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Carbon Fiber Reinforced Polymer (CFRP) Rehabilitation

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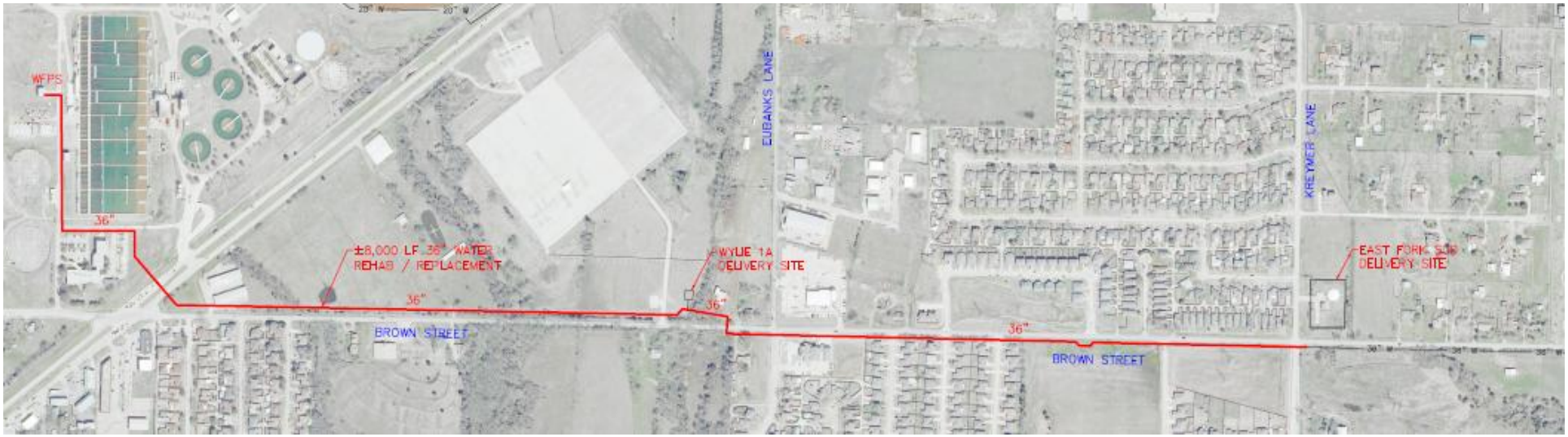
Kimley»Horn

Summary

- Project and Client Background
- CFRP Overview
- Design Challenges
- Lessons Learned/Takeaways
- Questions

Wylie-Rockwall-Farmersville 36” Pipeline Improvements, Phase 1



Owner - North Texas Municipal Water District

- Serve more than 1.6 million people in North Dallas area
- Provide water, wastewater, and solid waste service

Project Objectives

- Replace/Rehabilitate ~8,000 LF of 36” Water Line (WTP to East Fork SUD)
- Increase Pressure Rating (100 to 150 PSI)
- Minimize Disruption (Developed Corridor, Begins in WTP)

Trenchless Methods Evaluated

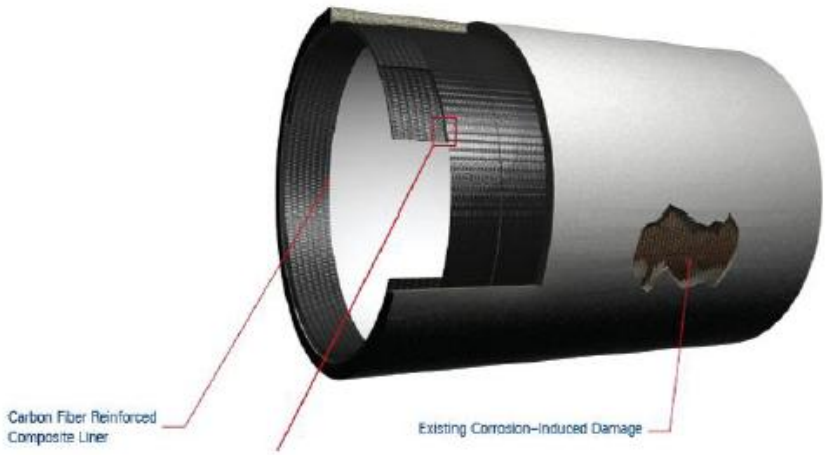
- Sliplining
- Swagelining
- CFRP
- Hybrid Fiberglass Reinforced Polymer System
- Spray-On Polymer Lining
- Cured in Place Pipe
- Pipe Bursting
- Tunneling/ Boring

Project Summary

- 5,300 LF of Open Cut
- 1,500 LF of Tunnel/Bore
- 910 LF of CFRP (3 segments)
- $6.9 Million Construction Cost
- 240 days for Substantial Completion

CFRP Overview

- Trenchless Pipe Rehabilitation
  - Small Project Footprint (20'x20')
- Utilizes Carbon Fiber Reinforced Polymer Composite
  - Applied longitudinally and circumferentially for hoop and tensile strength.
  - Number of Layers Determined by Strength Requirements
- Minimal Loss in Inside Diameter
- Creates a New Structural (Stand Alone) Pipe within Carrier Pipe
- Can be Utilized in Straight Section and Bends



CFRP Overview (Continued)

- Turnkey Operation
- Two Major Competitors
  - CFRP Manufacturer
    - Fyfe North America
    - Structural Technologies
  - CFRP Applicator
    - Fibrwrap Construction
    - Structural Preservation Systems
- Third Party Pipe Design
  - Simpson Gumpertz & Heger

structural

FIBRWRAP®
an AEGION company

CFRP Overview (Continued)

- Primary Design Considerations
  - Pressure Requirements (Working, Surge, Vacuum)
  - Design Type (Fully or Partially Structural)
  - Watertightness
- Critical Application Items
  - Surface Preparation
    - Hydro or Abrasive Blast, Concrete Surface Profile Level 3
  - Fabric Saturation
  - Dehumidification/Temperature Control
- QA/QC Measures
  - ASTM D4541 Adhesion Test
  - ASTM D3039 Tensile Coupon Tests

Design Challenges

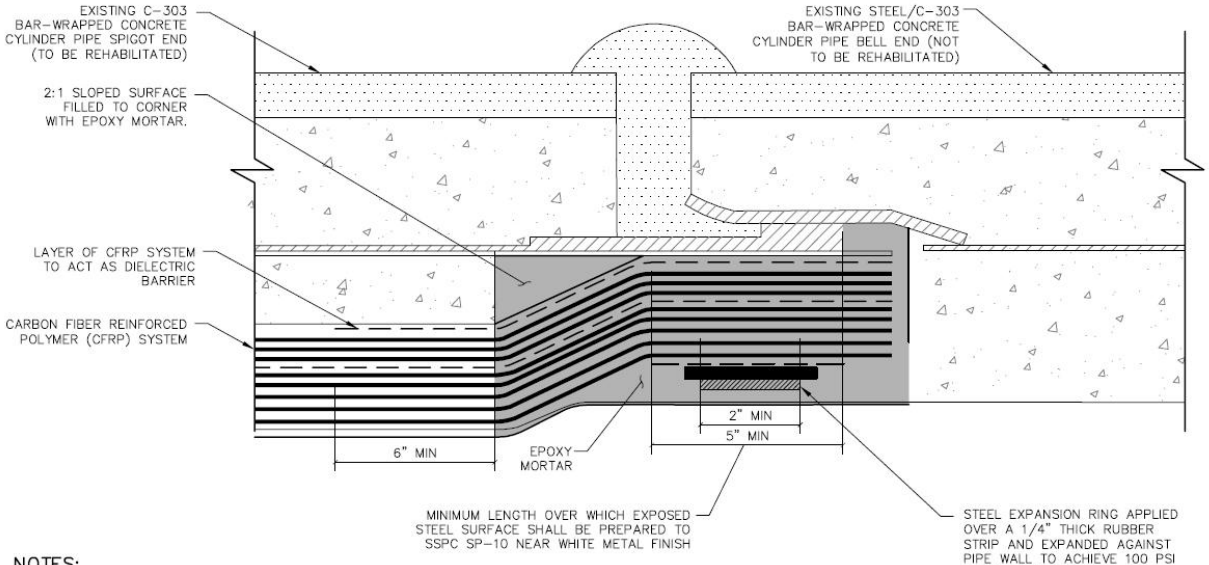
- Access
- CFRP Termination
- Design/Construction Coordination
- Sequencing
- Bidding
- Testing

Design Challenges – Access

- How to Provide Access?
  - ARV's, BOV's, Access Manhole
  - Cut the Existing Pipe and Provide Full Pipe Access
  - 1 or 2 Points of Access?
    - Confined Space Restrictions
    - Ventilation Requirements
    - Rehab Length

Design Challenges – CFRP Termination

- Recommended to Terminate at a Joint
  - Accuracy of Record Drawings
  - Cost Associated with Missing Joint Location
- Standard Termination Details



Design Challenges – Coordinating Design/Construction Responsibility

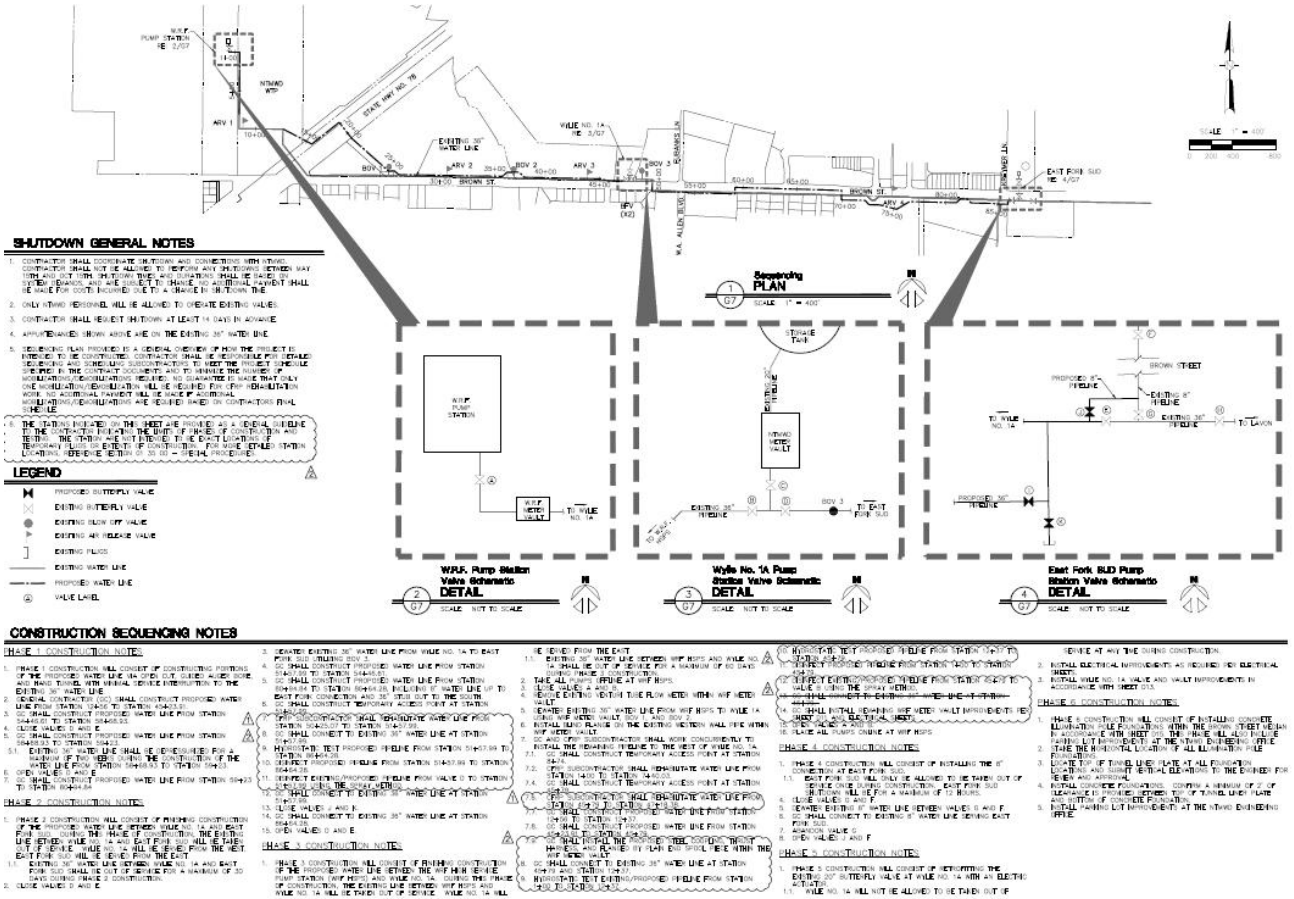
- Five Major Parties
  - Owner (NTMWD)
  - Engineer (Kimley-Horn)
  - General Contractor
  - CFRP Manufacturer/Installer (FibrWrap/Structural)
  - CFRP Design Engineer (SGH)
- Limit Construction Responsibility of CFRP Installer

Design Challenges – Coordinating Design/Construction Responsibility

- CFRP Manufacturer/Installer Responsibility
  - Materials
  - Cleaning, Drying, Dehumidification
  - Installation
  - Final Cleaning
- GC Responsibility
  - Staging Area
  - Pipe Access
  - Site Restoration
  - Fuel, Air Compressors, Generator, Etc.
- SGH Responsibility
  - Design CFRP System
  - Inspection, Testing, and Reporting

Design Challenges – Sequencing

- Tight Construction Schedule
  - 9/15 - 5/16
- Minimize Mobilizations
- Open Cut and CFRP Constructed Concurrently
- Maintain service to Delivery Sites

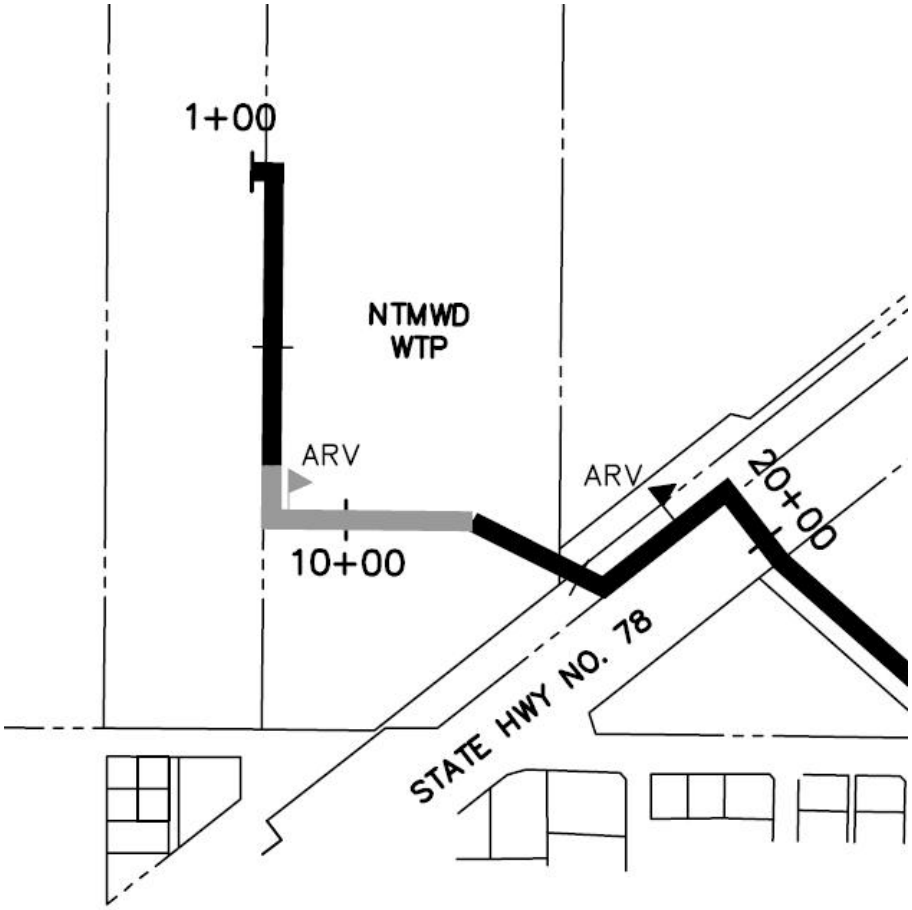


Design Challenges – Bidding

- Significant Budgetary Cost Differences
- Bidding Apples to Apples
  - All Design to be Prepared by SGH
  - Need to Provide Adequate Bid Duration to Prepare Preliminary Design
- CFRP Line Items
  - CFRP Mobilization (LS)
  - CFRP Rehab (LF)
  - Additional CFRP Rehab (LF)
  - SGH CFRP Design Allowance (LS)
  - SGH CFRP Inspection, Testing, and Reporting Allowance (LS)
  - Full Pipe Access Point (EA)
  - CFRP Construction Assistance (LS)

Design Challenges – Testing

- Hydrostatic Testing
  - No Industry Standard
  - Accounting for Existing Piping to Remain
- Disinfection
  - Spray Method vs Continuous Feed/Slug
- Testing Open Cut Separate from CFRP
  - Avoid Finger Pointing if Testing Fails



Lessons Learned

- GC's are not familiar with CFRP
- Shop Drawing Coordination
  - CFRP and proposed pipe submittals are correlated
  - Pothole requirements to locate joints
- Scheduling
  - Require mandatory scheduling meeting at start of construction

Questions?

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