

# External Quarterly Report

**Date of Report:** 10<sup>th</sup> Quarterly Report – March 31, 2024

**Contract Number:** #693JK3211RA0001

**Prepared for:** PHMSA DOT

**Project Title:** Assessment of Nondestructive Examination (NDE) and Condition Monitoring Technologies for Defect Detection in Non-Metallic Pipe

**Prepared by:** EWI

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**For quarterly period ending:** March 31, 2024

## 1: Items Completed During this Quarterly Period:

The tenth quarterly update meeting was held virtually on March 20, 2024.

Activity during Q9 and Q10 was delayed in part due to (1) difficulties in working with the ACUT subcontracted vendor, (2) delays in receipt of additional expected pipe samples and (3) coordination of the pipe damage program with the full suite of expected pipe samples and the range of NDE methods – to include ACUT.

The final set of additional pipe samples were delivered to EWI in February 2024, so now all expected donated pipes are on-hand for NDE evaluation. These additional pipes provide two alternative pipe production methods and expand the type and size of pipes to be evaluated by NDE. In addition, due to the type of manufacturing and the materials used to produce these pipes, the program now has the opportunity to examine the viability for NDE inspection for a wide-ranging portfolio of non-metallic pipe (in terms of pipe materials, type of reinforcement, manufacturing methods, design service, and size of pipe). This expansion of the project pipe portfolio should also enhance the knowledge gained from the pipe damage task, which will evaluate the effectiveness of UT and thermography methods for detecting, characterizing, and sizing intentional damage to the inner and outer jackets and reinforcement layers.

The vendor that had been contracted to perform air coupled UT (ACUT) inspections, has not provided a report for the initial scans they performed in 2023. After several unsuccessful attempts to communicate and pursue completion of the contracted work, EWI decided in December 2023 to cancel the contract and assess other options. Two other North American ACUT vendors were approached, but one did not have the resource availability to complete the work within a reasonable timeline due to prior commitments, and the other was hesitant to undertake the work without extensive development effort up front. Therefore, EWI decided to acquire the necessary probes to enable the ACUT scans to be performed in house. The necessary hardware was ordered in January 2024 with receipt expected by spring 2024, allowing the ACUT scans to be completed with the existing planned project execution timeline. In addition, this will improve efficiency and timing for including ACUT scans as part of the pipe damage task to be completed at EWI in the spring 2024.

Item #	Task #	Activity/Deliverable	Title	Federal Cost	Cost Share
21	10	Submit 10 <sup>th</sup> Quarterly Report	10 <sup>th</sup> Quarterly Status Report	\$10,000	\$0.00

## **2: Items Not Completed During this Quarterly Period:**

Due to the delays in receiving additional pipe samples in Q9 and early Q10, the planned NDE trials under Task 4 and the follow-on Task 5 for NDE statistical analyses have not been completed. The expected pipe samples arrived by mid-February 2024, allowing initial inspections to establish baseline condition are underway. In addition, completion of the initial ACUT scans that began in May 2023 have been delayed due to non-response from the vendor. EWI decided to cancel the contract with this vendor by late 2023 following numerous unsuccessful attempts to re-establish communication with the vendor. EWI has subsequently ordered the necessary hardware to permit these inspections to be completed in-house. Receipt and commissioning of the ACUT equipment is expected by spring 2024.

Completion of the intentional pipe damage matrix was planned for Q9 but has been put on hold to allow the expected new pipe samples to be part of this sample set. Pipe damage trials will begin June 2024. This will then allow completion of a comprehensive statistical assessment of NDE detection and characterization analyses under Task 5 covering manufacturing anomalies, minor in-service wear and tear and more substantial simulated field damage features. These inspections will include ACUT scans performed by EWI.

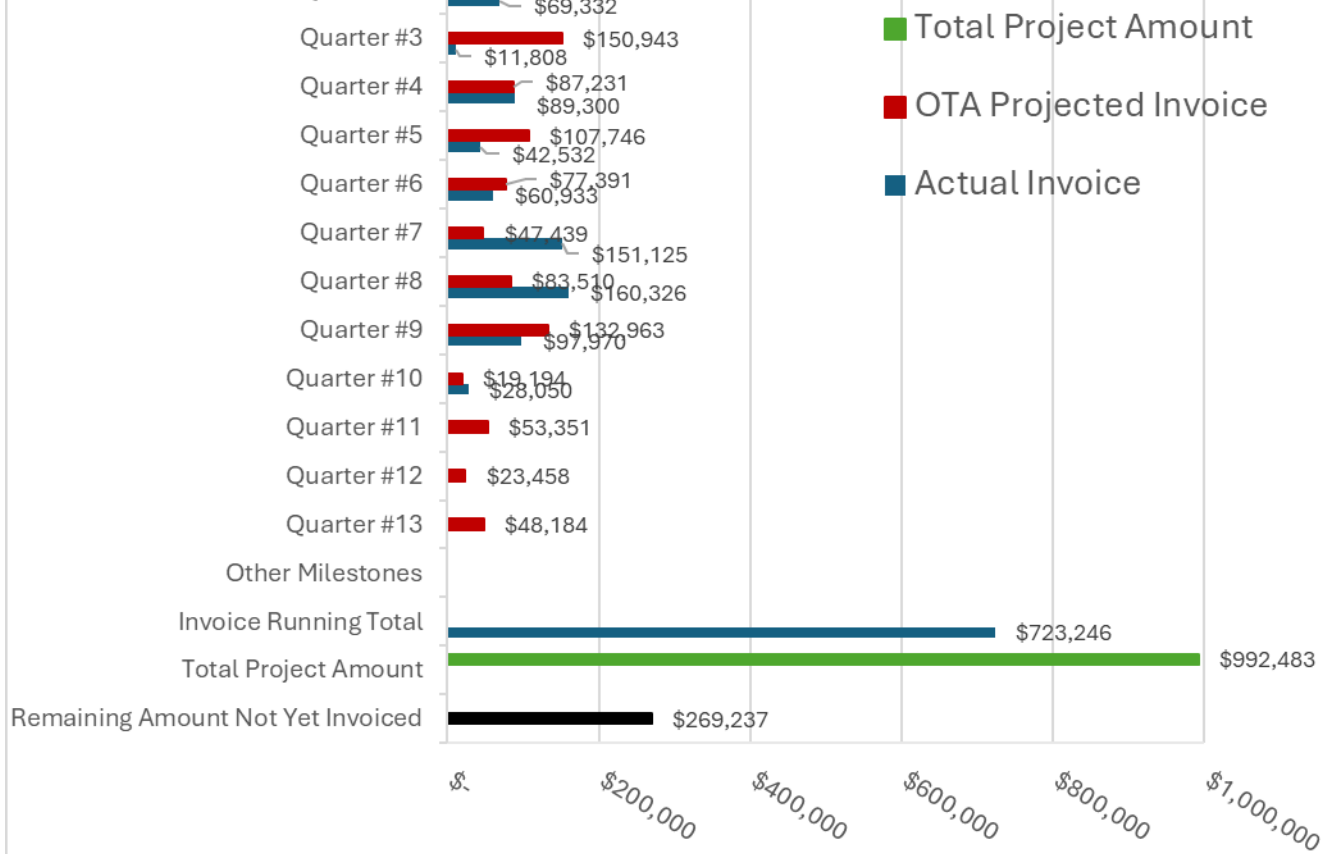
## **3: Project Financial Tracking During this Quarterly Period:**

The actual spend is behind planned.

- EWI received a modification in June 2023 and Another modification in March 2024 to allow additional testing of new pipe material. EWI has shifted the milestone table out due to these modifications and the arrival of pipes in late 2023 and early 2024. Extending the NDE tasks significantly from the initial spend plan. EWI has accounted for these delays in the updated contractual document. The two NDE deliverables 14-3 was completed and 16-5 has been drafted but is awaiting additional inputs from the mechanical damage testing scheduled for May and June. With this in mind EWI did not push out those milestones. Due to contractual modifications pushing out the NDE deadlines the projected invoices for quarters 7 onward were updated.

## Quarterly Payable Milestones/Invoices -

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#### 4: Project Technical Status –

Item	Task	Activity/Deliverable	Title
1	1	Task report summarizing findings of literature review	Literature review of recent research on NDE of polymers & composites - issue task report
2	2	NMP sample matrix detailing type of pipe and defects, anomalies, or damage per sample	Prepare detailed matrix of NMP samples
3	10	Submit 1st quarterly report	1st Quarterly Status Report & Quarterly collaboration meeting
4	3	Develop NDE procedures for inspection of NMP samples using non-contact and 3 coupled UT methods, microwave inspection method and 2 thermography methods	Completion of written NDE procedures
5	10	Submit 2 <sup>nd</sup> Quarterly Report	2 <sup>nd</sup> Quarterly Status Report & Quarterly collaboration meeting
6	6	Task 6 Test Procedures and Chamber Assembly	Prepare & Provide a Written Test Procedure for Erosion Tests
7	4	NDE Review Progress to date (samples, procedures, early inspection data)	Task 4 NDE Project Review
8	10	Submit 3 <sup>rd</sup> quarterly report	3 <sup>rd</sup> Quarterly Status Report & Quarterly collaboration meeting
9	10	4 <sup>th</sup> Quarterly Status Report	4 <sup>th</sup> Quarterly Status Report & Quarterly collaboration meeting
11	6	Perform inner linear erosion tests & assess NDE detection	Task report summarizing erosion test procedure and results, and NDE inspection results
12	10	5 <sup>th</sup> Quarterly Status Report	5 <sup>th</sup> Quarterly Status Report & Quarterly collaboration meeting
13	4	Comprehensive NDE trials on NMP samples and provide report summarizing procedures and initial outcomes	Task report summarizing NDE methods, procedures and initial outcomes.
14	4	Task 4 NDE Project Review	Review Progress to review NDE inspection data, outcome, and Trends – completed June 2023, reuploaded 2024
15	10	6 <sup>th</sup> Quarterly Status Report	6 <sup>th</sup> Quarterly Status Report & Quarterly collaboration meeting
16	5	Complete NDE validation and assessment. Provide task report document NDE results - POD and sizing performance.	Task report summarizing NDE outcomes and discussing viability of various NDE methods.
17	10	Submit 7 <sup>th</sup> Quarterly Report	7 <sup>th</sup> Quarterly Status Report & Quarterly collaboration meeting
18	12	NDE Report Update	Additional NDE effort predamage
19	12	Mechanical Damage Summary	Mechanical Damage Added scope
21	10	Submit 8 <sup>th</sup> Quarterly Report	8 <sup>th</sup> Quarterly Status Report & Quarterly collaboration meeting
22	13	Corrosion Damage summary Table	Corrosion Damage Added Scope

24	10	Submit 9 <sup>th</sup> Quarterly Report	9 <sup>th</sup> Quarterly Status Report & Quarterly collaboration meeting
27	10	Submit 10 <sup>th</sup> Quarterly Report	10 <sup>th</sup> Quarterly Status Report & Quarterly collaboration meeting

**Task 1** – Literature Review was completed by EWI and NDE4zero’s Mark Lozev. The report was supplied to the project team on 3/31/2022.

**Task 2** – NMP Sample Matrix. EWI received additional pipes from two new project team members in December and in mid-February. The Pipe Matrix spreadsheet was updated 3/6/2024.

**Task 3** – A revised internal NDE procedures report was prepared in February 2024 to update the original procedures with advancements that have been identified during this program. A revised compendium of NDE procedures has been provided.

**Task 4** – CT scanning was completed in mid-June on pipe samples that had been received by the project at that time. New pipe samples were received late summer 2022 and CT scanning was completed in December 2022. EWI NDE has begun testing selected pipe samples from this batch of material. The NDE testing, and analysis is underway, data and images were shared at the Q4 meeting on 9/21/22 and Q5 meeting on 12/16/2022. Testing will continue for several months with EWI completing multiple forms of NDE.

Initial air coupled UT (ACUT) scans were completed by Airstar in March-April 2023. Methods for ACUT sensor calibration, determination of sensor offset distances and scanning direction have been identified. Early observations suggest good sensitivity for detecting minor manufacturing anomalies and for dealing with typical pipe eccentricity and dimensional variances (wall thickness variability, air gaps in unbonded pipes, etc.). Unfortunately, data analysis and reporting by Airstar has not been completed and attempts to maintain communication with them have failed. EWI has subsequently decided to remove Airstar as a project subcontractor and has procured the necessary equipment to complete the ACUT scans internally. The ACUT scans at EWI will begin April or May 2024

All NDE work at EWI has been done without internal pressure. This can reduce sensitivity due to natural air gaps that can occur between the inner liner, reinforcement, and outer jacket in unbonded pipe when unpressurized. Options are being examined to produce sufficient internal pressure to compress any gaps in unbonded pipe. Once internal pressure can be applied, UT and thermography scans will be repeated on selected pipes to assess improvements in feature detection capability for unbonded pipe.

Refinements in the thermography method have been made by implementing larger and higher wattage light sources, evaluating frequency of image scans, and assessing through-wall sensitivity using tapes, foils and small artifacts (zip ties, etc.) on the ID surface. Overall, sensitivity is improving and ability to sense through-wall from the OD has been demonstrated. Features of the reinforcement layer are now detectable in several test pipes. The enhanced thermography procedures will be used on the new pipe samples to be received by EWI from the two additional pipe manufacturers that have joined the program over the past 8 to 10 months.

EWI’s initial plan for inducing mechanical and corrosion damage in selected pipe samples has begun now that the change request/project extension has been approved (June 5, 2023). Now that the remaining pipe samples have been received by EWI and the plans for completing ACUT finalized, the

pipe damage test plan will be carried out in April – May 2024 with several NDE inspections to be completed for pre- and post-damage conditions.

An NDE progress report (13-4) has been issued along with an updated procedural document to provide documentation about the various NDE methods used in this program, present initial results and observations, and discuss factors that either aid or inhibit feature or flaw detection, sizing and characterization for the types of NMP included in this program. A final NDE report will be provided following completion of the pipe damage task in Q12.

In Quarter 8 EWI completed microwave NDE testing with Evisive LLC using 24GHz probes. Non-metallic pipes were fully volumetrically inspectable using Microwave NDE. Four pipes were scanned from the outside while mounted on a rotating lathe-type unit with probes mounted to a linear stage for testing. Full inspection results will be presented in an NDE report/presentation. EWI is currently reviewing the microwave scan data in details and plans to present details at the next quarterly review meeting.

**Task 6** – The entire erosion task has been completed. The cost share portion of this task was completed 5/31/ 2022 (Item #6 Task 6): erosion test cells have been built and a test method developed. The task began in December 2021 and was completed in June 2022. The federally funded portion of this work began in August 2022. Erosion testing and analysis on a total of nine pipes from three manufacturers has been completed and NDE inspections were completed in September 2023 which completes the federally funded portion of this task. To provide a realistic configuration where the flow path of the sand is in the same direction as pipe scratches and defects, EWI completed a test where a pipe was abraded internally circumferentially in line with the flow path of the sand. Post test analysis of the change in surface scratches was performed to approximate the amount of erosion that was induced by the impeller and sand throughout the test.

The goal of this testing is to create a laboratory scale representative test to be able to quantify internal pipe erosion and erosion rate. This data will be able to be used to create a lifetime use prediction model for the NMP.

A final task report was issued in October 2023.

**Task 10** – The 1<sup>st</sup> quarterly status report was provided on 1/4/22. The 2<sup>nd</sup> quarterly status report was provided on 3/31/2022. The 3<sup>rd</sup> quarterly status report was provided on 6/30/2022. The 4<sup>th</sup> quarterly status report was provided on 9/30/2022. The fourth quarterly collaborative meeting occurred on 9/21/2022. The Fifth quarterly meeting was hosted on 12/16/22 with its quarterly report submitted on 1/4/2022. TAP attended two meetings 7/13/2022 and 11/29/2022, TAP was invited to the quarterly meeting on 12/16/2022 and these meetings will be combined going forward. The 6<sup>th</sup> quarterly meeting occurred 3/30/2023. The 7<sup>th</sup> quarterly report was completed on 6/29/2023. The 8<sup>th</sup> quarterly meeting is scheduled for 10/6/2023. The most recent quarterly report on 9/30/2023 was the 8<sup>th</sup> quarterly report.

The quarterly meeting planned for December 2023 was eliminated based on feedback from PHMAS and the delayed pipe samples to conserve funds for 2024

**Task 13** – Non-destructive evaluation of corrosion of a steel reinforced non-metallic pipe was performed intermittently over a period of 41 days. Corrosion was targeted in two locations of the pipe: a small hole on the outer jacket and a small hole on the inner jacket exposing the steel wire. Prior to corrosion, a full 360-degree inspection was performed on the outside of the pipe and a 120-degree inspection was performed on the inside of the pipe. At the end of the corrosion study with ultrasonic

inspection an infrared video was recorded for 40 seconds or more to capture the heat transfer through the pipe and the steel wires.

Results were presented at the October 5, 2023, quarterly review meeting. During this meeting, a preliminary plan was proposed by EWI to expand on this effort to more fully quantify NDE detection thresholds for locating embedded corrosion damage, but project team members felt this was not needed at this stage. Future trials may be warranted but team members suggested the project focus remain as is to assess manufacturing anomalies and mechanically induced service damage.

**5: Project Schedule** – The project schedule has been updated to incorporate the modification requested in March 2023 and awarded in June 2023 as well as the project modification in March 2024.

Below is the original Project Schedule:

Task	Description	Quarter											
		1	2	3	4	5	6	7	8	9	10	11	12
1	Literature Review & Report	X	X										
2	Selection, Procurement & Preparation of Pipe Samples	X	X	X	X	X							
3	Draft NDE Procedures		X	X	X	X							
4	NDE Trials			X	X	X	X						
5	NDE Validation & Assessment					X	X	X					
6	Characterization of Erosion Properties and Detectability		X	X	X	X	X	X	X				
7	Development of NDE Procedures and Best Practice Guide									X	X		
8	Establish Field Inspection Requirements									X			
9	Virtual Workshop								X	X			
10	Progress Meetings (virtual and in-person)			X			X		X				
	Annual Review				X				X				
	Quarterly Progress Reports	X	X	X	X	X	X	X	X	X	X		
	Final Report									X	X		
11	NDE Subcontractors and GTI travel							X		X			
12	NDE and Mechanical Damage								X				
13	NDE and Corrosion Damage									X			
PM	Program Management	X	X	X	X	X	X	X	X	X	X		

Per the contract modification we will be using the following table going forward:

[illegible]