

Well Casing Integrity Cathodic Protection Evaluation

Presented by:

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BASS

Corrosion (the enemy)

The deterioration of a substance (usually a metal) or its properties because of a reaction with its environment.

AMPP Definition

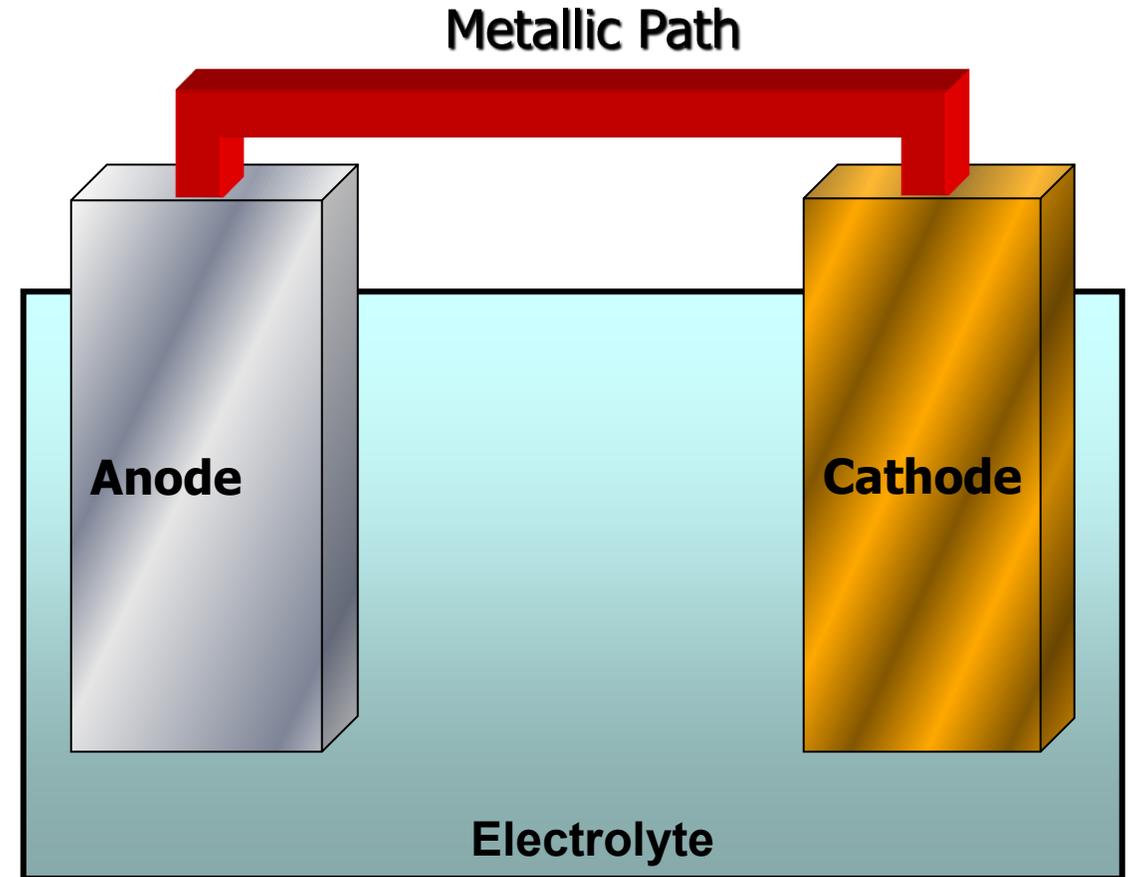


While energy is necessary to convert ores into metal, corrosion of these metals requires no supply of energy.

Corrosion; Electrochemical Cell

4 COMPONENTS:

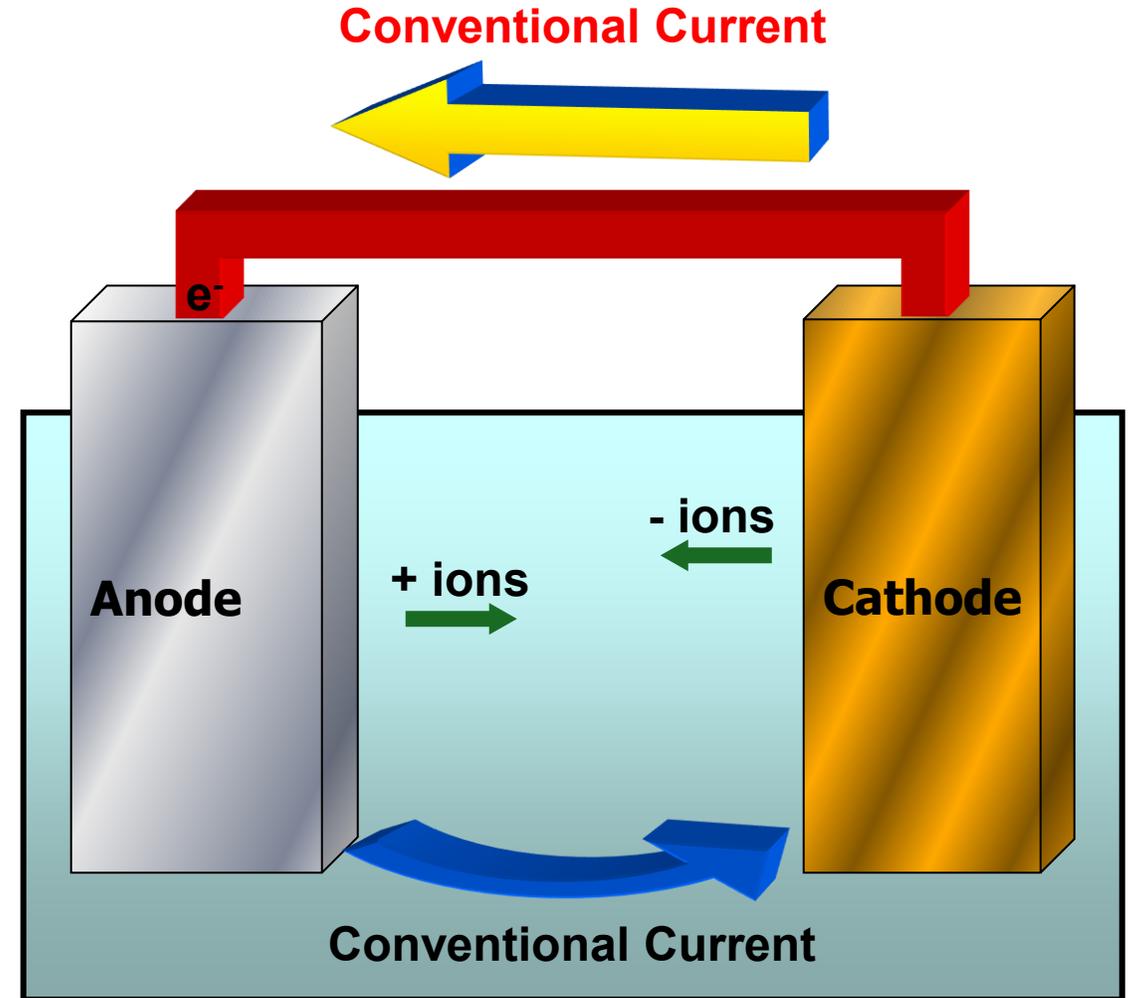
1. **Anode** – Corrosion
2. **Cathode** – No Corrosion
3. **Metallic Path** – Electrical connection /electron path
4. **Electrolyte** – Common conductive medium / ionic path



Corrosion; Electrochemical Cell

Corrosion Electrochemical Process

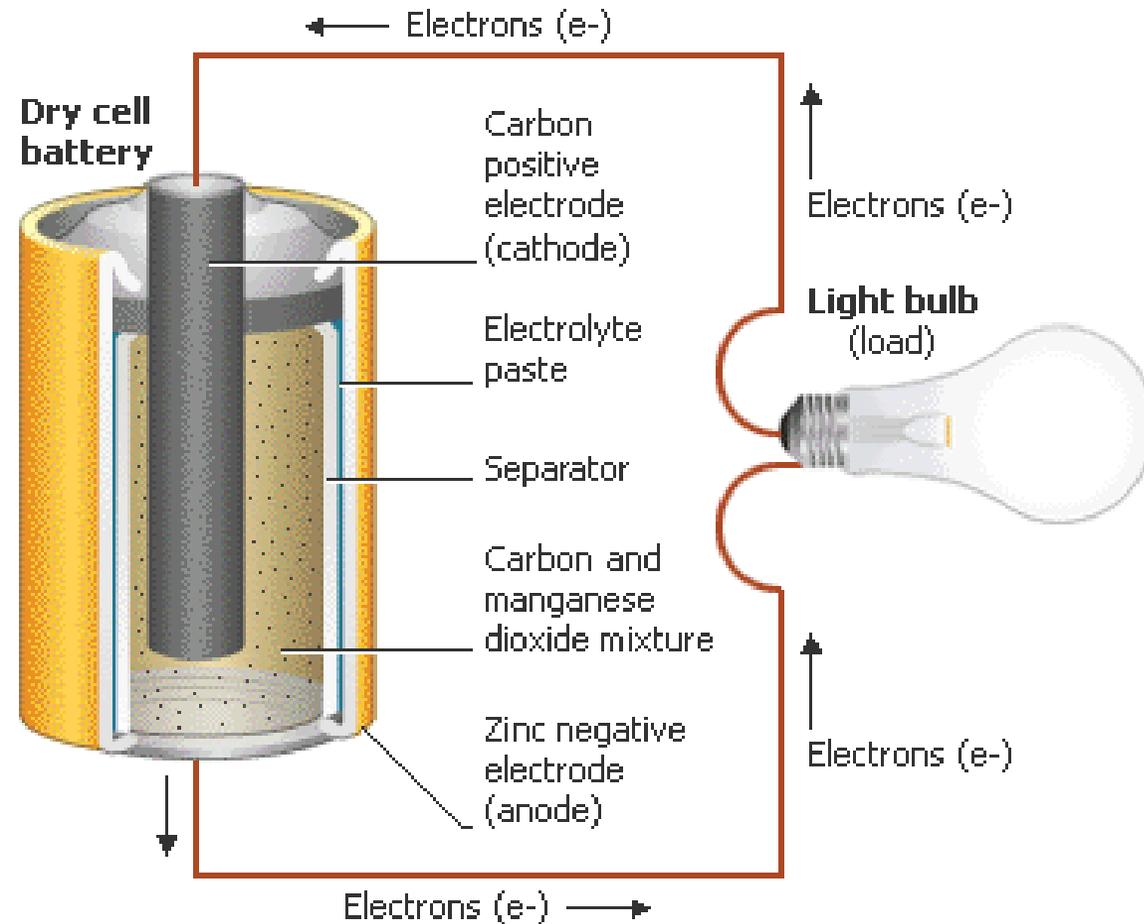
- Electrons flow from high-energy to low-energy (through the metallic path)
- Ions flow in the electrolyte.
- Oxidation occurs at the anodic site.
- Reduction occurs at the cathodic sites.



Useful Electrochemical Cells

4 COMPONENTS

1. Anode
2. Cathode
3. Metallic Path
4. Electrolyte



Dissimilar Metals Create Corrosion Control Challenges!!



Bi-Metallic Couples: Galvanic Series

Pipeline Integrity Assurance—A Practical Approach

TABLE 4-2. Typical potentials for selected materials in neutral soil referenced to a Cu/CuSO₄ electrode

Material	Potential Volts
Magnesium	-1.75
91Mg-6Al-32n-0.15Mn	-1.55
Zinc	-1.1
95Al-5Zn	-1.05
Aluminum	-0.8
Anode Steel (clean)	-0.5 to -0.8
Steel (rusted)	-0.2 to 0.5
Gray cast iron	-0.5
Lead	-0.5
Steel in concrete	-0.2
Cathode Copper, brass, bronze	-0.2
High-silicon cast iron	-0.2
Mill scale on steel	-0.2
Graphite (carbon)	+0.3

Peabody's Control of Pipeline Corrosion, Second Edition 2001

Consumption Rates



- Faraday's Law

- $W = Kit$

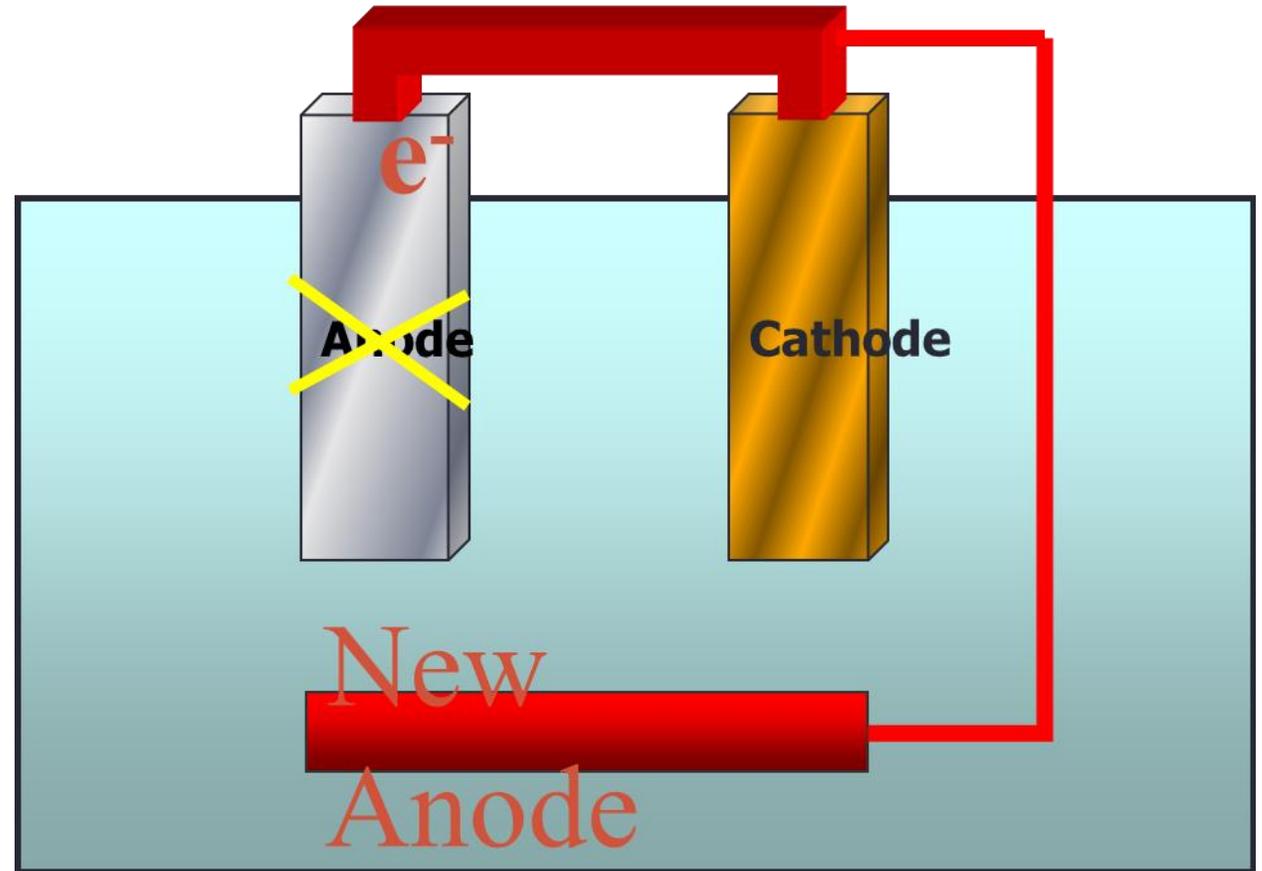
- W = Weight Loss (lbs)
- K = Electrochemical Equivalent (lbs/Amp-Year)
- i = Current (Amps)
- t = Time (Years)

- Metal Loss?

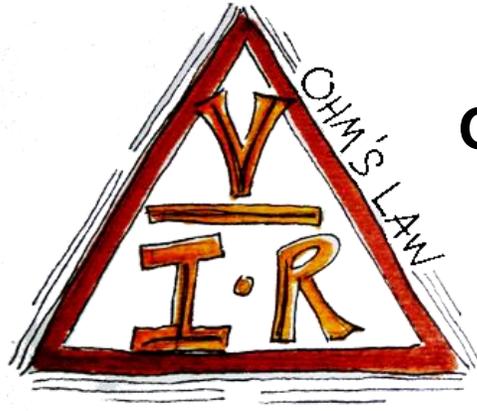
- **Steel: $K = 20.13$ lbs/amp-year**

Corrosion Control

- Material Selection
- Coatings & Linings
- Inhibitors
- Cathodic Protection (CP)



CP Systems



GALVANIC (GCP)

- No External Power Source Required
- Low Installation Cost
- Low Maintenance Cost
- Limited Current Output
- Limited Driving Potential
- Low Soil Resistivity Required



IMPRESSED CURRENT (ICCP)

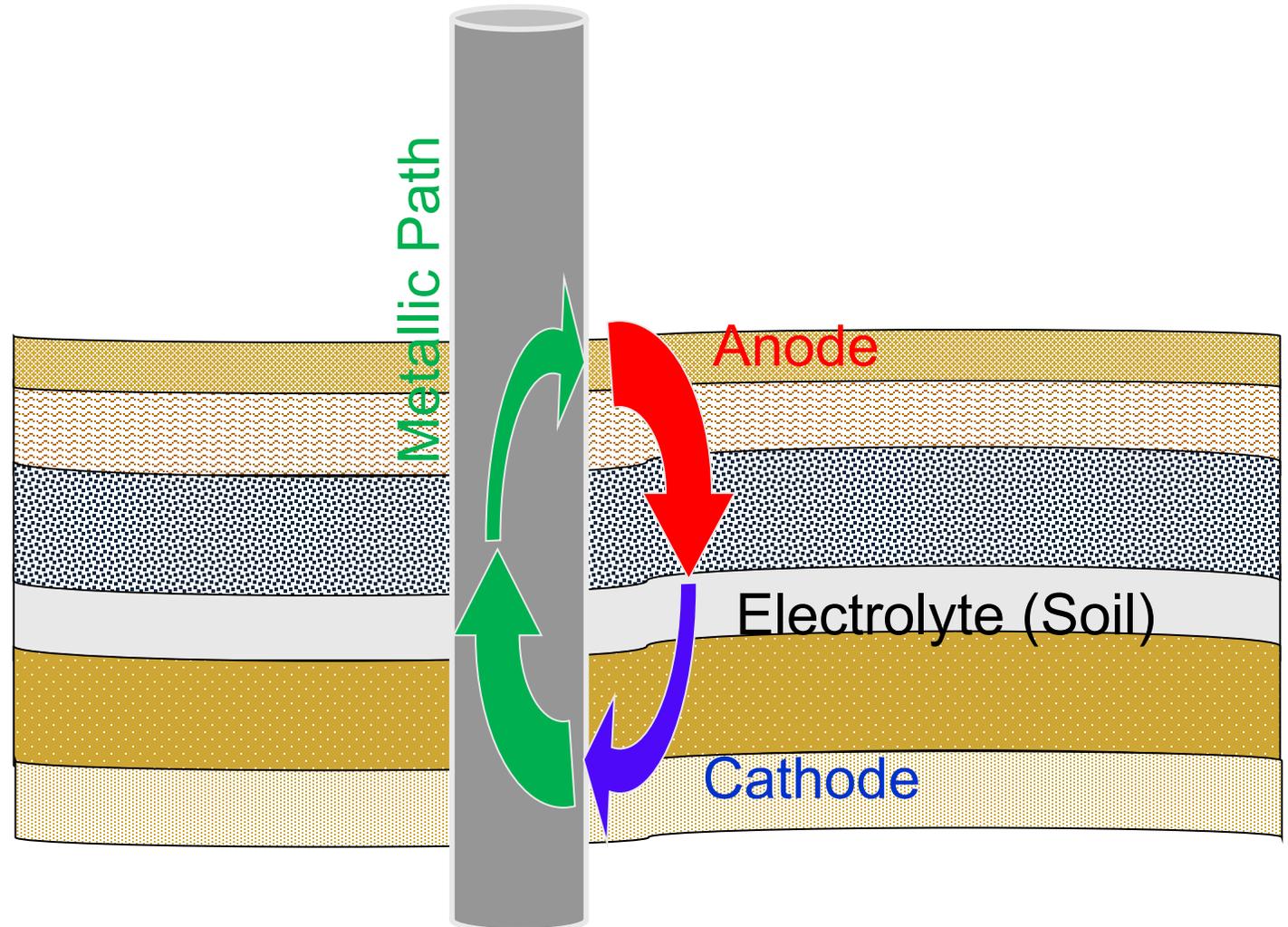
- Designed Current Output
- Designed Driving Potential
- Higher Installation Costs
- Higher Maintenance Costs
- Power Source Availability



Corrosion & Well Casing Integrity

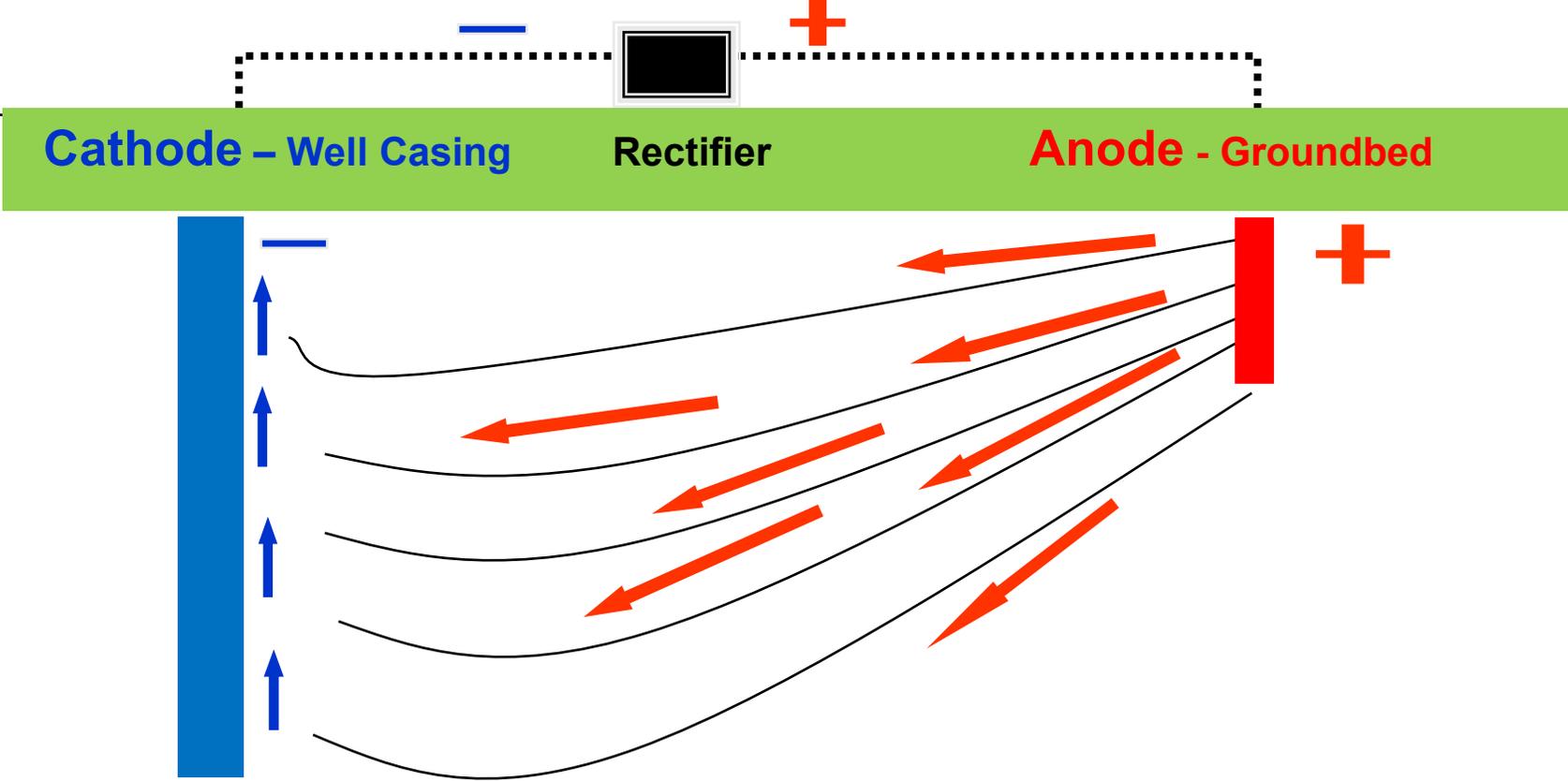
4 Components

1. Anode
2. Cathode
3. Metallic Path
4. Electrolyte



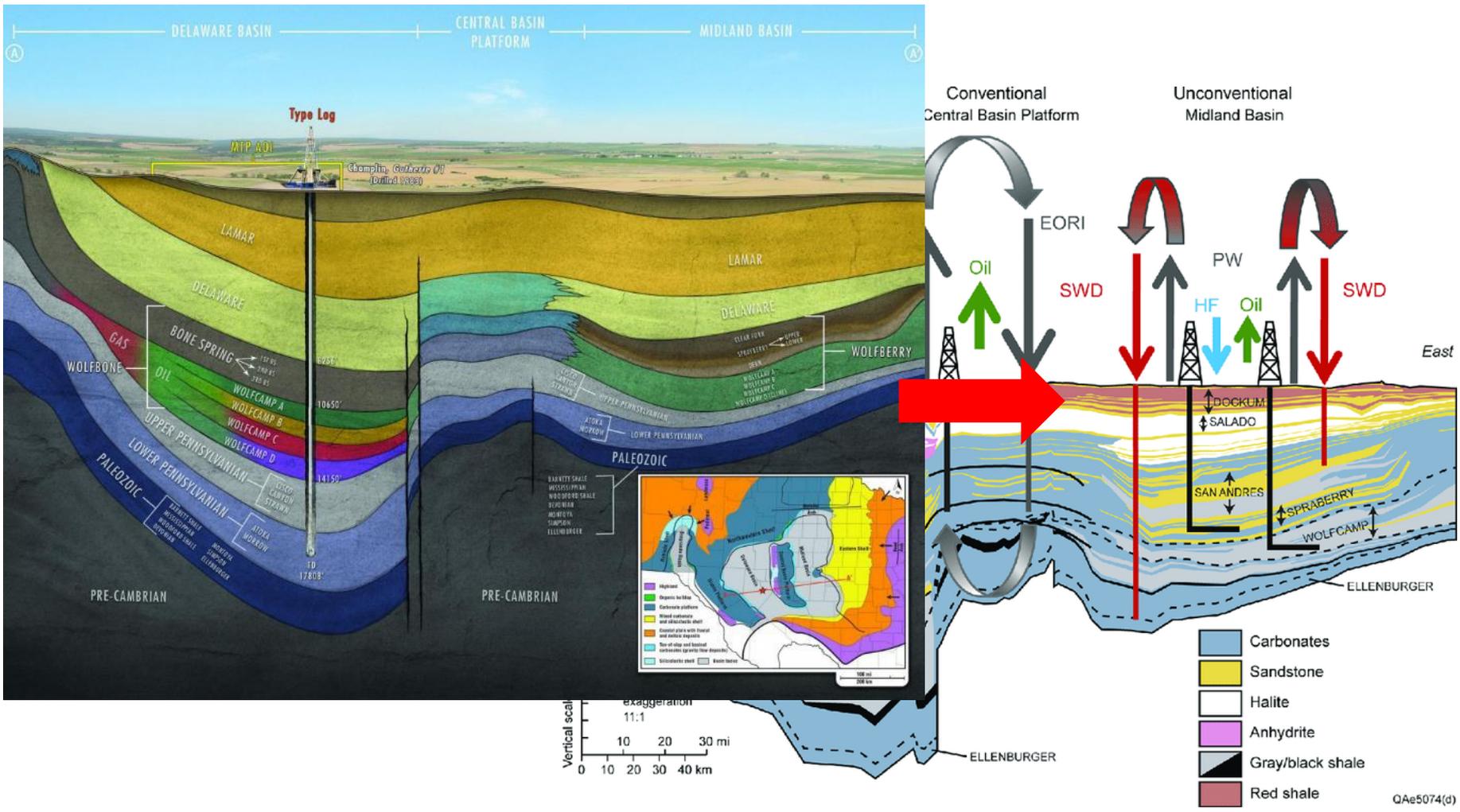
Cathodic Protection Application for Well Casings

- Carefully Designed Electrochemical Cell
 - Provide Consumable **Anode**
 - Make the Entire Structure the **Cathode**



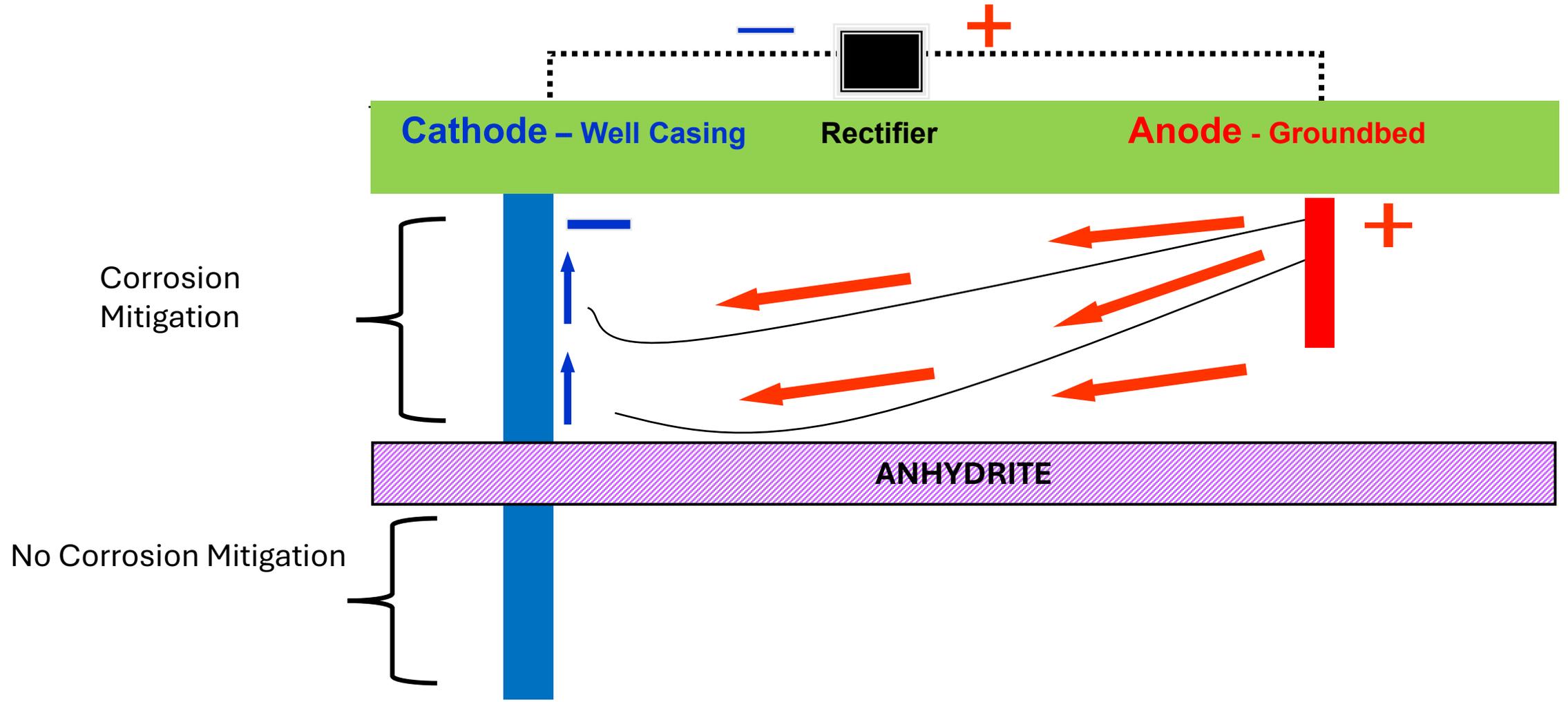
Delaware Basin

Water Disposal & Shallow Anhydrite Formations



Confidential - Internal Use Only

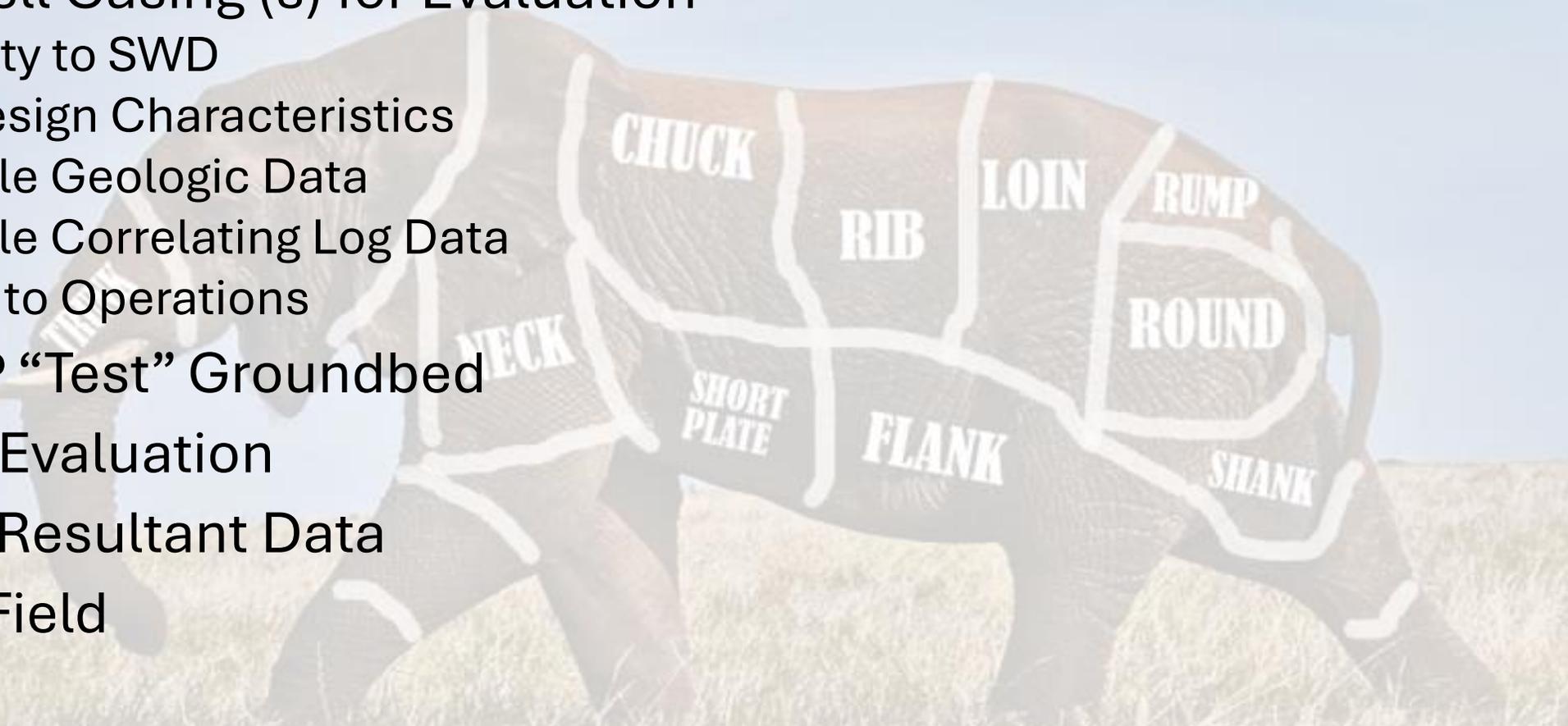
Cathodic Protection: Can We Reach the Target?



- Section 3: Determination of Need for CP
 - Asset design life
 - Economics
- Section 4: Criterion for CP and Current Requirement
 - Adequate when all anodic areas have been eliminated...
 - Current requirement
 - Profile tool
 - E-log-I
- Section 5: Design of CP Systems for Well Casings
- Section 8: Operation and Maintenance of CP Systems
 - Inspection methods and frequency

How do we do this? (One bite at a time)

- Select Well Casing (s) for Evaluation
 - Proximity to SWD
 - Well Design Characteristics
 - Available Geologic Data
 - Available Correlating Log Data
 - Impact to Operations
- Install CP “Test” Groundbed
- Conduct Evaluation
- Evaluate Resultant Data
- Apply to Field



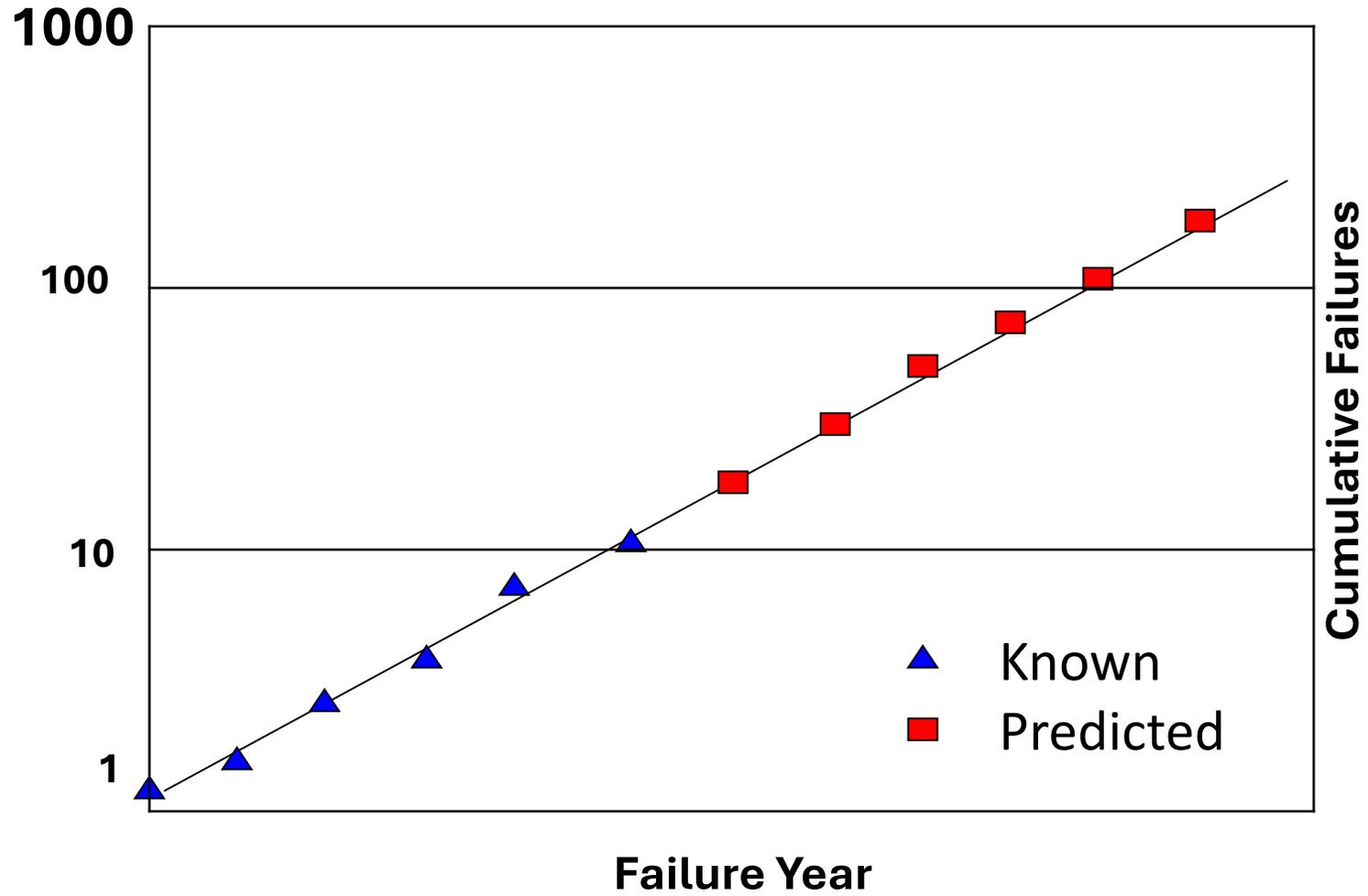
Cathodic Protection of Well Casings

- Application dates to 1940's
- Standard practice for major operators in long-life fields
- Domestic activity high through 1980s
- Use of CP for casings reduced as domestic production declined
- CP is primary method of controlling soil-side corrosion

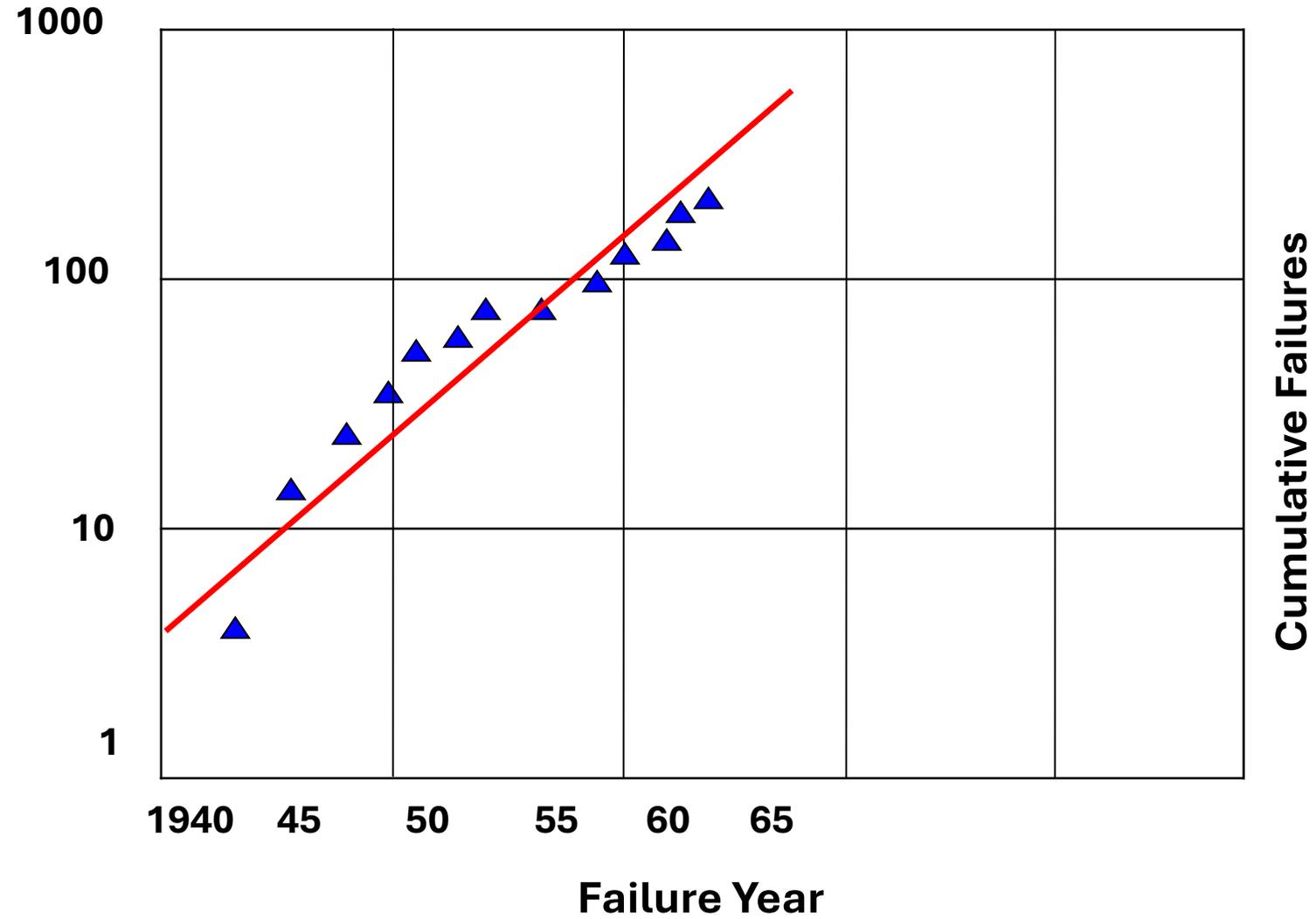
Leak Frequency Data

- Plot cumulative failures (y axis; log scale) vs time (x axis)
 - Allows for predictive analysis
 - Allows for economic analysis given average casing repair cost

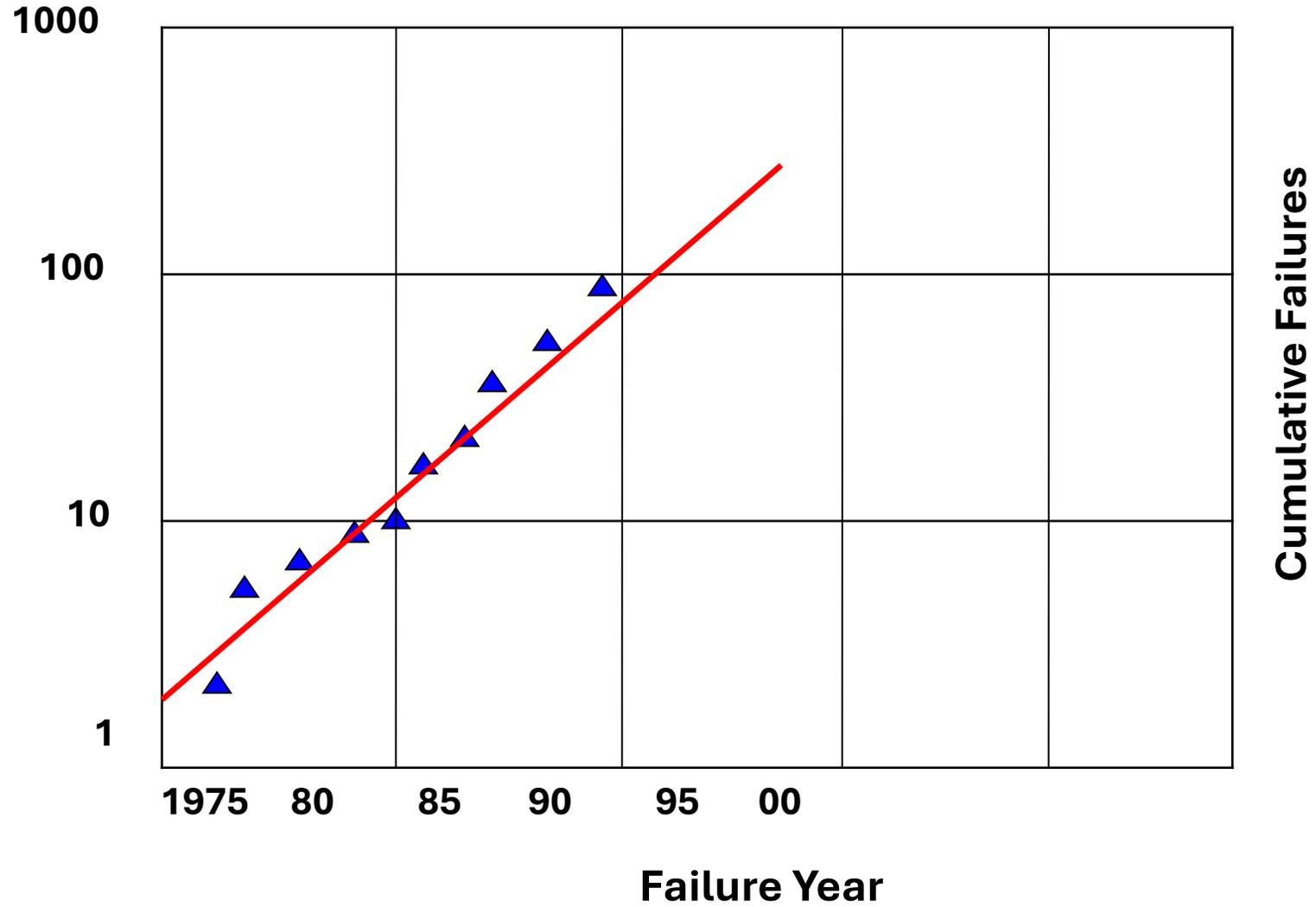
Casing Leak Frequency



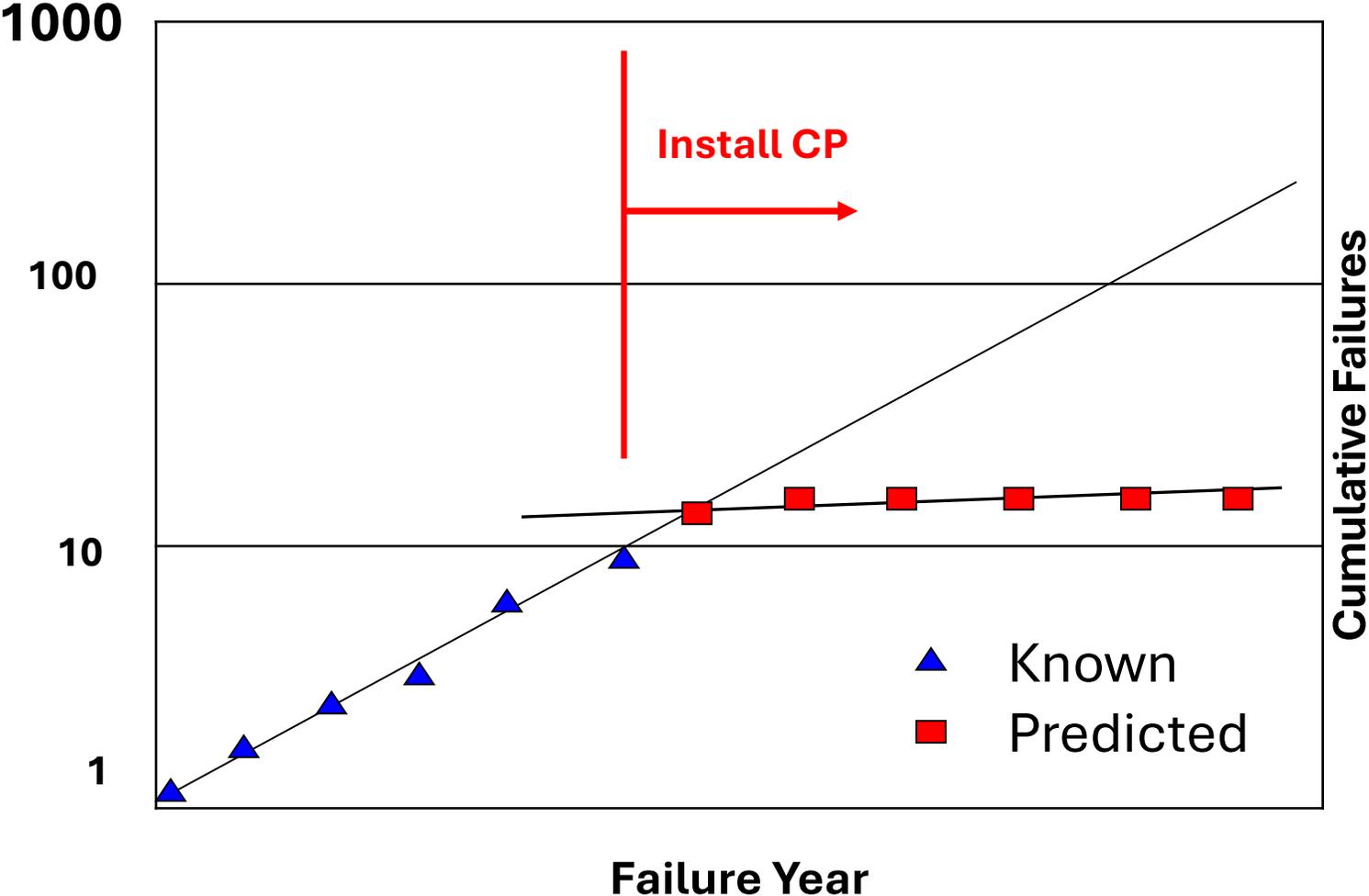
Western Kansas



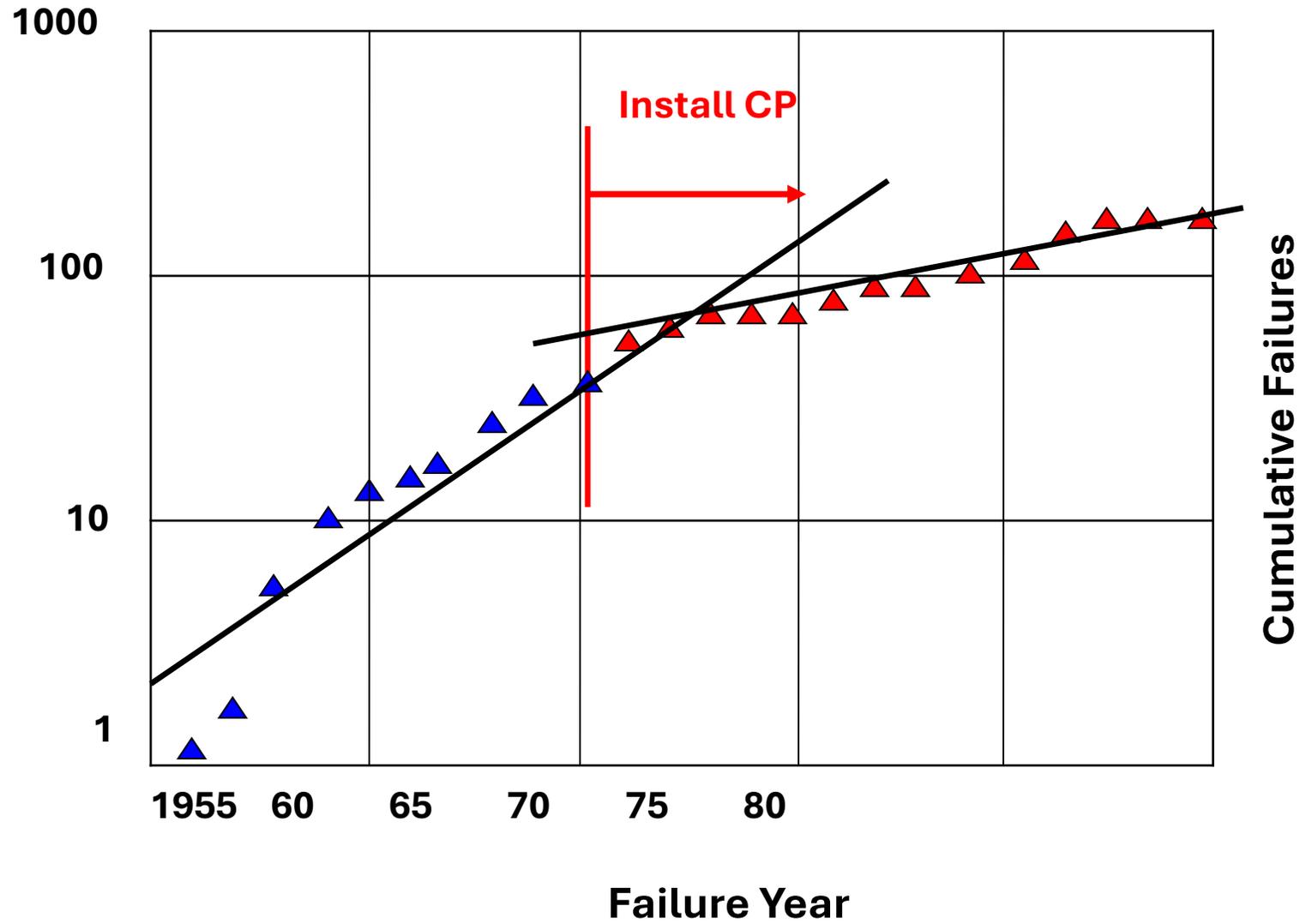
Arabian Gulf



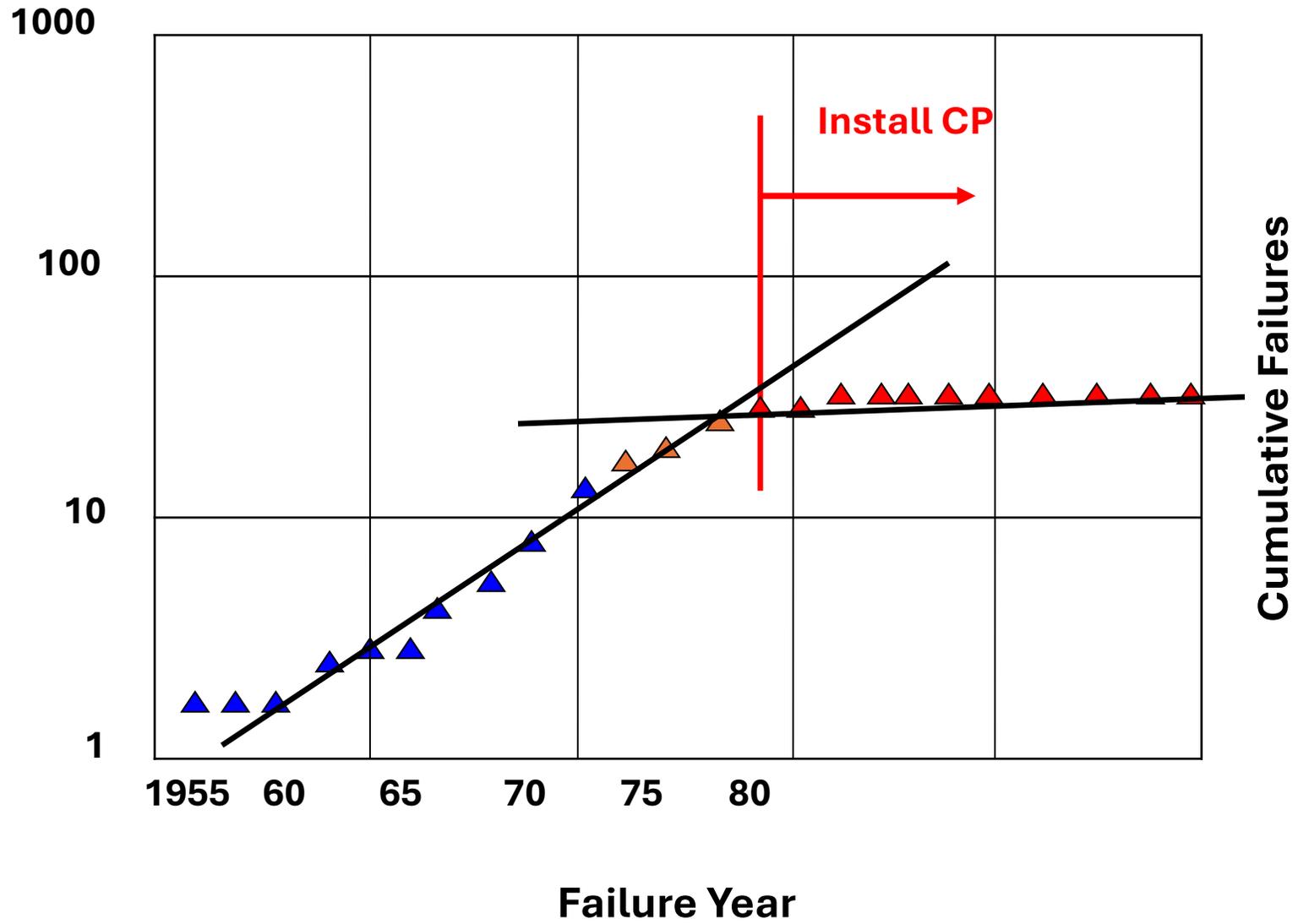
Effect of Cathodic Protection on Leak Frequency



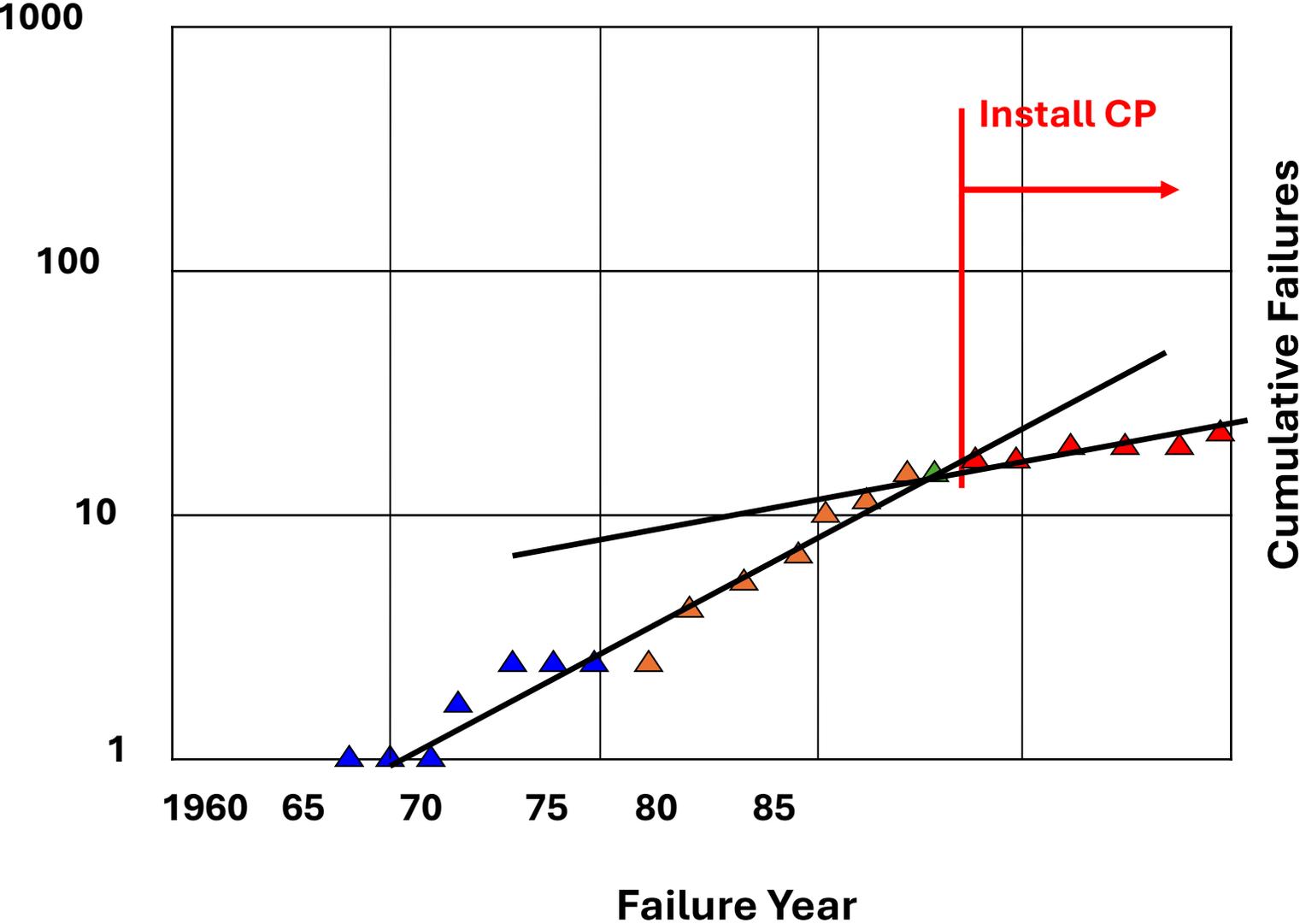
Jameson Field



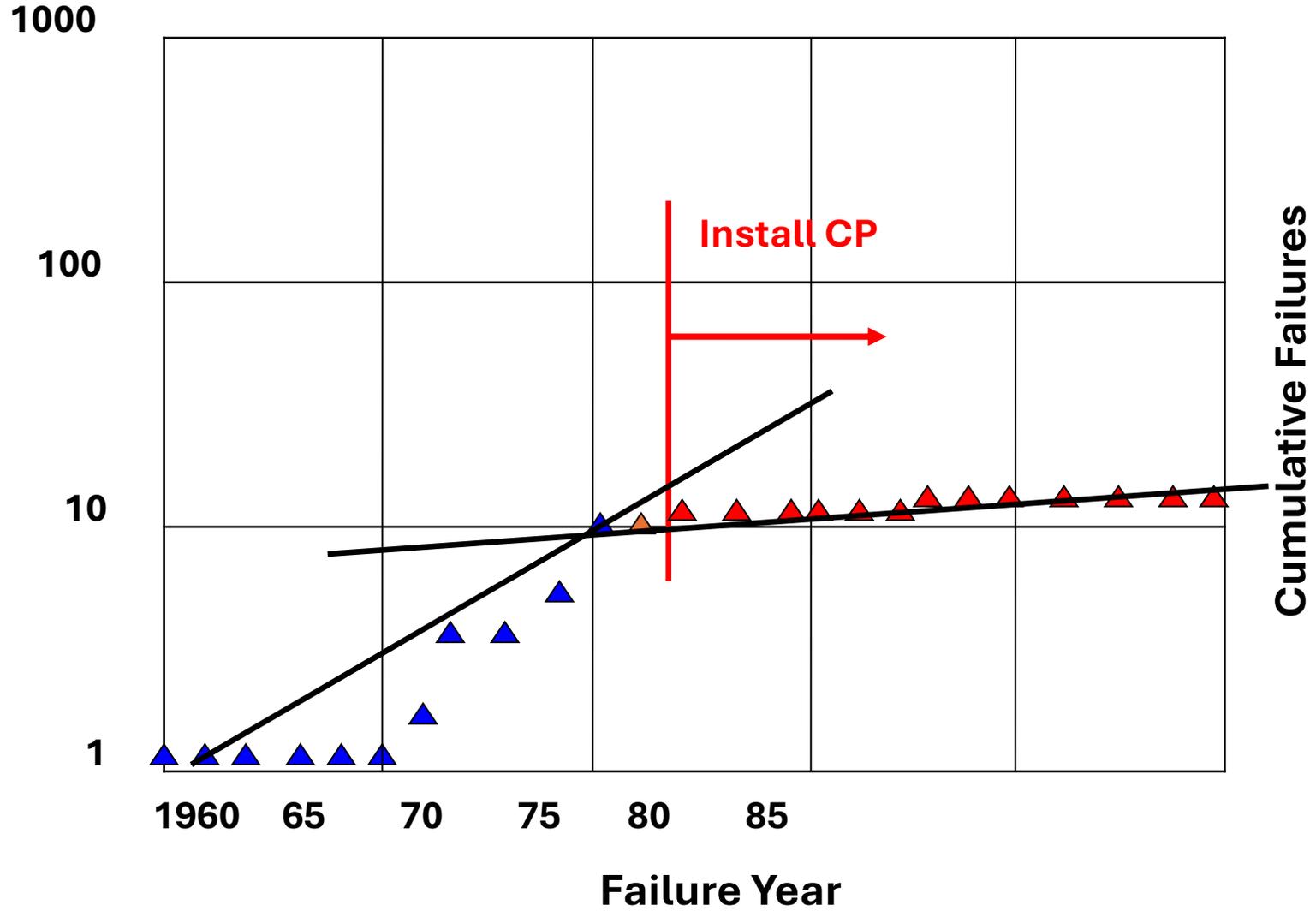
Sun Field



East Goldsmith Unit

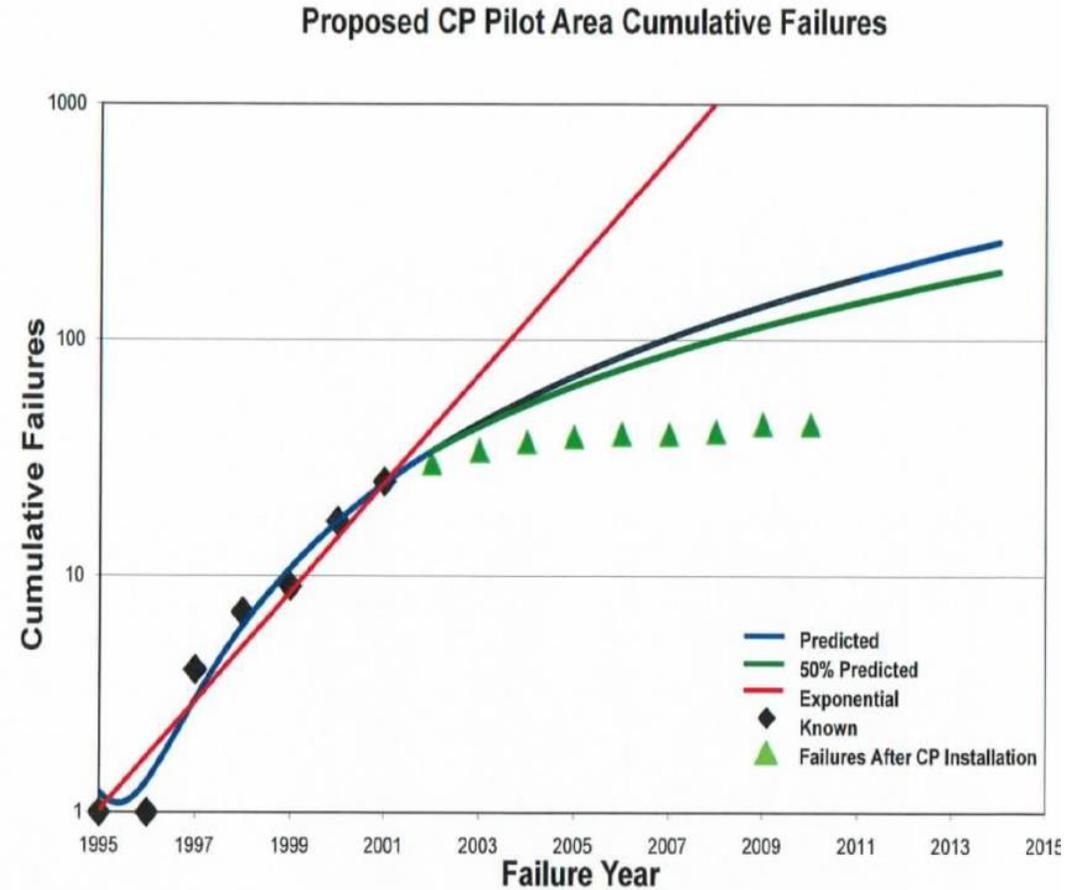


Hitts Lake Unit



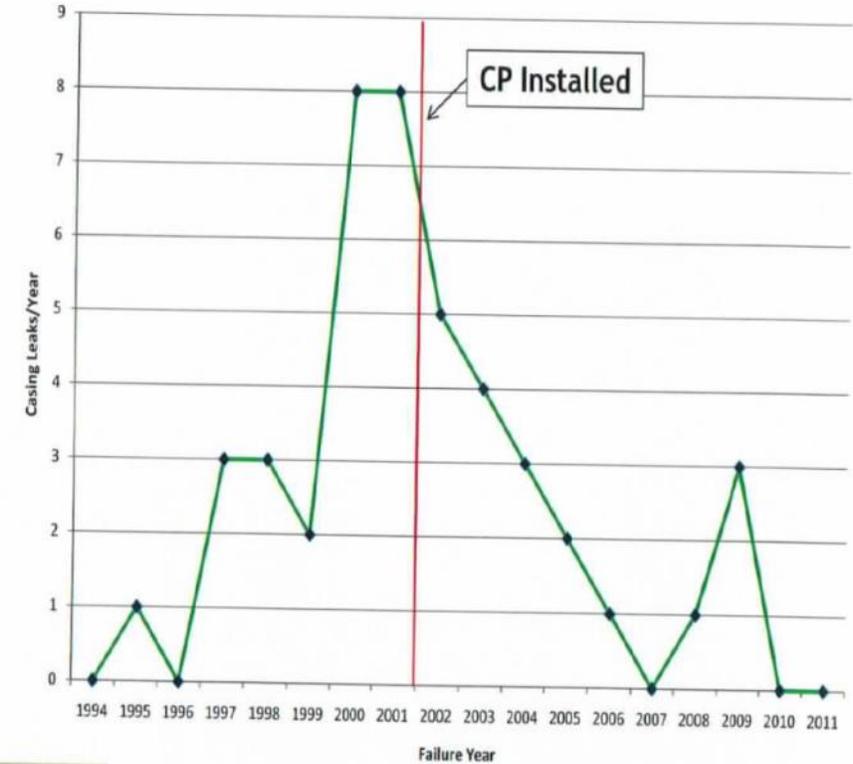
2002 Well Casing CP Evaluation

Pioneer Natural Resources
Spraberry Field



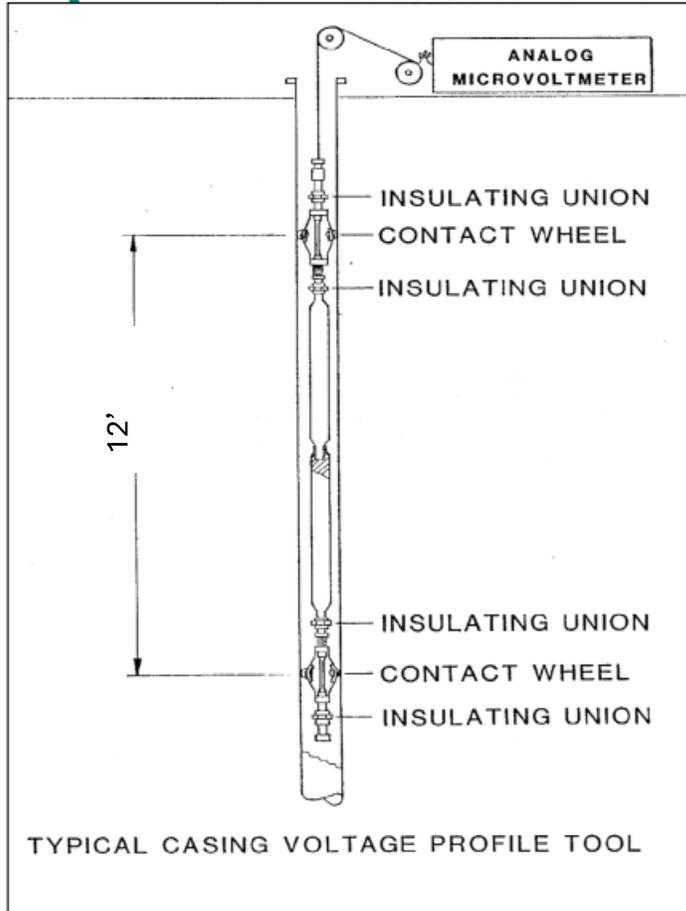
2002 Well Casing CP Program

Pioneer Natural Resources
Spraberry Field



Baker Hughes

Casing Potential Profile (CPP) Tool

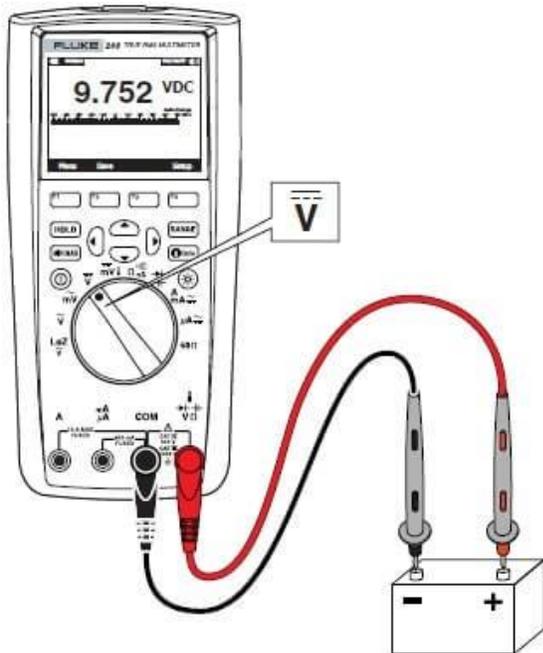


CPP Contacts

2 Arrays of 3 Each Metallic Contacts

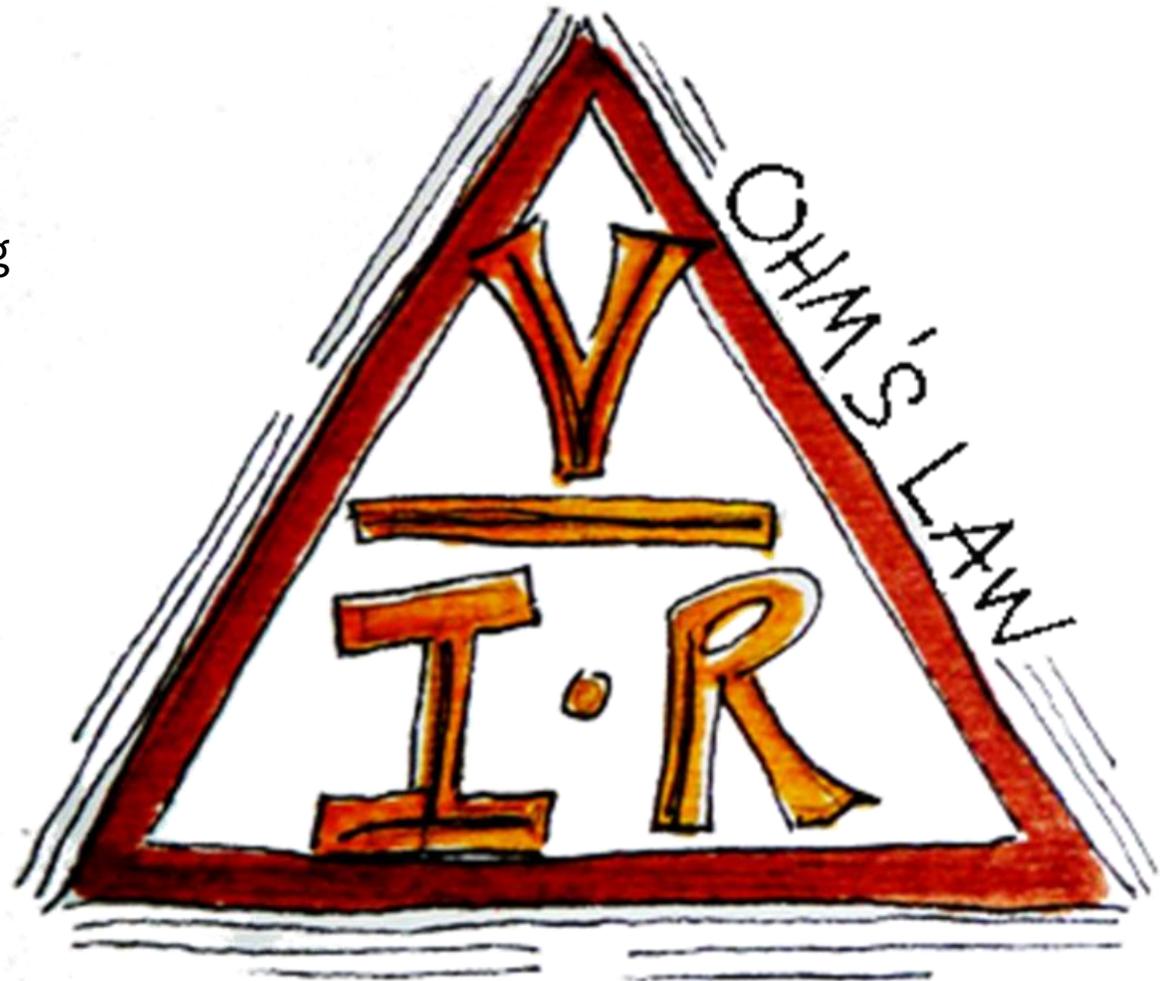
Bottom Set Designated as (+)

Top Set Designated as (-)



Tool Operation

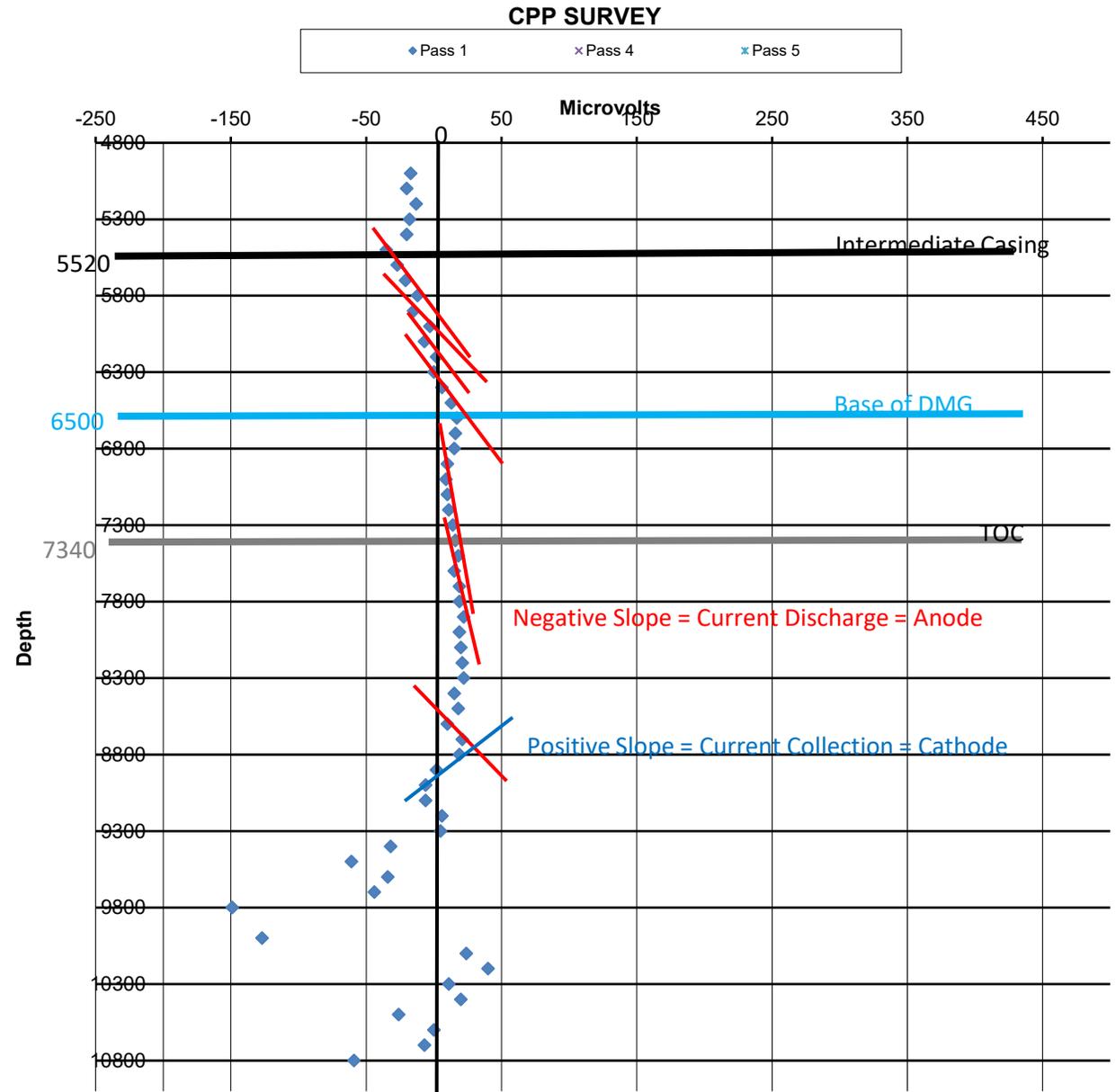
- Multiple Voltage Measurements (μV) Between Contact Arrays
 - Measurements recorded @ 100' spacing
 - Voltage measurements correlate to dc current flow on the casing



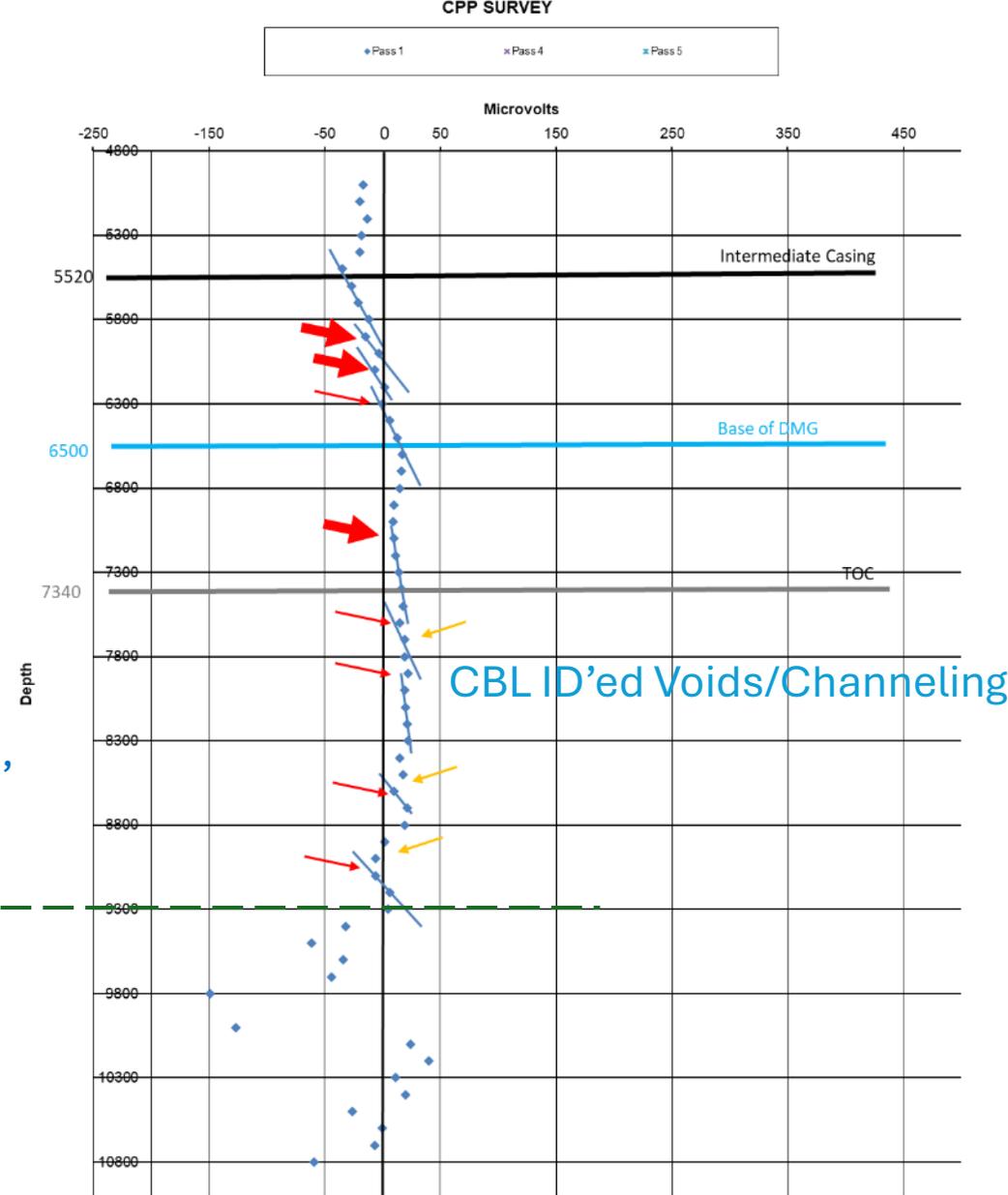
CP Test Equipment



CPP Analysis 101



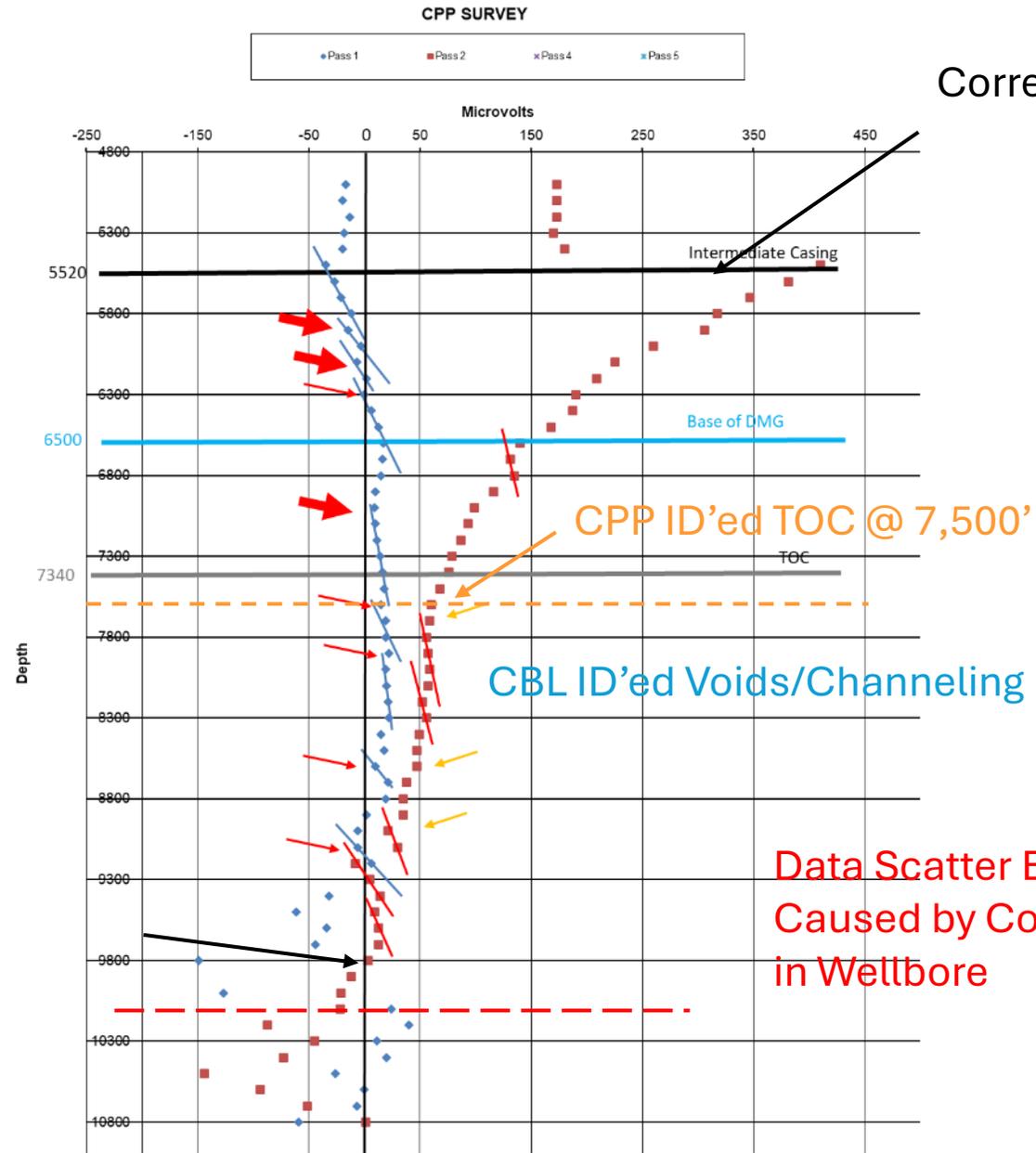
CPP “Native State”



Data Scatter Below 9,300'
Caused by Conductive
Fluid in Wellbore

CPP "1st CP Pass" @ 4 Adc

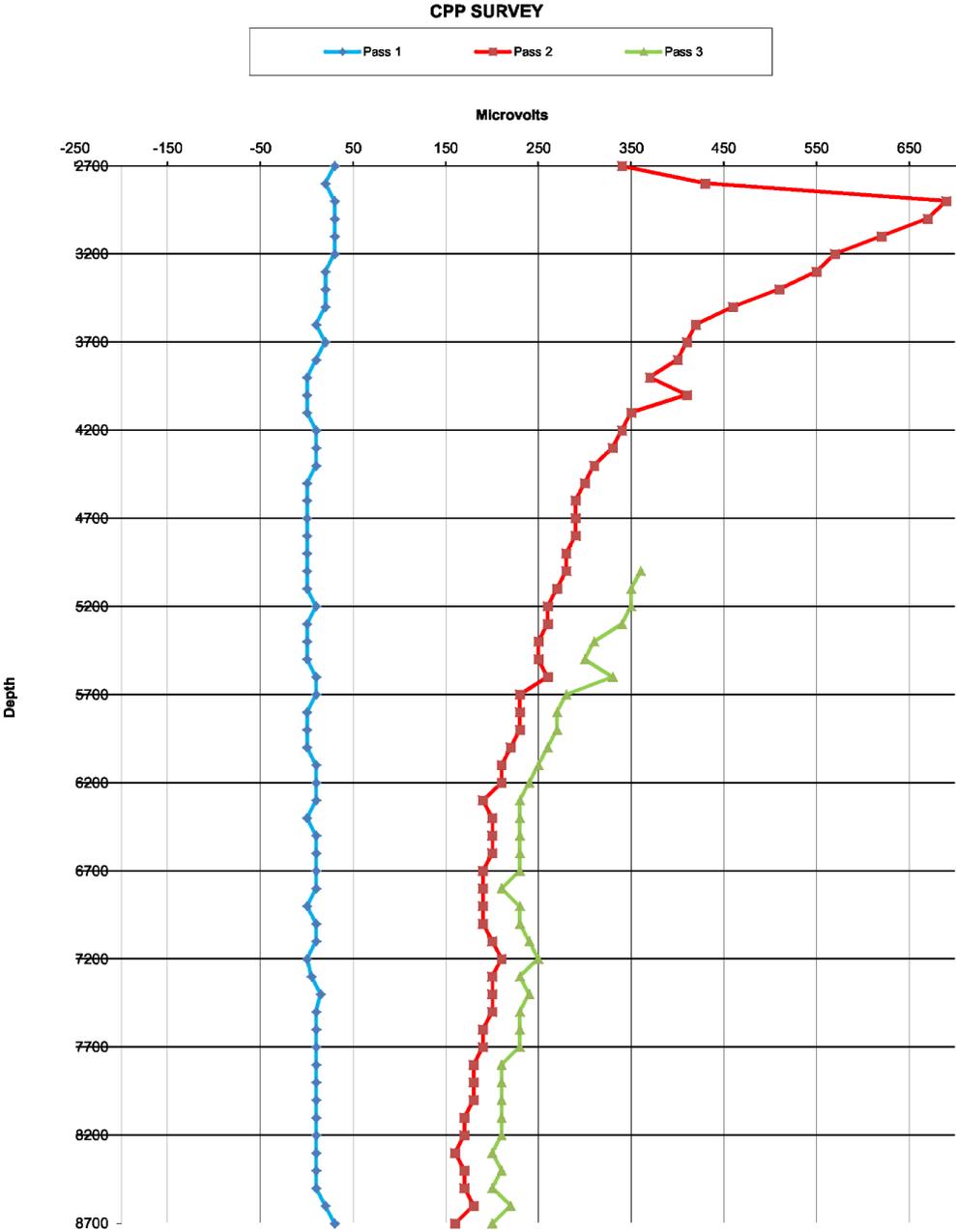
Correlation to ID'ed IC



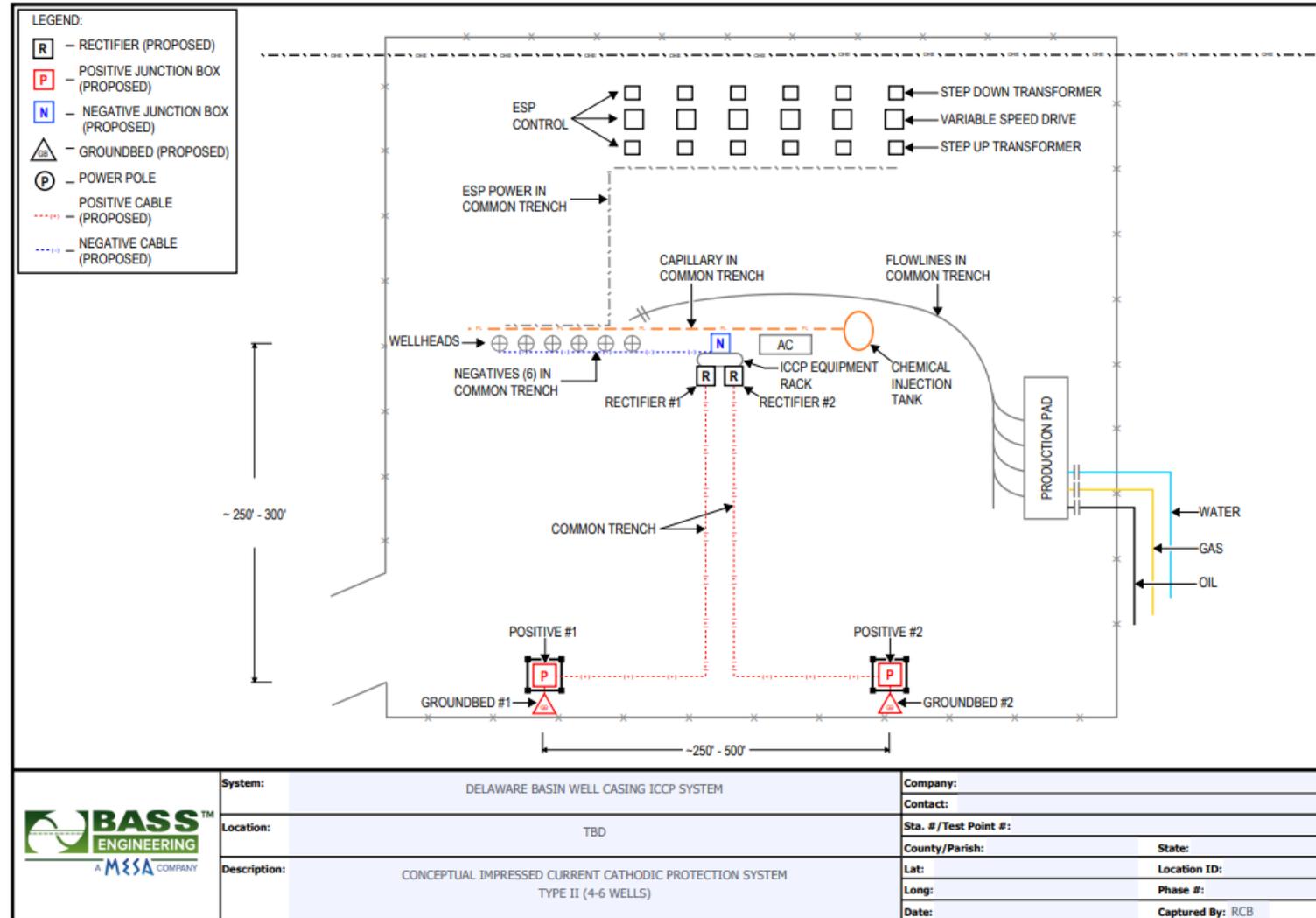
Shifted dc Current (+) to 9,800'

Final Product

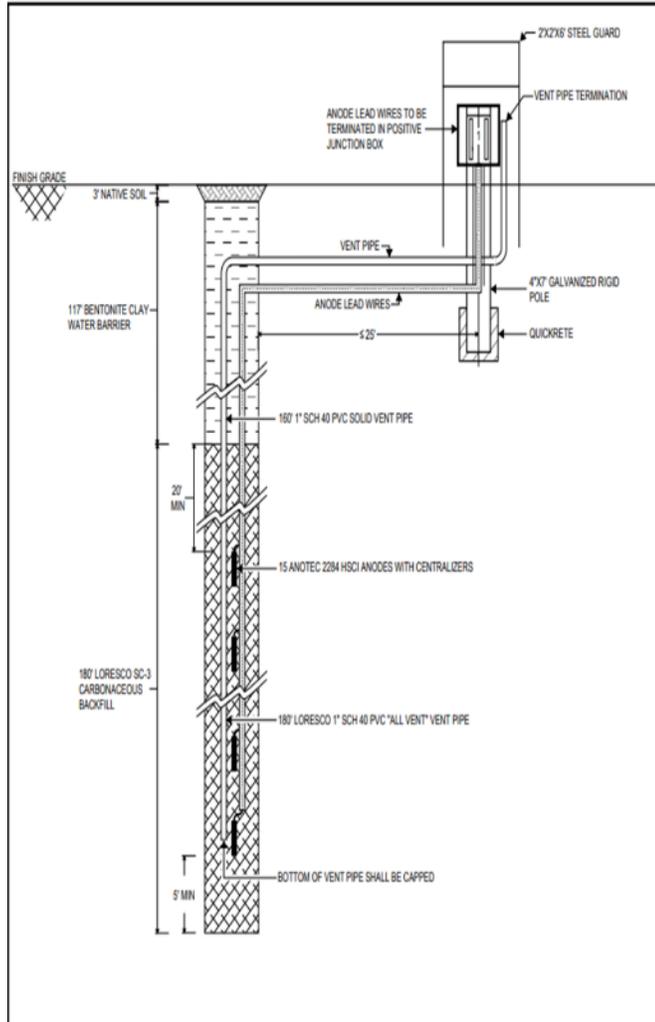
- PASS 1 (BLUE):** Native state voltage log before applying cathodic protection. Indicates current coming and going across the casing to soil interface.
- PASS 2 (RED):** With cathodic protection current applied. This shows success in applying cathodic protection current to depths beyond 9,000' deep.
- PASS 3 (GREEN):** With increased cathodic protection current. Indicates improved voltage response which will allow the ability to improve corrosion control by applying additional current if necessary.



Conceptual ICCP System



Well Casing CP System Concept



BASS

Questions / Comments

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