



Miter Gate Anchorages

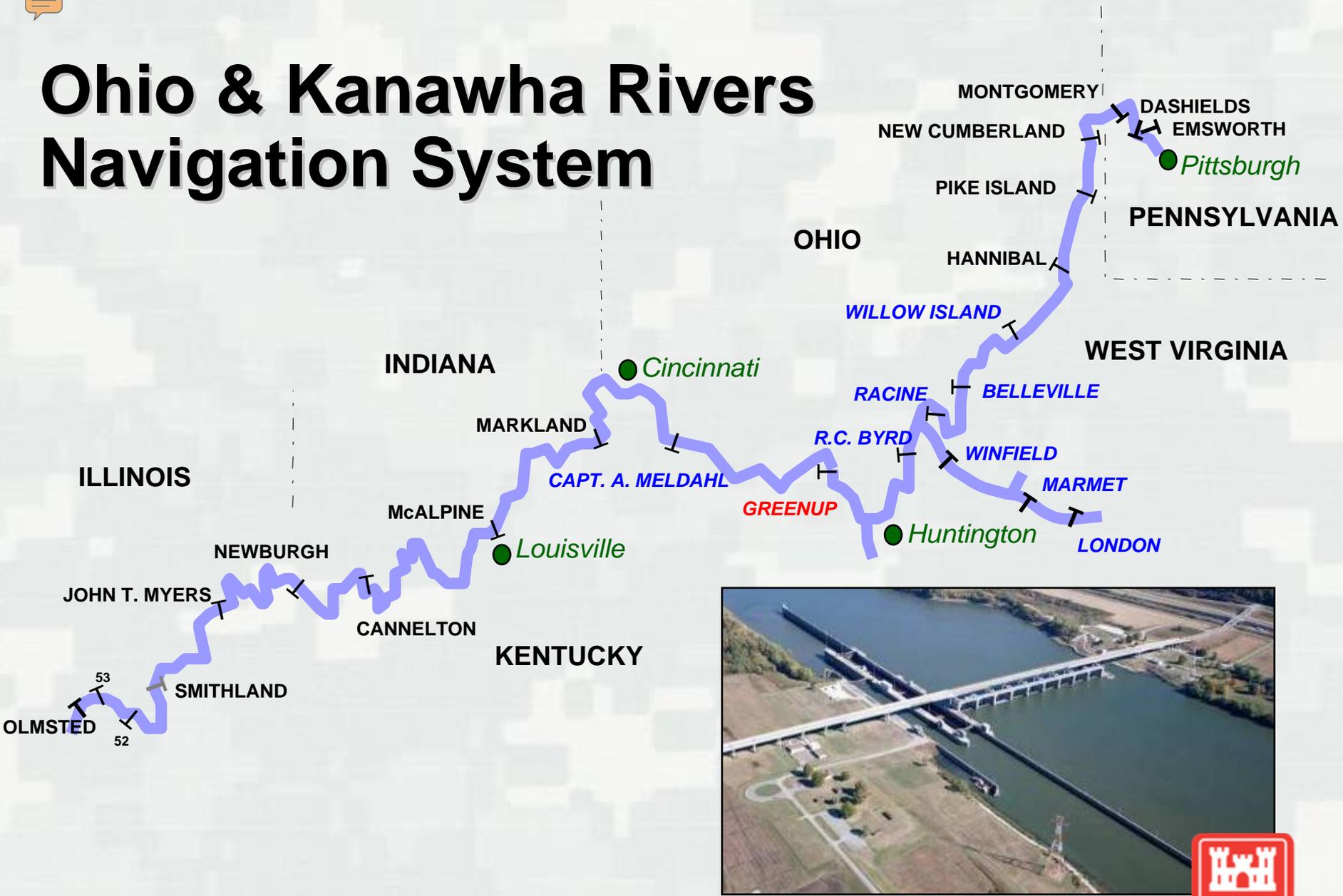
**Maintenance Meeting
February 13, 2013**

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**Structural Engineer
Huntington District
US Army Corps of Engineers**



Ohio & Kanawha Rivers Navigation System





Miter Gate Anchorage Failure

27 Jan 2010, 2:43 pm



Looking downstream – toe of gate dropped 1.2 ft



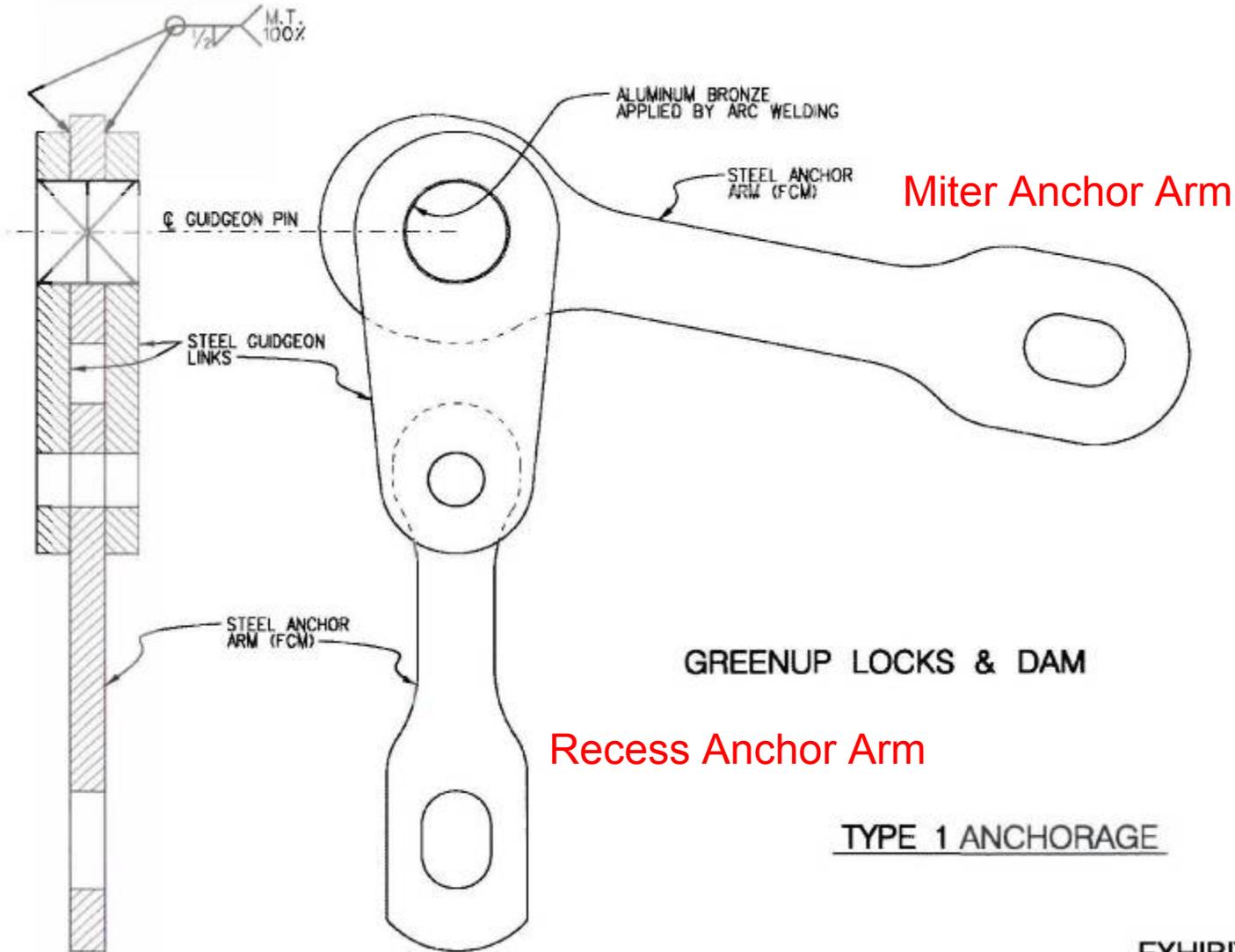


EXHIBIT 1





Miter Gate Anchorage Failure



Broken Anchor Arm





Miter Gate Anchorage Failure

27 Jan 1416 hours



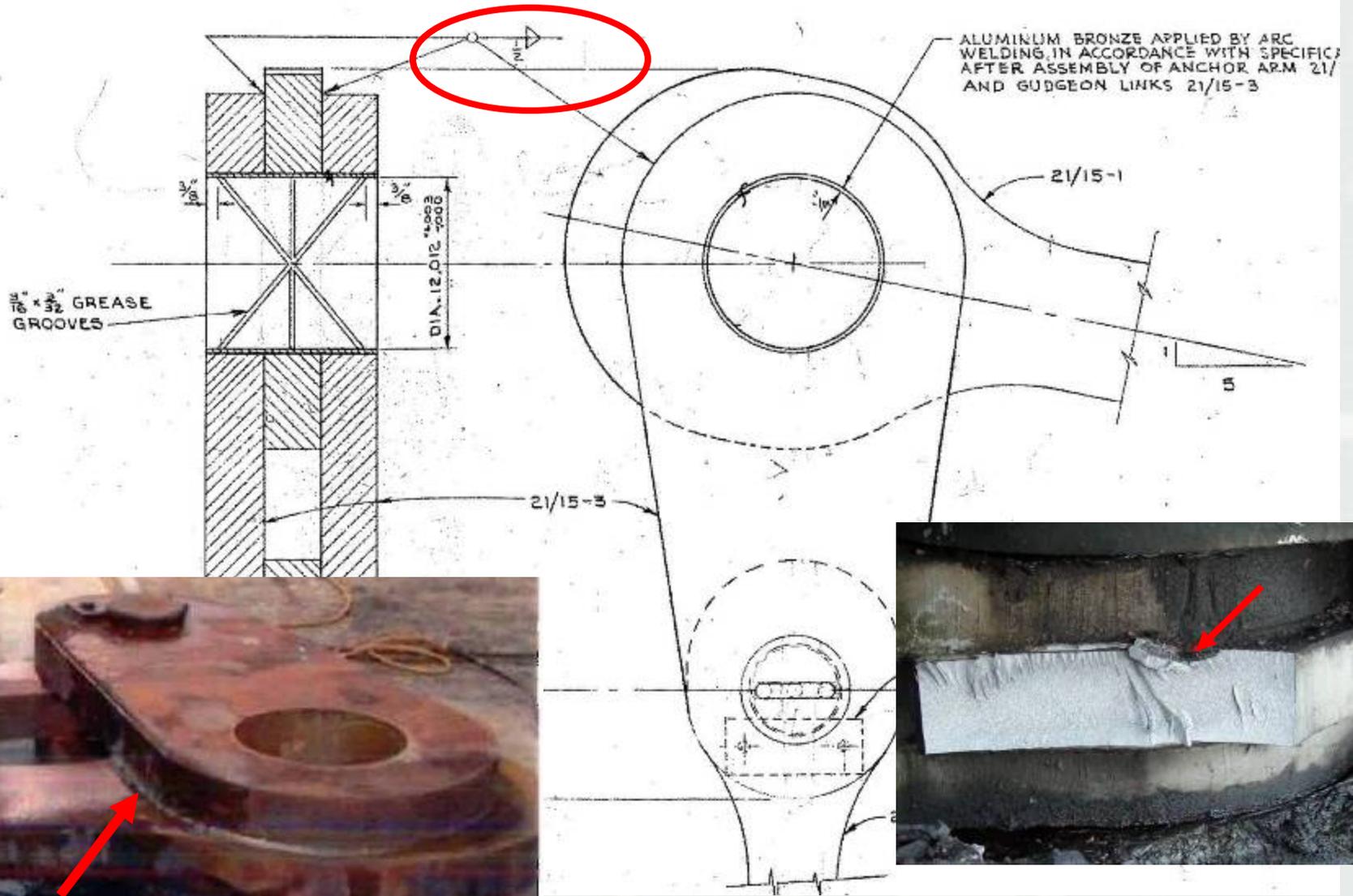
Broken Anchor Arm



Material

- Specification of Steel as designed
 - ▶ 1950's Steel
 - ▶ ASTM A7 with a yield stress of 33ksi
- Specification of Steel as Tested
 - ▶ Yield stress approx. 20-21 ksi
 - ▶ Charpy impact test value of 8 ft-lb at 65







Periodic Inspection 2008

- 2008 PI this type of weld was identified as a potential problem.
- Shown as detail in EM 1110-2-2703



Replacement Gate Anchorages



Repair parts



Lifting of Miter Gate





Frag. Order 3 – Miter Gate Anchorage Inspection and Testing

- Requires inspection and/or testing of all miter gate anchorage components at all projects.
- Identified four types of top anchorages typically used in LRD.
 - ▶ 2 types use anchor bars
 - ▶ 1 type uses eye bolts
 - ▶ 1 type uses eye bars
- Identified all FCM's of the anchorage assemblies
- Identified all Fatigue Sensitive Details
- Identified inspection criteria, inspector qualifications, and NDT techniques to be utilized.



Anchor Types

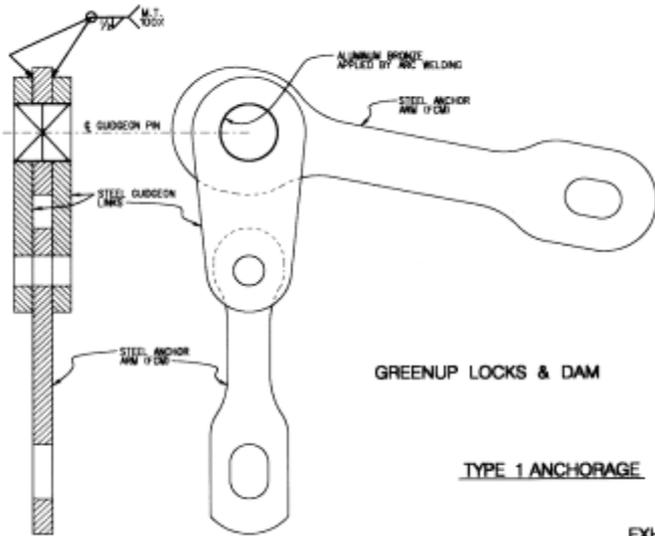


EXHIBIT 1

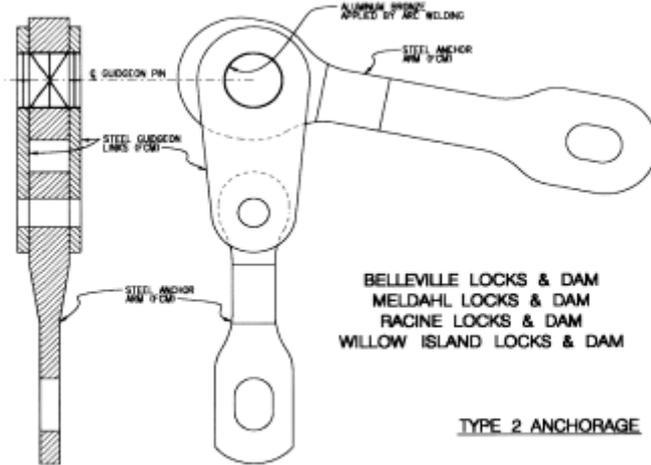


EXHIBIT 2

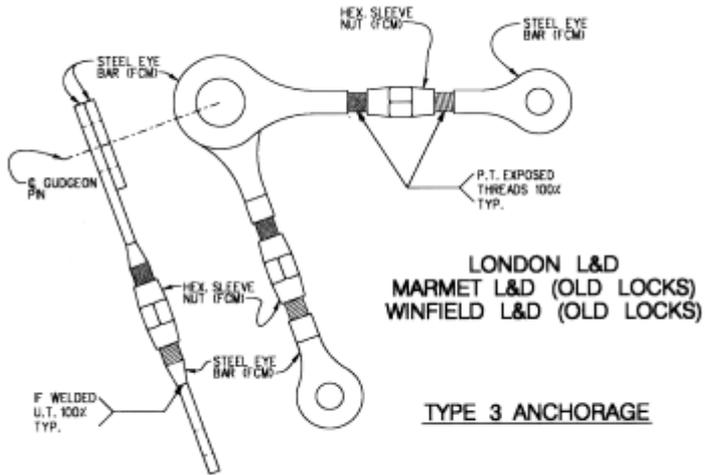


EXHIBIT 3

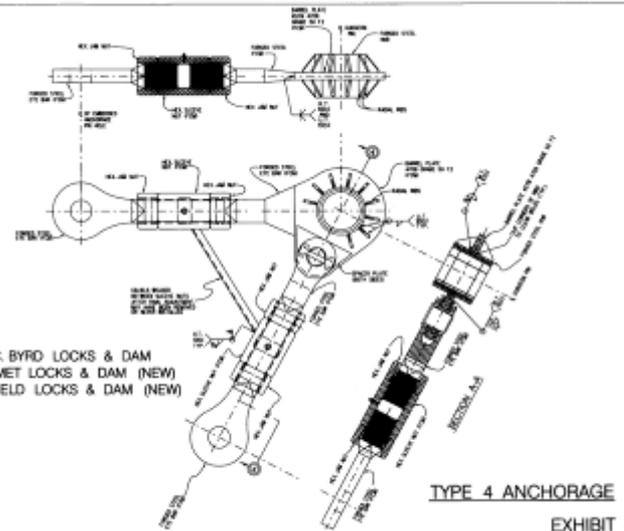


EXHIBIT 4



What did we learn?

- Found cracked welds at two other projects in LRH.
- Both projects are eye bar designs.
- The new Meldahl and Greenup Lock anchorages are eye bar designs and may have similar issues.



R.C. Byrd Locks



Winfield Locks & Dam



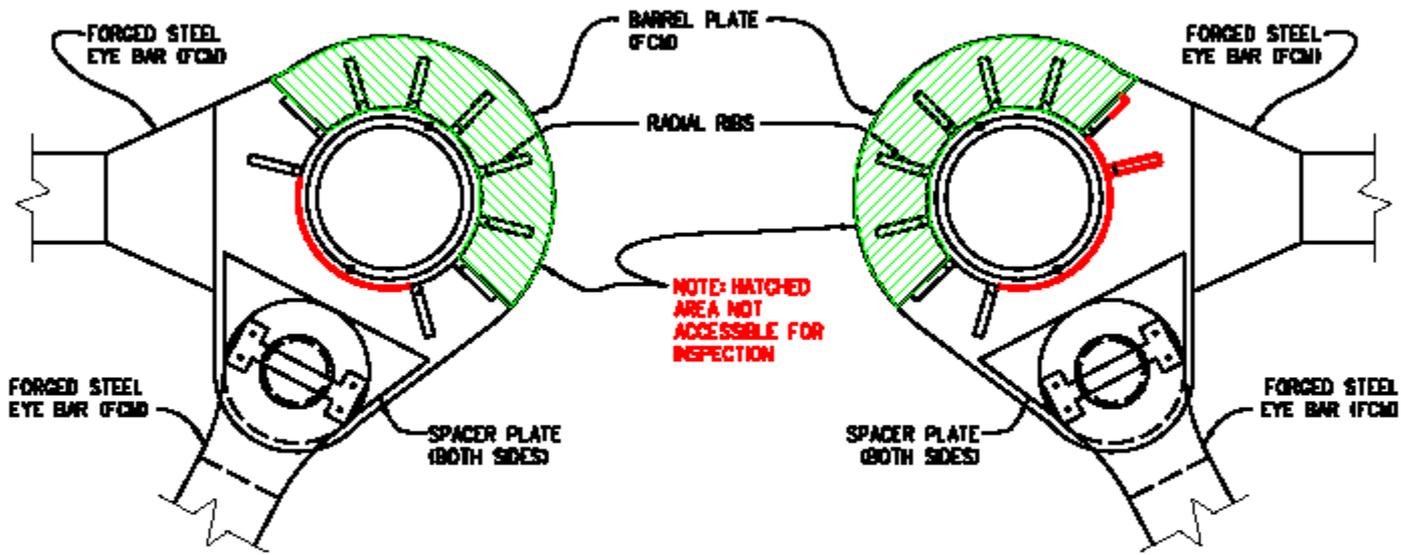
Cracks in Original Gudgeon Barrel



Winfield Locks & Dam



BUILDING STRONG®



LAND WALL LEAF

RIVER WALL LEAF

WINFIELD MAIN CHAMBER DOWNSTREAM GATE

NOTE: RED LINES INDICATE CRACK LOCATIONS



What did we learn SAM?



What did we learn SAM?



Holt Lock Anchorage Failure, 2006



What did we learn SAM?



Unused spare. Cracked during fabrication.



Path Forward, 2010

- Scrap the recently purchased eye bar anchor assemblies for Meldahl and Greenup Locks and replace with a new design.
- Replace eye bar anchor assemblies at R.C. Byrd, Winfield and Marmet Locks with a new design.
- Repair defects in the current systems that are repairable.
- Continue to inspect and test.
- Budget for extended closures to repair or replace anchorages.



Path Forward (New Design)

- Improve on the eye bar design by:
 - ▶ AISC Design Requirements
 - ▶ Fracture Critical Requirements
 - ▶ Better Weld Details or Eliminate Welds
 - ▶ Provide a Less Rigid System
 - ▶ Interchangeable
 - ▶ Simplify



New Design

- Improvements:
 - ▶ Meets AISC Design Requirements for Eye Bar Tension Members
 - ▶ Meets Fracture Critical Requirements (toughness both A709 and A668 material)
 - ▶ Only welds in system are welds to seal around the gudgeon barrel
 - ▶ Uses Spherical Bearings to eliminate bending forces in the arms
 - ▶ They are interchangeable between projects
 - ▶ Easy to install



New Design



New Design



Winfield Locks, 2012
Used existing embedded
anchorage w/ no change.



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Winfield, 2012



Meldahl and Greenup, 2012



Existing wedge system was exposed and modified.



Meldahl and Greenup, 2012



Modified for new anchor bars and pins.



Meldahl and Greenup, 2012

Twelve total assemblies have been installed at three different projects.

No issues to date.



Current Path Forward

- Continue to replace eye bar anchor assemblies at Meldahl and Greenup Locks in concurrence with new miter gate installations.
- Replace eye bar anchor assemblies at R.C. Byrd and Marmet Locks with the new design.
- Continue to repair defects that are repairable as they are identified.
- Continue to inspect and test existing anchorages.
- Continue to budget for extended closures to replace anchorages.



Questions?

