Condition Assessment

of the

Water Importation Mainline Pipeline

DRAFT Report Prepared for:

Tehachapi-Cummings County Water District

By:

Pure Technologies U.S. Inc.
V 2.0 – August 2017

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Quality Assurance and Quality Control Statement

By my signature I attest that this report has been prepared and reviewed in accordance with the Pure Technologies U.S. Inc. Quality Assurance and Quality Control procedures:

08/11/2017

Project Manager (A. McNealy) Date

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Executive Summary

Pure Technologies U.S. Inc. (Pure Technologies) conducted a condition assessment for Tehachapi-Cummings County Water District (TCCWD) of approximately 38,220 feet (7.24 miles) of Bar Wrapped Pipe (BWP) in the Water Importation Mainline Pipeline (the pipeline), supported by several data collection and analysis techniques. Between December 15 to 21, 2016, Pure Technologies conducted an electromagnetic survey utilizing the PureRobotics® inspection platform and a visual survey utilizing the onboard closed circuit television (CCTV) equipment. The limits of the assessment scope is highlighted in *Table ES.1*.

Table ES.1: Scope of the Water Importation Mainline Pipeline Assessment		
Pipeline	**Start Station[1]**	**End Station[1]**
Water Importation Mainline Pipeline	0+05	382+25

[1] *Station numbers are approximated from plan and profile drawings due to unavailability of pipe laying schedules.*

As part of the condition assessment, Pure Technologies performed transient pressure monitoring, three-dimensional, nonlinear Finite Element Analysis (FEA) structural evaluation, and material sampling of the pipeline. In 2015, Pure Technologies also conducted a leak and air pocket detection survey of the pipeline, the results of which are considered in the evaluation. This report details the results, conclusions, and engineering recommendations based on the inspection and analyses performed on the pipeline.

Based on the condition assessment of the pipeline, Pure Technologies concludes the following:

1. Of the 986 BWPs assessed, one (1) pipe (0.1%), Pure Pipe Reference Number 2103, exhibited an electromagnetic anomaly indicative of five (5) broken bar wraps,

2. Three (3) pipes (0.3%) contained an anomalous electromagnetic signal not characteristic of broken bar wraps that can be attributed to a change in the pipe cylinder. Pure Pipe Reference Numbers 4012, 5122, and 5155 contained these cylinder anomalies. These observations correlated to a visual observations of severe cylinder corrosion.

3. The visual and electromagnetic survey observed pipe repairs at Pure Pipe Reference Numbers 1178, 3037, 4078, 4130, 4177, and 5239.

4. The visual survey observed significant debris buildup in the pipe at Station 211+30. This location was marked above ground for follow-up.

5. Transient pressure monitoring identified a peak pressure of 80.5 psi, a minimum pressure of -1.8 psi, and an average pressure of 20 psi, indicating the pipeline operates well below the design capacity of 150 - 275 psi, depending on elevation.

6. Transient pressure monitoring identified several transient pressure events. This indicates the pipeline experiences water hammer effects or pressure spikes above standard operating pressures on a regular basis. These events were traced back to pump

operations and total plant shutdowns. These transient pressures remained well below the design pressure of the pipe.

7. Pure Pipe Reference Number 2103 contained 5 broken bar wraps and does not exceed the Yield Limit of 12 broken bars at the evaluated loading conditions of 80 psi of 4 feet of earth cover.

Pure Technologies provides the following recommendations for the short and long-term management of the pipeline. The recommendations were developed through analysis of pressure transient data, leak and air pocket detection results, material sampling, visual observations, evidence of repair history, application of a structural evaluation to the inspection data, and engineering judgement based on extensive pipeline management experience.

1. The pipeline contains no pipes beyond the Yield Limit within the given operating parameters, which is Pure Technologies' general threshold for immediate risk mitigation recommendations. As such, the pipeline is in serviceable condition from the standpoint of structural capacity.

2. Severe debris buildup located around Station 211+55 to 211+80 is reducing the hydraulic capacity of the pipeline. TCCWD should remove this debris as soon as is conveniently possible. The locations of spalled internal lining and internal cylinder corrosion should be considered for repair at TCCWDs convenience. These locations are listed in the video review in Appendix F.

3. Despite the pipeline operating at below design pressure and no pipes currently operating near their Yield Limit, the presence of transient pressure events will reduce the time to failure as the pipeline continues to age and deteriorate. TCCWD should evaluate both operational procedures and surge protection installation options to determine the most effective method of reducing the severity or occurrence of surge pressures.

4. All remaining useful life calculations are based on pipeline deterioration starting at the date of the pipeline's installation and the baseline condition established from the results of the 2016 survey. This method of evaluation uses linear assumed deterioration rates as boundary conditions, which results in uncertainty. To better determine the pipeline's main deterioration mechanism and rate, Pure Technologies recommends a structural reassessment within 10 years. Additional datasets should then be compared to more accurately determine the deterioration rate and update the RUL assessment.

1. Project Background

The inspected portion of the Water Importation Mainline Pipeline is composed of 30-inch concrete cylinder pipe also commonly referred to as BWP and was likely manufactured by Ameron Pipe Products Group in around 1972. The Water Importation Mainline Pipeline is owned and operated by TCCWD. The manufacturing details for the inspected pipes were not available at the time of issuing this report. While specific repair records are not available for the full history of the pipeline, knowledge of several leaks of various sizes correlate to what appear to be repair patches noted during the internal visual inspection. TCCWD conducted a leak and gas pocket detection survey in the 2015 shutdown season, which indicated the presence of a small leak and entrained air potentially getting trapped in the pipeline. It is Pure Technologies' understanding that the electromagnetic survey performed in 2016 was the first electromagnetic survey and condition assessment of this main. PureRobotics® was selected as the primary inspection platform over the PipeDiver® due to the requirement to understand the lining condition and other information only made possible with an internal CCTV survey.

Between December 15 and 21, 2016, Pure Technologies performed an electromagnetic and visual survey of the pipeline utilizing the PureRobotics inspection platform. The pipeline begins at the California Aqueduct located near the Edmonston Pumping Plant Road at Station 0+00, and traverses through Cummings valley and into Tehachapi Valley, a total of approximately 31 miles. The assessed portion of the pipeline included from the Aqueduct connection to the first of four (4) pump stations. The electromagnetic and visual survey spanned an overall distance of approximately 38,200 feet (7.21 miles).

A map of the inspected section of the Water Importation Mainline Pipeline is shown below *(Figure 1.1)*. This map shows the approximate geographical location of the pipeline.

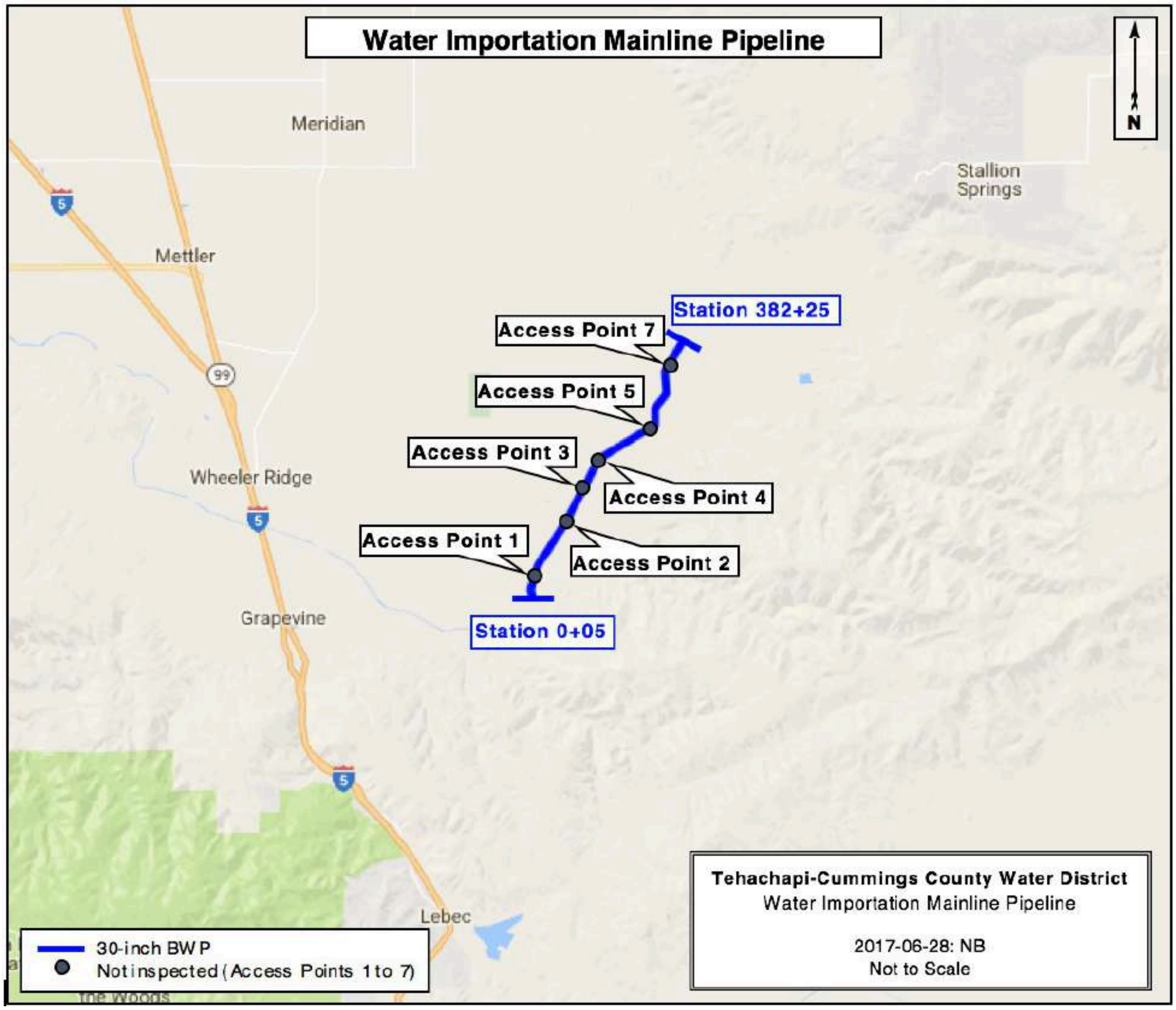


Figure 1.1: Inspection Limits

1.1 Project Scope

The scope of this report includes an internal inspection and condition assessment of the 30-inch Pipeline in order to provide an effective pipeline management strategy for TCCWD. The assessment utilized the following investigative techniques:

- PureRobotics® electromagnetic survey
- Video survey utilizing PureRobotics onboard CCTV equipment
- Transient pressure monitoring and hydraulic evaluation
- Three-dimensional, nonlinear FEA incorporating the electromagnetic inspection results
- Remaining useful life analysis based on previous risk analysis, leak and failure history, electromagnetic inspection data, and visual inspection results.

1.2 Overview of the Bar-Wrapped Pipe

The BWP used in the 30-inch Water Importation Pipeline was installed in 1972 and likely manufactured by Ameron Pipe Products. BWP is comprised of a welded steel cylinder and mild steel reinforcing bar that is wrapped helically around the cylinder under tension. An inner concrete lining and outer mortar coating provide corrosion protection for the steel components. BWP is manufactured in accordance with AWWA C303 using standard pipe sizes that range from 10 inches through 72 inches in diameter. The allowable design pressure for BWP is up to 400 psi, in addition to an external earth load. AWWA C303-08, Concrete Pressure Pipe, Bar-Wrapped, Steel-Cylinder Type, is the current standard that governs the design of BWP. The first edition of the AWWA C303 standard approved by the AWWA Board of Directors was on January 26, 1970. Figure 1.2 shows the construction and joint details of a typical AWWA C303 pipe.

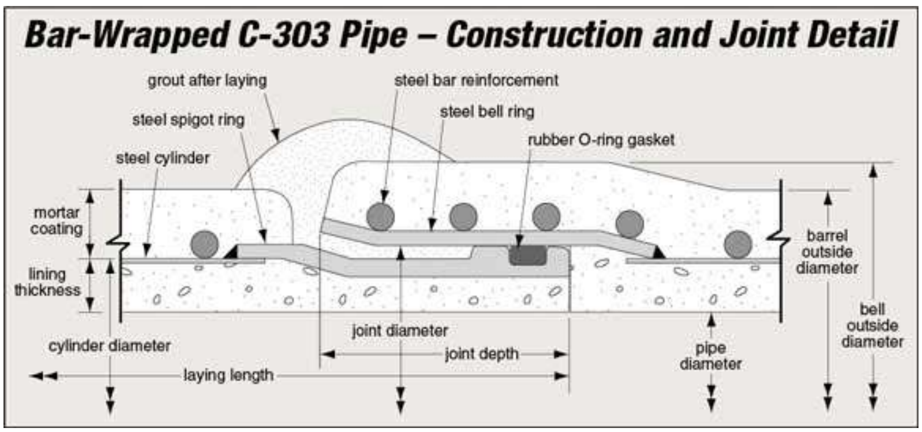


Figure 1.2: AWWA C303 BWP construction details [3]

There are four (4) important aspects to note regarding the deterioration of BWP:

- Deterioration can begin on the bars or on the cylinder.
- The bedding around the pipe is important for the structural capacity of the pipe.
- The integrity of the mortar coating is essential to protect the steel against corrosion and premature failure.
- Section geometry is important to protect the mortar coating from damage and delamination.

The BWP in the Water Importation Pipeline was likely manufactured in accordance with AWWA C303-70, *Standard for Reinforced Concrete Water Pipe-Steel Cylinder Type, Pretensioned, for Water and Other Liquids [2]*.

2. Inspection Methodologies and Results

2.1 Electromagnetic Inspection

2.1.1 Methodology

The PureRobotics electromagnetic inspection platform is a unique, non-destructive method of evaluating the current condition of the bar wraps and steel cylinder in a BWP. Electromagnetic inspections ascertain a magnetic signature for each pipe to identify anomalies and regions of broken bar wraps or cylinder corrosion. Various characteristics associated with an anomaly (length, magnitude, phase shift, etc.) are evaluated to quantify the amount of distress. The information collected during an electromagnetic inspection requires trained data analysts to review and identify electromagnetic signals associated with localized distress.

2.1.2 Results

Between December 15 and 21, 2016, Pure Technologies completed an electromagnetic survey of the BWP in the 30-inch Water Importation Mainline Pipeline. The survey utilized six (6) insertion locations to inspect approximately 38,200 feet (7.21 miles) of pipeline, for which TCCWD installed new access ports. Some preexisting access ports were planned but ultimately not useable due to their size being under the minimum required 16 inches, which resulted in the requirement of all new access locations. Figure 2.1 shows the tool at Access 6, an attempt at a side access insertion that ultimately caused damage to the tool. Figure 2.2 shows the insertion at excavated Access 7 used to replace Access 6.

Figure 2.1: Side insertion into Access 6

Figure 2.2: Insertion at Access 7

Figure 2.3 shows the access port created near the pump station due to the unsuccessful use of the side outlet as an access point. Figure 2.4 shows how major debris and spalling locations were marked onsite with a painted rock as they were discovered.

Figure 2.3: Exposed access with cable rollers set up

Figure 2.4: Method of above ground marking

Due to the insertion technique of the robotic tool, the pipes at the access points were not fully inspected. Below are Pure Technologies' resources used to perform the inspection, as well as the inspection schedule *(Table 2.1)*.

Table 2.1: Inspection Summary				
On-Site Staff	H. Ward, A. Kimmerly, J. Purkiss, H. Yang			
Analysts	C. Smith, N. Bose			
Project Manager	A. McNealy			
Tool	PureRobotics®			
Date	**Pipeline**	**Start Station[2]**	**End Station[2]**	**Distance**
December 15-17 and 19- 21, 2016	Water Importation Mainline Pipeline	0+05	15+24	0.29 miles
		16+03	99+13	1.58 miles
		99+53	155+80	1.07 miles

		156+20	181+80	0.49 miles
		182+20	265+55	1.57 miles
		265+96	382+25	2.21 miles
Total Distance				**7.21 miles**

[2] *Station numbers are approximated from plan and profile drawings due to unavailability of pipe laying schedules.*

A summary of the total number of pipes that had electromagnetic signatures consistent with broken bar wraps and pipes that exhibited cylinder anomalies is shown below *(Table 2.2)*.

Table 2.2: Summary of Inspected Pipes

Pipeline	Diameter (inches)	Number of Inspected Pipes	Pipes with Broken Bar Wraps	Pipes with Cylinder Anomalies
Water Importation Mainline Pipeline	30	986	1	3

A summary of the number of pipes with 5 broken bar wraps, 10 to 15 broken bar wraps, and more than 15 broken bar wraps detected during the inspection is presented in *Table 2.3*.

Table 2.3: Summary of Pipes with Broken Bar Wraps

Pipeline	Diameter (inches)	Length (feet)	Pipes with 5 Broken Bar Wraps	Pipes with 10 to 15 Broken Bar Wraps	Pipes with more than 15 Broken Bar Wraps
Water Importation Mainline Pipeline	30	38,077	1	0	0

Of the 986 pipes inspected in the Water Importation Mainline Pipeline, 1 pipe had electromagnetic anomalies consistent with broken bar wraps. The distressed pipe is presented in *Table 2.4*. The Pure Reference Number is the unique pipe number assigned by Pure Technologies for reference only and does not correlate with existing pipeline information. The stationing shown in the table is the low station for the pipe. The Break Position of the region with broken bar wraps is measured from the low station of the distressed pipe to the center of the distress region and was rounded to the nearest 0.5 feet. The Number of Broken Bar Wraps by Region have each been rounded to the nearest 5 broken bar wraps. Regions with fewer than 5 broken bar wraps are reported as having 5 broken bar wraps, which implies that regions shown as containing 5 broken bar wraps may be overestimated.

Table 2.4: Pipes with Broken Bar Wraps in the Water Importation Mainline Pipeline					
Pure Reference Number	**Low Station**	**Pipe Length (feet)**	**Break Position (feet)**	**Number of Broken Bar Wraps by Region**	**Total Number of Broken Bar Wraps**
2103	137+71	40	35.5	5	5

Break Position *of the break region is measured from the low station (feet).*

2.1.3 Pipes with Cylinder Anomalies

The electromagnetic analysis of the Water Importation Mainline Pipeline identified three (3) pipes with anomalous signals that do not resemble the characteristics of broken bar wraps.

The anomalous signals observed have been categorized as cylinder anomalies. These signals respond differently than the established baseline (undamaged) electromagnetic signal and indicate a region of the cylinder where a manufacturing feature or corrosion of the cylinder is the most likely source of the anomaly. The pipes with these anomalous signals are listed in *Table 2.5.*

Testing for cylinder anomalies involves forming various anomaly sizes and arrangements while using a variety of instrument configurations to conduct the scans. Cylinder anomalies may encompass variations that cause a decrease or increase of the cylinder thickness. There is currently no quantification process for reporting cylinder anomalies. Unlike broken bars which result in the same size of signal change regardless of circumferential position, the size of signal change for cylinder anomalies will vary based on its proximity to the exciter or detector. The Enhanced Electromagnetic PureRobotics array was used to observe the size, shape, and position of this anomaly. Further details for these pipes are provided in Appendix C.

Table 2.5: Pipes with Cylinder Anomalies in the Water Importation Mainline Pipeline				
Pure Reference Number	**Low Station**	**Pipe Length (feet)**	**Cylinder Anomaly Position (feet)**	**Cylinder Anomaly Area (square-inch)**
4012	186+58	40	26.0	50
5122	312+92	40	19.5	60
5155	325+85	40	13.5	60

Cylinder Anomaly Position *– represents the center of the observed anomalous signal. Signal position is measured from low station.*

2.2 CCTV Visual Inspection

2.2.1 Methodology

The CCTV sensor on the robotic crawler uses a pan-tilt-zoom camera that captures high-resolution video and images in the pipeline. The camera is designed for use in lower light environments. In addition to the camera lights, the robotic crawler is fitted with variable intensity quartz halogen and high intensity Light Emitting Diode (LED) lighting. During the inspection, the interior of each BWP was visually inspected for cracks, spalls, staining, or other indications of distress. Visual inspections also evaluate each of the pipeline joints for spalling, separation, and exposed steel and determine if any repairs are necessary. When reviewing the CCTV inspection videos, a reviewer has limited ability to closely examine any cracks, spalling or deterioration; therefore, pipes with visual damage are identified based on the physical appearance, size and location of the visual defect inside the pipe as well as review of plan and profile drawings for any unusual external loading condition around the pipe. Screen shots are taken of defects in order to document the locations of distress in the pipeline.

2.2.2 Results

Pure Technologies performed an internal visual inspection of the 30-inch pipeline using CCTV concurrently with the PureRobotics electromagnetic survey. The pipes observed with visual deficiencies are described in this section. The pipe number reported corresponds to the Pure Reference Number assigned during the electromagnetic inspection. All CCTV visual observations are provided in the video review in Appendix F. Overall, the visual survey of the pipeline identified features, bends, repairs, spalling, and debris. Also, some joints were noted for spalling or separation. Further, visual observations of cylinder corrosion correlated with the three (3) electromagnetic cylinder distress signals noted in section 2.1.3.

The Pure Pipe Reference Number 5155 containing a localized anomalous electromagnetic signal was observed with severe pitting of the steel cylinder collocated with the electromagnetic anomaly. Figure 2.5 shows the cylinder defect identified in Pure Reference Number 5155 located at Station 325+98.

Figure 2.5: Spalling and cylinder defect observed in Pure Reference Number 5155, Station 325+85

A section of spalling was observed in Pure Reference Number 1 located at approximate Station 0+25. The spalling was approximately 5 feet in length and located at the invert of the pipe. Figure 2.6 shows this spalled section of pipe.

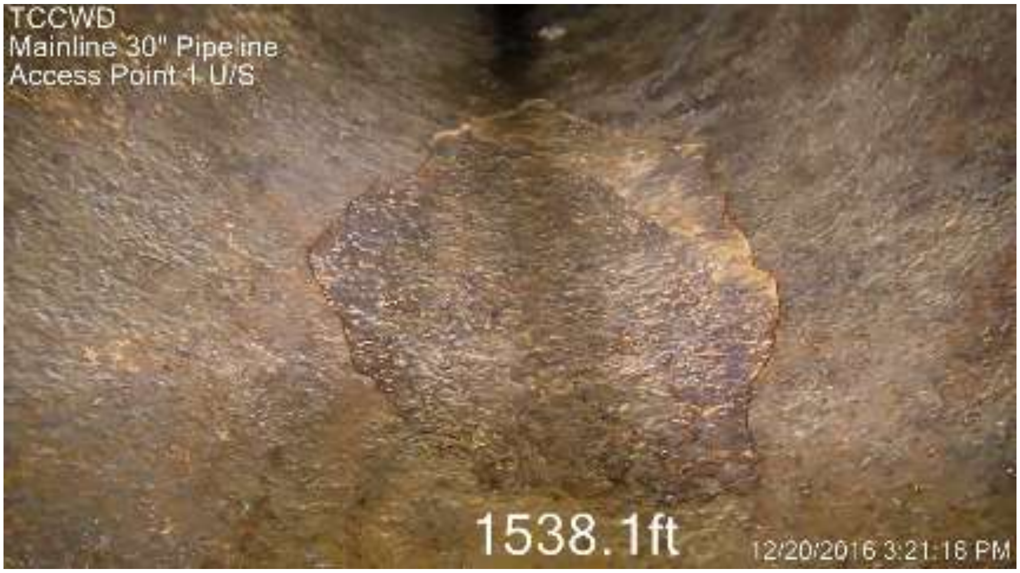


Figure 2.6: Section of spalling, Pure Reference Number 1, Station 0+25.

Figure 2.7 shows a typical example of circumferential cracking; this one identified in Pure Reference Number 5226 located at Station 353+40, upstream of Access 7.

Figure 2.7: Circumferential crack observed in Pure Reference Number 5226, Station 353+40

Figure 2.8 shows the largest debris pile encountered during the inspection, at Station 211+55. This location was marked above ground for immediate remedial action.

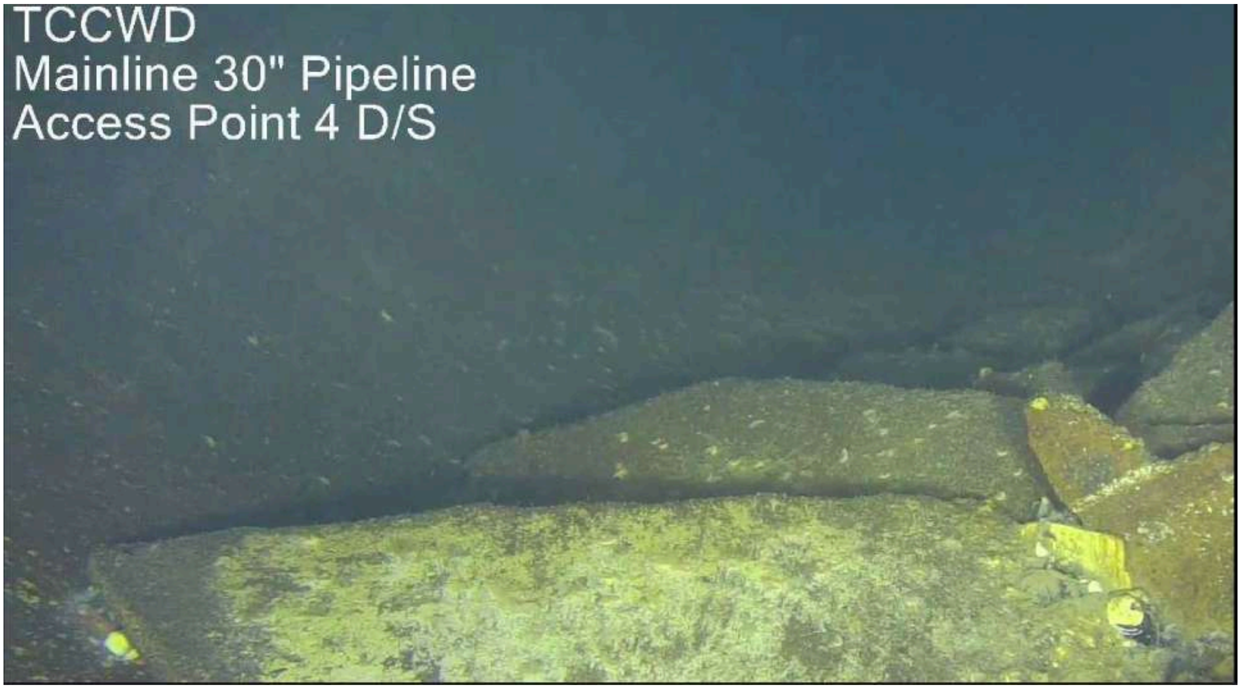


Figure 2.8: Large debris pile observed in Pure Reference Number 4080, Station 211+55 to 211+80

2.3 Transient Pressure Monitoring

2.3.1 Methodology

A hydraulic evaluation is conducted in order to understand the operational and surge pressures within a pipeline. When pipe wall degradation is combined with surge pressures, the likelihood of pipe failure can be significantly increased. Evaluation of the pump station operation, such as pump startup mode, typical and peak flows, operating and surge pressures, and surge protection, can provide important information on the stresses imparted on the pipeline.

Hydraulic pressure transients occur in pipelines when the steady-state conditions of the system change due to pressure and/or flow disturbances (e.g., the rapid closure of a valve, pump start-up/shutdown, gas pockets). The magnitude of a transient is related to several factors including the flow rate within the pipeline, the time (how fast) in which the change in steady-state condition occurs, and pipe hoop rigidity. During a transient event, the kinetic energy of the flow momentum is converted into potential energy, a rise in pressure, and strain energy in the pipe walls with the propagation of pressure waves. The resultant pressure transient is superimposed on the existing, steady-state pressure within the pipeline. Gas pockets combined with pressure transients can also have a significant impact on the structural integrity of the pipeline as vacuum conditions may be created. The rapid collapse of these gas pocket vacuum regions may cause cavitation as the transient passes, resulting in mechanical wear on the pipe wall and thereby increasing the risk of failure if the structural capacity has been compromised.

Conventional pressure monitors collect data in intervals of seconds or minutes while transients may occur in fractions of seconds and may be missed by traditional equipment. The Telog Instruments LPR-31i pressure monitor, utilized on this project, continuously samples pressure at a high rate and records data every few minutes under normal operating conditions; however, when a transient pressure event is detected in the pipeline, the device records at the high sample rate (20 Hz) to provide an accurate recording of the pressure transient event.

2.3.2 Results

A hydraulic evaluation of pipeline was conducted to understand the operational and surge pressures. Pressure data was collected for a total of 126 days, from January 30, 2017 to June 5, 2017, in order to identify the hydraulic stresses acting on the pipeline.

As part of the hydraulic analysis, a Telog Instruments LPR-3li transient pressure logger was installed on the pipeline just upstream of Pump Station 11 in similar configuration as seen in Figure 2.9.

Figure 2.9: Telog LPR-31i installed on Air Release Valve

Maximum, minimum, and average pressures were recorded by the pressure logger at 10 minute intervals. This interval was longer than standard procedure and was chosen to ensure the logger would not fill its data card before the longer than standard monitoring period was completed. The maximum pressure recorded during the monitoring period was 80.5 psi and occurred on May 4, 2017, and the minimum pressure recorded was -1.8 psi and occurred on April 7, 2017, with an average pressure of 20 psi. A chart of the pressures recorded over the full monitoring period is included in Figure 2.10.

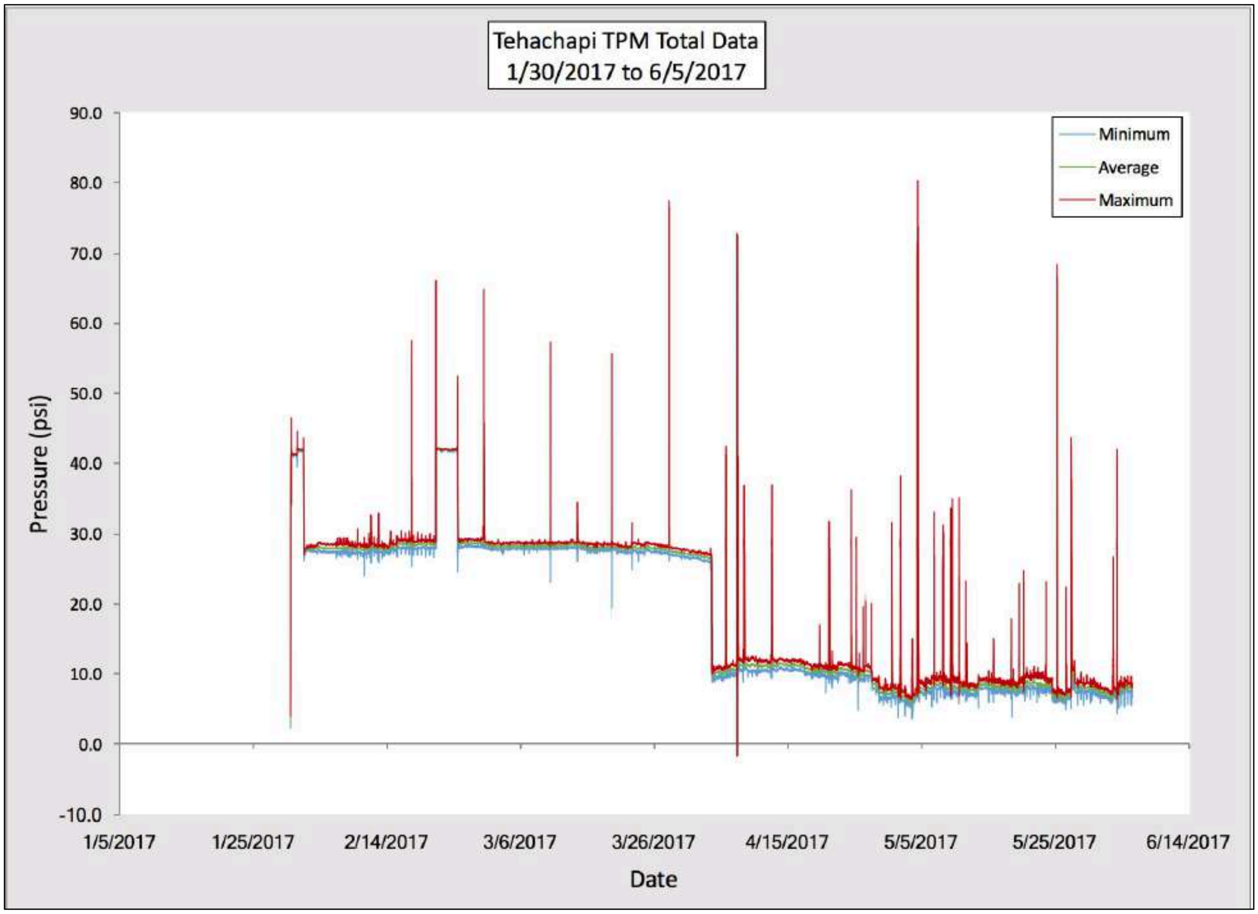


Figure 2.10: Summary of the complete pressure data collected from January 30 to June 5, 2017

Maximum pressures in a given 10-minute recording interval are plotted in red, minimum pressures are plotted in blue, and the average pressures over each 10-minute interval are plotted in green. The transient monitor is not able to save as much transient data as overall pressure data. Once the maximum amount of transient data is saved, all new transient data begins to overwrite previous transient data. Some transient events may have been overwritten during the month of February as the first transient event saved to disk and not written over occurred on March 10th, 2017.

The standard deviation of the recorded pressure data is 11.6 psi, a large percentage of the average pressure. This is expected as the pipeline was operating under several different pumping configurations during the monitoring period, from one pump operating to all pumps operating. Of all the pressure samples recorded, 68.2% are between 8.4 psi and 31.4 psi, and 95.4% are between -1.8 psi and 42.8 psi, indicating the pipeline operates below the minimum design capacity of 150 to 275 psi, depending on location.

19 transient pressure events were detected during the monitoring period: the number of recorded pressure peaks and valleys are a concern, especially during the later portion of the monitoring period from the beginning of May to the beginning of June. The pressure data was correlated to

flow data provided by TCCWD, and the transient pressure events often associated with individual pump operation. The largest events recorded by the monitor correlated to total plant shutdowns. These pressure transients are shown in Figure 2.11, Figure 2.13, and Figure 2.15, and their corresponding flow charts provided by TCCWD are shown in Figure 2.12, Figure 2.14, and Figure 2.16. The remainder of the transient data is provided in a digital spreadsheet separate from this report.

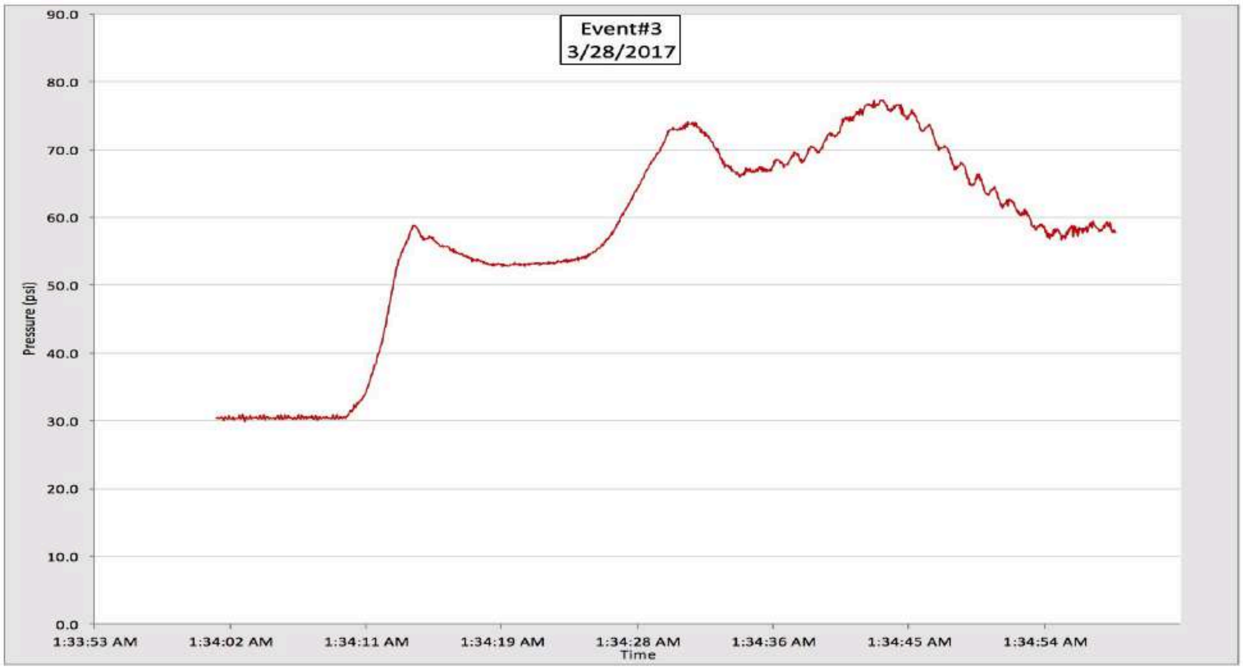


Figure 2.11: Transient (20 Hz) pressure data collected from transient event #3 on March 28, 2017

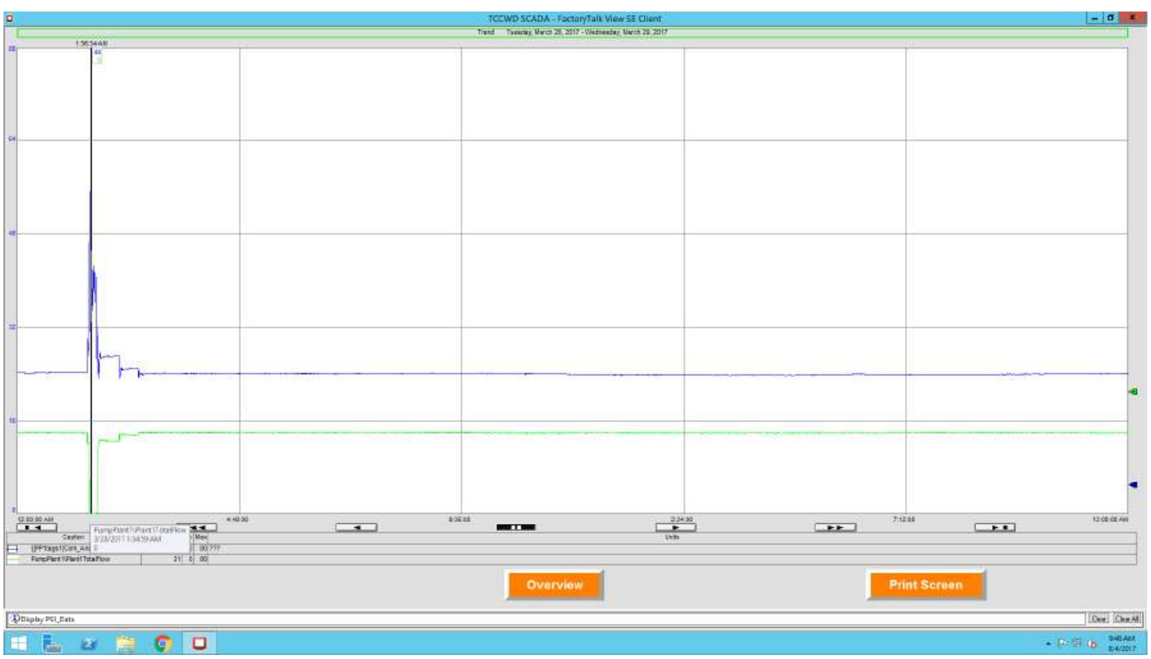


Figure 2.12: Plant shutdown corresponding with transient event #3

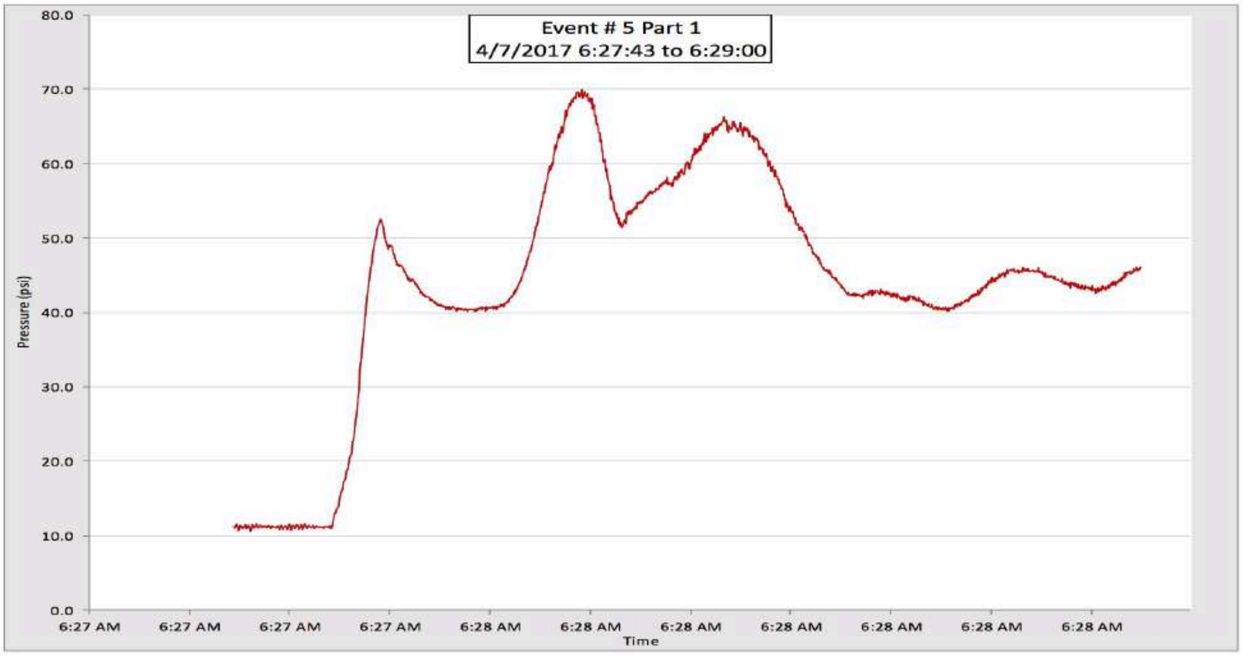


Figure 2.13: Transient (20 Hz) pressure data collected from transient event #5 on April 7, 2017

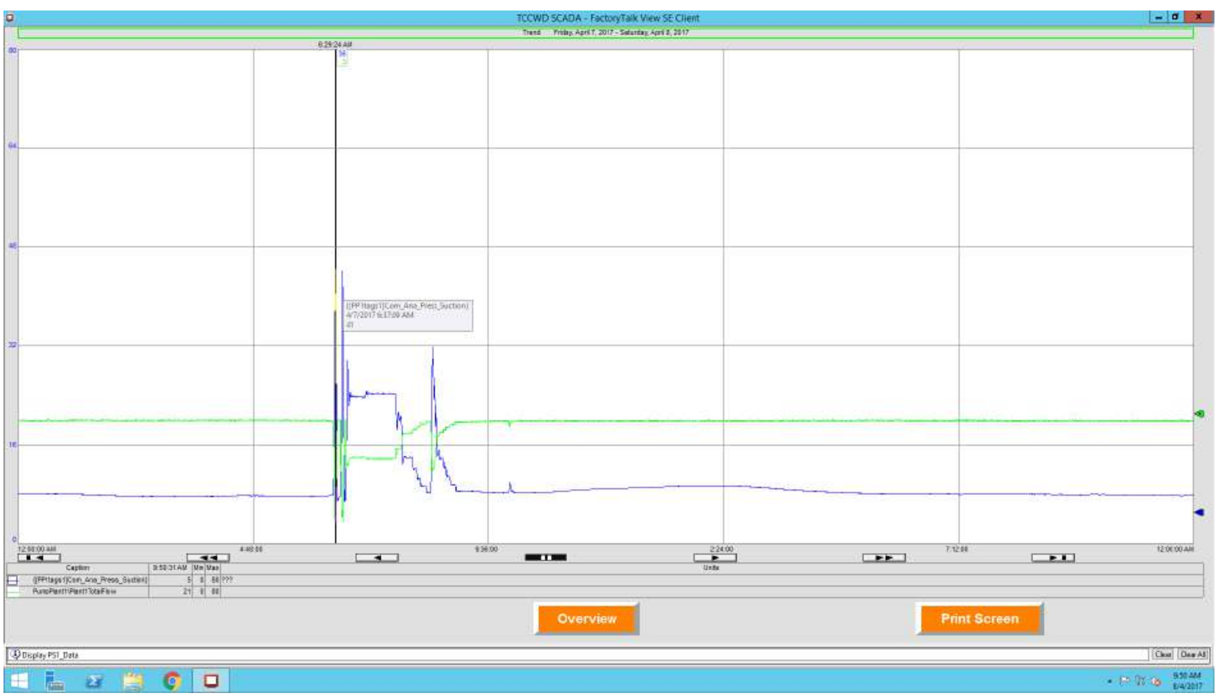


Figure 2.14: Corresponding plant shutdown for transient event #2

Figure 2.15: Transient (20 Hz) pressure data collected from transient event #9 on May 4, 2017

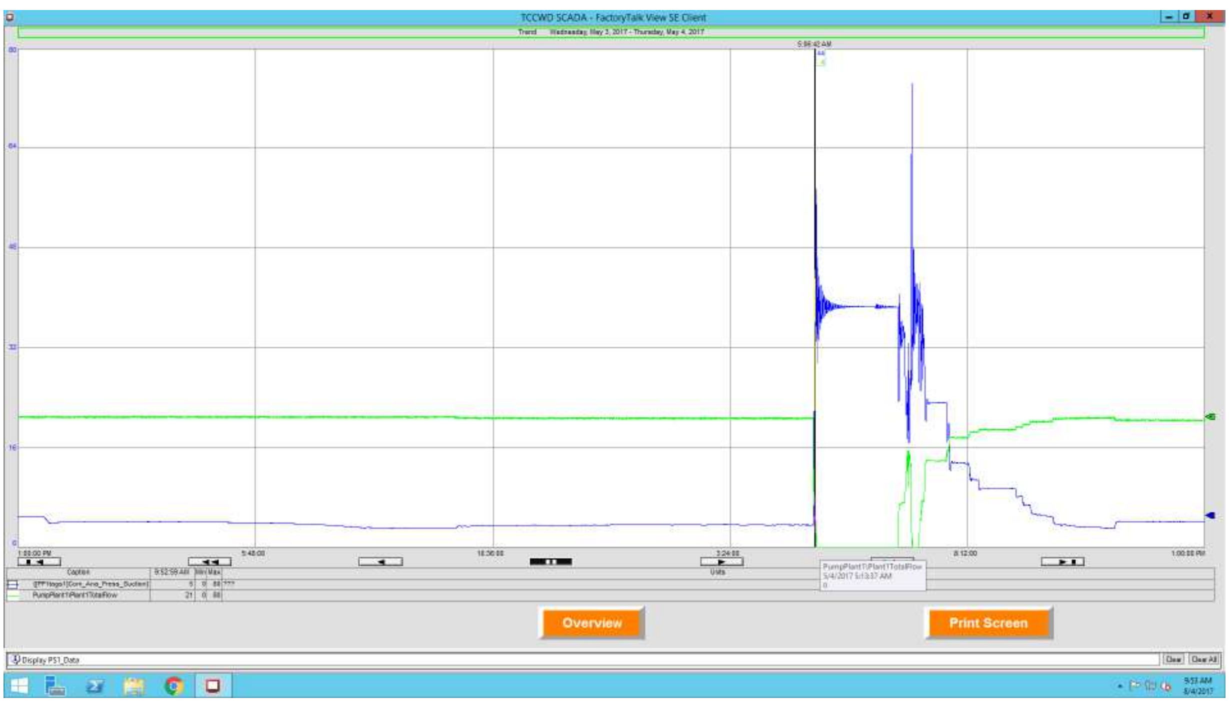


Figure 2.16: Pump start up and shutdown corresponding with transient event #9

Cyclic loading in other pipe materials is well understood to be a mode of failure and is a primary design consideration. It is understood that a component subjected to fluctuating stresses, such as cyclic loading or regularly occurring transients, may fail at stress levels much lower than its fracture strength. Strength reduction due to fatigue is attributed to two (2) primary factors: cycle frequency and amplitude. In the case of water pipelines, the recurring loading amplitude is half the pressure differential and the frequency is each pressure cycle. In water systems the frequency of pressure cycling is typically a few times a day. The operation of the pipeline is not consistent with this typical operation and since the amplitude of the recorded pressure differential is greater than expected. The effect of this loading, if not addressed, will be failures earlier than otherwise expected.

2.4 Structural Evaluation

2.4.1 Design Specifications and Assumptions for Modeling

2.4.1.1 Pipe Properties

Table 2.6 lists the design specifications used by Pure Technologies for the structural analysis and FEA modeling of the 30-inch, Class 150 BWP. Design values were obtained from the material sampling conducted onsite during inspection and correlation to plan and profile drawings.

Table 2.6: Design Specifications

Pipe Parameters	Units	Pressure Class 150
Assumed year of manufacture		1972
Internal diameter of the pipe	inches	30
Design operating pressure	psi	150
Average recorded pressure	psi	20
Maximum recorded pressure	psi	80.5
Earth cover	feet	4.0
Outside diameter of the steel cylinder	inches	32.156
Thickness of the steel cylinder	inches	0.078
Nominal lining thickness	inches	1.0
Nominal coating thickness	inches	1.0
Bar diameter	inches	0.25
Number of coils per foot	1/foot	6.25
Average Laid Length	feet	40

2.4.1.2 External Loading

The external earth load is extremely influential in the FEA. The pipe design was analyzed using 4 feet for maximum earth cover depth specified for the pipe.

The earth loading assumed a soil unit weight of 120 pounds per cubic foot (lb/ft^3) and a Kμ' value of 0.165, which is representative of sand and gravel. Kμ' is the ratio of the active lateral unit pressure to the vertical unit pressure times the coefficient of friction between the fill material and the sides of the trench. During the AWWA C303 analysis, the bedding factor used to analyze the pipe design was 1.0 with a bedding constant of 0.105. An Olander bedding angle of 45 degrees was used for the analysis, indicating a typical pipe installation in sand and gravel.

In order to determine the effect of traffic loading on the pipeline, the AASHTO HS-20 truck wheel load was used as the live load condition, with an associated live load impact factor applied to take into account the dynamic nature of traffic loading [4].

2.4.1.3 Internal Pressure

An important input for the structural evaluation is the actual operating pressure of the pipeline, which includes both working pressures and transient pressures. The 30-inch BWP was originally designed for an internal operating pressure of 150 pounds per square inch (psi). The observed average operating pressure during the transient pressure monitoring period was 20 psi (40 psi during the peak-pressure pumping condition) while the observed maximum pressure was 80.5 psi. These pressures were utilized in the structural evaluation.

2.4.2 Finite Element Analysis

Finite element analysis is an accurate method for modeling complex geometry under different loading conditions. Recent developments in finite element modeling and increased computational speed allow for the analysis of complex nonlinear problems, which is required to provide accurate models of BWP with broken bar wraps.

Pure Technologies developed FEA models to determine the structural capacity of a distressed pipe based on the number of discontinuous or broken bar wraps and an assumed level of steel cylinder corrosion. The FEA models utilize the current AWWA C303 specifications, design parameters, and distressed pipe conditions determined during the electromagnetic inspection. During the analysis, the model is subjected to internal pressures, pipe weight, fluid weights, and external loads including the earth load and the live load. The FEA can model any combination of external load, internal pressure, steel cylinder corrosion, and broken bar wraps to predict the performance of a pipe with varying levels of distress. Commercial finite element software (Abaqus) was used to investigate the structural response of the pressure Class 150 design under different loading conditions.

The FEA model predicts the performance of a BWP utilizing the strengths of the inner concrete lining, the steel cylinder, the reinforcing bar, and the outer mortar coating. The steel cylinder and reinforcing bars are the primary structural components providing strength to the BWP. The purpose of the inner concrete liner and the outer mortar coating are to pacify the steel by providing an alkaline environment to prevent corrosion of steel components of the pipe. The mortar coating and inner concrete liner also provide stiffness to the pipe to reduce deflection and maintain the section geometry. The FEA was performed for the Class 150 BWP design while varying the level of distress in the pipe. Stresses and strains are measured in the 1-1 direction of the local coordinate system, which is comparable to the hoop stress or hoop strain developed circumferentially around the pipe in the global coordinate system.

2.4.2.1 Performance Curves

The number of broken bar wraps and steel cylinder wall loss that a particular pipe design will tolerate under operational and surge conditions can be determined using an FEA performance curve. The FEA performance curve displays four (4) Limits, Micro Cracking, Visible Cracking, Yield, and Strength, to classify the condition of a distressed BWP. Table 2.7 defines the Limits used by Pure Technologies to describe the predicted condition of a BWP with a known quantity of distress (broken bar wraps and steel cylinder wall loss). The actual amount of distress required to reach these Limits varies according to the pipe design and earth cover.

Table 2.7: Predicted Condition of a Pipe with Distress

Limit	Description
Micro Cracking	Micro cracking of the outer coating or inner lining (defined by the strain associated with a crack that is greater than 0.001 inches wide)
Visible Cracking of the Inner Lining	Visible cracking of the inner lining (defined by the strain associated with a crack that is greater than 0.002 inches wide)
Yield	Reinforcing bar or steel cylinder reach their yield strength
Strength	Reinforcing bar or steel cylinder reach their ultimate strength

A pipe reaches the Micro Cracking Limit when strain in the outer coating or inner lining indicates cracking that is greater than 0.001 inches wide and 12 inches in length. Micro cracking is the preliminary level of damage in a BWP per the AWWA C303 standard. The Visible Cracking of the Inner Lining Limit is reached when the inner lining experiences cracks greater than 0.002 inches wide and 12 inches in length. The underlying cylinder and bar wraps of the pipes that exceed the Visible Cracking of the Inner Lining Limit are exposed to an interior and exterior environment with the potential for corrosion. However, due to the pressurized aqueous environment, visible cracks in the inner lining pose a higher threat of exposing the underlying steel components to a corrosive environment.

The values used to represent the performance of the steel components in the field are based on the yield strengths provided on the pipe design specifications sheet or the standard values in the relevant design standard, if the pipe design is not available. The yield strengths for the reinforcing bars and the steel cylinders were taken from the relevant American Society for Testing and Material (ASTM) standard in place at the time of production. The Yield Limit is reached when either the steel cylinder or the reinforcing bar reach the yield strength. Once a pipe reaches the Yield Limit, the inner lining and outer coating is likely delaminated from the steel, exposing the bars wraps and cylinder to a potentially corrosive environment. Yielding of the steel bar and cylinder can reduce the area of steel, allowing corrosion to more rapidly deteriorate the entire thickness of the steel.

2.4.2.2 Performance Curve - Results

By evaluating the predicted structural condition of a pipe using FEA and analyzing all critical variables, a risk assessment for distressed pipes can be performed to determine if and when a particular pipe should be rehabilitated. An FEA performance curve evaluates the impact of distress on the structural performance of a pipe and the corresponding likelihood of failure as a result of this damage. Risk of failure is expressed in terms of the Limits, provided in Table 2.11, as it relates to the capacity of a pipe with a particular level of distress. An FEA performance curve was created for the BWP design pressure Class 150 and 4 feet of earth cover, as indicated by the materials sampled and the plan and profile drawings. Based on this analysis, plots were generated that show the Limits in terms of the number of broken bar wraps or percent cylinder loss and the applied internal pressure. Table 2.8 provides the number of broken bar warps required to exceed each Limit at the actual operating pressure plus surge pressure (80 psi). Figure 2.17 provides the number of broken pretensioned bar wraps required to exceed each Limit at the actual operating pressure plus surge pressure.

Table 2.8: Number of Broken Bars Required to Exceed Each Limit

Analysis Pressure (psi)	Micro Cracking	Visible Cracking Of the Inner Lining	Yield
80	1	5	12

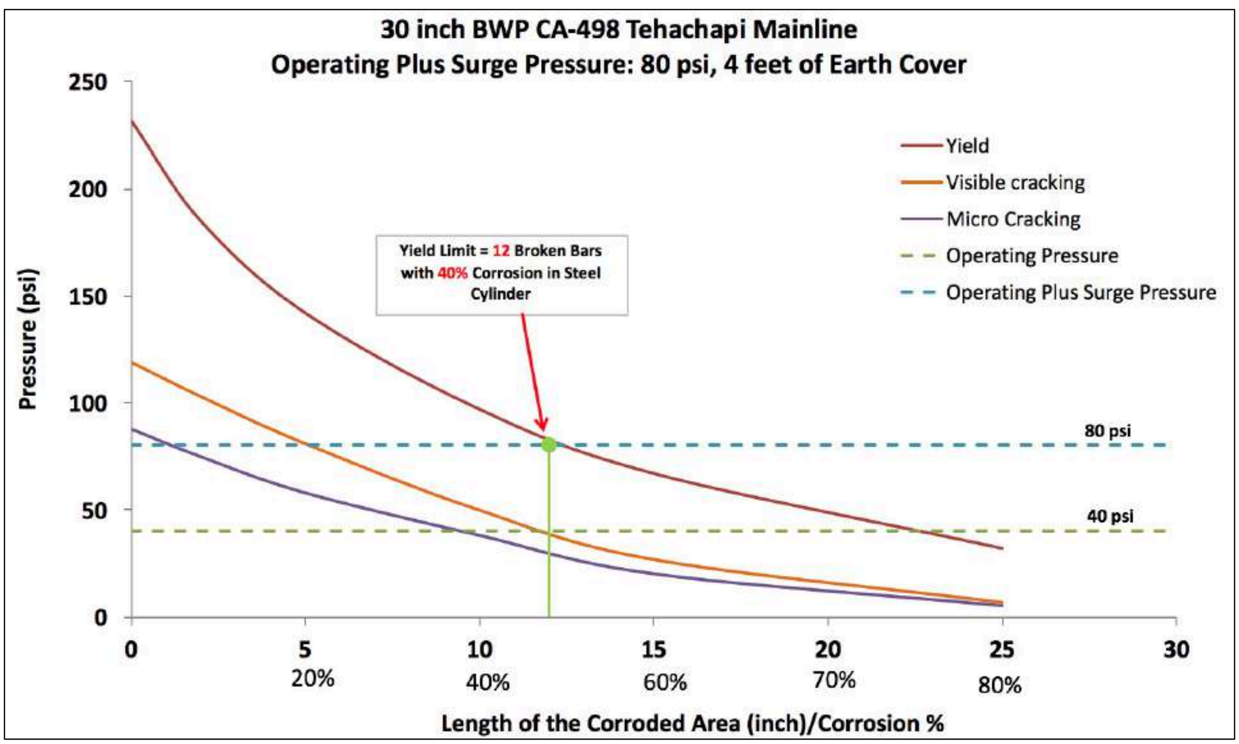


Figure 2.17: Performance curve for the 30-inch BWP pressure Class 150

Pure Technologies typically recommends mitigating the risk associated with operating a particular pipe when the model predicts that the pipe meets or exceeds the Yield Limit. In reality, the Limit that a pipe exceeds is only one factor to consider when deciding whether to rehabilitate a pipe. Other variables that are critical (e.g., redundancy and consequence of failure) should be evaluated when determining the risk tolerance associated with a distressed pipe. Once the number of broken bar wraps or percent cylinder loss reaches the Yield Limit, a pipe may experience a higher rate of bar wrap breaks until it reaches the Strength Limit. Due to the conservative nature of the FEA, reaching the Strength Limit does not necessarily indicate an immediate failure.

Pure Pipe Reference Number 2103, the only pipe with an electromagnetic signal indicating the presence of broken pretensioned bars, had an estimate of five (5) broken bars with an assumed less than 20% cylinder wall loss. This places the pipe somewhere between the Visible Cracking and Micro Cracking Limits on the performance curve when evaluated at the maximum recorded surge pressure.

2.5 Remaining Useful Life

2.5.1 Remaining Useful Life Methodology

Remaining Useful Life (RUL) is an estimate for the amount of time that an item, component, or system can be assumed to be operating within normal operational parameters for its intended purpose before requiring replacement or rehabilitation. The RUL can be determined based upon visual observations, average failure time estimates of similar items, or typical degradation pathways. Ideally, actual condition measurements are collected from field measurements and then evaluated to provide a more confident estimate of the RUL. When field measurements are provided, there are several analytical methods available that can provide a reasonable estimation of the RUL such as Monte Carlo or Markov Chain Monte Carlo simulations. These methods are particularly useful but become limited in the absence of quantified damage data (i.e., a pipe is in excellent condition with no distress) as they will typically return a result where the pipe has an extremely long or almost indefinite RUL. This is not to say that these analyses are incorrect; it simply means that the current degradation rates computed by these methods lead to incredibly long times on average which would be the case in ideal conditions. Due to the absence of degradation on the line, it becomes unreasonable to predict future failure condition with the given data until degradation actually initiates or can be otherwise quantified.

When appropriate data is available, the RUL evaluation is comprised of an integration of a number of steps:

1. Collect inspection data and evaluate historical failure record
2. Define initiation rate (i.e., first evidence of damage such as a broken wire or bar wrap) from historical failure records and inspection data

3. Define degradation rates based on inspection data (i.e., varying degradation rates that could potentially lead to current pipeline condition)
4. Simulate future failures utilizing the defined initiation and degradation rates and an iterative simulation approach called a Monte Carlo simulation

Figure 2.18 shows an example histogram of the results of RUL analysis.

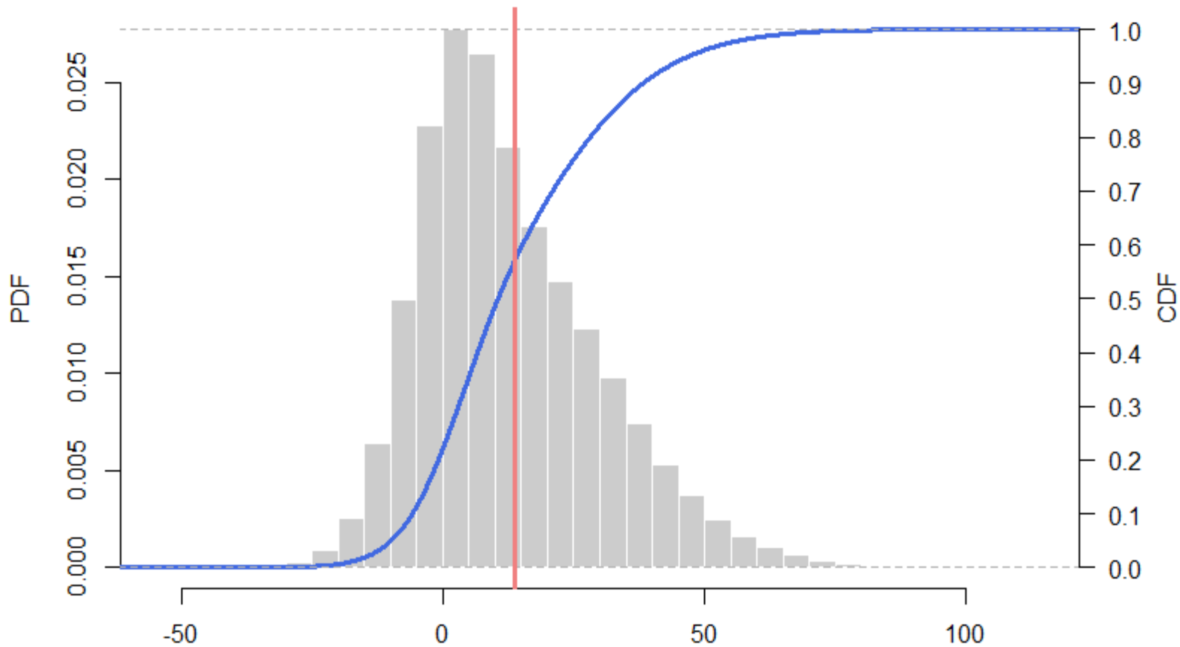


Figure 2.18. Example of an RUL histogram

Figure 2.18 shows the probability density function for failures based on a given set of degradation inputs to provide a mean time to failure. Confidence intervals and a cumulative density function can then be applied to the estimates to provide a fuller picture of what the overall outlook on the pipeline may be.

2.5.2 Remaining Useful Life Results

Based on an evaluation of the inspection results and failure history, the pipeline can be considered to be in good condition as only one (1) BWP exhibited stress estimated to be five (5) broken bar wraps. Based on this data, the analytical RUL analysis described above was is not possible. Because the pipe is considered in good condition, an analytical RUL approach would yield incoherent results and overstate the limited deterioration of the pipe. As such, a more traditional and subjective approach was adopted based on the historical and documented trends of the pipe designs. The pipeline life was estimated based on engineering judgement and the AWWA Buried No Longer survey of large utilities in US West region (Buried No Longer, 2012); the expected useful life of the BWP is 75 years from installation. Plan and profile drawings indicate the 30-inch BWP was installed in 1972. Based on this installation date and expected useful life information state above, it is expected that the BWP has a RUL of 30 years. Figure 2.19 illustrates the RUL for the BWP with respect to the general reliability curve, or “Bathtub” curve. The “Bathtub” curve is based on a component’s failure rate over time where a higher than average failure rate is observed during the early and end phases; while a lower, more stable phase is experienced between the early and end phases.

Based on the inspection data, there were no pipes that exhibited significant structural damage or any failures to signify that the pipeline might be moving toward the wear-out phase. Based on this it is assumed that the pipes are likely in the Useful Life stage as depicted on the life cycle curves illustrated in the figures below.

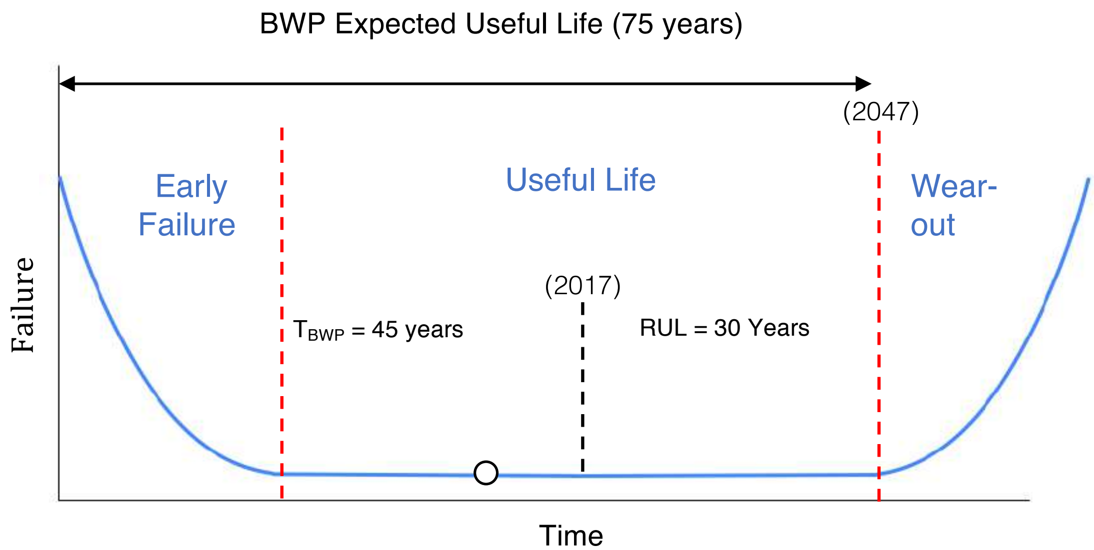


Figure 2.19: BWP “Bathtub” Curve for illustration purposes

Pure Technologies concludes that a heavily analytical RUL analysis could not be performed because there was little evidence of measurable corrosion or other signs of degradation, and the inspection results indicate limited damage in the pipe. It should be noted that the current condition of the pipeline and damage found may continue to progress leading to future failures. Further, one cannot presume that additional damage will not present itself over time and that the evaluation presented herein is a definitive estimate of time to failure. Rather this information should be used as a guide when making future decisions regarding this pipeline such as when to re-inspect and that future data should be gathered so that a degradation rate can be better defined and the RUL can be better quantified.

3. Conclusions and Recommendations

3.1 Conclusions

Based on the condition assessment of the pipeline, Pure Technologies concludes the following:

1. Of the 986 BWPs assessed, one (1) pipe (0.1%), Pure Pipe Reference Number 2103, exhibited an electromagnetic anomaly indicative of five (5) broken bar wraps,
2. Three (3) pipes (0.3%) contained an anomalous electromagnetic signal not characteristic of broken bar wraps that can be attributed to a change in the pipe cylinder. Pure Pipe Reference Numbers 4012, 5122, and 5155 contained these cylinder anomalies. These observations correlated to a visual observations of severe cylinder corrosion.
3. The visual and electromagnetic survey observed pipe repairs at Pure Pipe Reference Numbers 1178, 3037, 4078, 4130, 4177, and 5239.
4. The visual survey observed significant debris buildup in the pipe at Station 211+30. This location was marked above ground for follow-up.
5. Transient pressure monitoring identified a peak pressure of 80.5 psi, a minimum pressure of -1.8 psi, and an average pressure of 20 psi, indicating the pipeline operates well below the design capacity of 150 - 275 psi, depending on elevation.
6. Transient pressure monitoring identified several transient pressure events. This indicates the pipeline experiences water hammer effects or pressure spikes above standard operating pressures on a regular basis. These events were traced back to pump operations and total plant shutdowns. These transient pressures remained well below the design pressure of the pipe.
7. Pure Pipe Reference Number 2103 contained 5 broken bar wraps and does not exceed the Yield Limit of 12 broken bars at the evaluated loading conditions of 80 psi of 4 feet of earth cover.

3.2 Recommendations

Pure Technologies provides the following recommendations for the short and long-term management of the pipeline. The recommendations were developed through analysis of pressure transient data, leak and air pocket detection results, material sampling, visual observations, evidence of repair history, application of a structural evaluation to the inspection data, and engineering judgement based on extensive pipeline management experience.

1. The pipeline contains no pipes beyond the Yield Limit within the given operating parameters, which is Pure Technologies' general threshold for immediate risk mitigation

recommendations. As such, the pipeline is in serviceable condition from the standpoint of structural capacity.

2. Severe debris buildup located around Station 211+55 to 211+80 is reducing the hydraulic capacity of the pipeline. TCCWD should remove this debris as soon as is conveniently possible. The locations of spalled internal lining and internal cylinder corrosion should be considered for repair at TCCWDs convenience. These locations are listed in the video review in Appendix F.

3. Despite the pipeline operating at below design pressure and no pipes currently operating near their Yield Limit, the presence of transient pressure events will reduce the time to failure as the pipeline continues to age and deteriorate. TCCWD should evaluate both operational procedures and surge protection installation options to determine the most effective method of reducing the severity or occurrence of surge pressures.

4. All remaining useful life calculations are based on pipeline deterioration starting at the date of the pipeline's installation and the baseline condition established from the results of the 2016 survey. This method of evaluation uses linear assumed deterioration rates as boundary conditions, which results in uncertainty. To better determine the pipeline's main deterioration mechanism and rate, Pure Technologies recommends a structural reassessment within 10 years. Additional datasets should then be compared to more accurately determine the deterioration rate and update the RUL assessment.

4. References

1- Ameron. Concrete Cylinder Pipe Design Manual. U.S.A. 1988

2- American Water Works Association. AWWA C303, Concrete Pressure Pipe, Bar-Wrapped, Steel-Cylinder Type. Denver: AWWA; 2008.

3- American Water Works Association. Manual of Water Supply Practices M9. Third Edition. Denver. 2008.

4- American Concrete Pipe Association, Concrete Pipe Design Manual, Vienna: ACPA; 2007.

APPENDIX A

Glossary & Abbreviations

AV:	Air Valve
BO:	Blowoff
BWP:	Bar Wrapped Pipe
ECP:	Embedded Cylinder Pipe
EL:	Elbow
EM:	Electromagnetic
LCP:	Lined Cylinder Pipe
OL:	Outlet
MH:	Manhole
NSS:	Non-Shorting Strap
PCP:	Prestressed Concrete Pipe
PCCP:	Prestressed Concrete Cylinder Pipe
RCP:	Reinforced Concrete Pipe
RCCP:	Reinforced Concrete Cylinder Pipe
SP:	Short Pipe Length
SS:	Shorting Strap
STD:	Standard Pipe Length
TO:	Turn Out
VS:	Vent Structure
PW:	Pumping Well

Amplitude: A component of the data signal produced during pipeline inspection, amplitude is an indication of signal strength.

Anomalous Pipe: A pipe that produces a data signal that cannot be interpreted as distressed or distress-free due to some irregularity. This irregularity may be due to unexplained signal influence during the inspection process or due to the properties of the pipe itself.

Calibration: A controlled inspection of a pipe similar to the in situ pipe that is performed to determine the expected signal response. The data signal recorded while inspecting the in situ pipes is then compared to this signal to estimate number of broken bar wraps. Calibration typically requires the destructive testing of a removed pipe.

Distressed Pipe: A pipe that exhibits electromagnetic anomalies consistent with broken bar wraps. The amount of distress can be estimated by comparing the distress signal with the signal obtained during the calibration process.

Distressed Region: A section of pipe that exhibits electromagnetic anomalies consistent with broken bar wraps. There may be one or more regions of distress in any distressed pipe.

Downstream: In the direction of water flow.

Feature: Fixtures in the pipeline that affect the inspection (e.g., Manholes, Air Valves, Tees, Elbows).

Feature Pipe: Pipes with features that may be used to locate distressed pipes. The feature pipes cannot be analyzed for distress at or near the feature due to the signal distortion caused by the presence of the feature.

Joint: An area of the pipeline where two pipe ends are fixed together. Typically, pipe ends are joined spigot to bell; however, special pipes are available that join two bells ends or two spigot ends.

Phase: A component of the data signal produced during pipeline inspection, phase is a representation of the signal's travel time.

Rank: Listing of pipes with respect to the total number of broken bar wraps in the pipe (descending order).

Pipe: Single section of pipe, from bell end to spigot end.

Upstream: Against the direction of water flow.

APPENDIX B

Electromagnetic Inspection Technology

Primary Focus of Electromagnetic Inspection

Assessing the condition of a BWP transmission main is a challenging task that is best performed using a combination of non-destructive testing technology, internal visual inspection and sounding, engineering science, and experiential judgment. The primary goal of an inspection is to provide an understanding of the condition of the structural component that provides the pipe's strength— the reinforcing bar and steel cylinder. An electromagnetic inspection provides a non-destructive method of evaluating the baseline condition of the bar wraps. Electromagnetic inspections ascertain a magnetic signature for each pipe to identify anomalies that are produced by zones of broken bar wraps. Various characteristics associated with an anomaly (length, magnitude, phase shift, etc.) are evaluated to provide an estimate of the number of broken bar wraps. This inspection method is able to quantify the amount of bar wrap damage and is the best method of determining the baseline condition of a pipeline.

Background and Theory of Electromagnetic Inspection

For many years, it has been possible to exploit the concept of eddy currents to measure structural properties in metals. The application of a time-varying magnetic field to metal structures can create internal electric currents as free electrons are driven by the field along discontinuities in the metal itself. Many applications of this phenomenon have been developed to detect damaged sections in steel and iron pipelines.

For BWP, a different mechanism exists that can be used to determine the structural condition of the pipe. Eddy currents that are generated in a bar wrap can flow along the length of the bar wrap, generating a solenoidal field (see *Figure B.1*). If the current is interrupted by a break in the bar wrap, the field will be affected.

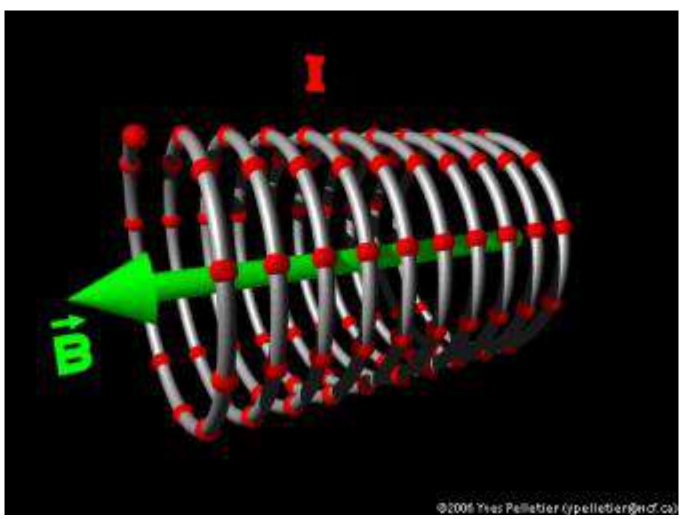


Figure B.1: Electric currents induced by time-varying magnetic field

The electromagnetic system used by Pure Technologies generates eddy currents in the bar wrap and detects where the field is altered by the presence of breaks in the reinforcing bar.

To create an electric current in the reinforcing bar, the Pure Technologies electromagnetic system generates a magnetic field inside a BWP. A signal generator outputs a low frequency alternating electric current (typically less than 100 Hz) into a coil of wire (known as an exciter coil) positioned near the inner surface of the pipe. The magnetic field generated by this coil extends through the concrete core, steel cylinder, and finally into the bar wrap. As the coil travels along the length of the pipe, the field moves as well, creating a localized magnetic field that then generates eddy currents in the reinforcing bar. As long as there are no breaks in the bar wrap, the current will flow uniformly along the bar; however, where a broken bar wrap exists, a discontinuity in the current forms. As the magnetic field passes over the section of the broken bar, currents are generated that form opposing magnetic field lines.

Detectors are placed on the opposite side of the pipe from the exciter coil to record the variations in the magnetic field that are created when broken bar wraps interrupt the current flow. Analyzing and interpreting the response of the magnetic field allows for estimates of the number of broken bar wraps and the approximate location of the broken bar wraps along the length of the pipe.

Analysis Considerations

Electromagnetic inspections detect electromagnetic anomalies, or differences, in the expected induced field of a BWP. Anomalies that are consistent with broken bar wraps in BWP are of particular importance; however, the induced field of interest is small and other interference can mask or distort the size and shape of the electromagnetic signal, affecting the ability to detect and quantify broken bar wraps. The accuracy of the broken bar wrap detection and quantification process on any given pipe depends on a number of factors including, but not necessarily limited to:

- Accuracy and completeness of the information supplied by the client
- Type and configuration of pipe being inspected
- Availability of relevant calibration information
- Type, complexity, location, and number of distressed regions on a given pipe
- Inspection conditions observed in the pipe during the data collection period

Accuracy and completeness of the information supplied by the client. The inspection system is sensitive to all magnetic properties of a pipe, including cylinder thickness and composition, bar spacing and diameter, and the number of bar wraps. Pure Technologies uses the information provided by the client to perform the analysis. Drawings that indicate the exact location of pipe features and varying pressure classes are used to correlate the inspection data. Drawings that indicate how each class of pipe is constructed (cylinder thickness, bar diameter and spacing, etc.) are used to identify and quantify regions of distress. Discrepancies in the drawings and the data may affect the accuracy of the analysis.

Unknown or sealed appurtenances along the pipeline. Although most appurtenances exhibit a signal that is different and distinguishable from broken bar wraps, in some cases, the signals are similar and an appurtenance could be misinterpreted as broken bar wraps if it is not listed on the drawings and not visible during the inspection.

Existence of ferromagnetic (steel) materials near the pipeline. When extra steel is located in close proximity to the pipeline, it can cause a signal distortion that may mask broken bar wraps or could cause anomalies that may be misinterpreted as broken bar wraps.

Changes in bar diameter and bar pitch. Broken bar wraps are estimated by measuring the physical length of an anomaly and entering it into a mathematical model known as a calibration curve. Calibration curves are based on either field testing of a similar pipe or mathematical modeling. If this information is not correct, the quantity of broken bar wraps will likely be incorrectly estimated.

Changing distance of the bar wrap and steel cylinder. If, during manufacturing of the pipe, there is variation in the distance of the reinforcing bar and the steel cylinder, the resultant signal during an electromagnetic inspection may vary, possibly mimicking broken bar wraps. Typically, it is unknown if there are any pipes affected by this issue as only excavation and forensic analysis can reveal manufacturing defects.

Discontinuities or variations such as abnormal welding in liner construction. These discontinuities can mask actual damage or mimic damage where none exists. This situation could cause over or under estimation of the number of broken bar wraps.

Proximity to power lines. In some cases, power lines can cause distortion in the signal due to the stray magnetic fields. This can limit the effectiveness of the analysis if the distortion is too severe. This interference is rare but is noted for completeness of this document.

Motion. Impacts, uneven pipe floor, excessive debris, and vibration all produce distortion which can cause overestimation of broken bar wraps or may mask actual damage. The inspection crew takes every effort to move the tool smoothly to ensure optimum data quality. Detailed field notes document excessive cart motion for analysis consideration, reducing the possibility of misinterpretation due to excessive motion. In addition, a sensitive accelerometer is integrated into the design of the cart, which allows analysts to determine where there was excessive cart motion and identify anomalous signals due to motion.

Type and Configuration of Pipe Being Inspected

The sensitivity to broken bar wraps is affected by the type of pipe being inspected. The following information on detection limits is based on previous calibration testing performed by Pure Technologies.

Bar Wrapped Pipe (AWWA C-303).

Bar wrapped pipe is similar in form to PCCP (AWWA C-301) but with several important distinctions. The primary difference is that the pipes use ¼-inch or thicker steel bars rather than the thinner prestressing wire for the structural support on the pipe.

Feature Pipes. The electromagnetic technology is able to detect distressed regions in some feature pipes; however, due to the impact of the feature on the signal, results are presented with less certainty for regions of the pipe near fittings, manholes, blowoff valves, or other features.

Short Pipes. As the joint effect span is constant regardless of the pipe length, its overall effect on a pipe will increase as the length of the pipe decreases. This means that for short pipes, a shorter length along the barrel of the pipe will remain unaffected by the joint signal and thus be analyzable. In addition, as short pipes typically make up a small portion of the pipe inventory inspected, there are not as many baselines (background signals) available for comparison. This makes the identification of distress on shorter pipes more challenging.

Details of Estimates of Broken Bar Wraps

Break Position. The data signal for a distressed region will vary along the length of a given pipe. Small numbers of broken bar wraps in the middle of a pipe are easier to detect and measure than distress at the joint. Low to moderate quantities of broken bar wraps within approximately 18 inches of the joint may be difficult to identify and quantify due to the increased presence of steel at the joint and the distress signal may be overcome by the much larger effect of the joint steel. Small quantities of broken bar wraps near the joint may not be detected and the accuracy of those that are detected may be less than those closer to the center of the pipe. Additionally, broken bar wraps are more difficult to detect and quantify at the bell end of the pipe than at the spigot end of the pipe, due to the fact that a portion of the bell section will overlap the spigot end. The number of broken bar wraps required for the signal to be detectable and quantifiable depends on the joint configuration, proximity of the center of the break region to the joint, and whether it is the bell or spigot end. Because of this, the estimated number of broken bar wraps near the center of a pipe will be provided with greater confidence than broken bar wraps near the joints, especially near the bell end.

End Effects. End effects refer to changes in the data signal near the end of a pipe (bell or spigot) that are due to a variety of installation methods of the pipe joint itself. End effects do not refer to distress at the joint. Beveled spigots, pulled joints, mitered joints, butt straps, closure pieces, steel fittings, etc., will all affect the data signal at the end of a pipe in some way. Research in this specific area has provided methods for analysts to determine if the signal is due to an end effect, or true end distress. The differences are subtle and examination of client records can provide the additional information necessary to conclude whether a particular data signal represents end effects or end distress. In the case where both end effects and end distress exist, quantification is more challenging.

Non-contiguous Broken Bar Wraps. This occurs when broken bar wraps are scattered amongst non-broken bar wraps.

During the inspection, a broad magnetic field is projected onto the reinforcing bar (several inches wide); therefore, it is difficult to analyze individual bar wrap. When broken bar wraps are separated by non-broken bar wraps, the non-broken bar wraps can be masked by the distress signals and may appear broken. Non-contiguous broken bar wraps may lead to an anomaly that is larger than the actual associated bar damage. The estimated number of broken bar wraps in any report normally assumes a region of consecutive broken bar wraps exist for each break region. This assumption is the only assumption that can be made without additional information, which may be obtained from field verification.

Background Signal Variations. The electromagnetic data signal is sensitive not only to physical differences in pipeline properties (bar diameter and spacing, cylinder thickness, etc.), but it is also sensitive to any magnetic differences in the steel components of the pipe. Pipe manufacturers may use different material suppliers for the various components of the pipes within a pipeline. Even though two pipes are manufactured exactly the same physically, if the steel for the cylinder and the reinforcing bar come from different suppliers, they will likely have slightly different magnetic properties, which will result in variations in the background signals.

Much like the fingerprint, every pipe in a pipeline, no matter how alike they are supposed to be, will exhibit a slightly different background signal. Since distress is quantified by measuring the distressed pipe signal relative to a background signal, any variations in background signals can affect the accuracy of the distress measurement and ultimately the estimate of the number of broken bar wraps.

Number of Distress Regions. Results are predicted with greater accuracy for pipes containing single distressed regions than for pipes containing multiple distress regions. As the number of distress regions per pipe increases, or as these regions become closer together, the complexity of the interpretation increases. In some cases, distress regions can interact with each other from an electromagnetic standpoint to create signals of varying complexity. In cases where the distress signal spans a wide region, a specific break position may not be provided. Instead the length of the damage zone will be shown and an approximate range of suspected broken bar wraps will be given.

Significantly distressed pipes (where most or all of the bar wraps are broken along the entire length of a pipe) are sometimes difficult to distinguish from pipes that just have different properties than the pipes around them. Determining if the signal change is due to changing pipe properties or significant distress is partially dependent on the accuracy and completeness of the information made available by the client, but there are also specific checks in the analysis methodology that are applied to make this distinction.

Other Factors

There are often overlaps amongst the key issues listed above and there may or may not be other factors related to these issues that decrease the level of confidence in the results presented in the report. Wide variations in manufacturing processes may not impact the structural performance of the pipe but can significantly affect the electromagnetic properties. The list of factors includes ones that are known, unknown, controllable, and uncontrollable. Some can be confirmed during excavation or inspection and some can be eliminated by studying construction records, although errors in these records are common. In all cases, every effort is made to consider the various factors during analysis; however, it should be noted that the results provide an estimate of the broken bar wraps in a pipe section based on all the information available and assuming that the signal changes are caused by discontinuity in the reinforcing bar.

APPENDIX C

Enhanced Electromagnetic Pipe Diagrams

Enhanced Electromagnetic Pipe Diagrams

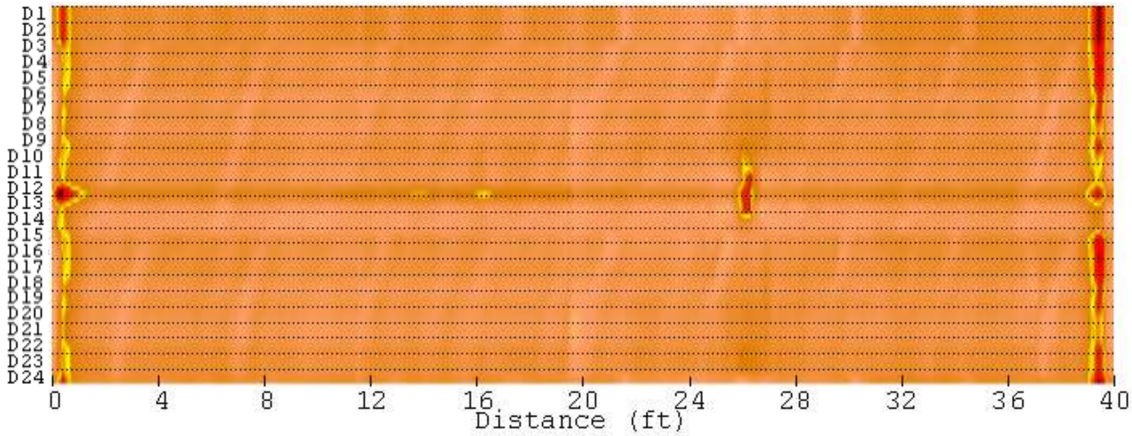
The graphs on the following pages illustrate the recorded electromagnetic inspection data for each of the pipes identified to have localized cylinder anomalies.

The best method of understanding these data sets is to imagine each pipe split down the length of the pipe at the crown and rolled out flat. The x-axis represents the distance, in feet, from the low joint of the pipe. The y-axis denotes D1 through D24, corresponding to the 24 detector coils on the enhanced electromagnetic PureRobotics tool. D1 represents the detector coil located at the crown of the pipe while D12 represents the detector coil at the invert of the pipe. In this manner, it is possible to identify the clock position on the pipe where an anomaly is located.

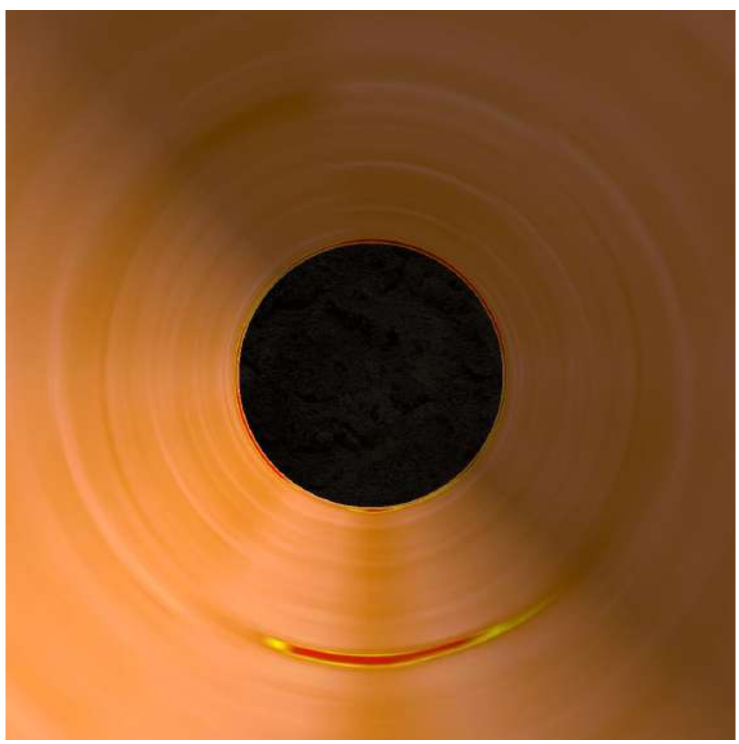
The color in the graph is used to denote the signal strength of the detector. The red or black bars at each end of the graphs denote the joints of the pipe. Since the pipe rollout graphs are difficult to interpret, the data was also rendered onto the inside of a cylinder to assist with illustrating the size, shape, and position of the anomalous area. However, unlike the rollout graphs, the condition of the pipe cannot be fully illustrated with a single viewpoint and several viewpoints need to be utilized to demonstrate all of the characteristics of the anomalous area.

Pure Reference Number 4012:

Pipe rollout map:

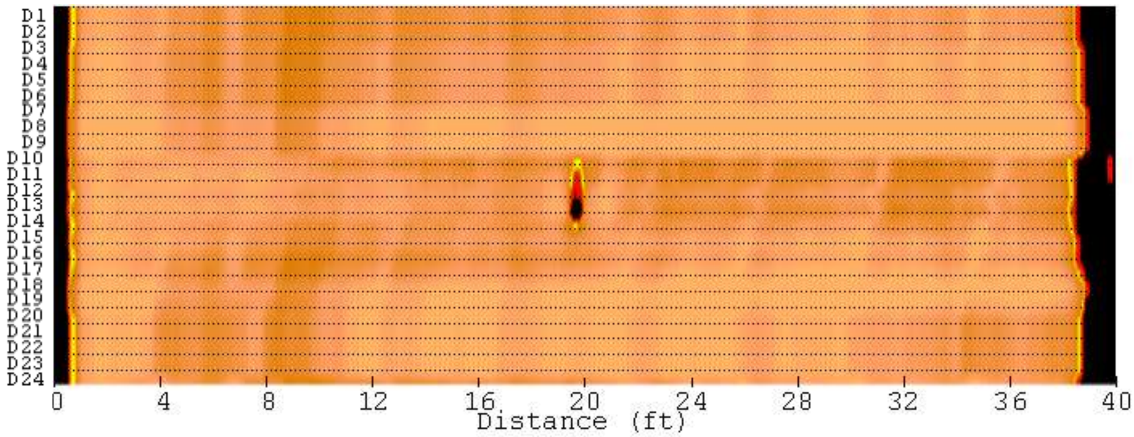


Internal 3D rendering of the pipe illustrating the anomaly size and position:

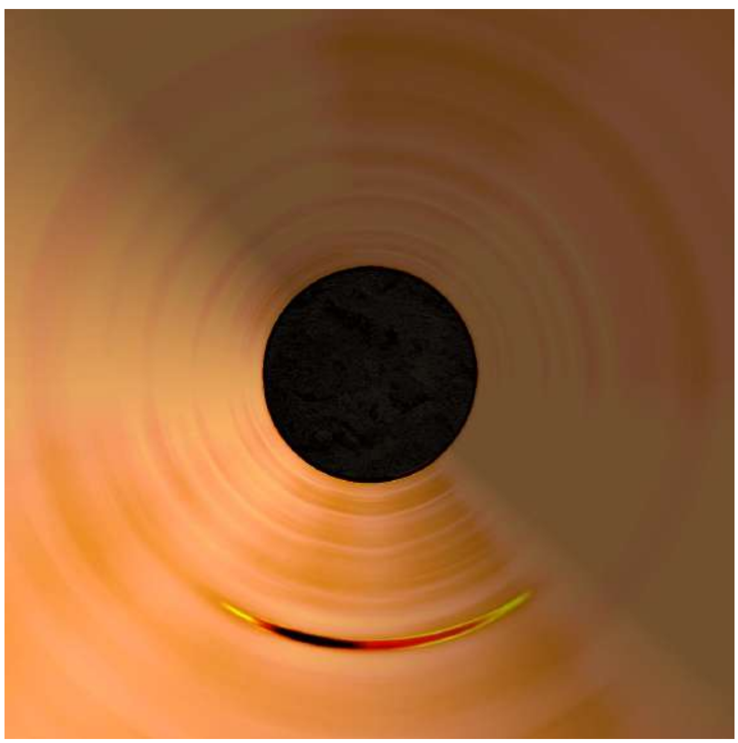


Pure Reference Number 5122:

Pipe rollout map:

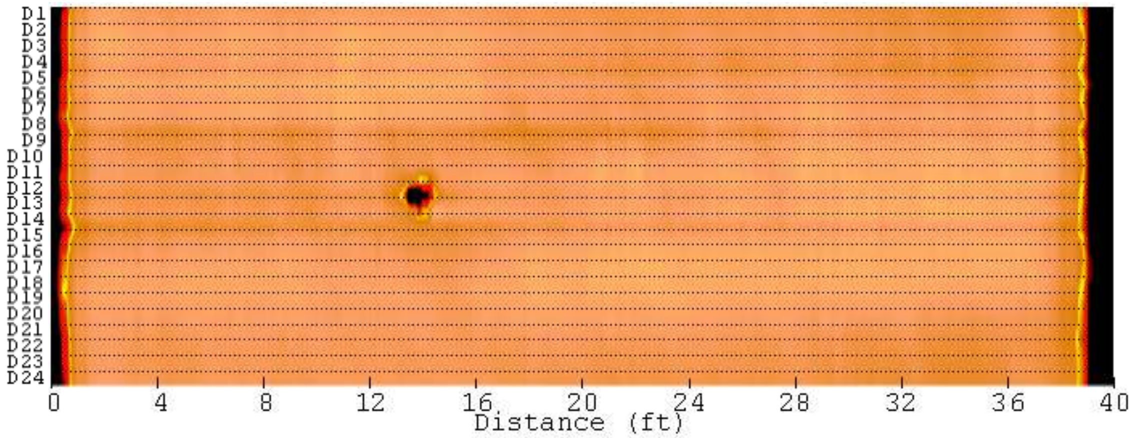


Internal 3D rendering of the pipe illustrating the anomaly size and position:



Pure Reference Number 5155:

Pipe rollout map:



Internal 3D rendering of the pipe illustrating the anomaly size and position:

APPENDIX D

Pipe List

Tehachapi Cummings County Water District
Water Importation Mainline Pipeline

Electromagnetic Inspection Results
Pipe Sections that Exhibit Electromagnetic Anomalies Consistent with Broken Bar Wraps

Pure Reference Number	Low Station	Pipe Length (feet)	High Station	Break Region Location (feet from Low Station)	Number of Broken Bar Wraps by Region	Total Number of Broken Bar Wraps	Layout	Comments
1	0+05	40	0+45					
2	0+45	40	0+85					
3	0+85	40	1+24				OL	OL.
4	1+24	40	1+64					
5	1+64	40	2+04					
6	2+04	40	2+44					
7	2+44	40	2+83					
8	2+83	40	3+23					
9	3+23	40	3+63					
10	3+63	40	4+03					
11	4+03	40	4+42					
12	4+42	40	4+82					
13	4+82	40	5+22					
14	5+22	40	5+62					
15	5+62	40	6+01					
16	6+01	40	6+41					
17	6+41	40	6+81					
18	6+81	40	7+21					
19	7+21	40	7+60					
20	7+60	40	8+00					
21	8+00	40	8+40					
22	8+40	40	8+80					
23	8+80	30	9+09					
24	9+09	40	9+49					
25	9+49	18	9+67					
26	9+67	40	10+07					
27	10+07	40	10+47					
28	10+47	40	10+86					
29	10+86	40	11+26					
30	11+26	40	11+66					
31	11+66	40	12+06					
32	12+06	40	12+45					
33	12+45	40	12+85					
34	12+85	40	13+25					
35	13+25	40	13+65					
36	13+65	40	14+04					
37	14+04	40	14+44					
38	14+44	40	14+84					
39	14+84	40	15+24					
N/A	15+24	40	15+63				OL	Access Point 1. Partially inspected due to insertion of robot. Pipe length reported with less certainty.
N/A	15+63	40	16+03					Partially inspected due to insertion of robot. Pipe length reported with less certainty.
1001	16+03	40	16+43					
1002	16+43	40	16+83					
1003	16+83	40	17+22					
1004	17+22	40	17+62					
1005	17+62	40	18+02					
1006	18+02	40	18+42					
1007	18+42	40	18+82					
1008	18+82	40	19+21					
1009	19+21	40	19+61					
1010	19+61	40	20+01					
1011	20+01	40	20+41					
1012	20+41	40	20+80					
1013	20+80	40	21+20					
1014	21+20	40	21+60					
1015	21+60	40	22+00					
1016	22+00	40	22+39					
1017	22+39	40	22+79					
1018	22+79	40	23+19					
1019	23+19	40	23+59					
1020	23+59	40	23+98					
1021	23+98	40	24+38					
1022	24+38	40	24+78					
1023	24+78	40	25+18					
1024	25+18	40	25+57					
1025	25+57	40	25+97					
1026	25+97	40	26+37					
1027	26+37	40	26+77					
1028	26+77	40	27+16					
1029	27+16	40	27+56					
1030	27+56	40	27+96					
1031	27+96	40	28+36					
1032	28+36	40	28+75					
1033	28+75	40	29+15					
1034	29+15	40	29+55					
1035	29+55	40	29+95					
1036	29+95	40	30+34					
1037	30+34	40	30+74					
1038	30+74	40	31+14					
1039	31+14	40	31+54					
1040	31+54	40	31+93					
1041	31+93	40	32+33					

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Electromagnetic Inspection Results
Pipe Sections that Exhibit Electromagnetic Anomalies Consistent with Broken Bar Wraps

Pure Reference Number	Low Station	Pipe Length (feet)	High Station	Break Region Location (feet from Low Station)	Number of Broken Bar Wraps by Region	Total Number of Broken Bar Wraps	Layout	Comments
1042	32+33	40	32+73					
1043	32+73	9	32+82					
1044	32+82	40	33+22					
1045	33+22	40	33+61					
1046	33+61	40	34+01					
1047	34+01	40	34+41					
1048	34+41	40	34+81					
1049	34+81	40	35+20					
1050	35+20	40	35+60					
1051	35+60	40	36+00					
1052	36+00	40	36+40				AV	2" Air Valve @ Station 36+00.
1053	36+40	40	36+80					
1054	36+80	40	37+20					
1055	37+20	40	37+60					
1056	37+60	40	38+00					
1057	38+00	40	38+40					
1058	38+40	40	38+80					
1059	38+80	40	39+20					
1060	39+20	40	39+60					
1061	39+60	40	40+00					
1062	40+00	40	40+40					
1063	40+40	40	40+80					
1064	40+80	40	41+20					
1065	41+20	40	41+60					
1066	41+60	40	42+00					
1067	42+00	40	42+40					
1068	42+40	40	42+80					
1069	42+80	40	43+21					
1070	43+21	40	43+61					
1071	43+61	40	44+01					
1072	44+01	40	44+41					
1073	44+41	40	44+81					
1074	44+81	40	45+21					
1075	45+21	40	45+61					
1076	45+61	40	46+01					
1077	46+01	40	46+41					
1078	46+41	40	46+81					
1079	46+81	20	47+01				AV	2" Air Valve @ Station 47+10
1080	47+01	20	47+21					
1081	47+21	40	47+61					
1082	47+61	40	48+01					
1083	48+01	40	48+41					
1084	48+41	40	48+81					
1085	48+81	40	49+21					
1086	49+21	40	49+61					
1087	49+61	9	49+70					
1088	49+70	40	50+10					
1089	50+10	40	50+50					
1090	50+50	40	50+90					
1091	50+90	20	51+10					
1092	51+10	20	51+30				AV	2" Air Valve @ Station 51+20.
1093	51+30	40	51+70					
1094	51+70	40	52+10					
1095	52+10	40	52+50					
1096	52+50	40	52+90					
1097	52+90	40	53+30					
1098	53+30	40	53+70					
1099	53+70	40	54+10					
1100	54+10	40	54+50					
1101	54+50	40	54+90					
1102	54+90	40	55+30					
1103	55+30	40	55+70					
1104	55+70	40	56+10					
1105	56+10	20	56+30					
1106	56+30	20	56+50					
1107	56+50	40	56+90				AV	2" Air Valve @ Station 56+50.
1108	56+90	40	57+30					
1109	57+30	40	57+70					
1110	57+70	40	58+09					
1111	58+09	40	58+49					
1112	58+49	40	58+89					
1113	58+89	40	59+29					
1114	59+29	40	59+69					
1115	59+69	40	60+09				BO	Blow Off.
1116	60+09	40	60+48					
1117	60+48	40	60+88					
1118	60+88	40	61+28					
1119	61+28	40	61+68					
1120	61+68	40	62+08					
1121	62+08	40	62+48					
1122	62+48	40	62+88					
1123	62+88	40	63+27					
1124	63+27	40	63+67					
1125	63+67	40	64+07					

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Pipe Sections that Exhibit Electromagnetic Anomalies Consistent with Broken Bar Wraps

Pure Reference Number	Low Station	Pipe Length (feet)	High Station	Break Region Location (feet from Low Station)	Number of Broken Bar Wraps by Region	Total Number of Broken Bar Wraps	Layout	Comments
1126	64+07	40	64+47					
1127	64+47	40	64+87					
1128	64+87	40	65+27					
1129	65+27	40	65+66					
1130	65+66	40	66+06					
1131	66+06	40	66+46				AV	2" Air Valve @ Station 66+40.
1132	66+46	40	66+86					
1133	66+86	40	67+26					
1134	67+26	40	67+66					
1135	67+66	40	68+05					
1136	68+05	40	68+45					
1137	68+45	40	68+85					
1138	68+85	40	69+25					
1139	69+25	40	69+65					
1140	69+65	40	70+05					
1141	70+05	40	70+45					
1142	70+45	40	70+84					
1143	70+84	40	71+24					
1144	71+24	40	71+64				AV	2" Air Valve.
1145	71+64	40	72+04					
1146	72+04	40	72+44					
1147	72+44	40	72+84					
1148	72+84	40	73+23					
1149	73+23	40	73+63					
1150	73+63	40	74+03					
1151	74+03	40	74+43					
1152	74+43	40	74+83					
1153	74+83	40	75+23					
1154	75+23	40	75+63					
1155	75+63	40	76+02					
1156	76+02	40	76+42					
1157	76+42	40	76+82					
1158	76+82	40	77+22					
1159	77+22	40	77+62					
1160	77+62	40	78+02					
1161	78+02	40	78+41					
1162	78+41	40	78+81					
1163	78+81	40	79+21					
1164	79+21	40	79+61					
1165	79+61	40	80+01				AV	2" Air Valve.
1166	80+01	40	80+41					
1167	80+41	40	80+80					
1168	80+80	40	81+20					
1169	81+20	40	81+60					
1170	81+60	40	82+00					
1171	82+00	40	82+40					
1172	82+40	40	82+80					
1173	82+80	40	83+20					
1174	83+20	40	83+59					
1175	83+59	40	83+99					
1176	83+99	40	84+39					
1177	84+39	40	84+79					
1178	84+79	40	85+19					Repair at crown of pipe.
1179	85+19	40	85+59					
1180	85+59	40	85+98					
1181	85+98	40	86+38					
1182	86+38	40	86+78					
1183	86+78	40	87+18					
1184	87+18	40	87+58					
1185	87+58	40	87+98					
1186	87+98	40	88+38					
1187	88+38	40	88+77					
1188	88+77	40	89+17					
1189	89+17	40	89+57					
1190	89+57	40	89+97					
1191	89+97	40	90+37					
1192	90+37	40	90+77					
1193	90+77	40	91+16					
1194	91+16	40	91+56					
1195	91+56	40	91+96					
1196	91+96	40	92+36					
1197	92+36	40	92+76					
1198	92+76	40	93+16					
1199	93+16	40	93+55					
1200	93+55	40	93+95					
1201	93+95	40	94+35					
1202	94+35	40	94+75					
1203	94+75	40	95+15					
1204	95+15	40	95+55					
1205	95+55	40	95+95					
1206	95+95	40	96+34					
1207	96+34	40	96+74					
1208	96+74	40	97+14					
1209	97+14	40	97+54					

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Pipe Sections that Exhibit Electromagnetic Anomalies Consistent with Broken Bar Wraps

Pure Reference Number	Low Station	Pipe Length (feet)	High Station	Break Region Location (feet from Low Station)	Number of Broken Bar Wraps by Region	Total Number of Broken Bar Wraps	Layout	Comments
1210	97+54	40	97+94					
1211	97+94	40	98+34					
1212	98+34	40	98+73					
1213	98+73	40	99+13					
N/A	99+13	40	99+53				OL	Access Point 2. Partially inspected due to insertion of robot. Pipe length reported with less certainty.
2001	99+53	40	99+93					
2002	99+93	40	100+33					
2003	100+33	40	100+73					
2004	100+73	40	101+13					
2005	101+13	40	101+52					
2006	101+52	40	101+92					
2007	101+92	40	102+32					
2008	102+32	40	102+72					
2009	102+72	40	103+12					
2010	103+12	40	103+52					
2011	103+52	40	103+91					
2012	103+91	40	104+31					
2013	104+31	40	104+71					
2014	104+71	40	105+11					
2015	105+11	40	105+51					
2016	105+51	40	105+91					
2017	105+91	40	106+30					
2018	106+30	40	106+70					
2019	106+70	40	107+10					
2020	107+10	40	107+50				BO	Blow Off @ Station 107+50.
2021	107+50	40	107+90					
2022	107+90	40	108+29					
2023	108+29	40	108+69					
2024	108+69	40	109+08					
2025	109+08	40	109+48					
2026	109+48	40	109+87					
2027	109+87	20	110+07				AV	2" Air Valve.
2028	110+07	20	110+27					
2029	110+27	20	110+47					
2030	110+47	20	110+67					
2031	110+67	40	111+06					
2032	111+06	40	111+46					
2033	111+46	40	111+85					
2034	111+85	40	112+25					
2035	112+25	40	112+65					
2036	112+65	40	113+04					
2037	113+04	40	113+44					
2038	113+44	40	113+83					
2039	113+83	40	114+23					
2040	114+23	40	114+62					
2041	114+62	40	115+02					
2042	115+02	40	115+42					
2043	115+42	40	115+81					
2044	115+81	40	116+21					
2045	116+21	40	116+60					
2046	116+60	40	117+00					
2047	117+00	40	117+39					
2048	117+39	40	117+79					
2049	117+79	40	118+19					
2050	118+19	40	118+58					
2051	118+58	40	118+98				AV	2" Air Valve.
2052	118+98	40	119+37					
2053	119+37	40	119+77					
2054	119+77	40	120+16					
2055	120+16	20	120+36					
2056	120+36	20	120+56					
2057	120+56	40	120+96					
2058	120+96	25	121+20					
2059	121+20	40	121+60					
2060	121+60	20	121+80				AV	2" Air Valve.
2061	121+80	40	122+19					
2062	122+19	40	122+59					
2063	122+59	5	122+64				BO	Blow Off.
2064	122+64	32	122+95					
2065	122+95	40	123+35					
2066	123+35	40	123+75					
2067	123+75	40	124+14					
2068	124+14	40	124+54					
2069	124+54	40	124+93					
2070	124+93	40	125+33					
2071	125+33	40	125+73					
2072	125+73	40	126+12					
2073	126+12	40	126+52					
2074	126+52	40	126+91					
2075	126+91	40	127+31					
2076	127+31	40	127+70					
2077	127+70	40	128+10					
2078	128+10	40	128+50					

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Pipe Sections that Exhibit Electromagnetic Anomalies Consistent with Broken Bar Wraps

Pure Reference Number	Low Station	Pipe Length (feet)	High Station	Break Region Location (feet from Low Station)	Number of Broken Bar Wraps by Region	Total Number of Broken Bar Wraps	Layout	Comments
2079	128+50	40	128+89				AV	2" Air Valve.
2080	128+89	40	129+29					
2081	129+29	9	129+38					
2082	129+38	40	129+77					
2083	129+77	40	130+17					
2084	130+17	40	130+56					
2085	130+56	40	130+96					
2086	130+96	40	131+35					
2087	131+35	40	131+75					
2088	131+75	40	132+15					
2089	132+15	40	132+54					
2090	132+54	40	132+94					
2091	132+94	40	133+33					
2092	133+33	40	133+73					
2093	133+73	40	134+13					
2094	134+13	40	134+52					
2095	134+52	40	134+92					
2096	134+92	40	135+31					
2097	135+31	40	135+71					
2098	135+71	40	136+10					
2099	136+10	40	136+50					
2100	136+50	40	136+90				BO	Blow Off @ Station 136+50.
2101	136+90	40	137+30					
2102	137+30	40	137+71					
2103	137+71	40	138+11	35.5	5	5	5	
2104	138+11	40	138+51					
2105	138+51	40	138+91					
2106	138+91	40	139+31					
2107	139+31	40	139+72					
2108	139+72	40	140+12					
2109	140+12	40	140+52					
2110	140+52	40	140+92					
2111	140+92	40	141+33					
2112	141+33	40	141+73					
2113	141+73	40	142+13					
2114	142+13	40	142+53					
2115	142+53	40	142+93					
2116	142+93	40	143+34					
2117	143+34	40	143+74					
2118	143+74	40	144+14					
2119	144+14	40	144+54					
2120	144+54	40	144+94					
2121	144+94	40	145+35					
2122	145+35	40	145+75					
2123	145+75	40	146+15					
2124	146+15	40	146+55					
2125	146+55	40	146+95					
2126	146+95	40	147+36					
2127	147+36	40	147+76					
2128	147+76	40	148+16					
2129	148+16	40	148+56					
2130	148+56	40	148+97					
2131	148+97	40	149+37					
2132	149+37	40	149+77					
2133	149+77	40	150+17					
2134	150+17	40	150+57					
2135	150+57	40	150+98					
2136	150+98	40	151+38					
2137	151+38	40	151+78					
2138	151+78	40	152+18					
2139	152+18	40	152+58					
2140	152+58	40	152+99					
2141	152+99	40	153+39					
2142	153+39	40	153+79					
2143	153+79	40	154+19					
2144	154+19	40	154+59					
2145	154+59	40	155+00					
2146	155+00	40	155+40					
2147	155+40	20	155+60					
2148	155+60	20	155+80				AV	2" Air Valve @ Station 155+60.
N/A	155+80	40	156+20				OL	Access Point 3. Partially inspected due to insertion of robot. Pipe length reported with less certainty.
3001	156+20	40	156+60					
3002	156+60	40	157+00					
3003	157+00	40	157+40					
3004	157+40	40	157+80					
3005	157+80	40	158+20				AV	2" Air Valve.
3006	158+20	40	158+60					
3007	158+60	40	159+00					
3008	159+00	40	159+40					
3009	159+40	40	159+80					
3010	159+80	40	160+20					
3011	160+20	40	160+60					
3012	160+60	40	161+00					

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Pure Reference Number	Low Station	Pipe Length (feet)	High Station	Break Region Location (feet from Low Station)	Number of Broken Bar Wraps by Region	Total Number of Broken Bar Wraps	Layout	Comments
3013	161+00	40	161+40					
3014	161+40	40	161+80					
3015	161+80	40	162+20					
3016	162+20	40	162+60					
3017	162+60	40	163+00					
3018	163+00	40	163+40					
3019	163+40	40	163+80					
3020	163+80	40	164+20					
3021	164+20	40	164+60					
3022	164+60	40	165+00					
3023	165+00	40	165+40					
3024	165+40	40	165+80					
3025	165+80	40	166+20					
3026	166+20	40	166+60				BO	Blow Off @ Station 166+30.
3027	166+60	40	167+00					
3028	167+00	20	167+20					
3029	167+20	40	167+60					
3030	167+60	40	168+00					
3031	168+00	40	168+40					
3032	168+40	40	168+80					
3033	168+80	40	169+20					
3034	169+20	40	169+60					
3035	169+60	40	170+00					
3036	170+00	20	170+20					
3037	170+20	40	170+60					Repair at crown of pipe.
3038	170+60	30	170+90					
3039	170+90	10	171+00				AV	2" Air Valve @ Station 170+90.
3040	171+00	40	171+40					
3041	171+40	40	171+80					
3042	171+80	40	172+20					
3043	172+20	40	172+60					
3044	172+60	40	173+00				BO	Blow Off @ Station 172+60.
3045	173+00	40	173+40					
3046	173+40	40	173+80					
3047	173+80	40	174+20					
3048	174+20	40	174+60					
3049	174+60	40	175+00					
3050	175+00	40	175+40					
3051	175+40	40	175+80					
3052	175+80	40	176+20					
3053	176+20	40	176+60					
3054	176+60	40	177+00				AV	2" Air Valve.
3055	177+00	40	177+40					
3056	177+40	40	177+80					
3057	177+80	40	178+20					
3058	178+20	40	178+60					
3059	178+60	40	179+00					
3060	179+00	40	179+40					
3061	179+40	40	179+80					
3062	179+80	40	180+20					
3063	180+20	40	180+60					
3064	180+60	40	181+00					
3065	181+00	40	181+40					
3066	181+40	40	181+80					
N/A	181+80	40	182+20				OL	Access Point 4. Partially inspected due to insertion of robot. Pipe length reported with less certainty.
4001	182+20	40	182+60					
4002	182+60	40	183+00					
4003	183+00	40	183+40					
4004	183+40	40	183+80					
4005	183+80	40	184+20				AV	2" Air Valve @ Station 183+80.
4006	184+20	40	184+59					
4007	184+59	40	184+99					
4008	184+99	40	185+39					
4009	185+39	40	185+79					
4010	185+79	40	186+18					
4011	186+18	40	186+58					
4012	186+58	40	186+98				C	Cylinder anomaly at invert, 26.0ft from low joint. Anomaly is approximately 50 in^2.
4013	186+98	40	187+37					
4014	187+37	40	187+77					
4015	187+77	40	188+17					
4016	188+17	40	188+57					
4017	188+57	40	188+96					
4018	188+96	40	189+36					
4019	189+36	40	189+76					
4020	189+76	40	190+15					
4021	190+15	40	190+55					
4022	190+55	40	190+95					
4023	190+95	40	191+35					
4024	191+35	40	191+74					
4025	191+74	40	192+14					
4026	192+14	15	192+29					
4027	192+29	20	192+49				BO	Blow Off @ Station 192+40.

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Pure Reference Number	Low Station	Pipe Length (feet)	High Station	Break Region Location (feet from Low Station)	Number of Broken Bar Wraps by Region	Total Number of Broken Bar Wraps	Layout	Comments
4028	192+49	40	192+88					
4029	192+88	40	193+28					
4030	193+28	40	193+68					
4031	193+68	40	194+08					
4032	194+08	40	194+47					
4033	194+47	40	194+87					
4034	194+87	40	195+27					
4035	195+27	40	195+66					
4036	195+66	40	196+06					
4037	196+06	40	196+46					
4038	196+46	40	196+86					
4039	196+86	40	197+25					
4040	197+25	40	197+65					
4041	197+65	40	198+05				AV	2" Air Valve @ Station 197+65.
4042	198+05	40	198+44					
4043	198+44	40	198+84					
4044	198+84	40	199+23					
4045	199+23	40	199+63					
4046	199+63	20	199+83					
4047	199+83	20	200+02					
4048	200+02	40	200+42					
4049	200+42	40	200+82					
4050	200+82	40	201+21					
4051	201+21	40	201+61					
4052	201+61	40	202+00					
4053	202+00	40	202+40					
4054	202+40	40	202+79					
4055	202+79	40	203+19					
4056	203+19	40	203+59					
4057	203+59	40	203+98					
4058	203+98	40	204+38					
4059	204+38	40	204+77					
4060	204+77	40	205+17					
4061	205+17	40	205+56					
4062	205+56	40	205+96					
4063	205+96	40	206+36					
4064	206+36	40	206+75					
4065	206+75	40	207+15					
4066	207+15	40	207+54					
4067	207+54	40	207+94					
4068	207+94	40	208+33					
4069	208+33	40	208+73					
4070	208+73	40	209+12					
4071	209+12	40	209+52				AV	2" Air Valve.
4072	209+52	40	209+92					
4073	209+92	30	210+21					
4074	210+21	40	210+61					
4075	210+61	30	210+91					
4076	210+91	20	211+10					
4077	211+10	20	211+30					
4078	211+30	10	211+40					Repair in pipe.
4079	211+40	15	211+55					
4080	211+55	25	211+80					Significant debris in pipe. Pipe reported with less certainty.
4081	211+80	25	212+04					
4082	212+04	40	212+44					
4083	212+44	40	212+83					
4084	212+83	40	213+23					
4085	213+23	40	213+63					
4086	213+63	40	214+02					
4087	214+02	40	214+42					
4088	214+42	40	214+81					
4089	214+81	40	215+21					
4090	215+21	40	215+60					
4091	215+60	40	216+00					
4092	216+00	40	216+39				AV	2" Air Valve @ Station 216+00.
4093	216+39	40	216+77					
4094	216+77	40	217+16					
4095	217+16	40	217+55					
4096	217+55	40	217+93					
4097	217+93	40	218+32					
4098	218+32	40	218+71					
4099	218+71	40	219+09					
4100	219+09	40	219+48					
4101	219+48	40	219+86					
4102	219+86	40	220+25					
4103	220+25	40	220+64					
4104	220+64	40	221+02					
4105	221+02	40	221+41					
4106	221+41	40	221+80					
4107	221+80	40	222+18					
4108	222+18	20	222+38					
4109	222+38	20	222+57					
4110	222+57	40	222+96					
4111	222+96	20	223+15					

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Electromagnetic Inspection Results
Pipe Sections that Exhibit Electromagnetic Anomalies Consistent with Broken Bar Wraps

Pure Reference Number	Low Station	Pipe Length (feet)	High Station	Break Region Location (feet from Low Station)	Number of Broken Bar Wraps by Region	Total Number of Broken Bar Wraps	Layout	Comments
4112	223+15	40	223+56				AV	2" Air Valve @ Station 223+15.
4113	223+56	40	223+97					
4114	223+97	40	224+37					
4115	224+37	40	224+78					
4116	224+78	40	225+19					
4117	225+19	40	225+60					
4118	225+60	40	226+00					
4119	226+00	40	226+41					
4120	226+41	40	226+82					
4121	226+82	40	227+23					
4122	227+23	40	227+64					
4123	227+64	40	228+04					
4124	228+04	40	228+45					
4125	228+45	40	228+86					
4126	228+86	40	229+27					
4127	229+27	40	229+68					
4128	229+68	40	230+08					
4129	230+08	40	230+49					
4130	230+49	40	230+90					Repair at crown of pipe.
4131	230+90	40	231+31					
4132	231+31	40	231+71					
4133	231+71	40	232+12					
4134	232+12	40	232+53					
4135	232+53	40	232+94					
4136	232+94	40	233+35					
4137	233+35	40	233+75					
4138	233+75	40	234+16					
4139	234+16	40	234+57					
4140	234+57	40	234+98					
4141	234+98	40	235+38					
4142	235+38	40	235+79					
4143	235+79	40	236+20					
4144	236+20	40	236+61					
4145	236+61	40	237+02					
4146	237+02	40	237+42					
4147	237+42	40	237+83					
4148	237+83	40	238+24					
4149	238+24	40	238+65					
4150	238+65	40	239+05					
4151	239+05	40	239+46					
4152	239+46	40	239+87					
4153	239+87	40	240+28					
4154	240+28	40	240+69					
4155	240+69	40	241+09					
4156	241+09	40	241+50					
4157	241+50	40	241+91					
4158	241+91	40	242+32					
4159	242+32	40	242+73					
4160	242+73	40	243+13					
4161	243+13	20	243+34					
4162	243+34	20	243+54					
4163	243+54	20	243+74					
4164	243+74	40	244+15					
4165	244+15	40	244+56					
4166	244+56	40	244+97				AV	2" Air Valve.
4167	244+97	40	245+38					
4168	245+38	40	245+78					
4169	245+78	40	246+19					
4170	246+19	40	246+60				AV	2" Air Valve.
4171	246+60	40	247+01					
4172	247+01	40	247+42					
4173	247+42	40	247+82					
4174	247+82	40	248+23					
4175	248+23	40	248+64					
4176	248+64	40	249+05					
4177	249+05	40	249+45					Repair at crown of pipe.
4178	249+45	40	249+86					
4179	249+86	40	250+27					
4180	250+27	40	250+68					
4181	250+68	40	251+09					
4182	251+09	40	251+49					
4183	251+49	40	251+90					
4184	251+90	40	252+31					
4185	252+31	40	252+72					
4186	252+72	40	253+12					
4187	253+12	40	253+53					
4188	253+53	40	253+94					
4189	253+94	40	254+35					
4190	254+35	40	254+76					
4191	254+76	40	255+16					
4192	255+16	40	255+57					
4193	255+57	40	255+98					
4194	255+98	40	256+39					
4195	256+39	40	256+80					

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Pure Reference Number	Low Station	Pipe Length (feet)	High Station	Break Region Location (feet from Low Station)	Number of Broken Bar Wraps by Region	Total Number of Broken Bar Wraps	Layout	Comments
4196	256+80	40	257+20					
4197	257+20	40	257+61					
4198	257+61	40	258+02					
4199	258+02	40	258+43					
4200	258+43	40	258+83					
4201	258+83	40	259+24					
4202	259+24	40	259+65				BO	Blow Off.
4203	259+65	19	259+84					
4204	259+84	40	260+25					
4205	260+25	40	260+66					
4206	260+66	40	261+07					
4207	261+07	40	261+47					
4208	261+47	40	261+88					
4209	261+88	40	262+29					
4210	262+29	40	262+70					
4211	262+70	40	263+11					
4212	263+11	40	263+51					
4213	263+51	40	263+92					
4214	263+92	40	264+33					
4215	264+33	40	264+74					
4216	264+74	40	265+15					
4217	265+15	40	265+55					
N/A	265+55	40	265+96				OL	Access Point 5. Partially inspected due to insertion of robot. Pipe length reported with less certainty.
5001	265+96	40	266+37					
5002	266+37	40	266+78					
5003	266+78	40	267+18					
5004	267+18	40	267+59					
5005	267+59	40	268+00					
5006	268+00	40	268+39				AV	2" Air Valve @ Station 268+00.
5007	268+39	40	268+79					
5008	268+79	9	268+87					
5009	268+87	20	269+07					
5010	269+07	40	269+46					
5011	269+46	40	269+86					
5012	269+86	40	270+25					
5013	270+25	40	270+65					
5014	270+65	40	271+04					
5015	271+04	40	271+43					
5016	271+43	40	271+83					
5017	271+83	40	272+22					
5018	272+22	40	272+62					
5019	272+62	40	273+01					
5020	273+01	40	273+41					
5021	273+41	40	273+80					
5022	273+80	40	274+19					
5023	274+19	40	274+59					
5024	274+59	40	274+98					
5025	274+98	40	275+38					
5026	275+38	40	275+77					
5027	275+77	40	276+17					
5028	276+17	40	276+56					
5029	276+56	40	276+95					
5030	276+95	40	277+35					
5031	277+35	40	277+74					
5032	277+74	40	278+14					
5033	278+14	40	278+53					
5034	278+53	40	278+93					
5035	278+93	40	279+32					
5036	279+32	40	279+71					
5037	279+71	40	280+11					
5038	280+11	40	280+50					
5039	280+50	40	280+90					
5040	280+90	40	281+29					
5041	281+29	40	281+68					
5042	281+68	40	282+08					
5043	282+08	40	282+47					
5044	282+47	40	282+87					
5045	282+87	40	283+26					
5046	283+26	40	283+66					
5047	283+66	40	284+05					
5048	284+05	40	284+44					
5049	284+44	40	284+84					
5050	284+84	40	285+23					
5051	285+23	40	285+63					
5052	285+63	40	286+02					
5053	286+02	40	286+42					
5054	286+42	40	286+81					
5055	286+81	40	287+20					
5056	287+20	7	287+27					
5057	287+27	40	287+67					
5058	287+67	40	288+06					
5059	288+06	40	288+46					
5060	288+46	40	288+85					

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Pure Reference Number	Low Station	Pipe Length (feet)	High Station	Break Region Location (feet from Low Station)	Number of Broken Bar Wraps by Region	Total Number of Broken Bar Wraps	Layout	Comments
5061	288+85	40	289+24				BO	Blow Off @ Station 288+85.
5062	289+24	40	289+64					
5063	289+64	40	290+03					
5064	290+03	40	290+42					
5065	290+42	40	290+82					
5066	290+82	40	291+21					
5067	291+21	40	291+60					
5068	291+60	40	292+00					
5069	292+00	40	292+39					
5070	292+39	40	292+78					
5071	292+78	40	293+18					
5072	293+18	40	293+57					
5073	293+57	40	293+96					
5074	293+96	40	294+36					
5075	294+36	40	294+75					
5076	294+75	40	295+14					
5077	295+14	40	295+54					
5078	295+54	40	295+93					
5079	295+93	40	296+32					
5080	296+32	40	296+72					
5081	296+72	40	297+11					
5082	297+11	40	297+50					
5083	297+50	40	297+90					
5084	297+90	40	298+29					
5085	298+29	40	298+68					
5086	298+68	40	299+08					
5087	299+08	40	299+47					
5088	299+47	40	299+87					
5089	299+87	40	300+26					
5090	300+26	40	300+65					
5091	300+65	40	301+05					
5092	301+05	40	301+44					
5093	301+44	40	301+83					
5094	301+83	40	302+23					
5095	302+23	40	302+62					
5096	302+62	40	303+01					
5097	303+01	40	303+41					
5098	303+41	40	303+80					
5099	303+80	40	304+19					
5100	304+19	40	304+59					
5101	304+59	40	304+98					
5102	304+98	40	305+37					
5103	305+37	40	305+77					
5104	305+77	40	306+16					
5105	306+16	40	306+55					
5106	306+55	40	306+95					
5107	306+95	40	307+34					
5108	307+34	40	307+73					
5109	307+73	40	308+13					
5110	308+13	40	308+52					
5111	308+52	40	308+91					
5112	308+91	40	309+31					
5113	309+31	40	309+70					
5114	309+70	40	310+10				AV	2" Air Valve @ Station 309+70.
5115	310+10	40	310+50					
5116	310+50	40	310+91					
5117	310+91	40	311+31					
5118	311+31	40	311+71					
5119	311+71	40	312+11					
5120	312+11	40	312+52					
5121	312+52	40	312+92					
5122	312+92	40	313+32				C	Cylinder anomaly at invert, 19.5ft from low joint. Anomaly is approximately 60 in^2.
5123	313+32	40	313+72					
5124	313+72	6	313+78					
5125	313+78	40	314+18					
5126	314+18	40	314+59					
5127	314+59	40	314+99					
5128	314+99	40	315+39					
5129	315+39	40	315+79					
5130	315+79	40	316+20					
5131	316+20	40	316+60					
5132	316+60	40	317+00					
5133	317+00	40	317+40					
5134	317+40	40	317+80					
5135	317+80	40	318+21					
5136	318+21	40	318+61					
5137	318+61	40	319+01					
5138	319+01	40	319+41					
5139	319+41	40	319+82					
5140	319+82	40	320+22					
5141	320+22	40	320+62					
5142	320+62	40	321+02					
5143	321+02	40	321+42					

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Pipe Sections that Exhibit Electromagnetic Anomalies Consistent with Broken Bar Wraps

Pure Reference Number	Low Station	Pipe Length (feet)	High Station	Break Region Location (feet from Low Station)	Number of Broken Bar Wraps by Region	Total Number of Broken Bar Wraps	Layout	Comments
5144	321+42	40	321+83					
5145	321+83	40	322+23					
5146	322+23	40	322+63					
5147	322+63	40	323+03					
5148	323+03	40	323+44					
5149	323+44	40	323+84					
5150	323+84	40	324+24				BO	Blow Off @ Station 324+00.
5151	324+24	40	324+64					
5152	324+64	40	325+04					
5153	325+04	40	325+45					
5154	325+45	40	325+85					
5155	325+85	40	326+25				C	Cylinder anomaly at invert, 13.5ft from low joint. Anomaly is approximately 60 in^2.
5156	326+25	40	326+65					
5157	326+65	40	327+05					
5158	327+05	40	327+46				AV	2" Air Valve.
5159	327+46	40	327+86					
5160	327+86	20	328+06					
5161	328+06	40	328+46				OL	Access Point 6.
5162	328+46	40	328+86					
5163	328+86	40	329+27					
5164	329+27	40	329+67					
5165	329+67	40	330+07					
5166	330+07	40	330+47					
5167	330+47	40	330+88					
5168	330+88	40	331+28					
5169	331+28	40	331+68					
5170	331+68	40	332+08					
5171	332+08	40	332+48					
5172	332+48	40	332+89					
5173	332+89	40	333+29					
5174	333+29	40	333+69					
5175	333+69	40	334+09					
5176	334+09	40	334+50					
5177	334+50	40	334+90					
5178	334+90	40	335+30					
5179	335+30	40	335+70				AV	2" Air Valve @ Station 335+30.
5180	335+70	40	336+10					
5181	336+10	40	336+50					
5182	336+50	40	336+90					
5183	336+90	40	337+30					
5184	337+30	40	337+70					
5185	337+70	40	338+10					
5186	338+10	40	338+50					
5187	338+50	40	338+90					
5188	338+90	40	339+30					
5189	339+30	40	339+70					
5190	339+70	40	340+10					
5191	340+10	40	340+50					
5192	340+50	40	340+90					
5193	340+90	40	341+30					
5194	341+30	10	341+40					
5195	341+40	20	341+60					
5196	341+60	40	342+00					
5197	342+00	40	342+40					
5198	342+40	40	342+80				AV	2" Air Valve.
5199	342+80	40	343+20					
5200	343+20	40	343+60					
5201	343+60	40	344+00					
5202	344+00	40	344+40					
5203	344+40	40	344+80					
5204	344+80	40	345+20					
5205	345+20	40	345+60					
5206	345+60	40	346+00					
5207	346+00	40	346+40					
5208	346+40	40	346+80					
5209	346+80	40	347+21				AV	2" Air Valve @ Station 346+80.
5210	347+21	40	347+62					
5211	347+62	40	348+02					
5212	348+02	40	348+43					
5213	348+43	40	348+84					
5214	348+84	40	349+25					
5215	349+25	40	349+65					
5216	349+65	40	350+06					
5217	350+06	40	350+47					
5218	350+47	40	350+88					
5219	350+88	40	351+28					
5220	351+28	40	351+69					
5221	351+69	40	352+10					
5222	352+10	40	352+50				AV	2" Air Valve @ Station 352+10.
5223	352+50	40	352+90					
5224	352+90	20	353+10					
5225	353+10	10	353+20					
5226	353+20	40	353+60					

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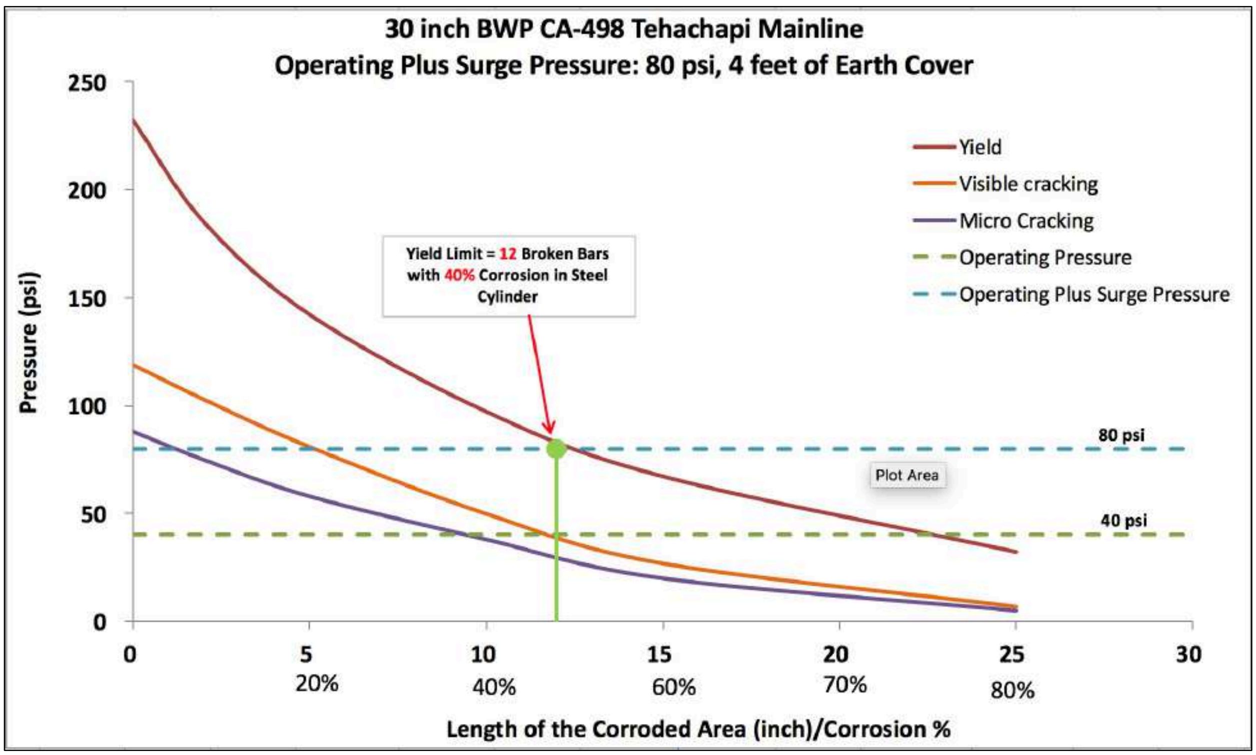
Pure Reference Number	Low Station	Pipe Length (feet)	High Station	Break Region Location (feet from Low Station)	Number of Broken Bar Wraps by Region	Total Number of Broken Bar Wraps	Layout	Comments
5227	353+60	40	354+00					
5228	354+00	40	354+40					
5229	354+40	40	354+80					
5230	354+80	40	355+20					
5231	355+20	40	355+60					
5232	355+60	40	356+00					
5233	356+00	40	356+40					
5234	356+40	40	356+80					
5235	356+80	40	357+20					
5236	357+20	20	357+38				AV	2" Air Valve @ Station 357+20.
5237	357+38	40	357+74					
5238	357+74	20	357+92					
5239	357+92	20	358+10					Repair at crown of pipe.
5240	358+10	5	358+15				BO	Blow Off @ Station 358+10.
5241	358+15	25	358+40					
5242	358+40	40	358+80					
5243	358+80	40	359+20					
5244	359+20	40	359+60					
5245	359+60	40	360+00					
5246	360+00	40	360+40					
5247	360+40	40	360+80					
5248	360+80	40	361+20					
5249	361+20	40	361+60					
5250	361+60	40	362+00					
5251	362+00	40	362+40					
5252	362+40	40	362+80					
5253	362+80	40	363+20					
5254	363+20	40	363+60					
5255	363+60	40	364+00					
5256	364+00	40	364+40					
5257	364+40	40	364+80					
5258	364+80	40	365+20					
5259	365+20	40	365+60					
5260	365+60	40	366+00					
5261	366+00	40	366+40					
5262	366+40	40	366+80					
5263	366+80	40	367+20					
5264	367+20	40	367+60					
5265	367+60	40	368+00					
5266	368+00	40	368+40					
5267	368+40	40	368+80					
5268	368+80	40	369+20					
5269	369+20	40	369+59				AV	2" Air Valve @ Station 369+20.
5270	369+59	40	369+97					
5271	369+97	40	370+36					
5272	370+36	40	370+74					
5273	370+74	40	371+13					
5274	371+13	40	371+52					
5275	371+52	40	371+90					
5276	371+90	40	372+29					
5277	372+29	40	372+68					
5278	372+68	40	373+06					
5279	373+06	40	373+45					
5280	373+45	40	373+83					
5281	373+83	40	374+22					
5282	374+22	40	374+61					
5283	374+61	20	374+80					
5284	374+80	40	375+20				AV	2" Air Valve @ Station 374+80.
5285	375+20	20	375+41					
5286	375+41	40	375+81					
5287	375+81	40	376+21					
5288	376+21	40	376+62					
5289	376+62	40	377+02					
5290	377+02	40	377+43					
5291	377+43	40	377+83					
5292	377+83	40	378+23					
5293	378+23	40	378+64					
5294	378+64	40	379+04					
5295	379+04	40	379+45					
5296	379+45	40	379+85					
5297	379+85	40	380+25				AV	2" Air Valve @ Station 379+85.
5298	380+25	40	380+65					
5299	380+65	40	381+05					
5300	381+05	40	381+45				OL	Meter chamber access.
5301	381+45	20	381+65					
5302	381+65	20	381+85					
5303	381+85	40	382+25					

APPENDIX E

FEA Performance Curve



30 inch BWP CA-498 Tehachapi Mainline
Operating Plus Surge Pressure: 80 psi, 4 feet of Earth Cover
Pressure (psi)
250
200
150
100
50
0
Yield
Visible cracking
Micro Cracking
Operating Pressure
Operating Plus Surge Pressure
Yield Limit = 12 Broken Bars with 40% Corrosion in Steel Cylinder
80 psi
Plot Area
40 psi
0
5
10
15
20
25
30
20%
40%
60%
70%
80%
Length of the Corroded Area (inch)/Corrosion %

APPENDIX F

Video Review

30-inch Importation Mainline Pipeline
CCTV Video Observations

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
Access 1 U/S					
40	40	27	67		
39	41	67	108		
38	40	108	148		
37	40	148	188		
36	40	188	228		
35	40	228	268		
34	40	268	308		
33	40	308	348		
32	40	348	388		
31	40	388	428		
30	40	428	468		
29	40	468	508		
28	40	508	548		
27	40	548	588	12 O' Clock Impact/Point Damage 559'	
26	14	588	602		
25	5	602	607	Elbow Left	
24	40	607	647		
23	30	647	677		
22	40	677	717		
21	40	717	757		
20	40	757	797		
19	40	797	837		
18	40	837	877		
17	40	877	917		
16	40	917	957		
15	40	957	997		
14	40	997	1037		
13	40	1037	1077		
12	40	1077	1117		
11	40	1117	1157		
10	40	1157	1197	1182' Light Spalling	

30-inch Importation Mainline Pipeline
CCTV Video Observations

Access Point 1 US

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
9	40	1197	1237	1236' Spalling	
8	41	1237	1278		
7	40	1278	1318		
6	40	1318	1358		
5	40	1358	1398		
4	40	1398	1438	7 O'Clock Large Spall 1434'	
3	40	1438	1478	12 O'Clock 13" Meter Outlet 1460'	
2	41	1478	1519		
1	40	1519	1559	6 O'Clock Large Spalling 1540'	

30-inch Importation Mainline Pipeline
CCTV Video Observations

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
0	7	1559	1566	Elbow Right w/ Top ARV Outlet	 
		1566	-	Reducer before Closed Valve	

30-inch Importation Mainline Pipeline
CCTV Video Observations

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
Access 1 D/S					
1001	40	36	76		
1002	40	76	116		
1003	40	116	156		
1004	41	156	197		
1005	40	197	237		
1006	41	237	278		
1007	41	278	319		
1008	40	319	359		
1009	40	359	399		
1010	40	399	439		
1011	40	439	479		
1012	41	479	520		
1013	41	520	561		
1014	40	561	601		
1015	40	601	641		
1016	41	641	682		
1017	40	682	722		
1018	40	722	762		
1019	41	762	803		
1020	40	803	843		
1021	40	843	883		
1022	41	883	924		
1023	41	924	965		
1024	40	965	1005		
1025	40	1005	1045		
1026	41	1045	1086		
1027	40	1086	1126		
1028	41	1126	1167		
1029	40	1167	1207		
1030	40	1207	1247		
1031	41	1247	1288		
1032	41	1288	1329		
1033	40	1329	1369		
1034	41	1369	1410		
1035	40	1410	1450		
1036	41	1450	1491		
1037	40	1491	1531		
1038	41	1531	1572		
1039	41	1572	1613		
1040	40	1613	1653	0% Water Level	
1041	40	1653	1693	80% Water Level	
1042	40	1693	1733	100% Water Level	
1043	10	1733	1743	Elbow Right	
1044	40	1743	1783		
1045	40	1783	1823		
1046	40	1823	1863		

30-inch Importation Mainline Pipeline
CCTV Video Observations

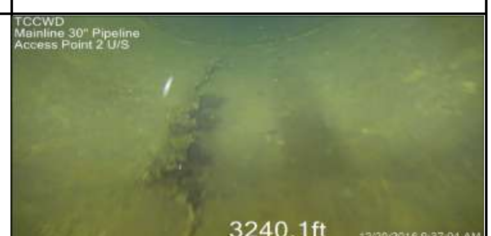
Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
1047	41	1863	1904	70% Water Level	
1048	40	1904	1944	0% Water Level	
1049		1944			

30-inch Importation Mainline Pipeline
CCTV Video Observations

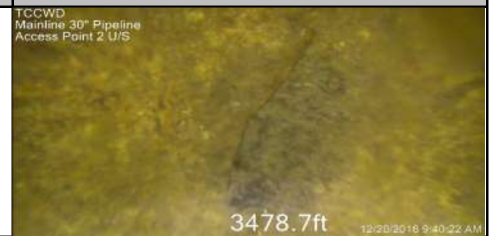
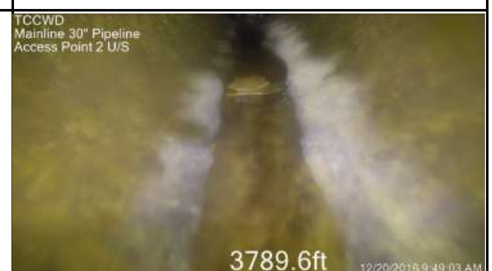
Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
1213	40	0	40	Video too foggy to tell features	
1212	40	40	80	Video too foggy to tell features	
1211	40	80	120	Video too foggy to tell features	
1210	40	120	160	Video too foggy to tell features	
1209	40	160	200	Video too foggy to tell features	
1208	40	200	240	Video too foggy to tell features	
1207	40	240	280	Video too foggy to tell features	
1206	40	280	320	Video too foggy to tell features	
1205	40	320	360	Video too foggy to tell features	
1204	40	360	400	Video too foggy to tell features	
1203	40	400	440	Video too foggy to tell features	
1202	40	440	480	Video too foggy to tell features	
1201	40	480	520	Video too foggy to tell features	
1200	40	520	560	Video too foggy to tell features	
1199	40	560	600	Video too foggy to tell features	
1198	40	600	640	Video too foggy to tell features	
1197	40	640	680	Video too foggy to tell features	
1196	40	680	720	Video too foggy to tell features	
1195	40	720	760	Video too foggy to tell features	
1194	40	760	800	Video too foggy to tell features	
1193	40	800	840	Video too foggy to tell features	
1192	40	840	880	Video too foggy to tell features	
1191	40	880	920	Video too foggy to tell features	
1190	40	920	960	Video too foggy to tell features	
1189	40	960	1000	Video too foggy to tell features	
1188	40	1000	1040	Video too foggy to tell features	
1187	40	1040	1080	Video too foggy to tell features	
1186	40	1080	1120	Video too foggy to tell features	
1185	40	1120	1160	Video too foggy to tell features	
1184	40	1160	1200	Video too foggy to tell features	
1183	40	1200	1240	Video too foggy to tell features	
1182	40	1240	1280	Video too foggy to tell features	
1181	40	1280	1320	Video too foggy to tell features	
1180	40	1320	1360	Video too foggy to tell features	
1179	40	1360	1400		
1178	40	1400	1440	1406.9ft, Repair or feature at 12 o'clock position	
1177	40	1440	1480	Water level at 50%	
1176	40	1480	1520	Water level at 100%	
1175	40	1520	1560		

30-inch Importation Mainline Pipeline
CCTV Video Observations

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
1174	40	1560	1600	Water at 90%	
1173	40	1600	1640		
1172	40	1640	1680	water at 70%	
1171	40	1680	1720	Water at 50%	
1170	40	1720	1760		
1169	40	1760	1800	Water at 50%	
1168	40	1800	1840	Water 25%	
1167	40	1840	1880	Water 0	
1166	40	1880	1920		
1165	40	1920	1960	2 Inch Outlet @ 1958	
1164	40	1960	2000		
1163	40	2000	2040		
1162	40	2040	2080		
1161	40	2080	2120		
1160	40	2120	2160	Debris at 2151	
1159	40	2160	2200		
1158	40	2200	2240	Water at 20%	
1157	40	2240	2280	Water at 40%	
1156	40	2280	2320		
1155	40	2320	2360		
1154	40	2360	2400		
1153	40	2400	2440		
1152	40	2440	2480	Water 20%	
1151	40	2480	2520	Water 0%	
1150	40	2520	2560		
1149	40	2560	2600	Water 70%	
1148	40	2600	2640	Water 100%	
1147	40	2640	2680		
1146	40	2680	2720	Water level 80%, Mortar Damage 2718	

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
1145	40	2720	2760		
1144	40	2760	2800	2" outlet	
1143	40	2800	2840		
1142	40	2840	2880		
1141	40	2880	2920		
1140	40	2920	2960		
1139	40	2960	3000		
1138	40	3000	3040		
1137	43	3040	3083	Debris at 3080, maybe Spalling	
1136	39	3083	3122	Corrosion at 6 o'clock	
1135	40	3122	3162	Water at 50%	
1134	40	3162	3202	Water 100%	
1133	40	3202	3242	Longitudinal crack at 6 o'clock position	
1132	40	3242	3282	Water level at 50%	
1131	41	3282	3323	Water level at 25%, Outlet 2" 12 o'clock, Debris on joint of pipe and Debris	
1130	40	3323	3363		
1129	40	3363	3403	Pieces of mortar	
1128	40	3403	3443		

30-inch Importation Mainline Pipeline
CCTV Video Observations

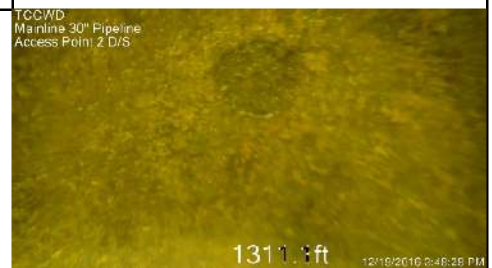
Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
1127	40	3443	3483	Longitudinal crack at 12 o'clock position	
1126	40	3483	3523		
1125	40	3523	3563		
1124	40	3563	3603	Longitudinal Crack for 3 feet at 3 o'clock position	
1123	40	3603	3643		
1122	40	3643	3683		
1121	40	3683	3723		
1120	40	3723	3763		
1119	41	3763	3804	Mortar Debris in line	
1118	40	3804	3844	Water 100%, visibility limited, cloudy	
1117	40	3844	3884		
1116	40	3884	3924	Visibility back	
1115	40	3924	3964	Blow off at the bottom of pipe at 3963	
1114	40	3964	4004		
1113	40	4004	4044	Longitudinal crack at 6 o'clock position	

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
1112	40	4044	4084	Longitudinal crack 7 o'clock position	
1111	40	4084	4124		
1110	40	4124	4164		
1109	40	4164	4204		
1108	41	4204	4245		
1107	40	4245	4285		
1106	40	4285	4325		
1105	40	4325	4365	Longitudinal crack at 5 o'clock position, looks 3 feet long	
1104	40	4365	4405	Longitudinal crack at 5 o'clock position, looks 3 feet long	
1103	40	4405	4445		
1102	40	4445	4485		
1101	10	4485	4495	4495 End of Inspection	
	-4495	4495			

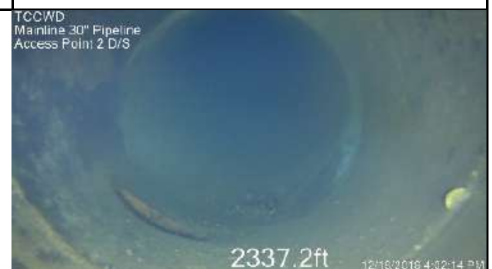
30-inch Importation Mainline Pipeline
CCTV Video Observations

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
Access 2 D/S					
2001	40	6	46		
2002	40	46	86		
2003	40	86	126		
2004	40	126	166		
2005	40	166	206	4 O'Clock Spalling 180'	
2006	40	206	246		
2007	40	246	286		
2008	40	286	326		
2009	41	326	367		
2010	40	367	407	3 O'Clock Hanging Mortar 407'	
2011	40	407	447		
2012	40	447	487		
2013	41	487	528		
2014	40	528	568		
2015	40	568	608		
2016	40	608	648	0% Water Level	
2017	40	648	688		
2018	40	688	728	100% Water Level	
2019	40	728	768		
2020	41	768	809	7 O'Clock Drain outlet 806'	
2021	40	809	849		
2022	40	849	889		
2023	40	889	929	Joint deterioration at 929'	
2024	40	929	969		

30-inch Importation Mainline Pipeline
CCTV Video Observations

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
2025	40	969	1009		
2026	40	1009	1049		
2027	20	1049	1069		
2028	20	1069	1089		
2029	20	1089	1109		
2030	20	1109	1129		
2031	40	1129	1169		
2032	40	1169	1209		
2033	40	1209	1249		
2034	41	1249	1290		
2035	40	1290	1330	11 O'Clock Spalled Ring 1312'	
2036	40	1330	1370		
2037	40	1370	1410		
2038	41	1410	1451		
2039	40	1451	1491		
2040	41	1491	1532		
2041	41	1532	1573		
2042	40	1573	1613		
2043	40	1613	1653		
2044	41	1653	1694		
2045	40	1694	1734		
2046	40	1734	1774		
2047	40	1774	1814		
2048	40	1814	1854		
2049	40	1854	1894		
2050	40	1894	1934		
2051	40	1934	1974	12 O'Clock 1" ARV 1936'	
2052	40	1974	2014		
2053	40	2014	2054		
2054	40	2054	2094	0% Water Level	
2055	20	2094	2114	15% Water Level	
2056	20	2114	2134	80% Water Level	
2057	40	2134	2174	70% Water Level	
2058	25	2174	2199		
2059	40	2199	2239	0% Water Level	

30-inch Importation Mainline Pipeline
CCTV Video Observations

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
2060	20	2239	2259	12 O'Clock 1" ARV 2242"	
2061	40	2259	2299	0% Water Level	
2062	40	2299	2339		
2063	37	2339	2376	7 O'Clock Drain Outlet 2341'	
2064	40	2376	2416	100% Water Level	
2065	40	2416	2456		
2066		2456	-	End of inspection 2478'	

30-inch Importation Mainline Pipeline
CCTV Video Observations

Access Point 3 US

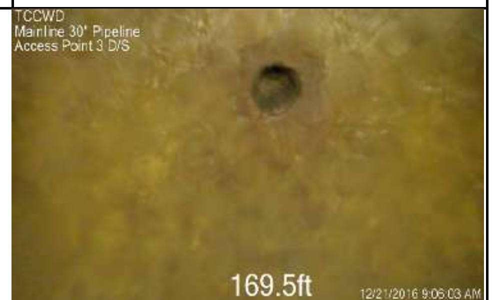
Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
Access 3 U/S					
2148	21	15	36	12 O'Clock 1" ARV 35'	
2147	20	36	56	Debris at joint/invert 36'	
2146	40	56	96	Debris at joint/invert 56'	
2145	40	96	136	Debris at joint/invert 136'	
2144	41	136	177	Small Debris at joint/invert 177'	
2143	40	177	217		
2142	41	217	258		
2141	40	258	298	Small Debris at joint/invert 258'	
2140	40	298	338		
2139	40	338	378		
2138	41	378	419		
2137	40	419	459	Small Debris at joint/invert 459'	
2136	41	459	500		
2135	40	500	540		
2134	41	540	581		
2133	41	581	622		
2132	40	622	662		
2131	41	662	703	Small debris at invert 685'	
2130	40	703	743		

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
2129	41	743	784		
2128	40	784	824		
2127	41	824	865		
2126	40	865	905	Small debris at joint/invert 905'	
2125	41	905	946		
2124	41	946	987		
2123	41	987	1028		
2122	40	1028	1068		
2121	40	1068	1108	Small Debris at joint/invert 1108	
2120	41	1108	1149		
2119	40	1149	1189		
2118	41	1189	1230		
2117	41	1230	1271		
2116	40	1271	1311		
2115	40	1311	1351		
2114	41	1351	1392		
2113	41	1392	1433		
2112	40	1433	1473		
2111	40	1473	1513		
2110	41	1513	1554		
2109	40	1554	1594		
2108	41	1594	1635		
2107	40	1635	1675		
2106	41	1675	1716	0% Water Level	
2105	41	1716	1757	100% Water Level	
2104	40	1757	1797		
2103	41	1797	1838		
2102	41	1838	1879		
2101	41	1879	1920		
2100	41	1920	1961	5 O'Clock Drain Outlet 1959'	
2099	40	1961	2001		
2098	40	2001	2041		
2097	41	2041	2082		
2096	40	2082	2122		
2095	40	2122	2162		
2094	41	2162	2203		
2093	40	2203	2243		
2092	40	2243	2283		
2091	40	2283	2323		
2090	40	2323	2363		
2089	40	2363	2403		
2088	40	2403	2443		
2087	41	2443	2484		
2086	41	2484	2525		
2085	41	2525	2566		
2084	40	2566	2606		
2083	40	2606	2646		

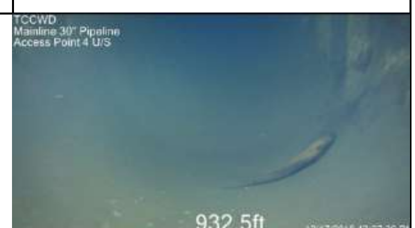
30-inch Importation Mainline Pipeline
CCTV Video Observations

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
2082	40	2646	2686		
2081	8	2686	2694	Short Pipe	
2080	40	2694	2734		
2079	40	2734	2774		
2078	40	2774	2814		
2077	40	2814	2854		
2076	40	2854	2894		
2075	40	2894	2934		
2074	40	2934	2974		
2073	40	2974	3014		
2072	40	3014	3054		
2071	40	3054	3094		
2070	40	3094	3134		
2069	40	3134	3174		
2068	40	3174	3214		
2067	40	3214	3254	3232 Overlap w/ Previous Insp	

30-inch Importation Mainline Pipeline
CCTV Video Observations

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
Access 3 D/S					
3001	40	7	47	5% Water Level	
3002	40	47	87	90% Water Level	
3003	40	87	127	100% Water Level	
3004	20	127	147		
3005	20	147	167	12 O'Clock 1" ARV 170'	
3006	40	167	207		
3007	40	207	247		
3008	40	247	287		
3009	41	287	328		
3010	40	328	368		
3011	41	368	409		
3012	41	409	450		
3013	40	450	490		
3014	41	490	531		
3015	40	531	571		
3016	41	571	612		
3017	40	612	652		
3018	41	652	693		
3019	41	693	734		
3020	40	734	774		
3021	40	774	814		
3022	40	814	854	821' Overlap w/ Previous Insp.	

30-inch Importation Mainline Pipeline
CCTV Video Observations

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
4000	8.1	4.7	12.8		
3999	40	12.8	52.8		
3998	40	52.8	92.8		
3997	40	92.8	132.8		
3996	40	132.8	172.8		
3995	40	172.8	212.8		
3994	40.4	212.8	253.2		
3993	40.3	253.2	293.5		
3992	40.6	293.5	334.1		
3991	40.3	334.1	374.4		
3990	40	374.4	414.4		
3989	40	414.4	454.4		
3988	40	454.4	494.4		
3987	41	494.4	535.4	12 O'Clock 1" ARV 535'	
3986	39	535.4	574.4		
3985	40	574.4	614.4		
3984	40	614.4	654.4		
3983	40	654.4	694.4		
3982	40	694.4	734.4		
3981	40	734.4	774.4		
3980	40	774.4	814.4		
3979	41	814.4	855.4		
3978	41	855.4	896.4		
3977	41	896.4	937.4	100% Water Level, 5 O'Clock BO 935.6'	
3976	38	937.4	975.4	60% Water Level	
3975	40	975.4	1015.4	0% Water level	
3974	40	1015.4	1055.4		
3973	40	1055.4	1095.4	12 O'Clock 1" ARV 1058'	
3972	40	1095.4	1135.4	12 O'Clock 1" ARV 1106'	
3971	41	1135.4	1176.4	Staining 12 O'Clock 1177'	
3970	20	1176.4	1196.4		
3969	40	1196.4	1236.4		
3968	41	1236.4	1277.4		

3967	40.6	1277.4	1318		
3966	40	1318	1358		
3965	40	1358	1398		
3964	40	1398	1438		
3963	40	1438	1478	100% water level	
3962	20	1478	1498		
3961	40	1498	1538		
3960	40	1538	1578	5 O'Clock BO 1577'	
3959	40	1578	1618		
3958	40	1618	1658	75% Water Level	
3957	40	1658	1698	0% Water level	
3956	40	1698	1738		
3955		1738		1750' Robot struggling to move	

30-inch Importation Mainline Pipeline
CCTV Video Observations

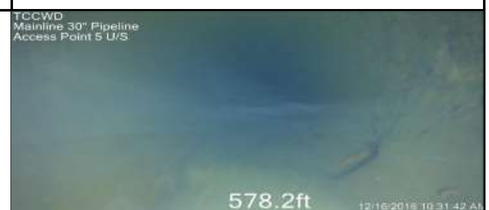
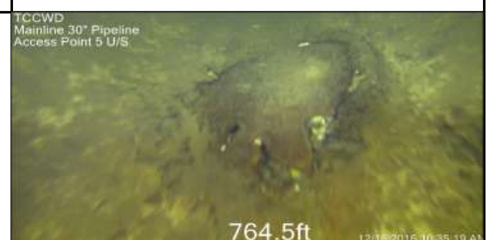
Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
Access 4 - D/S					
4001	40	10	50		
4002	40	50	90		
4003	40	90	130		
4004	40	130	170		
4005	40	170	210	12 O'Clock 1" ARV 172'	
4006	40	210	250		
4007	40	250	290		
4008	40	290	330		
4009	40	330	370		
4010	40	370	410		
4011	40	410	450		
4012	40	450	490	6 O'Clock Point Damage 475'	
4013	40	490	530		
4014	40	530	570		
4015	40	570	610		
4016	40	610	650		
4017	40	650	690		
4018	40	690	730	40% Water Level	
4019	40	730	770	80% Water Level	
4020	40	770	810	100% Water Level	
4021	40	850	890		
4022	40	890	930		
4023	40	930	970		
4024	40	970	1010		
4025	15	1010	1025		

30-inch Importation Mainline Pipeline
CCTV Video Observations

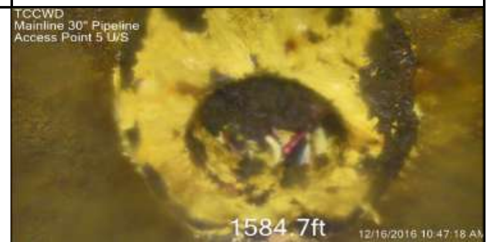
Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
4026	20	1025	1045	7 O'Clock Drain Outlet 1027'	
4027	40	1045	1085	6 O'Clock Small Debris 1052'	
4028	40	1085	1125	6 O'Clock Small Debris 1096'	
4029	40	1125	1165		
4030	40	1165	1205		
4031	40	1205	1245		
4032	40	1245	1285	80% Water Level	
4033	41	1285	1326	0% Water Level	
4034	40	1326	1366		
4035	40	1366	1406		
4036	40	1406	1446	12 O'Clock 1" ARV 1408'	
4037	41	1446	1487		
4038	40	1487	1527		
4039	40	1527	1567	50% Water Level	
4040	40	1567	1607	100% Water Level	
4041	40	1607	1647		
4042	40	1647	1687		
4043	40	1687	1727		
4044	40	1727	1767		
4045	20	1767	1787		
4046	20	1787	1807		
4047	40	1807	1847		
4048	40	1847	1887		
4049	40	1887	1927		

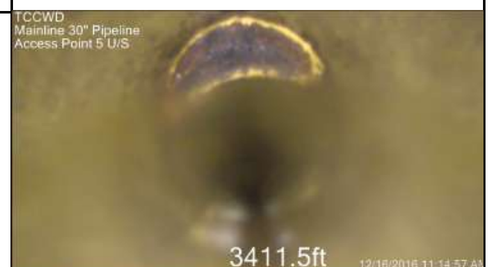
Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
4050	40	1927	1967		
4051	41	1967	2008		
4052	40	2008	2048		
4053	40	2048	2088		
4054	41	2088	2129		
4055	40	2129	2169		
4056	40	2169	2209		
4057	40	2209	2249		
4058	41	2249	2290		
4059	40	2290	2330	30% Water Level	
4060	40	2330	2370		
4061	40	2370	2410		
4062	41	2410	2451		
4063	40	2451	2491		
4064	41	2491	2532		
4065	40	2532	2572		
4066	40	2572	2612	0% Water Level	
4067	41	2612	2653		
4068	41	2653	2694		
4069	40	2694	2734		
4070	41	2734	2775	12 O'Clock 1" ARV 2736'	
4071	40	2775	2815		
4072	30	2815	2845		
4073	40	2845	2885		
4074	30	2885	2915		
4075	20	2915	2935	Debris	

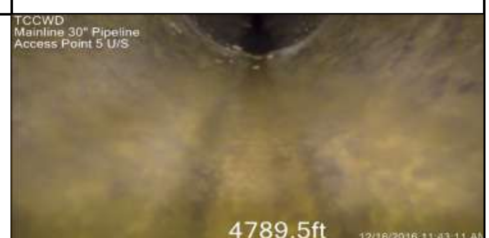
30-inch Importation Mainline Pipeline
CCTV Video Observations

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
4217	35.4	4.6	40		
4216	40	40	80		
4215	40.3	80	120.3		
4214	39.9	120.3	160.2	Water level 25%	
4213	39.8	160.2	200	Water level 40%	
4212	40	200	240		
4211	40	240	280		
4210	40.9	280	320.9		
4209	39.1	320.9	360	Water level 100%	
4208	40	360	400		
4207	40	400	440		
4206	40	440	480		
4205	40	480	520		
4204	40.5	520	560.5		
4203	16.5	560.5	577		
4202	41	577	618	BO at 5 o'clock position.	
4201	40	618	658		
4200	40.5	658	698.5		
4199	40.5	698.5	739		
4198	40	739	779	Debris in pipe	
4197	40	779	819	90% Water level	
4196	40.3	819	859.3		
4195	40.2	859.3	899.5	70% water level	
4194	40.5	899.5	940	50% Water level	
4193	40.2	940	980.2	0% water level	
4192	40.8	980.2	1021		
4191	40	1021	1061	Debris/Plant in Pipe	
4190	40	1061	1101		
4189	40.2	1101	1141.2		
4188	40	1141.2	1181.2		
4187	40	1181.2	1221.2		
4186	40.8	1221.2	1262		
4185	40	1262	1302		
4184	40.2	1302	1342.2		
4183	39.8	1342.2	1382		

30-inch Importation Mainline Pipeline
CCTV Video Observations

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
4182	40.2	1382	1422.2		
4181	40.3	1422.2	1462.5		
4180	40.5	1462.5	1503		
4179	40	1503	1543		
4178	40	1543	1583		
4177	40.2	1583	1623.2	Outlet at 12 o'clock position	
4176	39.8	1623.2	1663		
4175	40.5	1663	1703.5		
4174	40	1703.5	1743.5		
4173	40.3	1743.5	1783.8		
4172	40.2	1783.8	1824		
4171	40	1824	1864		
4170	40.3	1864	1904.3	2" ARV at 12 o'clock	
4169	39.7	1904.3	1944		
4168	41	1944	1985		
4167	40	1985	2025		
4166	40.7	2025	2065.7	2" ARV at 12 o'clock, 20% water level	
4165	40.3	2065.7	2106	50% Water level	
4164	39	2106	2145		
4163	20.5	2145	2165.5	90% water level	
4162	19.9	2165.5	2185.4	50% Water level	
4161	20.6	2185.4	2206	Water level 0	
4160	40	2206	2246		
4159	40	2246	2286		
4158	40	2286	2326		
4157	40.5	2326	2366.5		
4156	40.2	2366.5	2406.7		
4155	40.3	2406.7	2447		
4154	40	2447	2487		
4153	40	2487	2527		
4152	40	2527	2567		
4151	41	2567	2608		
4150	40	2608	2648		
4149	40	2648	2688		
4148	40	2688	2728		

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
4147	40	2728	2768		
4146	40	2768	2808		
4145	40	2808	2848	50% Water level	
4144	40	2848	2888	75% water level	
4143	40	2888	2928	100% Water level	
4142	40	2928	2968	90% water level	
4141	40.5	2968	3008.5	75% water level	
4140	40	3008.5	3048.5	50% water level	
4139	40	3048.5	3088.5	25% water level	
4138	40.5	3088.5	3129	0% water level	
4137	40	3129	3169		
4136	40	3169	3209		
4135	40.3	3209	3249.3		
4134	40	3249.3	3289.3		
4133	40.2	3289.3	3329.5		
4132	40.5	3329.5	3370		
4131	40	3370	3410		
4130	40	3410	3450	Large Previously Tapped Area 12 o'clock	 
4129	40	3450	3490	Video too foggy to determine joints	
4128	41	3490	3531		
4127	40	3531	3571		
4126	40	3571	3611		
4125	40	3611	3651		
4124	40.3	3651	3691.3		
4123	40.2	3691.3	3731.5		
4122	40.5	3731.5	3772		
4121	40	3772	3812		
4120	40	3812	3852		
4119	40	3852	3892		
4118	40.3	3892	3932.3		
4117	40	3932.3	3972.3		
4116	40	3972.3	4012.3		
4115	40.4	4012.3	4052.7		
4114	39.3	4052.7	4092	Outlet/Corrosion at 12 o'clock position	

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
4113	40	4092	4132		
4112	40	4132	4172	Outlet at 12 o'clock position	
4111	21	4172	4193	Spalling at joint	
4110	40	4193	4233	100%water level	
4109	40	4233	4273		
4108	39	4273	4312	Outlet at 5 o'clock position, 8" Blowoff, 50% water line	
4107	41	4312	4353	0% water level	
4106	40	4353	4393		
4105	40	4393	4433		
4104	41	4433	4474		
4103	40	4474	4514		
4102	39	4514	4553	50% Water level	
4101	40	4553	4593	80% water level	
4100	40.5	4593	4633.5		
4099	40.8	4633.5	4674.3	60% water level	
4098	39.7	4674.3	4714	30% water level	
4097	40	4714	4754	0% water level	
4096	40	4754	4794	Spalling at joint	
4095	40	4794	4834		
4094	40	4834	4874		
4093	41	4874	4915		
4092	40	4915	4955		
4091	41	4955	4996		
4090	40	4996	5036	25% water level	
4089	40	5036	5076	50% Water level	
4088	40	5076	5116	75% water level	
4087	40	5116	5156	90% water level	
4086	40	5156	5196		
4085	40	5196	5236	100% Water level	
4084	40	5236	5276	90% water level	

30-inch Importation Mainline Pipeline
CCTV Video Observations

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
4083	40	5276	5316	Spalling at joint	
4082	20	5316	5336		
	-5336	5336		Large Pile of Debris, End of inspection	

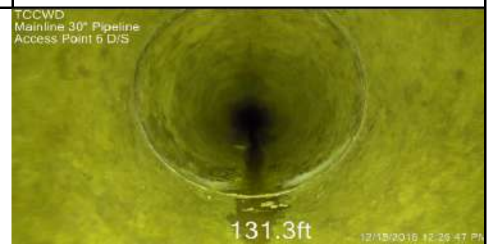
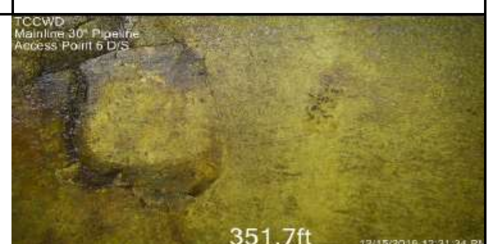
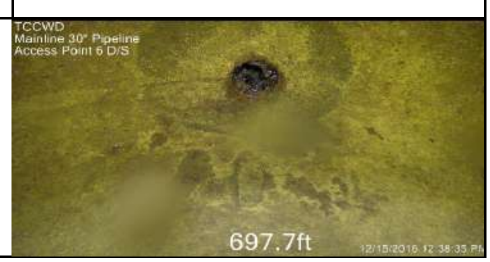
30-inch Importation Mainline Pipeline
CCTV Video Observations

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
4203	16.4	4.6	21		
4204	40	21	61		
4205	40	61	101		
4206	40	101	141		
4207	40	141	181		
4208	41	181	222		
4209	40	222	262	12 O'Clock 1" ARV 225', 10% Water level	
4210	41	262	303		
4211	8	303	311	Elbow Left	
4212	20	311	331		
4213	40	331	371	Small crack at invert and crown 362'	
4214	40	371	411		
4215	40	411	451		
4216	40	451	491		
4217	40	491	531		
4218	40	531	571		
4219	40	571	611		
4220	40	611	651		
4221	40	651	691		
4222	40	691	731		
4223	40.5	731	771.5		
4224	40.4	771.5	811.9		
4225	40.1	811.9	852		
4226	40	852	892		
4227	40	892	932	10% water level	
4228	40	932	972		
4229	40.1	972	1012.1		
4230	40.2	1012.1	1052.3		
4231	40.2	1052.3	1092.5	10% water level	
4232	40.3	1092.5	1132.8		
4233	40.2	1132.8	1173		
4234	40	1173	1213		
4235	40	1213	1253		
4236	20	1253	1273		
4237	20	1273	1293		
4238	40.2	1293	1333.2		
4239	40	1333.2	1373.2		
4240	40	1373.2	1413.2		
4241	40.3	1413.2	1453.5		
4242	40.4	1453.5	1493.9		
4243	40.1	1493.9	1534		
4244	40.1	1534	1574.1		
4245	40.4	1574.1	1614.5		
4246	40.4	1614.5	1654.9		
4247	40.1	1654.9	1695		
4248	40.2	1695	1735.2		
4249	40	1735.2	1775.2		

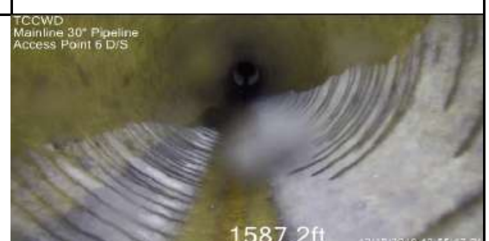
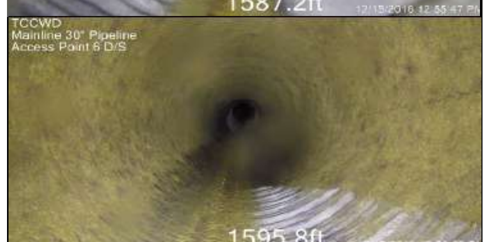
30-inch Importation Mainline Pipeline
CCTV Video Observations

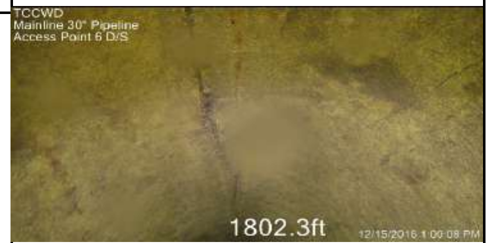
Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
4250	40.8	1775.2	1816		
4251	40	1816	1856		
4252	40	1856	1896		
4253	40.4	1896	1936.4		
4254	40.2	1936.4	1976.6		
4255	40.4	1976.6	2017	40% water level	
4256	41	2017	2058	60% water level	
4257	40	2058	2098	100% water level	
4258	40	2098	2138		
4259	40.5	2138	2178.5		
4260	7.5	2178.5	2186	elbow right	
4261	40	2186	2226		
4262	40	2226	2266		
4263	39.2	2266	2305.2		
4264	40.8	2305.2	2346		
4265	39.5	2346	2385.5	BO 7 O'Clock 2348'	
4266	40	2385.5	2425.5		
4267	40.5	2425.5	2466		
4268	40	2466	2506		
4269	40	2506	2546		
End of video Access 5 DS inspection.3.mp4					

30-inch Importation Mainline Pipeline
CCTV Video Observations

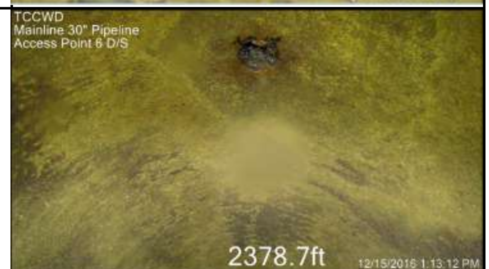
Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
				Access 6 D/S	
5162	40	14	54	10% water level	
5163	40	54	94		
5164	40	94	134	Minor joint spalling	
5165	40	134	174		
5166	40	174	214	Longitudinal cracking	
5167	40	214	254	20% Water level	
5168	40	254	294	Longitudinal cracking	
5169	40	294	334	10% water level	
5170	40	334	374	30% Water level, cracking at 351'	
5171	40	374	414	40% Water Level	
5172	40	414	454	20% Water level	
5173	40	454	494	10% water level	
5174	40	494	534		
5175	40	534	574		
5176	40	574	614		
5177	41	614	655	10% water level	
5178	40	655	695	20% Water level	
5179	40	695	735	12 o'clock 1" ARV; 698ft	

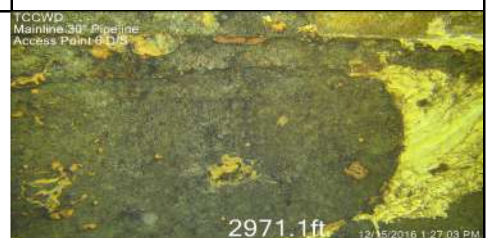
30-inch Importation Mainline Pipeline
CCTV Video Observations

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
5180	41	735	776	30% Water level, longitudinal cracking	
5181	40	776	816	40% Water Level	
5182	40	816	856	70% Water Level	
5183	40	856	896	80% Water Level	
5184	40	896	936	90% Water Level	
5185	40	936	976	90% Water Level	
5186	40	976	1016	90% Water Level	
5187	40	1016	1056	90% Water Level	
5188	40	1056	1096	90% Water Level	
5189	40	1096	1136	90% Water Level	
5190	40	1136	1176	80% Water Level	
5191	42	1176	1218	80% Water Level	
5192	40	1218	1258		
5193	42	1258	1300	70% Water Level	
5194	5	1300	1305	45deg bend	
5195	25	1305	1330	50% Water Level	
5196	41	1330	1371	20% Water level	
5197	40	1371	1411	10% Water Level	
5198	40	1411	1451	1" ARV	
5199	40	1451	1491	10% water level	
5200	40	1491	1531	20% Water level	
5201	40	1531	1571		
5202	41	1571	1612	Infiltration to pipe? 1578'-1595'	
5203	41	1612	1653	Mortar reline?	
5204	40	1653	1693		
5205	40	1693	1733		

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
5206	40	1733	1773		
5207	40	1773	1813	Longitudinal cracking	 
5208	40	1813	1853	1" ARV	
5209	41	1853	1894	1" ARV	
5210	40	1894	1934		
5211	40	1934	1974		
5212	41	1974	2015		
5213	40	2015	2055		
5214	40	2055	2095	Crack at 12 o'clock position circumfrential and longitudinal	
5215	40.5	2095	2135.5	Bulging at 12 o'clock position:	
5216	40.2	2135.5	2175.7	Repair at 9 o'clock position, and crack at same spot but a little back, Longitudinal	
5217	40.3	2175.7	2216		

30-inch Importation Mainline Pipeline
CCTV Video Observations

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
5218	40	2216	2256		
5219	40	2256	2296		
5220	40.5	2296	2336.5		
5221	40	2336.5	2376.5	Minor joint spalling	
5222	40.5	2376.5	2417	2" ARV, 12 o'clock position, water level 25%	
5223	40	2417	2457	100%water	
5224	20	2457	2477		
5225	10	2477	2487	Longitudinal Crack at 12 o clock position.	
5226	40	2487	2527	water at 50%, completely dry by end of pipe, minor join spalling	
5227	41	2527	2568	Minor joint spalling	
5228	40	2568	2608		
5229	40	2608	2648		
5230	41	2648	2689		
5231	40	2689	2729		
5232	40	2729	2769		
5233	41	2769	2810		
5234	40	2810	2850		
5235	40	2850	2890		

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
5236	20	2890	2910	2" ARV, 12 o'clock position	
5237	40	2910	2950	Repair at 3 o'clock position	
5238	20	2950	2970		
5239	20	2970	2990	100 % water, Repair or sealed manhole at 12 o'clock	
5240	5	2990	2995	Blow off at 7 o' clock position, looks to be a short pipe section, by the time he stopped to look there was too much dust and debris	
5241	18	2995	3013	End of Inspection	

Access Point 7 US

30-inch Importation Mainline Pipeline
CCTV Video Observations

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
Access 7 U/S					
5233	40	0	40		
5232	40	40	80		
5231	40	80	120		
5230	40	120	160		
5229	40	160	200		
5228	40	200	240		
5227	40	240	280		
5226	41	280	321	12 O'Clock Circum. Crack 298'	
5225	40	321	361	0% Water Level	
5225	10	361	371	Short Pipe	
5224	20	371	391		
5223	40	391	431		
5222	40	431	471	12 O'Clock 1" ARV 469'	
5221	40	471	511		
5220	40	511	551		
5219	40	551	591		
5218	40	591	631		
5217	40	631	671		
5216	40	671	711		
5215	40	711	751		
5214	40	751	791	12 O'Clock Circum. Crack 775'	
5213	40	791	831		
5212	40	831	871		
5211	41	871	912		
5210	40	912	952		

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
5209	40	952	992	12 O'Clock 1" ARV 991'	
5208	40	992	1032		
5207	40	1032	1072	12 O'Clock Long. Cracking 1038'	
5206	40	1072	1112		
5205	40	1112	1152		
5204	40	1152	1192		
5203	40	1192	1232		
5202	40	1232	1272		
5201	40	1272	1312		
5200	41	1312	1353		
5199	40	1353	1393		
5198	40	1393	1433	12 O'Clock 1" ARV 1431'	
5197	40	1433	1473		
5196	40	1473	1513	50% Water Level	
5194	30	1513	1543	Elbow Left 1542'	

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
5193	40	1543	1583	90% Water Level	
5192	40	1583	1623		
5191	41	1623	1664		
5190	40	1664	1704		
5189	40	1704	1744		
5188	40	1744	1784		
5187	40	1784	1824		
5186	40	1824	1864		
5185	40	1864	1904		
5184	40	1904	1944		
5183	40	1944	1984		
5182	40	1984	2024		
5181	41	2024	2065		
5180	40	2065	2105		
5179	40	2105	2145	12 O'Clock 1" ARV 2144'	
5178	40	2145	2185	15% Water Level	
5177	40	2185	2225		
5176	41	2225	2266		
5175	40	2266	2306		
5174	41	2306	2347		
5173	40	2347	2387		
5172	41	2387	2428	12 O'Clock Long. Cracking 2392'	
5171	40	2428	2468		
5170	41	2468	2509	6 O'Clock Debris 2509'	
5169	40	2509	2549		
5168	40	2549	2589		
5167	41	2589	2630		
5166	41	2630	2671		
5165	41	2671	2712		
5164	40	2712	2752		
5163	40	2752	2792		
5162	41	2792	2833		

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
5161	42	2833	2875	3 O'Clock Side Access 24" 2859'	
5160	20	2875	2895		
5159	40	2895	2935		
5158	40	2935	2975	12 O'Clock 1" ARV 2974'	
5157	40	2975	3015		
5156	40	3015	3055		
5155	40	3055	3095	6 O'Clock Point Damage 3084'	
5154	40	3095	3135		
5153	40	3135	3175		
5152	40	3175	3215		
5151	40	3215	3255		
5150	40	3255	3295	12 O'Clock Long. Crack 3270' 5 O'Clock Drain Outlet 3293'	
5149	40	3295	3335	50% Water Level	
5148	40	3335	3375		
5147	40	3375	3415		

30-inch Importation Mainline Pipeline
CCTV Video Observations

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
5146	40	3415	3455		
5145	40	3455	3495		
5144	40	3495	3535		
5143	40	3535	3575		
5142	40	3575	3615		
5141	40	3615	3655		
5140	40	3655	3695		
5139	41	3695	3736		
5138	41	3736	3777		
5137	40	3777	3817		
5136	41	3817	3858		
5135	40	3858	3898		
5134	40	3898	3938		
5133	41	3938	3979		
5132	40	3979	4019		
5131	41	4019	4060		
5130	40	4060	4100		
5129	40	4100	4140		
5128	40	4140	4180		
5127	40	4180	4220	30% Water Level	
5126	40	4220	4260	5% Water Level	
5125	40	4260	4300	1 O'Clock Point Damage 4274'	
5124	5	4300	4305	Elbow Right 4302'	
5123		4305	-	End Inspection at Overlap	

30-inch Importation Mainline Pipeline
CCTV Video Observations

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
Access 7 D/S					
5236	35.40	4.60	40.00	Too foggy to properly determine pipe joints	
5237	41.00	40	81	Too foggy to properly determine pipe joints, 100% water	
5238	20.00	81	101		
5239	20.00	101	121		
5240	5.00	121	126	Blow off at 7 o clock position, did not stop	
5241	28.00	126	154		
5242	40.00	154	194	Water level Gone	
5243	40.00	194	234		
5244	41.00	234	275		
5245	40.00	275	315		
5246	40.00	315	355		
5247	40.00	355	395		
5248	40.00	395	435		
5249	40.00	435	475		
5250	40.00	475	515		
5251	40.00	515	555		
5252	40.00	555	595		
5253	40.00	595	635		
5254	40.00	635	675		
5255	40.00	675	715		
5256	41.00	715	756		
5257	40.00	756	796		
5258	40.00	796	836	Debris in pipe at 819	
5259	40.30	836	876.3	piece of Debris in pipe at 837, water level rising to 20%	
5260	39.70	876.3	916	Water level 30%	
5261	40.00	916	956		
5262	40.00	956	996		
5263	40.00	996	1036	Water level 40%	
5264	40.00	1036	1076	Crack, U shaped, 2 o'clock position	
5265	41.00	1076	1117		
5266	39.70	1117	1156.7	Water level 0%	
5267	40.30	1156.7	1197		
5268	40.00	1197	1237		
5269	40.00	1237	1277	2" ARV, 12 o'clock	
5270	40.00	1277	1317	Water level 50%	

30-inch Importation Mainline Pipeline
CCTV Video Observations

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
5271	40.00	1317	1357		
5272	40.00	1357	1397		
5273	40.00	1397	1437		
5274	40.00	1437	1477		
5275	41.00	1477	1518		
5276	40.00	1518	1558		
5277	40.00	1558	1598		
5278	41.50	1598	1639.5		
5279	40.50	1639.5	1680		
5280	40.00	1680	1720		
5281	41.00	1720	1761		
5282	40.00	1761	1801	2" ARV, 12 o'clock	
5283	20.00	1801	1821	Water level 30%	
5284	40.00	1821	1861	Water level 80%	
5285	20.00	1861	1881		
5286	40.00	1881	1921	Wate level 50%	
5287	40.00	1921	1961		
5288	40.00	1961	2001	Water level 25%	
5289	41.00	2001	2042	Water level 10%	
5290	40.50	2042	2082.5	Water level 30%	
5291	40.50	2082.5	2123	Water level 20%	
5292	40.50	2123	2163.5	Water level 0%	
5293	40.50	2163.5	2204		
5294	41.00	2204	2245		
5295	40.00	2245	2285		
5296	40.00	2285	2325		
5297	41.00	2325	2366	2" ARV, 12 o'clock	
5298	41.00	2366	2407		
5299	40.00	2407	2447	Water 10%	

30-inch Importation Mainline Pipeline
CCTV Video Observations

Pipe No.	Calculated Pipe Length (ft)	First Encountered Video Joint Distance (ft)	Second Encountered Video Joint Distance (ft)	Video Comments	Corresponding Screenshot
5300	40.00	2447	2487	Water 50%, Manhole 12 o'clock	
5301	20.00	2487	2507	90% water level	
5302	21.00	2507	2528	70% water level	
5303	40.00	2528	2568		
5303	31.00	2568	2599	End of Inspection, Reducer