El Vado Dam Rehabilitation Case Study: Coatings & Cathodic Protection

Chrissy Henderson, Ph.D., P.E.
Materials and Corrosion Laboratory
chenderson@usbr.gov
7303-445-2348

Daryl Little, Ph.D.
Materials and Corrosion Laboratory
dlittle@usbr.gov
303-445-2384
• El Vado Dam is located on the Chama River in north central New Mexico

• Construction completed in 1935 by Middle Rio Grande Conservancy District

• Transferred to BOR in the 1950s

• Cathodic Protection added in the 1980’s.

• Faceplate is steel lined and needs new Cathodic Protection system.

• Radial Gate will be newly installed and needs Cathodic Protection.
Recap

Not the best location for a dam. Geological instability with seepage and erosion issues.

The location is right in the middle of a landslide zone.

A major contributing factor for the rehabilitation work
Recap

One of the few steel faced rockfill dams in the country.

• Substantial settlement along the dam.
• Expansion joints of faceplate are cracked and allow water to seep through.
• Voids underneath the faceplate.
• Deformations and distress are occurring on the faceplate.
Recap

• The steel plating hasn’t lost much thickness, via ultrasonic testing.

• To reduce the seepage issues a **PVC geomembrane** was selected. The top 88% of the Dam will be lined.

• The geomembrane will tie into the Cathodic Protection work that will be shared with you in this webinar. CP will be protecting the area that is not lined with the geomembrane.
Coatings Replacement (~1950s)

Not re-coating the faceplate.
For Cathodic Protection design we will treat the faceplate as bare!
Cathodic Protection

CP system was not installed until the 80’s. El Vado went about 50 yrs without CP.

Being replaced.
El Vado Dam
Cathodic Protection
Current Cathodic Protection System:

Faceplate, Steel Spillway, Spillway Radial Gate

- Impressed current cathodic protection (rectifier).
- 2 rectifiers with multiple horizontal anode beds per rectifier on left abutment.
- 3 rectifiers with multiple horizontal anode beds per rectifier on right abutment.
- 8 total horizontal groundbeds
Unknown owner of land

horizontal ground beds

Current rectifiers
New System

- Two separate systems instead of one.
  - Galvanic for gate
  - ICCP for faceplate

- Galvanic system for the radial gate along spillway wall.

- Rectifiers for ICCP in one location.

- Groundbeds for ICCP on hillside.
New ground bed locations, in large field

Location of new rectifiers on outer wall of control building
New Cathodic Protection Systems
(two separate systems)

1. Faceplate
   • Geomembrane will cover 88% of the faceplate surface.
   • Consider structure bare for the design.
   • Coating will not be replaced.
   • Very large bare area to protect.
   • Impressed current cathodic protection (rectifier).

2. Spillway Gate
   • New spillway is concrete, not steel.
   • Cathodic protection is for the gate ONLY
   • Gate will be coated.
   • Galvanic anode cathodic protection system (sacrificial magnesium anodes)
   • Anodes are located at a distance from the gate rather than via direct mount.
El Vado Dam Faceplate
Cathodic Protection
Deep Well Anode Bed

- Vertical rather than horizontal
- Groundbed resistance – designed so that resistance is low. Number of groundbeds and outputs need to be optimized.
- Groundbed discharge capacity should not be exceeded otherwise it will dry out anode bed.
- Spread out deep wells to mitigate mutual interference between them!!!
Deep well vs horizontal groundbed

• Less ground taken up, dig down vs. out.
  • Easier to get anode bed remote from structure.
  • Beneficial for limited ROW situations.

• Deep well can be treated like one very large anode with backfill dimensions.

• Can spread out easier to minimize mutual interference.

GACP, Mesa Verde National Park, 2013

ICCP, Vertical groundbed installation
Impressed Current Anodes

Option 1:
High Silicon Cast Iron
12 total anodes per deep well

Option 2:
Mixed Metal Oxide
12 total anodes per deep well

Farwest Corrosion Control website
Cable attachments to faceplate

Specific molds-
• Orientation
• Material type for bonding
• Uses powder and lighter for heat source

Bonds CP cable to metallic surface
Cable attachments to faceplate

- Exothermic weld locations
  - left, middle, right
  - underneath geomembrane
Cable attachments to faceplate

Multiple attachment points per location-
  • Redundancy
  • Minimizes attenuation of CP current
  • Decreases cable resistance in the circuit

Right, Left, and center of dam faceplate at the top near the road will have exothermic welding for the CP system
Cathodic Protection Challenges

Large bare surface area-
  • Need a lot of current
  • Structure resistance vs. Surface area (takes more to protect less)

\[ R = \frac{\rho}{2d} \]

Electrolyte resistivity-
  • Voids behind faceplate can skew resistivity of soil
    • Project will involve grouting voids but unsure how effective this may be due to extent on voids and path grout may take after entering the riprap
  • Higher resistance electrolyte = harder to push CP current
  • Resistivity of soil behind faceplate changes with elevation due to changes in saturation level of the soil
  • Soil resistivity may change with water elevation changes
El Vado Dam Radial Gate 
Cathodic Protection
New Spillway & new radial gate

Spillway moving into hillside & widening
Spillway steel plating will be encased in concrete - no need for CP

Radial gate coating options:
• abrasion resistant epoxy, polysiloxane topcoat
Radial Gate CP System

This spillway wall will remain

CP system located on other side of bridge deck
Radial Gate CP System
Galvanic Anode System

Galvanic anode system design:
- Anode location is close to remote (far enough for even current distribution)
- Coating between anode and concrete wall to limit current collection on rebar around anode
  (options: high solid epoxy or 100% solid epoxy)
Galvanic Anodes

- High potential magnesium anodes (-1750 mV)
- Size, number, dimensions chosen based on design needs for system
Current Status and Construction Schedule of El Vado Rehabilitation

• Mobilization ~ March 2022
• Grouting ~ May 2022 – March 2023
• Geomembrane Installation ~ May – Sept 2023
  • Two phase plan
• Demolition intake and crest ~ Oct – Nov 2023
• Demolition spillway chute ~ Oct 2023 – March 2024
• Installation gate CP ~ Jan 2026
## Materials & Corrosion Lab Capabilities: CP & Coatings

<table>
<thead>
<tr>
<th>Lab &amp; Research</th>
<th>Design</th>
<th>Fieldwork</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Standardized and specialized lab testing</td>
<td>• Basis of Design</td>
<td>• Inspections</td>
</tr>
<tr>
<td>• Coatings evaluation</td>
<td>• Materials Selection</td>
<td>• Condition assessment</td>
</tr>
<tr>
<td>• Lab-scale coating application</td>
<td>• Specifications</td>
<td>• CP system testing</td>
</tr>
<tr>
<td>• Coatings and CP research</td>
<td>• Quantities</td>
<td>• Rectifier inspection</td>
</tr>
<tr>
<td></td>
<td>• Drawings</td>
<td>• Repair/maintenance</td>
</tr>
<tr>
<td></td>
<td>• Construction support</td>
<td>• Installation</td>
</tr>
<tr>
<td></td>
<td>• AE reviews</td>
<td>• QA/QC</td>
</tr>
</tbody>
</table>

![Lab & Research](image1)
![Design](image2)
![Fieldwork](image3)
Questions?