L&D 07: Murray Lock Center Post Anchorage

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US Army Corps of Engineers

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Background

- On 30 June 2015, SWL decided to do a “light maintenance, heavy inspection” dewater at Murray due to an allision on 11 June 2015.

- From 30 June to 29 Aug, the Little Rock District and Russellville staff coordinated the dewater.

Planned Schedule

- Aug 10-14: Pre-dewater dive; preclean
- Aug 17-20: Prep and Load week
- Aug 24-27: Set-up week on site
- Aug 28-29: Final Dive
- Aug 30-Sept 4: Dewater
  - 24 hour shifts
    - Night Shift: Clean miter gates, remove bottom seal, clean pintle, pull anodes/bubblers/greaselines, clean up crew
    - Day Shift: Set and Remove closure, D/S Miter Gate Inspection (NDT), Fix bent diagonal on R/W MG, replace bottom seal, replace anodes/bubblers/greaselines, check pintle gap, MG tensioning, any other critical items identified during inspections

Dewater System

- Receiver in the concrete that anchors the centerpost in place.
- The centerpost marks the mid-point between the lock chamber width.

Dewater System

← Stoplogs are slid into place—stop log slots in the lock walls and centerpost.

Creates a closure system that allows the chamber to pumped dry to perform the required maintenance on below water assets. →

The Discovery

- On 29 August 2015, Craig Evans asked the dive team to do an underwater tactile inspection of the center post receiver.
- Our dive team inspected the embedded anchorage that holds the center post receiver.
  - ► Design: 8 – 9'6" long 2-1/4" diameter anchors resisting overturning.
    - Top 2' of anchor: Stainless Steel (ASTM A-193)
    - Option for the bolt to be Stainless Steel
  - ► Inspection: 6 of the 8 were corroded due to dissimilar metals (bolts are most likely carbon steel)
- These anchor bolts are considered fracture critical and are a life safety item during dewater operation.

Analysis

- A static analysis was performed summing the moments about the square slotted receiver anchored by the bolts.
  - D/S load on the anchor bolts = 30,000 lbs on all 8 bolts.
  - U/S tension load = 280,000 lbs.
- The stoplogs are bearing on the concrete sill. The center post would have to pick up the stoplogs to transfer the load.
- These bolts keep the stop log centerpost from overturning due to the hydrostatic pressure.

Team Brainstorming

- Alternatives and modifications to the dewater structure were considered
  - ► Add additional weight to the centerpost to counteract the overturning moment
  - ► Add additional anchor points to resist the overturning moment

- After all alternatives were discussed, it was decided that the safest path forward was to not set the closure.

SAFETY, SAFETY, SAFETY!

“Dewater” Change of Schedule

- Due to the inability to set the closure, the schedule of work to be accomplished was reevaluated.
  - ► Above water inspection
  - ► Any repairs we could accomplish above water and with dive team
  - ► 12 hour days
    - Allowed industry to lock through at night with 24 hour notice
- Multiple tours were cancelled

Lock Inspections Completed

INSPECTIONS

- Underwater Dive Inspection (U/S and D/S)
- Miter Gate Inspection
  - Non-destructive Testing above water only
- Tainter Valve Inspection
  - U/S and D/S river wall
- Floating Mooring Bit Inspection

DATE: 8-30-15 — LOCK DAM UNDERWATER INSPECTION — SIGNATURE: _____ LOCATION: LD 7

	LW	RW	
UPPER END OF LOCK			COMMENTS: RW Flex line Broke
Grease lines			LW - Flex line to Pintle Broke - Hard line going to top of Pintle Brok
Miter blocks	✓	✓	
Quoin blocks	✓	✓	
Sill	✓	✓	
Gate Seal/bolts/rubber	✓	✓	Quoin end seal missing 4"x2" RW
Air Bubbler line/straps	✓	✓	RW - Missing Clamps 5-6 clamps in the middle
Ground Straps	✓	✓	LW - Gone RW - Gone
Anodes	✓	✓	LW 50% or less gone / RW 50% or less
Brackets	✓	✓	
Intake racks	—	—	Didn't inspect
All Embedded Metals	✓	✓	
Center Post Receiver			
Stop Log Receiver			
Float Wells - grates			
Pintle Ball	✓	✓	
LOWER END OF LOCK			COMMENTS:
Grease lines	✓		FLEX LINE MISSING
Miter blocks	✓	✓	RW between pitted and busted and at surface
Quoin blocks	✓	✓	15" WATERLINE ↓ MISSING BELZONA
Sill	✓	✓	
Gate Seal/bolts/rubber	✓	✓	
Air Bubbler line/straps	✓		LW Lose in middle
Ground Straps	✓	✓	
Anodes	✓	✓	50% left on blocks under gate / Quoin Anodes 10%
Brackets	✓	✓	
All Embedded Metals	✓	✓	
Center Post Receiver	✓	✓	
Stop Log Receiver	✓	✓	8 anchors inspected and found faulty
~~Float Wells - grates~~			
Pintle Ball			RW Flex grease line missing
CHAMBER INSPECTION			COMMENTS:
Mooring Bit recessess			
Float Well Grates			

Scope of Work Change

COMPLETED

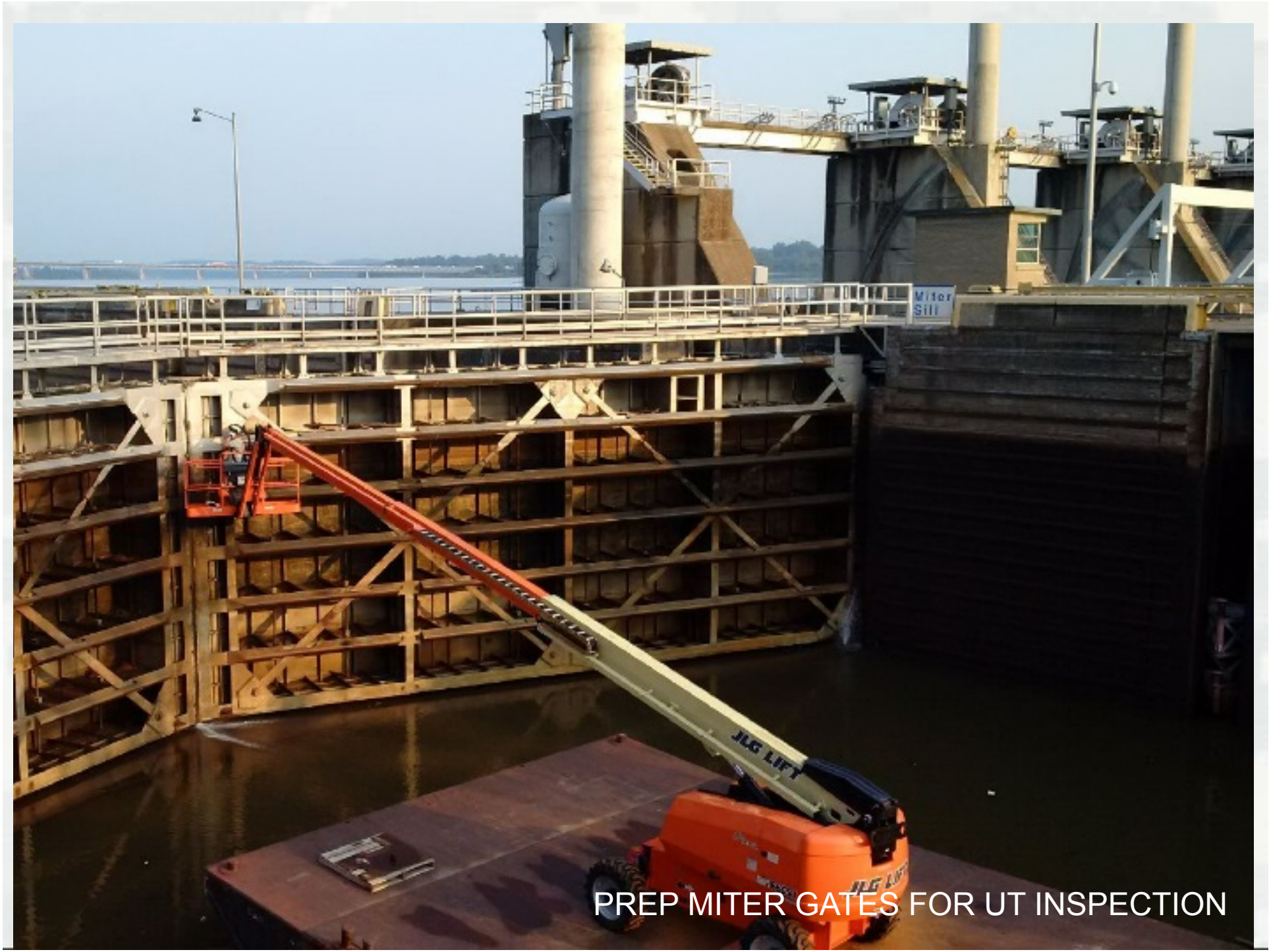
- Downstream miter gate anode replacement.
- Preparation of identified above water line fracture critical welds for UT on the downstream miter gate.
- UT inspection on the above water line fracture critical welds on the downstream miter gate.
- Paint the above water line fracture critical welds on the downstream miter gate after UT was complete.
- Replace the downstream miter gate grease lines.

NOT COMPLETED DUE TO INABILITY TO SET CLOSURE

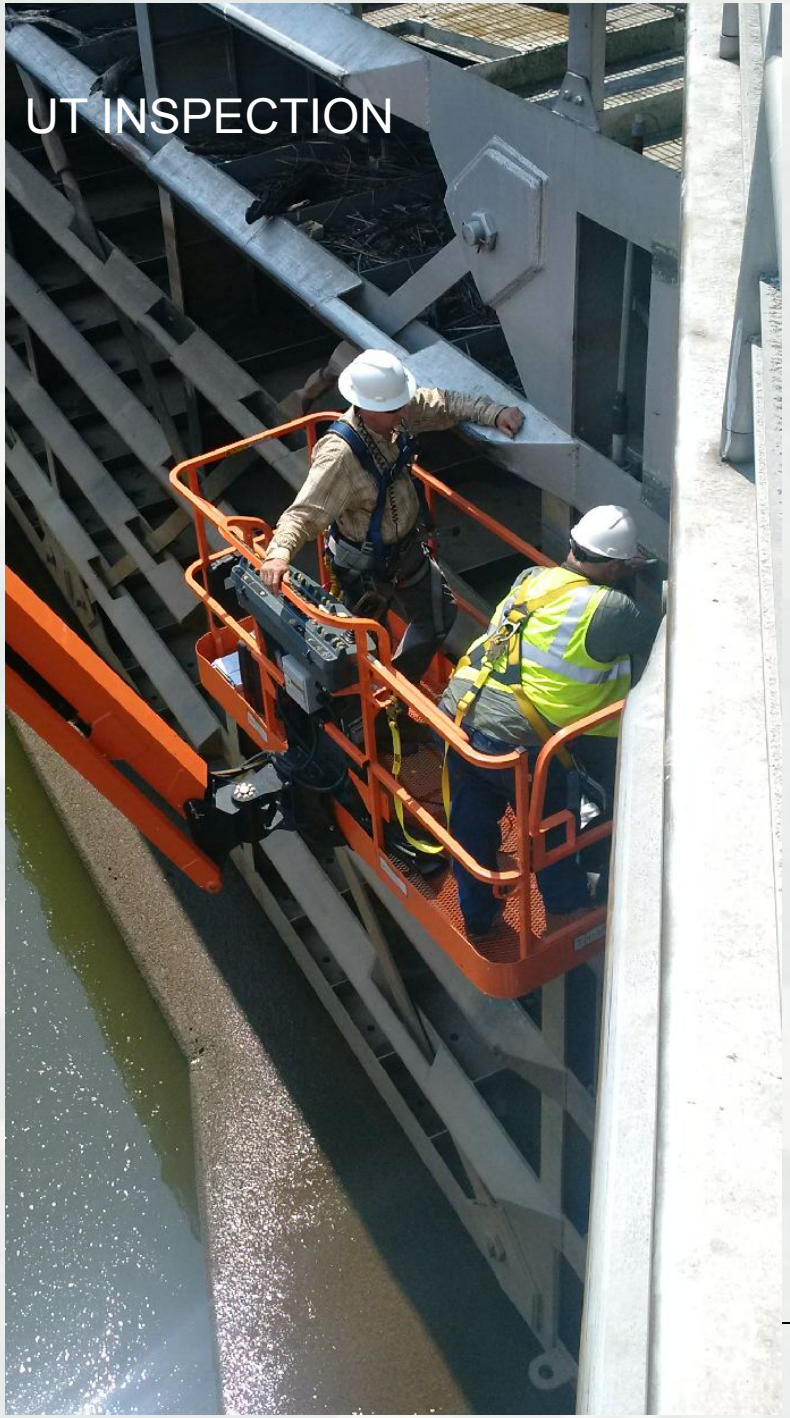
- Preparation of identified below water line fracture critical welds for UT on the downstream miter gate.
- UT inspection on the below water line fracture critical welds on the downstream miter gate.
- Paint the below water line fracture critical welds on the downstream miter gate after UT was complete.
- Replace the downstream miter gate bottom seal.

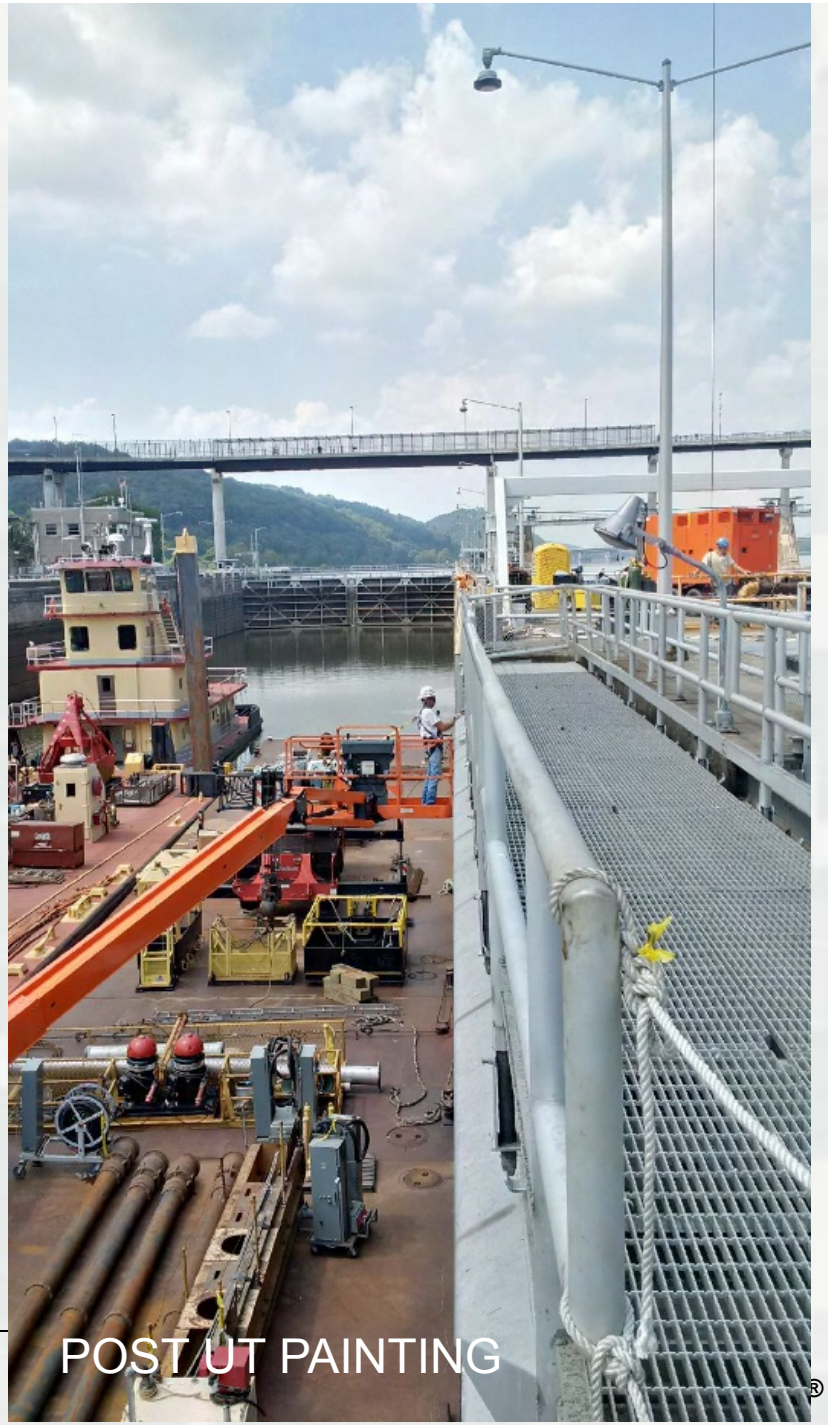
ADDED TO SCOPE OF WORK

- Full underwater dive inspection of the upstream and downstream miter gates and centerpost receiver.
- Repair of two downstream miter gate fenders.
- Upstream river wall tainter valve inspection and repairs.
- Replacement of upstream miter gate grease lines
- Preparation of identified fracture critical welds for UT on the upstream miter gate.
- UT inspection on the fracture critical welds on the upstream miter gate.
- Paint the fracture critical welds on the upstream miter gate after UT was complete.
- Downstream river wall tainter valve inspection and repairs.
- Pull and inspect a floating mooring bit.
- Troubleshoot the interlock system



PREP MITER GATES FOR UT INSPECTION


UT INSPECTION


POST UT PAINTING

MITER GATE FENDER REPAIR

BEFORE

AFTER

MITER GATE FENDER REPAIR

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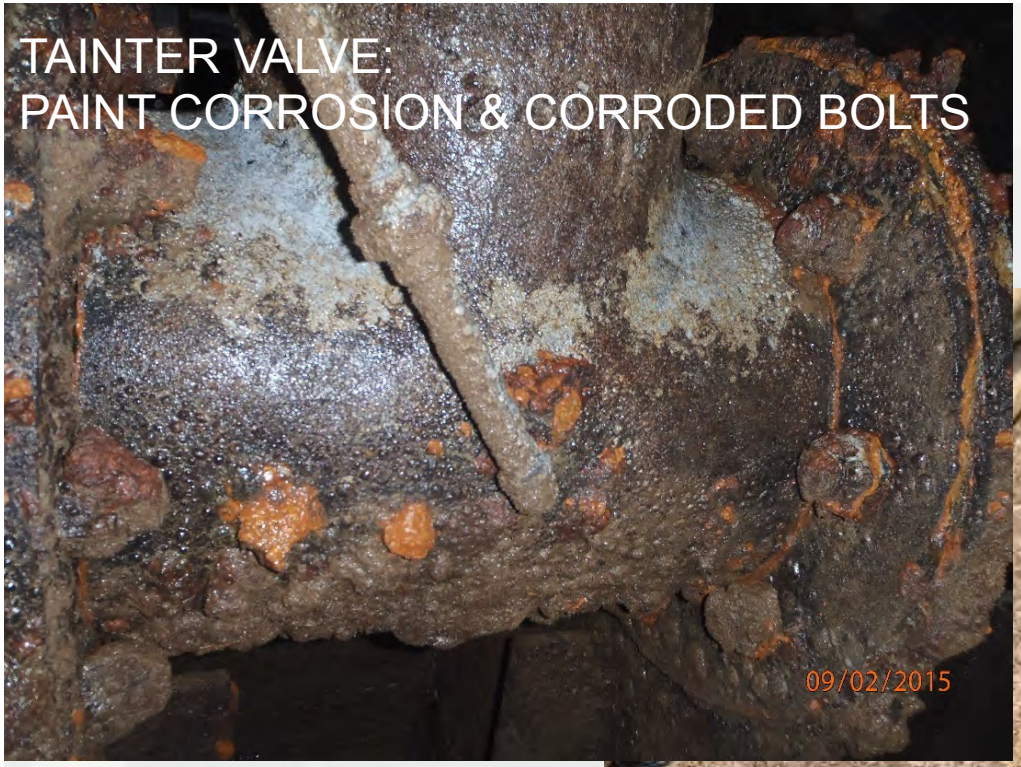
TAINTER VALVE:
PAINT CORROSION & CORRODED BOLTS



FLOATING MOORING BIT

D/S MITER GATE ANODE

What's Next?

- The extent of the issue on the system is unknown.
  - Since the discovery at Murray, the dive team inspected the centerpost recievers at Lock 3 and determined that this location is intact.
  - Dive team will dive at all other locations on the system
    - CRITICAL! If we have an issue at one of our locks that requires an emergency dewater/closure, we may not be able to accomplish if the centerpost receiver anchor bolts are not intact.
- A PDT has been assembled to determine a solution…
  - How to get the centerpost receiver in the dry at Murray?
  - What is the fix at Murray?
  - What is a long term strategy for the system? (extent of issue on the system will guide the strategy)

Options

OPTION A: Repair existing receivers.

- Confident, long-term inspection method(s) that satisfy HSS criteria and not just the current tactile-based methods.

OPTION B: 110’ stoplogs

- Will most likely require lock modifications.

OPTION C: Towable bulkhead/floating caisson

- Can be sunk and refloated, with associated lock modifications.

OPTION D: Gravity Dam

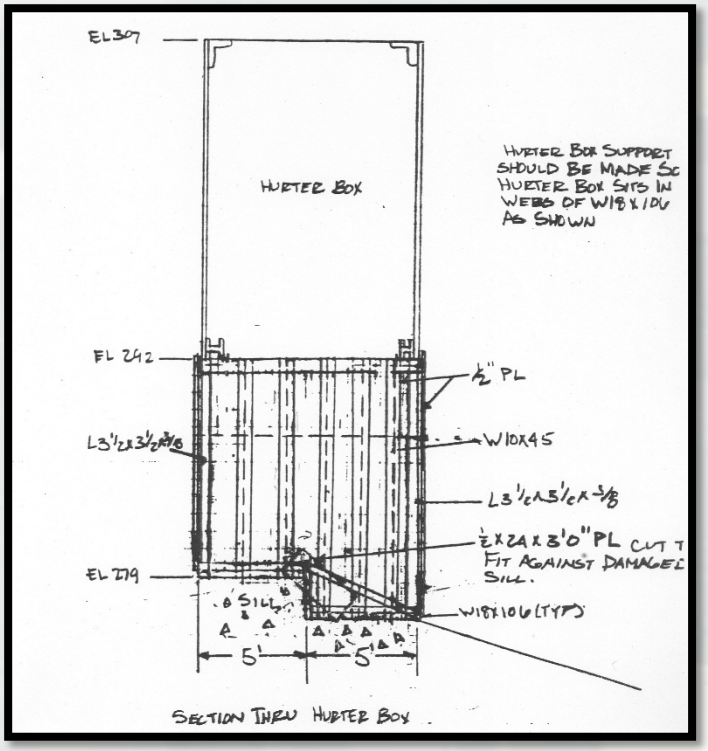
OPTION E: Use of weights, additional attach points, etc.

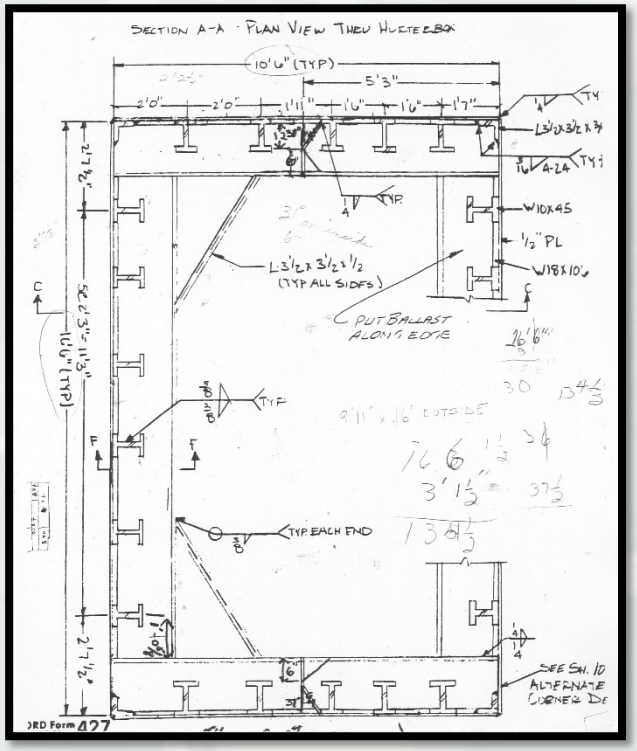
- Counter the overturning moment on the center post, with associated lock modifications

OPTION A:
Repair Existing Receivers

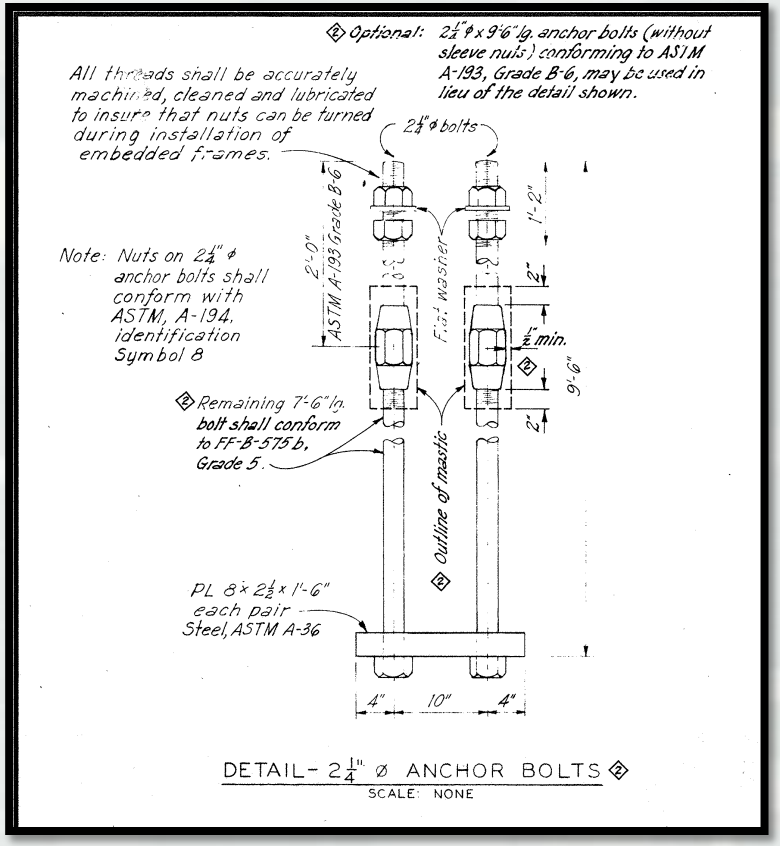
- Installation of a dewatering box
  - Estimated to weigh 90,000 lbs each
  - Anchored to the lock floor with concrete anchors
  - Dewater the box
- Remove and repair existing receiver/anchors
  - center post anchor has to be removed
  - corroded anchors will have to be core drilled to a depth of 36 inches
  - anchors will have to be cut off
  - sixteen new stainless steel anchors installed – grouted in place
- Total estimated ROM is $1.5 million.
  - This solution still has a problem in that the anchorage is fracture critical and can only be inspected underwater where visibility is next to zero.

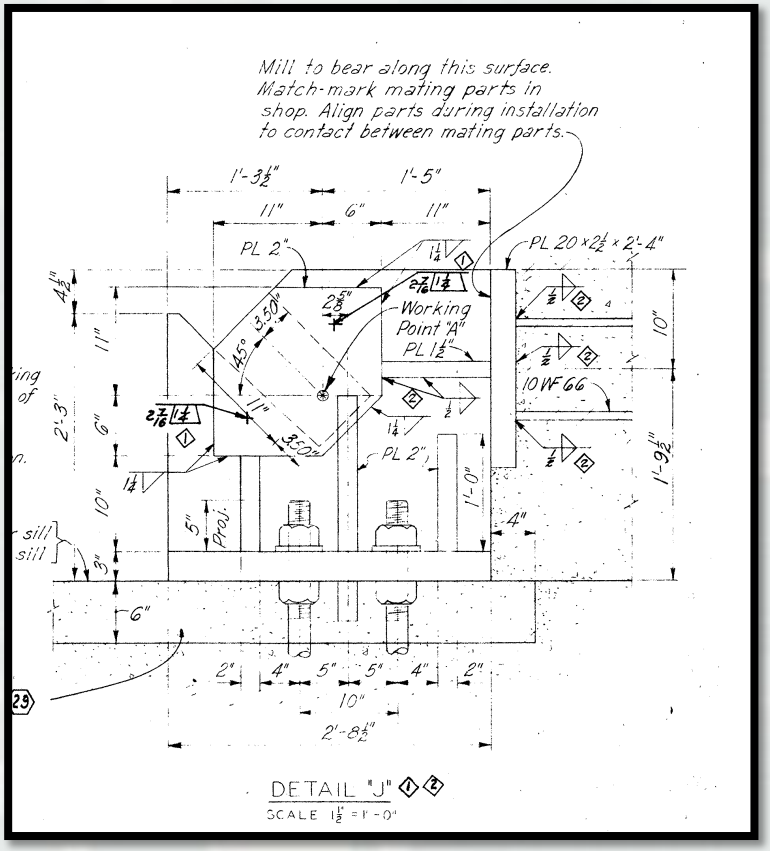
OPTION A:
Dewatering Box





Embedded Anchorage





OPTION B:
110’ Stoplogs

- Existing Stoplogs: 6 feet deep
- 110’ Stoplogs: 13’ deep, weigh 71,000 lbs with a lifting beam that weighs 43,000 lbs.
- New stoplog slots would have to be cut U/S & D/S the center post slot would have to be grouted up to keep the center post area from leaking.
  - If we move the U/S slots D/S, then we will be moving closer to the bridge above.
  - If we move U/S slots U/S, we will have to add concrete from the top of the rock to the top of the sill.
  - If we move the D/S slots U/S, we will be cutting into the miter gate anchorage.
  - If we move the D/S slots D/S, we will have to place concrete from the top of rock to the top of the sill.
- Total estimated ROM is $30 million.
  - new stoplogs, crane&barge, and repair work to the existing lock structure

OPTION B:
110’ Stoplogs

OPTION C:
Towable Bulkhead/Floating Caisson

- Nashville has a floating caisson
  - Weight: 417,000 lbs
  - Dimension: 113’-5” wide by 27’ 8” tall
  - Working Limits:
    - Drawings: 13’-26’
    - Actual: 17’ to 25’
    - (Murray is 15.5’ to 25’ feet)
- The newly designed floating bulkhead has had several issues with the actual operations of the new floating caisson. The floating bulkhead in theory will work. Slots will have to be cut to allow the caisson to fit into position.
- The total estimated ROM of $3 million.
  - Nashville District prefers the 110’ stoplog option.

OPTION C:
Towable Bulkhead/Floating Caisson

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OPTION D:
Concrete Gravity Dewatering Blocks

- A set of concrete blocks that use friction and gravity to resist the sliding forces and the overturning moments.
- The current design calls for a 20’ tall stack of concrete blocks that set on the concrete sill to dewater the lock.
  - The blocks are rated for 15’2” usual case
  - Factor of Safety of 1.5
- We could use this to dewater system for the d/s end. We could design some larger blocks with higher head limits.
- We would have to fill the center post recess with concrete, if we are going to use this option.
- This would be our new dewatering.
  - Total estimated ROM is $2 million.

OPTION D:
Concrete Gravity Dewatering Blocks

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OPTION E:
Counterweights To Resist Overturning

- A static analysis similar to a retaining wall analysis was performed by taking moments about the square slotted receiver anchored by the bolts in question.
- The D/S load on the anchor bolts could be overcome by using 45,000 lbs with a FS of 1.5.
- The U/S moments due to the higher differential head elevations are estimated to be 420,000 lbs with a FS of 1.5.
- There are stoplogs on both sides of the center post. But in order for these loads to reach the center post, the stoplogs will have to be picked up from the concrete floor. If there is much movement in the stoplogs this could lead to a dynamic failure. The anchor bolts also provide lateral stability and U/S & D/S stability.
- I do not think this option would be using sound engineering judgment.

Lessons Learned

- Check your fracture critical anchorages (regardless of type of design) well in advance of planning a dewater.
- Perform an underwater lock inspection with the Dive Team 6-8 weeks prior to setting the closure.
- Approximately 3-4 weeks prior to mobilizing the crews, determine a contingency plan on maintenance and inspection items that could be accomplished if the closure system cannot be placed.
- Approximately 4 weeks prior to mobilizing the crews, the mechanic on site needs to ensure all FEM work orders that require DMT/Fleet support are inputted into the FEM database.
- Remain flexible with the schedule, crews, and industry

Questions/Comments?

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