City of Winnipeg

600 mm Kildonan-Redwood Feeder Main

Condition Assessment Report, Standard Analysis

PICA- Pipeline Inspection & Condition Analysis Corporation
(A Subsidiary of Russell NDT Holdings Ltd.)

24in Potable Water Chimera RFT ILI Tool

600mm CML Spiral Welded Steel Pipe

Red River Crossing – RFP 495-2018

Redwood Ave from Main St to Glenwood Cr

Winnipeg, Manitoba

PICA Project: 8054

Inspection Date:	March 26-27, 2019
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City of Winnipeg:

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Executive Summary

PICA, under contract with the City of Winnipeg (RFP 495-2018), inspected two 24in river crossing feeder mains for the City of Winnipeg using Remote Field Testing (RFT) Technology from March 26-28, 2019. The inspected lines are referred to as the Kildonan-Redwood Feeder Main and the Charleswood-Assiniboia Feeder Main. This report documents the inspection results for the 24in Kildonan-Redwood line, which crosses beneath the Red River. The inspected portion spanned between chambers on the east and west sides of Red River (refer to the line map in Figure 4). The inspection was performed on March 26 and 27, 2019, with a supplementary visual inspection of accessible piping performed on March 30th. This report documents PICA's findings.

In general, the feeder main was found to be in good condition. Nine (9) pipes were found to show evidence of pitting corrosion with a total of 18 localized pitting indications reported. Of these 18 indications, 11 indications measured to be "shallow" (≥65% RW), and 7 indications measured to be "medium" (40-64% RW).

A listing of all logged anomalies together with detailed analysis information can be found in the companion document, "*PICA Inspection Results - 24in Kildonan Feeder Main (rev1.1).xlsx*". Figure 1 and Figure 2 illustrate the axial and circumferential distribution of localized defect indications along the Kildonan-Redwood Feeder Main. Note that some data points partially overlap due to proximity. Clock position information cannot be provided for the low confidence indication within the vertical pipe 0340, so it is not shown in Figure 2.

A condition assessment summary detailing the top three defect indications, minimum and maximum circumferential remaining wall, and pipe average remaining wall (PARW) values for each pipe segment (greater than 2.11m in length) of the Feeder Main river crossing is provided in Figure 3. One pipe segment (0210) had a recorded average wall thickness more than 115% remaining wall, indicating a different pipe type with heavier wall thickness compared to those specified in construction records provided to PICA. Pipe segment 0340 is a single vertical pipe located in the chamber shaft on the west side of the Red River. This pipe segment has a greater nominal wall thickness value (12.7mm) than the other pipes (7.9mm) and was therefore scanned using a different frequency during the RFT inspection.

Various areas of interest were identified during a visual inspection of accessible piping within the Tunnel located on the west side of the river. These areas of interest included damage to the coating in the form of gauges and scratches, and imprints possibly left from transport or construction equipment. No visual damage to the external coating was observed at the anomaly locations flagged in the RFT data.

Table 1. Overview of the RFT findings for the 600mm Kildonan-Redwood Feeder Main

Table 1: Feature Indication Summary	
Inspected Length	237.76m
Number of Pipe Sections:	34
Number of Analyzed Pipe Sections:	34
Number of Elbows:	One 90° (Long Rad. CI, 25.4mm NWT)
Thinnest circumferential pipe wall (Tcircmin) (RW%):	96% (in pipe 0140)
Number of pipes without localized wall loss indications:	25
Number of pipes with localized wall loss indications:	9
• **Number of indications with >65% RW:**	11
• **Number of indications with 40-65% RW:**	7
• **Number of indications with <40% RW:**	0
Total number of wall loss indications reported:	18
Total Number of Connections:	34
• **Number of Flange-Pair Connections:**	25
• **Number of Victaulic Couplings:**	5
• **Number of Dresser Couplings:**	1
• **Number of Welds**	3
Number of Open Flange Faces:	1

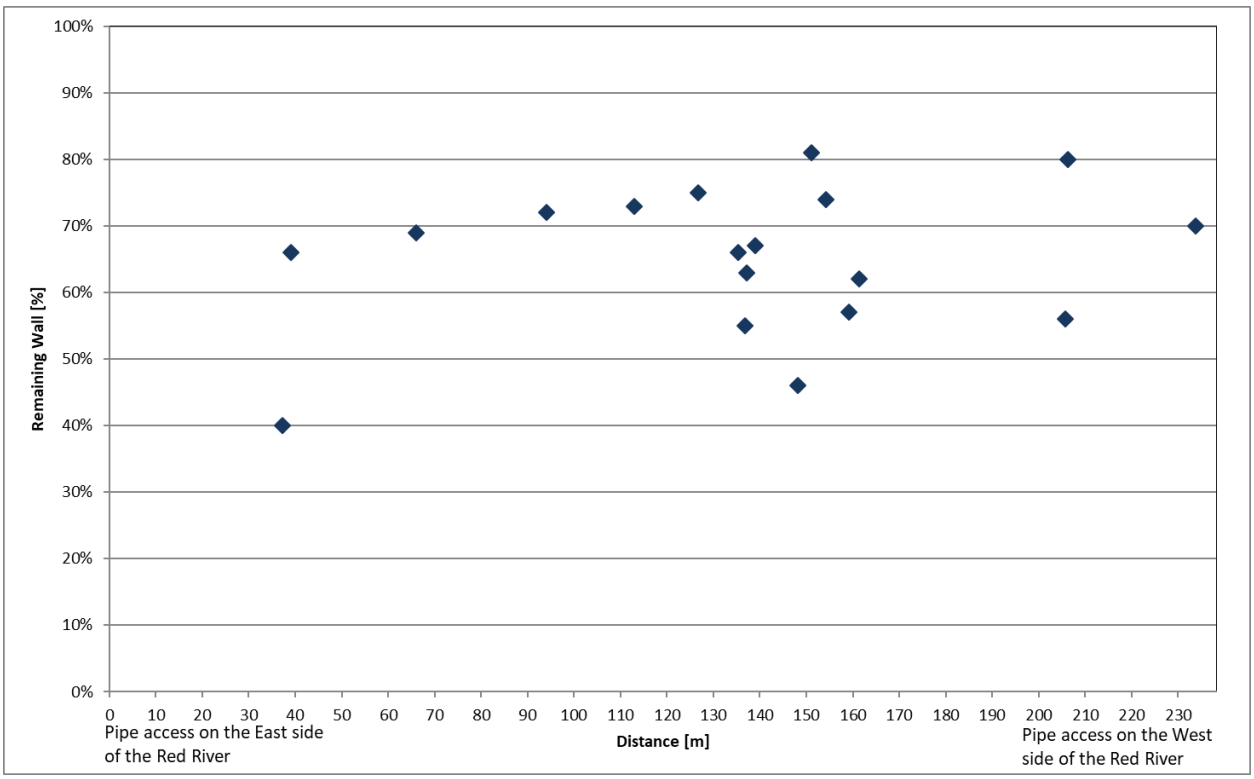

Figure 1. Axial distribution of defect indications and remaining wall (%) within the scanned length of the Kildonan-Redwood Feeder Main

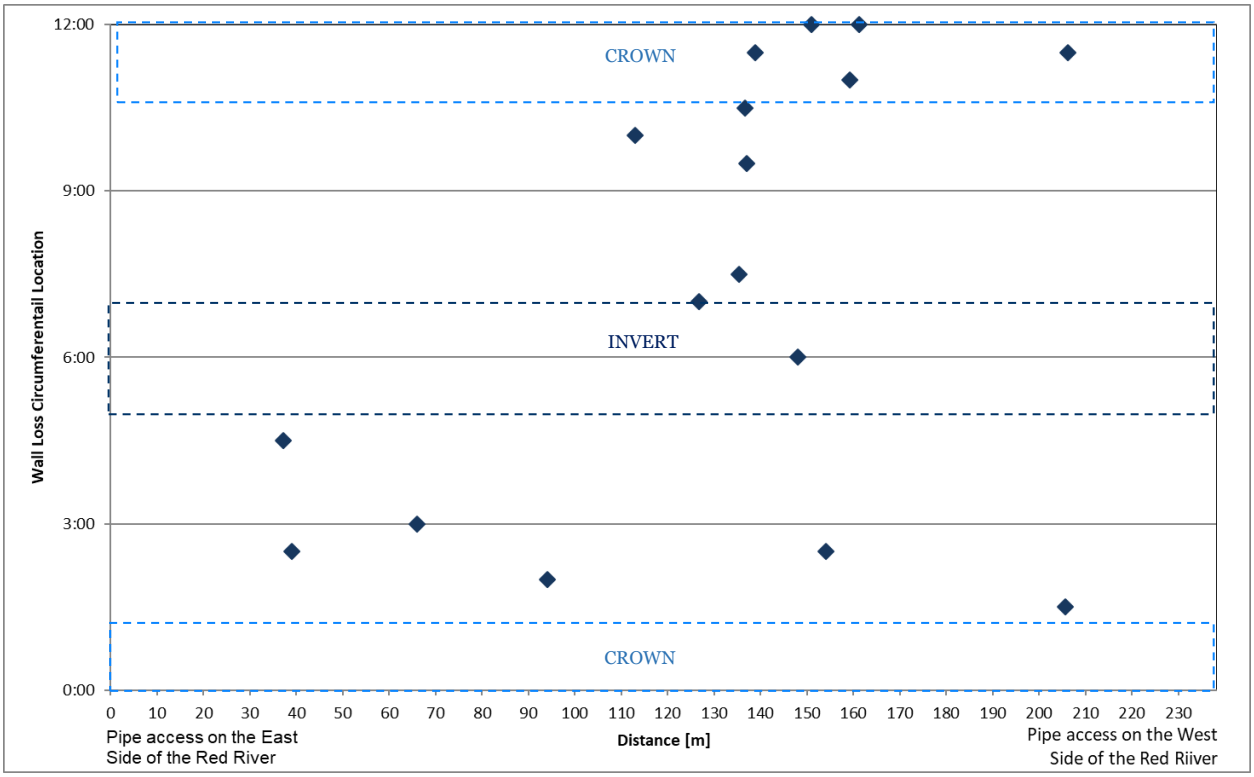

Figure 2. Circumferential distribution of pitting regions along the Kildonan-Redwood Feeder Main, described with clock positions referenced by looking from east to west. Note that the defect reported in pipe 0340 is not included in chart as clock position information is not available for this pipe.

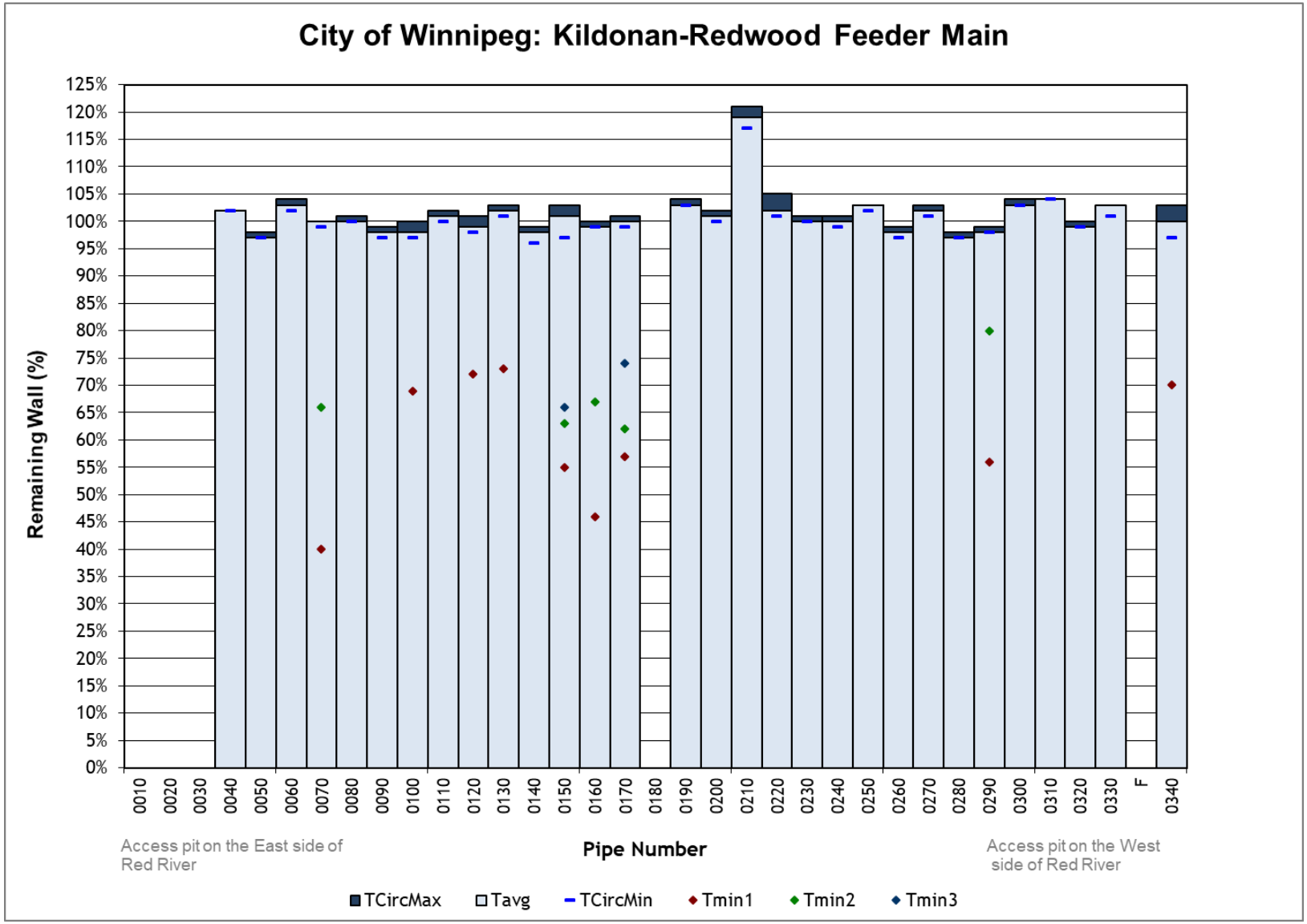

Figure 3. Condition assessment summary for the Kildonan-Redwood Feeder Main. Pipes less than 2.11 meters in length were not analyzed for pipe average remaining wall values. Pipe 0340 is the vertical pipe on the west side of the Red River and has a wall thickness of 12.7mm, differing from 7.9mm pipe wall thickness which was documented for the horizontal piping in drawing 12530. This pipe's Tavg is set to 100%.

Pipeline Inspection Background

The Kildonan-Redwood Feeder Main is a 600mm (24-inch) diameter steel main transporting potable water. A dual tethered Remote Field Technology (RFT) inspection of the feeder main was conducted by PICA on March 28th, 2019. The section inspected by PICA crosses beneath the Red River and extended between two access chambers east and west of the river (located along Redwood Avenue).

Table 2. Pipeline and RFT inspection information for the 600mm Kildonan-Redwood Feeder Main river crossing

Client:	City of Winnipeg	
Location:	Redwood Ave from Main St to Glenwood Cr Winnipeg, Manitoba	
Line Name/ Identifier:	Kildonan-Redwood Feeder Main	
Product:	Potable Water	
Pipe Diameter:	600 mm (24-inch)	
Material:	Steel, spiral welded; One Cast Iron elbow (90°)	
NWT:	(Steel) 7.9 mm (horizontal piping) and 12.7 mm (vertical pipe)	
Grade:		
Internal Liner:	Coal Tar Epoxy, ~4mm thick	
External Coating:	Asphalt dipped felt	
Bends:	Mitered: Two 20°; 13°, 7°, 12°; Radiused: one LR CI 90° elbow	
Joint Type:	Welding Flanges; Victaulic couplings; Welds	
Age:	65 yrs. (1954)	
RFT Inspection Access Locations:	Chambers east and west of river, along Redwood Ave	
	Elevation	**GPS Coordinates**
East Chamber:	231m	49°54'56.81"N, 97°07'30.55"W
West Chamber:	232m	49°54'59.55"N, 97°07'40.96"W
RFT Inspection Length:	**Vertical Portion:** 10.80m	**Horizontal Portion:** 225.60m
Reported Inspection Direction:	East to West	

The Kildonan-Redwood Feeder Main was divided into two inspection lengths separated by a 90-degree cast iron elbow. Due to the unknown ID of the cast iron elbow, it was not attempted to pull the Chimera tool through the elbow. The 90-degree cast iron elbow is located at the bottom of the West Chamber, within an access tunnel that extends approximately 49.02 meters southeast towards the river. The 600 mm Feeder Main runs through this tunnel, and past the end of the tunnel to the opposite bank of the Red River.

The two inspection lengths are:

1) Vertical pipe section at the West Chamber (10.80m length) extending down to the 90-degree elbow at the bottom of the vertical shaft.
2) Horizontal piping (225.60m length) from the East Chamber to the east facing flange face of the 90-degree cast iron elbow at the bottom of the vertical shaft at the West Chamber.

Figure 4 shows an overview map of the Kildonan-Redwood Feeder Main section inspected by PICA that crosses beneath the Red River, and the profile drawing of the Feeder Main section.

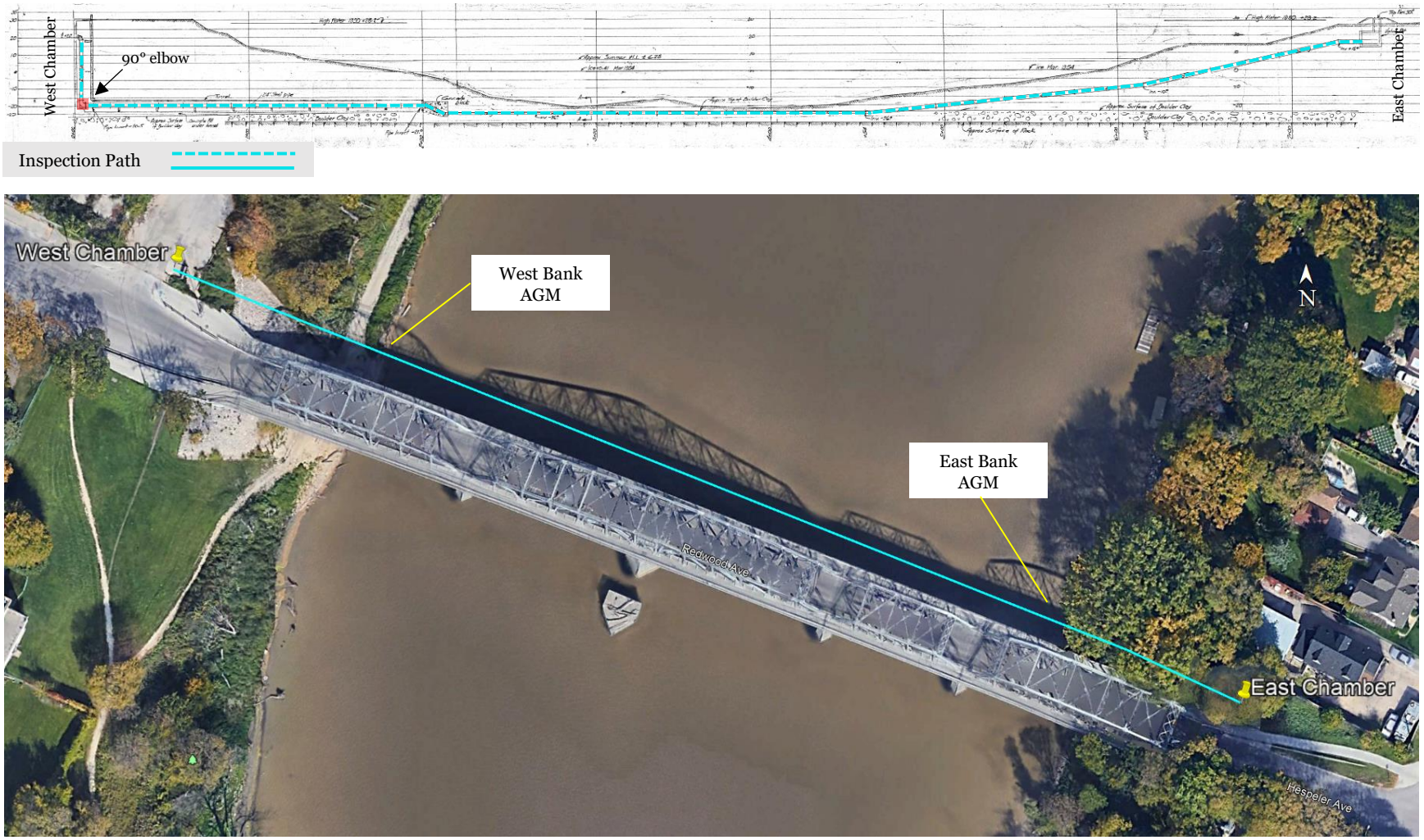

Figure 4. Profile drawing (Drawing No. 12529) and overview path map (Google Earth) of the Kildonan-Redwood Feeder Main that was inspected by PICA during the March 2019 mobilization, which crosses beneath the Red River (source: Google Earth)

Inspection Details

RFT Inspection Preparation

Prior to performing the RFT inspection, all available Critical Application Information (CAI) was reviewed including drawings and measurements of pipes and wall thicknesses provided by the client and subcontractor to ensure a successful inspection.

In advance of the RFT in-line inspection (ILI), the pipeline section was isolated, and a line cleaning was performed. A gauge pig was pulled through the horizontal portion of the Main by J-Con to confirm the minimum bore of the section and ensure Chimera RFT tool passage. A tagline was left through the entire length of the river crossing after preparatory activities for use during the RFT inspection of the Main.

To facilitate the inspection, winches were positioned at the East and West Chambers. The winchline at the West Chamber was connected to the tagline in the pipe. The tagline and connected winchline from the West side winch were pulled up on the East side of the river to be connected to the Chimera RFT ILI tool for the dual tethered inspection runs.

Before contacting the Main, the RFT Chimera tool assembly was sprayed with a 200mg/L free chlorine disinfecting solution (Figure 5). The tool was then lowered into the West Chamber to begin the inspection of the vertical piping section (Figure 6).

Figure 5. Disinfecting the Chimera assembly using a 200 mg/L free chlorine solution

Figure 6. Chimera tool being lowered into the chamber on the west side of the river crossing

RFT Inspection Procedure

Vertical Pipe at West Chamber

The vertical portion (on the west side of the river) of the Kildonan-Redwood Feeder Main was inspected first. The winch positioned at the West Chamber (Figure 8) was used to lower the tethered tool into the chamber and into the vertical piping (Figure 7). The winchline odometer as well as the on-board odometers were zeroed with the Chimera tool's odometer wheels flush with the pipe opening. For the first run, the RFT tool's detector module was leading (first to enter pipe) scanning at a frequency of 7 Hz.

Once the tool reached the 90-degree cast iron at the bottom of the vertical piping, the winch was stopped, and the pull was reversed to bring the Chimera tool back up to be extracted from the pipe.

Figure 7. Looking down into West Chamber from above. Chimera tool is in vertical steel pipe.

Figure 8. Winch set-up on west side of Red River.

Figure 9. East side of Red River winch set-up.

The total length of the vertical portion of the Main is documented as 10.91m, and was measured by the Chimera RFT tool's odometers as spanning 10.80 meters in length. Figure 10 shows an image taken from the tunnel showing the vertical piping extending from the tunnel up to the West Chamber.

A second run was performed with the Chimera's exciter module leading, and a third run with the detector module again leading, both runs completed at a frequency of 5 Hz. Once the tool was received for the final time at the top of the vertical shaft in the West Chamber, data was downloaded, and the Chimera was disconnected from the winchlines. The Chimera RFT tool was brought to the East Chamber to begin the inspection of the horizontal portion of the Feeder Main.

Figure 10. Looking up vertical shaft from tunnel. Image shows the vertical steel pipe portion of the Kildonan-Redwood Feeder Main.

Horizontal Pipe from East Chamber to Cast Iron Elbow

A second winch was positioned at the East Chamber (Figure 9) to enable a dual tethered inspection of the horizontal section of the Feeder main.

First, the winchline from the winch at the West Chamber was pulled through the pipeline to allow connection to the tool in the East Chamber.

The tool was lowered into the chamber on the East side of the river (Figure 11). Winchlines from the East and West access locations were connected to either end of the Chimera tool and the tool was then inserted into the pipe in the East Chamber with the detector module leading (facing west).

Figure 11. Chimera tool being lowered into East Chamber to inspect the horizontal portion of the Feeder Main.

Using the winches, the Chimera was pulled from the East Chamber (Figure 12, Figure 13) west towards the 90-degree elbow in the tunnel on the west side of the Red River. The tool scanned at a frequency of 14 Hz, traveling at a velocity of 2.1 m/min. Once the tool had reached the elbow, the pull was reversed, and the Chimera was brought back to the East Chamber. The distance the tool traveled (in one direction) for this portion of the pipeline was 225.60 meters, with data being collected successfully over the entire inspected length. The length of the inspected portion was measured from the open pipe end in the east chamber.

Figure 12. Chimera with trailing pig loaded into the pipe in the East Chamber.

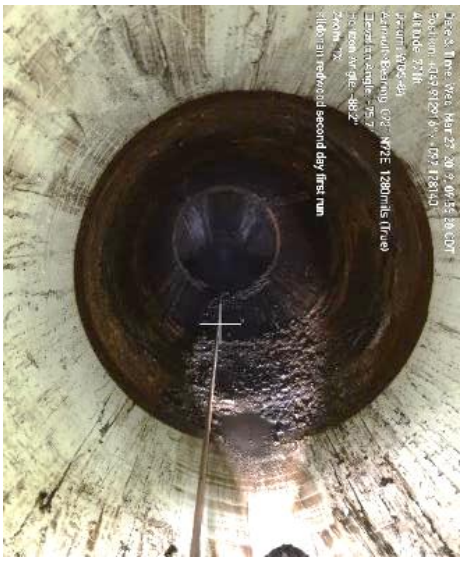

Figure 13. Looking into pipe from the East Chamber towards first downward deflection.

Due to the use of flange connections in the construction of this portion of the Feeder Main, multiple inspection runs were necessary to collect RFT data for the full length of the pipeline. As a result, two additional runs were completed on the following day; one inspection run was conducted at 14Hz, with the tool's exciter module leading, and one 10Hz inspection run was conducted with the detector module leading, targeting the tunnel section of the force main.

During the inspection of the horizontal section of the Feeder Main, PICA's custom Above Ground Monitors (AGMs) were used as an additional source of positional information. AGM units were positioned above the pipeline on both the east (Figure 14) and west (Figure 15) banks of the Red River so that the underwater portion of the Feeder Main could be identified in the data during analysis and reporting. These units are designed to pick up the signal from the RFT ILI tool and are used to track the location and time of passage of the tool during inspections.

Figure 14. AGM unit on the east side of the Red River, recording tool passage

Figure 15. AGM units on the west side of the Red River

Following the completion of the RFT inspection, a visual inspection was conducted on the horizontal portion of the Main that runs through the tunnel (Figure 16) on the west side of the Red River. Measurements were taken of construction features such as the straps, Victaulic couplings and flange pair connections (Figure 17). Details about the visual investigation can be found in the section ***Analysis Results – Visual Inspection***.

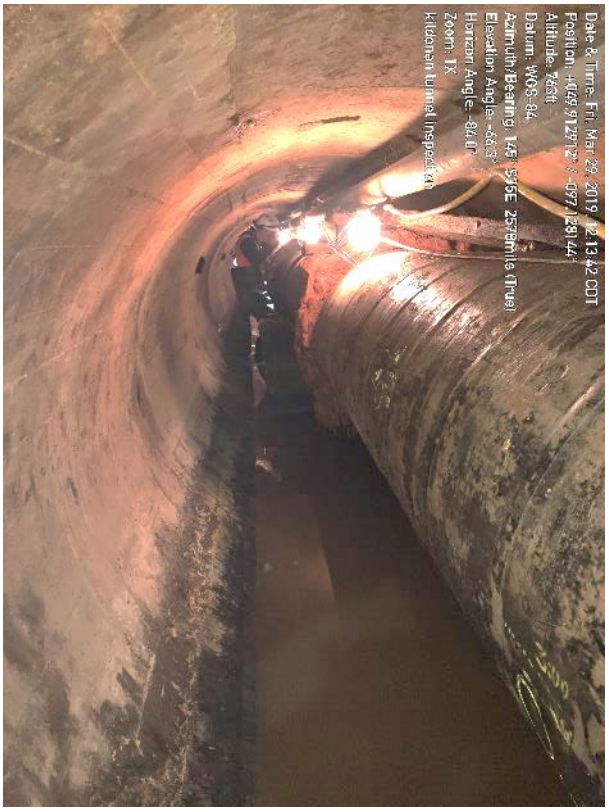

Figure 16. Visual investigation of the horizontal portion of the Kildonan-Redwood Feeder Main within the tunnel on the west side of the river.

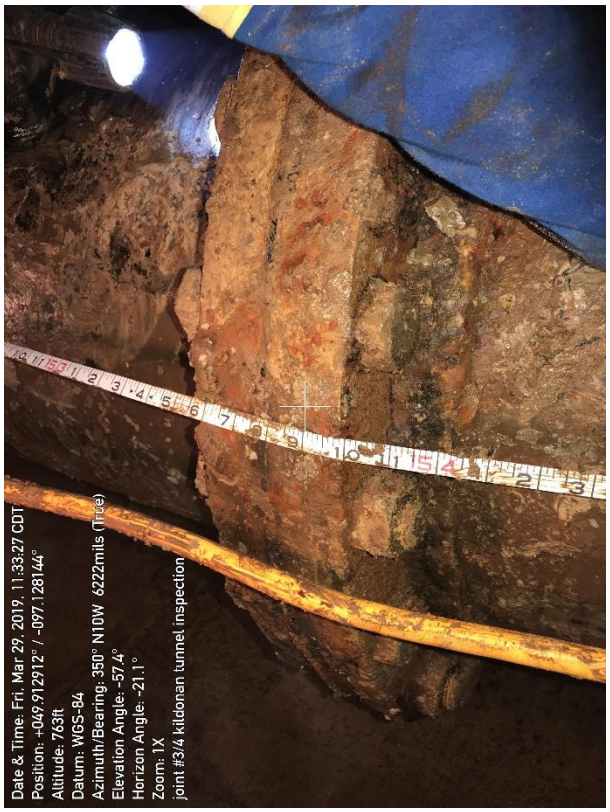

Figure 17. Measurements were taken of construction features within the horizontal portion of the pipe in the tunnel on the west side of the river.

Analysis Results

For reporting purposes, the Zero Reference Datum (ZRD) point was set to the open face of the pipe in the East Chamber. The End Reference Datum (ERD) was established at the open flange face at the top of the vertical pipe in the West Chamber. Pipe segments are therefore reported from east to west, and pitting indications described with clock positions referenced by facing west. Distances stated in this report refer to the distance from the ZRD at the East Chamber unless otherwise noted.

Multiple data sets were collected during the inspection of the Kildonan-Redwood Feeder Main. Three runs were completed within the vertical pipe section at the West Chamber, resulting in six data sets being collected. These runs were performed at 5Hz and 7Hz frequencies, and with the tool's orientation flipped for one of the runs.

Three runs were completed within the horizontal piping section of the Feeder Main, which also resulted in six data sets being collected. Two runs were performed at 14Hz with the detector and exciter orientation alternating, and one run was performed at 10Hz, with the tool's detector leading. For the 14Hz inspections, only the launch portions (east to west runs), were acquired at the optimal inspection velocity. The 10Hz inspection run targeted the tunnel section of the force main, and an optimal inspection velocity was achieved for the launch portion of the inspection run from approximately 127.28m to the 90-degree elbow.

The three data sets gathered at the proper inspection velocities were compared and analyzed for defect indications, with recorded indications correlated between the data sets. This provides a high level of confidence in the location and sizing of the reported defect indications. Odometer and Inertial Measurement Unit (IMU) data were compared between all six data sets.

Location Reporting, Pipe Lengths & Features

Resource information collected and reviewed during the inspection project was used to supply the most accurate summary of positional information for each of the reported potential wall loss indications. This information included data collected by an Inertial Measurement Unitwhich recorded the pitch, yaw and roll of the Chimera tool as it was pulled through the pipeline; AGM passage locations; and physical measurements of accessible piping. This information was compared with the client supplied drawings of the Feeder Main and was used for corroboration of reported construction feature and wall loss indications.

A visual inspection was performed on the accessible portion of the Main that runs through the tunnel on the west side of the Red River. During the visual inspection, measurements of pipe lengths, connection types, and other key areas of interest were taken. Pipe segment lengths recorded with the Chimera tool's on-board odometers correlate well with the physically measured pipe segments within the tunnel.

The total length inspected of the Kildonan-Redwood Feeder Main was 237.76m. The Main was constructed with pipe segments of various lengths, most measuring around either 12.15m (~40.9 feet) or 4.25m (~13.9 feet). Some discrepancies were found between the client records and RFT findings. The length of the horizontal portion of the Feeder Main was expected to be 231.34 meters; however, during review of the data collected during the inspection, the length was

measured to be 225.60m. This 5.74m difference is thought to be mostly due to errors within the construction records, partially related to the piping modifications made for access in the East Chamber (pipe 0010).

Pipe number 0330 measured 2.0m shorter in length than described in client records (detail "11" in drawing No. 12530). Physical measurements were taken during the visual inspection, which confirmed the reported length of pipe 0330 to be 3.95m (instead of 6.09m).

The length of the 90-degree elbow at the bottom of the west shaft was estimated at 1.36m, based on the dimensions of an AWWA 90° long sweep bend found in the *CIPRA 2952 Cast Iron Pipe Handbook*.. The actual length of the elbow may differ from this estimated centerline length.

Pipe segments were connected primarily with flanges, though five Victaulic Couplings and one Dresser Coupling were also identified in client provided drawings. Record drawing number 12530 details two pipe segments joined with a Dresser Coupling (detail "5"), spanning 12'0" (3.66m) together. These two pipe segments measured 1.54 and 2.37 meters in length respectively, using odometer data that was recorded during the RFT inspection.

Two connections at the east side of the river crossing are thought to be welds, concurrent with suspected Dresser Style 63 connection rings. These two connections join pipe segments 0010 with 0020, and 0020 with 0030. Pipe 0010 is the white-painted pup piece that was welded to the main in the East Chamber. This pipe segment measures approximately 0.7m in length (please note that odometer data collected at the very beginning of the pipeline is poor in quality due to inconsistencies in the velocity of the RFT tool as it is brought up to the target inspection velocity). Figure 18 shows an image of the pup piece photographed in the East Chamber during one of the inspection runs.

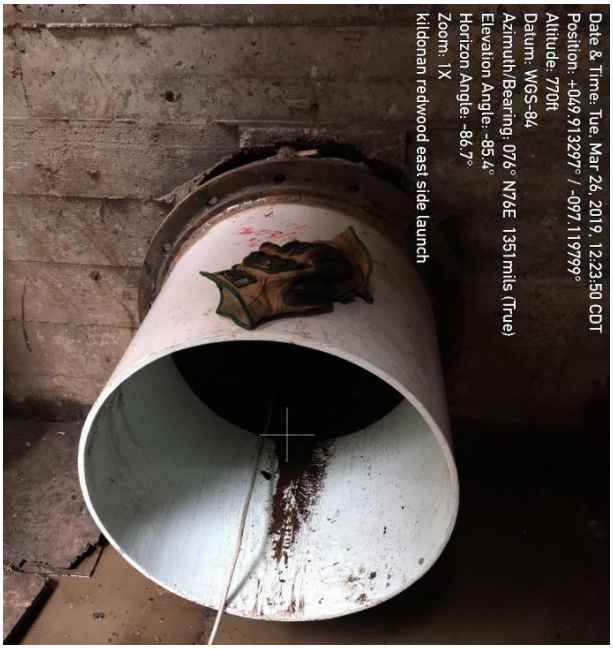

Figure 18. Short segment of pipe in the East Chamber.

A third girth weld was identified between pipes 0030 and 0040. At the connection between these two pipe segments, a pitch change of -6.0 degrees was recorded by the on-board IMU module, while a -5.6-degree pitch change was recorded at the flange connection between pipes 0040 and 0050. Client records provided to PICA report a 12-degree vertical bend between pipes detailed "9" (PICA pipe number 0050) and "10" (pipe 0040) (drawing 12530). This documented 12-degree bend is thought to be inaccurate, as the RFT weld indications as well as the corresponding pitch changes were recorded in all data sets collected during the condition assessment. Table 3 provides a summary of construction features noted in collected data from the inspection of the Kildonan-Redwood Feeder Main.

Table 3. Summary of construction features recorded during the RFT inspection of the 600mm Kildonan-Redwood Feeder Main. Connections not mentioned in table are flange pairs which make up most pipe connections.

Distance (m)	Pipe Number	Description
0.68	0020	Weld
1.43	0030	Weld
2.65	0040	Weld
163.75	0190	Dresser Coupling
166.58	0200	Possible Water Stop
172.62	0210	Strap
174.68	0220	Victaulic Coupling
175.31	0220	Possible Water Stop
180.60	0230	Strap
186.74	0240	Strap
187.49	0250	Victaulic Coupling
193.56	0260	Strap
199.73	0270	Strap
200.29	0280	Victaulic Coupling
206.41	0290	Strap
212.52	0300	Strap
213.10	0310	Victaulic Coupling
219.20	0320	Strap
221.64	0330	Victaulic Coupling
226.28	Between 0330, 0340	90-Degree Elbow**
229.96	0340	Stiffener
232.38	0340	Stiffener
235.11	0340	Stiffener

*Connection types refer to start of pipe number given

**90-degree elbow length is estimated based on the dimensions of an AWWA 90˚ long sweep elbow as documented on pg266 of the CIPRA 1952 Cast Iron Pipe Handbook.

General Wall Thickness

Pipe sections longer than 2.11m were analyzed to obtain the Pipe Average Remaining Wall (PARW) thickness calculated over the length of the inspected section. This value is reported as the "Tavg" RW in Table 4. The Chimera's sensor-exciter spacing (SES) is 2.11m, therefore pipe segments shorter than 2.11m were not analyzed for Tavg to ensure that the Chimera was not spanning between two or more separate pipes.

Due to manufacturing tolerances, fluctuations of ±15% in the individual PARW values are common. Variations outside the ±15% spread can be an indicator of a different nominal wall thickness or pipe type or point towards a problem like aggregate pitting or general wall loss. All pipes that were analyzed in the 600mm (24in) Kildonan-Redwood Feeder Main fall within this tolerance allowance, except pipe 0210. This pipe presented a clear baseline shift to a higher wall thickness which was observable in all data sets. This suggests a different pipe type with a larger nominal wall thickness (NWT) was used for stick 0210 in place of a pipe with a NWT of 7.9mm.

The vertical pipe segment 0340 was scanned with a lower frequency as the pipe has a thicker NWT value (12.7mm) than the majority of the Main (7.9mm). The Tavg for this pipe segment was 12.7mm (100%).

Local Wall Thickness

Nine (9) pipes show evidence of pitting corrosion with a total of 18 localized pitting indications reported. Of these 18 indications, 11 indications measured to be "shallow" (≥65% RW), and 7 indications measured to be "medium" (40-64% RW). Five of these indications have been reported with low confidence. Confidence levels are assigned based on signal strength, noise levels, signal reproducibility between RFT recordings, and sizing consistency between the recordings.

Table 4 details the three worst pitting indications per pipe (Tmin1, Tmin2 and Tmin3), as well as the average (Tavg), minimum circumferential (Tcircmin) and maximum circumferential (Tcircmax) remaining wall values for the inspected portion of the Kildonan-Redwood Feeder Main.

Colour maps can highlight wall loss, wall gain, and material stresses within the pipe. Figure 24 to Figure 34 in Appendix 1 show colour maps of the data for the medium-high confidence wall loss indications. Defect indications are highlighted in the figures with bounding boxes.

If AECOM and the City decide to perform verification and repair work on the onshore portions of the feeder main crossing, please let your PICA representative know. PICA can assist by providing dig sheets for the selected areas.

Data Quality

Prior to the inspection of the Kildonan-Redwood Feeder Main, the 24-inch Chimera RFT ILI tool was calibrated using a calibration pipe at PICA's shop. Details about the calibration can be found in Appendix 2.

Flange connections are difficult to assess. Flange pairs produce very large signals in the RFT data due to the amount of material present; these large flange signals can mask small wall loss indications at or adjacent to the connections. To mitigate the effects of the large RFT signal indications from flange pairs, the Chimera tool was pulled through the Main alternating between the detectors leading and exciter leading for each run. This maximizes the area of analyzable data collected on either side of these connections.

The nominal pipe wall thickness of the vertical pipe is considerably thicker than the calibration pipe. As a result, signal-to-noise levels are lower, and the one defect identified in the vertical portion is reported with low confidence.

Table 4. Summary of pipe tally and wall thickness readings for the Kildonan-Redwood Feeder Main

Pipe List and Wall Thickness Readings – 600 mm (24in) Kildonan-Redwood Feeder Main																
PICA Pipe #	Pipe Location***			Tavg RW	Circumferential Wall Thickness		Local Wall Thickness**									Comments
							Tmin1			Tmin2			Tmin3			
	Start (m)	End (m)	Length (m)		Tcircmax RW	Tcircmin RW	RW	Location (m)	Clock Position**	RW (%)	Location (m)	Clock Position	RW (%)	Location (m)	Clock Position	
0010	0.00	0.68	0.68													Prelim zero datum is the pipe opening at the east end of the line
0020	0.68	1.43	0.75													Start weld concurrent with suspected Dresser Style 63 Connection Ring
0030	1.43	2.65	1.22													Start weld concurrent with suspected Dresser Style 63 Connection Ring
0040	2.65	5.75	3.10	102%	102%	102%										-6.0° mitered vertical bend at start of segment
0050	5.75	16.39	10.64	97%	98%	97%										-5.6° mitered vertical bend at start of segment
0060	16.39	28.57	12.18	103%	104%	102%										
0070	28.57	40.62	12.05	100%	100%	99%	40%	37.20	4:30	66%	39.00	2:30				Two defect indications reported
0080	40.62	52.69	12.07	100%	101%	100%										mitered 6.2° vertical bend and 8° horizontal bend left (south) at start of segment

Pipe List and Wall Thickness Readings – 600 mm (24in) Kildonan-Redwood Feeder Main																
PICA Pipe #	Pipe Location***			Tavg RW	Circumferential Wall Thickness		Local Wall Thickness**									Comments
							Tmin1			Tmin2			Tmin3			
	Start (m)	End (m)	Length (m)		Tcircmax RW	Tcircmin RW	RW	Location (m)	Clock Position**	RW (%)	Location (m)	Clock Position	RW (%)	Location (m)	Clock Position	
																East side AGM is located at 46.51m
0090	52.69	64.85	12.16	98%	99%	97%										
0100	64.85	77.06	12.21	98%	100%	97%	69%	66.03	3:00							One defect indication reported
0110	77.06	89.22	12.16	101%	102%	100%										
0120	89.22	101.40	12.18	99%	101%	98%	72%	94.15	2:00							6.0° mitered vertical bend One defect indication reported
0130	101.40	113.59	12.18	102%	103%	101%	73%	113.01	10:00							One defect indication reported
0140	113.59	125.75	12.16	98%	99%	96%										
0150	125.75	137.94	12.19	101%	103%	97%	55%	136.74	10:30	63%	137.15	9:30	66%	135.39	7:30	Four defect indications reported
0160	137.94	150.14	12.20	99%	100%	99%	46%	148.13	6:00	67%	138.92	11:30				Two defect indications reported
0170	150.14	162.22	12.08	100%	101%	99%	57%	159.19	11:00	62%	161.37	12:00	74%	154.17	2:30	Four defect indications reported
0180	162.22	163.76	1.54													30.0° mitered vertical bend at start of segment
0190	163.76	166.14	2.37	103%	104%	103%										-30.0° mitered vertical bend at end of segment. Possible water stop at 166.58m.

Pipe List and Wall Thickness Readings – 600 mm (24in) Kildonan-Redwood Feeder Main

PICA Pipe #	Pipe Location***			Tavg RW	Circumferential Wall Thickness		Local Wall Thickness**									Comments
							Tmin1			Tmin2			Tmin3			
	Start (m)	End (m)	Length (m)		Tcircmax RW	Tcircmin RW	RW	Location (m)	Clock Position**	RW (%)	Location (m)	Clock Position	RW (%)	Location (m)	Clock Position	
0200	166.14	170.43	4.29	101%	102%	100%										West side AGM is located at 173.54m
0210	170.43	174.68	4.25	119%	121%	117%										Strap located at 172.6m. Possible water stop at 175.31m
0220	174.68	178.97	4.29	102%	105%	101%										
0230	178.97	183.24	4.27	100%	101%	100%										Strap located at 180.6m
0240	183.24	187.50	4.26	100%	101%	99%										Strap located at 186.7m
0250	187.50	191.76	4.26	103%	103%	102%										
0260	191.76	196.03	4.26	98%	99%	97%										Straps located at 193.6m
0270	196.03	200.30	4.27	102%	103%	101%										Strap located at 199.7m
0280	200.30	204.57	4.27	97%	98%	97%										
0290	204.57	208.84	4.27	98%	99%	98%	56%	205.66	1:30	80%	206.24	11:30				Strap located at 206.4m Two defect indications reported
0300	208.84	213.11	4.26	103%	104%	103%										Strap located at 212.5m
0310	213.11	217.37	4.26	104%	104%	104%										
0320	217.37	221.65	4.28	99%	100%	99%										Strap located at 219.2m
0330	221.65	225.60	3.95	103%	102%	101%										
F	225.60	226.96	1.36*													90° elbow

Pipe List and Wall Thickness Readings – 600 mm (24in) Kildonan-Redwood Feeder Main																	
PICA Pipe #	Pipe Location***			Tavg RW	Circumferential Wall Thickness		Local Wall Thickness**									Comments
							Tmin1			Tmin2			Tmin3			
	Start (m)	End (m)	Length (m)		Tcircmax RW	Tcircmin RW	RW	Location (m)	Clock Position**	RW (%)	Location (m)	Clock Position	RW (%)	Location (m)	Clock Position	
0340	226.96	237.76	10.80	100%	103%	97%	70%	232.84	Not available							Vertical west shaft. One defect indication reported. End datum at open flange face in west chamber.

*90-degree elbow length is estimated based on the dimensions of an AWWA 90˚ long sweep elbow as documented on pg266 of the CIPRA 1952 Cast Iron Pipe Handbook.
**Clock positions are reported clockwise facing west. Clock positions are not available for defects in the vertical west pipe segment.
***Reported pipe segment lengths may not all be consistent with the segment start and end locations due to rounding.

Visual Inspection

A visual inspection was performed by PICA on the Kildonan-Redwood Feeder Main that was accessible within the tunnel on the west side of the Red River. The portion of the Main that runs through the tunnel is comprised of eleven (11) full pipe segments, eight (8) flange pairs, four (4) Victaulic Couplings, seven (7) straps, and a total measured distance of 49.02m from the end of the tunnel to the center of the flange connection between pipe 0330 and the 90-degree vertical elbow.

Asphalt-dipped felt was used to coat the exterior of the pipeline during construction of the Main. Though this coating was found to be in good condition over most of the accessible length, multiple areas of interest were identified and recorded. These areas of interest included damage to the coating in the form of gouges and scratches; imprints possibly left from transport or construction equipment; and potential repair points. Figure 19 to Figure 23 show some of the anomalies that were observed during the visual inspection. Note that the distances stated are measured from the 90-degree elbow flange connection at the bottom of the west shaft, east towards the end of the tunnel. Clock positions described are referenced by facing west.

Figure 19. Coating anomaly observed at the 3 o'clock position on pipe 0300, at 13.8m from the center of the flange pair connecting the 90-degree elbow to the first horizontal pipe.

Figure 20. Coating anomaly observed on pipe 0280, at 21.85m from the 90-degree elbow flange. Ridges can be seen pushed up in the coating, as well as what appears to be an imprint resembling fabric, possibly caused by a transport strap.

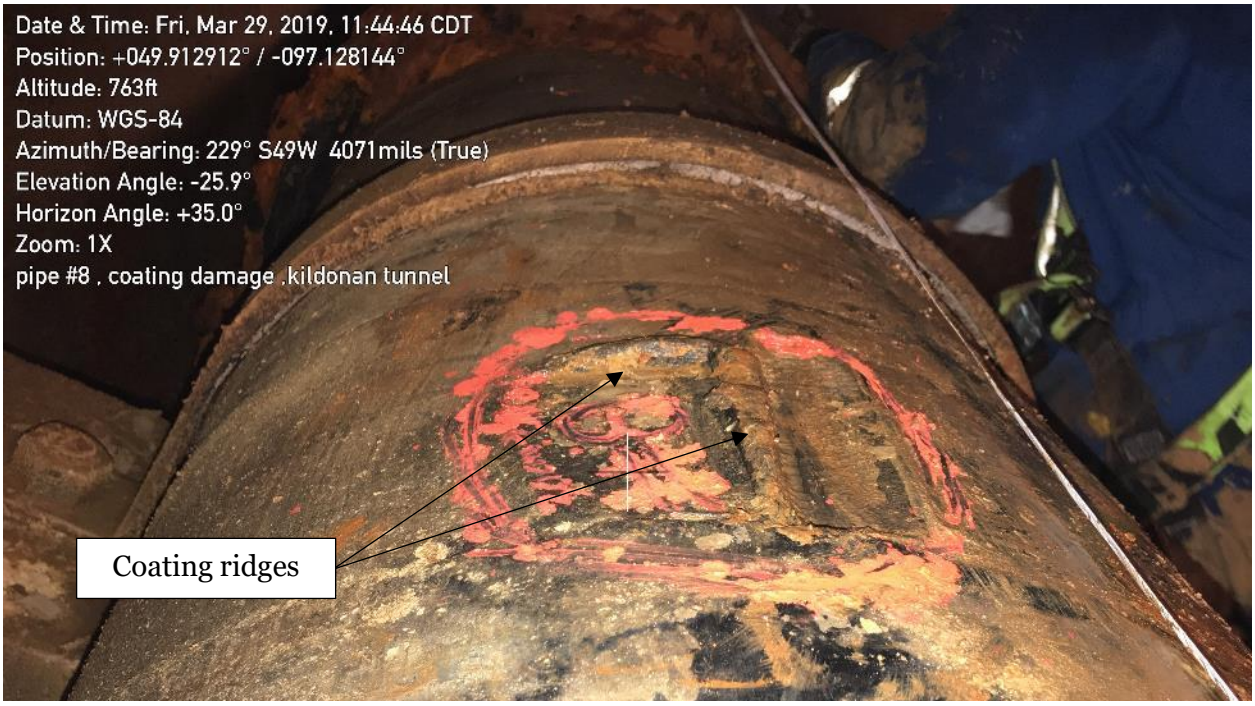

Figure 21. Coating anomaly observed on pipe 0270, at 26.4m from the 90-degree elbow flange.

Figure 22. Divot observed in coating material at the 1:30 clock position on pipe 0310, 10.5m west from the 90-degree elbow.

Figure 23. Coating loss at 2 o'clock position on pipe 0220, 47.33m from the 90-degree elbow flange.

Disclaimer – PICA Corporation

Scope of Services

The agreement of PICA Corp to perform services extends only to those services provided for in writing. Under no circumstances shall such services extend beyond the performance of the requested services. It is expressly understood that all descriptions, comments and expressions of opinion reflect the opinions or observations of PICA Corp based on information and assumptions supplied by the owner/operator and are not intended nor can they be construed as representations or warranties. PICA Corp is not assuming any responsibilities of the owner/operator and the owner/operator retains complete responsibility for the engineering, manufacture, repair and use decisions as a result of the data or other information provided by PICA Corp. Nothing contained in this Agreement shall create a contractual relationship with or cause of action in favor of a third party against either the Line Owner or PICA Corp. In no event shall PICA Corp's liability in respect of the services referred to herein exceed the amount paid for such services.

Standard of Care

In performing the services provided, PICA Corp uses the degree, care, and skill ordinarily exercised under similar circumstances by others performing such services in the same or similar locality. No other warranty, expressed or implied, is made or intended by PICA Corp.

Appendix 1: Colour Maps of Signal Indications

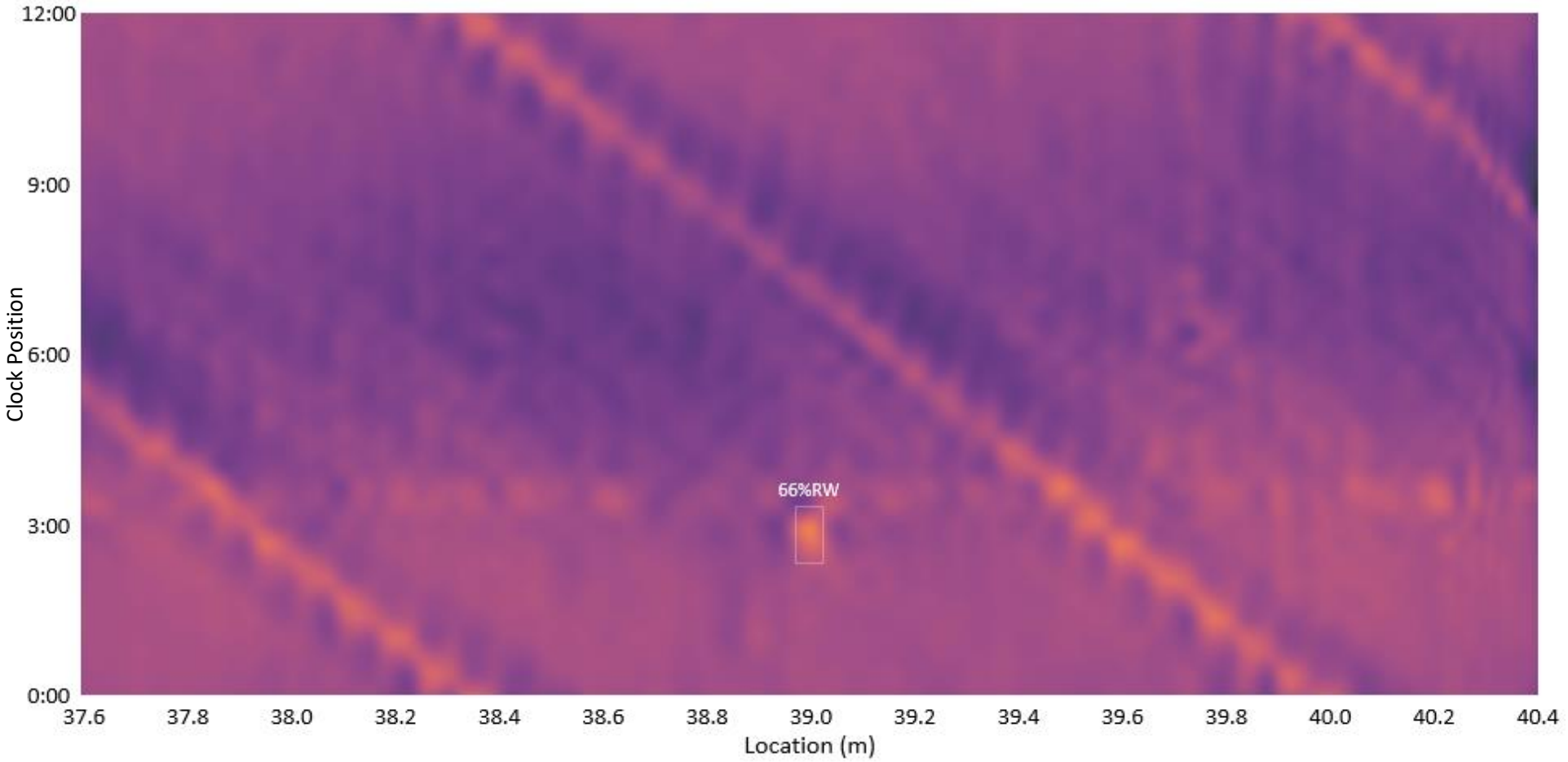

Figure 24. Pipe 0070 colour map showing 66% remaining wall indication, 39.00 meters from the ZRD.

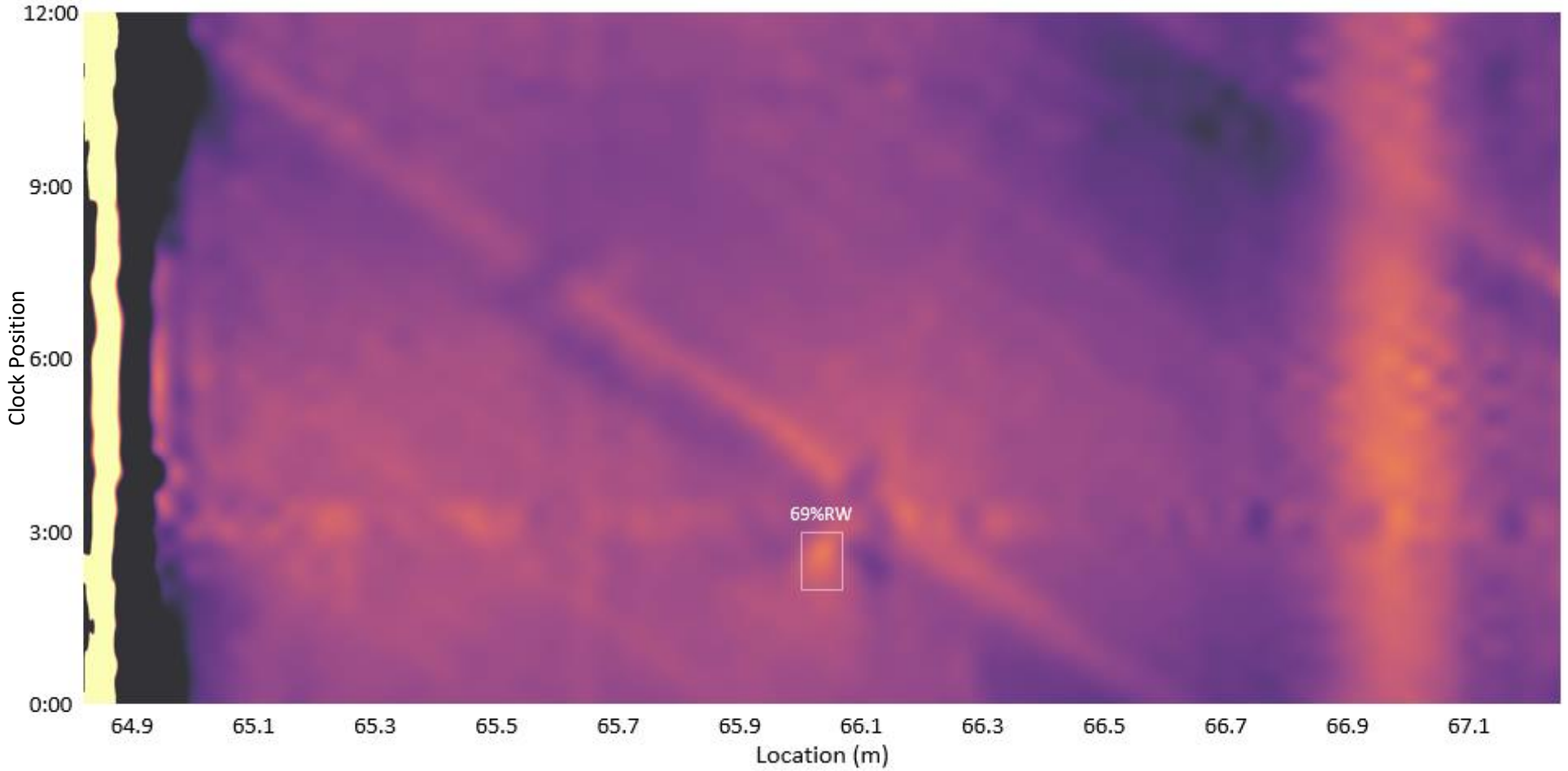

Figure 25. Pipe number 0100 colour map showing 69% RW indication, 66.03 meters from the ZRD.

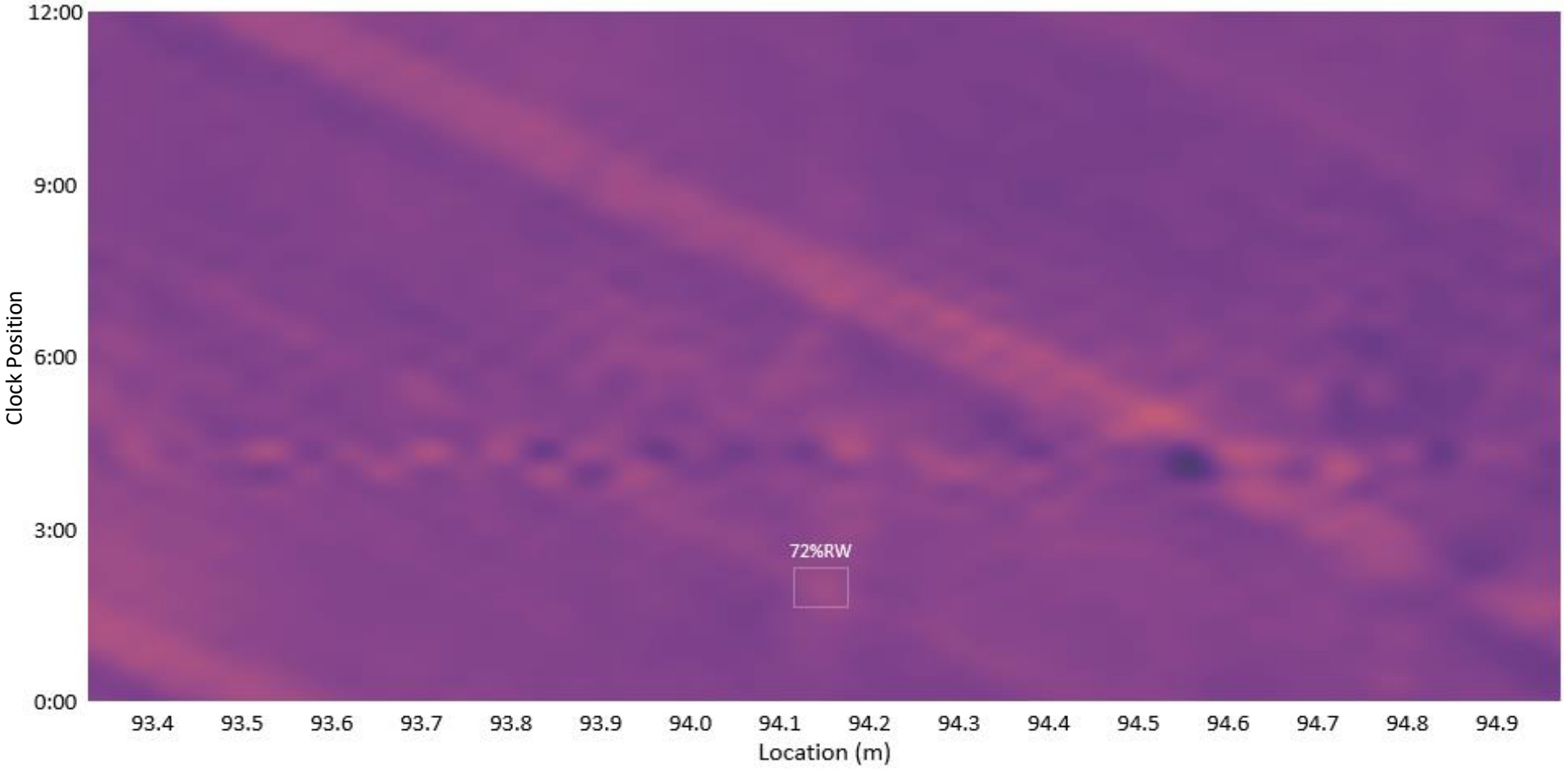

Figure 26. Pipe 0120 colour map of 72% RW indication, 94.15 meters from the ZRD.

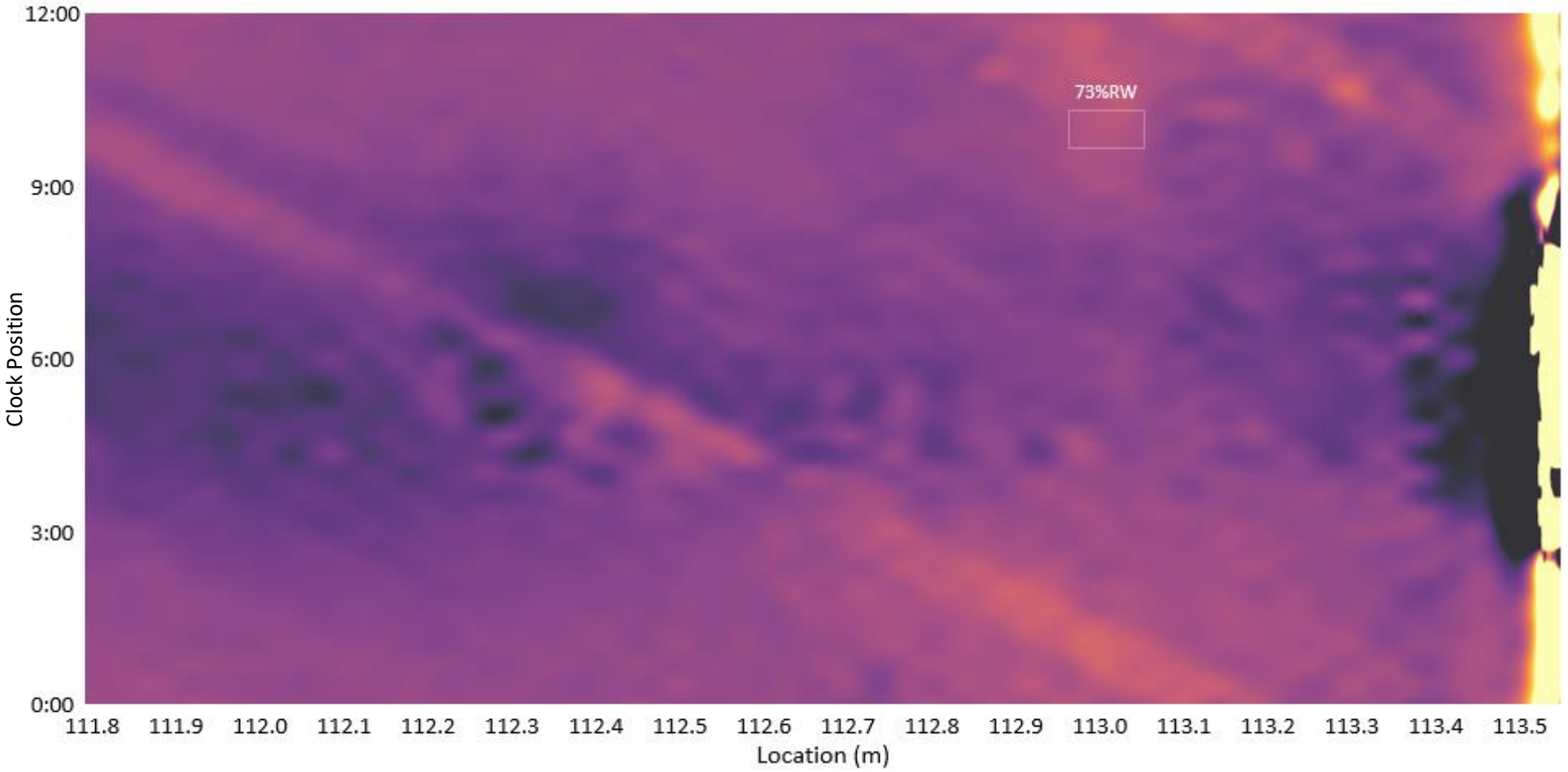

Figure 27. Pipe 0130 colour map showing 73% RW indication at 113.01 meters from the ZRD.

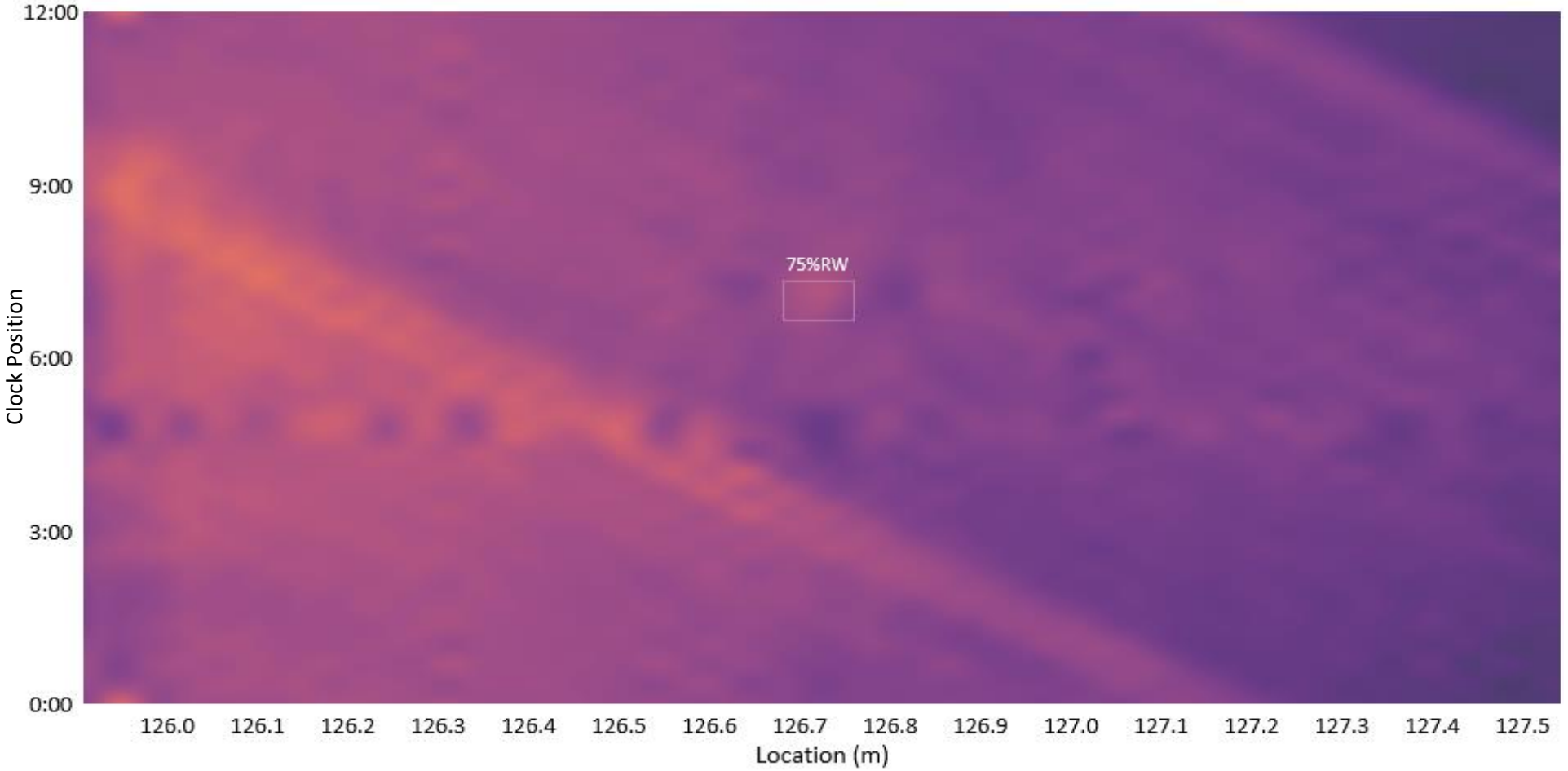

Figure 28. Pipe 0150 colour map showing 75% RW indication, 126.73 meters from the ZRD.

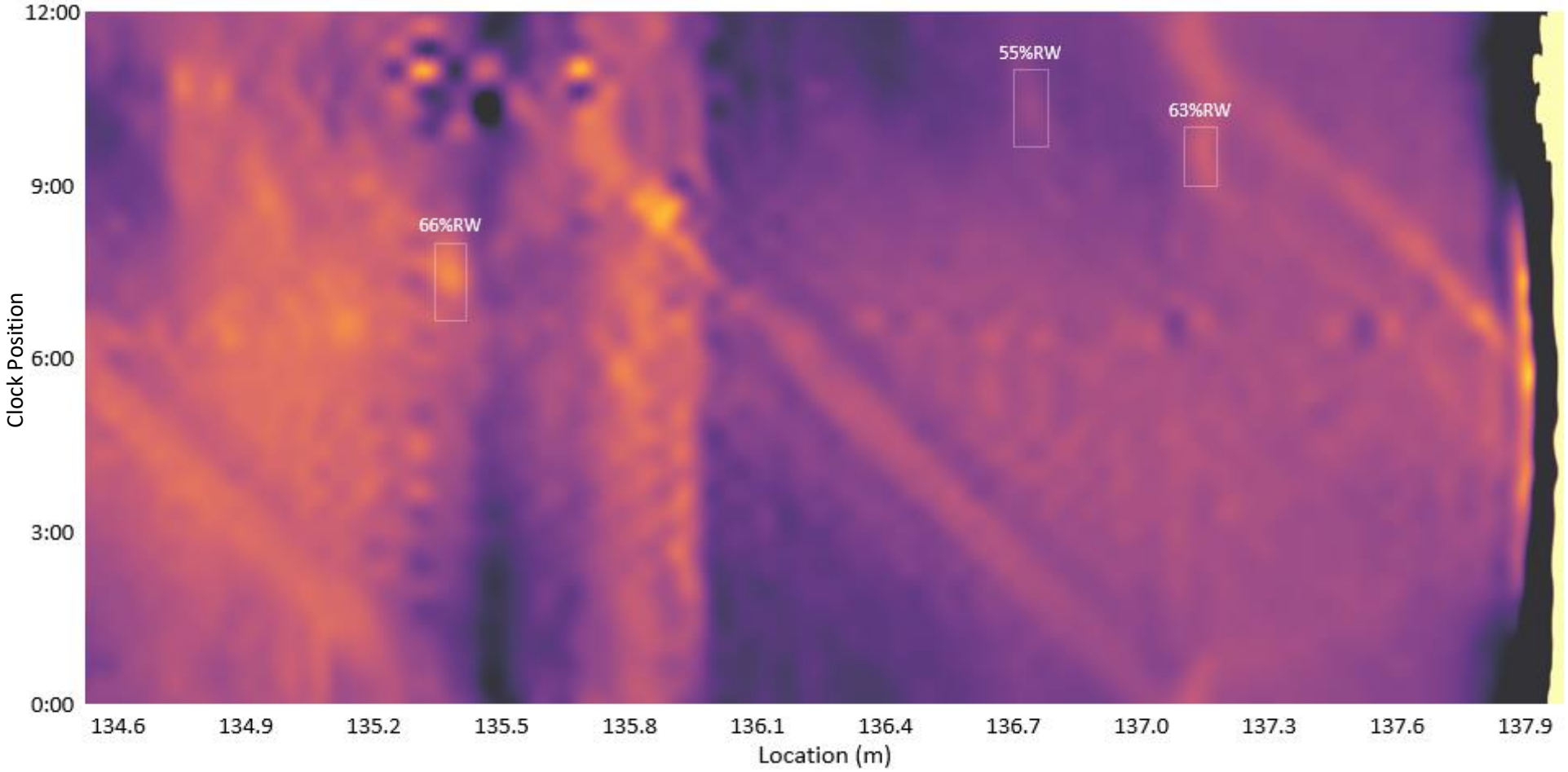

Figure 29. Pipe 0150 colour map showing the 66% RW, 55% RW, and 63% RW indications.

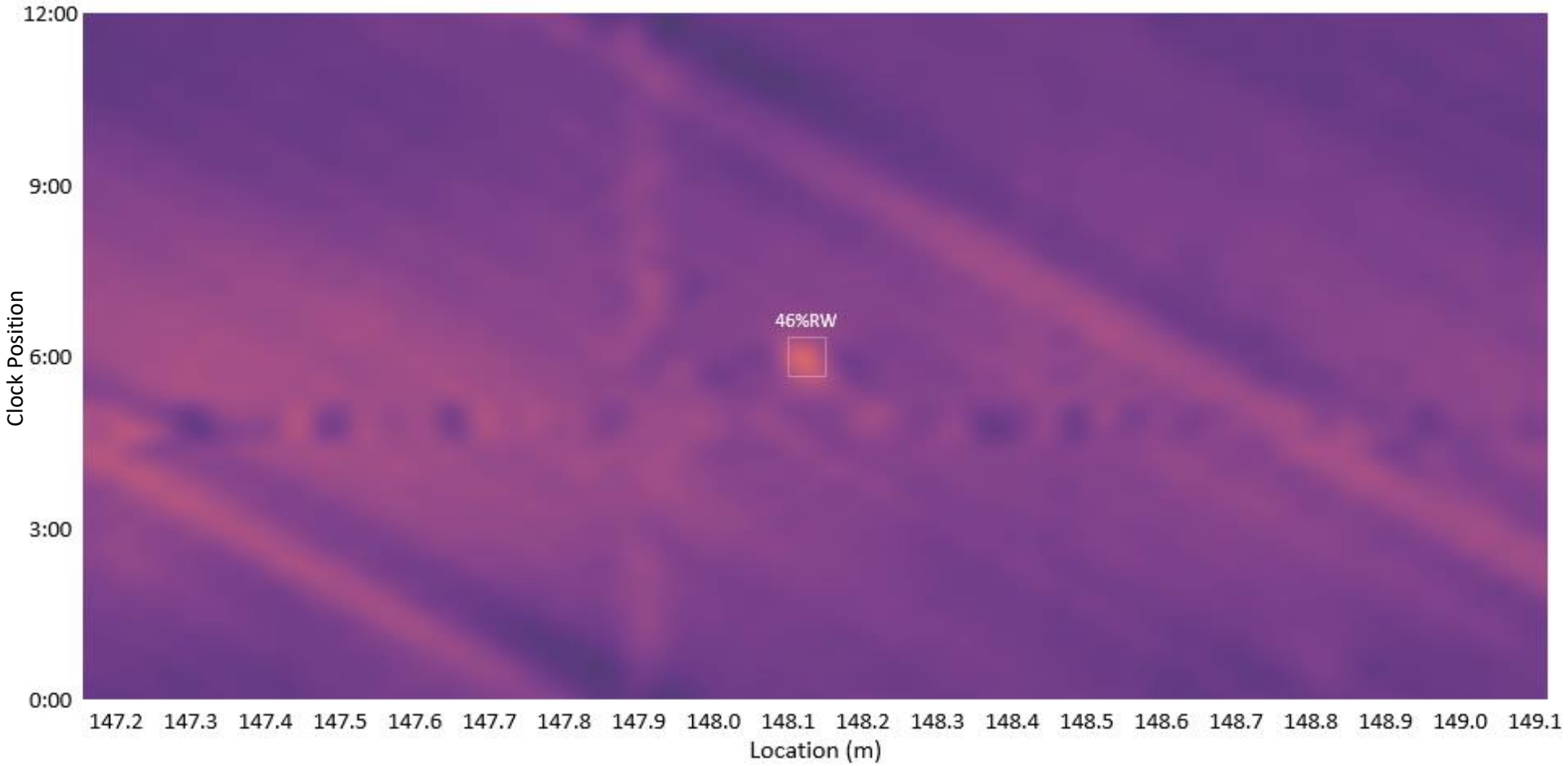

Figure 30. Pipe number 0160 showing the 46% RW indication, 148.13m from the ZRD.

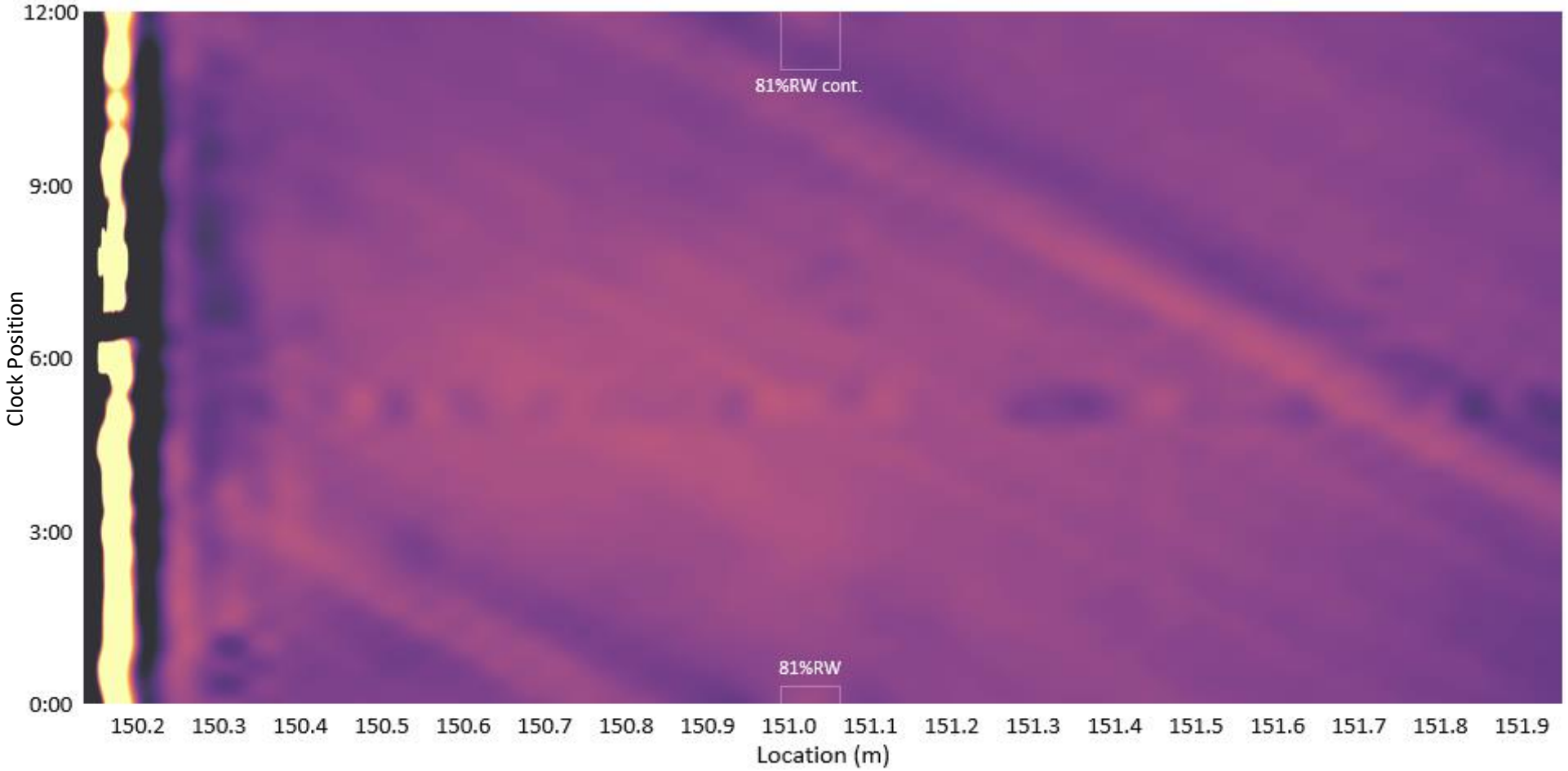

Figure 31. Pipe 0170 colour map showing 81% RW indication at 151.03m from the ZRD.

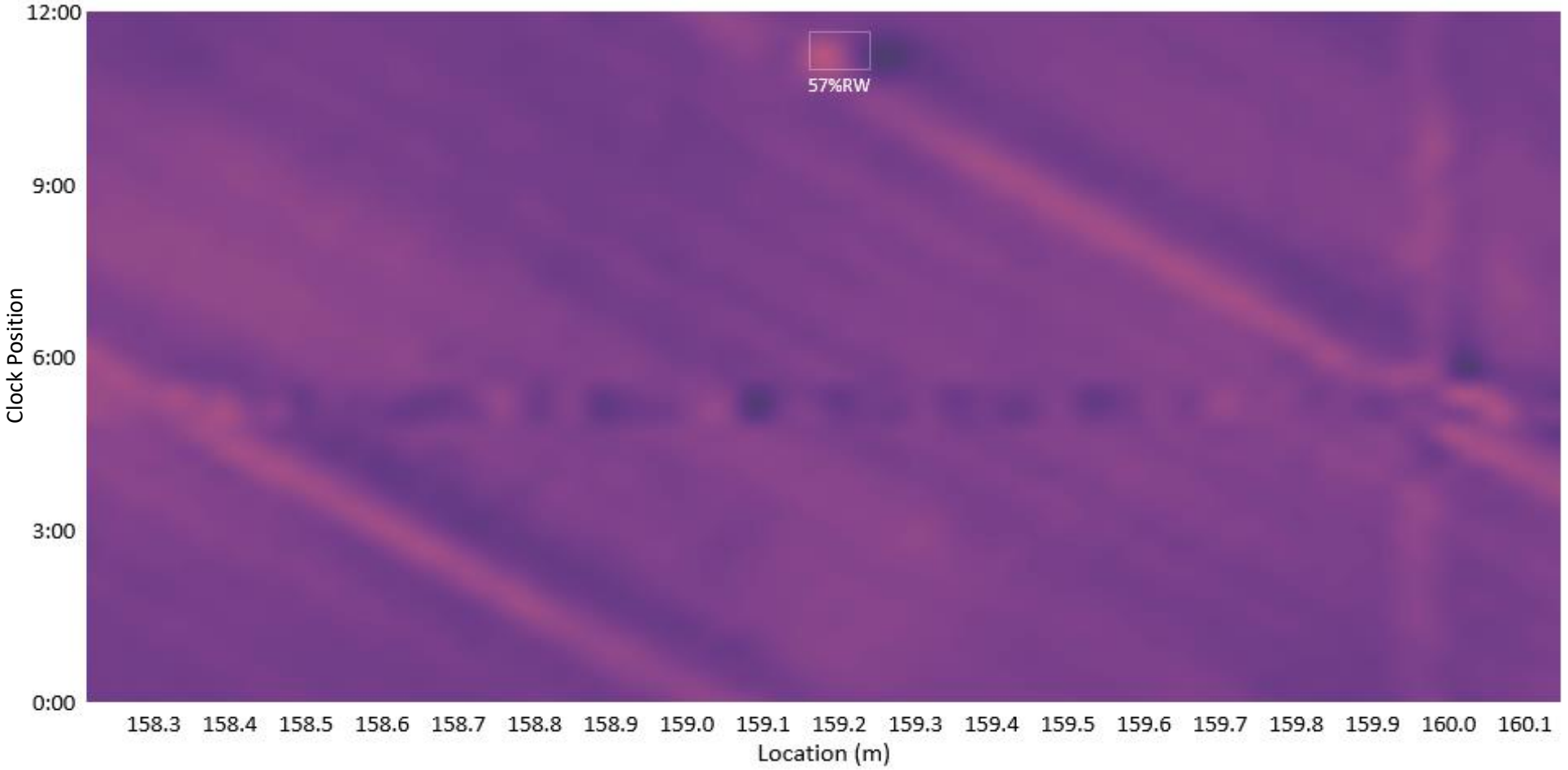

Figure 32. Pipe 0170 colour map showing the 57% RW indication, 159.19m from the ZRD.

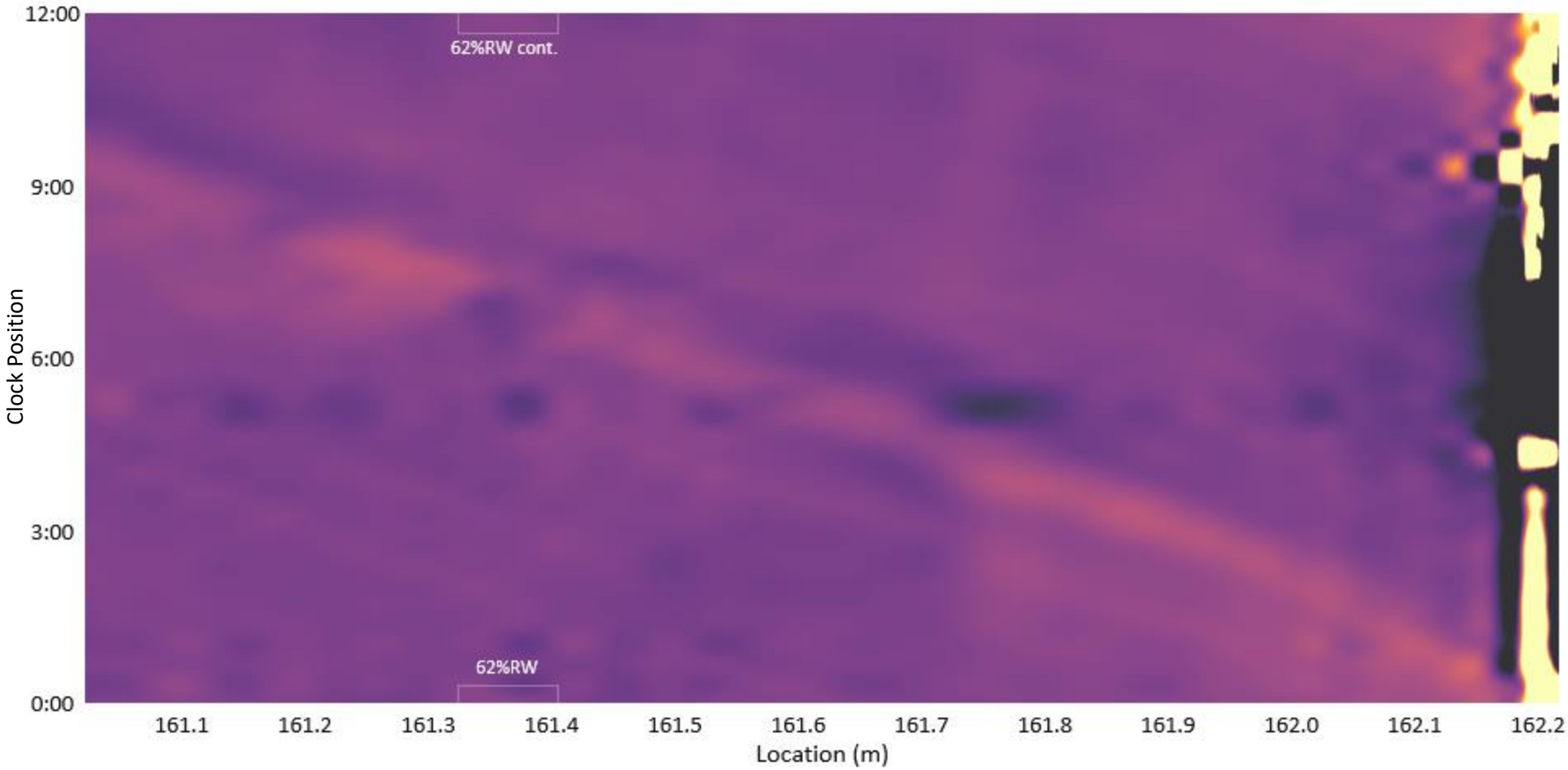

Figure 33. Pipe 0170 colour map showing the 62% RW indication, 161.37m from the ZRD.

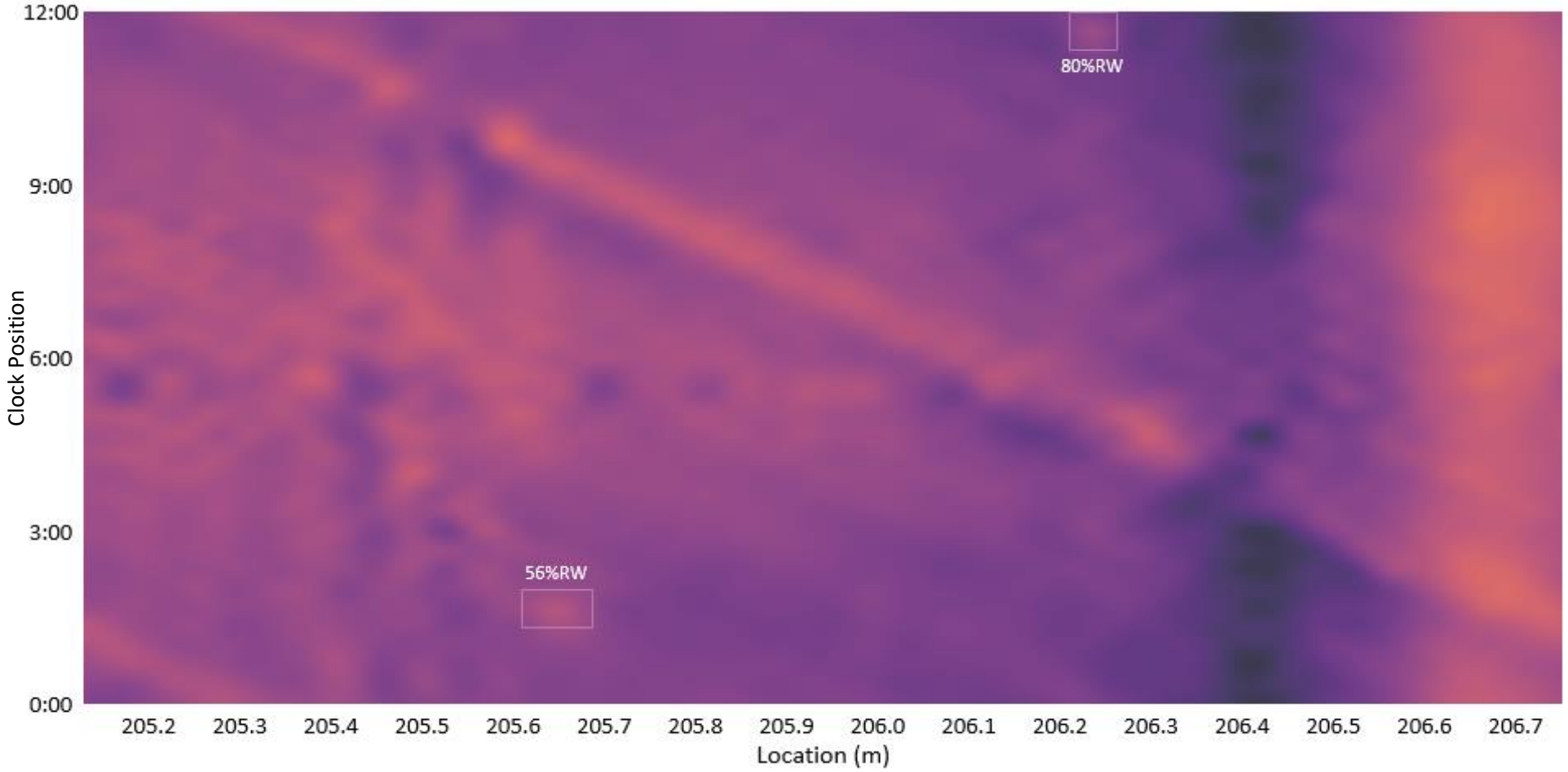

Figure 34. Pipe 0290 colour map with 56% RW and 80% RW indications shown.

Appendix 2: RFT Tool Calibration

Prior to arriving on site, PICA performed a test run of the 24in Chimera tool in a 24in diameter, 9.5mm (0.375in) NWT, unlined spiral welded steel pipe to ensure that the tool was in proper working condition. The calibration pipe contained 5.1cm diameter circular flat bottom defects of varying wall loss percentages, and circular through holes (TH) of varying diameters. Machined defects were measured with an Ultrasonic Testing (UT) device to confirm final wall thicknesses. Table 5 provides an overview of the defects present in the calibration pipe.

Table 5. Defects machined into the 600mm diameter, 9.5mm (0.375in) NWT spiral welded steel calibration pipe

Defect Type	Remaining Wall:	Volume of Defect:
Circular Flat Bottom Defects 5.1 cm (2.0 in) diameter:	73%	5.2 cm^3 (0.3 in^3)
	53%	9.1 cm^3 (0.6 in^3)
	20%	15.4 cm^3 (0.9 in^3)
	Diameter of Defect:	**Volume of Defect:**
Circular Through Holes (0% RW):	1.3 cm (0.5in)	1.3 cm^3 (0.1 in^3)
	2.5 cm (1.0in)	4.7 cm^3 (0.3 in^3)
	5.1 cm (2.0in)	19.5 cm^3 (1.2 in^3)
	7.6 cm (3.0in)	43.2 cm^3 (2.7 in^3)
	10.2 cm (4.0in)	77.8 cm^3 (4.7 in^3)

Figure 35 show the circular flat bottom defects, and Figure 37 shows the circular through hole defects machined into the calibration pipe. All defects were visible in the RFT scan of the calibration pipe, including the 1.3cm (0.5in) diameter through hole and the 5.1cm x 73%RW flat bottom defect. Figure 36 shows the RFT scan of the calibration pipe. It is important to note that the results of the calibration may not be directly comparable to the 6.4 mm (0.250in) CML pipe used to construct the Kildonan-Redwood Feeder Main due to the differences in nominal pipe wall thickness and steel grade.

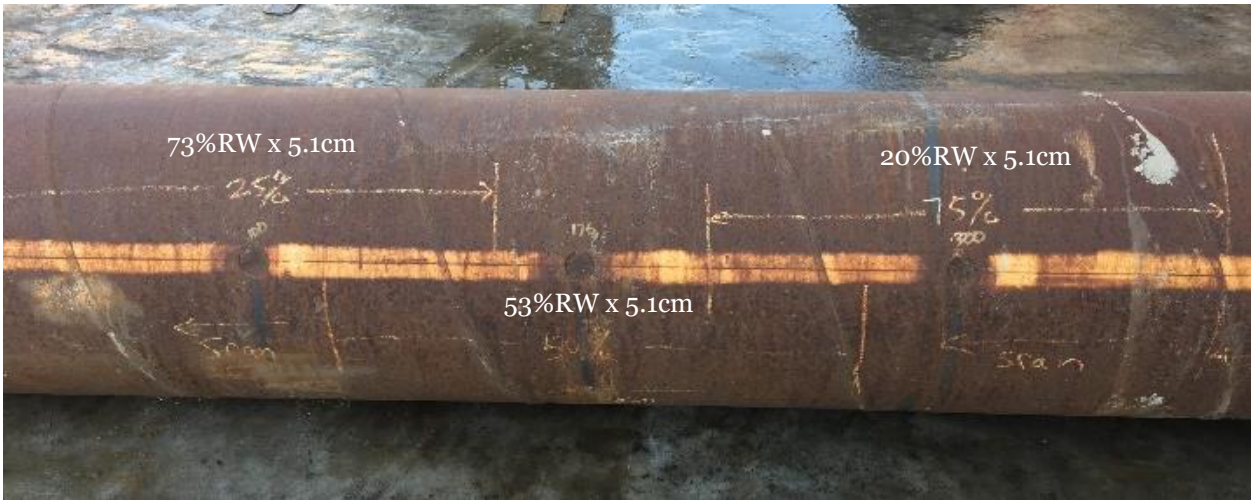

Figure 35. Calibration pipe with 73% RW, 53% RW, and 20% RW 5.1cm diameter flat bottom defects.

Figure 37. Through holes machined into the 24in calibration pipe. Defects measured 1.3 cm, 2.5 cm, 5.1 cm, 7.6 cm, and 10.2 cm (0.5in, 1.0in, 2.0in, 3.0in, and 4.0in) in diameter.

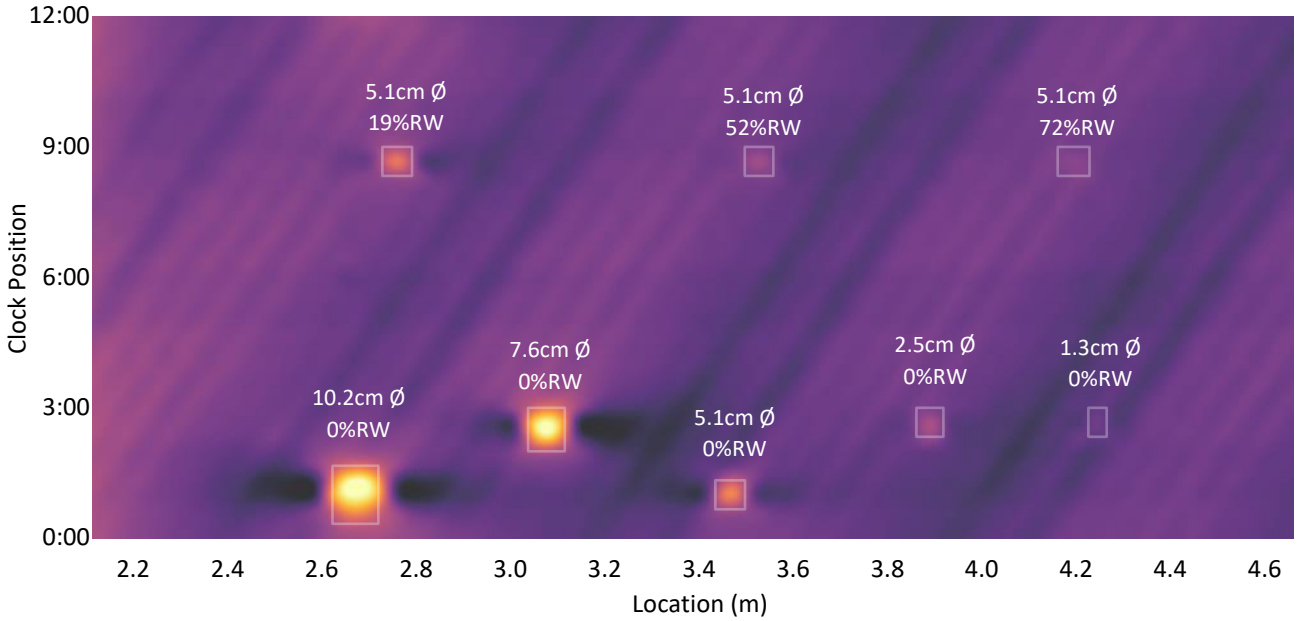

Figure 36. Colour map produced of scanned calibration pipe showing flat-bottom and through hole defects.

Appendix 3: Job Notes and Tool Log

Time (CST)	Operational Comments
Mar 26, 2019	
7:35	Inspection crew arrive on site at Kildonan-Redwood Feeder Main, West Chamber
7:40	First (mechanical Winch) skid steer off trailer
7:48	Laptop synced
8:20	Tool assembled
9:00	Odometer calibrated
9:14	Chimera tool powered up
9:32	Zeroed the wireline odometer with odometer wheel flush with pipe opening.
9:33	Tool scans at 7 Hz with detector leading as the tool begins its descent through the vertical piping
9:45:15	Tool reaches bottom of vertical piping, begin to pull tool back up
10:40	Doing rerun at 5hz with Exciter leading
11:12	Stopped recording
11:14	Restart tool at 5Hz for detector leading run
12:06	East side crew leaves with tool in preparation for inspection of horizontal section.
13:30	Wireline odometer zeroed when Exciter end plate is flush with white painted pipe opening at 13:30. Begin inspection with detector leading at 14 Hz. Start logging at 13:34.
15:13	AGM passage time (west side, AGM Q08874)
15:38	Tool arrived at 90 degrees elbow – start retrieve.
17:05	East side all packed up. Finished pulling tagline back into main from East to West.
17:20	Leave Site
Mar 27, 2019	
7:43	Arrival at Kildonan West side. Tail gate safety meeting.
8:02	Tool is brought to East Chamber
9:00	Tagline is pulled out on the East side, bringing up west winchline.
9:19	Chimera tool powered up. Begin inspection of horizontal portion of Feeder Main at 14Hz.
10:10	Tool passing AGM P40171 on East side of river.
11:21	Tool passing AGM Q08874 on West side of river.
11:49	Tool arrived at 90-degree elbow.
11:59	Tool passing AGM Q08874 on West side of river.
13:02	Data download complete.
13:14	Startup Chimera tool for last 10 Hz run.
13:31	Tool launch east to west at 10Hz.
14:12	Tool passes AGMs on West side of river.
14:41	Tool arrived at 90-degree elbow, start retrieve.
15:16	Tool arrives at East chamber.
16:45	Leave site.
Mar 28, 2019	
7:43	Arrive on site at Kildonan-Redwood, north excavation access.
10:25	Run Start north to south
11:02	Passage of AGM Q08874 on North side of river.
12:08	Tool arrives at south excavation
14:00	Winch slipped at South Chamber. Tool dropped and requiring repairs.
16:00	Zeroing wireline odometers with trailing conical pig 3 inch into the pipe.
16:08	Tool launch south to north.
16:38	Passage of AGM P40171 on South side of river.
17:21	Passage of AGM Q08874 on North side of river.
17:55	Tool arrives