RECLAMATION
Managing Water in the West

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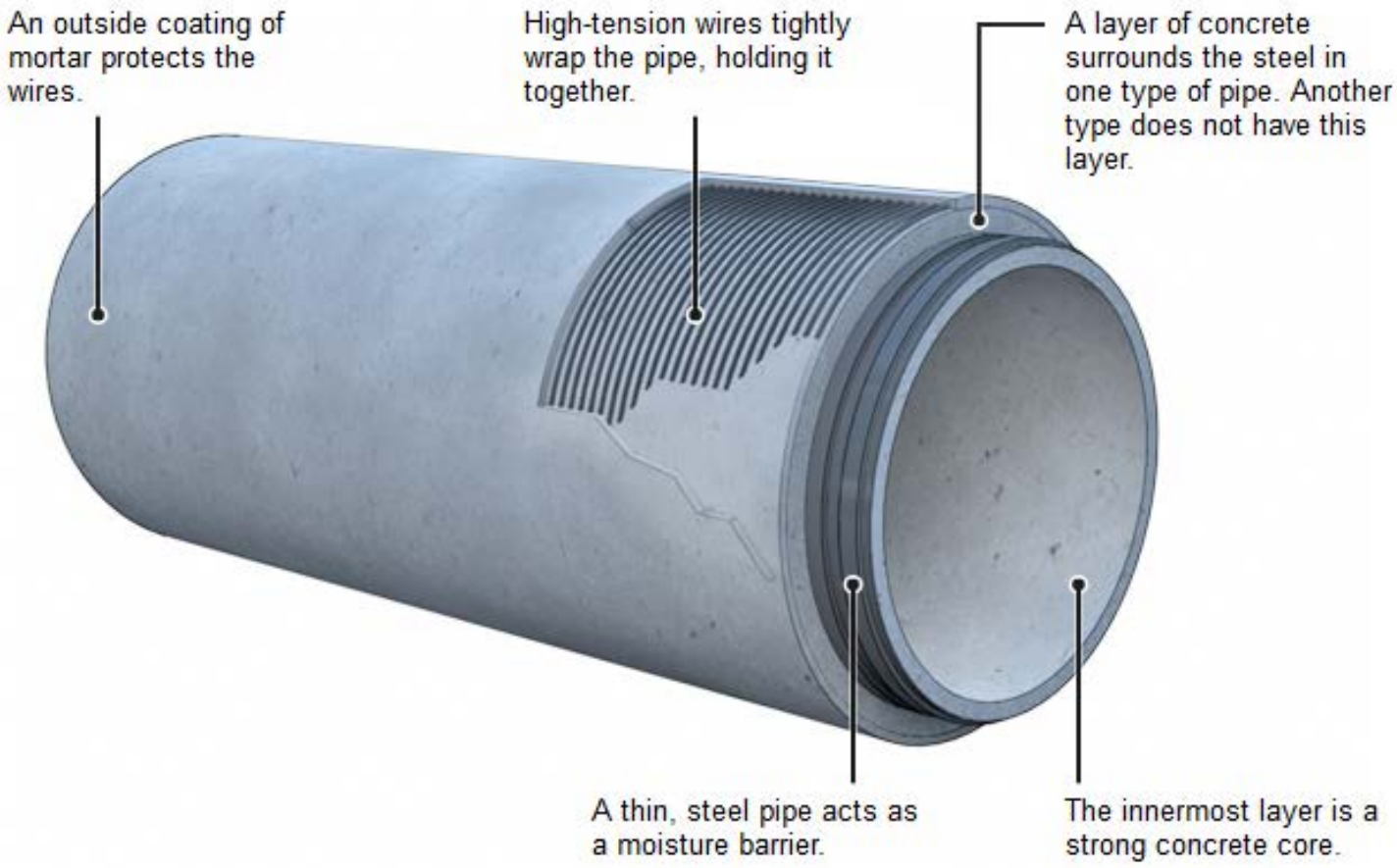
Corrosion Webinar Series

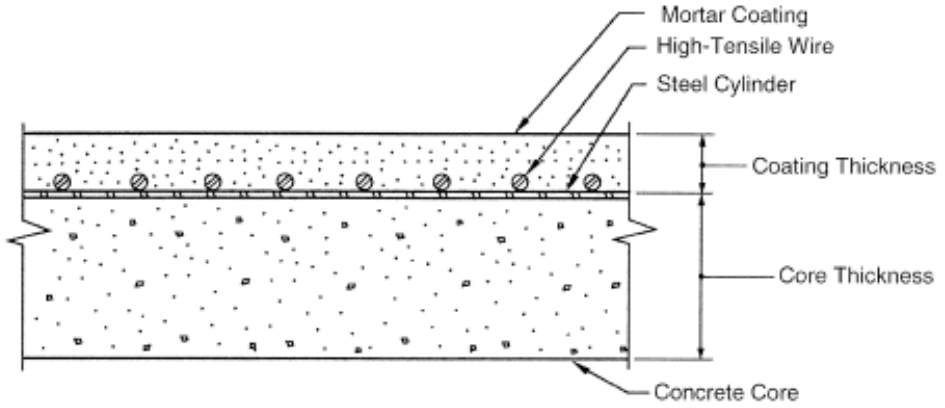
PCCP at Reclamation

What is PCCP?

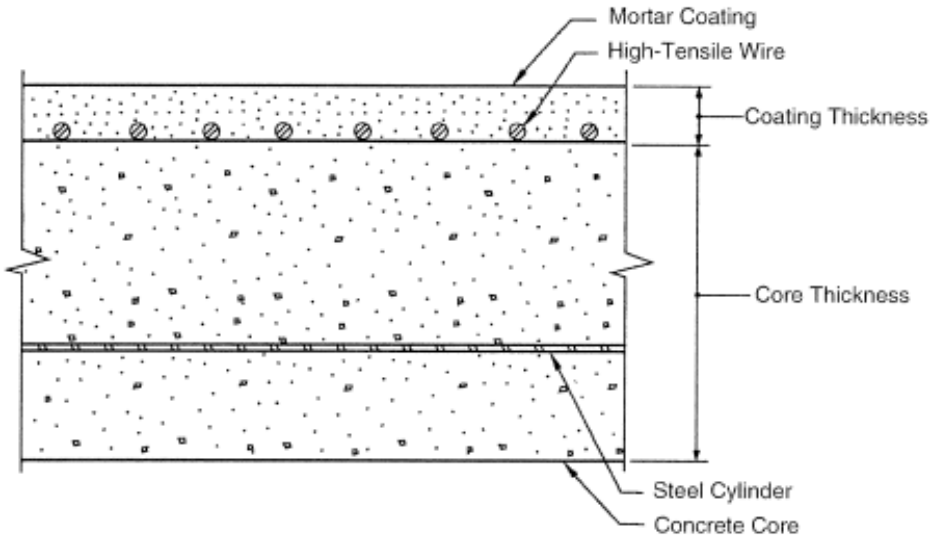
Prestressed Concrete Cylinder Pipe



Source: Pure Technologies, www.puretechltd.com



Lined-Cylinder Pipe



Embedded-Cylinder Pipe

Note: also non-cylinder pipe

What is PCCP?


Spiral weld steel liner


Spiral weld steel liner


Cast concrete core


Cure concrete core


Wind prestressing wire


Spray mortar coating


Cure and store

Historical Perspective

- **Reclamation specified PCCP from ~1960 to 1990**
- **Current Reclamation-owned active inventory:**
  ~90 miles in 48 sections
- **In the 1970's, Class II and IV wire were introduced, and one manufacturer in particular produced pipe with wire that has had high probability of failure**
- **After several failures, Reclamation stopped installing PCCP in 1990**
- **AWWA C301 and C304 are the manufacture and design standards**

PCCP: Principle Causes of Failure

- **Corrosion of Wire leading to Breaks**
  - **Defective prestressing wire**
  - **Incomplete encasement of wire with mortar/cement slurry**
  - **Insufficient mortar cover**
  - **Cracking of mortar**
  - **Carbonation of mortar**

Ak-Chin Link Pipeline

Ak-Chin Link Pipeline

Santa Clara Conduit

CAP Causes and Extents Report

Reclamation PCCP Failures

- **1984- Central Utah Project (UT), Jordan Aqueduct Reach 3**
  - **Failed one month after going into service**
  - **Defective wire had longitudinal cracks, was wound exceeding specified tensile stresses**
  - **2.3 miles lined with steel liner at cost of ~$5 million**

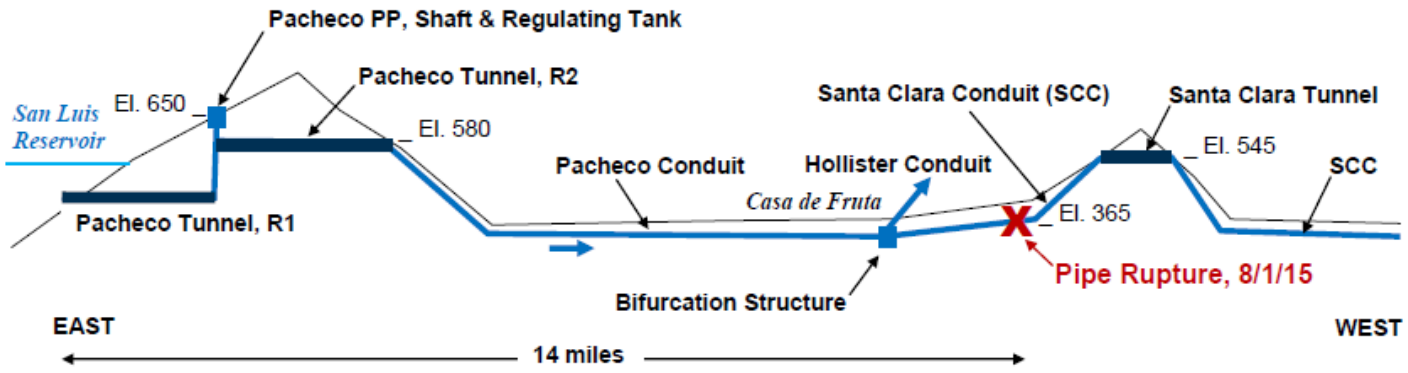
- **1990- Central Arizona Project (AZ)**
  - **6.5 miles of 21’ diameter PCCP siphons constructed from 1975-1980**
  - **Exposed 223 units, 40% were distressed and needed repair, 10% of those needed replacement**
  - **Estimated cost of implementing repairs at the time was $117 million**

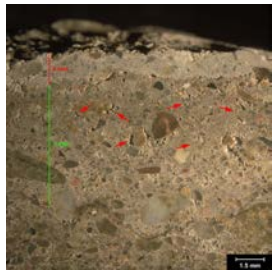
- **2015- Central Valley Project (CA), Santa Clara Conduit**

- **2016- Navajo Indian Irrigation Project (NM), Kutz Siphon**

Santa Clara Conduit Failure

- Central Valley Project, California
- Saturday, August 1, 2015
- 10’ long, 8’ diameter PCCP section failed
- Failure mode: corrosion leading to broken wires
  - Corrosive soil
  - Microcracking and carbonation in mortar coating



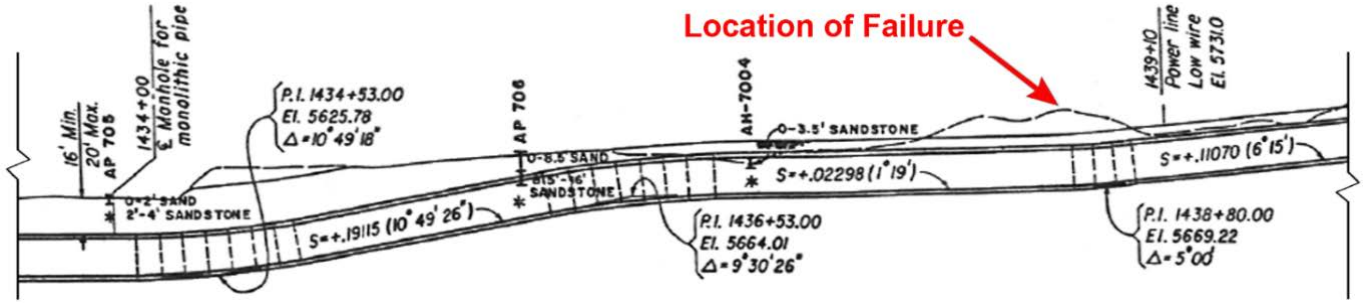


Santa Clara Conduit Failure

- **Emergency Repair:**
  - **Replaced with cement mortar lined and coated steel pipe**

Kutz Siphon Failure

- Navajo Indian Irrigation Project, New Mexico (now BIA owned)
- Friday, May 13, 2016
- Two 40’ long, 17.5’ diameter PCCP sections failed
- Concrete and water projected 200’
- Lost 1,000 cfs into the San Juan River
- Put 75,000 acres of irrigated land out of service
- Failure mode: corrosion leading to broken wires



Kutz Siphon Failure

- **Emergency Repair:**
  - **Replace with steel**
  - **Fill with CLSM, no corrosion protection**
- **2017-2018 Repair:**
  - **Line steel sections with epoxy**
  - **Install cathodic protection at repair**

Lessons Learned

- **Prevention!**
  - **Know your system- risk assessment**
  - **Regular electromagnetic (EM) inspections for wire breaks, 3-5 yrs**
  - **Timely action to address problem areas or institute more frequent monitoring**
  - **Install corrosion protection**
  - **Schedule future repairs/replacement for deteriorating sections**

- **Prepare for future emergencies**
  - **Have spare replacement sections and butt-straps on hand**
  - **Have design ready for future replacements**
  - **Have emergency action plan ready**

- **Maintenance and planned repairs are cheaper than reacting to pipe breaks.**

Condition Assessment

- **Site Evaluation**
  - **Topographic and geologic evaluation: near-surface groundwater, high corrosivity soils, arroyos and washes**
  - **Man-made features that could increase corrosion potential: electrical transmission lines, foreign line crossings, roadways**
  - **Soil resistivity surveys or corrosivity laboratory analysis**

- **Potential Surveys**
  - **Pipe-to-soil/close interval survey or cell-to-cell survey**
  - **Conducted above ground to identify areas of anomalous potential gradients indicating corrosion is occurring**

Condition Assessment

- **Visual Inspection (Pipe Interior)**
  - Cracks in core
  - Leaks at joints
- **Acoustic Inspection**
  - Manual sounding- delamination of concrete or un-grouted areas/hollows
  - Impact Echo Testing- delamination, hollows, cracks
  - Free-floating acoustic sensor- leak detection
- **Electromagnetic Inspection**
  - Number and location of prestressing wire breaks
  - Can be conducted for in-service or dewatered pipe
- **Acoustic Fiber Optic Monitoring**
  - Continuous monitoring for wire breaks
  - Cables installed inside pipe
  - Requires monthly/annual monitoring contract

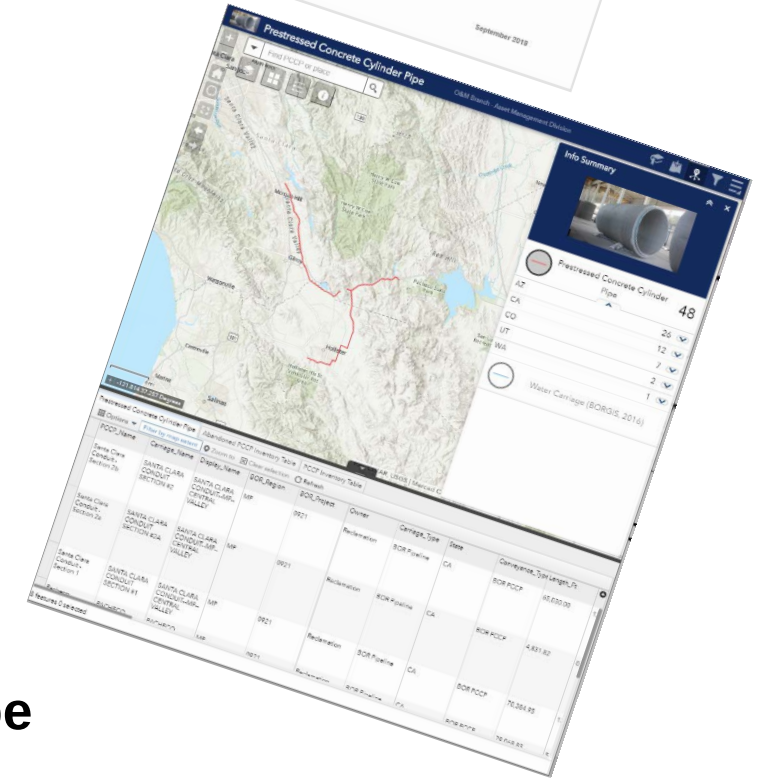
Repair Methods

- **Interior Crack and Joint Repair**
  - Reclamation's "Guide to Concrete Repair, 2nd ed."
  - Surface preparation, repair product application, curing
- **Installation of Cathodic Protection**
  - Requires electrical continuity of protected sections
  - Should not be polarized more negative than -1000 mV_{CSE} to avoid hydrogen embrittlement
- **Wire Splicing and Tendon Wrapping**
  - Exterior repair requiring pipe excavation
  - Use anchor blocks and tensioning devices to install replacement wire or tendons
- **Structural Liner**
  - Internal repair to provide structural support for distressed sections
  - Carbon Fiber Reinforced Polymer (CFRP)
  - Spray-in-Place Pipe (SIPP)

Current PCCP Activities in TSC

- **Science & Technology Program research projects (Research Office)**
  - **ST-2019-7108-01/TM 8540-2019-31**
    PCCP: Condition Assessment, Repair, Replacement Strategies
  - **FY19-22: PCCP Educational Demonstration**

- **Inventory and GIS-Viewer for PCCP (Joint RO and PO)**



- **PCCP electromagnetic inspections (Policy Office)**
  - **Fund and award contract for EM inspection of prioritized Reclamation-owned PCCP installations**
  - **Coordinate and facilitate inspections**
  - **Compile all inspection data into PCCP database**
  - **TM OOP-PCCP-8140-RA-2019-1**
    Risk Analysis Process for Prestressed Concrete Cylinder Pipe

PCCP Inventory

- **Tabular inventory of Reclamation-owned PCCP**
- **Collected:**
  - **Basic pipe specs: age, diameter, length, operating pressure**
  - **Design data, as-built drawings, specs**
  - **Inspection reports**
  - **Monitoring or cathodic protection details**
  - **Details of repairs/replacements**
- **Data linked to GIS-Viewer**

Region	State	Project	# PCCP Sections	Length (miles)	Construction Year(s)
LC	AZ	Ak-Chin Indian Water Rights Settlement	3	15.7	1981
LC	AZ	Central Arizona	21	23.5	1980-1992
LC	AZ	Salt River	3	0.5	1992
MP	CA	Central Valley	9	27.3	1986-1987
MP	CA	Ventura River	3	2.5	1958
PN	WA	Columbia Basin	1	0.4	1976
UC	CO	Dolores	7	18.5	1982-1992
UC	UT	Central Utah	1	0.2	1987
		TOTAL:	**48**	**89**	

PCCP Web-based Geospatial Viewer

- **Confirm all PCCP on map (start and end locations only)**
  - **Tool: visualize PCCP locations and identify those in proximity to high risk areas (high population, gas/power lines, etc.)**
- **Populate Master Table**
  - **Tool: manually query database to find high-risk sections (i.e., search for any pipe with max press > 650 and # breaks > 15)**
- **Tie Master Table to Graphic Data Table**
  - **Tool: query database and then locate exact pipe on map**
  - **Tool: snapshot summary box for each pipe**
- **Collect and Tie Relevant Documents to Database (ongoing)**
  - **Tool: access documents associated with a given PCCP section directly from map**
- **Stationing and Association with # of wire breaks (future work)**
  - **Tool: visualize wire breaks along pipe layout on map; see if breaks are dispersed or clustered**

PCCP Viewer Demo

Resources

- **TSC – Materials and Corrosion Laboratory (S&T Research Projects)**
  - **POCs Jessica Torrey and Matt Jermyn**
  - **Project ID 7108: Critical Review of PCCP at Reclamation**
  - **Project ID 19275: PCCP Inspection Truthing and Educational Demonstration**

- **TSC – Water Conveyance Group (EM Inspection Coordination)**
  - **POCs Kylie Pelzer and Chris Duke**

- **Policy Office – Asset Management Division (Inspection Contract and Viewer)**
  - **POC Nick Casamatta**

- **Corrosion Webinar Series**

Questions/Comments/Discussion

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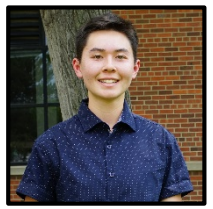

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