CENTRAL UTAH WATER

Corrosion Case Studies in the Water Industry

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Bonneville Unit Operations and Maintenance Engineer

SIEO - January 2023

Background

- MSE in Civil Engineer
- AMPP CP 2
- ~5 Years – Questar Pipeline – Natural Gas
  - Compliance
  - Corrosion
- ~4 Year – CUWCD
  - Water Management
  - Hydro Power
  - Corrosion Control

Presentation Outline

- Central Utah Water Conservancy District
- Natural Gas vs Water
- Corrosion Case Studies & Lessons Learned
  - Coating
  - Condition Assessment
  - Galvanic Corrosion
  - Electrical Shorting

"With 62% of our growing state living in Central Utah Water's boundaries we are dedicated to planning for the future by developing, delivering and efficiently using our limited water resources. Thank you for your trust."

— GENE SHAWCROFT, GENERAL MANAGER

Managing **$3.5 billion** in infrastructure

Treating more than **100 million** gallons per day

Serving **1.5 million** people every day

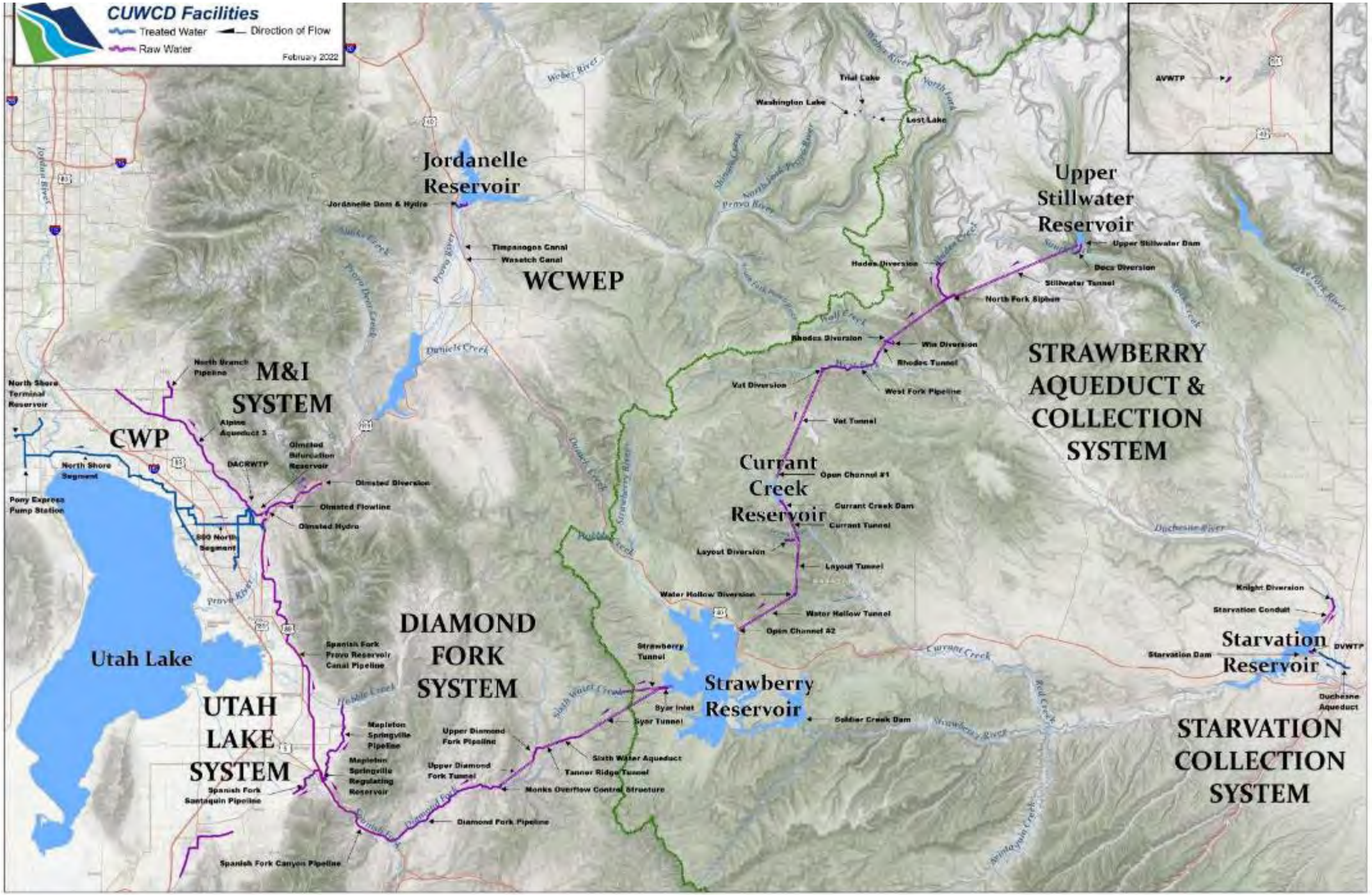
Maintaining **178 miles** of canals, tunnels and pipelines

Delivering more than **400,000 acre-feet** annually

Storing **565 billion gallons** in reservoirs

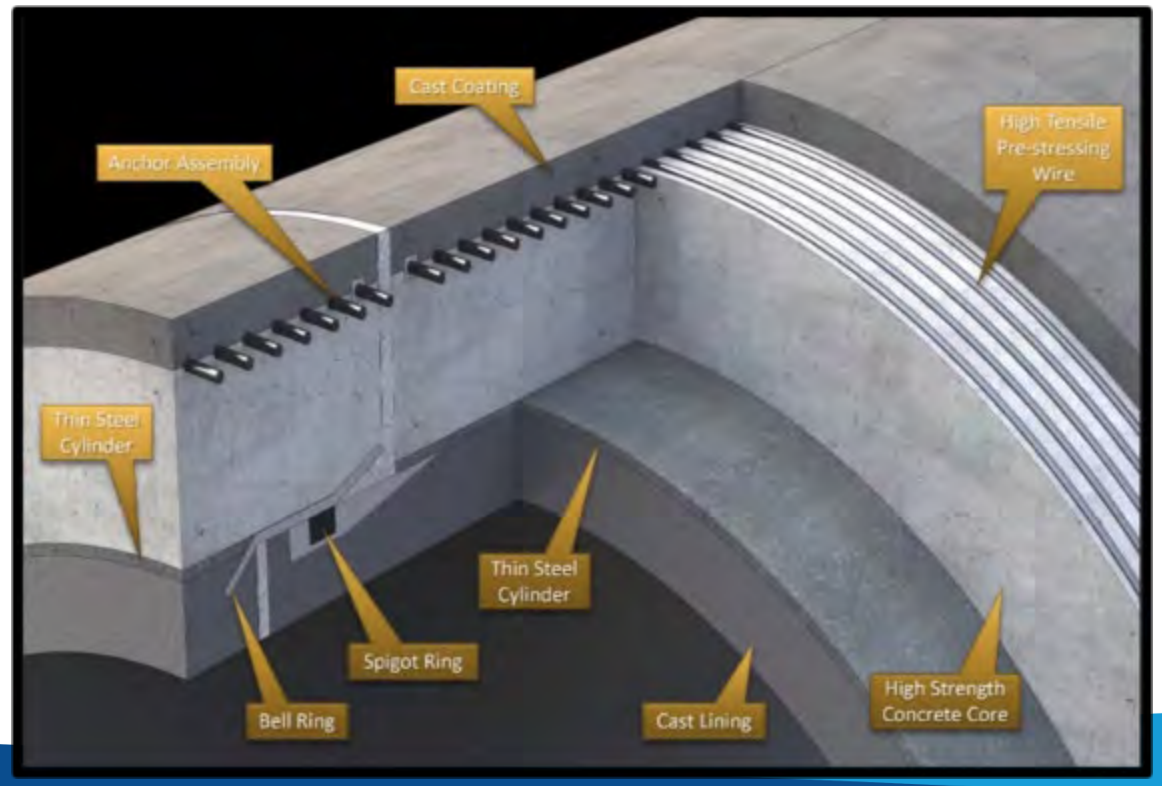
Central Utah Water Operates and Maintains

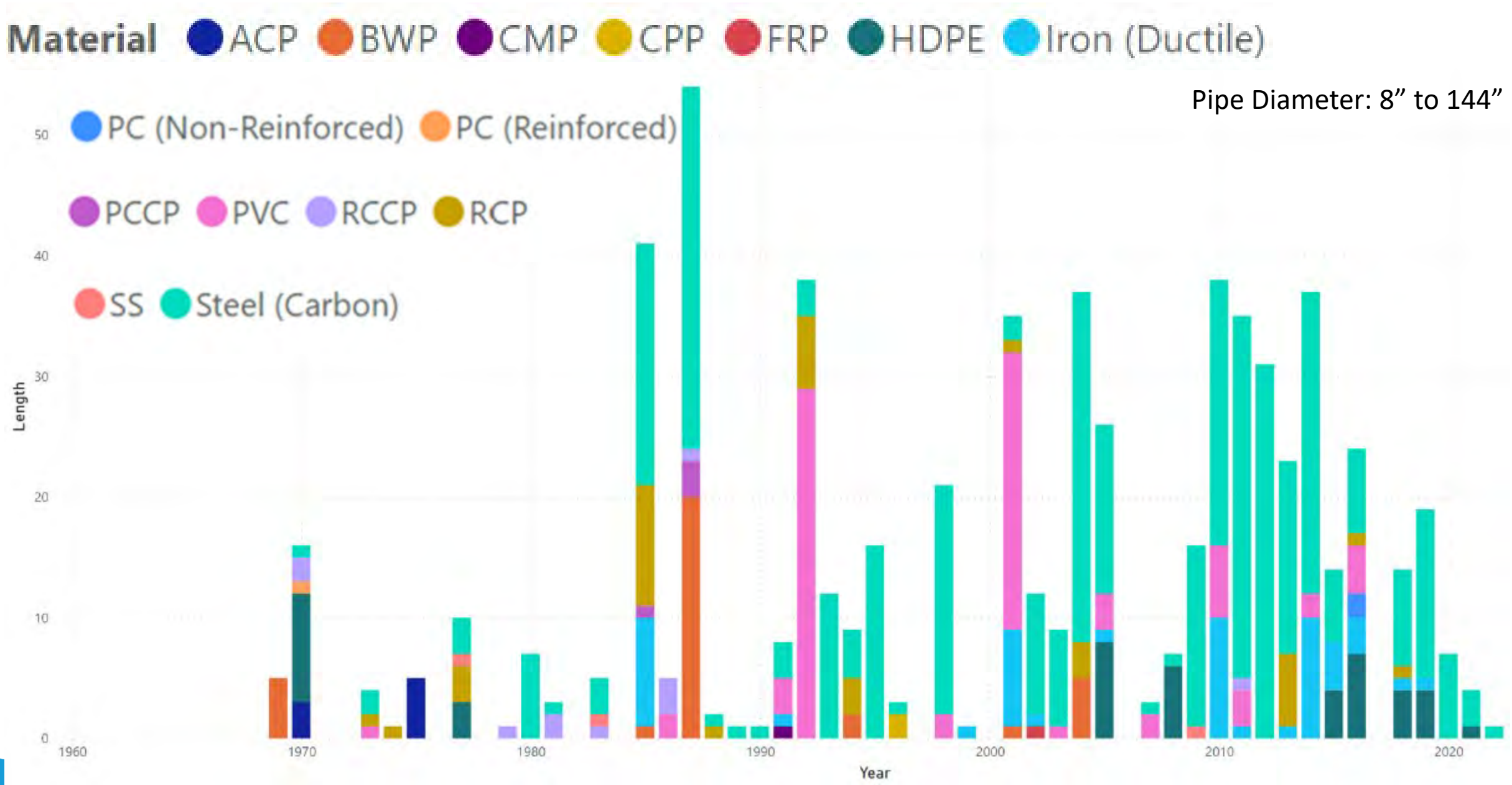
- 9 dams and reservoirs – 1.6 million A-F of storage
- 3 major and 6 minor diversion dams
- 3 water treatment plants
- 2 hydroelectric power plants: 13 MW and 11.7 MW
- 16 Impressed Current System
- ~75 miles Protected by Galvanic Anodes


CUWCD Facilities
Treated Water
Raw Water
Direction of Flow
February 2022
AVWTP
Jordanelle Reservoir
Jordanelle Dam & Hydro
Timpanogos Canal
Wasatch Canal
WCWEP
Trial Lake
Washington Lake
Lost Lake
Upper Stillwater Reservoir
Upper Stillwater Dam
Hades Diversion
Docs Diversion
Stillwater Tunnel
North Fork Siphon
Rhodes Diversion
Win Diversion
Rhodes Tunnel
Vat Diversion
West Fork Pipeline
Vat Tunnel
STRAWBERRY AQUEDUCT & COLLECTION SYSTEM
M&I SYSTEM
CWP
North Branch Pipeline
North Shore Terminal Reservoir
Alpine Aqueduct 3
Olmsted Bifurcation Reservoir
DACRWTP
North Shore Segment
Olmsted Diversion
Olmsted Flowline
Olmsted Hydro
Pony Express Pump Station
800 North Segment
Currant Creek Reservoir
Open Channel #1
Currant Creek Dam
Currant Tunnel
Layout Diversion
Layout Tunnel
Water Hollow Diversion
Water Hollow Tunnel
Open Channel #2
Utah Lake
DIAMOND FORK SYSTEM
Spanish Fork Provo Reservoir Canal Pipeline
Strawberry Tunnel
Strawberry Reservoir
Syar Inlet
Syar Tunnel
Soldier Creek Dam
Knight Diversion
Starvation Conduit
Starvation Reservoir
Starvation Dam
DVWTP
Duchesne Aqueduct
STARVATION COLLECTION SYSTEM
UTAH LAKE SYSTEM
Mapleton Springville Pipeline
Mapleton Springville Regulating Reservoir
Spanish Fork Santaquin Pipeline
Upper Diamond Fork Pipeline
Upper Diamond Fork Tunnel
Sixth Water Aqueduct
Tanner Ridge Tunnel
Monks Overflow Control Structure
Diamond Fork Pipeline
Spanish Fork Canyon Pipeline

Corrosion Control Differences

- Federal Partners & Regulations
- Pipe Materials
  - Concrete Pipe
  - Gasketed Joint
- Pipe Sizes
- Concrete Coating/Lining
  - Monitored Corrosion
- Staffing & Resource

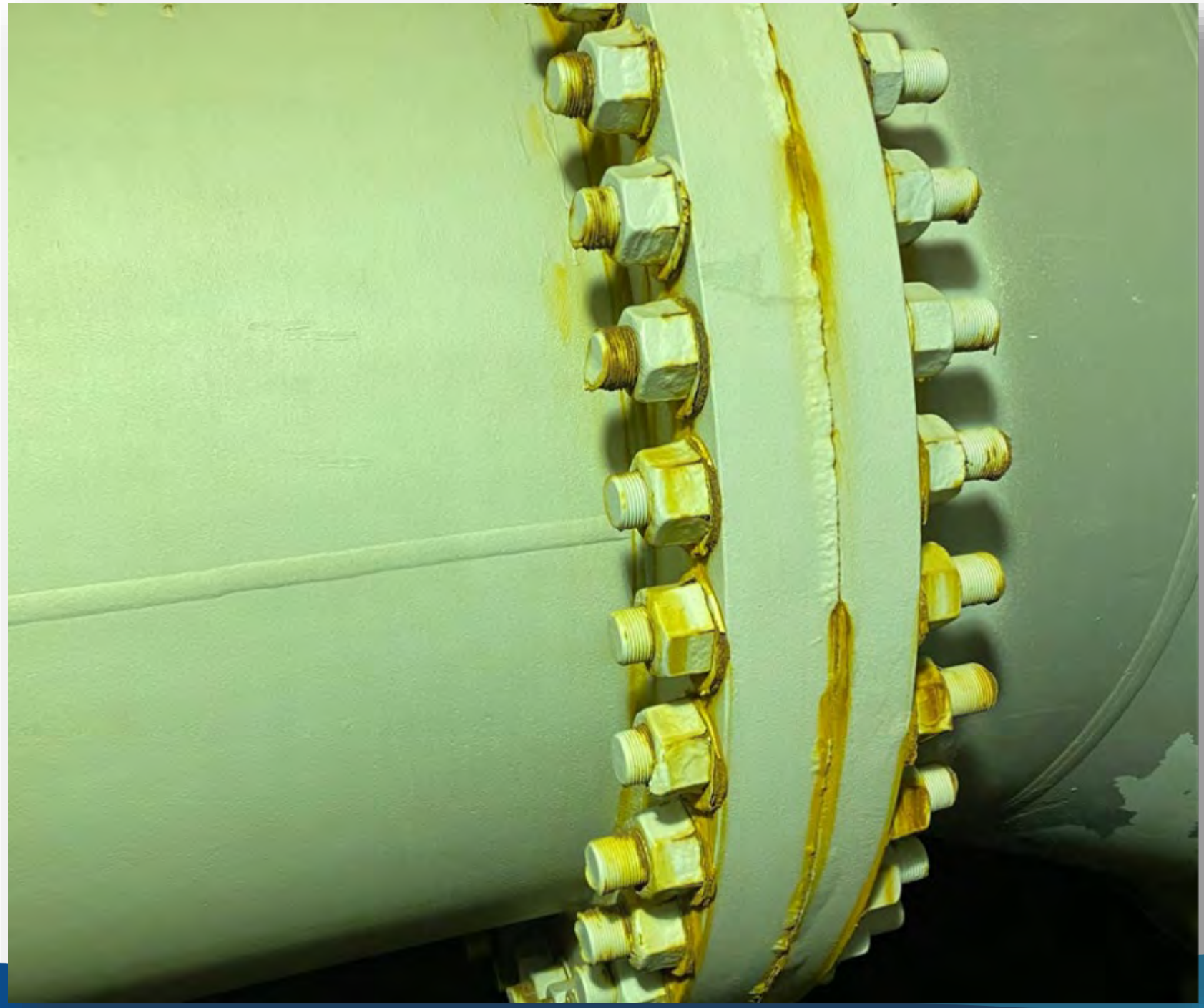




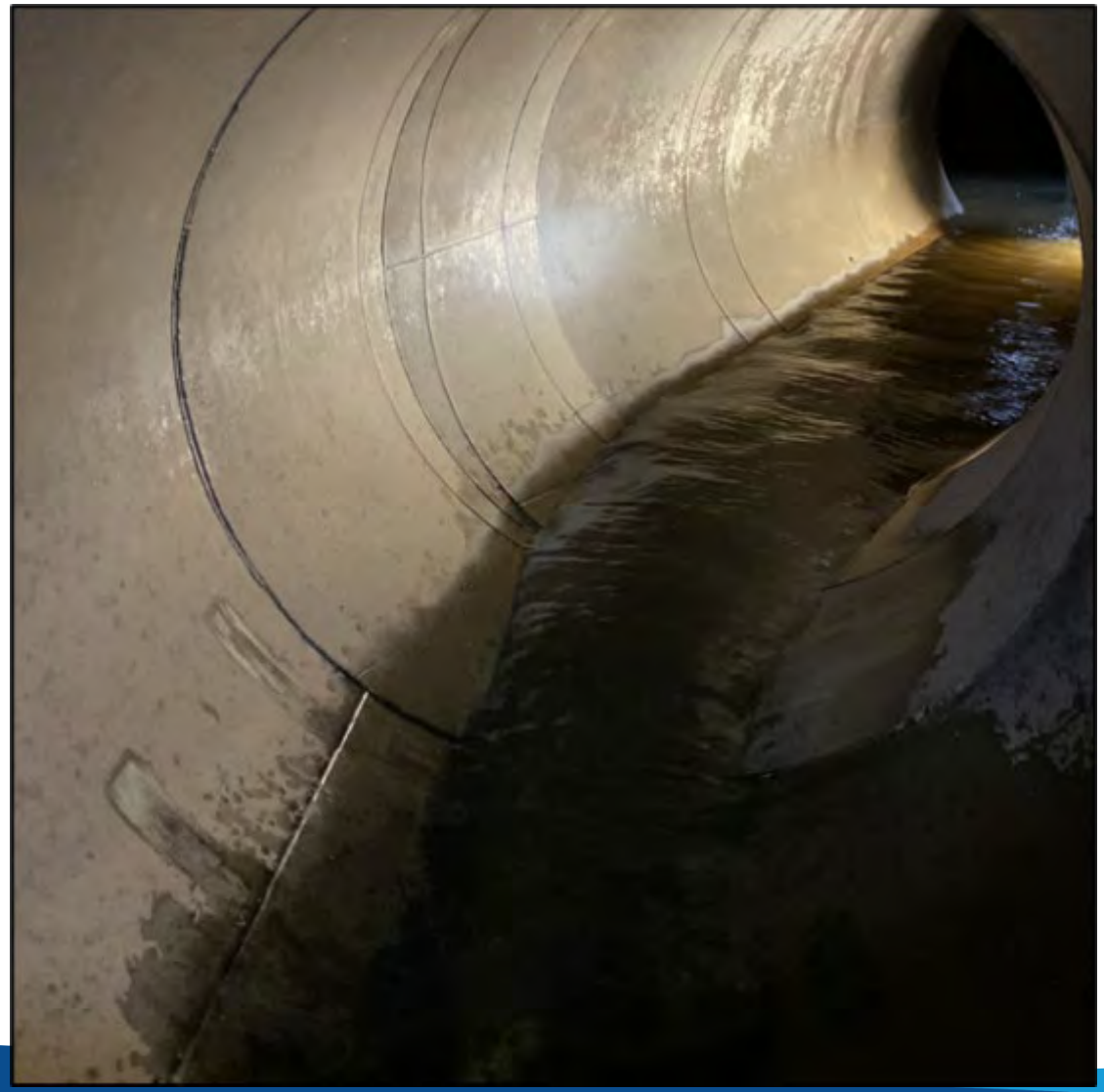
Pipe Diameter: 8” to 144”

Corrosion Case Studies & Lessons Learned

Coatings



Dam Outlet Works – Coating Replacement

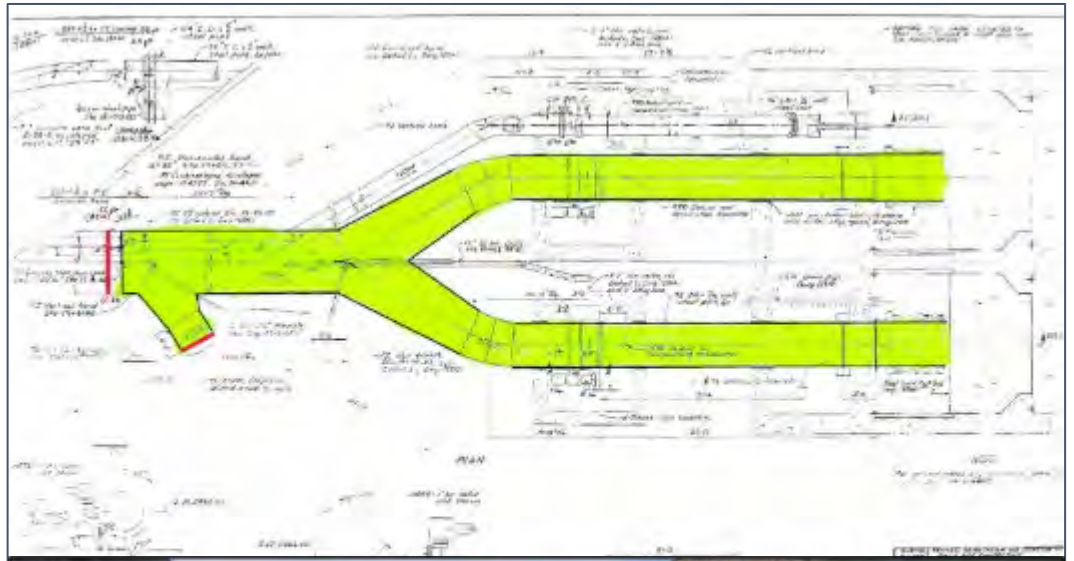


Coating Failure and Pitting Corrosion

Coating and Pitting Repairs

Scope of Work

- Abrasive Blast and Re-Coat
- 10,000 square feet
- Schedule: 10-day shut down window
  - One day planned for corrosion/ pitting repairs found after abrasive

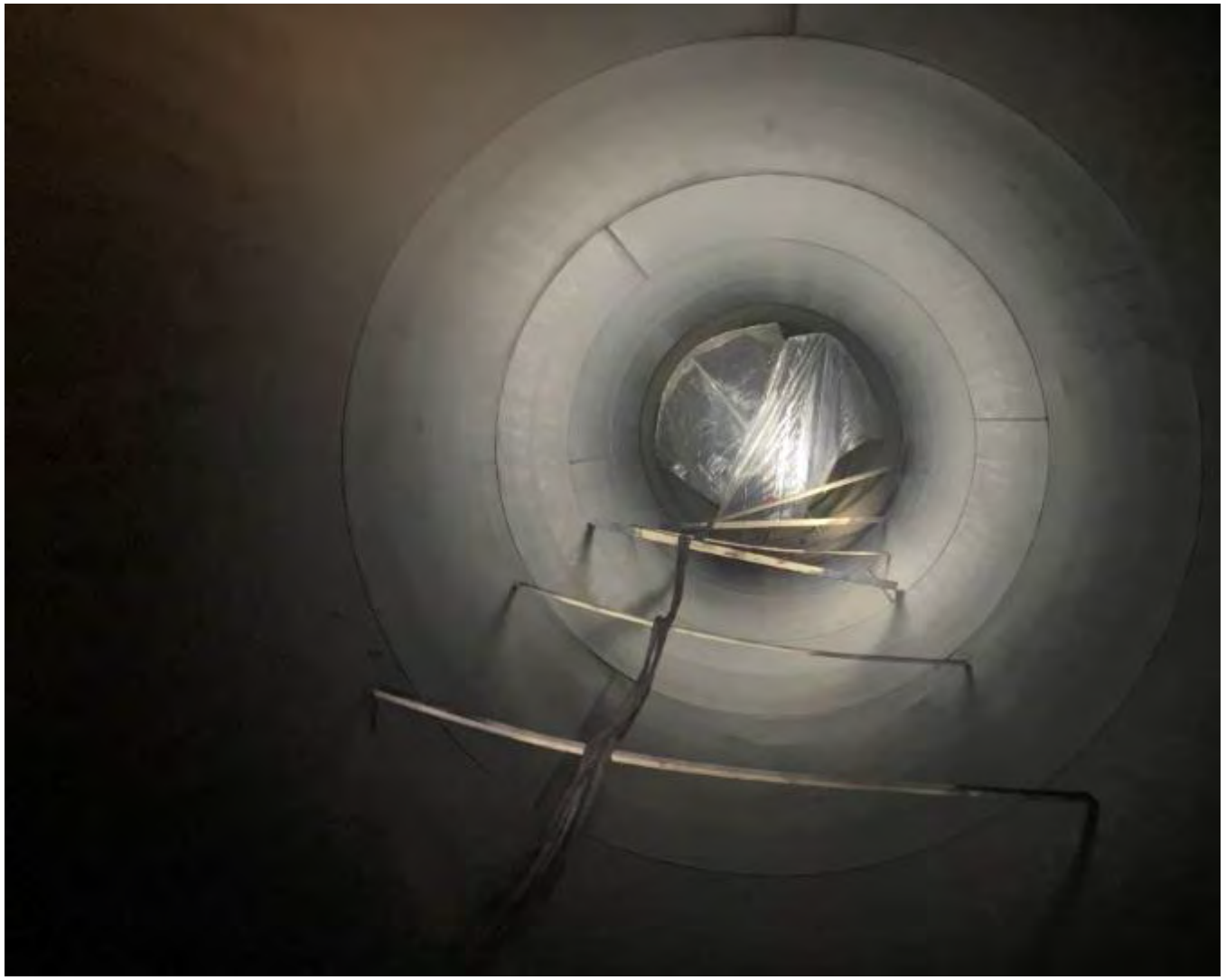


Surface Prep.	Coating Material	Min. Coats, Cover
Abrasive Blast, or Centrifugal Wheel Blast (SP 10)	Wasser MC-Zinc 100	1 coat, 4 MDFT
	Wasser MC-Tar 100	1 coat, 6 MDFT
	Wasser MC-Tar 100	1 coat, 6 MDFT

BUREAU OF RECLAMATION


Testex PRESS-O-FILM™
HT
X-Coarse


elcometer



WEATHER	READING TIME	9:00 PM	1230	530					
1. DRY BULB TEMP (F)		52	51	51					
2. WET BULB TEMP (F)		44	45	45					
3. REL. HUMIDITY (%)		72	67	68					
4. SURFACE TEMP (F)		49	48	48					
5. DEW POINT (F)		42	42	41					
6. DIFFERENCE: 4 - 5 (F)		7	6	7					
7. WIND SPEED/DIRECTION									

INSPECTION EQUIPMENT IDENTIFICATION Manufacturer Anerose Model THWD Serial No. 13D803425

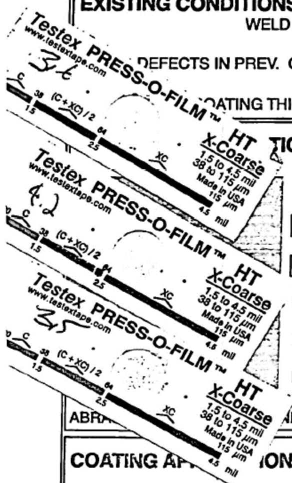
GENERAL WEATHER COMMENTS: Inside pipe

EXISTING CONDITIONS:

WELD DEFECTS: Edges on corners

DEFECTS IN PREV. COATING: Pin Holes

COATING THICKNESS: ______ MILS pH TEST: ______ NON-LEAD [X] LEAD [ ]



…TION: COMPRESSOR 1600 CFM NO. 1 AIR CLEANLINESS TEST: PASS [✓] FAIL [ ]

DEHUMIDIFICATION EQUIP. [ ] SIZE OF UNIT ______ CFM

[ ] SP1 - SOLVENT [ ] SP1 - WATER [ ] SP2 HAND TOOL [ ] SP3 PWR TOOL [ ] SP11 PWR TOOL

[ ] SP5 WHITE METAL [ ] SP6 COMM'L [ ] SP7 BRUSH OFF [X] SP10 NEAR WHITE

SURFACE PREP INSPECTION NOTES: ______

BLAST PROFILE TEST RESULTS: 4.2 MILS DOES BLAST MEET SPECS? [✓] YES [ ] NO

RETRIEVAL/RECYCLING METHOD: Ecs CLEAN? [X] YES [ ] NO

ABR… NEW [ ] RECYCLED MFG'R Erwin Ind OTHER: TYPE: Steel Grit GRADE: 50/50

COATING AP…ION: METHOD: [X] AIRLESS [ ] CONVEN. [ ] BRUSH/ROLLER [ ] TROWEL [ ] OTHER ______

WET FILM THICKNESS CHECKS: 1.____ 2.____ 3.____ 4.____ 5.____ 6.____ 7.____ 8.____

PAINT MFGR/PRODUCT #	BATCH #	EXP DATE	GALS	COAT #	COLOR	THINNER #	GAL/OZ /%	PWR MIX TIME	SWEAT TIME
WasseR m-zinc 100	210519	09-12	12 kits	1	Green	W41 MC	5%	2 min	NA

ILLUMINATION: (Space) Interior or Exterior Sq. Ft. **Lighting** Natural Artificial

Explosion Proof Lighting ✓ Portable ✓ Light Towers ______ - Foot Candles ______

COMMENTS: Brush Blast pipe and prime with zinc

REPORTED BY: [signature] QA/QC MANAGER: ______

DISTRIBUTION: WHITE COPY: SUPERINTENDANT, OPERATIONS MANAGER, DIVISION MANAGER, QA/QC DIRECTOR, JOB FILE (CROSS-OFF YOUR NAME AFTER REVIEW)
YELLOW COPY: CUSTOMER
PINK COPY: FOREMAN

ITEMS INSPECTED: USE SPACE PROVIDED TO DIAGRAM (ATTACH SEPERATE SHEET IF REQUIRED)

Tail works South side

SPECIFICATION:

PAINT SYSTEM: Wasser SURFACE PREPARATION: SSPC-SP# 10 BLAST PROFILE (AVG.) 3.5 MILS

COAT #1: MATERIAL MC Zinc 100 THICKNESS ______ MILS

COAT #2: MATERIAL Stripe Coat MC Tar Red Oxide THICKNESS ______ MILS

COAT #3: MATERIAL MC Tar Red Oxide THICKNESS ______ MILS

COAT #4: MATERIAL MC Tar THICKNESS ______ MILS

PAINT SYSTEM SPECIFIED MINIMUM TOTAL DRY FILM THICKNESS 13 MILS (19 MILS MAXIMUM)

READINGS: TAKE MIL READINGS OF COMPLETE SYSTEM. GIVE READINGS FOR SAMPLE AREAS IN THREES & AVERAGES.

SAMPLE AREA #	A	B	C	1.	A	B	C	2.	A	B	C	3.	A	B	C	4.	A	B	C	5.	A	B	C	6.	A	B	C	7.
DFT READINGS	[illegible]	[illegible]	[illegible]	18.3	[illegible]	[illegible]	[illegible]	17.4	[illegible]	[illegible]	[illegible]	16	[illegible]	[illegible]	[illegible]	17.3												
DFT READINGS	[illegible]	[illegible]	[illegible]	21.4	[illegible]	[illegible]	[illegible]	17.1	[illegible]	[illegible]	[illegible]	16.3	[illegible]	[illegible]	[illegible]	17.5												
DFT READINGS	[illegible]	[illegible]	22.5	17.6	[illegible]	[illegible]	[illegible]	17	[illegible]	[illegible]	[illegible]	17.9	[illegible]	[illegible]	[illegible]	17.8												
DFT READINGS	[illegible]	[illegible]	[illegible]	16.1	[illegible]	[illegible]	[illegible]	18	[illegible]	[illegible]	[illegible]	15.3	[illegible]	[illegible]	[illegible]	16.5												
AVERAGE DFT				18.3				17.4				16.4				17.4												

CALIBRATION PERFORMED: [✓] YES ______ [ ] NO THIS COATING PASSED [ ] FAILED [ ] DFT REQUIREMENTS

APPEARANCE OF COATING: (GLOSS, COLOR, OVERALL QUALITY, & ANY APPARENT DEFECTS) ______

SPARK TEST: CONTINUITY TEST METHOD USED [ ] SPONGE TESTER [ ] HIGH VOLTAGE TESTER: SET AT ______ VOLTS

NUMBER OF HOLIDAYS DETECTED: 4 [X] MARKED NOTES: Touched up all 4 Areas

GENERAL COATING QUALITY: [ ] EXCELLENT [X] VERY GOOD [ ] GOOD [ ] FAIR [ ] POOR

NOTES: ______

THE UNDERSIGNED CERTIFIES THAT THE STATEMENTS MADE HERE ARE TRUE AND FACTUAL TO THE BEST OF MY KNOWLEDGE.

INSPECTOR: [signature] WITNESS: ______

Coatings – Lessons Learned

- Outline
  - Annual – Evaluation
  - Define Scope of Work
  - Develop Specification
  - Inspection Services
  - Bids
  - Communicate
  - Feedback & Inspection
  - Documentation

Condition Assessment

Tunnel and 12” Bypass

Pipe Characteristics:

- Installed in Year 1970
  - Note – Over 50 years of service

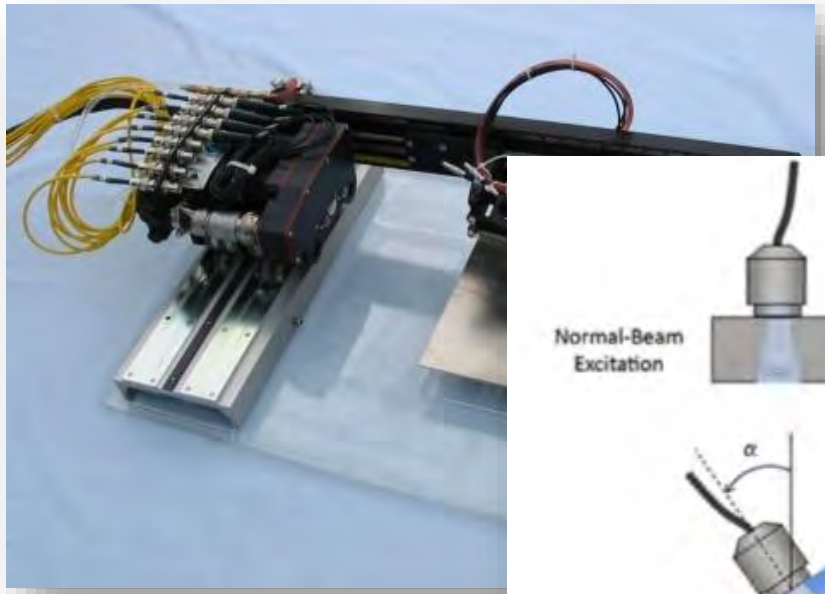
Purpose:

- Bypass
- 15 cfs minimum environmental flow commitment in Strawberry River

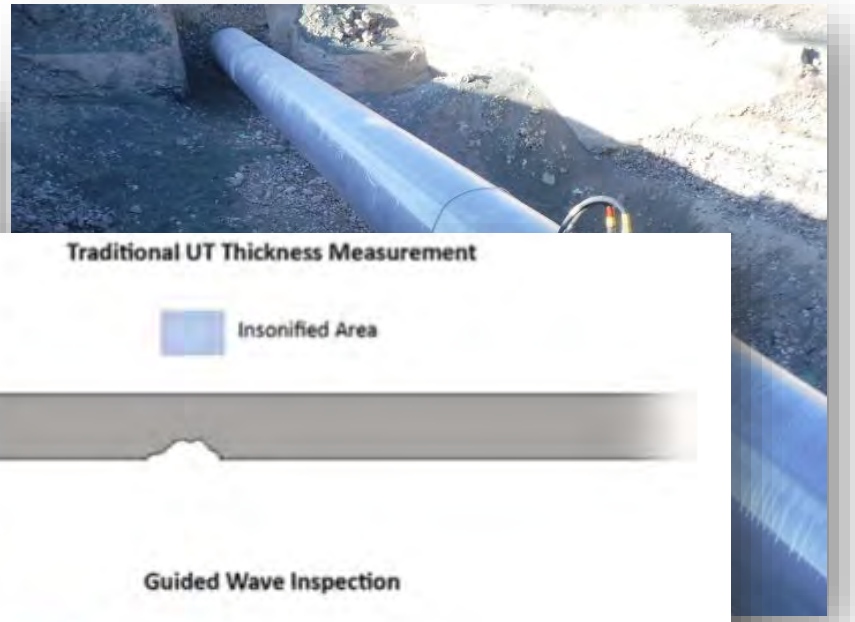
O&M Recommendation: Repair or replace the corroded outlet bypass pipeline and couplers

Ultrasonic Wall Thickness Options

Automated Ultrasonic Examination



Guided Wave



http://www.gwultrasonics.com/knowledge/gw-intro/

Condition Assessment

- Repair vs replace?
- Non-Destructive Examination
  - Internal Corrosion
  - External Corrosion
- Visual Evaluation
- Integrity Digs

CENTRAL UTAH WATER CONSERVANCY DISTRICT

Central Utah Water Conservancy District

BID OPENING REPORT

Project: Starvation Dam - Bypass Line Condition Assessment

Bids were opened on: Wednesday, February 18, 2022
Time: 1:00 P.M. MDT
For: Central Utah Water Conservancy District

Engineers Estimate: **$10,000.00**

	Contractor	Total Lump Sum Bid
1	Hand Scan	$6,150.50
2	Full Coverage	$31,445.00
3	Hand Scan	$5,485.00
4	Full Coverage	$22,034.00

Will Garner, P.E., Project Engineer

Date

Bids were reviewed by Will Garner, Troy Ovard, and Kevin Workman. The decision was made to use Acuren with their hand scan proposal. They offer more scans than QTI and would to a 2" band around the pipe, pitting gauge analysis, and 24" band on the buried portion of the pipe.

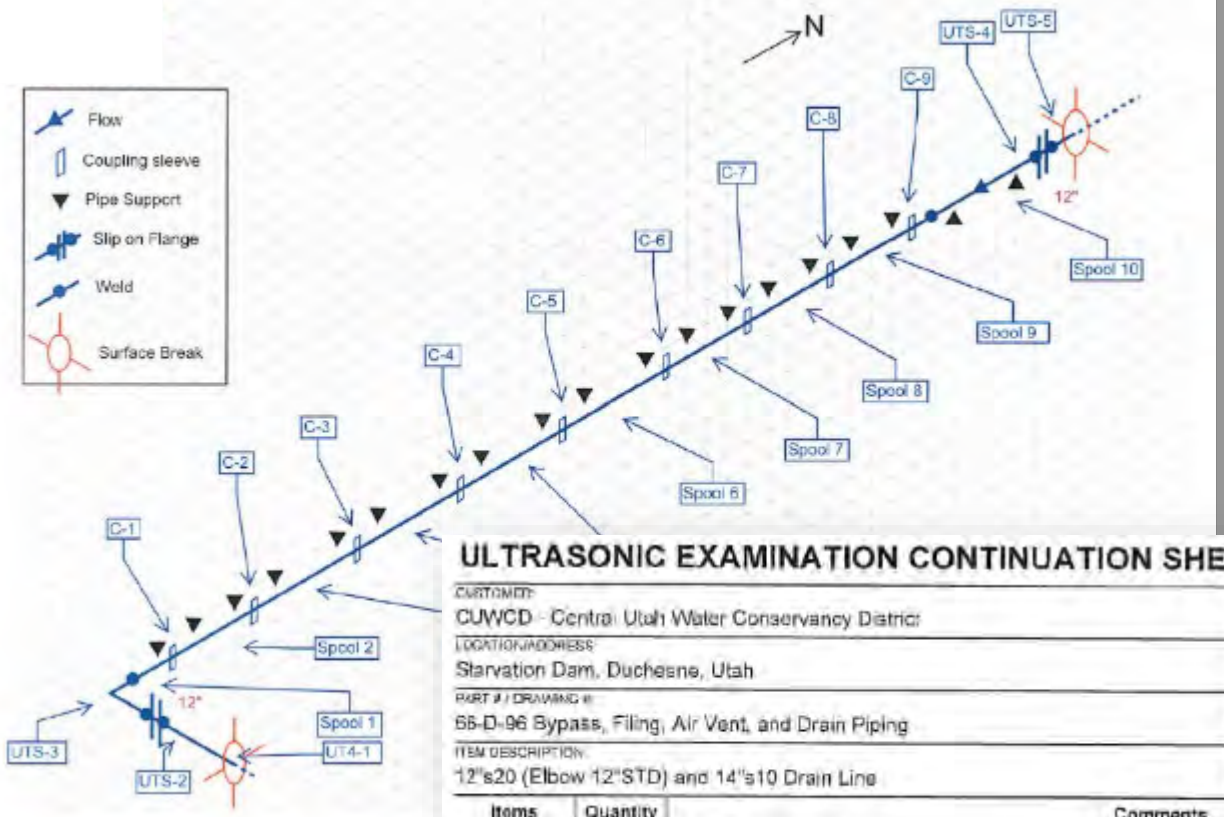
Ultrasonic – Hand Scan

Ultrasonic – Hand Scan

Customer: CUWCD @ Starvation Dam
Project: 12",14" Drain Piping

Drawing: 66-D-96
Description: UT Corrosion Scans

Drawn By: L John
Date: 03/18/2022



https://www.vertex42.com/ExcelTemplates/graph-paper.html

ULTRASONIC EXAMINATION CONTINUATION SHEET

Page 2 of 6

CUSTOMER:	ACUREN SERVICE CALL #:	DATE:
CUWCD - Central Utah Water Conservancy District	775537	03/18/2022
LOCATION/ADDRESS:	CUSTOMER CONTACT:	
Starvation Dam, Duchesne, Utah	Troy Ovard	
PART # / DRAWING #:	CUSTOMER PO #:	CUSTOMER WO #:
66-D-96 Bypass, Filing, Air Vent, and Drain Piping	N/A	N/A
ITEM DESCRIPTION:	STAGE OF MANUFACTURE:	SURFACE CONDITION:
12"s20 (Elbow 12"STD) and 14"s10 Drain Line	In Process	Coated

Items	Quantity	Comments	Accept/Reject
12" Drain Line	Spool 6 C-5 N	A .248" B .247" C .247" D .248"	Info. Only
	Spool 6 C-6 S	A .247" B .247" C .247" D .247"	
	Spool 7 C-6 N	A .251" B .247" C .248" D .247"	
	Spool 7 C-7 S	A .248" B .249" C .247" D .240"	
	Spool 8 C-7 N	A .243" B .244" C .245" D .244"	
	Spool 8 C-8 S	A .246" B .247" C .248" D .215"	
	Spool 9 C-8 N	A .247" B .246" C .240 D .245"	
	Spool 9 C-9 S	A .248" B .247" C .248" D .247"	

Blister Cleanup and UT Evaluation

Lowest Pipe Thickness Reading .191” Spool 3

Visual Inspection

Typical Coupling Bolt Damage Spool 3 & 4

Integrity Digs

Summary of Results

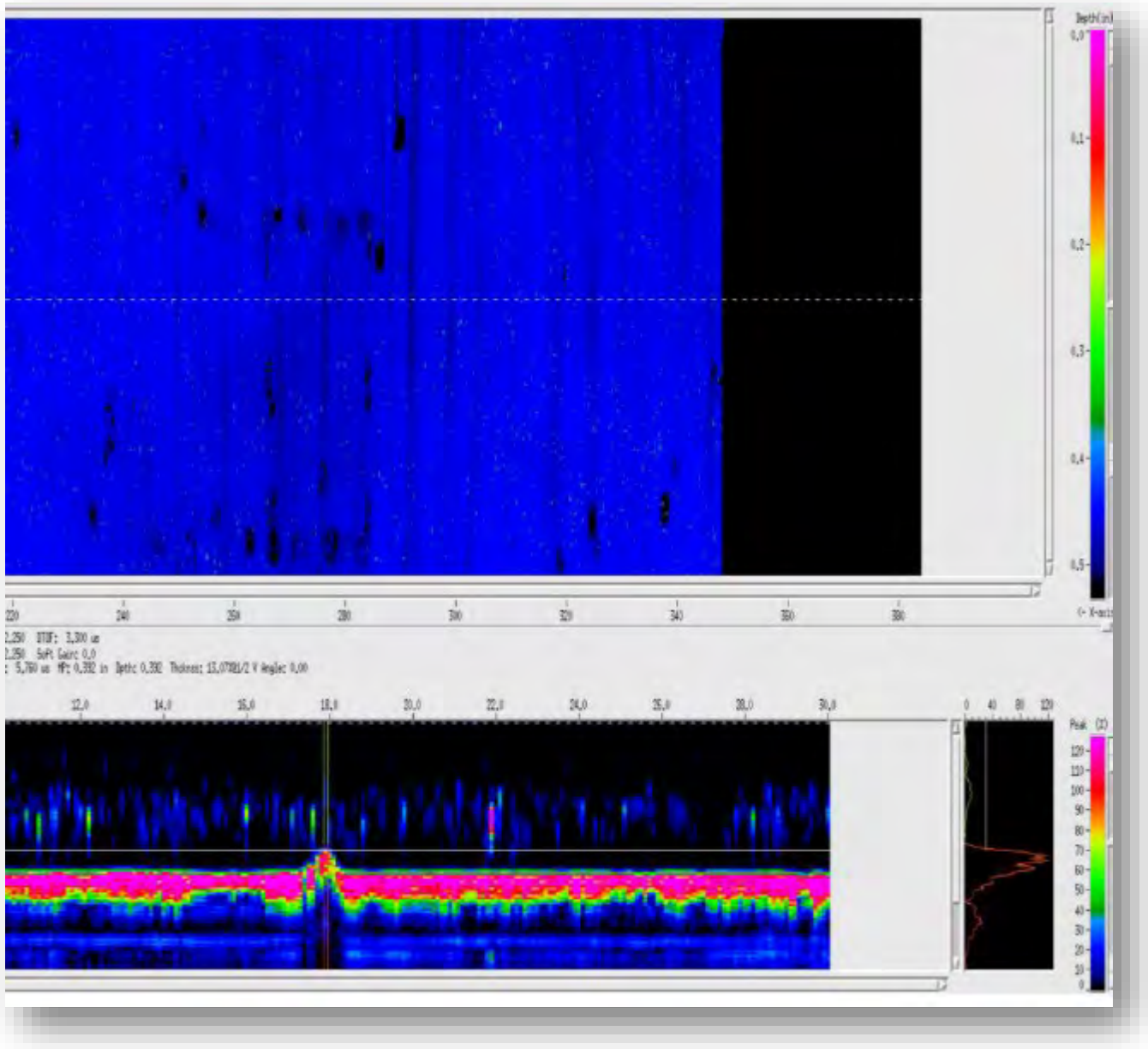
- Pipe – Fairly good condition. Little internal corrosion and external corrosion
- Bracket Hanger – Replace as soon as possible
- Buried Pipe - Wing Wall settling caused leak and needs to be replaced

Considerations

- Repair & Re-Coat
  - Bracket would still need to be replaced
- Full replacement
  - More expensive, but longer lasting
  - Design and Build

Coatings – Lessons Learned

- NDE and other NDT examination techniques
- Evaluate and Re-Coat Pipe Early – Don’t Wait
- If you don’t know – Gather Data



GALVANIC CORROSION

Selected Electrochemical Potentials in Sea W

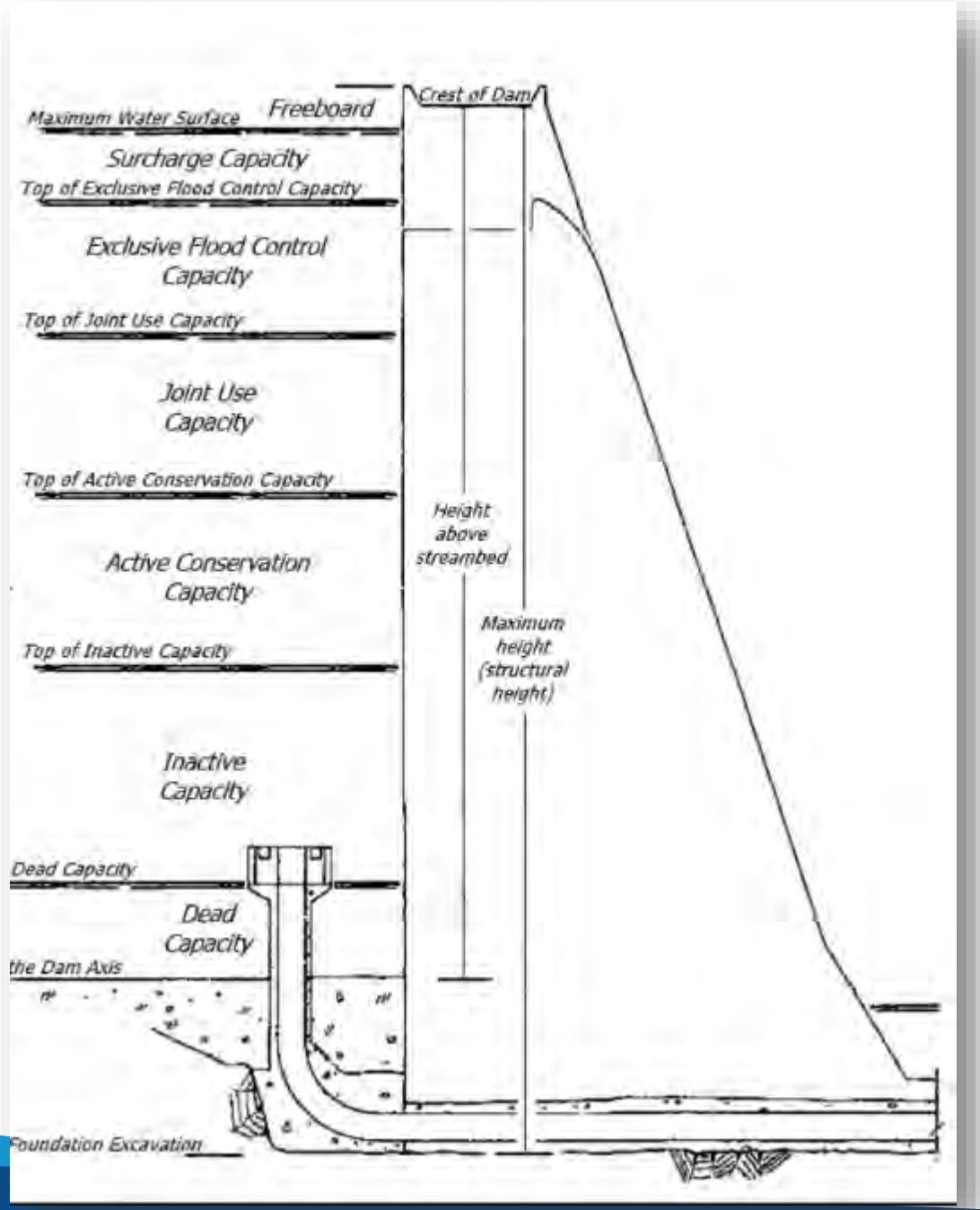
	Reaction	E^{o}(V)
More Noble	Platinum	+0.45
	Titanium (passivated)	+0.24
	316 Stainless Steel (passivated)	+0.18
	Silver	+0.09
	Lead	+0.02
	Admiralty Brass	-0.07
	Copper	-0.09
	Low Alloy Steel	-0.36
	Cadmium	-0.47
	Aluminum alloys	-0.63
More Active	Zinc	-0.77
	Magnesium	-1.38

Adapted from: H. P. Hack, Metals Handbook Vol. 13, Corrosion, 9th ed. ASM, Metals Park, OH

Fix



Stainless Steel Valve – Located Inside an Untreated Water Tank


Maximum Water Surface
Freeboard
Crest of Dam
Surcharge Capacity
Top of Exclusive Flood Control Capacity
Exclusive Flood Control Capacity
Top of Joint Use Capacity
Joint Use Capacity
Top of Active Conservation Capacity
Height above streambed
Active Conservation Capacity
Maximum height (structural height)
Top of Inactive Capacity
Inactive Capacity
Dead Capacity
Dead Capacity
the Dam Axis
Foundation Excavation

Composite System – Belzona SuperWrap II

Application:

1. Preparation

Repair any thin- or through-wall defects prior to application.

2. Wetting Out

The substrate and the reinforcement sheet are wetted out with resin.

3. Wrapping

Wrap or patch is applied according to design or procedure.

4. Consolidating

Release film is used to compress and tighten the wrap.

5. Inspection

Once cured, release film is removed and the wrap is inspected.

FLEXURAL PROPERTIES	
When determined in accordance with ASTM D790 (68°F/20°C cure & 68°F/20°C test), typical values for the **Belzona 1981 / Belzona 9381** composite will be	
Flexural Strength (0° axis - hoop)	95.48 x 10^3 psi / 658 MPa
Flexural Strength (90° axis - axial)	24.05 x 10^3 psi / 166 MPa
Flexural Modulus (0° axis - hoop)	55.07 x 10^5 psi / 37977 MPa
Flexural Modulus (90° axis - axial)	20.66 x 10^5 psi / 14247 MPa

[illegible]	
When determined in accordance with ISO 11359, typical values of the **Belzona 1981 / Belzona 9381** composite will be:	
Coefficient of Thermal Expansion (0° axis - hoop)	9.44 x 10^{-6} mm/mm°C
Coefficient of Thermal Expansion (90° axis - axial)	12.96 x 10^{-6} mm/mm°C

TENSILE PROPERTIES	
When determined in accordance with ASTM D3039 (68°F/20°C cure & 68°F/20°C test), typical values for the **Belzona 1981 / Belzona 9381** composite will be:	
Tensile Strength (0° axis - hoop)	75.98 x 10^3 psi / 524 Mpa
Tensile Strength (90° axis- axial)	18.27 x 10^3 psi / 126 Mpa
Poisson's Ratio (0° axis - hoop)	0.26
Poisson's Ratio (90° axis - axial)	0.27
Young's Modulus (0° axis - hoop)	56.26 x 10^5 psi / 38800 MPa
Young's Modulus (90° axis - axial)	26.54 x 10^5 psi / 18300 MPa
Strain to Failure (0° axis - hoop)	1.37 %
Strain to Failure (90° axis - axial)	0.81 %

[illegible]

Pull Off Adhesion
The PosiTest Daily Pull Off Strength on 10mm thick grit blasted mild steel, as determined in accordance with ASTM D4541 and ISO 4624, will typically be:

5520 psi / 38.1 MPa (68°F/20°C cure & test)

Tensile Shear Adhesion
The Tensile Shear Adhesion on grit blasted mild steel, as determined in accordance with EN 1465, will typically be:

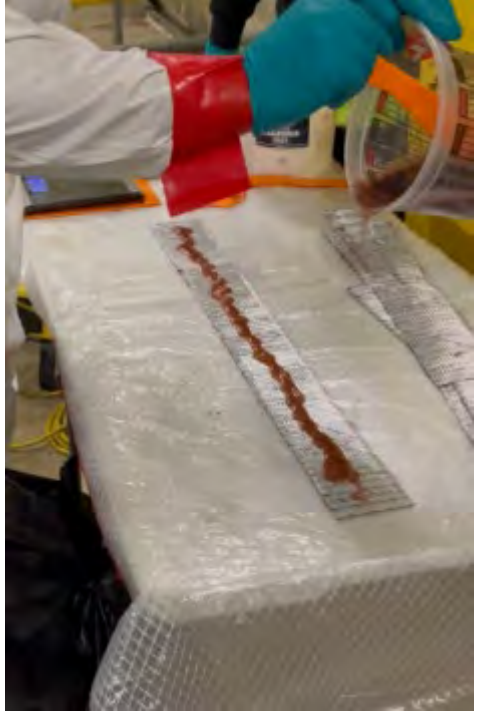
Cure (Test) temperature	Tensile Shear Adhesion
68°F/20°C (68°F/20°C)	2241 psi / 15.5 MPa
140°F/60°C (68°F/20°C)	1856 psi / 12.8 MPa
140°F/60°C (140°F/60°C)	1972 psi / 13.6 MPa

Tensile Shear Adhesion (Immersion)
The Tensile Shear Adhesion on grit blasted mild steel, as determined in accordance with EN 1465 measured after 1000 hours immersion in water at 104°F/40°C will typically be:

Cure (Test) temperature	Tensile Shear Adhesion
104°F/40°C (68°F/20°C)	2246 psi / 15.5 MPa

Build up with Belzona 1212

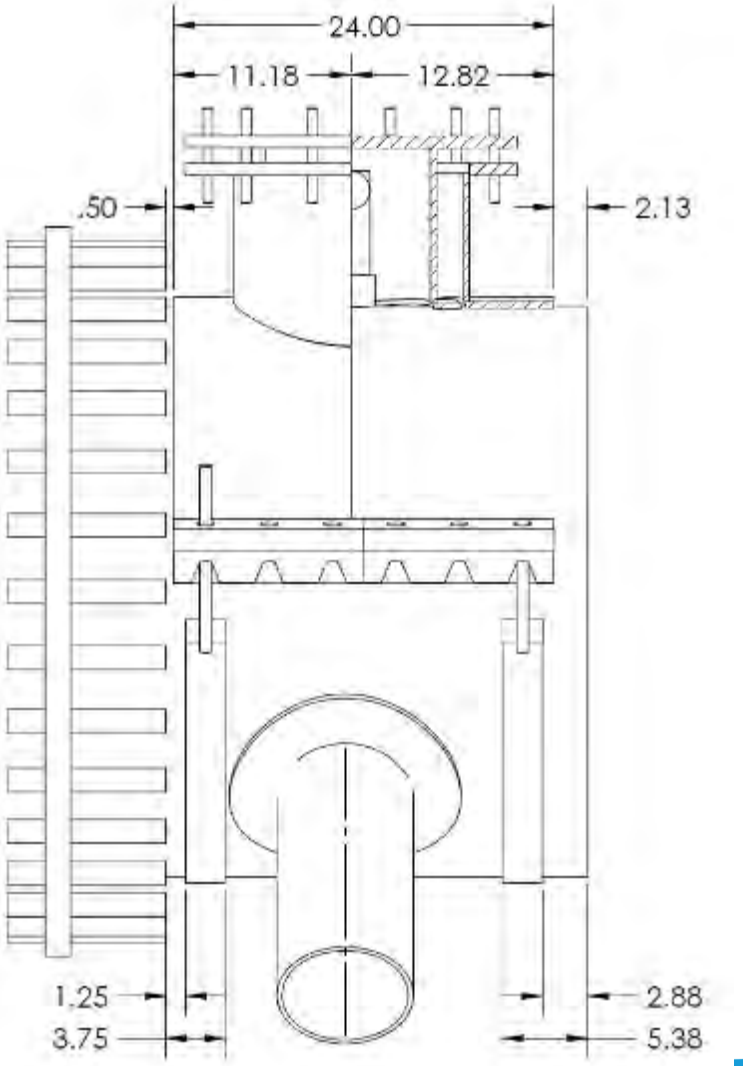
Surface Preparation



Carbon fiber mess was saturated with belonza 1981.

Application of Belzona SuperWrap II System

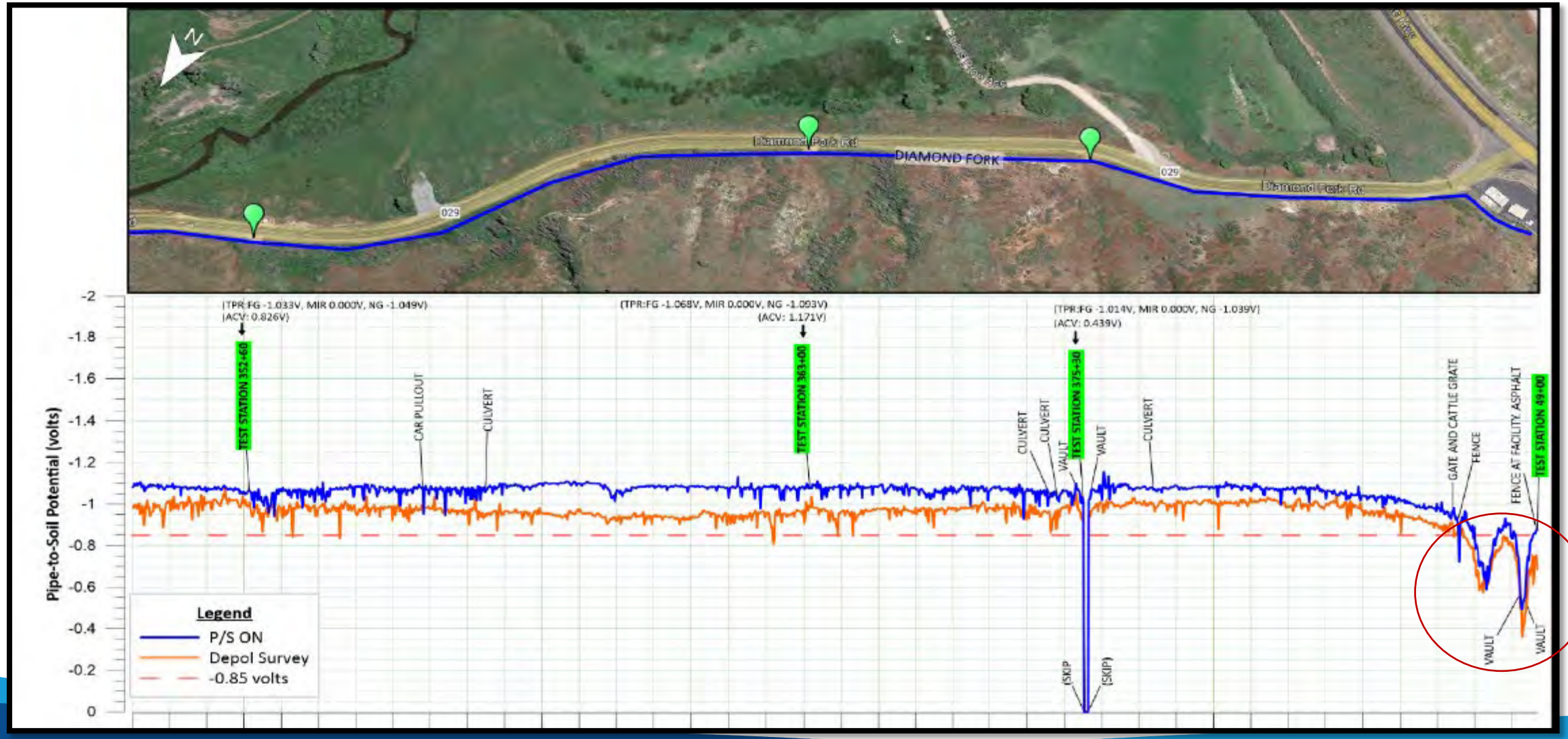
Post Construction & Steps Forward



Galvanic Corrosion – Lessons Learned

- Existing pipe configuration may have galvanic corrosion cells
- Material Selection
- Monitoring and Inspection during construction
- Viable Methods for Inservice repairs

Electrical Isolation and Shorting



North Fork Siphon Blowoff Shorting

Construction – Replacement Blow-off Vault


06.08.2021 09:10


06.07.2021 13:17

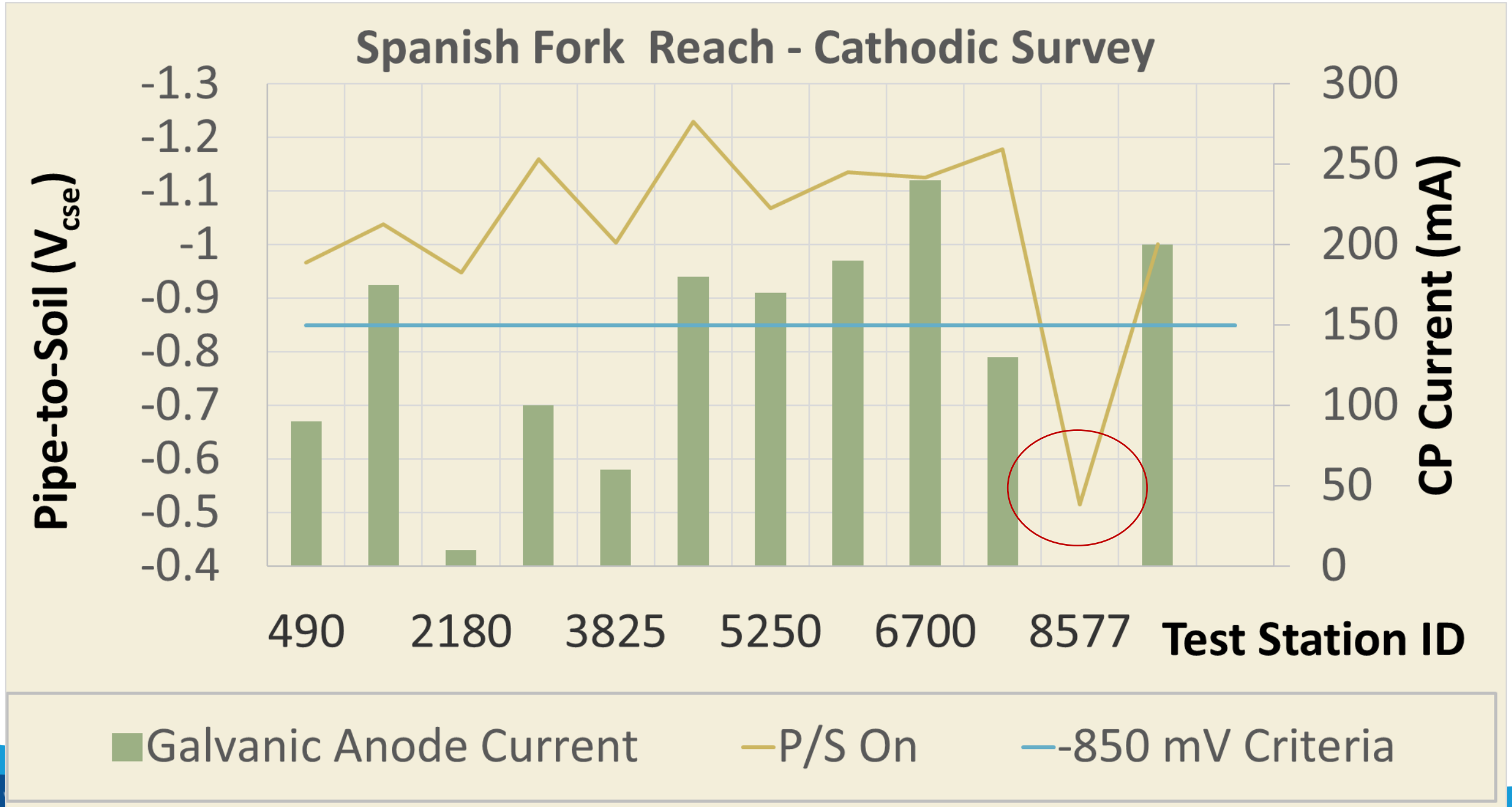

06.11.2021 08:51

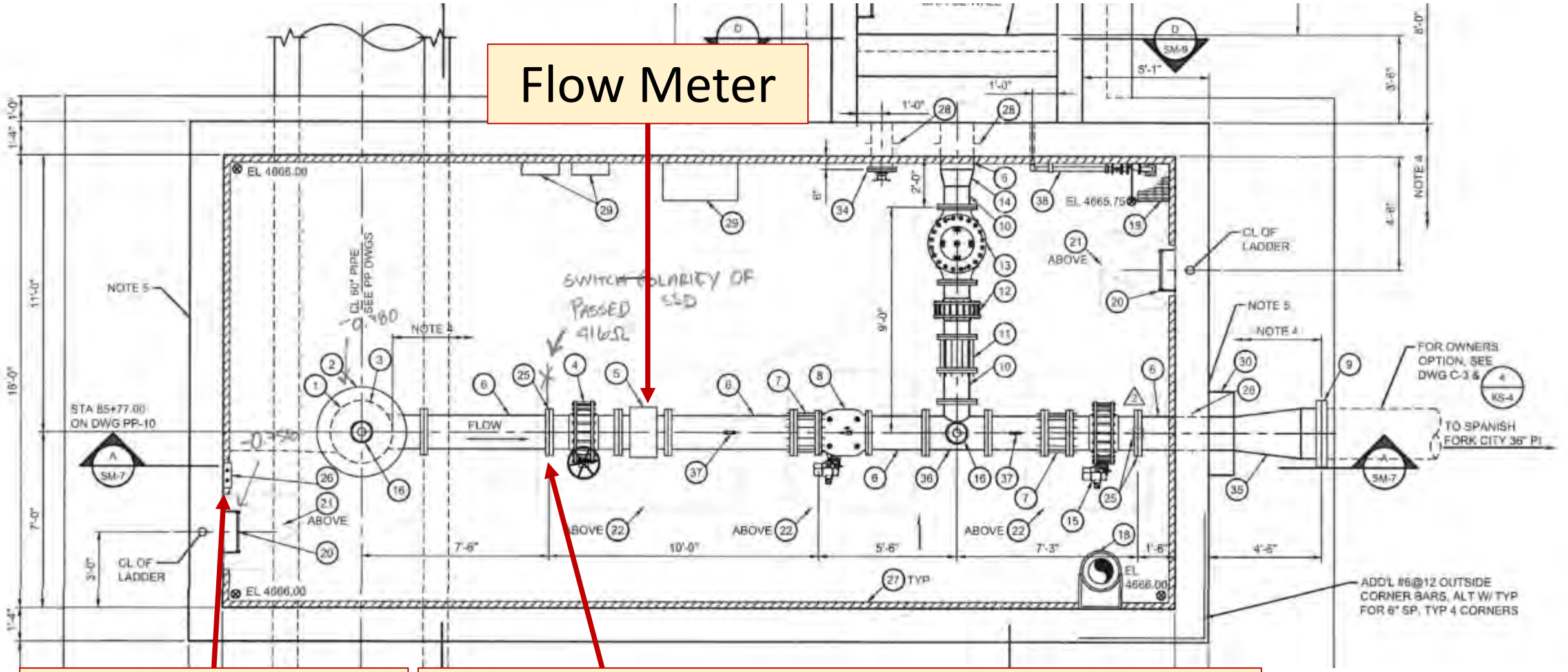

06.14.2021 12:49


06.15.2021 11:37


06.16.2021 08:53

Spanish Fork Meter Vault


Spanish Fork Reach - Cathodic Survey
Pipe-to-Soil (V_{cse})
-1.3
-1.2
-1.1
-1
-0.9
-0.8
-0.7
-0.6
-0.5
-0.4
300
250
200
150
100
50
0
CP Current (mA)
490
2180
3825
5250
6700
8577
Test Station ID
Galvanic Anode Current
P/S On
-850 mV Criteria


Flow Meter
Solid State Decoupler (SSD)
Isolation Flange
Passed RF-IT Isolation Flange Check
FLOW
NOTE 5
NOTE 4
CL OF LADDER
TO SPANISH FORK CITY 36" PI
ADD'L #6@12 OUTSIDE CORNER BARS, ALT W/ TYP FOR 6" SP, TYP 4 CORNERS
EL 4666.00
EL 4665.75
STA 85+77.00 ON DWG PP-10
ABOVE
TYP

Method for Testing

1. Visual Evaluation
2. Check Isolation Flanges
3. Stationary Ref. Electrode
4. Disconnect Electrical and/or Instrumentation

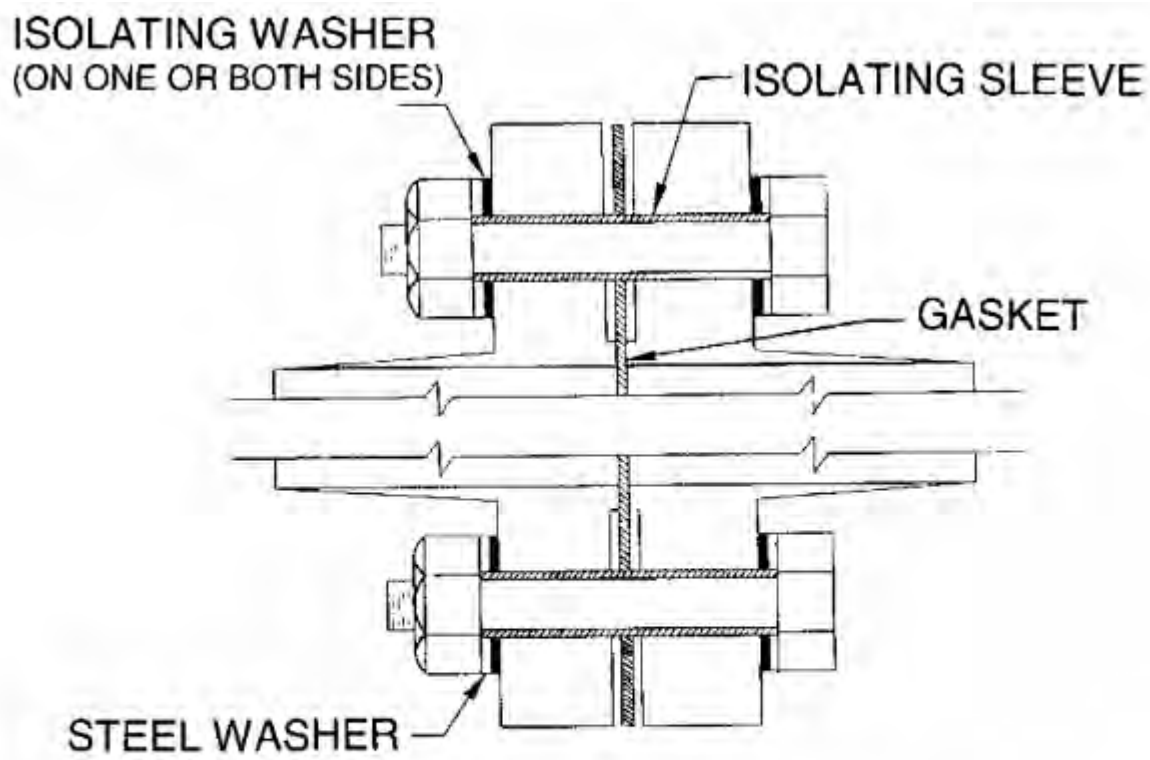


FIGURE 1a:
Full-Length Bolt Sleeves
This figure shows the use of full-length bolt sleeves.


FLUKE
FLUKE 177 TRUE RMS MULTIMETER
-0.493 DC V
Auto Range
AutoHOLD
HOLD
MINMAX
RANGE
mV
Ω
Hz V
Hz V

Location	P/S Before (Vdc)	P/S After (Vdc)
Station Ground (tested on ladder)	-0.756	-0.49
Pipe on riser	-0.78	-1.262
Test station	-0.805	-1.152
Test station	-0.515	-1.152

Electrical Isolation and Shorting – Lessons Learned

- Inspection During Construction
- Annual Survey
- Methodically Evaluate Possible Shorting locations
- NACE SP0286 “Electrical Isolation of Cathodically Protected Pipelines”

Summary

- Central Utah Water Conservancy District
- Natural Gas vs Water
- Corrosion Case Studies & Lessons Learned
  - Coating
  - Galvanic Corrosion
  - Electrical Shorting
  - Condition Assessment

QUESTIONS?

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Thank you!