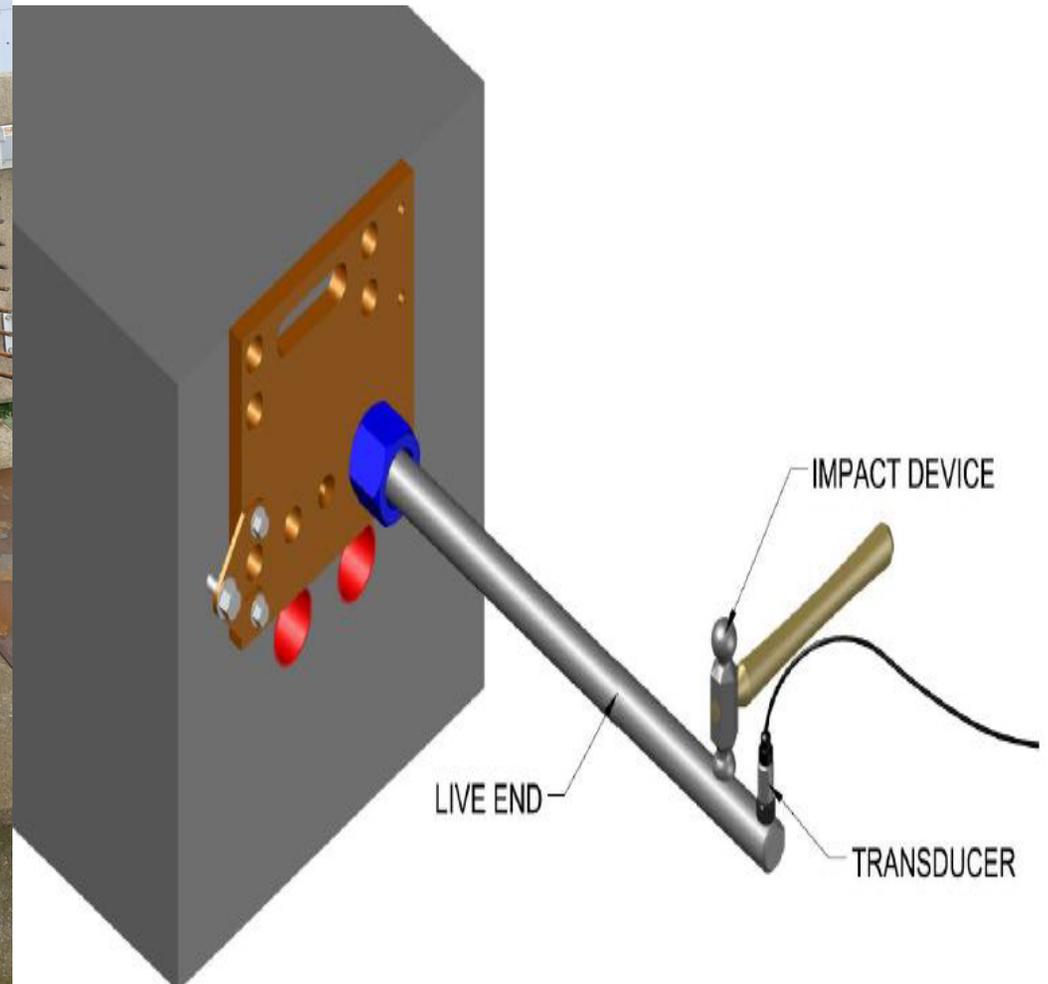


# Dispersive Wave (DW) Testing of Trunnion Rods



# Trunnion Rods

- Mandated Design by USACE HQ. (1960s)
- COE Standard (EM 1110-2-2702)
- Adopted by other Government Agencies and Industry
- Offered Advantages over Steel Beam/Girder Designs
- Limited Suppliers
- Difficult for Inspection / Repair

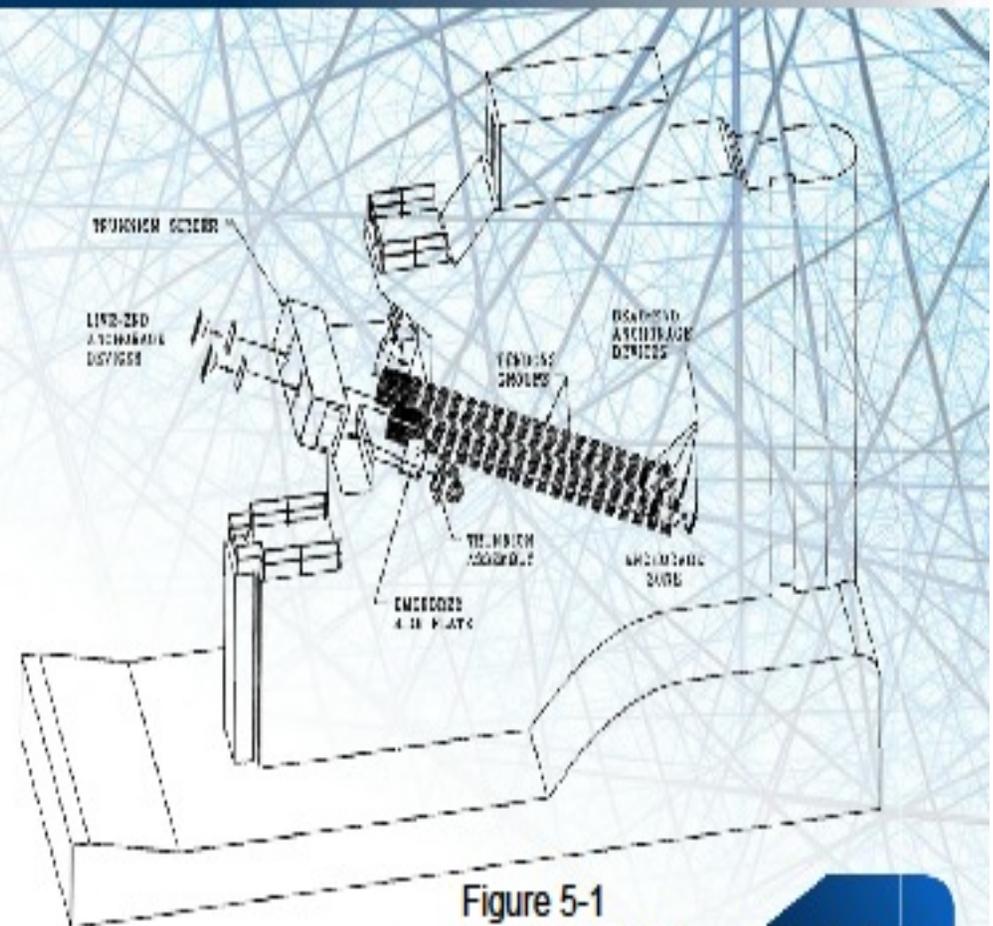


Figure 5-1  
EM1110-2-2702





# Rod Inventory - How many known failures??

| Location      | Failures                            |
|---------------|-------------------------------------|
| Greenup       | 4 tension loss, 2 broken            |
| Meldhal       | 7 tension loss                      |
| Belleville    | None reported                       |
| Racine        | 1 tension loss (not re-tensioned)   |
| Willow Island | 1 loss (not re-tensioned), 6 broken |
| Winfield      | 6 broken                            |
| Markland      | 2 tension loss, 2 broken            |
| McAlpine      | None reported                       |
| Cannelton     | 61 tension loss, 2 broken           |
| Newburgh      | 3 tension loss, 2 broken            |
| J T Myers     | 37 tension loss, 6 broken           |
| Smithland     | 3 tension loss, 2 broken            |
| West Point    | 5 broken                            |
| R. F. Henry   | 6 broken                            |



# Safety

- Examples of Rod Failures

## WEST POINT PROJECT



**Pier #10 Trunnion Anchor Boxes  
West (10W) and East (10E)  
March 6, 2008**

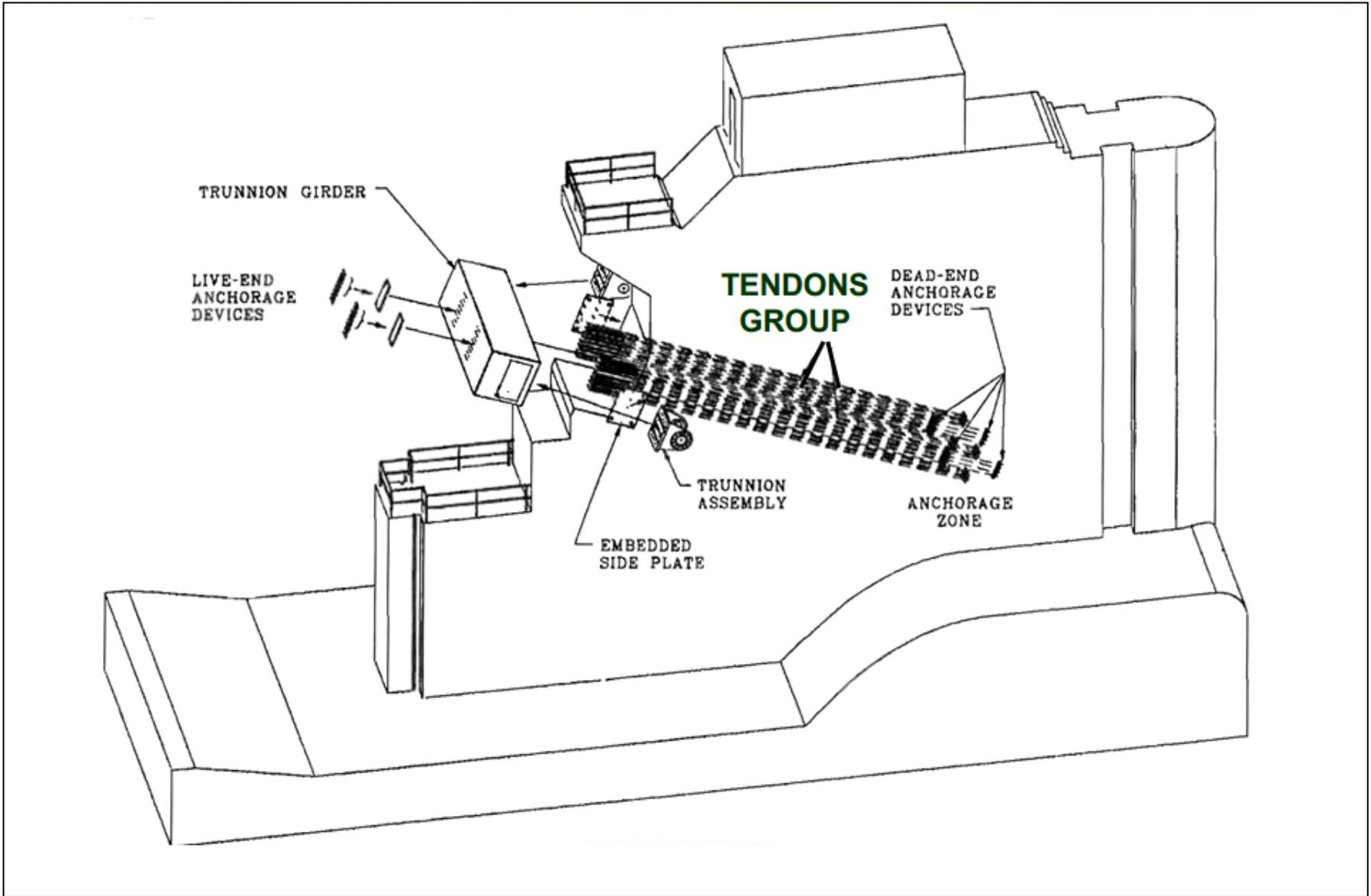


# Safety

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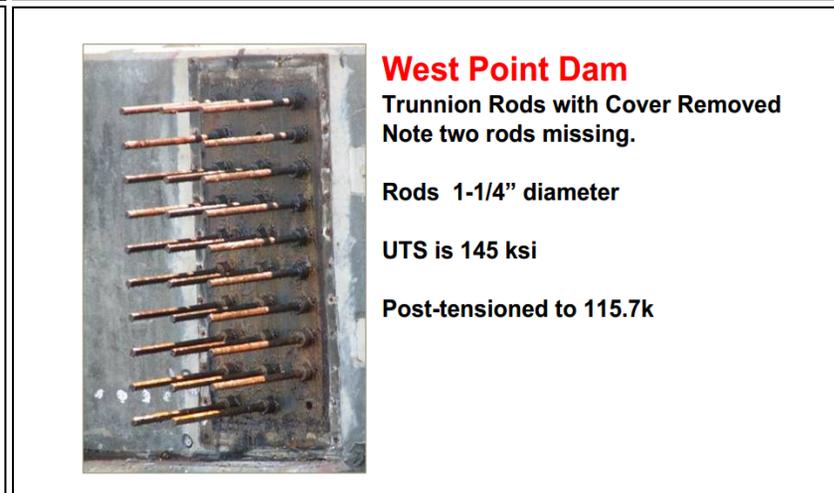
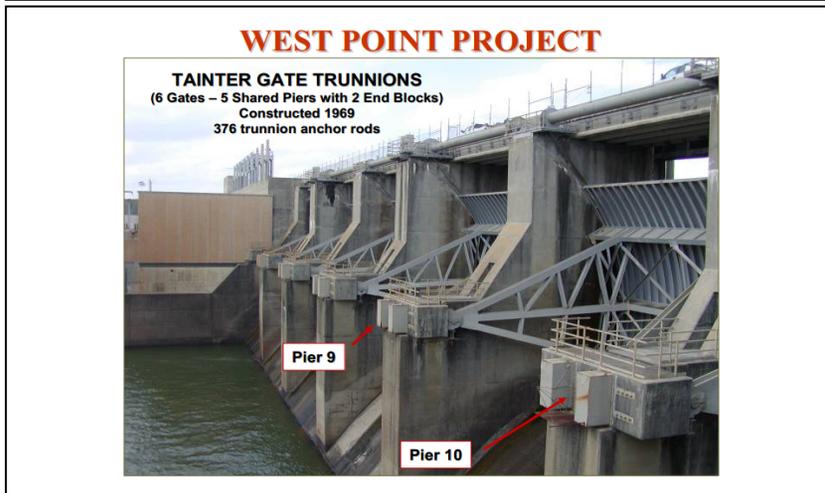
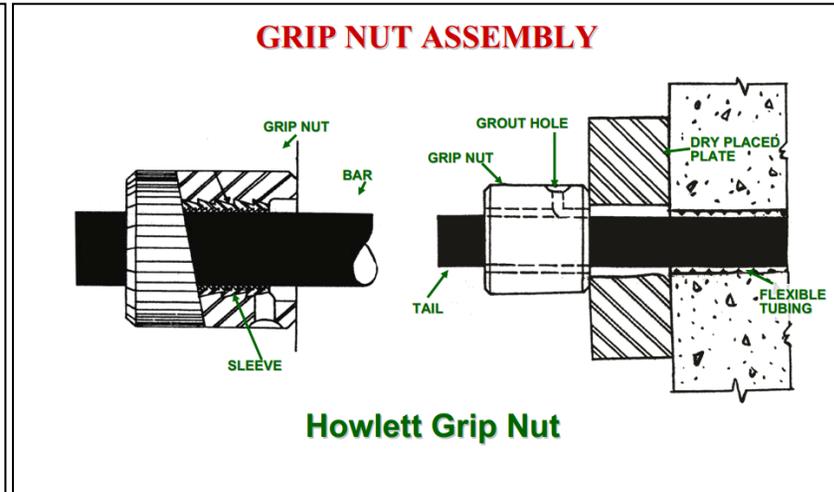
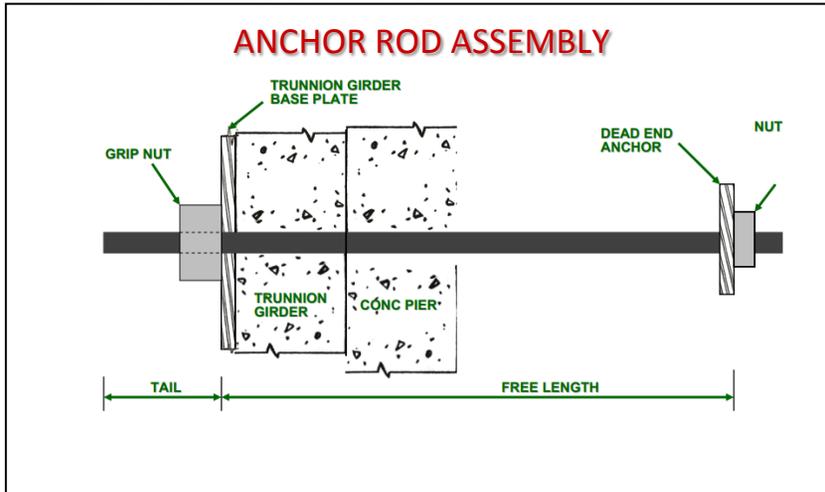
- Although every project should be approached with care and consideration for safety, the nature and environment of dam inspections creates a much lower margin for error than typical job sites.
  - Slips, trips, and falls: We use fall arrest systems similar to those used in tower climbing, but given the proximity to water, the other threat lies in falling into that water.
  - Heavy equipment: Most inspections involve the use of heavy equipment in confined spaces as well as the presence of ongoing construction (i.e. usually inspections are completed in tandem with repairs)
  - Rod failure: The anchor rods supporting the dam are under thousands of pounds of tension, and while we do our best to mitigate risk associated with man-made rod failure, **RODS CAN FAIL SPONTANEOUSLY AT ANY TIME WITHOUT WARNING.**
    - **AVOID STANDING IN FRONT OF RODS AS MUCH AS POSSIBLE.**

# Dam Anchor Rod Testing General Concept



# Dam Anchor Rod Testing

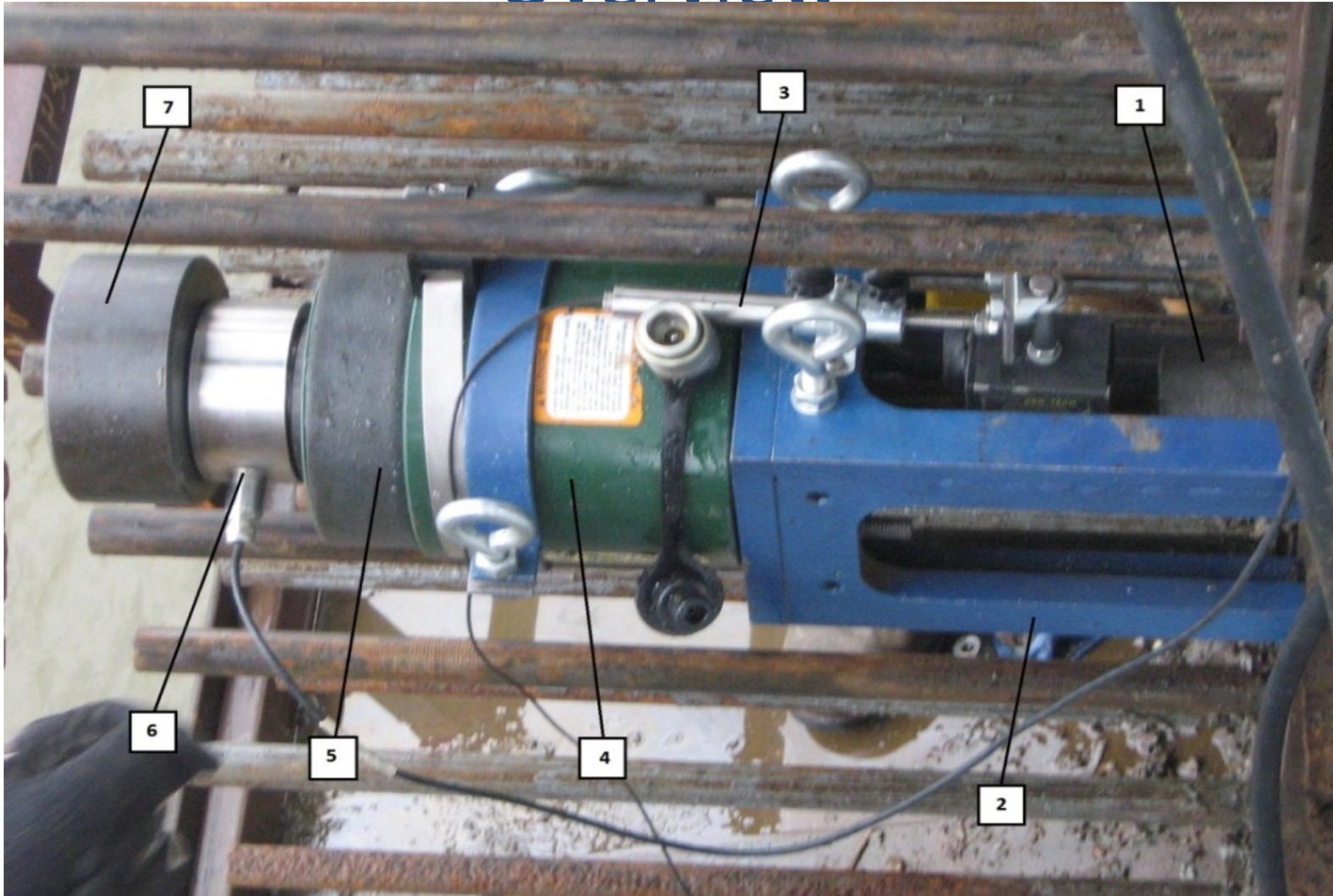
## General Concept



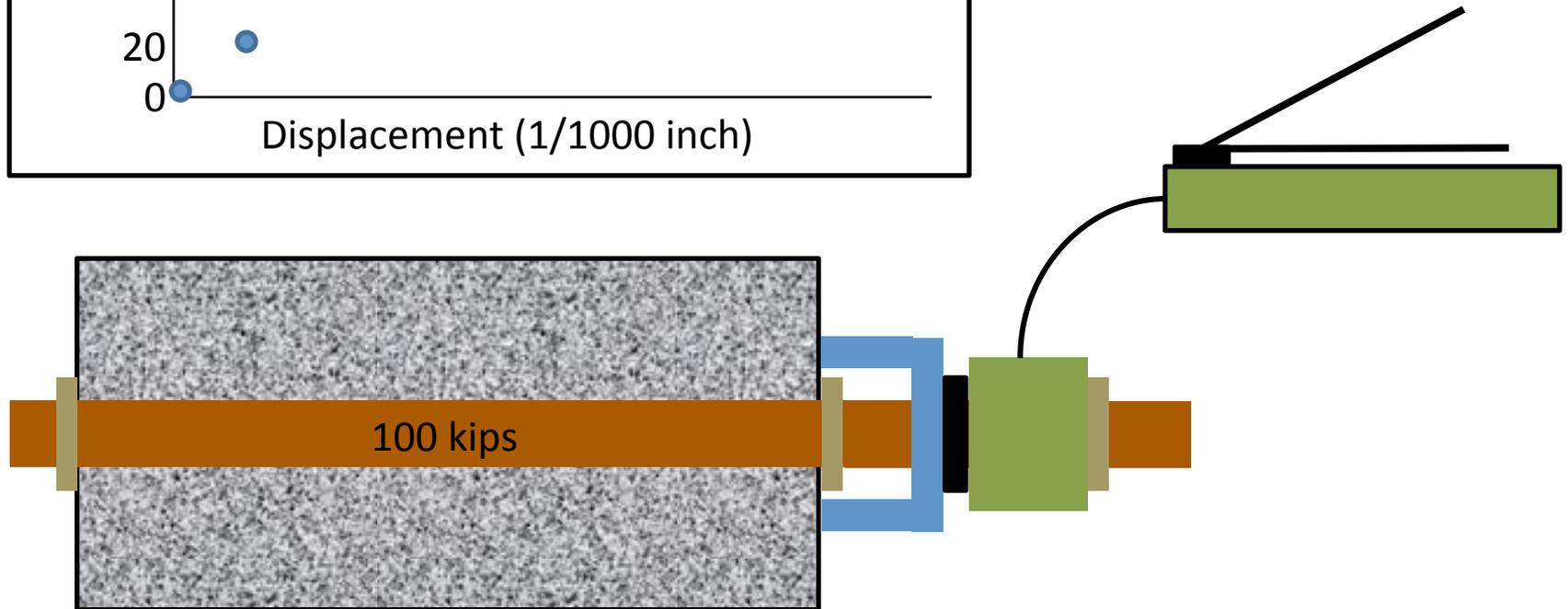
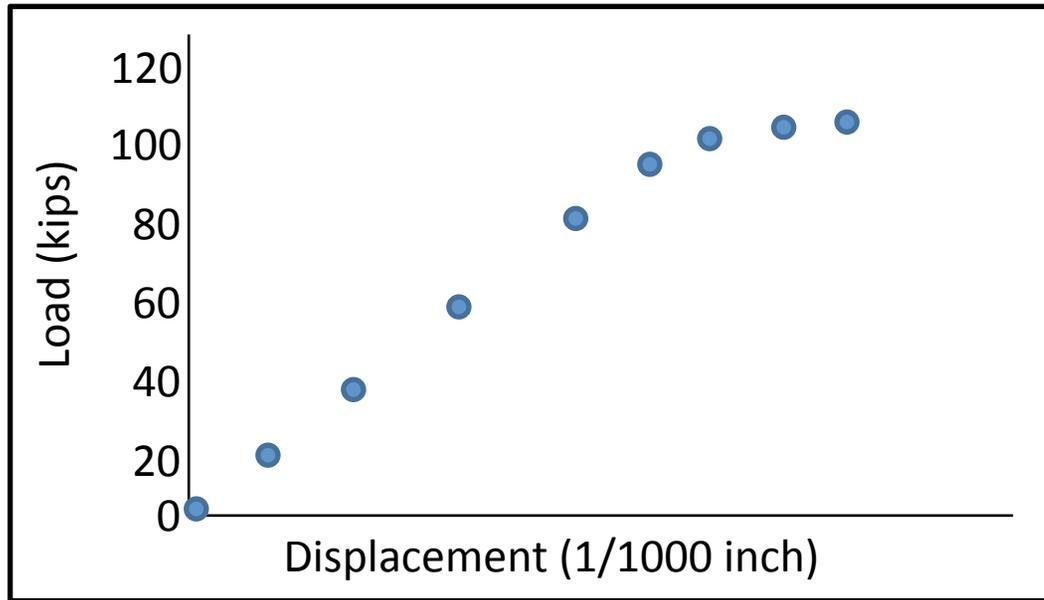


# Dam Anchor Rod Testing LO Testing - Equipment

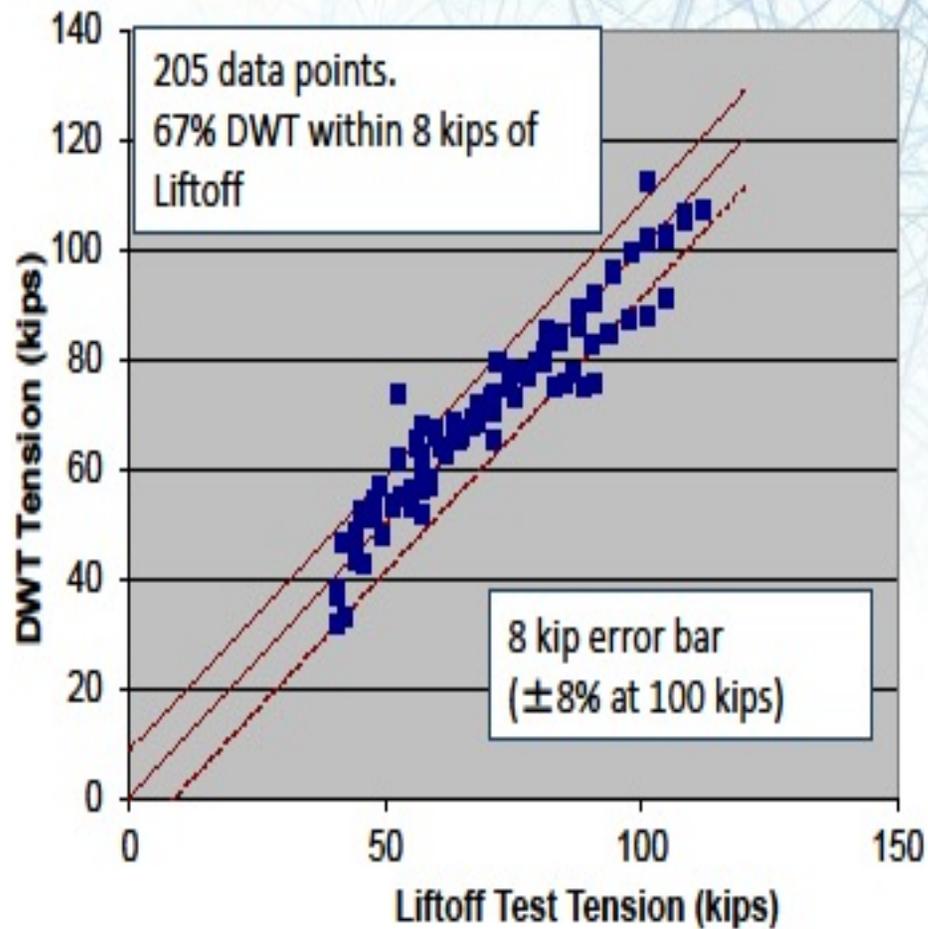
## Overview



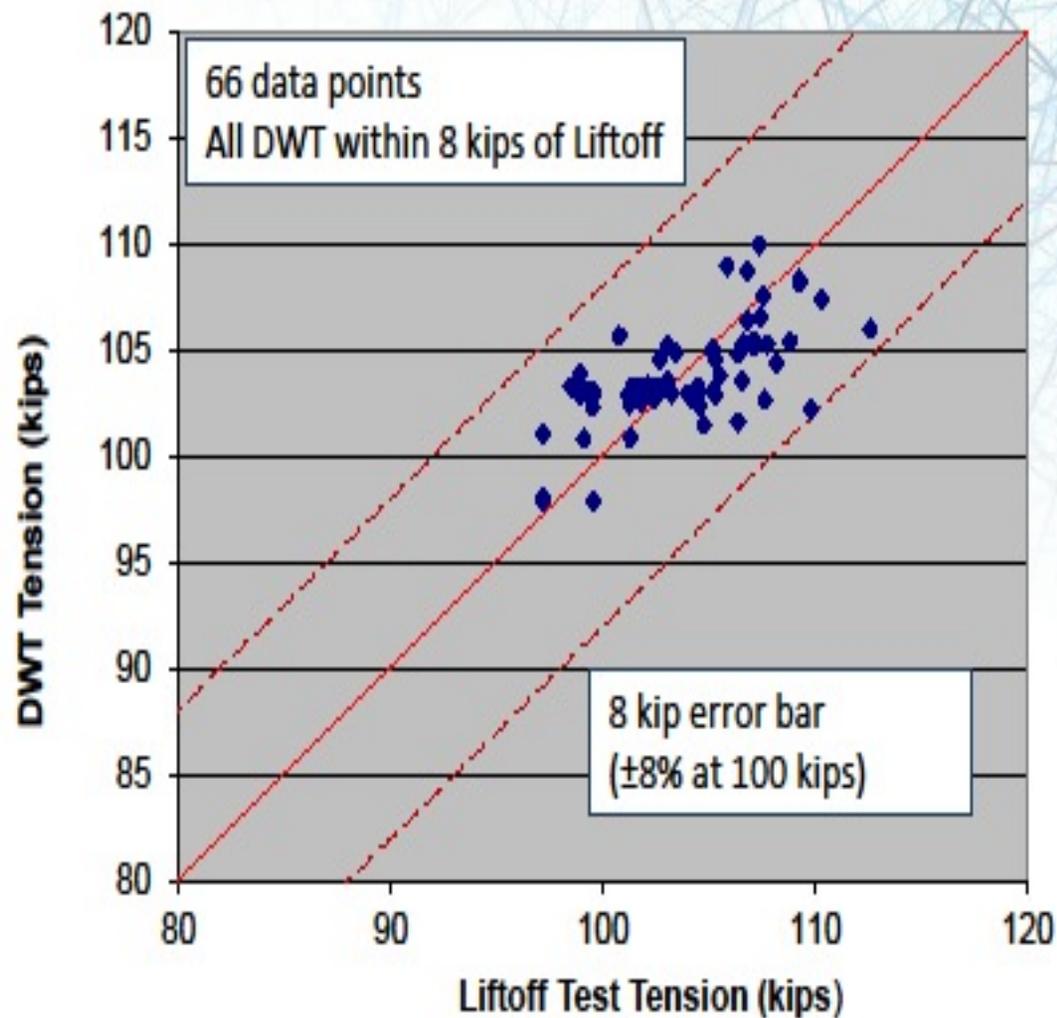
# Dam Anchor Rod Testing Liftoff Testing



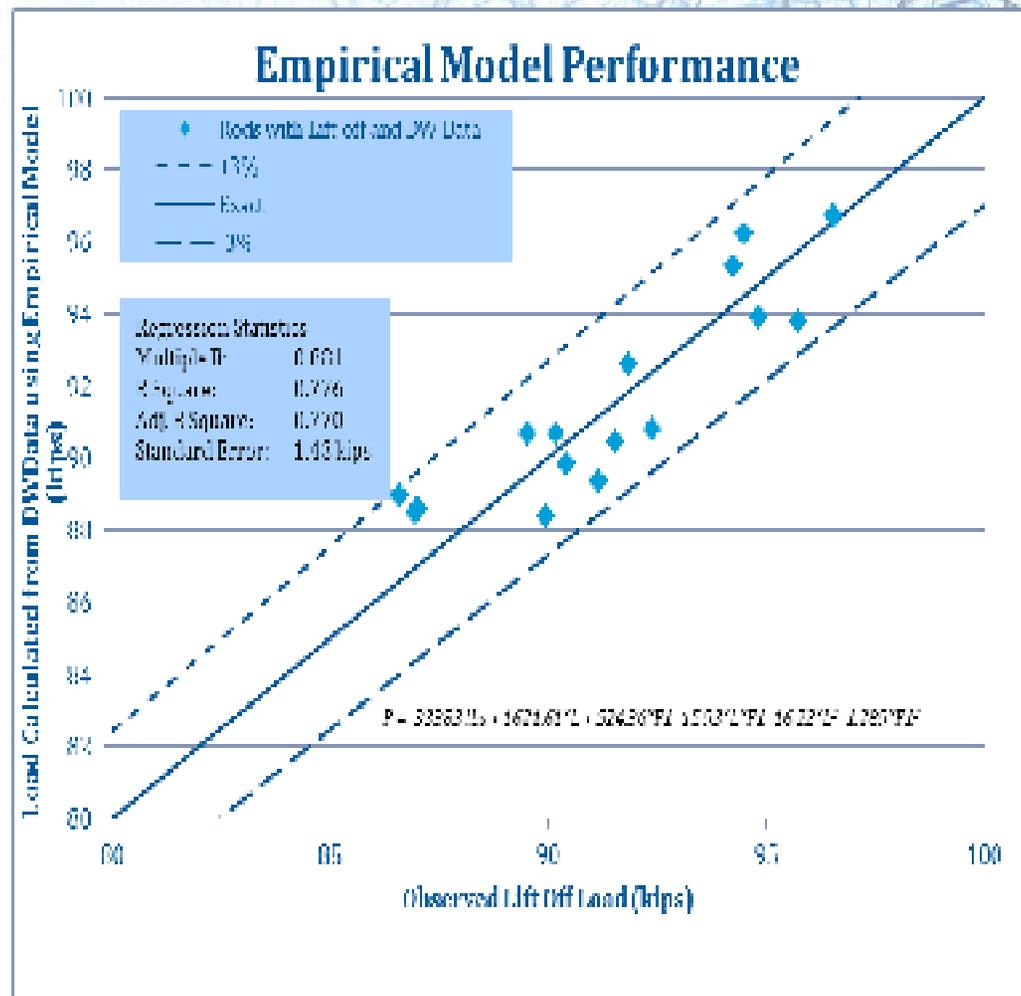
# Prototype Testing at FDH Lab



# R. F. Henry Dam – Results



# Greenup Dam – DWT & Lift-off Results



# Greenup Dam – Test Program



- » 206 rods tested

- » Two piers (Piers 2 & 3), 206 rods total
- » Dispersive Wave (DW) data collected on all rods – 12 sets of data/rod
  - 3 impact devices – varying excitation frequency
  - 4 tests per device
  - Acceleration recorded at rod end
  - Cantilever length measured
- » Twenty (20) liftoff tests
  - Pier 2: Ten (10) selected by USACE
  - Pier 3: Ten (10) randomly selected by FDH
- Maximum load = 110 kips



# Greenup Dam – Lift-off Testing



- » Chair, Jack, load cell and locking ring attached to rod

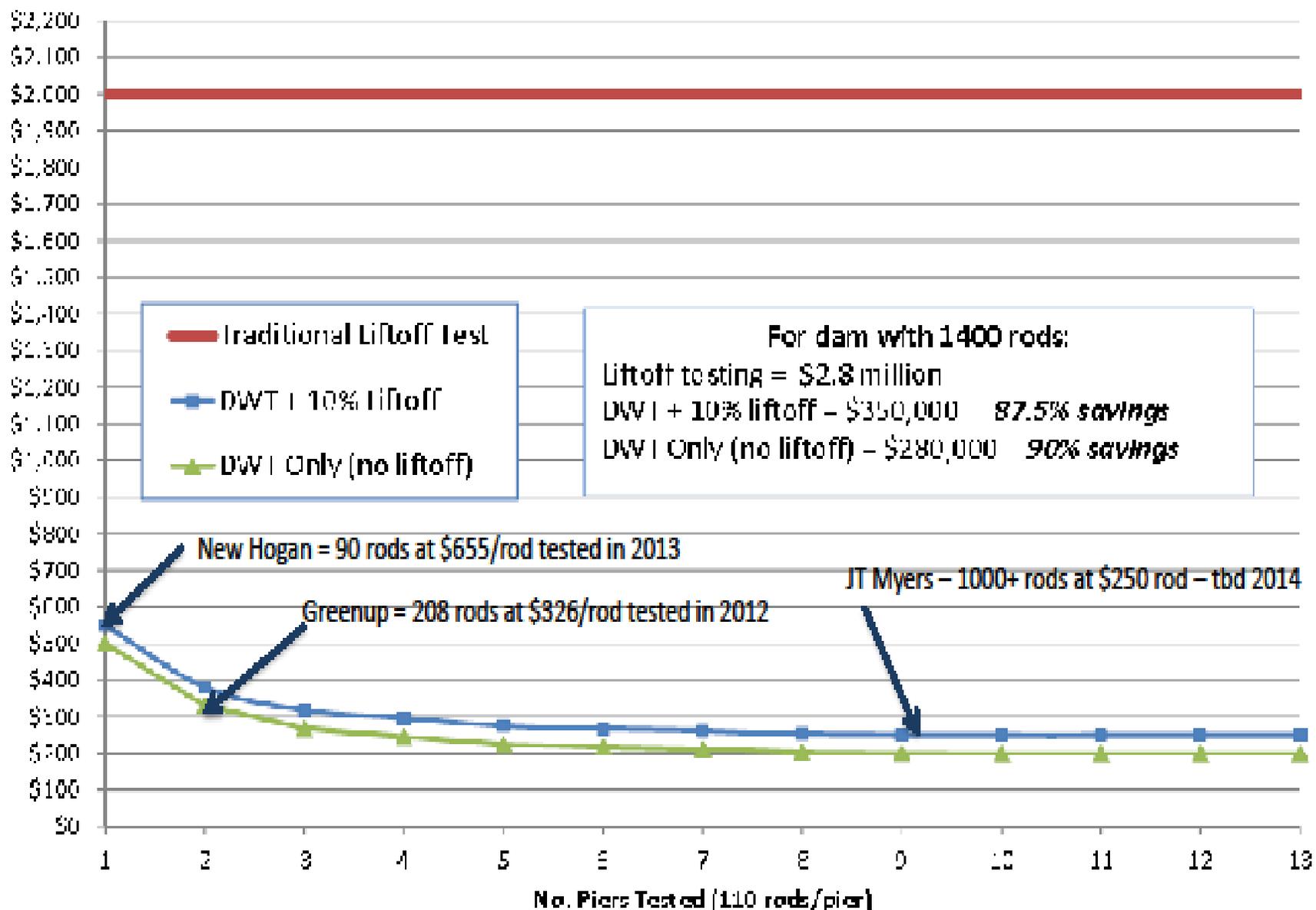
- » Equipment enabled precise control of test, while maximizing safety
  - Hand-operated hydraulic pump
  - Electronic load cell and displacement transducer
  - All personnel off of lower platform during test
- » Maximum load allowed = 110 kips
- » Twenty tests
  - 16 achieved liftoff
  - 4 reached max load before liftoff
- » Rods re-tensioned to increase load by up to 5%, with max load = 100 kips

# VALIDATION PROGRAM

1. At direction of USACE HQ – FDH partnered with USACE ERDC (Vicksburg)
2. Select 4-8 dams for validation of FDH DWT method:
  - A. Perform DW Test on all rods in each dam
  - B. Perform confirming liftoff test in 10% of rods
3. Perform additional “blind” testing at ERDC facility in Vicksburg
4. Future dams can then be tested without confirming liftoff test
5. First two dams (JT Myers and Markland) to be tested in summer 2014
6. Additional dams needed to complete validation study.



## Cost Savings Using DWT Method



# QUESTIONS?



**FDH goes the extra mile for its clients!**

