



Engineer Research and  
Development Center

# Simple Lock Operation Improvements

## LRD Maintenance Workshop

**Stuart Foltz**

ERDC – Construction Engineering  
Research Laboratory

**Dan Hooks**

Lockport Lock, Rock Island District

10 Feb 2016



# Lessons Learned

## General categories

- Components
- Verification and redundancy
- Design
- Operational practices
- Interlocks



# Encoders and Resolvers

## Resolvers:

- One moving part
- Less likely to fail prematurely
- Longer expected life
- More accurate



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# Gear Box Cover



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# Magnetic Proximity Switch

- More dependable
- No contact so less damage and wear
- Avoids icing issues
- Preset distance, mounts adjustable, magnet size changeable



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# Mel Price Magnetic Proximity Switch on Gate



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# Gate Position



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# Redundant Close Switches



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# Limit switch failure



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# Cam-operated limit switch gearbox

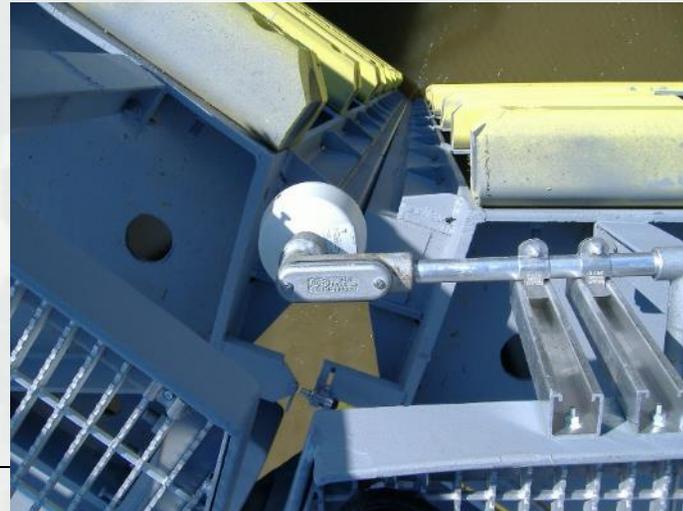
- Originally US made Bearings
- Old part# (with Taiwan bearings):  
147A4786P530009
- New Part# (with Japanese bearings):  
147A4786P53



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# Overhead monitors, including of miter



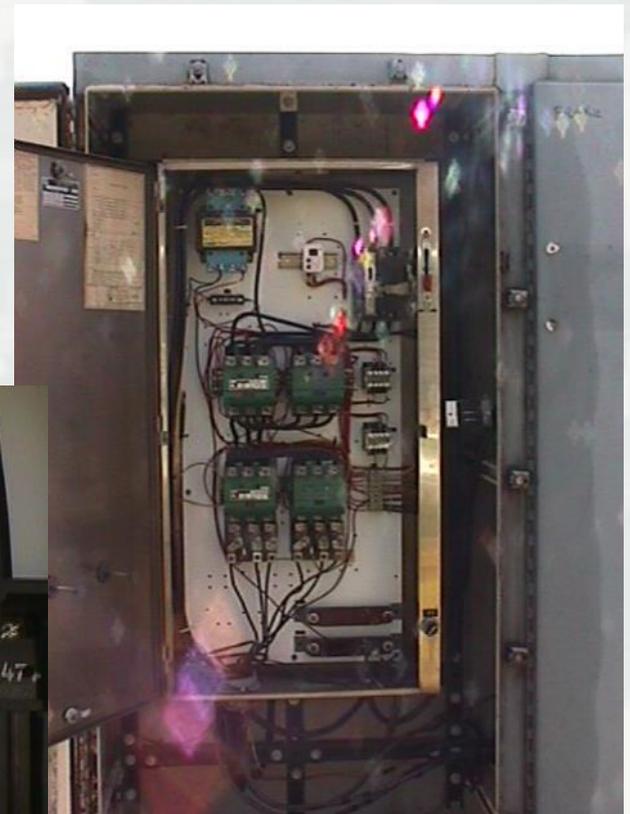
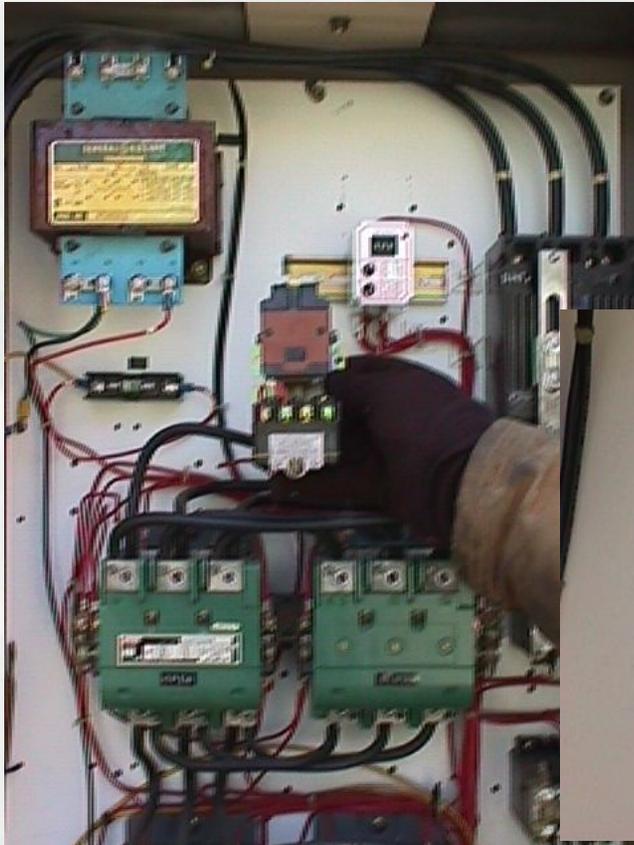
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# Gate Mechanical Timers

- Mechanical timers
- Solid state timers
- PLC software timers



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# Flushing Accidents

- Flush ice, debris and cuts by opening upper valves
  - Interlocks to prevent flushing unless lower gates are full open and lower valves full closed.
  - Need PLC interlock to prevent downstream gates closed until 5 minutes after closing upper valves
  - PLC delay programming isn't included in the current IMTS interlock standards

Lockport Lock (~2003)

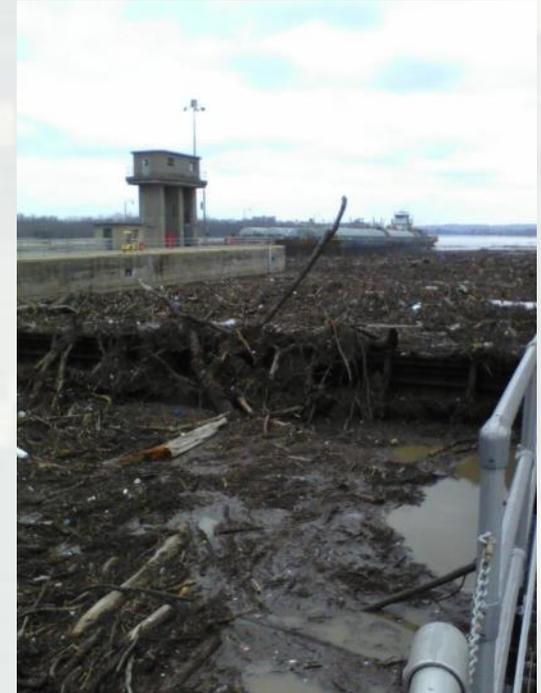
(Stem bolt, 2004)

Dresden (Jan 2005)

(Stem bolts and buffer boxes)

Markland – lack of G-V interlocks

(Upper valves open)



# Miter Gate Hammering

## Problem:

- Hammering due to chamber/tail water not equalized

## Solution:

- PLC programming
    - “3 strikes & you're out”
  - Engagement of limit switches in buffer box
  - When the green "miter gate running" light blinks 3 times, the miter gates/s will be disabled for 3 minutes
- 
- Gates without buffer boxes may have other hammering issues.



# Interlocks Policy

## (in Stuart's opinion)

- Interlocks should be set to prevent inadvertent errors in normal conditions
- Temporary over-ride of interlocks in unusual situations is to be expected
  - All lock operators should be informed while it is occurring
  - It should be documented and District personnel outside of lock should at least be informed
- Interlock over-ride that is longer term should be reviewed and approved by chain of command outside of lock personnel.
- Interlocks should be clearly documented and functionally tested on a recurring basis, possibly with periodic inspection



# Bumpers and Fenders



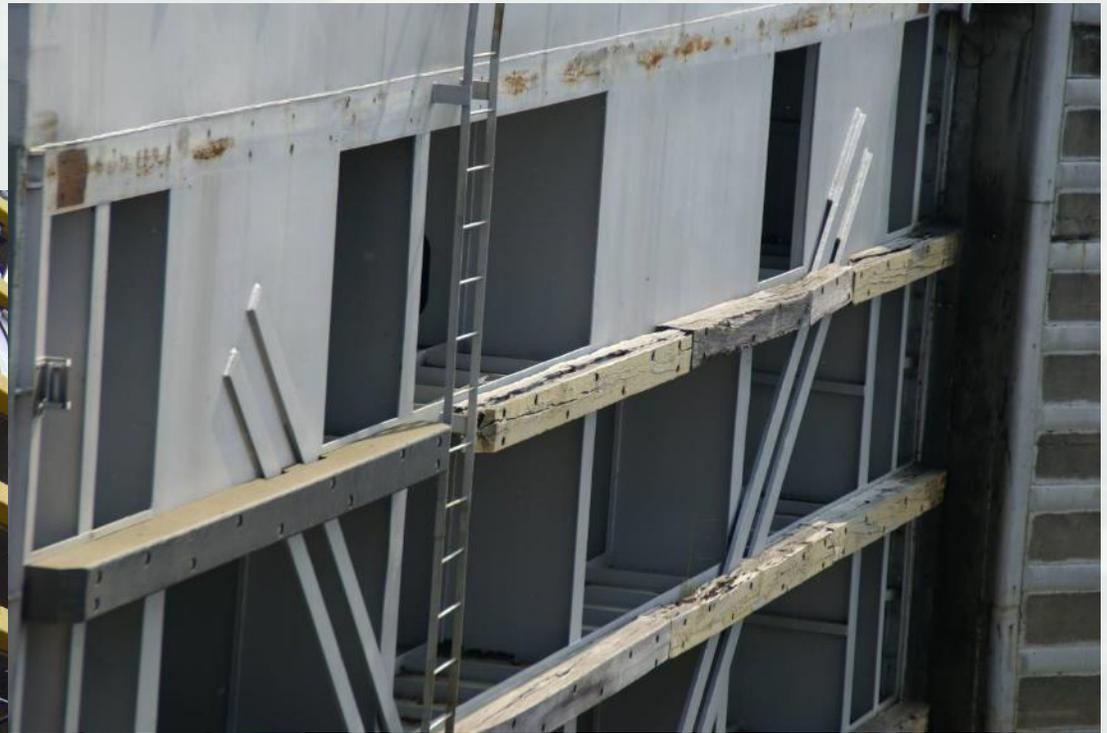
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# Bumpers and Fenders

## Miter Gate Fenders

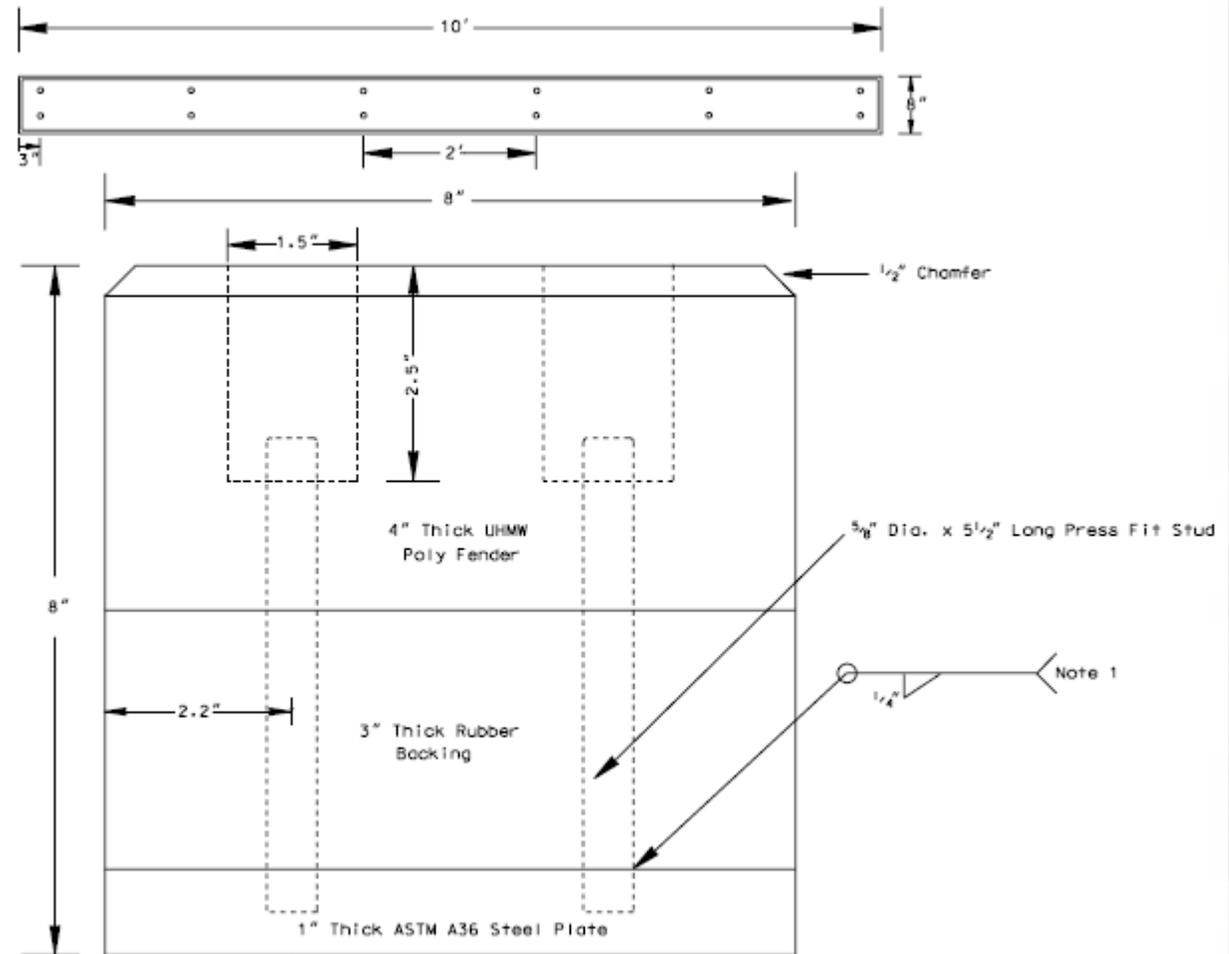


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# Bumpers and Fenders



NOTE: 1. 5/8" DIA. STUD IS TO BE PRESS FIT INTO 1" STEEL BACKING PLATE AND WELDED ALL AROUND ON BACKING PLATE SURFACE.

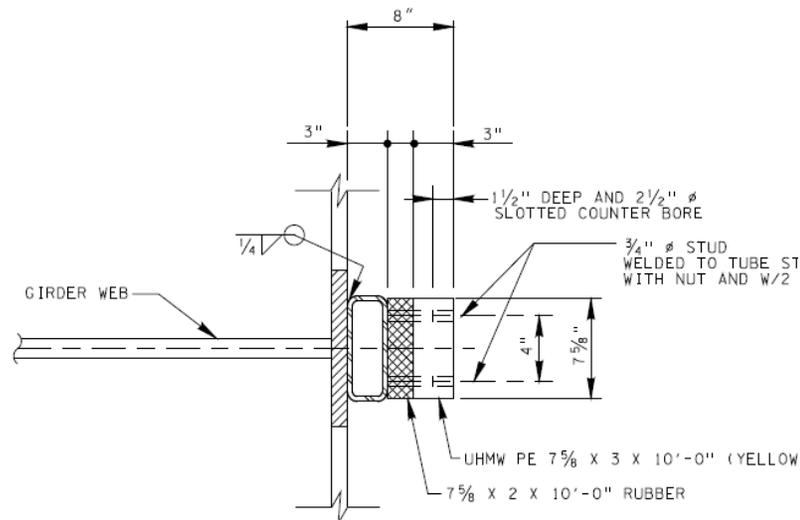
# Bumpers and Fenders

## Composite and Fabricated Fenders

NOTE: HOLES IN UHMW AND RUBBER BLOCKS SHALL BE SLOTTED 2 INCHES LONG, IN DIMENSION PARALLEL TO LENGTH OF FENDER.

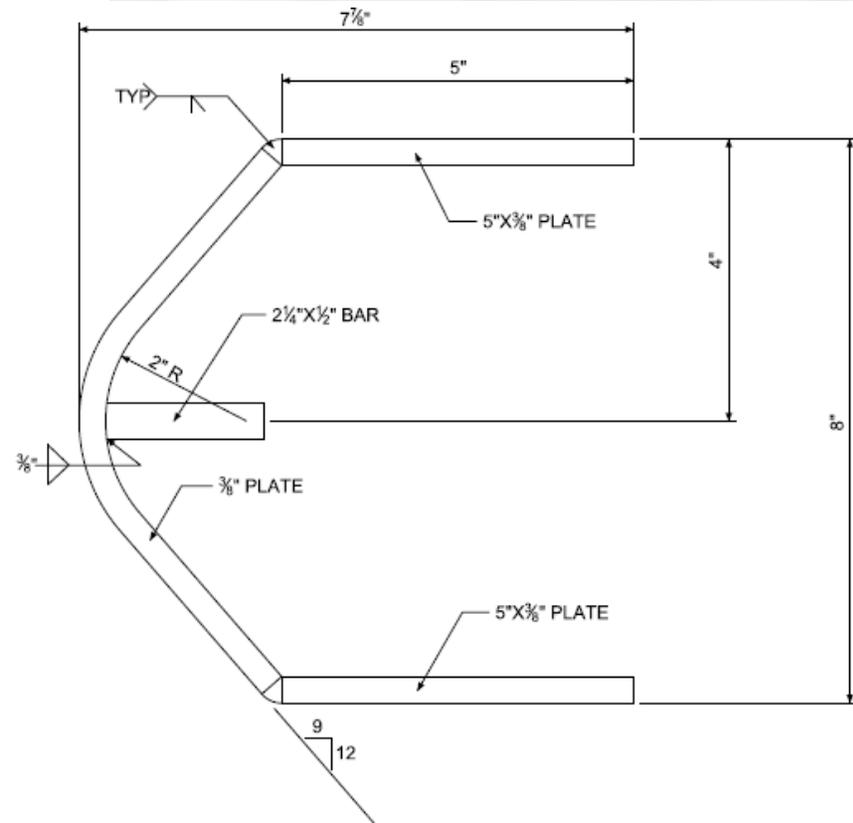
### TYPICAL FENDER FRAMING

SCALE: 1"=1'-0"



### TYPICAL FENDER MOUNTING DETAIL

SCALE 1 1/2"=1'-0"



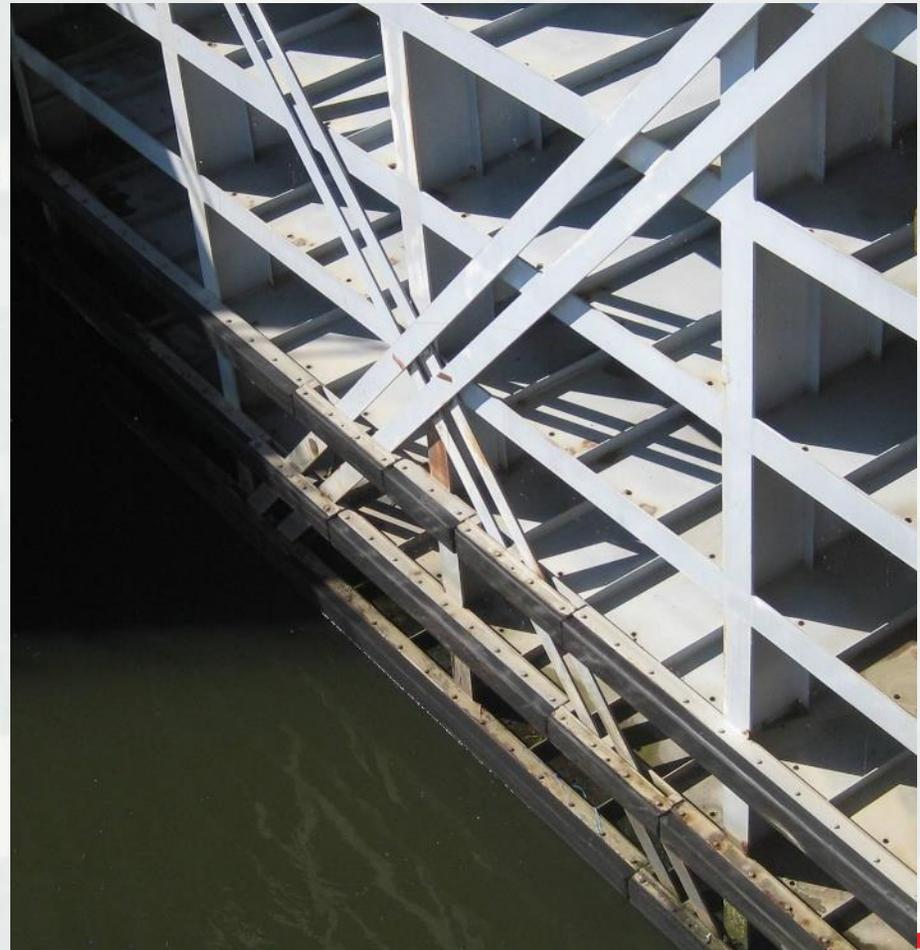
### FENDER STOCK CROSS SECTION

MAKE: 30 @ 10' LENGTH  
 MATERIAL: ASTM A36 STEEL  
 PAINT ACCORDING TO PAINT SPEC

# Bumpers and Fenders



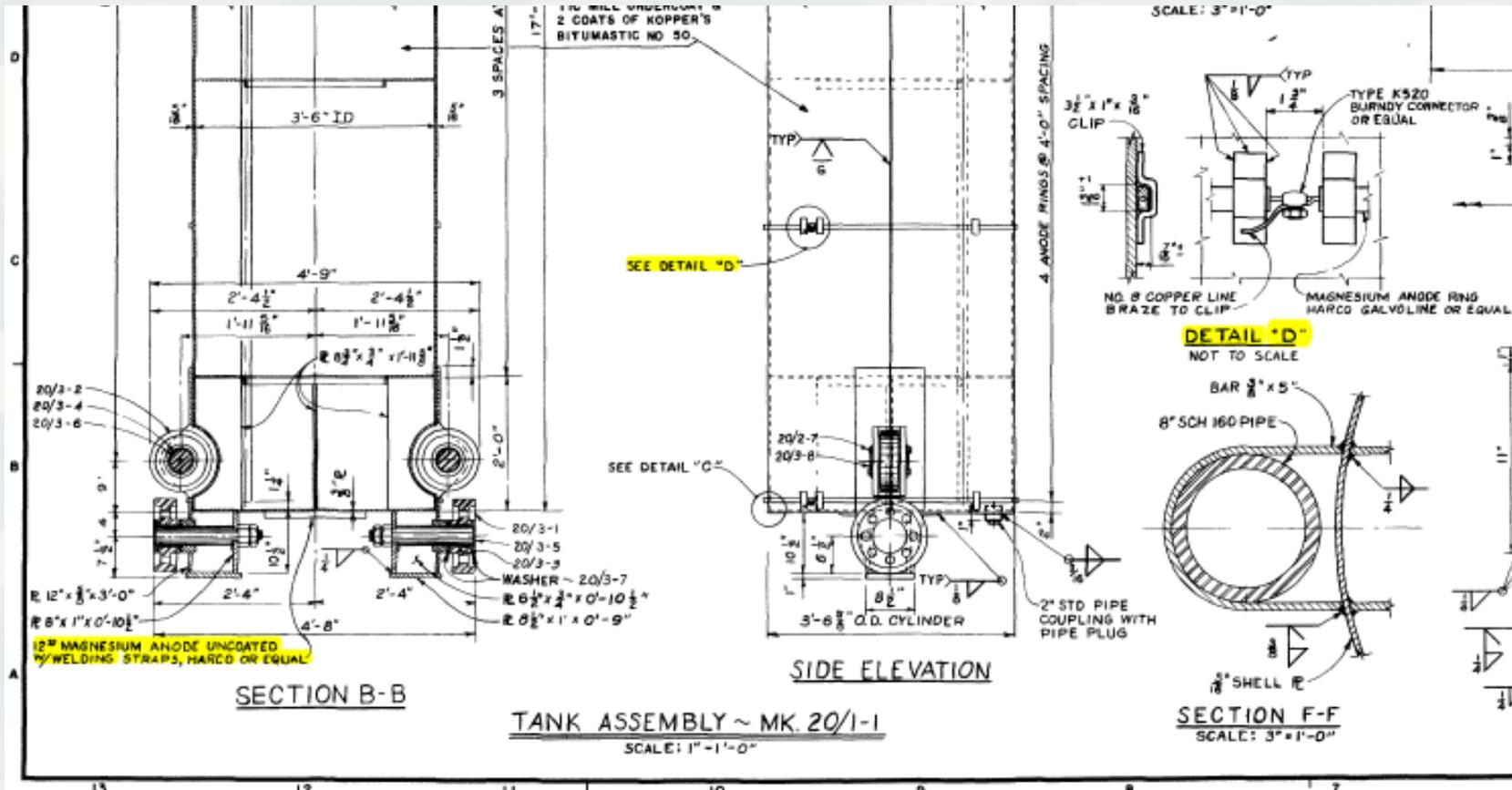
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# Cathodic Protection Floating Mooring Bit



CESAM – Jamie Whitten Lock



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# Mooring Bits



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# Re-Useable Lock Nuts

- For couplings between the miter gate gearboxes & the drive gears
  - Single use nut; custom made, reduced head bolt, grade 8
  - Nylock nuts; require longer bolts, allen head grade 9



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# Hardened steel (Australian steel)



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# Corrosion on old Emergency Gate S/S wire rope cable connections.



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# Tow Haulage



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# High Grade Anti-Freeze and Synthetic Oil



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# Pumps

- Less expensive
- Inexpensive rebuild



# Light Poles



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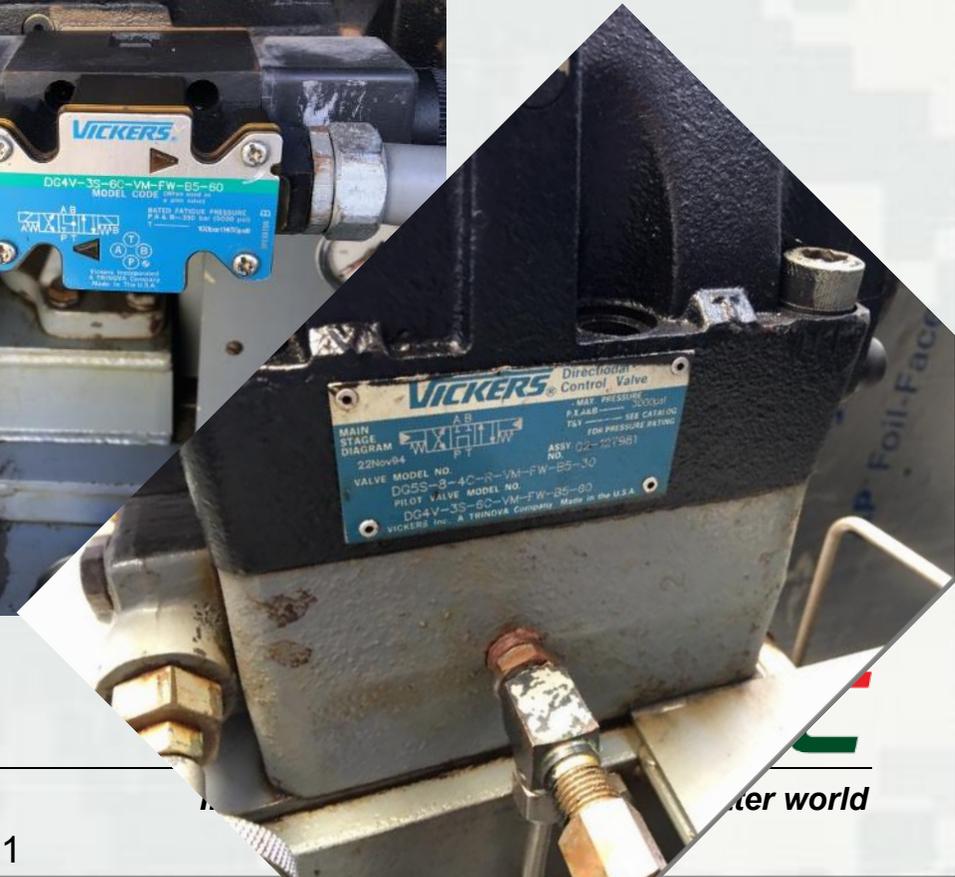
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# Conclusions

- Lots of little things can be done to improve reliability of lock operating equipment
  - Resolvers
  - Gear covers
  - Pumps
  - Valves
  - Solid state timers
  - High grade oil and anti-freeze
- Lots can be done to make operation safer
  - Cameras
  - Proximity switches
  - Redundant position indicator and verification
  - More and better interlocks
  - Interlock over-ride policy



# Valves



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# Unscheduled Closures (mechanical) Based on LPMS



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# Lock Closure Data

## LPMS

- Location (EROCC, River code, Lock #)
- Begin stop date/time
- End stop date/time
- Scheduled (Y/N)
- Reason code

**LPMS includes no details on what failed or how**



# USACE Navigation High Priority Performance Goals

According to the **USACE CW Program Five-Year Development Plan, FY 2011 to FY 2015**, the only high priority performance goals in navigation are lock closures due to mechanical failures lasting more than 24 hours and 7 days.

- Mechanical failures are determined based on data in LPMS



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# Scheduled and Unscheduled Closures

LPMS allows users to record whether a closure is scheduled or unscheduled.

- LPMS offers insufficient guidance on how to determine whether a closure is scheduled or unscheduled.

**Scheduled** - Scheduled stoppages are announced via Navigation Notices (via mail, email, web posting or bulletin board), Broadcasts to Mariners etc. or should be something that is performed regularly.

**Unscheduled** - Stoppages must be either scheduled or unscheduled. Unscheduled stoppages are events that force navigation to cease and are not planned.

Asset Management MMIP

**Unscheduled Maintenance** – Unscheduled maintenance work, usually due to a breakdown of a critical asset/component.



# Scheduled and Unscheduled Closures

- Chief of navigation (CECW-CO-D) is not aware of any official definition of scheduled and unscheduled closure. (Nov 2013)
- Former Chief of navigation (CECW-CO-D) recalled 72-hour advance notice but noted industry was not fully supportive of this timeframe (Jan 2014)
  - Missing IMTS guidance may have said one month notice via Navigation Notices
  - Tracey Keel said LRL considers any summer season closure not scheduled by April/May to be unscheduled.
  - Bill Frechione said that LRP schedules closures for inspections/repair work about two years in advance. “To me any closure with a lead time too small to allow shippers time to adjust is an unscheduled closure.”



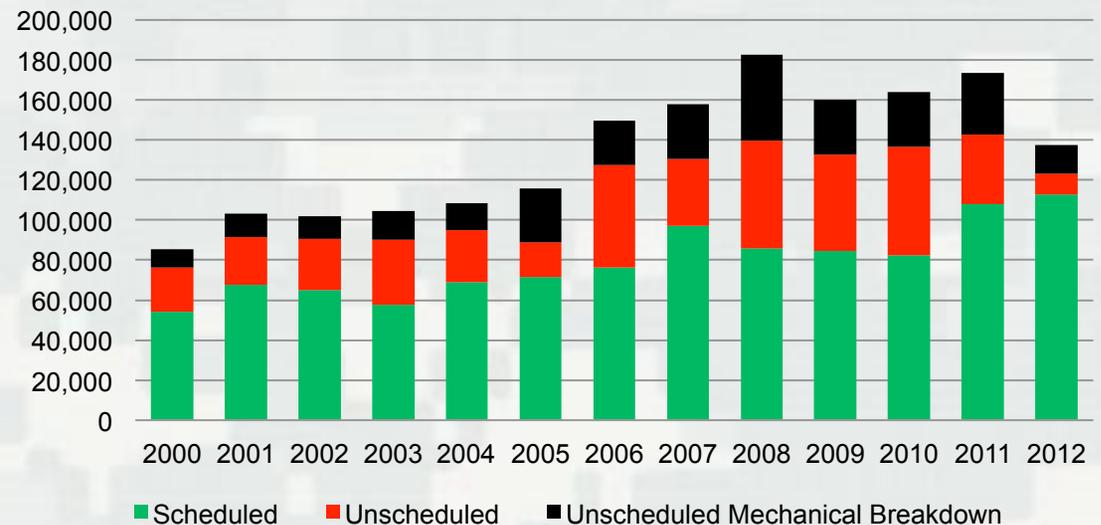
# Navigation Performance

## USACE Campaign Goal Objective 3c:

Deliver reliable infrastructure using a risk-informed asset management strategy

### High Priority Goal:

**INLAND NAVIGATION:**  
Scheduled & Unscheduled  
lock closures due to  
mechanical breakdowns  
lasting longer than 1 day  
and 7 days



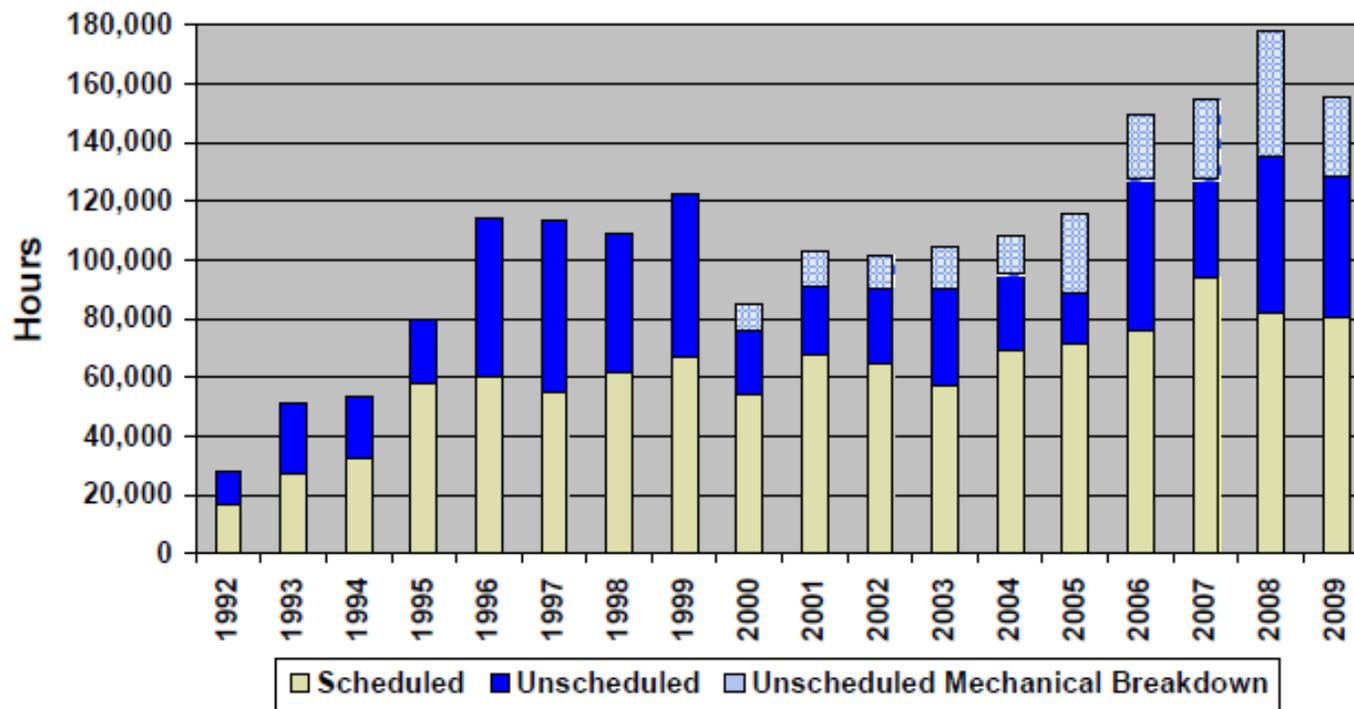
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# Navigation Performance

## IMTS Capital Projects Business Model report (2010)



Note: Total unscheduled closures includes both unscheduled and unscheduled mechanical breakdowns



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# Mechanical Failures (LPMS reason codes)

## List A (HQ)

## List B (IWR)

EE - Repairing lock or lock hardware

= repairing lock or lock hardware

Q - Debris in lock recess or lock chamber

= debris in lock recess or lock chamber

R - Lock hardware or equipment malfunction

= lock hardware or equipment malfunction

S - Lock staff occupied with other duties

= lock staff occupied with other duties

T - Maintaining lock or lock equipment

= maintaining lock or lock equipment

U - Ice on lock or lock equipment

= ice on lock or lock equipment

V - Tow detained by Coast Guard or Corps

≠ Y (y) inspection or testing



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# Lock Closure Data

## LPMS Reasons

- LPMS includes 34 closures reasons in 6 different categories
  - Weather Conditions
  - Surface Conditions
  - Tow Conditions
  - **Lock Conditions**
  - Other Conditions
  - Unknown



# Lock Closure Data

## LPMS Reasons

### Lock Conditions

- AA – Accident or collision in lock
- BB – Closed (unmanned shift)
- **EE – Repairing lock or lock hardware**
- Q – Debris in lock recess or lock chamber
- **R – Lock hardware or equipment malfunction**
- M – Tow staff occupied with other duties
- **T – Maintaining lock or lock equipment**
- U – Ice on lock or lock equipment
- **Y – Inspection or testing lock**



# Unscheduled Lock Closure Data infrastructure and barge impacts

## Data needed:

- Location (EROC, River code, Lock #)
- Begin stop date/time
- End stop date/time
  
- What component,
- What happened to the component,
- How it was discovered, and
- How it impacted gate operation



# Other Data on Unscheduled Mechanical Closures



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# Lock Closure Data Emergency Closures

HQ Navigation branch compiled data from 1999 – 2005

- District, **Project**, Year opened, **Closure month-yr**, **Closure length days**, **Reason for Closure**, Funding, Cost of Repairs, **Impact of Closure**, **Remarks**

| INFRASTRUCTURE EMERGENCY CLOSURES (1999 - 2005) |                  |             |                 |                     |  |         |                 |   |   |
|---|------------------|-------------|-----------------|---------------------|--|---------|-----------------|---|---|
| MSC/DI<br>MYD<br>/MYR                           | PROJECT          | YEAR OPENED | CLOSURE MO - YR | CLOSURE LENGTH DAYS | REASON FOR CLOSURE                                   | FUNDING | COST OF REPAIRS | IMPACT OF CLOSURE                       | REMARKS   |
| <b>Illinois Waterway</b>                        |                  |             |                 |                     |  |         |                 |   |   |
| 1   | Marseilles L&D   | 1933        | Jul-99          | 1.6                 | Miter gate pintle ball shim                          | O&M     | \$66,000        | 29 tows waiting - longest waited 2 days | Upstream River Gate was misaligned at gate closure.   |
| 2   | Laqrang L&D      | 1939        | Jan-02          | 2                   | Gate anchor broke                                    | O&M     | \$70,000        | 40 tows waiting                         | Gate anchor was on the lower landwall miter gate. Cu  |
| 3   | Laqrang L&D      | 1939        | Mar-02          | 16                  | New miter gate anchors                               | O&M     | \$37,000        | 44 tows waiting                         | New miter gate anchors were installed during 8 2-day  |
| 4   | Laqrang L&D      | 1939        | Dec-02          | 1                   | Miter gate gudgeon loose                             | O&M     | \$16,000        | 8 tows waiting                          | Gudgeon pin in lower land wall miter gate worked its  |
| 5   | Laqrang L&D      | 1939        | Jan-03          | 1.2                 | Bull gear gate arm broke                             | O&M     | \$13,000        | 10 tows waiting                         | Bull gear gate arm on lower miter gate broke          |
| 6   | Starved Rock L&D | 1933        | Feb-04          | 1                   | Buffer box on miter gate broke                       | O&M     | \$17,000        | 6 tows waiting                          | Buffer box broke and plunger bolt sheared off. Main   |
|   |                  |             |                 | 22.8                |  |         | \$219,000       |   |   |
| <b>Mississippi River</b>                        |                  |             |                 |                     |  |         |                 |   |   |
| 7   | L&D 21           | 1938        | Feb-99          | 7                   | Repaired #1 and #3 miter gates                       | O&M     | \$311,900       | Minimal due to scheduled closure timing | Closure was during normal winter slow period - howe   |
| 8   | L&D 11           | 1937        | Jul-99          | 1                   | Replaced failed strut arm on #2 miter gate           | O&M     | \$40,500        |   |   |
| 9   | L&D 22           | 1938        | Jan-00          | 47                  | Replaced machinery bases & elec cables; repaired gas | O&M     | \$1,201,200     | Minimal due to scheduled closure timing | Closure was during normal winter slow period - howe   |
| 10  | L&D 21           | 1938        | Jan-00          | 60                  | Installed bubbler system & replaced damaged seals    | O&M     | \$2,700,000     | Minimal due to scheduled closure timing | Closure was during normal winter slow period - howe   |
| 11  | L&D 19           | 1957        | Jan-01          | 53                  | Repaired lower miter gates                           | O&M     | \$2,648,800     | Minimal due to scheduled closure timing | Closure was during normal winter slow period - howe   |
| 12  | L&D 11           | 1937        | Apr-01          | 28                  | Flood of 2001 - Repaired damage caused by flood      | O&M     | \$436,200       |   | Closure period includes time of flooding when lock ne |
| 13  | L&D 12           | 1939        | Apr-01          | 31                  | Flood of 2001 - Repaired damage caused by flood      | O&M     | \$785,400       |   | Closure period includes time of flooding when lock ne |
| 14  | L&D 13           | 1938        | Apr-01          | 30                  | Flood of 2001 - Repaired damage caused by flood      | O&M     | \$3,540,000     |   | Closure period includes time of flooding when lock ne |
| 15  | L&D 14           | 1922/1939   | Apr-01          | 27                  | Flood of 2001 - Repaired damage caused by flood      | O&M     | \$521,400       |   | Closure period includes time of flooding when lock ne |
| 16  | L&D 15           | 1934        | Apr-01          | 24                  | Flood of 2001 - Repaired damage caused by flood      | O&M     | \$1,048,200     |   | Closure period includes time of flooding when lock ne |
| 17  | L&D 16           | 1937        | Apr-01          | 28                  | Flood of 2001 - Repaired damage caused by flood      | O&M     | \$1,129,800     |   | Closure period includes time of flooding when lock ne |
| 18  | L&D 17           | 1939        | Apr-01          | 28                  | Flood of 2001 - Repaired damage caused by flood      | O&M     | \$1,146,600     |   | Closure period includes time of flooding when lock ne |

# Lock Closure Data

## LRD Repair Records

### LRD repair records

#### Appendix E - Scheduled Work vs. Work Performed

#### Repair/Maintenance Schedule for 2005

Scheduled and Performed   
 Scheduled but Not Performed   
 Performed but Not Scheduled 

| <u>River Mile</u>  | <u>Project</u>                                 | <u>Repairs</u>   | <u>Dates</u>            | <u>Remarks</u>                 |
|--|--|--|-------------------------|--------------------------------|
| <b><u>Green River System</u></b>   |  |  |                         |                                |
|  9.1    | Lock and Dam 1<br>(Louisville District)        | Sill repairs & dewatering  | Aug 10 – Aug 27, 2005   | Lock closed, no auxiliary lock |
| <b><u>Kanawha River System</u></b>   |  |  |                         |                                |
|  82.2 | London L&D<br>(Huntington District)            | Roller Gate Bottom Seal Mod<br>Main Chamber Lower Gate Seal Repair/Mod<br>Main Chamber Top Anchorage Adj/Repairs | May 23 – Jul 1, 2005    | Main Lock Closed               |
|  67.7 | Marmet L&D<br>(Huntington District)            | Roller gate Chain Repair/Replacement   | Concurrent<br>(14 days) | No Delays                      |
|  31.1 | Winfield Lock and Dam<br>(Huntington District) | Aux Lock Repairs<br>(Old Land Chamber Lower Gates)   | Jul 4 – Jul 29, 2005    | No Delays                      |
| <b><u>Ohio River System</u></b>  |  |  |                         |                                |
|  6.2  | Emsworth L&D<br>(Pittsburgh District)          | Repair Dam Gates 3 & 11  | Feb 22 – Mar 12, 2005   | No Delays                      |



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# Lock Closure Data

## Accidents and Equipment Failures Reported to HQ Navigation Branch

EP 1130-2-520, Chapter 2

29 Nov 96

### 2-6. Special Reports.

a. Changes affecting navigation will be made promptly whenever information of immediate concern to navigation becomes known. Refer to ER 1130-2-520 for the circumstances requiring special reports. Items of information especially desired are: (1) \_\_\_\_\_; (2) \_\_\_\_\_; (3) \_\_\_\_\_; (4) \_\_\_\_\_; (5) \_\_\_\_\_; **(6) accidents or equipment failures at USACE locks and dams or along navigable waterways, that will result in closure of the lock or waterway for 24 hours or more, or will result in a significant impact to navigation.** For item (6), district commanders are to forward an **incident report** to HQUSACE (CECW-OD) through their MSC office as soon as possible following the incident. Reporting of navigation incidents to CECW-OD is required even though the districts may be sending situation reports to the HQ Emergency Operations Center during natural disasters or more regional or localized events.



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# Special (Incident) Reports

>>Subject: Inner Harbor Navigation Canal (IHNC) Lock Closed - Damaged Miter

>>

>>INITIAL REPORT: MVD at 0206 hrs 5 Feb 2013

>>

>>BLUF: IHNC Lock in MVN - Gate #8 strut arm failed, but can be repaired

>>first thing this morning after overnight weather front passes. Lock is

>>closed with 29 tows on turn (awaiting transit). Unsafe working conditions

>>prevented MVN staff from repairing immediately.

>>

>>What: IHNC Lock miter gate damaged strut arm, cause of failure unknown,

>>but possibly from over-travel of gate/photo eye issue.

>>

>>When: Monday, 4 FEB 13, ~1900 hrs

>>

>>Where: New Orleans, LA

>>

>>Impacts: some to navigation customers with 29 tows on turn. Industry and

>>USCG have been apprised of the situation. MVN believes the arm can be

>>repaired in-place much faster than a complete swap out as the damage

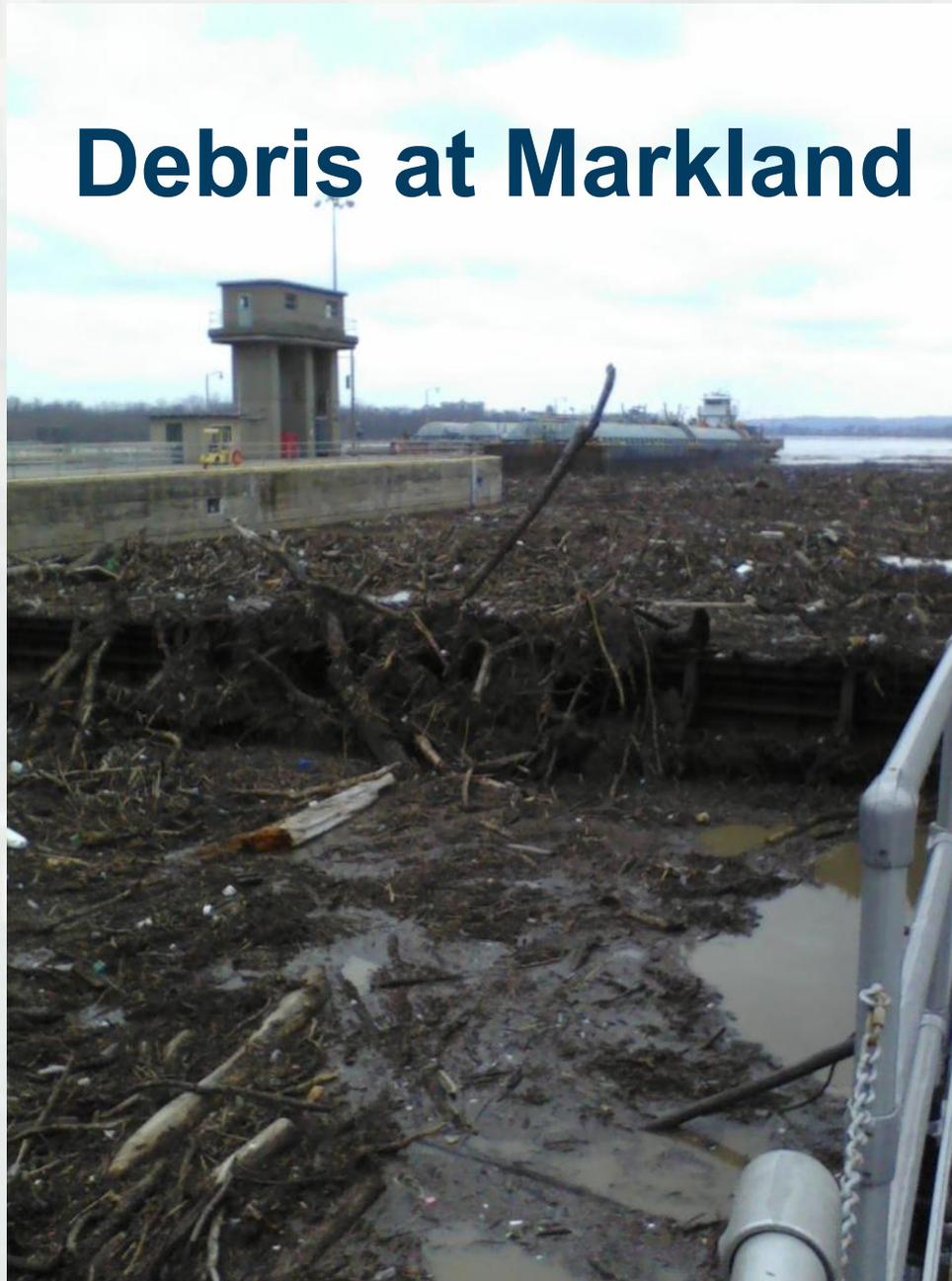
>>appears to be minimal. MVN does have the spare arm ready to go if needed,

>>and Operations Division teams are ready to respond at daybreak. Poor

>>weather conditions made it unsafe to address Monday night.



# Debris at Markland



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# Debris at Markland



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**Department of the Army**  
**U.S. Army Corps of Engineers Civil Works Program**  
**Five-Year Development Plan**  
**Fiscal Year 2011 to Fiscal Year 2015**

| <i>Fiscal Year</i>   | 2002   | 2003   | 2004  | 2005  | 2006  | 2007             | 2008              | 2009              | 2010              | 2011 |
|--|--------|--------|-------|-------|-------|------------------|-------------------|-------------------|-------------------|------|
| <b>Actual Instances of Lock Closures due to Mechanical Failures Lasting Longer than 24 Hours</b> | 45     | 45     | 36    | 19    | 33    | <del>38</del>    | <del>42</del>     | <del>37</del>     | 61                | NA   |
| <b>Total Hours for Lock Closures due to Mechanical Failures Lasting Longer than 24 Hours</b>     | 13,448 | 12,575 | 9,265 | 5,029 | 9,817 | <del>9,317</del> | <del>16,033</del> | <del>11,096</del> | <del>19,562</del> | NA   |
| <b>Actual Instances of Lock Closures due to Mechanical Failures Lasting Longer than 7 Days</b>   | 25     | 27     | 19    | 13    | 21    | <del>18</del>    | <del>28</del>     | 19                | 37                | NA   |
| <b>Total Hours for Lock Closures due to Mechanical Failures Lasting Longer than 7 Days</b>       | 12,255 | 11,399 | 7,929 | 4,728 | 8,871 | <del>7,805</del> | <del>15,073</del> | <del>9,675</del>  | <del>17,638</del> | NA   |



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# LPMS Reason Codes

## Surface Conditions

O - Debris

## Lock Conditions

Q - Debris in lock recess or lock chamber

## Tow Conditions

P – Tow accident or collision

## Lock Conditions

AA – Accident or collision in lock

## Other Conditions

W – Collision or accident



# LPMS Reason Codes

## Lock Conditions

- EE – Repairing lock or lock hardware
- R – Lock hardware or equipment malfunction
- T – Maintaining lock or lock equipment
- Y – Inspection or testing lock

