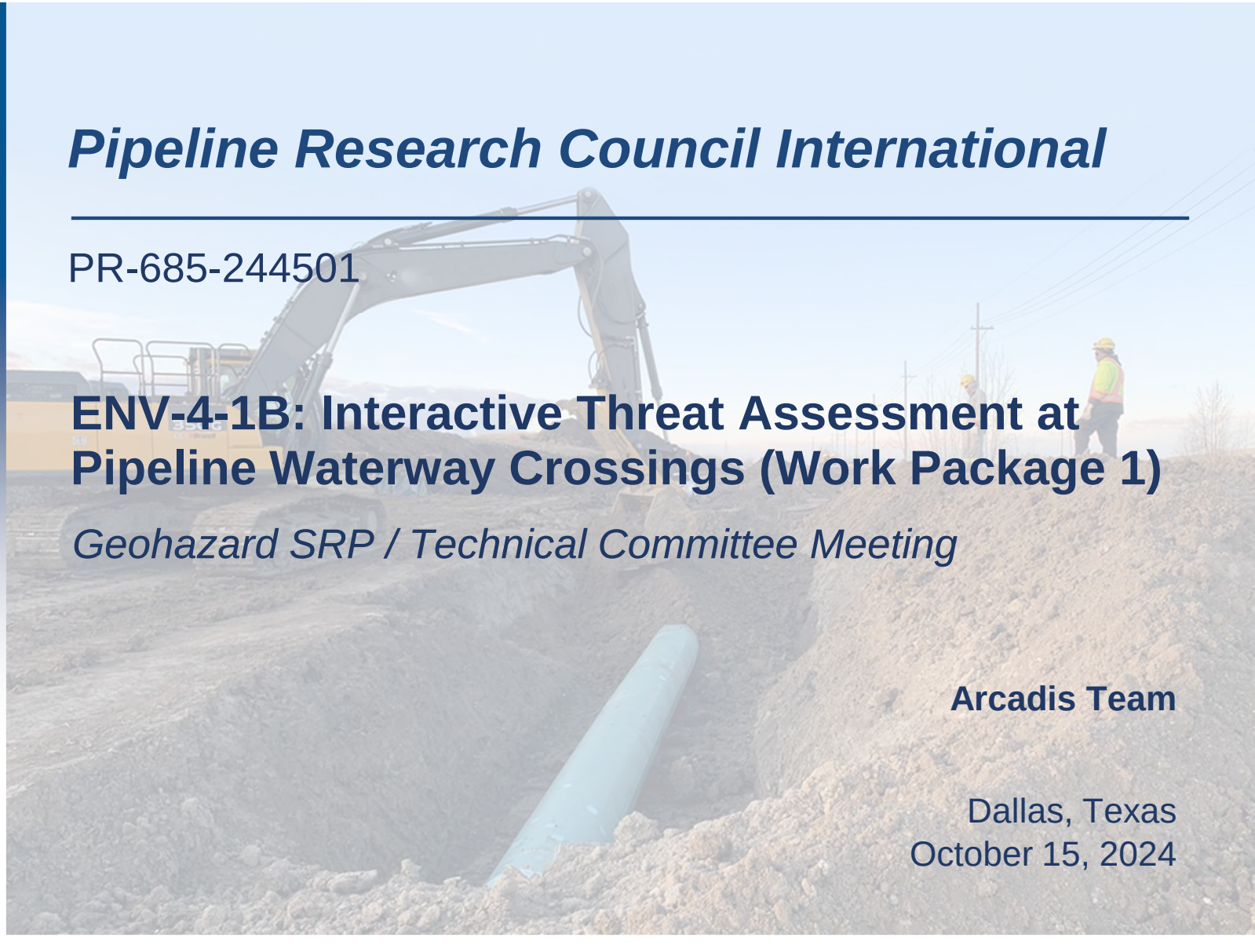


# *Pipeline Research Council International*

PR-685-244501

## ENV-4-1B: Interactive Threat Assessment at Pipeline Waterway Crossings (Work Package 1)

*Geohazard SRP / Technical Committee Meeting*

**Arcadis Team**

Dallas, Texas
October 15, 2024

LEADING PIPELINE RESEARCH

# Interactive Threat Assessment of Pipeline Waterway Crossings



- Background
  - End of 2021 looked into furthering efforts related to ENV-4-1A
  - Based on current industry advancements, developed initial proposal in early 2022
  - Morphed into a potential SRP initiative, then was re-tooled
- Principal Investigator: Arcadis
- Project Team Leader: Justin Taylor, TransCanada Energy (*Ashton Friesen)*
- Total Costs: $235,000
- Project Team
  - Justin Brooks, Kinder Morgan
  - Karineh Gregorian, SoCal Gas
  - Jared Rinker, Marathon Pipe Line
  - Svetlana Shafrova, Exxon

# Framework



This project will be multi-phased with the following components:

- **Work Package 1 – this phase will have desktop and field components and consist of the screening and initial field investigation items of building bank stability assessments at pipeline waterway crossings.**
  - Task 1 – Desktop Screening and Programmatic Development
  - Task 2 – Field Verification and Threat Assessment
- *Work Package 2 – this phase will utilize the screening and assessment findings of Phase 1 and generate predictive analysis aspects for each location, including appropriate monitoring and mitigation measures.*

***Arcadis will work closely with the PRCI Team on sharing of data/information, development, and implementation of Work Package 2**

# ENV-4-1B: Interactive Threats

**Status:** Critical Needs Attention On Plan

## Overview

| Activities Underway/Completed (since last report) | Overall Project Status/Significant Findings |
|---|---|
| • Continuation of Task 1 | • Agreement signed May 2024<br>• 5 Team meetings providing plans and decision making; taking in feedback and direction<br>• June TC Meeting share |
| **Planned Activities (next period)** | **Current Issues, Risks and Decisions Needed** |
| • Continue Task 1 | • NA |

## Status

| | Rationale/Explanation of Deviations between Plan and Forecast | |
|---|---|---|
| **Overall Schedule** | • Commencing | |
| **Active Task(s)** | • PM<br>• Task 1 | |
| **Cost to Date** | • 1st lump sum billing in September 2024 | |
| **Threats/Scope Changes or Additions** | • None currently | |

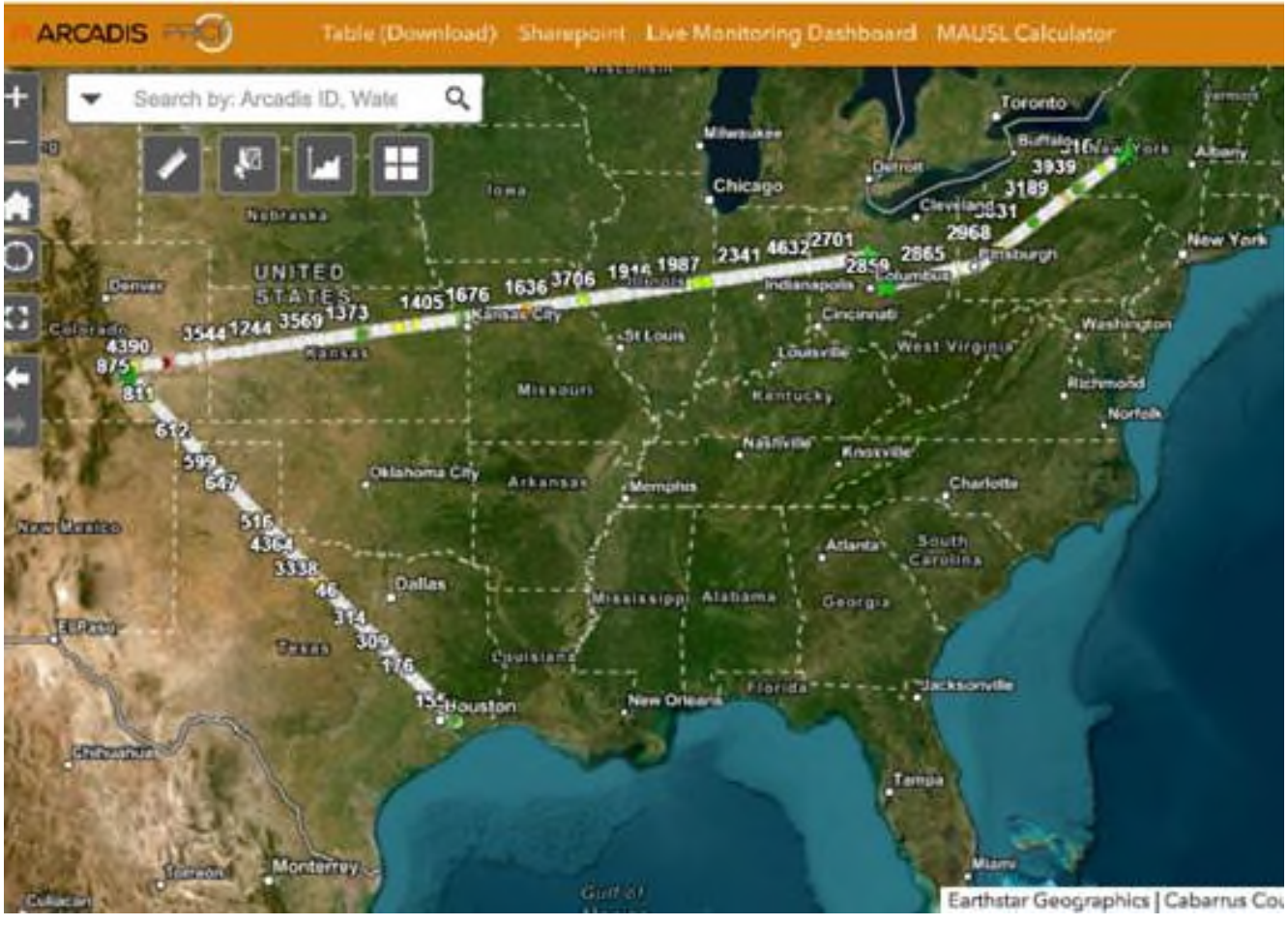
# Screening Assessment



Working on ENV-4-1A fictious pipeline:

- ~3,000 miles
- ~4,500 inventoried waterway crossings

Developing ‘screening’ protocol and worksheet



# Screening Assessment Worksheet



## Screening Based on Visual Assessment Of:

- Soil Type
- Vegetation Cover
- Depressions/Sinkholes
- Historical Landslides
- Bank Cutting/Erosion
- Land Drainage
- Drainage Area (Bank Height)
- Known hydrotechnical threats

# Soil Type



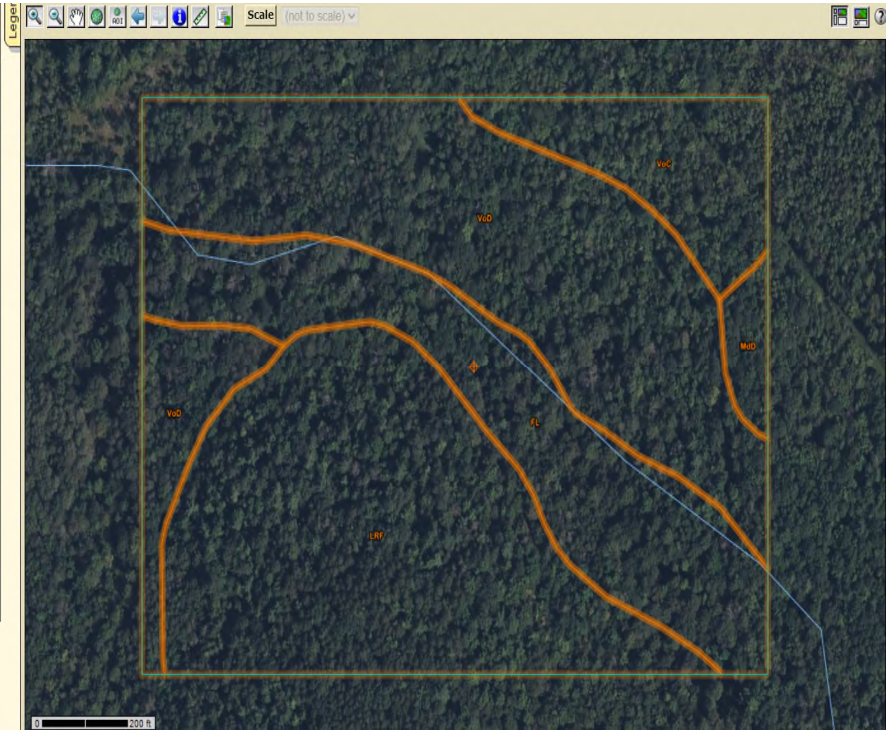
- Clay soil: 5 (High risk)
- Loamy soil: 4 (Moderate risk)
- Sandy soil: 3 (Low risk)
- Rocky soil: 2 (Very low risk)
- Bedrock: 1 (Minimal risk)

Map Unit Legend

Steuben County, New York (NY101)

Steuben County, New York (NY101)

| Map Unit Symbol | Map Unit Name | Acres in AOI | Percent of AOI |
|---|---|---|---|
| FL | Fluvaquents and Ochrepts | 7.0 | 20.4% |
| LRF | Lordstown-Arnot complex, very steep, very rocky | 11.5 | 33.5% |
| MdD | Mardin channery silt loam, 15 to 25 percent slopes | 0.6 | 1.8% |
| VoC | Volusia channery silt loam, 8 to 15 percent slopes | 2.9 | 8.4% |
| VoD | Volusia channery silt loam, 15 to 25 percent slopes | 12.4 | 36.0% |
| **Totals for Area of Interest** | | **34.5** | **100.0%** |



# Vegetation Cover



- No vegetation: 5 (High risk)
- Sparse vegetation: 4 (Moderate risk)
- Moderate vegetation: 3 (Low risk)
- Dense vegetation: 2 (Very low risk)
- Very dense vegetation: 1 (Minimal risk)

2016

2018

2024

# Depressions/Sinkholes and Historical Landslides



## Depressions/Sinkholes

- Many large depressions/sinkholes: 5 (High risk)
- Several small depressions/sinkholes: 4 (Moderate risk)
- Few small depressions/sinkholes: 3 (Low risk)
- Isolated small depressions/sinkholes: 2 (Very low risk)
- None: 1 (Minimal risk)

## Landslides

- Several major landslides: 5 (High risk)
- Few major landslides: 4 (Moderate risk)
- Several minor landslides: 3 (Low risk)
- Few minor landslides: 2 (Very low risk)
- No historical landslides: 1 (Minimal risk)

# Bank Cutting/Erosion



- Severe bank cutting: 5 (High risk)
- Moderate bank cutting: 4 (Moderate risk)
- Minor bank cutting: 3 (Low risk)
- Minimal bank cutting: 2 (Very low risk)
- No bank cutting: 1 (Minimal risk)

# Land Drainage and Drainage Area (Bank Height)



## Land Drainage

- Very poor drainage: 5 (High risk)
- Poor drainage: 4 (Moderate risk)
- Moderate drainage: 3 (Low risk)
- Good drainage: 2 (Very low risk)
- Excellent drainage: 1 (Minimal risk)


## Drainage Area Correlation

**Depth = 0.30DA^0.213**

- >138,235 sq mi (>15ft): 5 (High risk)
- 48,460-138,235 sq mi (12-15ft): 4 (Moderate risk)
- 7,230-48,460 sq mi (8-12ft): 3 (Low risk)
- 794-7,230 sq mi (5-8ft): 2 (Very low risk)
- <795 sq mi (<5ft): 1 (Minimal risk)

# Known Hydrotechnical Threats



## Hydrotechnical Screening Criteria (ENV4-1A)

- Scour
- Erosion
- Avulsion

## Interactive Scoring

- Geotechnical screening looks at specifically avulsion score and factors in the risk of avulsion occurring into the overall screening.

# Screening Assessment Scoring



## Risk Rating Scale:

- 7-12: Minimal Risk
- 13-16: Low Risk
- 17-22: Moderate Risk
- 23-28: High Risk
- 29-35: Very High Risk

| Location ID | State | State Plan Projection (NAD83) | Latitude | Longitude | WSS Type | Vegetation Cover | Depressions/Sinkholes | Historical Landslide | Bank Undercutting/Erosion | Land Drainage | Drainage Area | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3119 | NY | NAD83 | 43.004269 | -75.592479 | 4 | 2 | 1 | 1 | 3 | 3 | 1 | 15 |
| 3212 | NY | NAD83 | 43.000800 | -75.600982 | 4 | 1 | 1 | 1 | 1 | 3 | 1 | 12 |
| 3091 | NY | NAD83 | 42.981860 | -75.639005 | 4 | 1 | 1 | 1 | 1 | 3 | 1 | 12 |
| 2205 | IN | NAD83 | 40.196525 | -87.402934 | 5 | 3 | 1 | 1 | 4 | 4 | 2 | 20 |
| 428 | TX | NAD83 | 33.685308 | -99.426909 | 3 | 5 | 1 | 2 | 4 | 1 | 2 | 18 |
| | | | | | | | | | | | | 0 |
| | | | | | | | | | | | | 0 |

# Screening Update

| Location ID | State | State Plan Projection (NAD83) | Latitude | Longitude | WSS Type | Vegetation Cover | Depressions/Sinkholes/ Open Pits/ Underground Mines | Historical Landslide | Bank Undercutting/Erosion | Land Drainage | Bank Height (Drainage Area) | Score | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4226 | TX | NAD83 | 30.323553 | -95.598517 | 4 | 2 | 1 | 1 | 2 | 2 | 1 | 13 | |
| 133 | TX | NAD83 | 30.347451 | -95.625732 | 4 | 2 | 1 | 1 | 1 | 4 | 1 | 14 | |
| 167 | TX | NAD83 | 30.35324 | -95.632325 | 4 | 3 | 1 | 1 | 1 | 4 | 1 | 15 | |
| 192 | TX | NAD83 | 30.355826 | -95.63527 | 4 | 2 | 1 | 1 | 1 | 4 | 1 | 14 | |
| 245 | TX | NAD83 | 30.361391 | -95.641607 | 4 | 2 | 1 | 1 | 2 | 4 | 1 | 15 | |
| 117 | TX | NAD83 | 30.365239 | -95.645989 | 4 | 2 | 1 | 1 | 1 | 2 | 1 | 12 | *START* |
| 119 | TX | NAD83 | 30.367188 | -95.648209 | 5 | 2 | 1 | 1 | 1 | 2 | 1 | 13 | |
| 184 | TX | NAD83 | 30.372321 | -95.654055 | 5 | 2 | 1 | 1 | 1 | 2 | 1 | 13 | |
| 4117 | TX | NAD83 | 30.380646 | -95.663535 | 5 | 3 | 1 | 1 | 2 | 2 | 1 | 15 | Crossing at pond |
| 110 | TX | NAD83 | 30.38086 | -95.663779 | 5 | 3 | 1 | 1 | 2 | 2 | 1 | 15 | Crossing at pond |
| 4118 | TX | NAD83 | 30.381166 | -95.664127 | 5 | 3 | 1 | 1 | 2 | 2 | 1 | 15 | Crossing at pond |
| 247 | TX | NAD83 | 30.388061 | -95.67198 | 5 | 2 | 1 | 1 | 1 | 2 | 1 | 13 | |
| 3241 | TX | NAD83 | 30.389378 | -95.67348 | 5 | 2 | 1 | 1 | 1 | 3 | 1 | 14 | |
| 3242 | TX | NAD83 | 30.389565 | -95.673692 | 5 | 2 | 1 | 1 | 1 | 3 | 1 | 14 | |
| 3243 | TX | NAD83 | 30.389733 | -95.673883 | 5 | 2 | 1 | 1 | 1 | 3 | 1 | 14 | |
| 4201 | TX | NAD83 | 30.392144 | -95.676629 | 5 | 3 | 1 | 1 | 3 | 4 | 1 | 18 | |
| 4202 | TX | NAD83 | 30.392472 | -95.677002 | 5 | 3 | 1 | 1 | 3 | 4 | 1 | 18 | |
| 233 | TX | NAD83 | 30.402661 | -95.688606 | 5 | 4 | 1 | 1 | 2 | 3 | 1 | 17 | |
| 230 | TX | NAD83 | 30.402905 | -95.688884 | 5 | 4 | 1 | 1 | 5 | 3 | 1 | 20 | |
| 3272 | TX | NAD83 | 30.405621 | -95.691977 | 5 | 2 | 1 | 1 | 1 | 3 | 1 | 14 | |
| 3273 | TX | NAD83 | 30.40565 | -95.69201 | 5 | 2 | 1 | 1 | 1 | 3 | 1 | 14 | |
| 3274 | TX | NAD83 | 30.405719 | -95.692088 | 5 | 2 | 1 | 1 | 1 | 3 | 1 | 14 | |
| 3275 | TX | NAD83 | 30.406049 | -95.692465 | 5 | 2 | 1 | 1 | 1 | 3 | 1 | 14 | |
| 3276 | TX | NAD83 | 30.406947 | -95.693487 | 5 | 2 | 1 | 1 | 1 | 3 | 1 | 14 | |
| 3277 | TX | NAD83 | 30.410895 | -95.697984 | 5 | 3 | 1 | 1 | 2 | 2 | 1 | 15 | Crossing is at a drainage ditch |
| 157 | TX | NAD83 | 30.420843 | -95.709311 | 4 | 2 | 1 | 1 | 2 | 3 | 1 | 14 | Eroded based off Soil survey name (ObC2 - Woodville soils, 2-5% slopes, eroded) |
| 242 | TX | NAD83 | 30.421703 | -95.710291 | 4 | 2 | 1 | 1 | 2 | 3 | 1 | 14 | Eroded based off Soil survey name (ObC2 - Woodville soils, 2-5% slopes, eroded) |
| 179 | TX | NAD83 | 30.431017 | -95.720899 | 5 | 1 | 1 | 1 | 2 | 4 | 1 | 15 | Eroded based off Soil survey name (ObC2 - Woodville soils, 2-5% slopes, eroded) |
| 206 | TX | NAD83 | 30.431401 | -95.721336 | 5 | 1 | 1 | 1 | 2 | 4 | 1 | 15 | Eroded based off Soil survey name (ObC2 - Woodville soils, 2-5% slopes, eroded) |
| 112 | TX | NAD83 | 30.436696 | -95.727365 | 4 | 1 | 1 | 1 | 1 | 4 | 1 | 13 | |
| 130 | TX | NAD83 | 30.438703 | -95.729651 | 4 | 1 | 1 | 1 | 2 | 4 | 1 | 14 | |
| 216 | TX | NAD83 | 30.445781 | -95.737712 | 4 | 2 | 1 | 1 | 2 | 4 | 1 | 15 | Crossing near man made pond between the year 2020 and 2021 |
| 255 | TX | NAD83 | 30.450929 | -95.743574 | 4 | 3 | 1 | 1 | 2 | 4 | 1 | 16 | |
| 237 | TX | NAD83 | 30.452233 | -95.74506 | 5 | 3 | 1 | 1 | 4 | 4 | 1 | 19 | Crossing near man made pond between the year 2021 and 2022 |

thank you

PRCI LEADING PIPELINE RESEARCH

Pipeline Research Council International

**Jeff Budzich and Liz Pittman**

*Arcadis Team*

jeffrey.budzich@arcadis.com

elisabeth.pittman@arcadis.com

# Supplemental

# Recent Application



## Pre-Screening:

| Location ID | State | State Plan Projection (NAD83) | Latitude | Longitude | WSS Type | Vegetation Cover | Depressions/Sinkholes/ Open Pits/ Underground Mines | Historical Landslide | Bank Undercutting/Erosion | Land Drainage | Bank Height (Drainage Area) | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 442 | TX | NAD83 | | | 4 | 3 | 1 | 1 | 1 | 2 | 1 | 13 |

## Onsite Findings:

Flat Land

Low Banks

Good Vegetation

LEADING PIPELINE RESEARCH



# Recent Application

## Pre-Screening:

| Location ID | State | State Plan Projection (NAD83) | Latitude | Longitude | WSS Type | Vegetation Cover | Depressions/Sinkholes/ Open Pits/ Underground Mines | Historical Landslide | Bank Undercutting/Erosion | Land Drainage | Bank Height (Drainage Area) | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | TX | NAD83 | | | 4 | 5 | 2 | 3 | 5 | 4 | 3 | 26 |

## Onsite Findings

Sever Erosion Gullies

High Banks

Sparse Vegetation

# Pipeline Research Council International

SRP GHZ-03-01

## Desktop Study of the Effectiveness of Hydrotechnical Mitigation Options

*Project Status Update*

Project Team Lead: Jared Kowis, PE, Enbridge

Andreas Kammereck, *PE*
*WEST Consultants, Inc.*

PRCI DMC Fall TC Mtg (Dallas)
October 15, 2024

LEADING PIPELINE RESEARCH

1



## Overview

2

- Project Schedule
- Outcome and Objectives
- Scope Overview with Task Updates
- Summary Status
- Questions



2

## Project/Task Schedule

3

- **T1 Project Management/Meetings May/2024 – Apr/2026 (ON-GOING)**
- **T2 Literature Review: May – Jul 2024 (COMPLETED)**
- **T3 Evaluation and Analysis: Aug 2024 – Jan 2025 (ON-GOING)**
- **T4 Case-Study Development: Feb – Jun 2025 (EARLY START)**
- **T5 Draft Final Report: Jul – Dec 2025**
- **T6 Final Report: Jan – Apr 2026**



3



## Project Scope Outcomes & Objectives

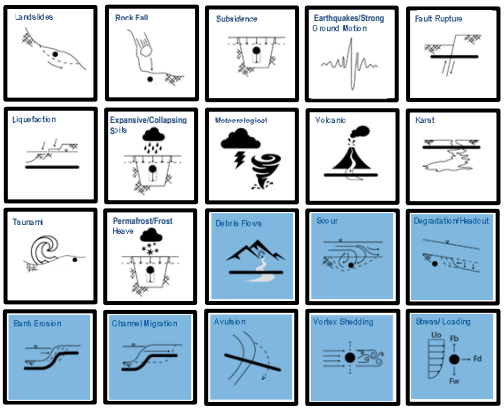
4

- **Proposed Research**
  - Desk-top Review of guidelines for selection of **mitigation options for hydrotechnical hazards** for a combination of crossing types and events affecting pipelines.
- **Outcome of proposed research**
  - Provide pipeline operators with the ability to understand and select appropriate mitigation options and validate their performance reliability through industry-wide knowledge sharing.
- **Targeted Deliverables**
  - Guideline document for types of mitigation options based on crossing type; expected pipeline failure mode with documentation on historical service life; performance observed in various contexts; and techno-economical feasibility in practical pipeline contexts.
  - Collection of performance experience of temporary and permanent mitigation options in various applications (e.g., bank stabilization, scour and erosion control, girth-weld strengthening, composite applications) from pipeline and other related industries.



4

# Focus on Hydrotechnical Hazards:





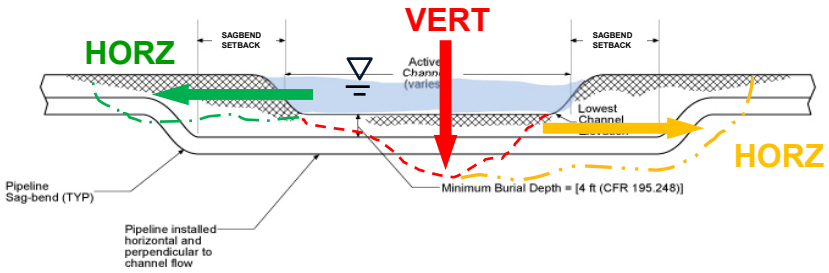



5



# HYDROTECHNICAL THREATS RELATIVE TO PIPELINE:

## …Scour, Erosion, Channel Migration, Vortex Shedding and Stress




**Note: Conceptual section view looking downstream**





6

## Project Scope Outcomes & Objectives

7

- **Proposed Research**
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7



## Example Bank Erosion/Exposed Sagbend

8

8



8

## Example Head-cutting and Exposed Pipeline

9





9



## Example Channel Migration at White River, WA

10





10

## Project Scope Outcomes & Objectives

11

- **Proposed Research**
  - Desk-top review of guidelines for selection of mitigation options for hydrotechnical hazards for a combination of crossing types and events affecting pipelines.
- **Outcome of proposed research**
  - Provide pipeline operators with the ability to understand and select appropriate mitigation options and validate their performance reliability through industry-wide knowledge sharing.
- **Targeted Deliverable(s)**
  - Guideline document for **types of mitigation options** based on **crossing type**; expected pipeline **failure mode** with documentation on historical service life; performance observed in various contexts; and technical/economical feasibility in practical pipeline contexts.
  - Summary of **risk-based performance** experience for **temporary and permanent mitigation options in various applications** (e.g., bank stabilization, scour and erosion control, girth-weld strengthening, composite applications) from pipeline and other related industries.



11



## Project Scope Overview

12

- **T1 Project Management/Meetings (ON-GOING)**
  - Project kick-off, meetings, planning, resources, accounting/invoicing, project administrative communications and coordination with PRCI.
- **T2 Literature Review (May – Jul 2024)**
  - Compile listing of available published studies, industry guidance, and related technical documents related to hydrotechnical mitigation options. Examples: focused on Conference & Seminar publications, White Papers, Research, Pipeline Industry technical sources, and other linear facility guidance, e.g. WSDOT and FHWA transportation corridor, USACE, etc.
- **T3 Evaluation and Analysis (Aug 2024 – Jan 2025)**
  - Develop review/discussion/listing/matrix of applicable measures (from literature source review), looking at qualitative performance metrics, develop guidelines for selection of mitigation options for hydrotechnical hazards for a combination of crossing types, select appropriate mitigation options and validate their performance reliability, etc.



12

## Project Scope Overview

13

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13



## Sources…

14

**…related to erosion, scour, channel migration, and other hydrotechnical threats, and the corresponding mitigation and countermeasures from technical papers, studies, published doc's, etc:**

- **~60 technical references/sources (pipeline and other industries)**
- **~90 public DOT sources**
- **still adding/updating**

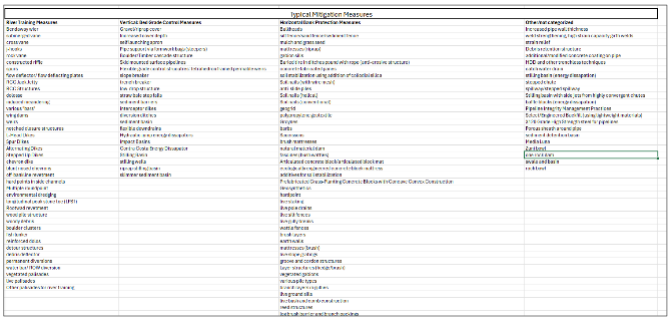


14

## List of Typical Mitigation Measures…

15

- **Bed Grade Control (Vertical Riverine Processes): ~25**
- **Bank Protection (Horizontal Riverine Processes) ~90**
- **Training Structures (Combined Vert and Horz) ~40**
- **Other measures ~20**





15



## Project Scope Overview

16

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  - Project kick-off, meetings, planning, resources, accounting/invoicing, project administrative communications and coordination with PRCI.
- **T2 Literature Review (May – Jul 2024, COMPLETED)**
  - Compile listing of available published studies, industry guidance, and related technical documents related to hydrotechnical mitigation options. Examples: focused on Conference & Seminar publications, White Papers, Research, Pipeline Industry technical sources, and other linear facility guidance, e.g. WSDOT and FHWA transportation corridor, USACE, etc.
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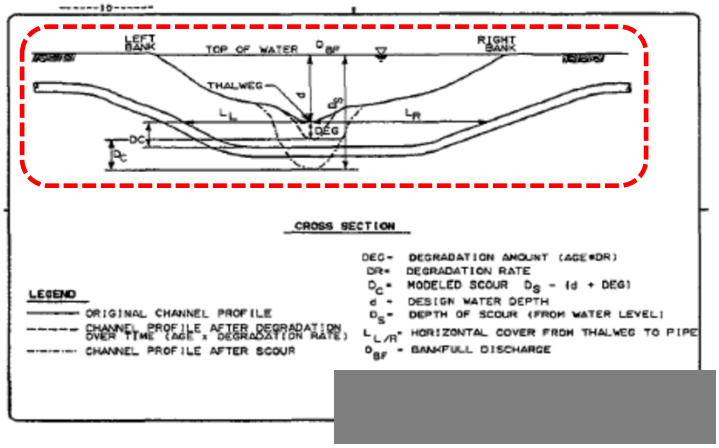
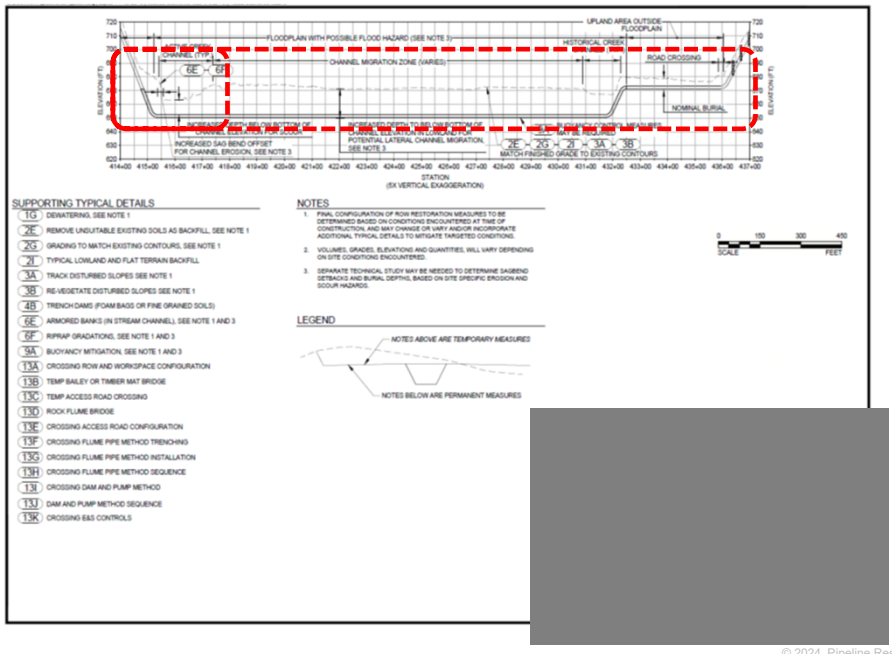
16






17

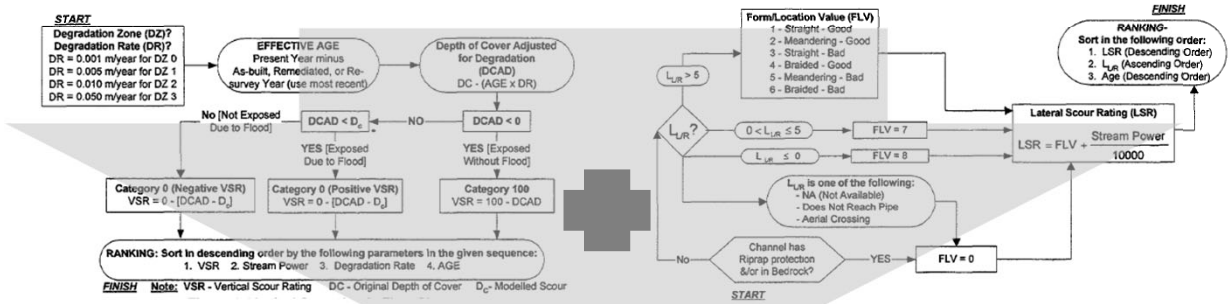







18

# Evaluation/Selection Workflow…




## VERTICAL COVER

## HORIZONTAL COVER

## SELECT MITIGATION MEASURE(S)/OPTION(S)

Ref: A Methodology to Maintain Pipeline Integrity at Water Crossings (Zhou, Beckstead, Westmacott, Samchek, Rizkalla, 2000)

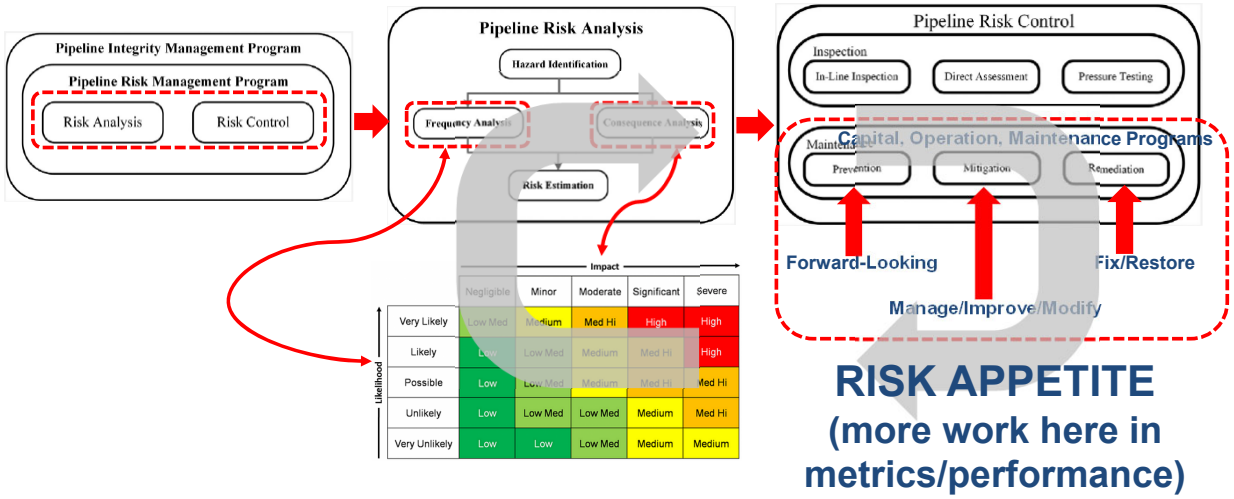


19



# Risk Perspective for selecting Mitigation…

20




## RISK APPETITE

## (more work here in metrics/performance)

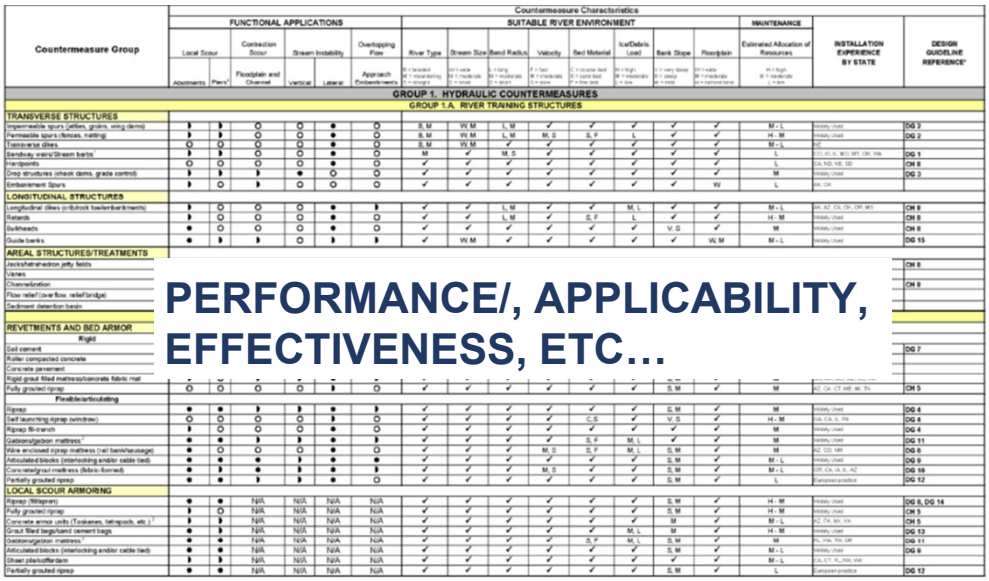
Ref: Risk-based Pipeline Integrity Management: A road map for the resilient pipelines (Kahn, Yarveisy, Abbassi, 2019)



20

## PERFORMANCE METRICS (Prevention, Mitigation, Remediation)

MITIGATION MEASURES




Ref: HEC 23 (2009)



21



## Project Scope Overview (continued)

22

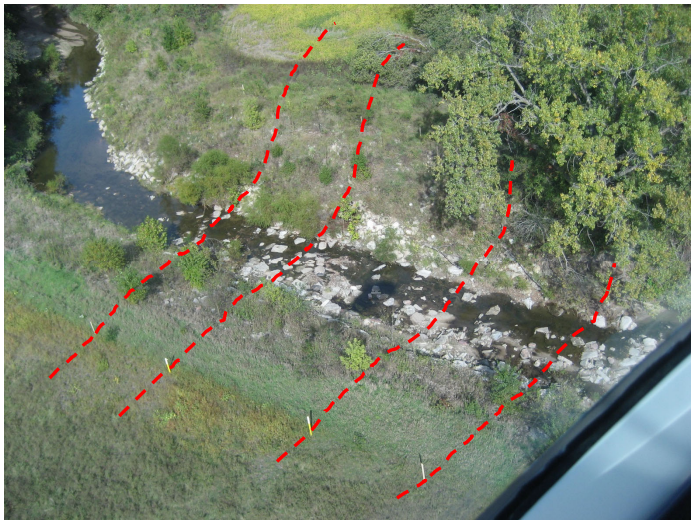
- **T4 Case-Study Development (Feb – Jun 2025, EARLY START)**
  - Work closely with participating operators to identify targeted and ‘most commonly’ used hydrotechnical mitigation measures for defined crossing scenarios; and develop brief summary descriptions of key learnings, performance, effectiveness, relative costs, O&M considerations, etc. Information gathered through brief ‘project summary template’, distributed/coordinated with participating Operators, with intent to provide feedback from Operators on current practices (i.e. connected and reflective of real-world standard of practice).
- **T5 Draft Final Report (Jul – Dec 2025)**
  - Compilation of draft final report package, including coordination and review with PRCI on format and organization per study requirements.
- **T6 Final Report (Jan – Apr 2026)**
  - Compilation of Final Report package.



22

## Case Study: Bed Armoring/Multiple Crossing









23



## Case Study: Headcut Erosion (CO)



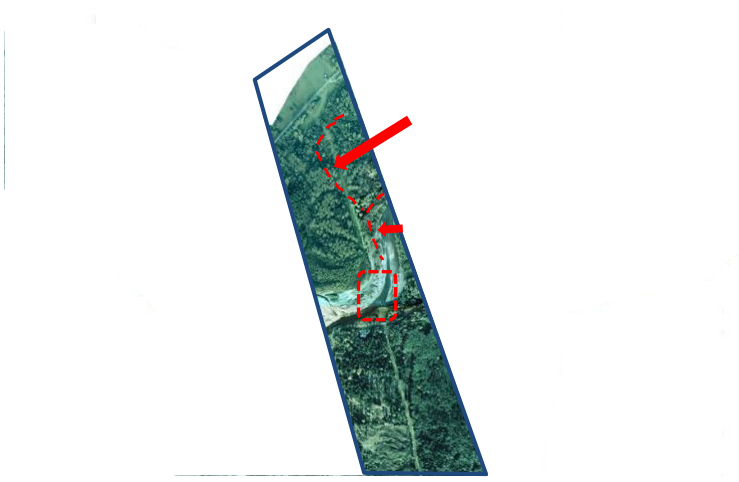




24

## Case Study: Channel Migration (WA)

25







25



## Case Study: Headcut Erosion (WA)

26





26

## Case Study: Headcut Erosion (KY)

27





27



## Case Study: Headcut and Bank Erosion

28





28

## Case-Study: Headcut Erosion (TX)

29





29



## Case Study: Channel Migration (WA)

30





30

## Project Scope Overview (continued)

31

- T4 Case-Study Development (Feb – Jun 2025, EARLY START)
  - Work closely with participating operators to identify targeted and 'most commonly' used hydrotechnical mitigation measures for defined crossing scenarios; and develop brief summary descriptions of key learnings, performance, effectiveness, relative costs, O&M considerations, etc. Information gathered through brief 'project summary template', distributed/coordinated with participating Operators, with intent to provide feedback from Operators on current practices (i.e. connected and reflective of real-world standard of practice).
- **T5 Draft Final Report (Jul – Dec 2025)**
  - Compilation of draft final report package, including coordination and review with PRCI on format and organization per study requirements.
- T6 Final Report (Jan – Apr 2026)
  - Compilation of Final Report package.



31



## Project Scope Overview (continued)

32

- T4 Case-Study Development (Feb – Jun 2025)
  - Work closely with participating operators to identify targeted and 'most commonly' used hydrotechnical mitigation measures for defined crossing scenarios; and develop brief summary descriptions of key learnings, performance, effectiveness, relative costs, O&M considerations, etc. Information gathered through brief 'project summary template', distributed/coordinated with participating Operators, with intent to provide feedback from Operators on current practices (i.e. connected and reflective of real-world standard of practice).
- T5 Draft Final Report (Jul – Dec 2025)
  - Compilation of draft final report package, including coordination and review with PRCI on format and organization per study requirements.
- **T6 Final Report (Jan – Apr 2026)**
  - Compilation of Final Report package.



32

## GHZ-03-01: Effectiveness of Hydrotechnical Mitigations

Status: Critical Needs Attention On Plan

### Overview

| Activities Underway/Completed (since last report) | Overall Project Status/Significant Findings |
|---|---|
| • On-going T1 Project Management<br>• Completed T2 Literature Review Task<br>• Underway on T3 Evaluation/Analysis Task<br>• Early Start on T4 Case Studies Task | • T3 Eval/Analysis task work highlighting the importance of t4 Case Studies; prompted early-start on ID'ing case studies.<br>• Importance of Risk-Based Methods<br>• Targeted T3 Eval/Analysis team discussions at IPC |
| **Planned Activities (next period)** | **Current Issues, Risks and Decisions Needed** |
| • Continue on T3 Evaluation/Analysis Task (through Jan-Feb 2025) | • None |

### Status

| | Rationale/Explanation of Deviations between Plan and Forecast | |
|---|---|---|
| **Overall Schedule** | • T2 Lit. Review started early-May/'24 and wrapped-up end-July/'24<br>• T3 Evaluation/Analysis starting Aug/'24, continues through Jan/'25<br>• Overall project completion Apr/'26 | • No issues anticipated at this time, project schedule is on track |
| **Active Task(s)** | • T3 Evaluation/Analysis: Completed team workshop on Sept 13, 2024 to review/discuss details on Eval/Analysis approach, currently continuing with work-flow. | • No issues anticipated at this time, work progressing as planned |
| **Cost to Date** | • ~21-percent of total (2024-2026) effort | • No issues anticipated at this time |
| **Threats/Scope Changes or Additions** | • None to date | |



33

# Questions…

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Pipeline Research Council International

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34

Geosyntec consultants

engineers | scientists | innovators

# *Pipeline Research Council International*

GHZ-03-02

## Desktop Review and Gap Analysis of Remote and Continuous Scour Monitoring Technologies

*Project Status Update*

**Alexander McKenzie-Johnson**

*Senior Principal Geologist, Geosyntec Consultants, Inc.*

Dallas, TX

October 15, 2024

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# Status Update

**Status:** Critical Needs Attention On Plan

## Overview

**Activities Underway/Completed (since last report)**

- Submission of Deliverables 1 and 2 (Literature review, industry survey, and gap analysis)

**Overall Project Status/Significant Findings**

- On Schedule – Need to Resolve Project Objectives

**Planned Activities (next period)**

- Complete Deliverable 3 (Recommended Technologies and Vendors)

**Current Issues, Risks and Decisions Needed**

- Resolve Project Objectives to Establish Preferred Path

## Status

| | Rationale/Explanation of Deviations between Plan and Forecast | |
|---|---|---|
| **Overall Schedule** | • On schedule | |
| **Active Task(s)** | • Completing next deliverable (Recommended Technologies and Vendors) | • On target for November delivery |
| **Cost to Date** | • On target | |
| **Threats/Scope Changes or Additions** | • None identified to date | |

# Desktop Review and Gap Analysis of Remote and Continuous Scour Monitoring Technologies - Overview



- **Principal investigator: Geosyntec Consultants, Inc.**
  - Alexander McKenzie-Johnson
  - Bailey Theriault
- **PRCI Project Team Leader: Jared Rinker (Marathon)**
- **Total costs: $99,000**

# Project Objectives



- To identify current scour monitoring technologies or approaches that are ready or near ready for field validation and deployment.
- To identify gaps in current scour monitoring technologies and provide recommendations for technologies that may be ready for deployment in the near future or that could be repurposed to serve as scour monitoring technologies.
- To set performance metrics to evaluate the performance of these technologies
- To define the requirements for field testing and to develop a list of field-testing sites and requirements to conduct the field testing.

# Project Deliverables



## Five main deliverables:

- **Deliverable 1: Literature review and industry survey on the current state of scour monitoring technologies. (Completed)**
- **Deliverable 2: Gap analysis. (Completed and Combined with Deliverable 1)**
- Deliverable 3: Recommended technologies and vendors (as applicable) for field trials in the 2025-2027 timeframe. (November ‘24)
- Deliverable 4: Recommended scope, performance metrics to evaluate the success of the technologies, permitting requirements, and a schedule for the field trials. (January ‘25)
- Deliverable 5: A final report and presentation summarizing the above. (May ‘25)

# Industry Survey



- Industry survey sent to participants (first task performed)
- 13 questions on desired project outcomes, economics and considerations for technology selections
- 9 responses from 8 companies
- Some broad areas of broad agreement and some areas of strong differences

# Industry Survey



- **Objectives**
  - Roughly evenly divided between:
    1. Calibration of methods used to assess and predict scour
    2. Scour monitoring (monitor the channel)
    3. Pipeline monitoring (monitor the pipeline)

- **Current Status:**
  - Very limited use of on-site instrumentation
  - Mostly:
    - Visual monitoring
    - Pre- and post-flood streambed surveys
    - Predictive modeling
    - Post-flood scour modeling
    - Depth of cover measurements

# Industry Survey



- **Technologies being considered**
  - Acoustic
  - Large stand-off magnetometry
  - Fiber optic
  - ILI
  - Predictive models
  - Temperature
  - Scour monitoring sensor
  - Remote sensing
  - Drones
- **Frequency of Measurement and Reporting**
  - Large range from minute by minute to annually
  - Most respondents prefer relatively high-frequency reporting during flood events (near real-time)

# Industry Survey

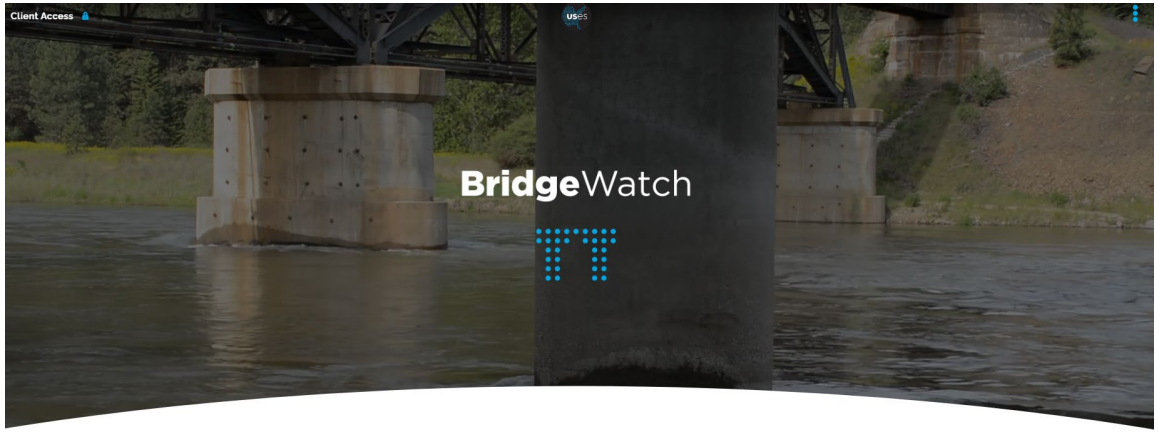


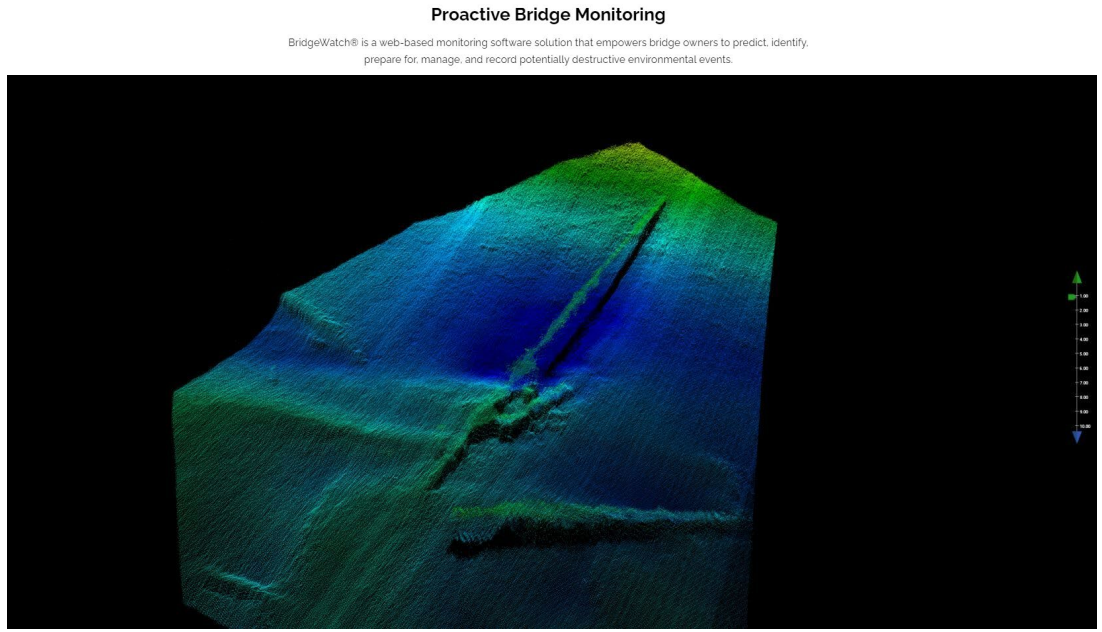
- **Number of Locations and Longevity:**
  - Most respondents would deploy technology at less than 100, with some less than 10.
  - One respondent desired 1,000s of locations.
  - Generally desired 8 to 10 years of functional life prior to replacement.
- **Economics:**
  - Generally desired modest cost outlays, comparable or less than current costs for landslide monitoring systems.
  - Some notion that costs should be cross-compared to other alternatives, such as mitigation or replacement of current practices.

# Literature Review



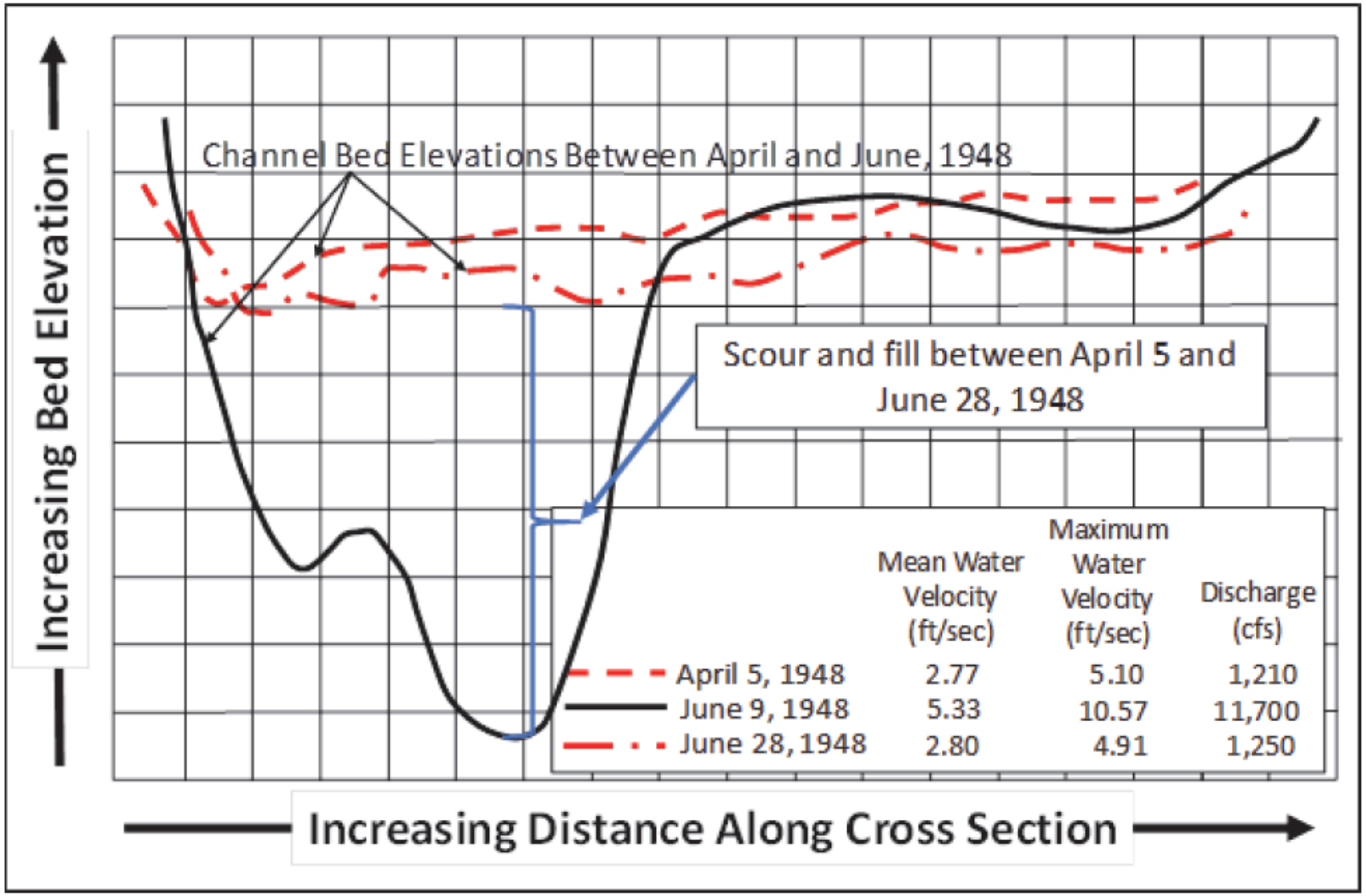
- **Summary of Findings:**
  - Most scour monitoring (pipelines and other industries) is based on predictive modeling and direct physical surveys
    - Predictive models are indirect method of evaluating scour based on data such as stream gauges, precipitation, etc.
    - Physical surveys measure channel elevation before and after floods
      - Generally will not measure total depth of scour



# Literature Review





# Literature Review

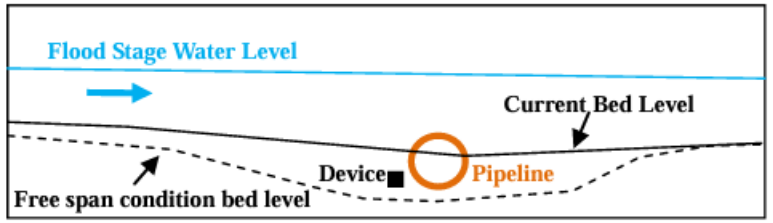


- Extensive research into methods to measure provide site-specific maximum scour and near real-time monitoring since at least 1990s for bridges
  - **Much more limited research for pipelines**
- No silver bullet solution for dams or pipelines
- For pipelines, research has focused on:
  - Float-out systems
  - Thermometry
  - Acoustic
  - Strain

# Float-Out Systems



- Subject of GHZ-02-01
- Also tested by Dewar et al. (2014) with fish tags for short-term application (months)
- Noted as being difficult to install in areas with flowing water (e.g., perennial streams)
- May be suitable for intermittent streams with high flow variability
- One source notes extensive use by Caltrans (California)
  - **Permitting concerns for burial in streambeds??**




Dewar et al. (2014)

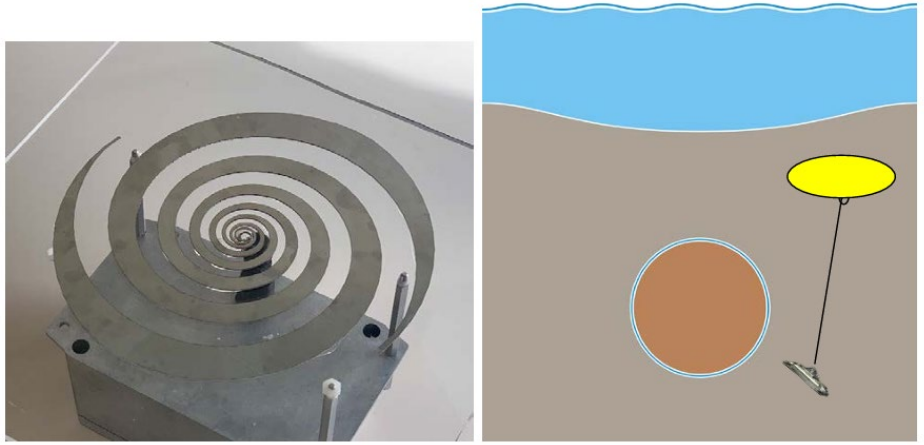


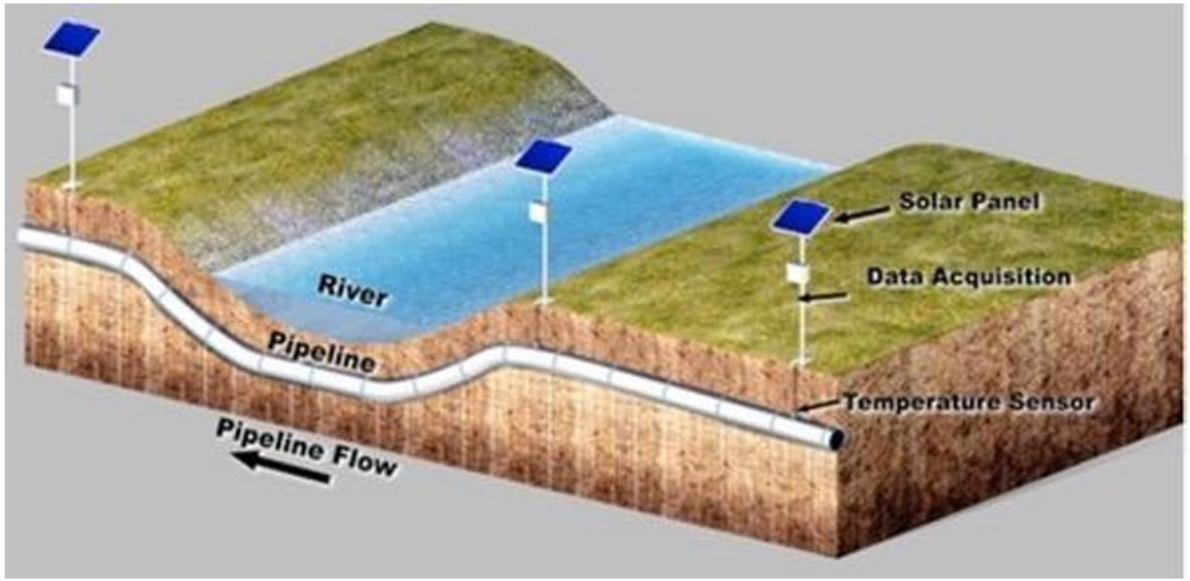
Figure 2: Final Prototype River Buoy with Spiral Antenna for Burying in Riverbed


From GHZ-02-01

# Thermometry Systems



- Work on the principle that heat dissipation occurs faster in water than in sediment
- Active and passive systems
  - **Active: Added heat, measure temperature dissipation**
  - **Passive: Measure temperature change**
- Developed for onshore and offshore applications
- Some testing for pipelines, with potential successful detection of exposed pipe during one test




From Ariaratnam and Lich, 2023; image credited to PureHM

# Acoustic/Strain Systems



- Mentioned in vendor literature (HiFi, Geomorphic Solutions)
- Work on principle of acoustical/strain changes being picked up by sensors or fiber optic cable
- Acoustic/strain profile changes as scour progresses
- May have picked up scour and exposure during flood event based on vendor literature

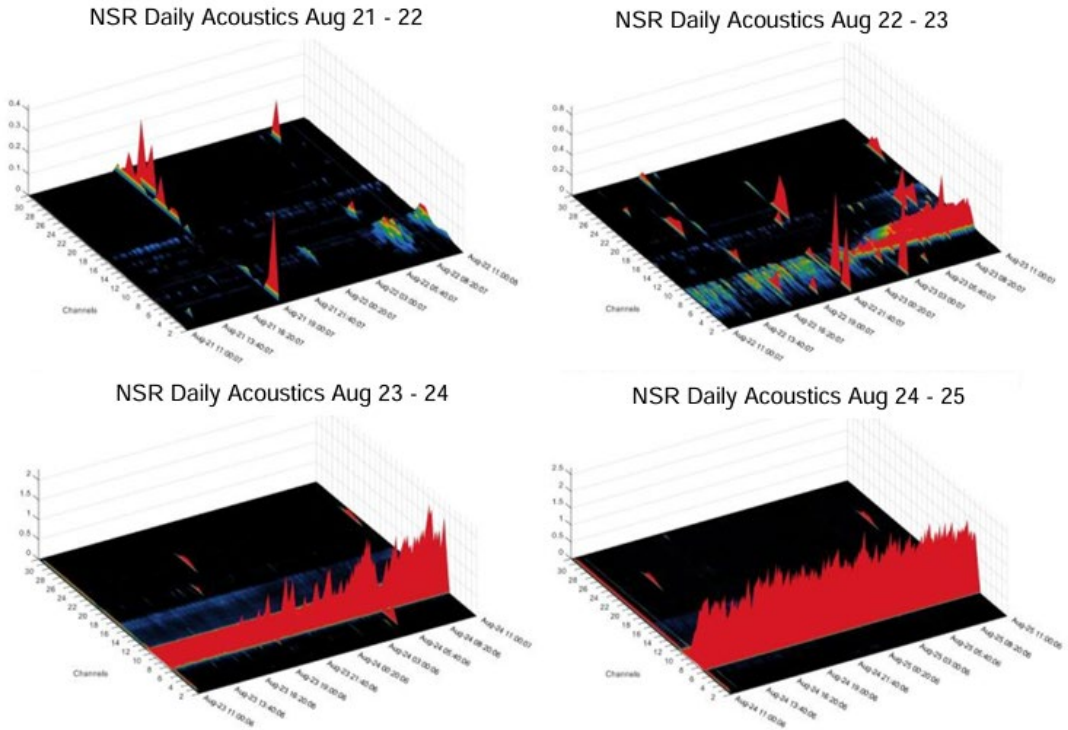



Image from HiFi Brochure

# Literature Review



- **Three main gaps identified based on literature review:**
  - ***Calibrating/validating scour equations in real-world conditions (vs. laboratory or controlled settings)***
    - How accurate are these equations?
    - How often do they overpredict scour? Underpredict?
  - ***Measuring scour during flood events***
    - How deep did the scour actually go?
    - How does this compare with what was predicted?
  - ***Identifying if pipeline exposed/suspended/impacted***
    - Is my pipeline being exposed during the flood?
    - Should I make operational changes?
    - Do I need to deploy response teams to the location?
    - Should I inspect the pipeline after the flood?

# Why Do These Gaps Exist?



- **Periods of maximum scour are destructive to in-water instruments and challenging to measure**
  - Many instruments work well in controlled/laboratory settings, but are destroyed or damaged during actual flooding or have difficulty in making accurate measurements
- **Cost of installation/maintenance (economics)**
- **Noisy/hard to interpret data**

# Next Steps



- **Selection of recommended technologies and vendors**
  - To be documented in next deliverable (November, 2024)
- **Identification of scope, performance metrics, permitting requirements, and schedule for field trials**
  - Anticipated delivery January, 2025
- **Final reporting and hand-off to field trial team**
  - May, 2025

# Value to Members/Knowledge Transfer



- **Target audience:** Teams responsible for pipeline integrity at watercourse crossings (e.g., geohazard management teams, integrity engineers, Operations)
- **Value:** Risk reduction, fewer false positives/false negatives of pipeline impact from flooding
- **Knowledge transfer recommendations:** Deliverables to be published by PRCI; ultimate results will depend on results of field testing
- **Questions/comments?**

# Thank you


**Alexander McKenzie-Johnson**

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# *Pipeline Research Council International*

## GHZ-03-03 Fitness-for-Service Framework to Address Circumferential Cracks Near Water Crossings

*Scope-of-Work Development*

**Ali Fathi** Ph.D., P.Eng.
*Engineering Specialist, PI Engineering (Enbridge)*

Fall 2024 TC Meeting
October 15, 2024

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# GHZ-03-03

**Status:** Critical Needs Attention On Plan

## Overview

| Activities Underway/Completed (since last report) | Overall Project Status/Significant Findings |
|---|---|
| • Scope of work development | • Project is in early phase |
| **Planned Activities (next period)** | **Current Issues, Risks and Decisions Needed** |
| • Selection of contractors and forward SOW to selected contractors & receive their feedback/quotes | • N/A |

## Status

| | Rationale/Explanation of Deviations between Plan and Forecast | |
|---|---|---|
| **Overall Schedule** | • On schedule | • N/A |
| **Active Task(s)** | • Complete review and finalizing SOW | • N/A |
| **Cost to Date** | • N/A | • N/A |
| **Threats/Scope Changes or Additions** | • N/A | |

# GHZ-03-03 – Overview



- Principal investigator: TBD
- PRCI Project Team Leader: Ali Fathi, Enbridge
- Total costs: $283,200
- Background: Fitness-for-service assessment of circumferential cracks requires assessment of loading conditions encountered at water crossings as well as pipeline resistance to crack growth and pressure containment loads expected at water crossings. Current assessment methods lack consensus on loading scenarios to be considered for circumferential cracks at or near water crossings. Models to predict fatigue capacity of girth welds were developed primarily for offshore pipelines. The validity of applying the offshore girth weld models to onshore pipelines is unknown.

# GHZ-03-03 – Overview (cont.)



- **Research Objectives/Project Deliverables:**

**This project will provide an updated framework to address circumferential cracks or potentially cracking anomalies at or near water crossings by leveraging and expanding the scope of assessment considered under NDE-4-24 and the River-X projects, and it will be used as a basis for updating the fitness-for-service assessment for circumferential cracks at water crossings in API 1176. This project will also provide the background information required for the future River-X software update.**

# Value to Members/Knowledge Transfer



- Target audience: pipeline operators, consultants and regulators
- Value: Ability to address the fitness-for-service of circumferential cracks using appropriate stress-based, strain-based or risk-based framework
- Knowledge transfer recommendations: Update fitness-for-service assessment for circumferential cracking at water crossings in API 1176
- Questions/comments?

Thank you

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# *Pipeline Research Council International*

GHZ-03-04

## New Multi-Year Project: Field-validation of remote and continuous scour monitoring, technology 1

*Project Scope Overview*

Dallas, TX
October 15th, 2024

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# Field-validation of remote and continuous scour monitoring, technology 1 - Overview

- **Principal investigator: TBD – RFP to be issued**
- **PRCI Project Team Leader: Tammy Moore**
- **Total costs: $1,284,400**
- **Research Objectives/Project Deliverables:**
- 1) identification of 4-5 water crossing sites or river research facility for deployment of technologies, the selection of sites should be geographical diverse with high potential for flood events over a two-to-three year monitoring period. Selection of sites may also include locations where technologies were already deployed by operators,
- 2) selection of vendors and technologies and coordination of field validation for performance evaluation which may also include permitting for temporary or permanent site-specific installations,
- 3) planning for alternate measurement techniques for technology validation, and approaches to validate quality of the measurements including bathymetry,
- 4) data collection and analysis, and
- 5) comparison of the technology performance and scour predictions set by the performance indicators

# 2024 Preparation Activities



- Completed technology workshop on April 2.  Well-attended, good technology brainstorming session
- Technologies tested will depend on group decisions stemming from the desktop study (GHZ-03-02)
- Looking for field sites – Let Tammy/John know if you are interested

*thank you*


Pipeline Research Council International