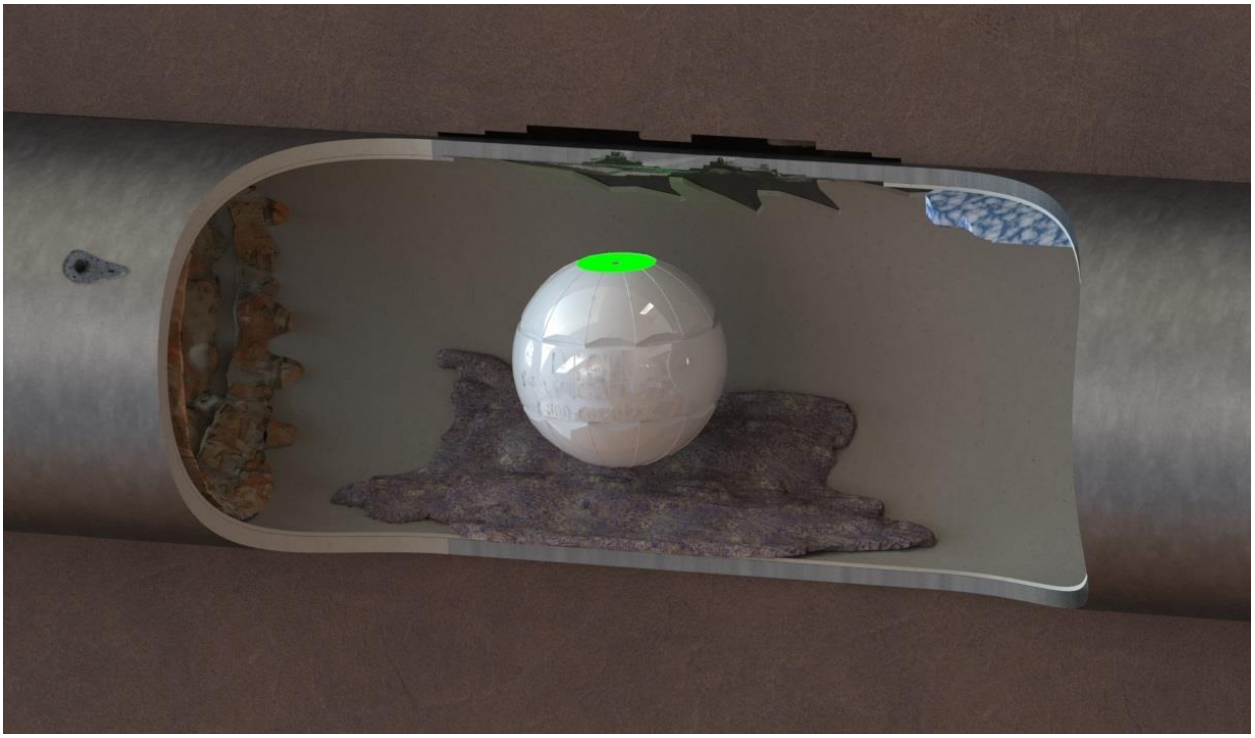
Pipeline Inspection and Condition Analysis Corp.

DRAFT REPORT



Navigator Survey

Conducted For: ABC Consulting
Location: Anytown, CT
Pipeline Inspected: Subway 12” FM 3
Inspection Date: April 10, 2024
Revision: 1.0
Submitted By: Dmitri Shilov
Submitted on: May 13, 2024

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Executive Summary

ABC Consulting was provided two Navigator Kits, two Navigator devices in each, to perform an inspection of Subway 12” FM 3. ABC Consulting conducted a self-deployed Navigator screening survey in Anytown, CT on April 10, 2024. During the field operations, one Navigator data collection run was performed. The data was pre-screened after upload and deemed good. PICA and its data analysis team found two possible leaks, an unclassified acoustic anomaly, 6 areas of trapped air/gas, observed up to 5-135 PSIG swings in pressure when the pump was shut down at the end of a pump cycle, and located one obstruction. The original plan was to have the device complete the run within a single pump cycle, as that allows for the best accuracy of mapping the findings to the actual location in the pipe. The data shows that the device remained stationary for the first 1 hour 56 minutes, and then traveled during subsequent pump cycles.

The following tables provide the summary of the Navigator deployment.

Table 1 Information from Customer Data

Pipeline Identification	Subway 12” Force Main
Launch Location	41 ° -75°
Retrieve Location	42 ° -73°
Pipe Diameter	12”
Pipe Material	DIP
Pipeline Length	5,522 LF
Survey Fluid	Sewer
PICA Project Manager	Tim Andrews
ABC Consulting Project Manager	Lisa Loeb

Table 2 Information from Inspection Data

Duration from: device placed in water to pipe exit	5 hours 17 minutes 24 seconds
Calculated Flow Speed	1.65-2.3 ft/s
Pressure	135 PSIG (peak) to 0 PSIG (retrieve MH)
Leaks	2
Unclassified Acoustic Findings	1
Air pockets	6
Magnetometer Findings	315 joint indications
Pressure findings	Up to 5 to 135 PSIG pressure swing, 1 obstruction

Location Overview

The customer supplied a KMZ file that PICA added markers onto to identify the following: a single marker for point start and end of findings. The KMZ file attached with the report includes all the markers in **Figure 1**. In the bottom right of the image, the launch location can be seen. In the top left the retrieval location is found. The findings are shown as Placemarks. The pipeline path is the red line that is in the center of the image. Google Earth elevation profile along the path is included under the overview for reference.

Figure 1 Map Overview of Pipeline Path

Fieldwork Details

The fieldwork was performed by ABC Consulting. **Figure 2** shows the launch location at the Subway Pump Station and **Figure 3** shows the retrieve location (MH. SR-31 Sta. 21+60). The flow speed was calculated using the pressure and elevation profiles, combined with visible pipe joints.

Figure 2 Launch Location at Subway Pump Station

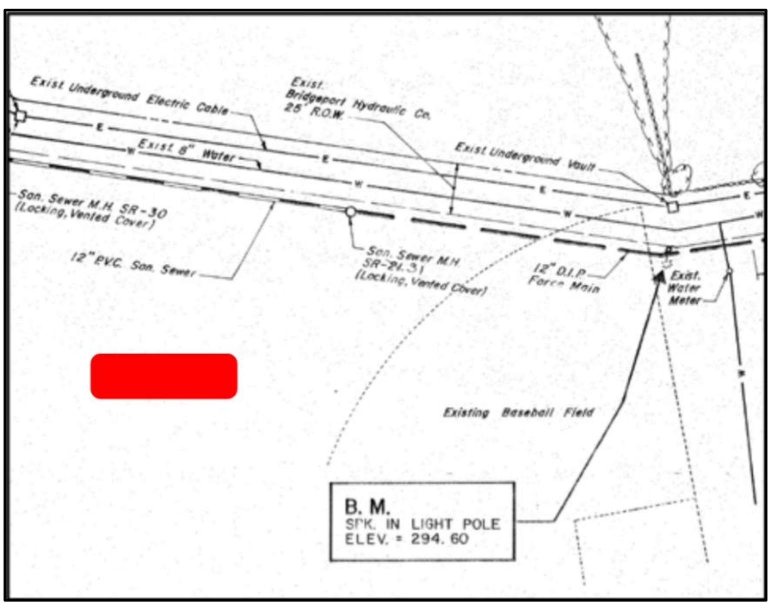

Figure 3 Retrieve Location MH. SR-31 Sta. 21+60

Inspection Overview

Figure 4 shows the pressure log of the full run. The following **Figure 5** shows the pressure chart from the start of the device up to 600 seconds (s), plotted against time. Markings are added to indicate the device placed in water, first valve opened, second valve opened to head pressure, and first pump turning on. After device was placed in water, no significant movement was observed during this time.

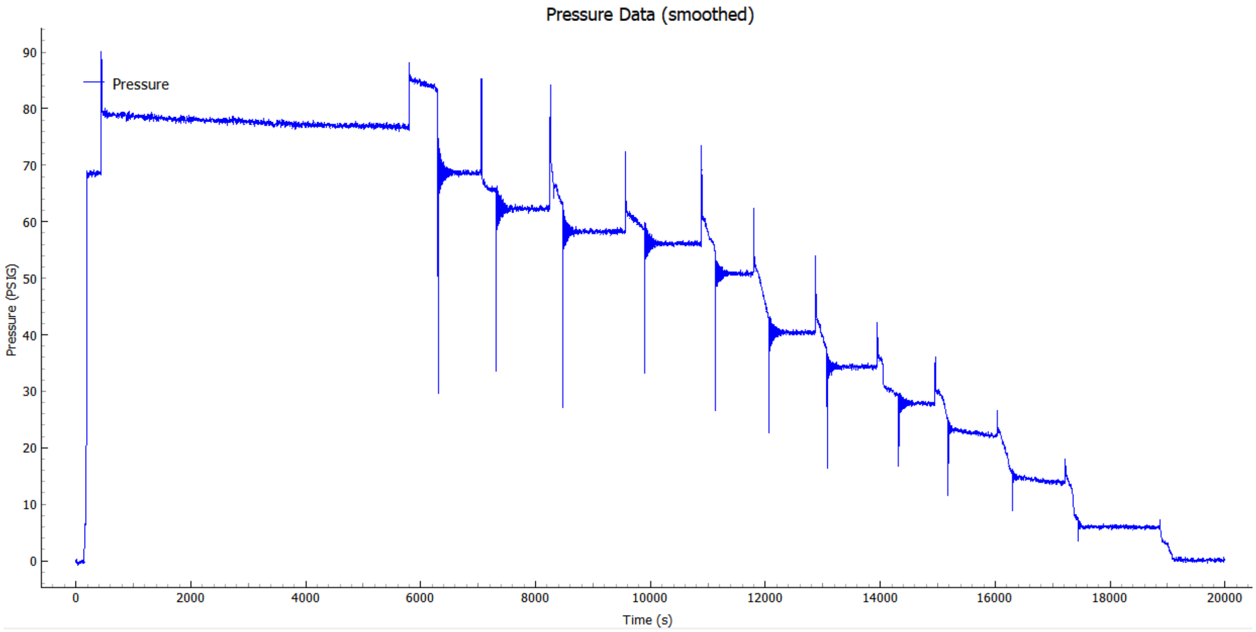

Figure 4 Pressure log of the full run.

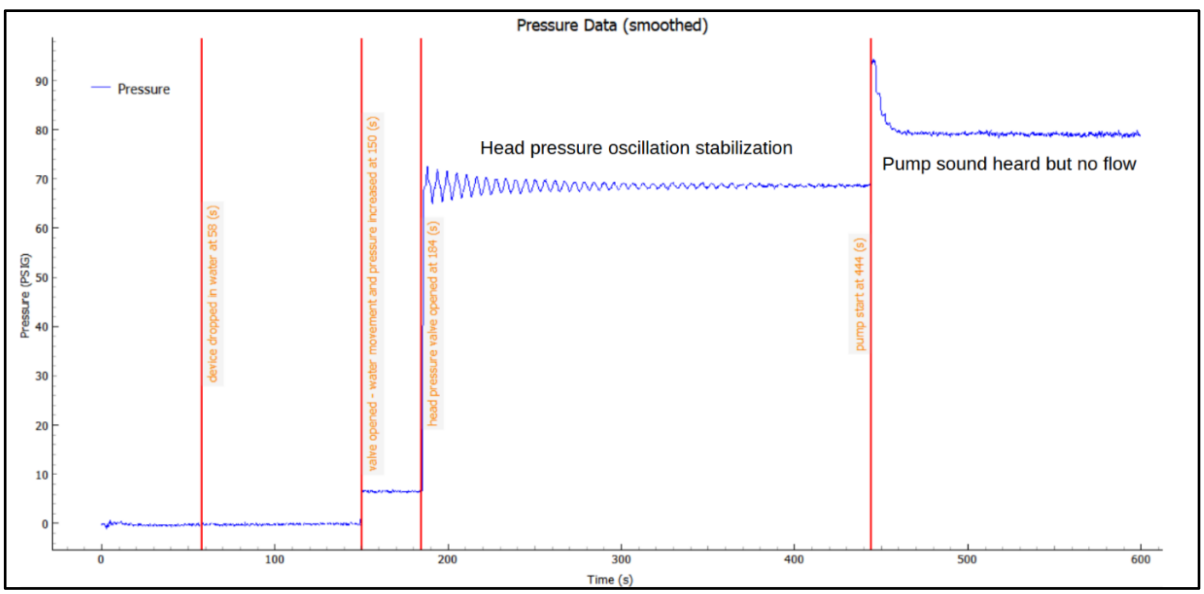

Figure 5 Pressure Data from 0 to 600 Seconds

Slowly declining pressure and no flow condition is observed until 5,802 (s) **Figure 6**.

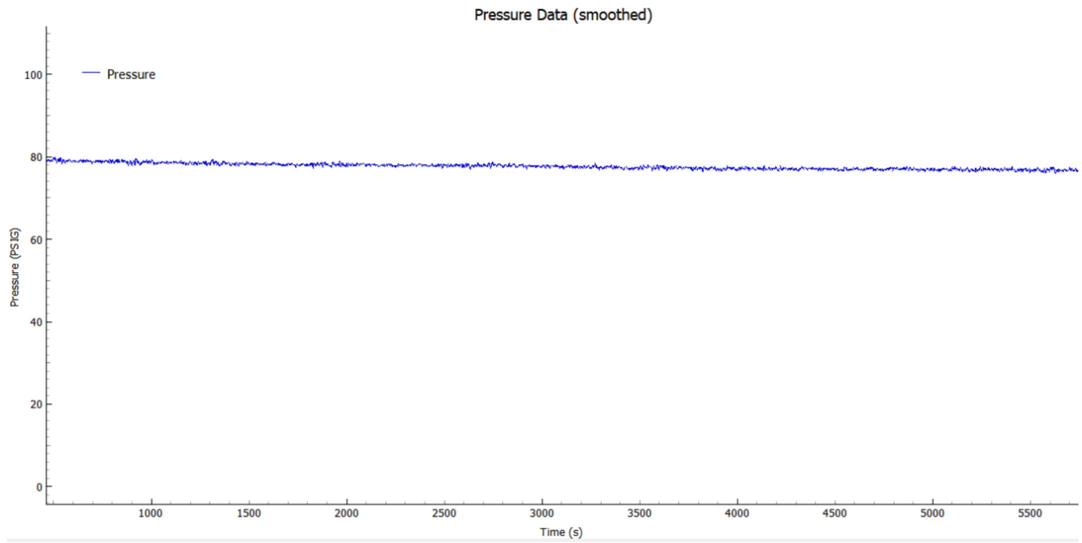

Figure 4 Slowly Declining Pressure

The second pump can be heard coming on and water flow is heard by the Navigator at 5,802 (s), although it remains mostly stationary with slight vibrations seen in the IMU data. All pumps stop at 6,304 (s). That is also when the most significant pressure swing down to 5 and up to 135 PSIG is observed. (**Figure 5**)

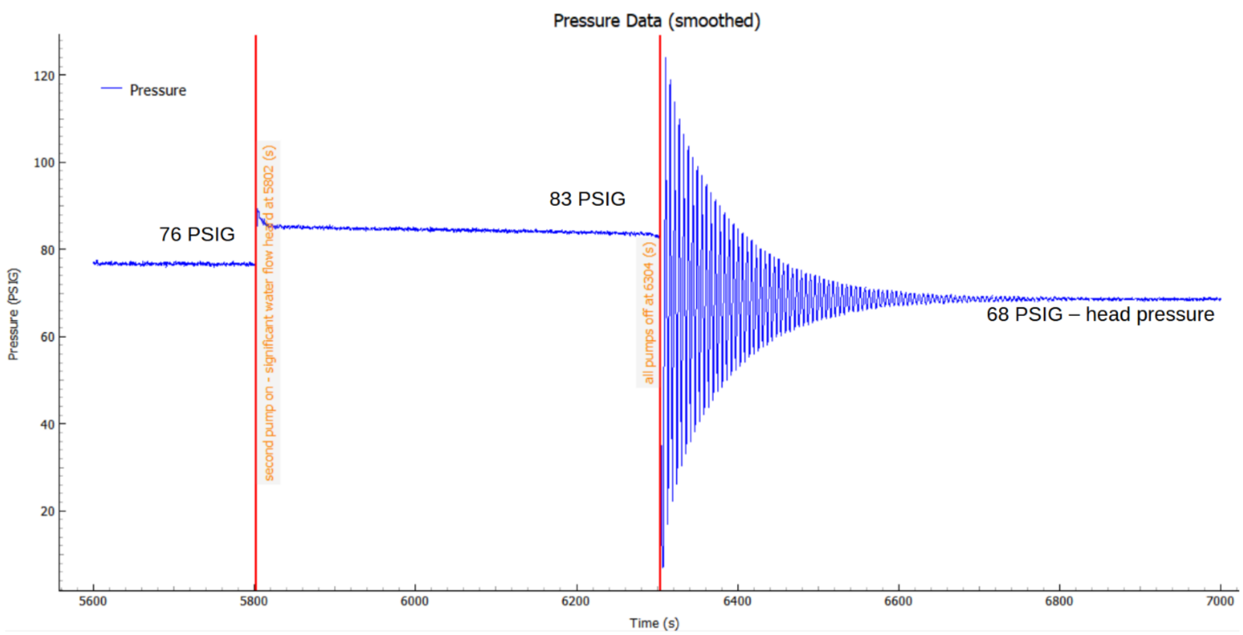

Figure 5 The second pump turns on until all pumps are shut off.

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At 7,054 (s), a pump can be heard powering up, and at 7,058 (s) the pressure at the Navigator increases and the device starts moving. The device gets properly stuck for 2 seconds between 7,067 and 7,069 (**Figure 6**, **Figure 7**), likely in some features inside the pump station piping system. The device moved steadily with each pump cycle after.

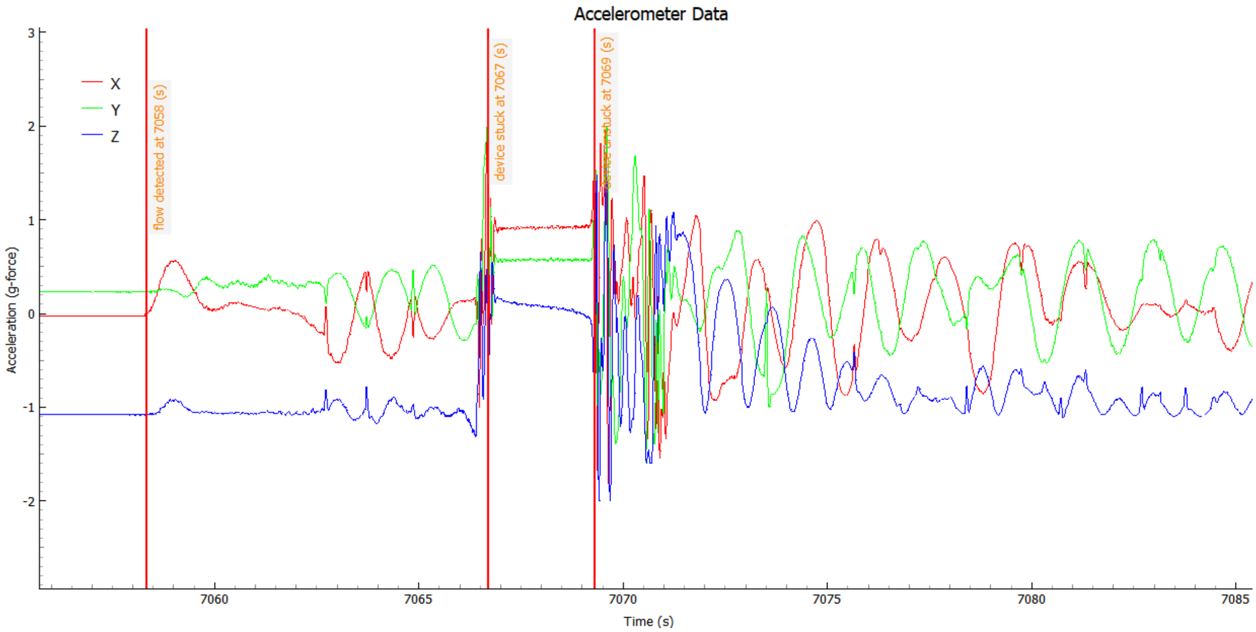

Figure 6 IMU data at 7067 (s), where the device was briefly stuck.

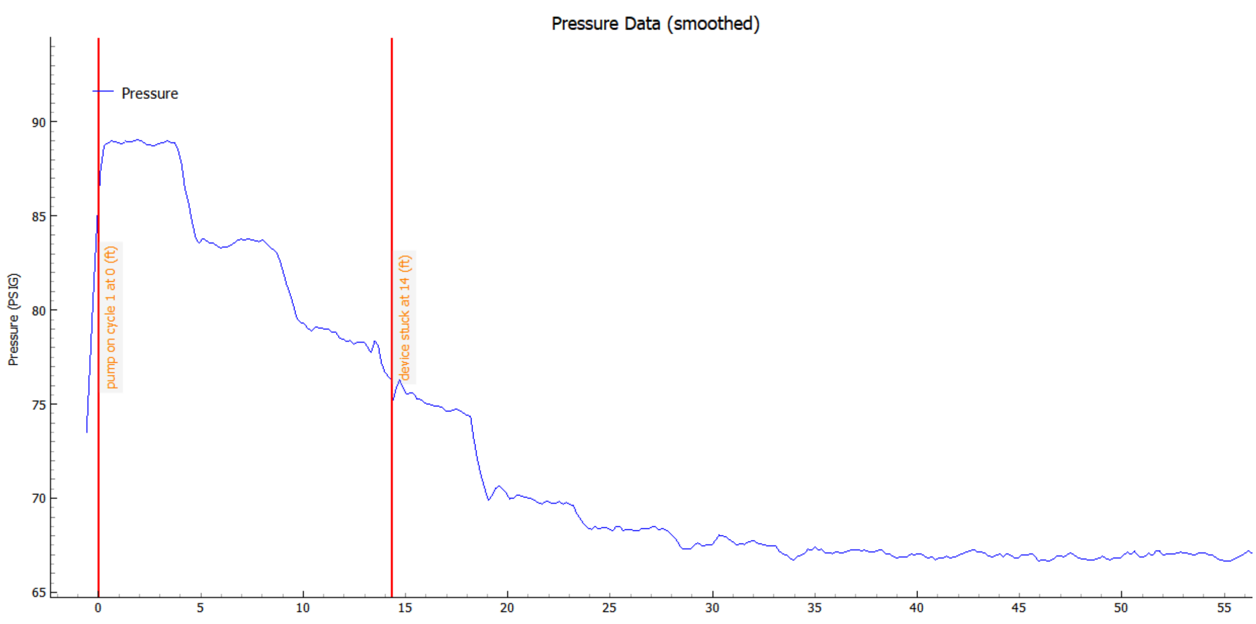

Figure 7 Pressure log at estimated distance where the device briefly stopped.

Once in motion, the average pump cycle time was 260.8 seconds, with a total of 11 cycles, and a total travel time of 2869 seconds, or 47 minutes and 49 seconds. The device moved at an average speed of 1.92 ft/s. Two distinct average speeds were observed during alternating pump cycles, possibly due to alternating pumps used during the inspection. Odd-numbered cycles were estimated to have an average speed of 1.67 ft/s, and even cycles had an average speed of 2.33 ft/s. Inspection findings are summarized in **Table 3.**

Table 3 Inspection findings

Finding	Location (ft)	Length of section (ft)
Leak #1	473.2	
Obstruction	579.0	
Unclassified Anomaly	1130.4	
air/gas pocket #1 start	1612.5	25.7
air/gas pocket #1 end	1638.2	
air/gas pocket #2 start	2015.3	88.1
air/gas pocket #2 end	2103.4	
air/gas pocket #3 start	2938.5	210.4
air/gas pocket #3 end	3148.9	
air/gas pocket #4 start	3169.2	24.4
Leak #2	3184.3	
air/gas pocket #4 end	3193.6	
air/gas pocket #5 start	5183.5	9.7
air/gas pocket #5 end	5193.2	
air/gas pocket #6 start	5479.8	42.2
End of pipe	5522	

Leak Detection Survey

When there is a leak in a pressurized pipe, the water gets forced out due to the pressure difference between the inside of the pipe and the outside environment. The escape of water from the pressurized system into the lower-pressure environment produces vibrations as the fluid interacts with the pipe material at the leak point. The strength and frequency of these vibrations vary based on factors such as the size of the leak and the water pressure. These vibrations generate sound waves. Once created, these sound waves propagate along the pipe, through the water, and even into the surrounding medium (such as the soil around an underground pipe or the air in a room for an indoor pipe). The sound can be amplified or dampened based on factors like the pipe's material, the temperature and properties of the water, and the characteristics of the surrounding medium. If the sound waves reach a point where they can be detected they will be perceived as the characteristic sound - often a hissing, gurgling, or whooshing sound. In the spectral representation, the acoustic manifestation of the leakage can be discerned as a distinct peak, characterized by rapid descent in intensity at the peripheries due to the progressive attenuation of the acoustic signal. The frequency of a leak will usually be broadband, from tens of Hz up to tens of kHz.

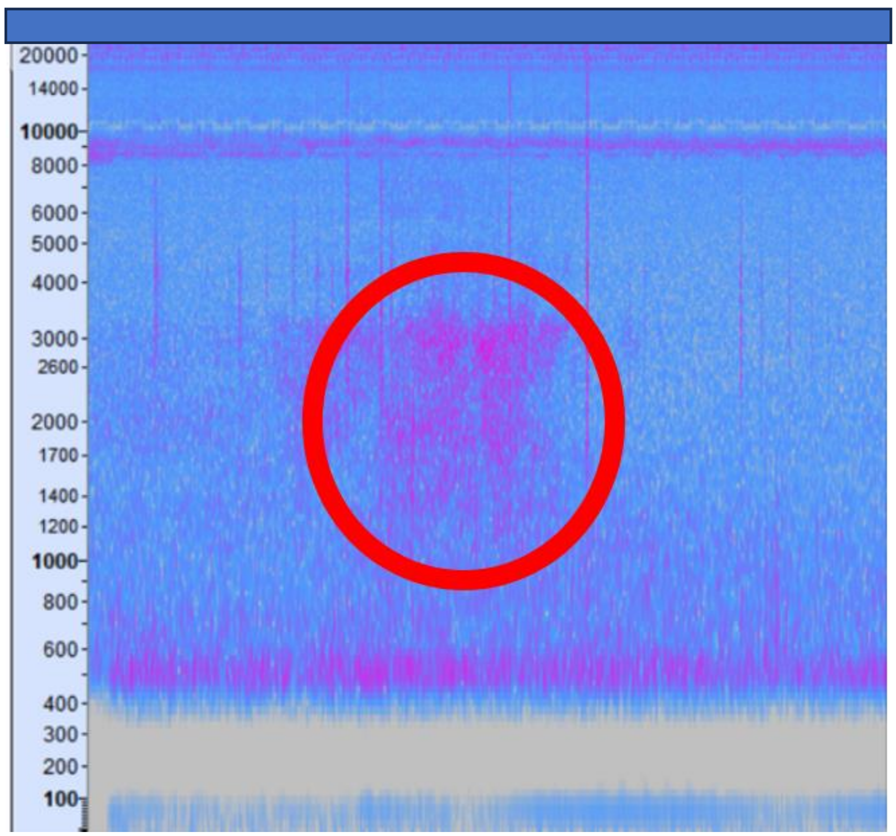

Figure 8 Leak # 1 acoustic signal as seen in spectrogram view. Color represents loudness of sound (grey to red), x-axis is time. Audio attached to report.

An acoustic indication was found at 473 ft. **Figure 10** shows the indication. The indication is believed to be a leak (Leak #1), as it has a distinct sound of a leak. It doesn't present every characteristic of a leak, such as reaching into the kHz range of frequencies, but enough characteristics (distinct peaks, rapid fall-off of signal, "hissing" characteristic) to give a likelihood of 90-100% probability.

An additional acoustic indication was found at 3,183 ft (**Figure 11**). It is found within an air pocket, and it is believed to be a factor in reducing the loudness of this indication. There are enough characteristics to give a likelihood of 66-100% probability.

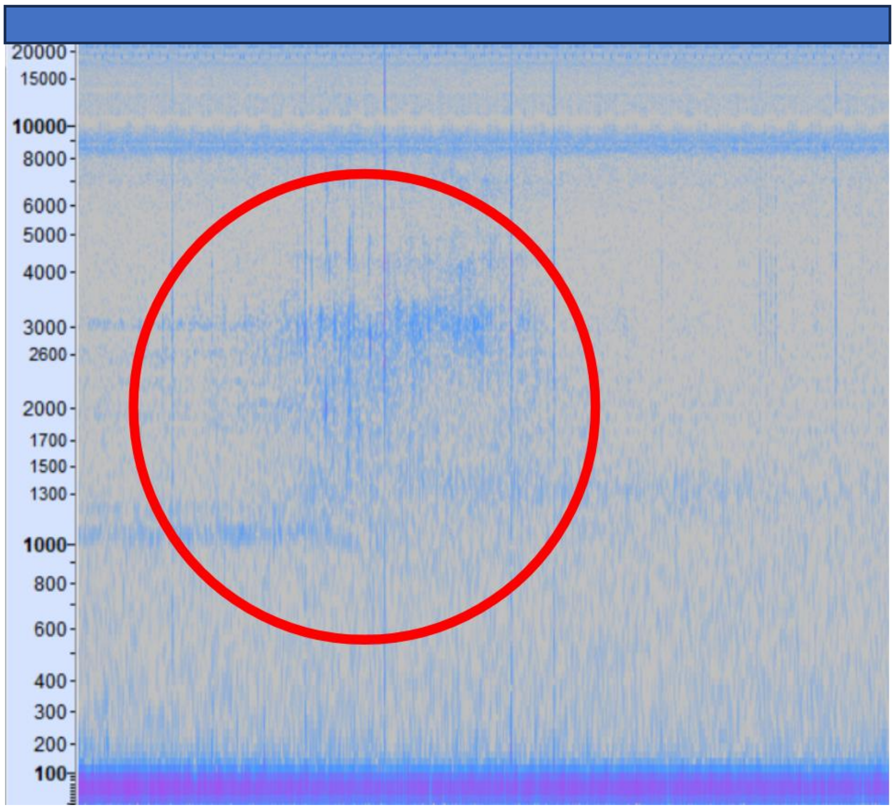

Figure 9 Leak # 2 acoustic signal as seen in spectrogram view. Color represents loudness of sound (grey to red), x-axis is time. Audio attached to report.

An acoustic anomaly was found at 1,130 ft that does not fit into an established classification system. It is unlikely (0-33% probability) to be a leak.

Gas Pocket Survey

The air or gas pockets in pipes produce a signature that will be distinguishable from a leak. The signature will not have a characteristic peak. The frequency range of the signature will be lower, typically under ten kHz. When present, the sound will be perceived as the characteristic sound of running water or turbulent flow. In some cases, when flow is not turbulent, the sound can be heard, but cannot be visually distinguished in a spectrographic view. The distance a pocket can encompass can be much longer than a leak. The location of the pockets will often be correlated with high points along the profile of the pipe.

Six air pockets were found. Their locations are marked on the KML file and below in **Table 4**.

Table 4 Air pocket findings

Finding	Location (ft)	Length of section (ft)
air/gas pocket #1 start	1612.5	25.7
air/gas pocket #1 end	1638.2	
air/gas pocket #2 start	2015.3	88.1
air/gas pocket #2 end	2103.4	
air/gas pocket #3 start	2938.5	210.4
air/gas pocket #3 end	3148.9	
air/gas pocket #4 start	3169.2	24.4
air/gas pocket #4 end	3193.6	
air/gas pocket #5 start	5183.5	9.7
air/gas pocket #5 end	5193.2	
air/gas pocket #6 start	5479.8	42.2
End of pipe	5522	

Most of the air pockets found cannot be visualized. **Figure 12** is air pocket number 4.

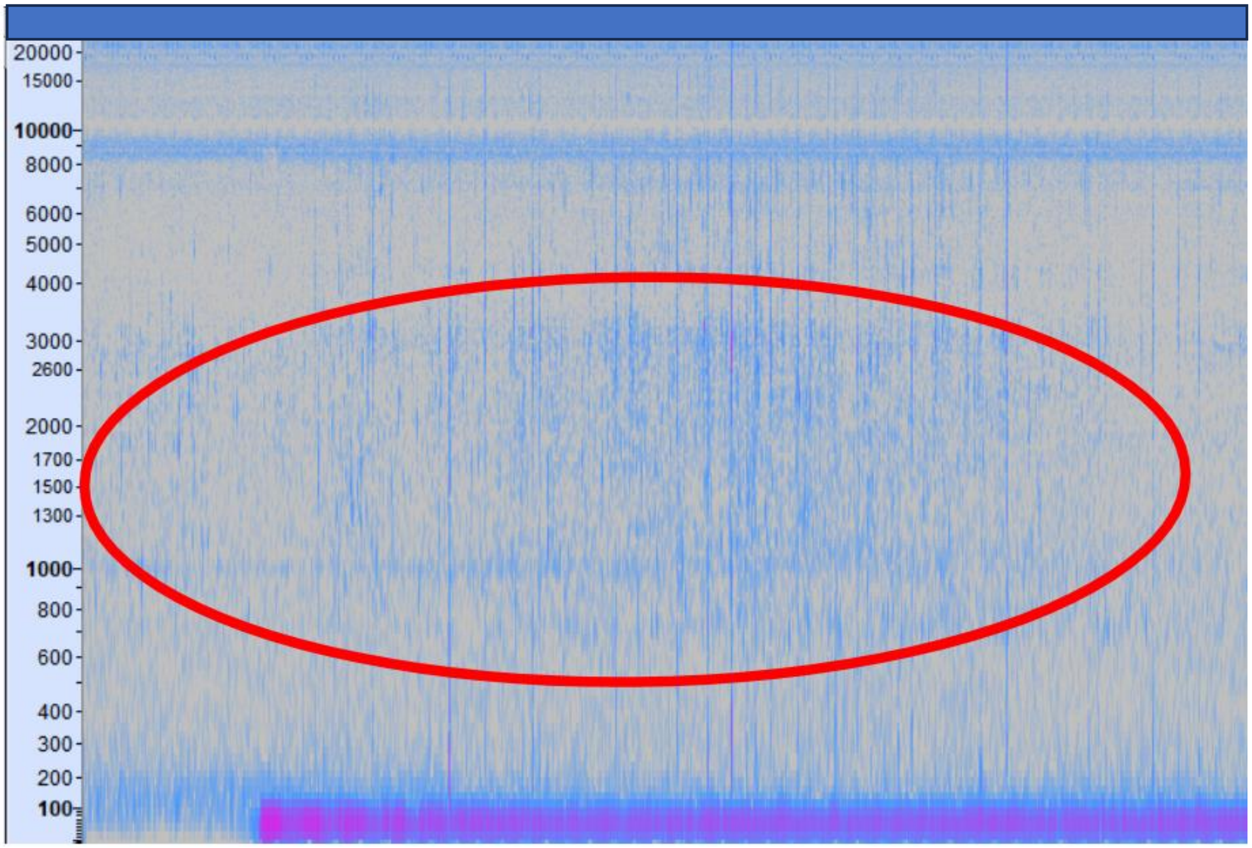

Figure 10 Air Pocket #4

Magnetometer

The Earth's magnetic field can be harnessed to inspect metallic pipes. As this natural magnetic field interacts with a pipe's structure, features like joints, bends, and inconsistencies in thickness alter the magnetic field flow in specific ways. A tool called a magnetometer, built into the Navigator, detects these changes. Joints create distinct signatures, while variations in thickness may be indicative of wear or damage. By analyzing these magnetic patterns, we can gain an idea of the pipe's internal structure and condition without physically accessing or visually inspecting it. A magnetometer in a free-floating approach introduces variables such as unpredictable positioning and orientation within the pipe making it difficult to correlate magnetic anomalies with specific physical attributes of the pipe, such as exact locations of joints or precise measurements of wall thickness. This data can only yield qualitative insights rather than precise, quantifiable data about the pipe's condition. Magnetic data can only yield qualitative insights rather than precise, quantifiable data about the pipe's condition.

During this inspection, observed joints were used to refine the speed estimate for the Navigator device.

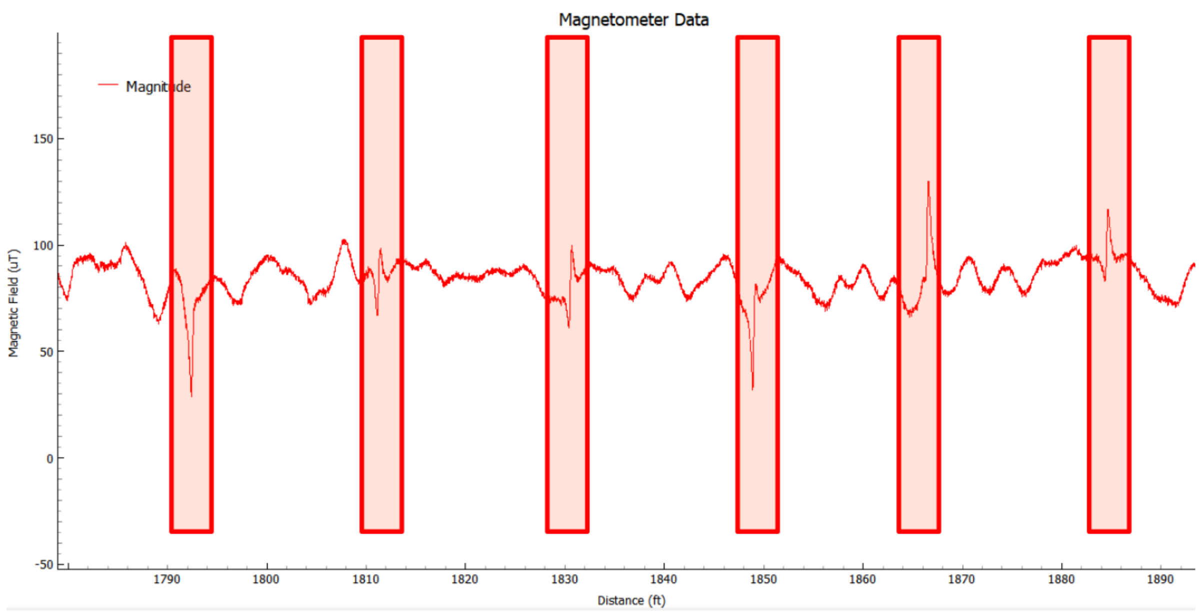

Figure 11 Excerpt of magnetometer data, highlighting the joints.

Pressure Data

Pressure data was successfully logged (**Figure 12**). Pressure swing of 5-135 PSIG (**Figure 14)** and an obstruction **(Figure 14**) were observed.

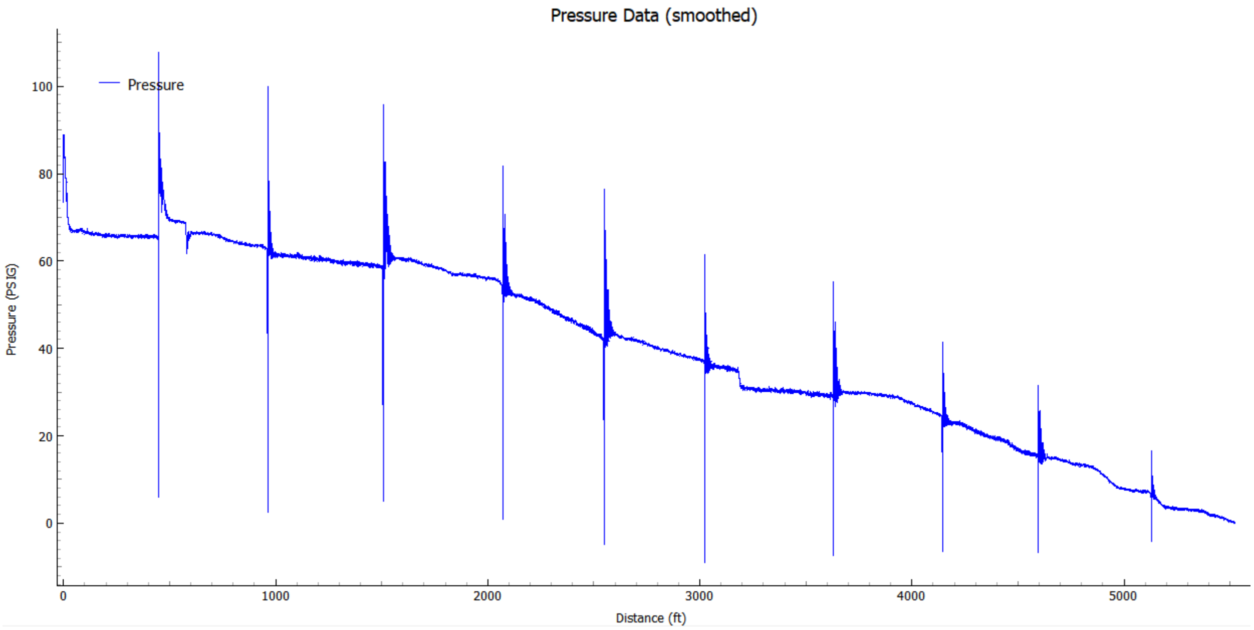

Figure 12 Complete run pressure log vs. distance. Note large swings of pressure at every pump cycle end.

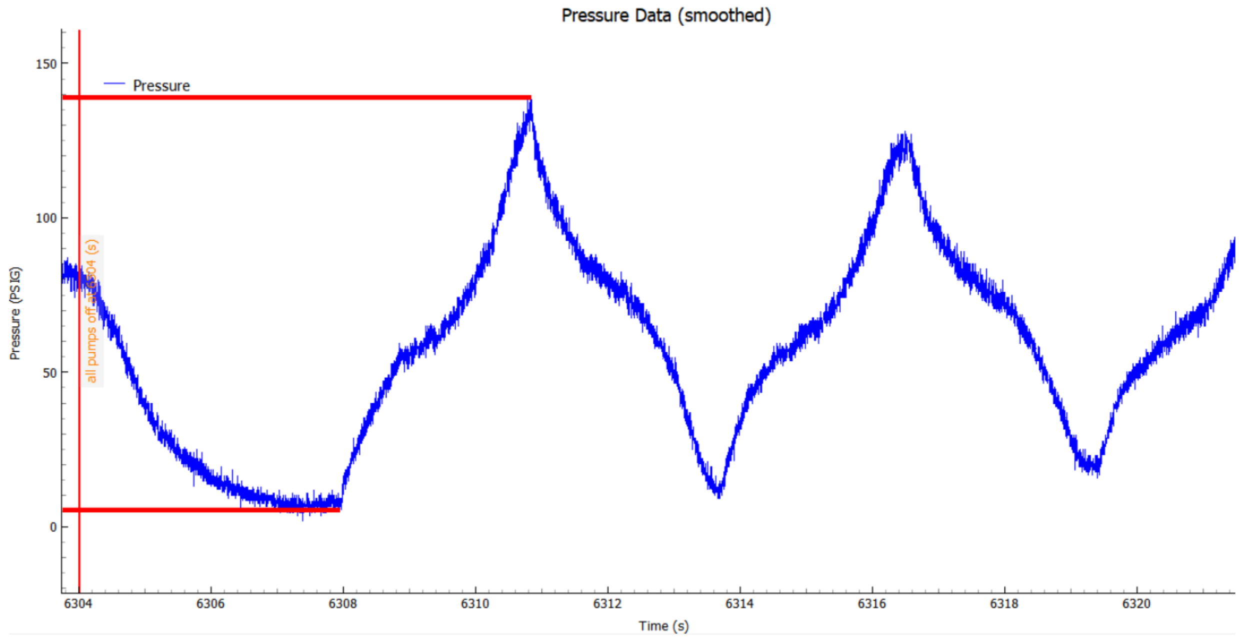

Figure 13 Data log of pressure swing at pump shutdown.

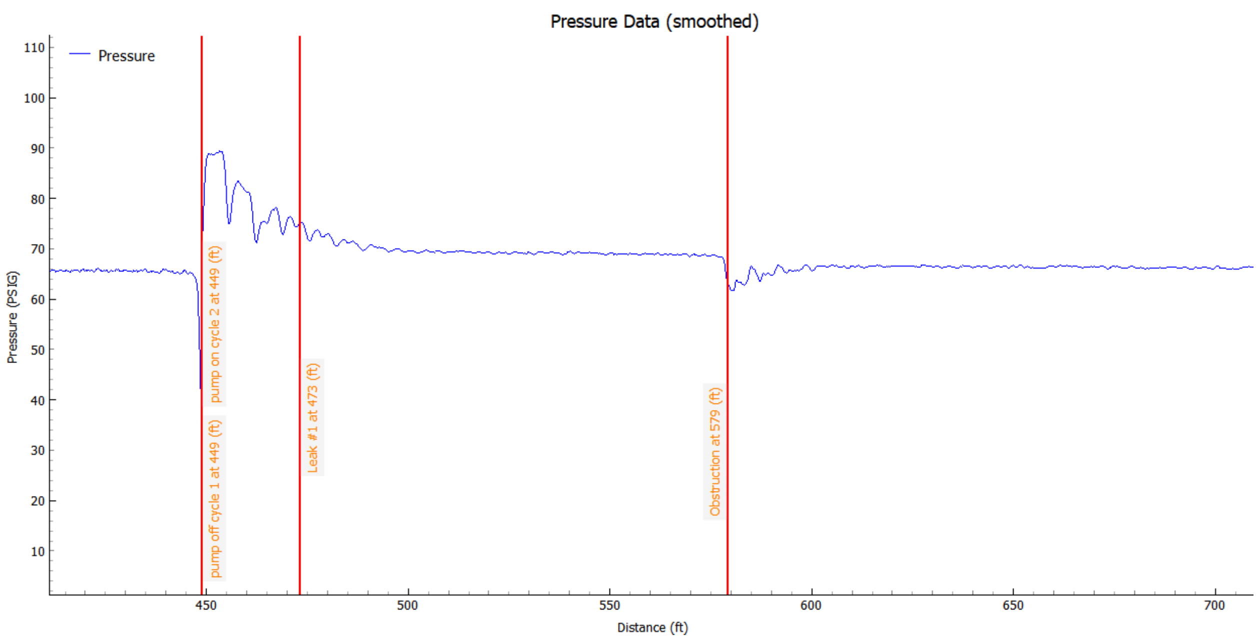

Figure 14 Pressure indication of an obstruction.

Scope of Services

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

Our Commitment: Accurate, reliable, actionable results

PICA (Pipeline Inspection and Condition Analysis) is a US and Canadian-owned and operated corporation, with its head office located in Edmonton, Alberta. We have branch offices in the USA in New Orleans, Dallas, and San Diego, and in Canada in Montreal, Toronto, Ottawa, and Vancouver.

PICA was incorporated in 2008 to provide world-class In-Line Inspection services for the municipal water market, the municipal wastewater market, and the power generation market. To accomplish this goal, PICA has borrowed years of experience gained from its sister company, Russell NDE (Non-Destructive Evaluation) Systems Inc. (founded in 1972), which designs and manufactures the In-Line Inspection Tools that PICA uses.

PICA has a dedicated team of scientists who have advanced the science of Remote Field Testing (RFT), Near Field Testing (NFT), and Leak detection and Prescreening (Navigator) for pipeline condition analysis further than any other NDE techniques available. As a result, our technologies provide accurate and reliable information that pipeline owners can use to make repair, rehabilitation, or replacement decisions. Our commitment is that after our inspection you will understand the condition of your pipeline infrastructure more precisely.

Appendix A: Navigator Methodology Description

The collected data is comprised of the audio, magnetometer, and pressure sensor recordings. The audio data is processed to enhance the unique features within it to aid analysis. The analyst will review all audio in the spectrogram view (Frequency as Y-axis, time as X-axis, sound intensity as color shift from grey to red). To identify audio features, analysts use previously classified features as a guide, as well as listening to the features, as the spectrogram only tells a part of the story. See **Figure 15** for an example of previously detected and verified leak in the previous inspection.

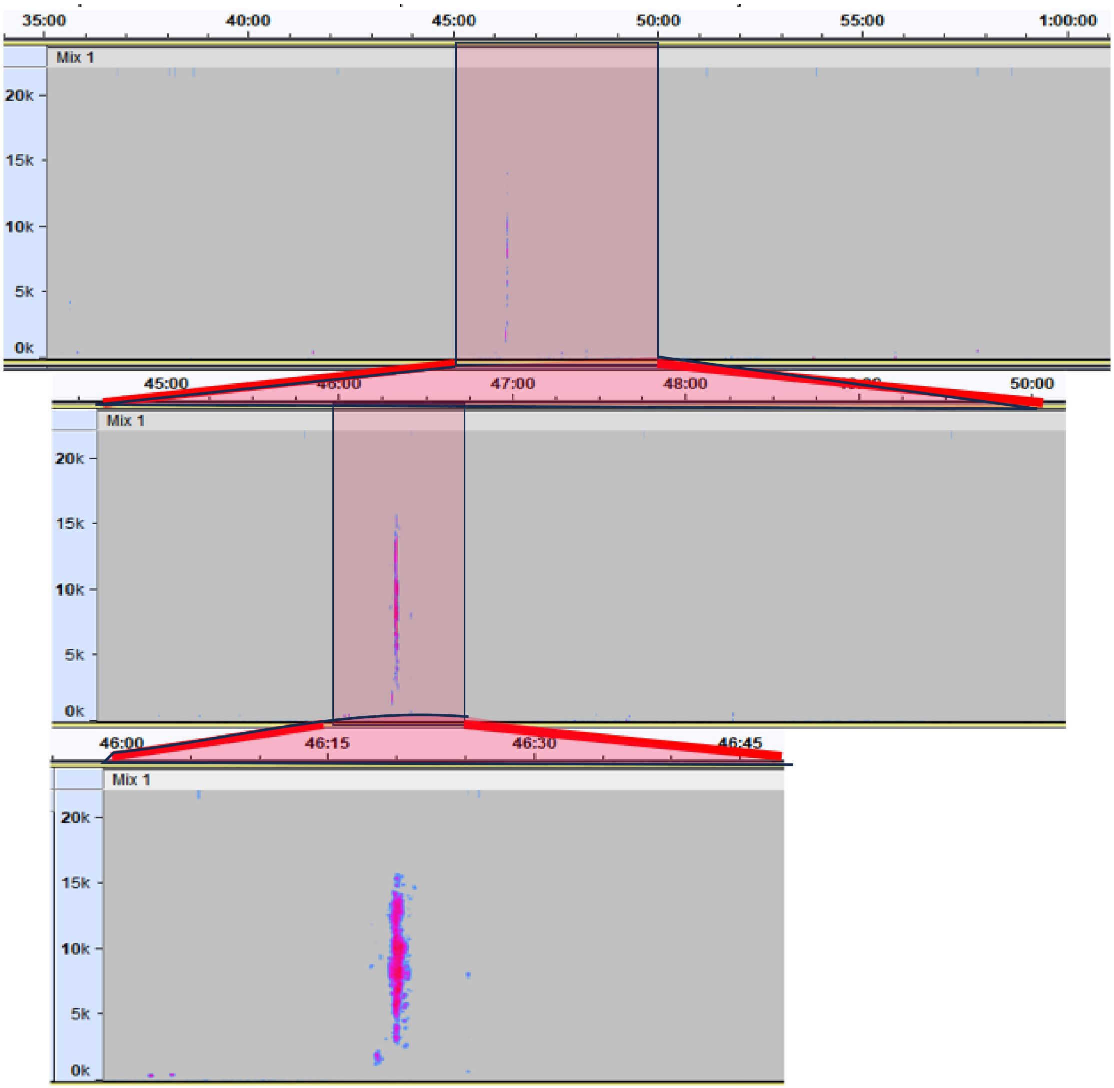

Figure 15 Steps of Audio Data Analysis

Following that, **Figure 16** is an example of the data from a previous customer, recorded when the Navigator is in motion.

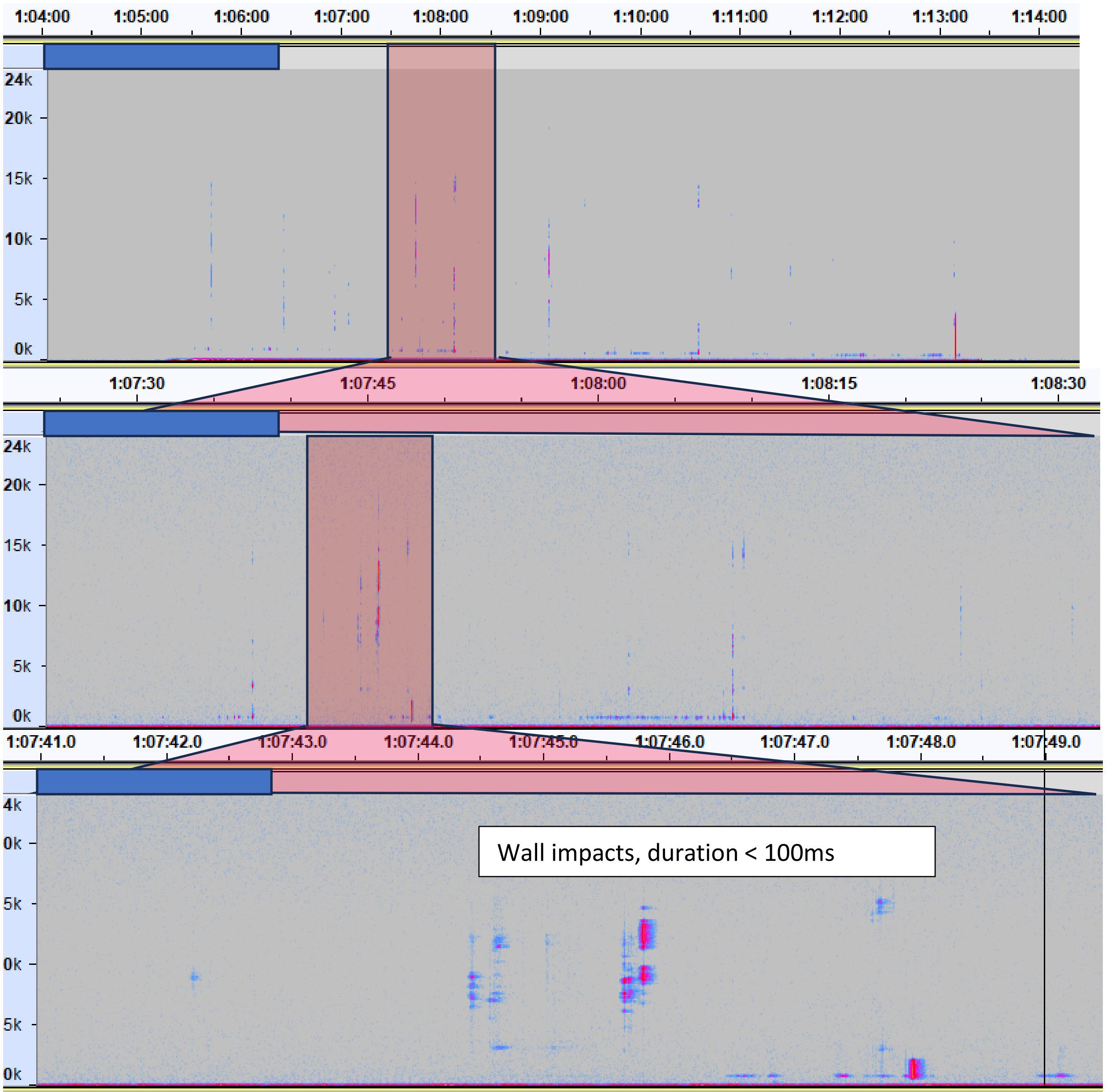

Figure 16 Sample Navigator Audio Visualization

Appendix B: Navigator Device Description

PICA's Navigator is an autonomous, free-swimming, adjustable buoyancy, screening tool used to detect leaks, gas pockets, and magnetic features. For normal operation, the Navigator is adjusted to neutral buoyancy. This allows that in a pipe with flow, the Navigator will travel in the fluid column. Navigators can be weighted to float so that if they discharge into a reservoir or tank, the device can be retrieved from the surface. The Navigator has an LED flashing light on top so that it can be easily seen when floating.

The Navigator has the following features:

- Multiple pipeline inspection runs and data sets can be stored on board.
- Data is uploaded immediately after the run(s).
- All data sets are recorded on one, removable, non-volatile micro-SD card.
- For new runs, the SD Card is replaced. Labeling the run and micro-SD associated with the data collection is imperative.
- Each Navigator is pressure tested before being sent to the field.
- For potable lines, the resin used in making the Navigator is potable safe.
- A test ball with the same buoyancy except without electronics is run before deploying the Navigator to prove passage.
- Navigators use an enhanced audio transducer that should be "best in class" for detecting leaks and gas pockets.
- The two half-shells screw together and are sealed with an O-ring. Making access to the micro-SD card and battery charging easy.
- The flashing LED light changes color when:
  - Flashing Blue – Waiting for SD card insertion.
  - Inserted micro - SD Card…Flashing green, indicating that the recording has started.
- Charging time is 5 hours. Running time is 24 hours, allowing time to screen long pipelines or to add multiple runs in the same or different pipelines.
- The data is uploaded immediately, and data analysis can start immediately, leading to a quicker turnaround for reports.