

# Overview of Non-Traditional ILI Projects for Challenging Pipeline Segments with Background on Scoping, Planning, Coordination and Execution for Multiple Project Types

Unpiggable Pipeline Solutions Forum  
May 12-13, 2015 | Houston, Texas

---

**Robert Liddicoat**

Gas Transmission Systems (GTS)

Walnut Creek, CA

This paper provides a detailed review of experience relating to the scoping, planning, coordinating, and execution of 19 non-traditional ILI (NT ILI) projects. These projects have utilized a variety of NT ILI tools and illustrate key considerations for scoping and deployment based on examples from projects managed by GTS from 2012 to present. Topics covered include data gathering and analysis to determine options available to solve a project's specific challenges, selecting the appropriate NT ILI tools and identifying the methods for deployment. Also discussed are the key elements of successful project planning, coordination, and project execution. Factors considered when evaluating a non-traditional ILI project, challenges faced in planning and execution, and how those challenges were overcome using various tools and techniques will be highlighted throughout.

---

## **EXECUTIVE SUMMARY**

Emerging non-traditional ILI (NT ILI) methods and technologies are providing new solutions for pipeline operators to inspect and gather critical asset data at locations never before accessible by internal inspection tools. Additionally, internal pipeline features can be identified and pinpointed in preparation for future projects such as replacements or hydrostatic tests.

The multitude of NT ILI methods and tools available requires a rigorous data gathering and scoping effort in order to determine the most suitable NT ILI method and tool for each project. There are multiple types of NT ILI tools available with variations in how they are propelled and the Non Destructive Examination (NDE) technology utilized on-board. Delivery platforms for NT ILI Tools include robotic crawlers with and without tethers, tethered “pigs” which are pulled through the pipeline, and free-swimming tools. The NDE technologies considered and utilized on the projects referenced in this paper include Magnetic Flux Leakage (MFL), High Definition Video, Ultrasonic Transducer (UT), Electro Magnetic Acoustic Transducer (EMAT), Eddy Current, and Laser Deformation.

Detailed project coordination and planning efforts are required to ensure roles and responsibilities are understood by the multi-disciplinary project team and to drive critical project milestones and deadlines to completion. Project execution details and contingencies must be clearly defined, meticulously planned, and effectively communicated to the project team. On-site presence of key project leaders during project execution is required in the event that decisions outside of the established plan are required to be made in the field due to changing project conditions.

NT ILI has proven to be a valuable addition to the operator’s toolkit for performing integrity inspections and other transmission pipeline investigations. Successfully executed NT ILI projects provide the operator valuable information on the condition of the asset at difficult locations where alternative inspection methods are infeasible or impractical.

The content and perspective of this paper is based on a thorough evaluation of 40 challenging pipeline segments scoped for NT ILI, execution of 19 of those projects, with an additional 9 projects in-progress at the time of this paper’s drafting. The examples used throughout provide practical information and results from deployment of NT ILI tools for inspecting challenging pipeline segments. This paper is not intended to be a comprehensive review of all industry tools available; but rather, information and first-hand knowledge based on the actual experience from evaluating and conducting these projects.

---

## CONTENTS

EXECUTIVE SUMMARY .....	1
CONTENTS.....	2
INTRODUCTION.....	3
DRIVERS AND OBJECTIVES FOR NON-TRADITIONAL ILI PROJECTS .....	3
Challenging Integrity Management Inspections.....	3
Project Profile: ECDA Excavation Near Structural Foundation .....	5
Project Profile: ECDA Dig in Levee Bank .....	5
Internal Feature Locating and Identification .....	6
Project Profile: Pinpointing Reducer Location.....	6
Project Profile: Confirming Presence of Internal Drip in Creek Crossing .....	7
PROJECT SCOPING .....	8
EXECUTION METHODS.....	10
Delivery Platforms .....	10
Project Profile: Multi-Diameter Pipeline Cleaning Prior to Tethered Robotic EMAT Inspections.....	11
Project Profile: Cased Span Investigated for Micro Robotic Inspection .....	12
Project Profile: Elbow Inspected for Internal Corrosion at Creek Crossing in Live Pipeline.....	13
Project Profile: Tethered Non-Robotic Inspection in Environmentally Sensitive Area .....	15
Project Profile: Gas-Driven Free-Swimming Inspection in Environmentally Sensitive Area .....	16
PROJECT PLANNING & COORDINATION .....	17
PROJECT EXECUTION .....	19
Project Profile: Contingency Plan Implementation .....	20
CONCLUSIONS.....	21

## **INTRODUCTION**

Non-Traditional In-Line Inspection (NT ILI) as used in this paper refers to utilizing internal inspection tools to inspect challenging pipeline segments by means other than “traditional” free-swimming ILI tools deployed from established launcher and receiver facilities. NT ILI projects may be conducted to perform integrity inspections or to locate and examine internal pipeline features and obtain physical, material, construction and other information regarding the pipeline asset.

NT ILI methods have proven especially successful in completing inspections at locations subject to long-lead permitting and/or abnormally challenging or costly construction, such as at waterway crossings, cased spans, extended casings and inserted pipe sections. Alternative inspection methods may be infeasible or impractical in these situations, making NT ILI methods a viable and vital option for pipeline operators to perform critical inspections.

When scoping a NT ILI project there are many factors that must be considered. Primary among these factors are the specific project goals and inspection requirements. Additional key factors include viable entry points for tool insertion, pipeline configuration and condition, and resource availability. All of these project details must be evaluated in order to determine a project’s unique conditions and constraints which ultimately lead to the determination of which execution methods and NT ILI tools will provide the highest probability of success for the particular project.

After initial project scoping is conducted and an execution method and NT ILI tool are selected, assembling a comprehensive project team and development of a detailed task list is required to ensure all critical elements of these complex projects are accounted for in the planning process. A detailed execution and contingency plan are also key components of successfully executed NT ILI projects.

---

## **DRIVERS AND OBJECTIVES FOR NON-TRADITIONAL ILI PROJECTS**

Drivers for conducting NT ILI projects can vary greatly, however they generally fall into one of two main categories:

- 1) Performing integrity management inspections on pipeline segments with challenging physical attributes or locations
- 2) Identifying and/or locating internal pipeline features

---

## **CHALLENGING INTEGRITY MANAGEMENT INSPECTIONS**

Current NT ILI methods are most suitable for use on shorter, targeted pipeline segments which are not feasible or practical for traditional ILI methods. If a pipeline is considered “unpiggable” with traditional ILI tools, the operator will look to other solutions that are available for the specific situation and location, which may include NT ILI methods.

### **Traditional ILI**

For many transmission pipeline segments it may not be suitable nor cost effective to utilize traditional ILI methods due to the presence of unpiggable features, low pipeline operating pressure, flow conditions, or short segment length. While replacing unpiggable features and performing other work on the pipeline to allow for a traditional

ILI is an option, this may not be the most practical nor timely solution. Some pipeline segments may be too short to be practical for ILI retrofit. In some cases the best solution may be to work with an ILI tool vendor to design or modify traditional ILI tools customized for the specific application to enable them to perform the ILI with the challenging conditions identified. In cases where new tools are developed, a rigorous testing program should be planned and implemented to validate the durability, navigation performance, and detection performance of the new tool prior to use in an active pipeline.

### **Strength Test**

NT ILI may be used in advance of in-situ pipeline strength testing for investigative purpose if information is needed on pipeline features that may impact the success of the test. Additionally, a pre-strength test ILI may be appropriate if a heightened risk of strength test failure has been identified, or if there is an abnormally high impact of unplanned release of water due to a test failure. Similarly, if engineering has heightened concern over metal loss due to third party activity (e.g. pipelines in active agricultural areas), or corrosion concerns (analysis of CP requirements, leak survey data, etc.) a pre-strength test ILI may prove beneficial. The data obtained can be helpful to the engineering team in the design and execution of the strength test project related to locating features, setting pressures, contingency preparation, identification of anomalies requiring mitigation, etc.

### **Direct Assessment**

NT ILI methods have been proven successful in completing required Direct Assessment (DA) inspections in challenging locations when DA is not feasible or practical. Some scenarios present unique challenges in applying DA Criteria at locations such as cased spans, extended casings, and sections of inserted pipe.

DA programs may also identify excavation locations for direct examination that are subject to abnormally expensive or difficult construction and/or long-lead permitting. Typical locations tend to be at water crossings, environmentally sensitive areas, or locations in close proximity to other significant utilities or structural foundations. These scenarios are especially well suited to NT ILI methods due to the flexibility to locate an excavation point for tool entry into the pipeline at a more practical location from which to conduct the inspection.

When deploying NT ILI methods to inspect these targeted locations, pipeline operators can also take advantage of acquiring data on the asset beyond the identified DA target location. In



**Figure 1: Cased Span - 10" carrier pipe inside 16" casing contained within bridge structure at a major river crossing**



**Figure 2: ECDA dig identified inside canal levee on 6" pipeline**



instances where several DA excavations are located in close proximity on the same pipeline, a single NT ILI project may potentially cover multiple locations with a single NT ILI project. For projects utilizing robotic or tethered pig methods from a single entry point, it may be beneficial to expand the inspection to match the maximum distance capability for the NT ILI tool. This may include deployment of the tool in both directions from the entry point. When utilizing a free-swimming tool with a launcher and receiver installed to inspect a specific location, data can be acquired for all footage in between the launcher and receiver. Furthermore, placement of the launcher and receiver locations may potentially be extended in order to maximize the inspection distance while achieving the primary goal of inspecting the targeted location.

**Project Profile: ECDA Excavation Near Structural Foundation**

<b>Scenario:</b>	An ECDA indirect inspection survey identified a location on 12"OD pipeline for direct examination near a structural foundation. Due to unstable soil conditions the dig project was put on hold pending deployment of either an engineered shoring plan or an NT ILI inspection.
<b>NT ILI Solution &amp; Key Accomplishment:</b>	An evaluation of schedule, risk and cost to safely complete the ECDA dig without damage to the structure was performed. It was decided to perform a NT ILI utilizing an untethered robotic MFL tool. Due to other indications identified by the ECDA indirect inspection survey in the vicinity, the NT ILI scope was expanded in order to both validate the ECDA survey data, as well as maximize the range of the NT ILI tool to inspect as much pipeline as feasible from the single entry point. The project was conducted successfully over two days of ILI inspection obtaining data on 3,668 feet of pipeline in addition to the targeted location.

Figure 3: Aerial of NT ILI tool entry point, original ECDA dig location, and end of inspection points for Day 1 & Day 2 of ILI execution



**Project Profile: ECDA Dig in Levee Bank**

<b>Scenario:</b>	Direct examination location identified on 20" OD pipeline based on ECDA indirect inspection survey inside the levee bank of a river. Although not directly in the water way, conducting the direct assessment would require a 26' deep excavation and be subject to long-lead environmental and jurisdictional permitting, as well as significant groundwater management challenges.
<b>NT ILI Solution &amp; Key Accomplishment:</b>	Due to the abnormally high construction cost associated with conducting the DA excavation in the levee, an NT ILI option was initiated to inspect the target location along with significantly more pipe than the single DA excavation would have inspected. Due to the

	<p>infeasibility of taking an outage on the pipeline segment, an untethered robotic MFL tool was selected to complete this inspection because of its ability to conduct the inspection without taking the pipeline segment out of service. In addition to inspecting the target area, the NT ILI project plans to inspect the entire river crossing and a total of 2,600' of pipe, significantly more than the 12' of pipe that would have been inspected via the Direct Assessment dig at the levee. As of the writing of this paper this project is in its planning phase.</p>
<p>Figure 4: Aerial of NT ILI tool entry point, original ECDA dig location, and end of inspection points for Day 1 &amp; Day 2 of ILI execution</p>	

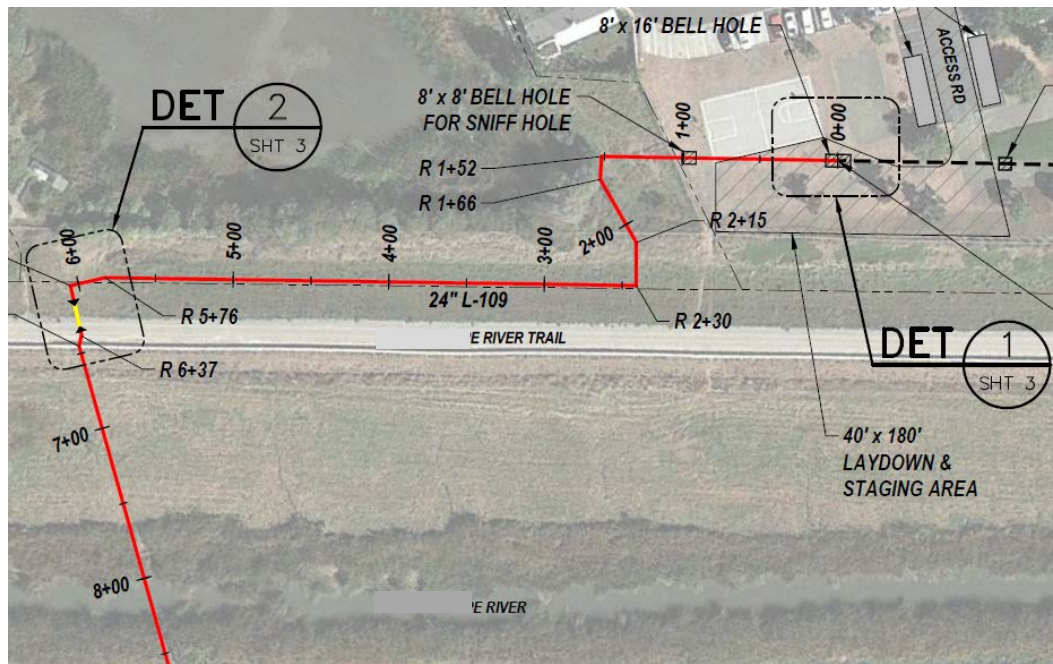
## INTERNAL FEATURE LOCATING AND IDENTIFICATION

In line video investigations to locate and identify internal pipeline features can be achieved with the use of robotic NT ILI tools utilizing their on-board camera systems. Drivers for employing visual investigations can include confirming the presence and/or pinpointing the exact location of pipeline features such as reducers, internal drips, pressure control fittings, and farm taps which may be used in preparation for upcoming projects such as replacements or hydrostatic tests. More detailed visual data such as certain seam weld types and internal stenciling from initial pipeline construction may also be obtained if the camera has high resolution capability and pan/tilt/zoom functionality. In addition to pipeline features and properties, in line video tools may also be deployed in order to locate tool parts dislodged in the pipeline from a failed traditional ILI tool run.

<b>Project Profile: Pinpointing Reducer Location</b>	
<b>Scenario:</b>	In order to obtain an Army Corps of Engineers permit for an upcoming pipeline replacement project at a river crossing, the exact location of a reducer within the levee bank required verification. Because the excavation required to locate and replace the reducer was within the structure of the levee, the exact limits of the excavation had to be verified.
<b>NT ILI Solution &amp; Key Accomplishment:</b>	A tethered robotic camera was utilized to perform a visual identification of the reducer. Once identified, the tool's on-board odometer measured the exact distance from the reducer to an elbow that was previously field-verified. The inspection was performed by inserting the tool via a cut-out section removed during a pipeline shutdown and was performed in coordination with another project on the same pipeline.



Figure 5: Exhibit showing tethered robotic camera tool entry point and the inspection area (in yellow) in the levee bank



### Project Profile: Confirming Presence of Internal Drip in Creek Crossing

<b>Scenario:</b>	During the engineering phase of an in-situ hydrostatic test, the engineering team required validation that an internal drip did not exist at the creek crossing. The potential existence of an internal drip introduced risk for the project team during pipeline cleaning and preparations for the hydrotest. The contingency to remove the drip would have required an excavation in an environmentally sensitive area and significant Liquefied Natural Gas (LNG) support to maintain customers in the area.
<b>NT ILI Solution &amp; Key Accomplishment:</b>	An untethered robotic ILI tool capable of conducting inspections in live pipelines was selected for its ability to perform a camera inspection of the creek crossing without requiring a pipeline shutdown. Additional rigor was applied in evaluating the potential risks of the ILI tool becoming stuck or immobilized due to the inability to shutdown the pipeline segment. Contingency planning for the NT ILI tool run included a high-level feasibility review of installing a bypass to facilitate tool cut-out if required. The project was successfully conducted and confirmed no internal drip present in the creek crossing section.

Figure 6: Aerial view showing NT ILI tool entry point and suspected internal drip location to be visually inspected





## **PROJECT SCOPING**

Determining the available execution methods and tool options to perform an inspection requires a clearly defined project goal along with rigorous data gathering and review processes. Once the project requirements and constraints are evaluated, the most appropriate execution method can then be identified and planning initiated.

### **Understanding Inspection Goals and Requirements**

A clearly defined objective of the inspection must be established in order to determine the best method to achieve the project goal. Determination up front whether the project is to be an inspection for Integrity Management purposes or if the project has an informational or data gathering objective is essential for success. If the project is an Integrity Management inspection, the type of threat being assessed must be considered by the pipeline operator's Engineer when selecting an NT ILI tool and the NDE method to be used during the inspection. The likelihood of identifying a particular type and severity of anomaly should also be considered during contingency planning. The primary target area, and if applicable, secondary coverage area of the inspection should be clearly defined in advance of project planning as this information may impact tool entry points and execution methods considered. Key project requirements also must be defined at the beginning of the scoping process to ensure decisions are made with the project's most critical requirements in-mind first.

### **Entry Point & Preliminary Site Planning**

Utilizing aerial imagery to identify the target inspection location along with potential NT ILI tool entry points is a key first step in scoping an NT ILI project. Entry points both upstream and downstream and as close to the target area as possible should be identified using this method. Viable alternative options should also be considered in the early planning phase to identify multiple excavation options to perform the project. This is especially important as some options may become unviable during the planning process. Potential excavation locations should take into account the specific activities that will occur at each location, including the area necessary for staging construction equipment and materials. Impact to local residents, logistics and transportation impacts resulting from traffic control, workspace barricades, potential gas release, and noise related to the specific activities occurring at each site must also be considered. A desktop review by an experienced land planner is essential to identify all applicable permitting jurisdictions associated with any planned excavation locations and project activities, along with the likely timeframe to obtain required permits and/or temporary construction easements (TCEs). To the extent that data is available, additional field conditions that may affect construction should be identified, such as high water table and unstable soils. Given the resources required to conduct a site visit, the use of aerial imagery in advance helps to ensure that the site visit is as comprehensive as possible, and minimizes the need for future site visits if the initial excavation locations have to change as the project planning progresses.

### **Pipeline Configuration Analysis**

A detailed understanding of the pipeline material properties and configuration must be obtained from the Pipeline Features List (PFL), GIS, and other Documents of Record. This information is critical in order to determine the best NT ILI tool option and to validate the feasibility of potential NT ILI insertion points. Key pipeline properties that must be identified to verify NT ILI tool options include; pipeline diameter (OD) and wall thickness, internal drips, taps, 1.0D bends, miter bends, field bends, combination bends, valves, diameter changes / reducers, significant angles of inclination, and unique construction features. Pipeline depth, the presence of casings, and the presence of unpiggable pipeline features must also be taken into account in relation to

confirming the excavation location for NT ILI tool insertion. Depending on the type of NT ILI method used, additional data on material properties may also be necessary to validate welding requirements.

### **Pipeline & System Conditions Research**

Two key areas that must be investigated include gas system hydraulics and the condition of the internal pipeline surface for debris and liquids.

The operator's Gas System Planning staff must determine the scope, feasibility, and conditions of conducting a pipeline shutdown from hydraulic and system reliability perspectives. This includes shutdown timing restrictions as well as requirements for Compressed Natural Gas (CNG) or Liquefied Natural Gas (LNG) to maintain service. If the NT ILI is to be conducted via hot-tap tool insertion without a shutdown, the potential for a pressure reduction to facilitate welding, tapping, and plugging operations must be considered. Gas System Planning will need to determine if, and to what extent a pressure reduction can be accommodated in support of the proposed welding and hot tapping operations. Another important role of Gas Planning is their holistic view of the system and understanding of timing and impacts of all projects requiring shutdowns. Efficiencies may be achieved if multiple projects can be accommodated under a single pipeline shutdown.

Internal pipeline conditions should be researched to determine the potential presence of contaminants, debris, and liquids. The extent of these conditions may impact the quality of data that can be gathered during the inspection and can also impact the performance of the NT ILI tool. For robotic tools, the presence of liquid may result in traction loss and reduced tool performance when traversing inclinations. Excessive liquid may necessitate an inspection be stopped if the tool is unable to pass the location without significant risk of tool damage. This information can be gathered by interviewing key engineering and gas operations staff and examining Documents of Record that provide information as to the internal conditions of the pipeline. The findings from this data gathering effort may suggest the use of a particular type of NT ILI tool, or may also reveal the need to clean the pipeline prior to execution of the NT ILI.

### **Resource Review and Preliminary Team Building**

Prior to having a confirmed execution method, NT ILI tool, and full project scope, potential resources should be contacted and preliminary team building should begin. Local resources that are geographically based should be made aware of the project and potential scope and timing. These resources include local gas operations personnel, transmission and distribution system planning, the pipeline asset owner and pipeline engineer, as well as key outreach staff including governmental and customer relations. Additional key resources to identify what will impact the project schedule include ILI and Design Engineering, Construction, Project Management, and potential ILI vendors. Items such as Pressure Control Fittings, launchers & receivers, and other long-lead materials should also be identified and their availability and lead time confirmed.

### **Potential Execution Methods and NT ILI Vendor Reviews**

Potential NT ILI vendors should review all available project data including requirements and objectives, constraints, PFL, and relevant Documents of Record to determine the feasibility of successfully conducting the project. In addition to project feasibility, vendor availability and flexibility must also be taken into account relative to the project's required deadline and potential risk for schedule shift.

### **Determination of Execution Method and NT ILI Tool**

Based on all data and feedback gathered, a comprehensive understanding of the project's constraints can be gained and a determination made regarding viable execution methods and NT ILI tool options. Multiple methods and/or tools may be feasible, or in some cases there may only be a single viable option.

---

## **EXECUTION METHODS**

There are multiple methods of conducting NT ILI projects, with no single method being suitable for every project scenario. Pipeline configuration, operational limitations, and tool entry point location will impact the type of NT ILI tool delivery platform most appropriate for a project. The type of Non-Destructive Examination (NDE) sensors vary between NT ILI tools and must also be considered to ensure it is appropriate for the inspection requirements and other project constraints. In addition to the technical considerations, availability of the vendor and other required resources must also be considered as the project requirements can vary greatly depending on the type of method used.

---

## **DELIVERY PLATFORMS**

### **Tethered Robotic**

Tethered robotic NT ILI tools are offered by a number of vendors and include a variety of available NDE sensors. These tools utilize cameras to navigate through the pipeline and typically have tracks or wheels to propel the tool. NDE sensors utilized on the projects included in this paper are video, EMAT, and Eddy Current. Deploying these tools requires a shutdown of the pipeline segment to be inspected and is performed via a single entry point at a pipeline cut-out. The tool is lowered into the excavation, often on a tray, and then piloted into and through the pipeline.

Most of these tools utilize the tether to provide power for tool propulsion and for communications including the video feed required for tool operation. The tether is a significant factor to consider when planning inspections with these types of robotic tools. The distance is typically limited by the number and angles of the bends that the tool must travel through between the entry point and the inspection location, as opposed to the actual length of the tether itself. Each bend that is traversed will result in cable resistance which accumulates with each bend encountered on the planned inspection run. One benefit of tethered tools is that the tether can be used as a contingency for tool extraction if it becomes stuck or disabled in the pipeline.

Tethered robotic tools are available for use in multiple pipe diameters, however for the projects evaluated in this paper these tools were proven to be most effective on pipeline diameters 20" and greater. Given demand for this capability, vendors are expanding tethered tools into the smaller diameter ranges as well as increasing their navigational capabilities.

### **Considerations for Project Planning**

Determination of the closest viable entry point based on permitting and project schedule constraints is one of the first key considerations in planning a tethered robotic inspection project. Once the option(s) for the entry points are confirmed, analyzing the pipeline configuration between the entry point and the inspection area is essential. The Pipeline Features List (PFL) and Documents of Record must be analyzed to ensure there are no features present that could limit tool progress and to determine if the total travel distance, quantity and degree of traversed bends are feasible for the tool to successfully conduct the inspection.

Vertical inclinations and the presence of liquids in the pipeline must also be considered. Some tethered robotic tools are capable of navigating vertical pipeline segments while some have a limited climbing ability, and therefore the pipeline geometry must be closely analyzed to ensure success. The presence of liquids in the line may negatively impact tool traction, and depending on the amount of liquid, may affect the tool's hardware and electronics.


Although this method allows project execution with a single entry point, it also means that the pipeline will likely not be cleaned prior to the inspection. Pipeline cleanliness and the likelihood of liquids and debris is something that should be investigated prior to deploying a tethered robotic ILI tool. The various NDE sensors available have different requirements related to pipeline cleanliness which should be taken into account when selecting an NT ILI tool. If cleaning is required, a launcher and receiver or test heads may be planned as part of the project in order to facilitate pipeline cleaning prior to NT ILI execution.

<b>Project Profile: Multi-Diameter Pipeline Cleaning Prior to Tethered Robotic EMAT Inspections</b>	
<b>Scenario:</b>	Two low points on a multi-diameter pipeline located within $\frac{3}{4}$ of a mile of one another were identified for internal corrosion inspection. The first inspection was on a 24" OD section of line located at a creek bottom, and the second inspection was on a 30" OD section of line located underneath a major utility crossing. The NT ILI tool identified for the projects was a tethered robotic crawler with an EMAT sensor. The pipeline was confirmed to contain liquids, and in order to ensure the highest data quality possible and reduce the potential for traction loss, the project necessitated liquids removal and pipeline cleaning prior to inspection.
<b>NT ILI Solution &amp; Key Accomplishment:</b>	Entry points for the NT ILI tool were identified as close as possible to the inspection locations. Launcher and receiver locations were identified on either side of these points to ensure the pipeline cleaning program encompassed all locations where the tool would be inspecting and traveling. A multi-diameter chemical cleaning program was engineered and deployed based on the known liquid properties. After the initial cleaning runs, a tethered robotic video crawler was deployed to confirm that the low points had been adequately cleaned. Based on this visual inspection, additional chemical cleaning was performed and subsequently confirmed as ready to proceed with the EMAT inspection. The tethered robotic EMAT tool successfully conducted inspections of the two target areas.
<b>Figure 7: Overview schematic of Launcher and Receiver for multi-diameter pipeline cleaning plus NT ILI tool entry points and reducers</b>	



Since taking the pipeline out of service is required for the Tethered Robotic method, the timing and requirements associated with the project must be planned for both gas hydraulics and system operations. These requirements will impact the overall project scope and must be accounted for in schedule, cost, construction, and gas operations resources.

Shoring set-up during construction should allow for lowering the NT ILI tool tray into the excavation and positioning the tool for insertion into the cut pipeline. Both travel and inspection speed of the ILI tool should be accounted for during project planning to ensure the time required to conduct the inspection is adequate. The inspection timeframe has the potential to affect local and jurisdictional permitting, construction and engineering resources, traffic control planning and execution, and the potential need for night work.

<b><u>Project Profile: Cased Span Investigated for Micro Robotic Inspection</u></b>	
<b>Scenario:</b>	As part of an ECDA project, a cased span was identified for inspection via NT ILI. The 8" OD pipeline at this location was contained within a 12" OD casing which was attached to the side of a bridge spanning 239 feet crossing over a river. Visual examination of the carrier pipe was infeasible due to the casing, and a standard buried pipe casing inspection was not feasible. The project engineer requested a feasibility review of utilizing a micro robotic crawler to visually assess the condition of the carrier pipe within the annular space.
<b>NT ILI Solution &amp; Key Accomplishment:</b>	As part of the feasibility investigation the casing end-seals were removed and a pole-mounted camera inserted into the annular space to assess the feasibility of conducting the inspection with the micro robotic crawler. The investigation determined that there was not adequate space for the NT ILI tool to travel or obtain sufficient data as required for this inspection. The project was subsequently scoped as a tethered MFL inspection which was used to complete the inspection.
<b>Figure 8: End of cased span and elbow</b>	

### **Untethered Robotic**

Currently available untethered robotic NT ILI tools utilize on-board batteries for power, antennas for communication with the tool operator, and front and rear cameras and lights for piloting the tool. These tools are designed to be deployed and retrieved through pressure control fittings (PCFs) utilizing a sandwich valve and launch tube assembly to gain access into live pipelines. This "hot-tap" method allows for minimal impact to system operations and does not require a pipeline shutdown. Tethering the tool for use as a contingency for emergency tool extraction is possible if the project is performed during a pipeline shutdown.

In addition to video, these tools contain MFL sensors for metal loss and laser deformation sensors in order to identify and map anomalies. These untethered robotic tools are currently available and can be operated from 8" OD up to 36" OD, with a 6" OD MFL tool in development. A tool is currently available in the 6-8" range which utilizes an Eddy Current NDE sensor.

The range capabilities of these tools vary based on the specific tool and OD of the pipeline, as well as the pipeline geometry of the specific project. Projects can be conducted from a single location acting as both the entry and exit point, as well as a point-to-point inspection with separate entry and exit locations. Range can be extended by the addition of in-line charge points, where the tool may be recharged through a 2" hot tap fitting while the device is in the live pipeline.

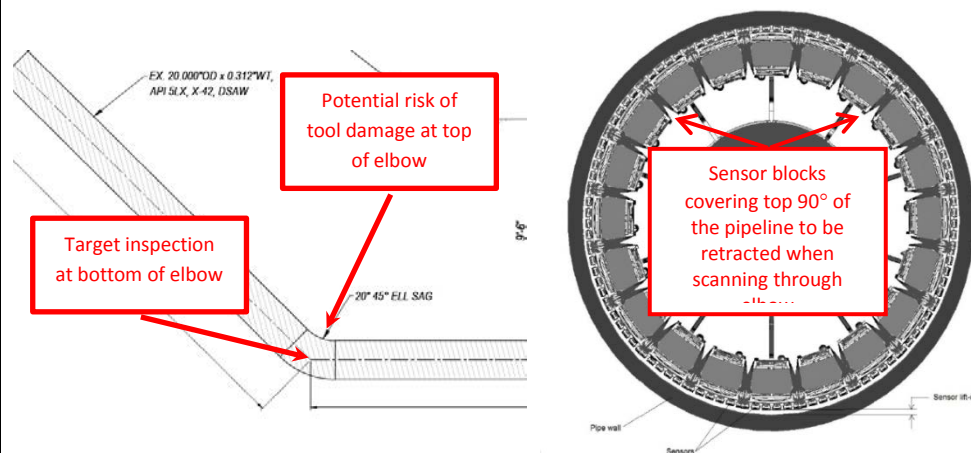
Utilizing untethered robotic ILI tools may decrease overall resource requirements by eliminating additional construction, loss of gas to atmosphere, and additional gas operations staff associated with performing a pipeline shutdown.

**Project Profile: Elbow Inspected for Internal Corrosion at Creek Crossing in Live Pipeline**

**Scenario:** An internal corrosion inspection was identified in a creek crossing which could not be permitted and excavated prior to the project deadline. The pipeline segment could not be taken out of service without significant impacts to gas operations. The inspection requirements dictated that the bottom 180° of the elbow be inspected for metal loss.

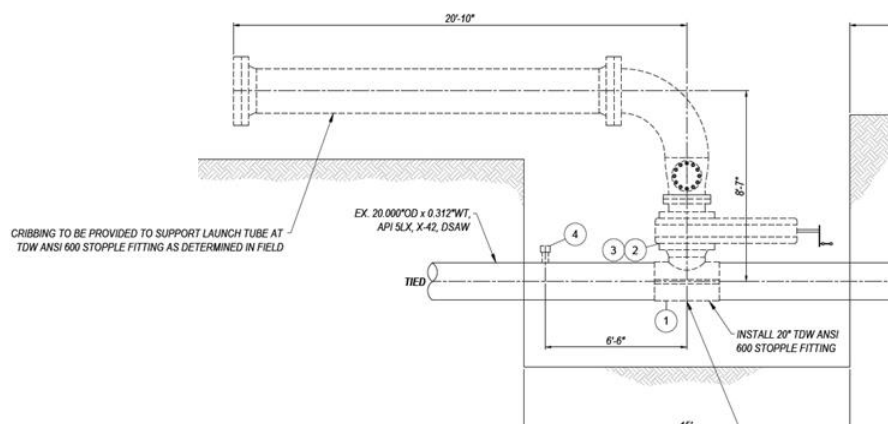
**NT ILI Solution & Key Accomplishment:** An untethered robotic ILI tool was identified to conduct the inspection while the pipeline remained in operation. In order to obtain the required data inside the fitting, the ILI vendor deployed the bottom 270° of the MFL sensors which accomplished two goals: 1) Magnetization was achieved and data collected on the bottom 180° of the fitting, satisfying the inspection requirement, and 2) by keeping the top 90° of the sensor blocks retracted it minimized the risk of tool damage on the intrados (top) of the sag elbow. The project was successfully completed prior to the deadline, without sustaining damage to the tool, and obtaining the required data inside the fitting.

**Figure 9: Schematic showing inspection target at bottom of elbow & location most at-risk for tool damage (Left). Schematic showing cross-section of MFL sensor and top 90° of sensors to remain retracted when scanning through bend (Right).**



## Considerations for Project Planning

As of the writing of this paper the options for untethered robotic tools are limited, and thus vendor availability is a key consideration. Lead time for the pressure control fitting materials and tapping support is a key schedule consideration especially for larger diameters.



**Figure 10: Schematic showing above-grade access to launcher**

Pressure is a consideration when planning hot-tap inspections related to both the capabilities of the inspection device and fittings, as well as the welding requirements related to pipeline pressure for the specific project. These tools can also be deployed via pipeline cut-out if a hot-tap inspection is not required. If a hot-tap inspection is to be conducted, the contingency plan should consider how the tool recovery effort would be conducted if the tool were to become stuck or immobilized while in the pipeline. If the pipeline cannot be taken out of service for emergency tool extraction via cut-out then a temporary bypass should be considered.

The presence of liquids should be investigated during the project feasibility review, especially if the tool will need to inspect or traverse a low point in the pipeline. The presence of liquids may impact the tool's traction in vertical pipeline sections. If significant liquid is encountered it may make continuation of the inspection infeasible if there is potential to damage the tools electronics.

Pipeline depth must be confirmed in advance to determine if access to the launcher is to be above or below grade. A construction plan for launcher installation must be developed to take into account for the preferred option.

### Tethered MFL (Non-Robotic)

Tethered, non-robotic MFL tools operate by pulling the tool through the pipeline via tether. Bi-directional operations allow for a single point of entry, propelling the tool away from the launch point via compressed air and utilize a winch to pull the tool back to the launch point. Bi-directional project execution allows for two data sets to be gathered, one while the tool is traveling away from the entry point, and another upon tool return to the entry point. Depending on the pipeline features it may also be possible to inspect both directions from a single entry point, maximizing inspection coverage. Tethered non-robotic MFL tools may also operate in a single direction with cut-outs at each end of the project, pulling the tool from one end and removing it from the other.

This execution method may potentially inspect longer distances as long as the minimum bend radius included in the inspection is within the specifications of the tool, and depending on the total number and degree of bends within the inspection scope. The drivers for NT ILI projects frequently require navigation through bends with radii that may not be navigable for this type of tool. If the bend radius is feasible for this method and there are no

other pipeline features considered unpiggable for the tool, the overall distance achievable is typically dictated by the tool's tether length and the number and total degree of the bends within the inspection distance.

This method has proven beneficial in scenarios with relatively straight inspection parameters that contain few bends. Additionally, these inspections can typically be conducted in a single shift.

Since taking the pipeline out of service is required for this method, the timing and requirements associated with the project must be planned for accordingly from both a gas hydraulics and system operations standpoint. These requirements will impact the number of excavations, required welding and construction support, and must be accounted for in schedule, cost, and construction resources.

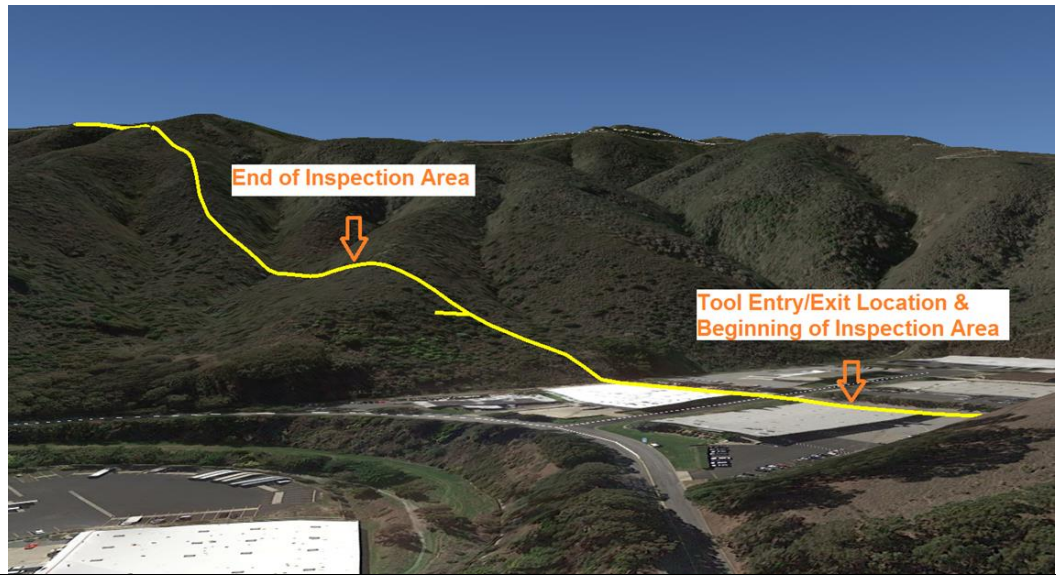
### Considerations for Project Planning

The primary item in planning a tethered non-robotic MFL inspection is the location of the access point(s) on the pipeline and ensuring that the pipeline features included within the inspection scope are feasible for the tool to navigate. During design engineering and site planning, the excavation size and site lay-out must consider pipeline depth, location of the winch used to pull back the tool, and management of the tether. Rigging including pulleys will be required to manage the tether based on the site configuration. Shoring installation within the excavation should allow adequate space for the tool tray to be lowered and aligned with the cut face of the pipe. The method by which the tool will be maneuvered from the loading tray into the pipeline should be planned ahead of time to ensure safe loading operation. Additional safety precautions must be taken while the winch is pulling the tool through the line. The ILI vendor identifies the area at-risk, and the operator's construction team keeps the area clear of personnel while the tool is being pulled through the pipeline.

<b>Project Profile: Tethered Non-Robotic Inspection in Environmentally Sensitive Area</b>	
<b>Scenario:</b>	An ECDA IIT survey identified a location for direct examination on a 30" OD pipeline approximately 1,500' up a mountainside in an environmentally sensitive area. Due to construction requirements the excavation was infeasible to complete by the required deadline.
<b>NT ILI Solution &amp; Key Accomplishment:</b>	A previously planned gas shutdown for a nearby replacement project was able to incorporate the area needed to execute the NT ILI project, making NT ILI execution methods requiring a pipeline shutdown a viable option on short notice. Multiple NT ILI tools were determined to be feasible to conduct the inspection, including a tethered robotic EMAT tool and a tethered non-robotic MFL tool. Ultimately the tethered non-robotic MFL tool was selected due to the vendor's ability to mobilize on short notice, as well as the tool's ability to inspect the entire ~ 1,700' within a single day. A key planning item was to determine the exact distance to stop the tool in order to ensure it did not travel past the crest of the hill which could have caused difficulty when pulling the tool back to the launch point. The Pipeline Features List and GIS were used to determine the distance that the tether was to be set in order to ensure the tool stopped at a location past the primary inspection point but before the hill crest. The inspection was successfully performed 19 days after project initiation, inspecting a total of 1,785' including the target area.



Figure 11: Image showing inspection location on mountainside and NT ILI tool entry location in warehouse parking lot



### “Traditional” Free-Swimming Tools Deployed at Targeted Locations

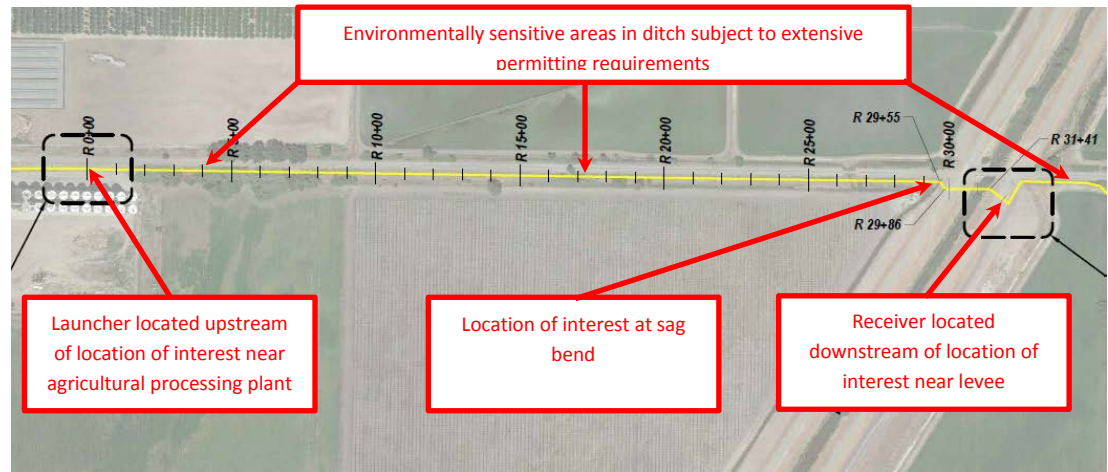
Inspecting a targeted location with a “traditional” free-swimming ILI tool is an additional method that may be employed based on project parameters. In some cases this method may provide a feasible option, especially for smaller pipeline diameters when robotic and tethered options are not viable. The free swimming method typically requires a pipeline shutdown to install launchers and receivers, including more excavations and welding than other NT ILI methods. Because this method utilizes traditional ILI technologies, there are more vendors with these types of tools available which can allow for greater flexibility in project scheduling. The option may also exist to extend the inspection limits beyond the targeted inspection point of depending on the piggability of the pipeline around the target location.

Natural gas, an inert gas such as nitrogen, or liquids may be utilized to execute a free-swimming project with MFL and/or geometry tools. When a liquid medium is used to run a free-swimming tool, ultrasonic (UT) tools may be viable and typically have greater flexibility to navigate restricting pipeline features such as 1D and miter bends.

#### **Project Profile: Gas-Driven Free-Swimming Inspection in Environmentally Sensitive Area**

<b>Scenario:</b>	A low point on a 6” OD pipeline was identified in an environmentally sensitive area for an internal corrosion inspection. The location of interest was a 10’ segment centered at a sag elbow next to a canal levee. The environmental permitting requirements at the location of interest made completion of the Direct Assessment infeasible prior to the required deadline.
<b>NT ILI Solution &amp; Key Accomplishment:</b>	Locating excavations to access the pipeline was a significant factor in this project since the pipeline was located in a wetland area subject to environmental restrictions. The closest upstream access point identified was approximately 3,000’ from the location of interest, and the closest downstream access point was roughly 500’ across a canal containing a number of 1.5D bends. The project was investigated for robotic tools but determined infeasible for tools available at that time due in large part to the small pipeline diameter. A free-swimming combination high resolution MFL and geometry tool was selected and successfully performed the inspection using the line gas as the propellant.

Figure 12: Aerial photo showing project locations and environmentally sensitive wetland area



## PROJECT PLANNING & COORDINATION

Once the project sponsor has confirmed the NT ILI method and authorized the project to proceed, significant planning and coordination is required in order to ensure a successful project.

### Project Team Assembly

All key stakeholders and other relevant parties must be identified and key roles established. The core project team should consist at minimum of ILI engineering, design engineering, project management, construction support, gas system hydraulic planning, gas system operations, land and environmental permitting, customer outreach, and governmental relations. Construction support should include excavation and restoration, welding, ILI vendor support, and if necessary hot-tapping, hot-tapping support, and pipefitting. A location and primary site contact must be identified for where the NT ILI tool and related equipment can be shipped to, stored until project execution, and maintenance performed during the project. This should include identification of space required and any special accommodations such as in-door shop space and access to power the ILI vendor will need.

A kickoff meeting with the full project team is critical to review the project scope and ensure that roles and responsibilities are clearly identified, communicated, and understood by all core team members. In addition to the core project team and project sponsor, additional project Stakeholders must be identified and included in key project communications appropriate relative to their level of involvement and influence on the project. This may include other project teams whose project may be affected by the NT ILI project, or executives with an interest in the project.

### Project Schedule & Detailed Task List

An overview project schedule must be created in order to identify key schedule drivers including; permitting, pipeline shutdown, construction resources, and ILI vendor availability. A detailed task list outlining all necessary steps that must occur, by when, and by whom is key to driving completion of crucial tasks in order to meet the critical project milestones. The detailed task list also assists in identifying how changes to individual task completion dates will impact the rest of the project schedule. Key areas to incorporate in the detailed task list include:

- Administrative items such as the cost estimate and official job authorization to secure funding
- Design engineering including design drafting and permit exhibit creation
- Procurement of materials and services
- Permitting and outreach
- Shutdown and gas operations planning
- Construction & ILI execution
- Project close-out

### **Core Team Meetings and Project Communications**

The draft schedule and task list should be reviewed in detail with all members of the project core team, preferably as a group, to ensure all critical items are identified, assigned, and understood. Weekly or bi-weekly project core team meetings are important to review progress, update the task list, review and edit project documents, and address any new developments as they occur. Regular distribution of meeting minutes that highlight key discussion topics and current action items, as well as including an updated task list, team contact list, and any other relevant project documents is a key component of effective project communication. This technique assures that the core team stays well-coordinated, key issues and project risks gain visibility, and project sponsors and other interested parties stay informed of project progress.

### **Detailed Site Planning, Permitting, and Engineering**

A site visit should be conducted as soon as possible after project initiation to confirm assumptions made during review of aerial imagery. Prior to the site walk, all potential excavation locations should be marked in the field, and utility locating initiated so that all utilities are field-located in advance of the site walk, including the exact location of the pipeline to be inspected. Additional site walk preparations should include identifying the specific activities to be conducted at each location, the work hours desired or required for the various phases of the project, as well as the type and size of equipment necessary at each site. During the site walk for each location, the core team should confirm pipeline depth and pinpoint the exact excavation location and dimensions. This is especially true in highly urbanized areas where there are typically many underground utilities in common easement areas where a slight shift in excavation location has the potential to have a significant impact on traffic and local residents/businesses. Details covered on the site walk should also include confirmation the work area needed, and for each phase of the project determine the type of traffic control, desired work hours, and determine if security is required during non-working hours. Each phase of the project construction and inspection should be addressed. For example, during excavation temporary/removable traffic control may suffice during work hours, with the excavation plated at night. If temporary above-ground piping is required during ILI execution then that phase of the project may require 24 hour traffic control secured with K-Rail or other barriers to maintain pipeline and public safety.

Following the site walk, jurisdictions should be confirmed to ensure all applicable local, state, and federal permitting agencies are identified. Additionally, private land owners should be identified so that required agreements or notifications can be generated, submitted and validated prior to mobilization. Permit exhibits and as required, traffic control plans should be prepared showing excavations and work areas based on the site walk, and permit applications should include the team's desired construction hours and work days. Based on the detailed information gathered and determined immediately following the site walk, the project scope should be reevaluated to confirm the entry point for the NT ILI tool is feasible for the tool selected. A review of the

permitting requirements and expected schedule is required to ensure these requirements are in-line with the project schedule.

Construction drawings that include a detailed Bill of Materials should be prepared and reviewed with key members of the project team to ensure all aspects of the construction portion of the project are planned. Shoring methods and materials should be considered during the engineering and planning to ensure it is appropriate to the type of execution method being used. If a NT ILI tool delivery tray is required based on the tool selected, planning for the method in which it is to be lowered into the excavation must be performed. Positioning of the tool for entry into the pipeline, the tool tray length, location of the pipeline cut should and shoring installation must be planned to ensure that the tool tray can be positioned with minimal obstruction during project execution. Strength Test Pressure Reports (STPRs) should be prepared for any tie-in piping and for temporary launchers and receivers if required. Welding procedures will have to be confirmed relative to the project requirements and confirmation of the acceptable welding and tapping (if applicable) pressure should be affirmed based on the pipeline material properties. If a pipeline pressure reduction is required to allow for in-service welding, the planning should be initiated as soon as confirmed in order to plan for potential timing restrictions due to system hydraulics. Additionally, permits or traffic control plans may be required in order to execute the pressure reduction if the required control valves are located in such areas.

### **Risk Identification & Contingency Planning**

Risks that could be realized during project execution should be identified prior to execution with contingency plans created to mitigate those risks. The framework and options for the various risks and contingencies should be established and discussed with key personnel in advance. Back-ups for key personnel required to implement any of the contingencies should also be identified and briefed in advance in case the primary contact cannot be reached. One typical project risk includes a stuck, broken, or immobilized NT ILI tool inside the pipeline. This scenario may require an emergency tool cut-out necessitating pinpointing of the tool's location, notifications to be made to relevant agencies, along with construction mobilization to the tool location. Another contingency option may be engineering and installing a temporary bypass for hot-tap inspections conducted on live pipelines. Other common project risks include an incomplete inspection, either due to the NT ILI tool not reaching the inspection location or insufficient data quality due to pipeline conditions or a tool malfunction. Depending on the project constraints and requirements, options to consider for contingency planning may include additional time in the schedule for tool repair, permitting and construction preparedness for an additional NT ILI tool entry point, remobilizing to allow execution of a pipeline cleaning effort, or potentially executing an alternative inspection method. An additional risk to consider is that an anomaly requiring immediate repair may be identified during the course of the inspection. The team should have an understanding of required internal and agency notifications that would be required if an emergency pipeline repair must be initiated.

---

## **PROJECT EXECUTION**

A detailed project work plan is critical to coordinate project execution from construction team mobilization through project completion and the site restoration. With the complexities of coordinating a multi-disciplinary team, roles and responsibilities must be clearly identified and understood by all team members and a team roster including contact information should be distributed. Given that highly specialized NT ILI tools are often transported to the project site from around the country and sometimes internationally, a highly detailed sequence of operations is important for ensuring the schedule for construction and inspection remains on-track



and that critical details of each task are identified. Project risks must be identified and contingencies built in order to ensure contingency implementation is feasible in the event the execution does not go according to plan. When decisions are required to be made in the field that are outside of the established plan, on-site project management, field engineering, and ILI engineering support is critical to provide background knowledge of the project and ensure that decisions made on-site are within and support key project goals and parameters. Daily updates during job execution are important to ensure all project stakeholders are aware of progress and work occurring on and in the pipeline.

### **Detailed Sequence of Operations**

The sequence of operations should identify and confirm the status of the critical pre-mobilization milestones including release to construction / notice to proceed from the Land team, approval of the shutdown or gas release procedure, and any other relevant items crucial to construction mobilization. A summary of the execution team's roles and responsibilities should be created, especially if construction-related activities will be performed by more than one group. The address of the NT ILI tool storage/staging facility along with the facility's primary contact person's information should be included. The delivery date for the tool and equipment, and the tool prep and maintenance schedule should be discussed with the facility in advance to ensure the ILI tool vendor has the access necessary during project execution.

Identifying key equipment and materials for each work task and determining who is supplying these items is a critical component of keeping job execution on track. This is especially true if construction support is being provided by multiple groups. Each day of construction and inspection work should clearly identify the on-site arrival time of each work group, the person in charge of the site, who is providing transportation to the job site for key materials including the NT ILI tool, and relevant details on daily tasks. Key safety items should be identified for different tasks and covered in a daily pre-work safety discussion. Relevant permit information may be included such as weather-related work restrictions or any other important details the execution team should be aware of. Task details may include items such as the minimum bore diameter for hot-taps, and if a robotic inspection is being conducted the ILI execution task should include a "road map" of the pipeline for the vendor, identifying key pipeline features visible from the tool's camera and approximate distances in between features. A clear understanding of hard-stops must be gained ahead of time and identified in the sequence of operations, such as dates and times for NT ILI vendor demobilization, pipeline tie-in and pressurization, etc. Contingency time should be built in to accommodate potential delays during execution, including potential tool damage requiring repair and reinspection.

<b><u>Project Profile: Contingency Plan Implementation</u></b>	
<b>Scenario:</b>	A free-swimming ILI execution method was selected to inspect a 6" OD pipeline at a canal crossing originally identified as an ECDA excavation site. In order to perform the inspection, the plan was to isolate the pipeline segment and utilize compressed nitrogen to propel the combination MFL/Geometry tool from the launcher to the receiver.
<b>NT ILI Solution &amp; Key Accomplishment:</b>	During ILI execution, the ILI tool was damaged and unable to complete the inspection. There was an upcoming deadline for the assessment requiring it to be completed within the planned schedule. One of the contingency plans for this scenario was implemented which resulted in the execution of a nitrogen strength test of the pipeline segment. While the ILI data of the canal crossing was not obtained, the assessment deadline was met with an alternate method.

Figure 13: Aerial view of launcher and receiver locations to conduct free-swimming ILI, and subsequently nitrogen strength test of canal crossing



## CONCLUSIONS

Based on experience gained in scoping, planning, and executing NT ILI projects since 2012, it is clear that there is no single NT ILI method or tool that is appropriate for every situation. Each project must be thoroughly analyzed to identify its unique requirements and conditions in order to determine the optimal solution. Once that solution has been decided upon, rigorous Project Management including project planning and coordination efforts must be undertaken due to the high level of complexities, details, and nuances involved with the various execution methods. A well planned project has a much greater chance of success, however projects do not always go as planned and thus the various risks must be identified for each individual project, and a thoughtful framework must be established for the contingencies that may be required. Key project team members must be on-site during project execution to participate in critical discussions if changes to the project plan are required in the field.

NT ILI has proven to be a valuable tool in completing critical inspections and gathering key pipeline data in challenging pipeline locations where alternative methods prove infeasible or impractical. The projects managed by GTS have been challenging and rewarding, providing us with the opportunity to be part of an evolving inspection platform that supports making the non-piggable achievable through innovation and a can-do approach to project planning and execution.