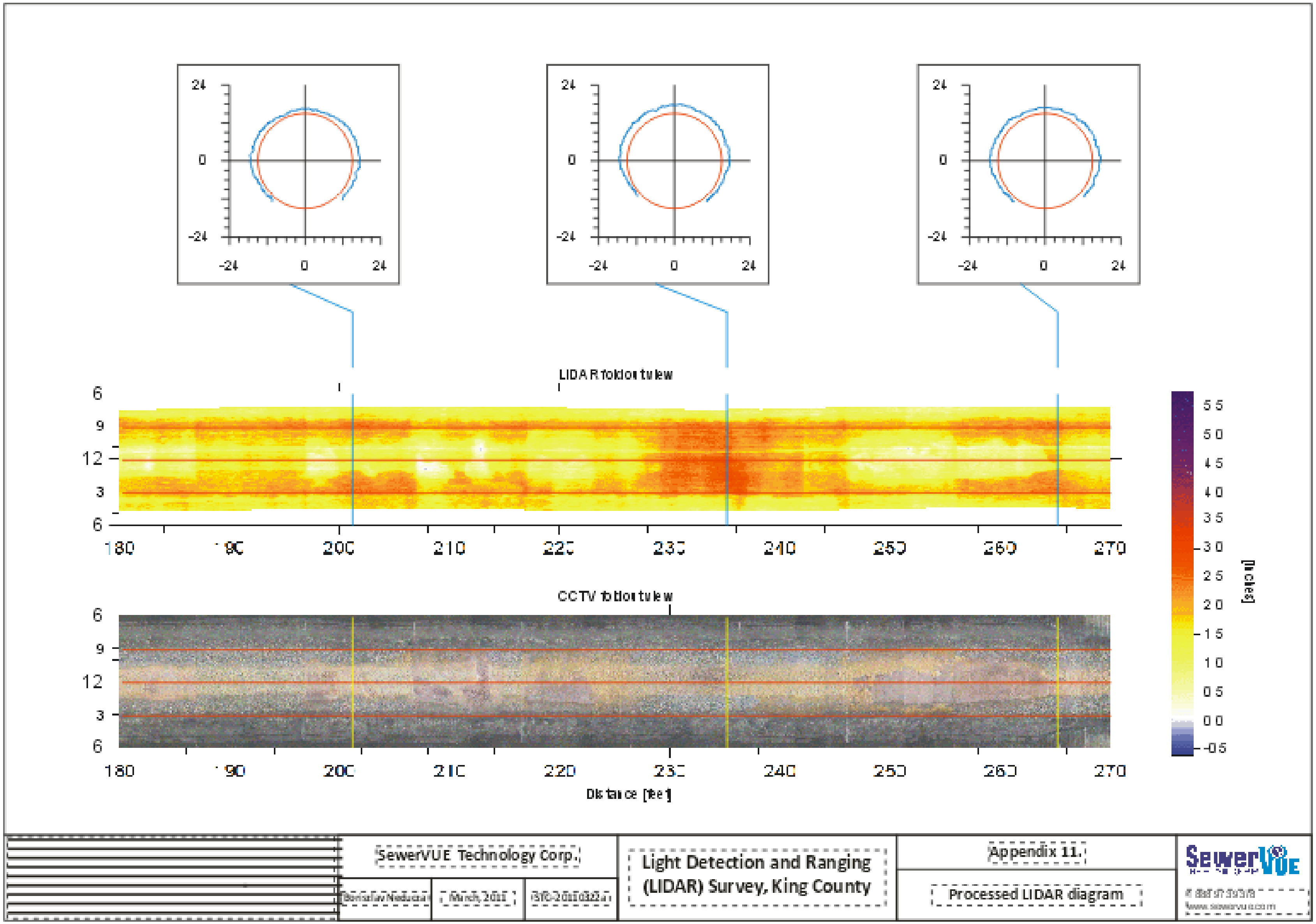
Measured pipe-wall thickness from PPR inspection

LIDAR Data (King Co., WA)



Unique Pipe Wall Attributes

Pipe wall thickness → Benefit → Determine extended **pipe life**

Placement of **metal reinforcement** → Benefit → Verify pipe **design strength**

See through soft concrete (H_2S **corrosion)** → Benefit → True pipe wall condition, and **integrity**

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Unique Pipe Zone Attributes

Voids surrounding the pipe

.

Benefit → **Eliminate failure & liability**

Missing gaskets and **joint configuration**

Benefit → Remedy impact of joint condition to **control leakage**

Accurate determination of **grout placement**

Benefit → **Verify structural integrity** of rehab methods

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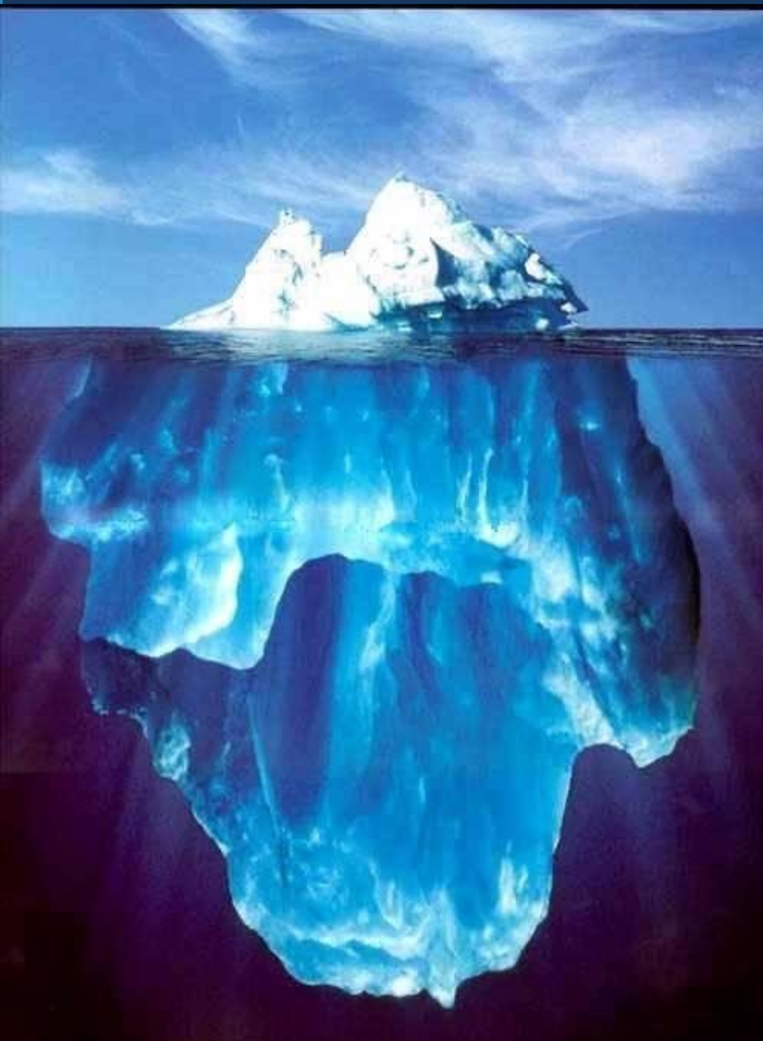
Sometimes What You Don't See is the Most Important



Questions and Contact

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