Rehabilitation of Lafayette Aqueduct No. 1

Marisa Boyce, P.E.

October 1, 2013

CA-NV AWWA AFC 2013
Outline

- EBMUD Background
- History of Lafayette Aqueduct No. 1
- Studies
- Temporary Repairs
- Long-term Plans & Next Steps
EBMUD Service Area
Lafayette Aqueduct No. 1
Leakage History

- Leakage problem started almost immediately after the aqueduct was put into service in 1929
- Established leakage problem is seasonal
- Leakage problem primarily due to thermal strains and absence of expansion joints
Repair & Inspection History

1920
- 1929 In-service
- 1932 1,316 Repair Locations

1940
- 1951 125 Repair Locations

1960
- 1960 Relocation of Pleasant Hill Tunnel No. 1 & Section of aqueduct at First Street due to accommodate Highway 24 construction
- 1968 9 Repair Types at 69 Locations

1980
- 1989 3 Locations using water-activated epoxy injection
- 1990 9 Weko Seals near the Pleasant Hill Tunnel West portal
- 1994 2/94 - Oakhill Road - Exterior repair w/epoxy injection
  3/94 - Dolores Drive - Exterior repair w/epoxy injection & SS band

2000
- 2008 Install 79 Weko Seals & perform spot repairs WCEP to Lafayette Center
- 2009 315 LF Reinforced Concrete Liner w/Contact & Chemical Grout; 2,500 repairs to Lafayette Aqueduct No. 1 Tunnel

2020
- 2022 Reline Lafayette Aqueduct No. 1
1960’s Repair & Inspection

- Found 557 defects including:
  - Circumferential cracks
  - Longitudinal cracks
  - Previous gunite & mortar repairs
- Made repairs at 69 locations
1990 Repair & Inspection

- 225 locations in need of repair
- 145 Circumferential cracks sealed by Weko Seals
- Minor leakage observed at 3 joints inside PH Tunnel
- Mortar shrinkage & cracking at joints
  - 2 inside tunnel
  - 1 near First Street
Purpose of Study was to:

- Investigate leakage problem to address numerous deficiencies identified in 1990 inspection
- Identify & evaluate long-term repair alternatives
# Summary of Previous Repairs

<table>
<thead>
<tr>
<th>Repair Category</th>
<th>Repair Methods</th>
<th>EBMUD Experience</th>
<th>Long-Term Repair Method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Favorable</td>
<td>Unfavorable</td>
</tr>
<tr>
<td><strong>Exterior</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Concrete Collar</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Lead Wool Packing &amp; Gunite</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Oakum &amp; Hydraulic Cement</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Water Activated Epoxy Injection</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Coating</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><strong>Interior</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Polyurethane Sealant w/Cement Mortar</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gunite</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sawdust</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weko Seal</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Steel Liner</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><strong>Replacement</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Concrete Cylinder Pipe</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Steel Pipe w/Cement Mortar Lining &amp; Coating</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>
Improvement Alternatives

- Slip-lining
- Cured-in-place pipe (CIPP)
- Fold-and-formed lining
- Spiral wound lining

Lining

- Parallel new pipe
- Remove-and-replace
- Pipe bursting

Replacement

- Weko Seals
- Grouting
- Spray-on-membrane
- Expansion joints at existing cracks

Point Repairs
2008 Leak Study

- 1996 Study - Leakage estimated to be about 0.3 mgd
- French Drain measurements (visible & accessible leaks) – 0.4 mgd
- Outage test results – 2 mgd
French Drain Locations

Lafayette Aqueduct No. 1 - Typical Section

Walnut Creek Tunnel No. 1 Section

Pleasant Hill Tunnel No. 1 Section (Circa 1966)

Reliez Creek French Drain

Project Limits

McKeeoma Aqueducts

Walnut Creek WTP

Lafayette Aqueduct No. 1

Moraga Aqueduct

Oak Hill Hill Circle

Green Hill

Stevens Creek Dr

Cisco-Creek Dr

Figure 1

Lafayette Aqueduct No. 1 Area Map & Study Limits
Lafayette Aqueduct No. 1 Outage - Leak Test
Brown Avenue Pressure Transducer

Elevation (Feet)

Time (Hours)

$\Delta H_t = 7.10 \sim 9$ feet
Phase 1 Repairs

- Approx. 4 mi
- $0.5M
- 75 days, 10/08 – 01/09
- Furnish & Install 79 Weko Seals
- Spot repairs to the Aqueduct & Walnut Creek Tunnel concrete lining
Relining w/Shotcrete
Grouting

- Injection ports for contact grouting (cost per port)
- Contact grout (cost per sack)
- Injection ports for chemical grouting (cost per port)
- Chemical grout (cost per gallon)
Circumferential Crack
Spot Repairs
Repair Long Rock Pocket
Repair & Inspection History

1920
- 1929 In-service
- 1932 1,316 Repair Locations

1940
- 1951 125 Repair Locations
- 1960 Relocation of Pleasant Hill Tunnel No. 1 & Section of aqueduct at First Street due to accommodate Highway 24 construction
- 1968 9 Repair Types at 69 Locations

1980
- 1989 3 Locations using water-activated epoxy injection
- 1990 9 Weko Seals near the Pleasant Hill Tunnel West portal
- 1994 2/94 - Oakhill Road - Exterior repair w/epoxy injection
- 3/94 - Dolores Drive - Exterior repair w/epoxy injection & SS band

2000
- 2008 Install 79 Weko Seals & perform spot repairs WCEP to Lafayette Center
- 2009 314 LF Reinforced Concrete Liner w/Contact & Chemical Grout; 2,474 repairs to Lafayette Aqueduct No. 1 Tunnel

2020
- 2022 Reline Lafayette Aqueduct No. 1

2040
Replacement Constraints

• Physical - R/W width
• Operational
• Environmental
• Permitting
Benefits of Replacement

- Eliminates remaining leaks
- Improve seismic reliability of the EBMUD water supply system
- Reduce/eliminate the risk of the potential catastrophic structural failure of the aqueduct
- Eliminates operational impacts associated with continuing large unplanned emergency repairs
- Extend service life of Aqueduct by 75+ years
- Redundancy
Scope of Replacement

- Slip-lining w/steel liner
- Cost $28 million
- Schedule – FY22 Implementation
  - Phase 1
    - Survey interior and exterior of aqueduct
    - Evaluate modern alternatives (2020)
    - Prepare environmental document
  - Phase 2: Install steel liner in cast-in-place pipe segments
Questions

Marisa Boyce, P.E.
Associate Civil Engineer
Large Diameter Pipeline and Aqueduct Section
East Bay Municipal Utility District
mboyce@ebmud.com
(510) 287-0987