Quarterly Report – Public

Date of Report: *1st Quarterly Report – December 31, 2022*

Contract Number: *693JK32210010POTA*
Prepared for: *DOT PHMSA*
Project Title: ***Risk-Based Decision Support for Rehabilitation of Natural Gas Distribution Pipelines***
Prepared by: *GTI Energy*
Contact Information: *PM: Khalid Farrag, Ph.D., P.E.*
kfarrag@gti.energy - Phone: 847-344-9200
For quarterly period ending: *December 31, 2022*

1: Work Performed During this Quarterly Period

Task 1- Conduct Kick-off Meeting and Form Technical Advisory Panel (TAP): This task consisted of the following:

- Finalize project scope and analytical procedures.
- Form Technical Advisory Panel (TAP): The TAP currently consists of 8 gas distribution pipeline operators, one manufacturer, two faculty members, GTI, and PHMSA AOR. Additional members may be added throughout the project tasks. The TAP list is included in the Interim Report.
- Kickoff Meeting was during the OTD meeting on November 2nd, 2022.

2: Project Technical Status

The Interim Report, in the Attachment, includes the kickoff meeting presentation.

4: Project Schedule

Figure 1 shows the project schedule and progress as of the end of first quarter. No time-related issues are reported in this quarter.

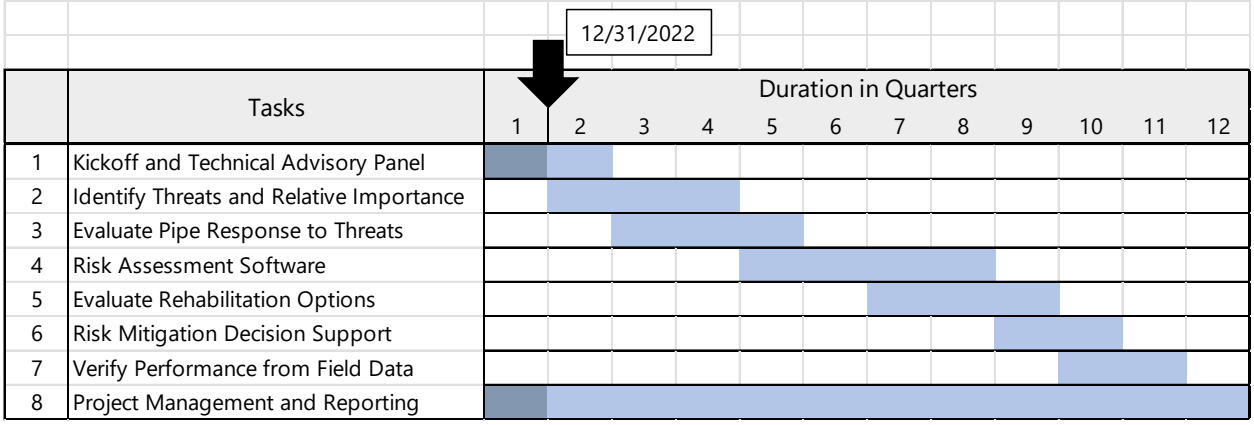


Figure 1 - Project time schedule

Task 1 Report

Work in this task included project Kickoff Meeting and forming the Technical Advisory Panel (TAP):

- The kickoff Meeting was performed on November 2nd, 2022, during the OTD (Operations Technology Development), project co-sponsor meeting.
- Presented project scope and procedures. The project discussion resulted in increasing the scope of the investigation from steel and cast-iron systems to include plastic pipes. This change in scope investigates various vintage PE pipes and includes them in a decision support system.
    - Formed Technical Advisory Panel (TAP): The project team contacted industry experts and OTD members for the TAP membership.

GTI ENERGY
solutions that transform

Risk-Based Discission Support for Gas Distribution Systems

Kickoff Projects Meeting:

- PHMSA Project No. 982
- OTD Project No. 7.22.n

Khalid Farrag, GTI
OTD Spring Meeting | November 2, 2022

Kickoff Meeting Agenda

GTI ENERGY

- Objective
- Scope of Work
- Project Tasks
- Tasks & Deliverables
- Schedule
- Discussion

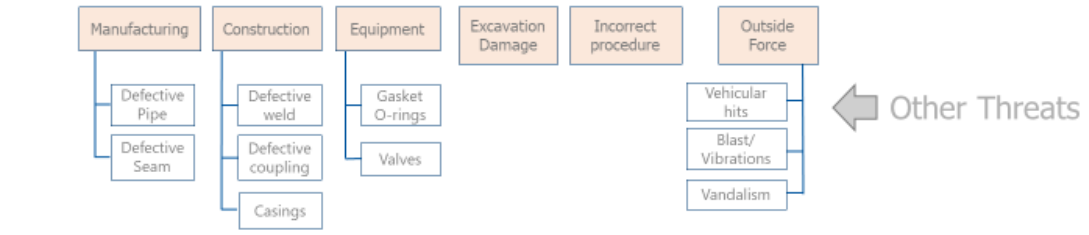
Page 2

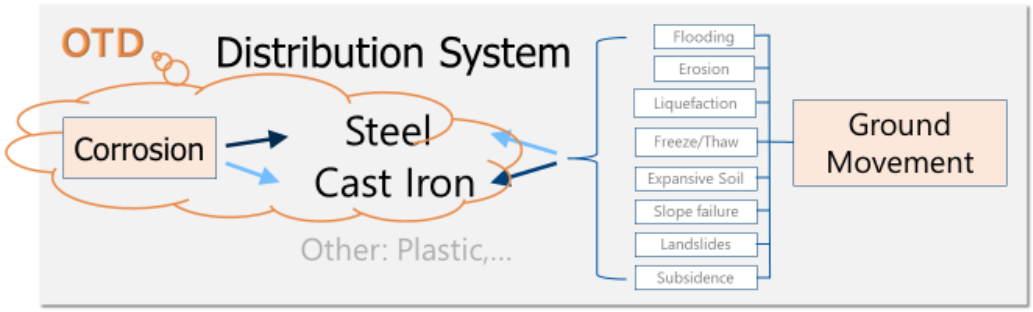
Objective

- Evaluate and rank threats on aged cast iron and bare steel gas distribution lines.
- Establish a risk-based approach (Bayesian Analysis) for ground movement and corrosion, based on site conditions and pipeline attributes.
- Evaluate rehabilitation options of pipe segments (monitoring, composite repair, and liners rehabilitation) in comparison with other alternatives such as open trench replacement.

Page 3

Scope of Work





Page 4

Projects Tasks

Task		Duration
1	Kickoff and Data Coordination	Month 3
2	Data for Corrosion Parameters	Month 6
3	Pipe Response to Corrosion Threat	Month 12
4	Establish Risk Assessment Procedure	Month 18
5	Incorporate a Web-Based Risk Model	Month 24
-		
-		
8	Project Management & Reporting	Project Duration

- OTD Project No. 7.22.n

Task		Duration
1	Kickoff and TAP Group	Month 6
2	Identify Threats and Relative Importance	Month 12
3	Evaluate Pipe Response to Threats	Month 15
4	Risk Assessment Procedure	Month 18
5	Evaluate Rehabilitation Options	Month 24
6	Risk Mitigation Decision Support	Month 30
7	Verify Performance from Field Data	Month 36
8	Project Management & Reporting	Project Duration

- PHMSA Project No. 982

Page 5

Task 2 – Identify Threats and Collect Data

- Outside force, natural force, excavation damage, and corrosion are main threats to aged cast iron and bare steel pipe.

Failure Type	Root Cause of Failure	Damage Indicators
Structural Failure	Pitting and graphitization corrosion	Coating damage, wall loss, graphitization, leaks, and pressure loss
	Manufacturing defects	Cracks on pipe body and bell joints
	Soil movement, seismic loads, loss of bedding, thermal contraction	Circumferential cracks, pipe uplift, crack leaks
	Internal Pressure, external load	Longitudinal cracks
Leaks	Soil movement, seismic loads, loss of bedding, thermal.	Pipe movement, loss of support, joint leaks.

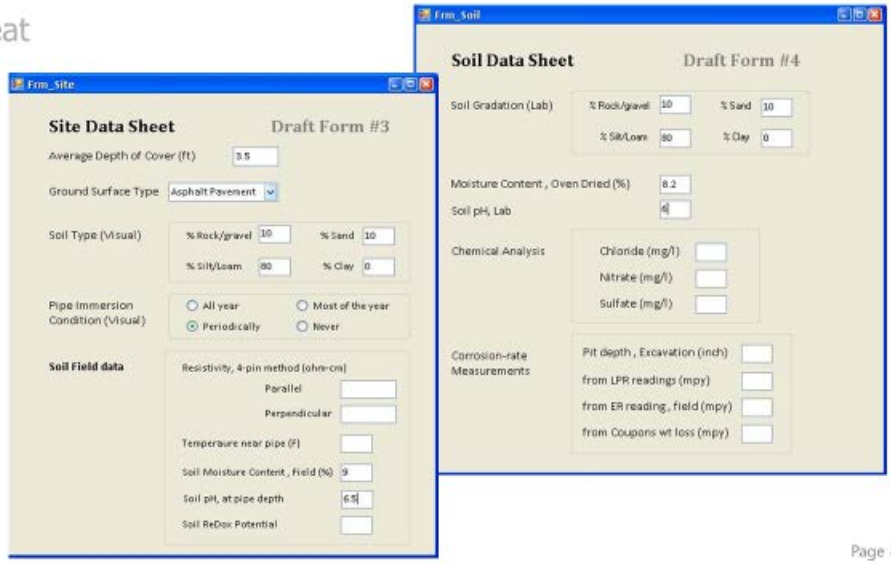
Main Threats and Damage Indicators

Page 7

Task 2 – Identify Threats and Collect Data

GTI ENERGY

- Corrosion Threat



Task 2 – Identify Threats and Collect Data

GTI ENERGY

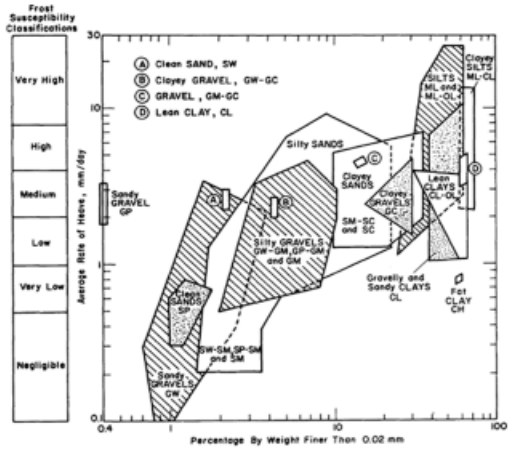
- Ground Movement Threat

Table 2 - Percentages of Failure Modes of Iron Pipes in U.K. [14]

Circumferential	Longitudinal	Hole	Joint
66.4%	13.3%	16.1%	4.2%

Table 3 - Change of Burst Rate with Pipe Diameter in Water Mains [12]

Diameter	Burst rate	
	Per km-year	Per mile-year
75mm (3 inch)	0.40	0.64
l00mm (4 inch)	0.25	0.4
150mm (6 inch)	0.15	0.24
300mm (12 inch)	0.10	0.16



Rate of Heave for various soils

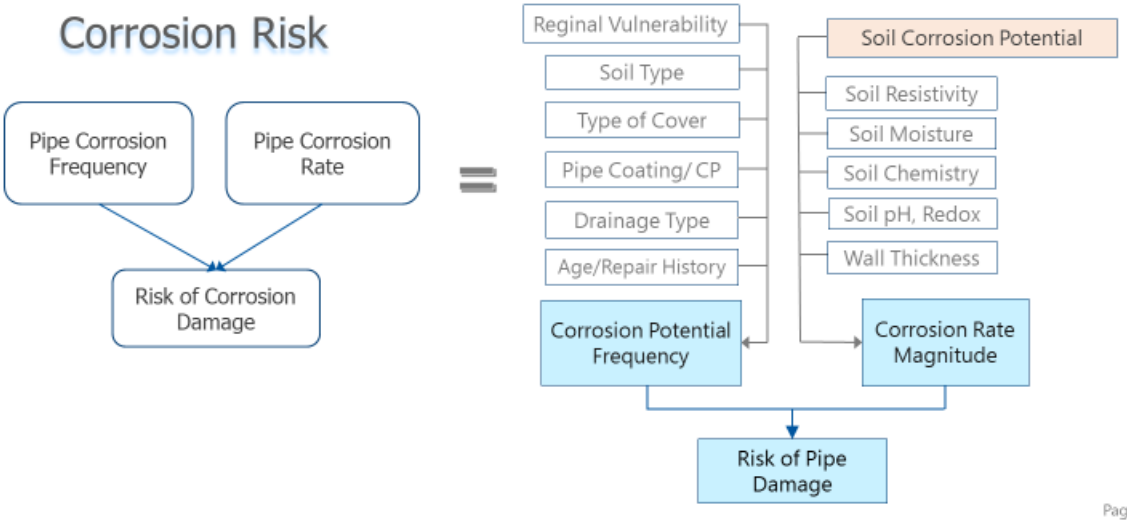
Task 3 – Evaluate Pipe Response to Threat

Challenges →

Quantitative Analysis →

Page 10

Task 3 - Corrosion Risk [Quantitative]



Page 11

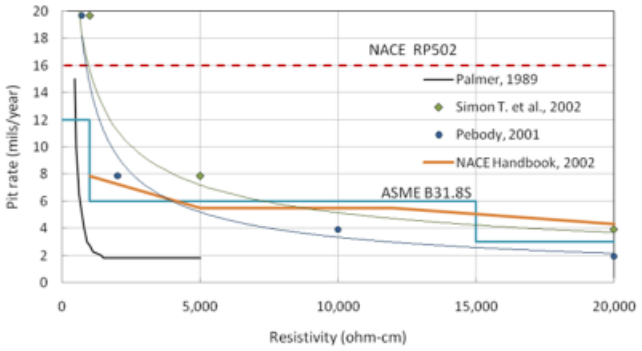
Task 4 – Risk Assessment & Web-Based Program

GTI ENERGY

Corrosion Risk

Corrosivity classification based on soil resistivity

Resistivity (ohm-cm)	Classification
<1000	Extremely corrosive
1,000-3,000	Highly corrosive
3,000-5,000	Corrosive
5,000-10,000	Moderately corrosive
10,000-20,000	Mildly corrosive
>20,000	Essentially non-corrosive

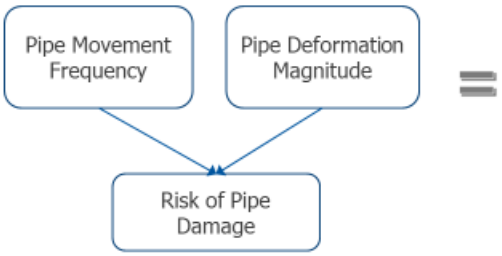


Page 12

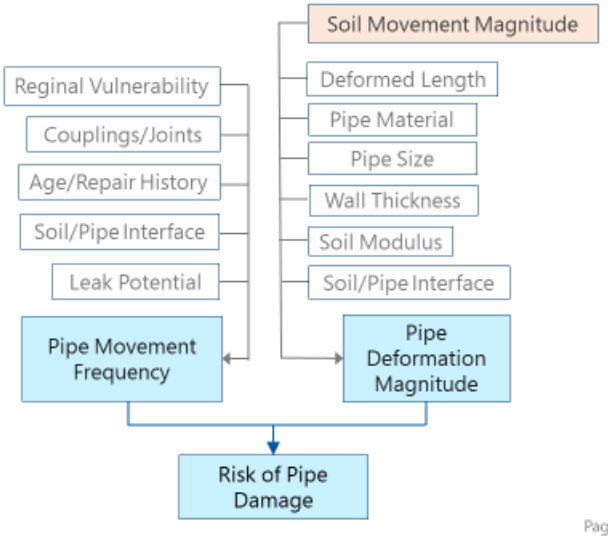
Task 3 - Ground Movement Risk [Quantitative]

GTI ENERGY

Soil Movement Risk



=

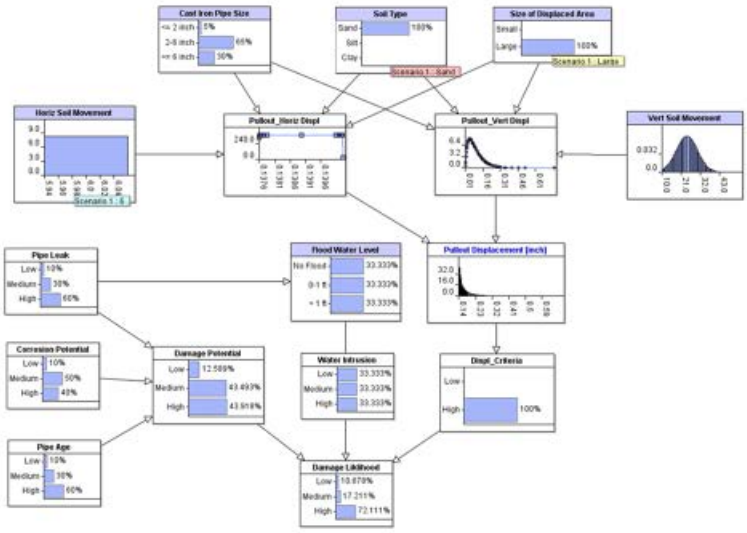


Page 13

Task 4 – Risk Assessment & Web-Based Program

GTI ENERGY

Soil Movement Risk



Schematic of a Bayesian Analysis of Pipe Damage from Soil Movement

Page 14

Task 5 – Evaluate Rehabilitation Options [PHMSA]

GTI ENERGY

Historical Repair Data Needed:

- Failure rate estimates for the threats on each PL segment
- Time to Failure (TTF) estimates (Corrosion)
- Mitigation effectiveness for each contemplated measure

- Monitor
- Repair Options [sleeves, composites,…]
- Rehabilitate [Liners options]
- Replace [HDD, open cuts]

Page 15

Task 6 – Risk Mitigation Decision Support [PHMSA]

GTI ENERGY

- Prioritize pipeline segments
- Evaluate benefits of mitigation
- Determine most effective mitigation
- Evaluate inspection intervals
- Assess the use of alternative assessment
- Estimate resources

https://www.phmsa.dot.gov/sites/phmsa.dot.gov/files/docs/technical-resources/pipeline/risk-modeling-work-group/

Page 16

Task 7 – Verify from Field Data [PHMSA]

GTI ENERGY

- The decision-making tool will be evaluated against data from existing rehabilitated segments.
- The evaluation compares the proposed rehabilitation with field installation data, based on its operation conditions and rehabilitation cost.

https://www.progressivepipe.com/blog/twenty-years-pioneering-pipeline-technology

Page 17

Task 8 – Project Management & Reporting

GTI ENERGY

	Tasks	Duration in Quarters											
		1	2	3	4	5	6	7	8	9	10	11	12
1	Kickoff and Technical Advisory Panel												
2	Identify Threats and Relative Importance												
3	Evaluate Pipe Response to Threats												
4	Risk Assessment Software												
5	Evaluate Rehabilitation Options												
6	Risk Mitigation Decision Support												
7	Verify Performance from Field Data												
8	Project Management and Reporting												

GTI ENERGY

https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=982

Research & Development Program
Server Version: 3.02.00-rc.1 Server Time: 10/26/2022 03:55 PM UTC

Risk-Based Decision Support for Rehabilitation of Natural Gas Distribution Pipelines

Main Objective
The project will evaluate the following:

- Threats to aged cast iron and bare steel gas distribution pipes by establishing a risk-based approach to 1) provide acceptable pipe deformations, and 2) recommend actions for pipe rehabilitation.
- Segments suitable for rehabilitation or trenchless repair based on attributes, site conditions, and installation cost.

A web-based tool will provide risk levels in a Geographic Information System (GIS) platform.

Public Abstract
The project: (a) Evaluates and ranks the threats on aged cast iron and bare steel gas distribution pipelines. (b) Establishes a risk-based approach which provides the acceptable deformations and strain limits of pipeline segments and recommends actions for their monitoring, rehabilitating, or replacement options. (c) The segments, deemed suitable for rehabilitation, are evaluated for trenchless repair, such as cured-in-place liners, based on pipeline attributes, site conditions, and cost of installation in comparison with other alternatives such as open trench replacement. A web-based user interface tool will provide the risk levels of the selected segments in a GIS platform. The risk analysis will be based on the probabilities of corrosion and ground movement threats and associated pipe deformations in a Bayesian Analysis approach.

Fast Facts	
Research Award Recipient:	Gas Technology Institute 1700 South Mount Prospect Road Des Plaines, IL 60018-1804
AOR/TTI:	Louis Cardenas, louis.cardenas @ dot.gov, 713-773-7206 Robert Smith, Robert.W.Smith @ dot.gov, 919-238-4759
Contract #:	693JK32210010POTA
Project #:	982
Researcher Contact Info:	Dr. Khalid Farrag, 847-768-0803, kfarrag @ gti.energy
Downloads of Project Reporting	
Since Jan 1, 2017:	0
Financial and Status Data	
Project Status:	Active
Start Fiscal Year:	2022 (09/30/2022)
End Fiscal Year:	2025 (09/29/2025)
PHMSA $$ Budgeted:	$400,000.00

Anticipated Results: The project will provide a web program to the gas distribution utilities for a decision-support of pipeline replacement and rehabilitation considerations. The reliability of the program will be evaluated against operational data in existing utilities rehabilitated segments.

Potential Impact on Safety: The risk-based decision support system provides a selection tool and procedures for replacement and rehabilitation options of aged infrastructure. It increases safety and reduces gas emissions from high-risk cast iron and bare steel pipes in the infrastructure. The risk-based approach addresses the gas Distribution Integrity Management Program (DIMP) requirements to establish effective rehabilitation and replacement programs to prevent leaks and breakage of aged pipelines.

[END OF DOCUMENT]