

# Automated Ullage Sensors for Hopper Dredge Bin Measurement

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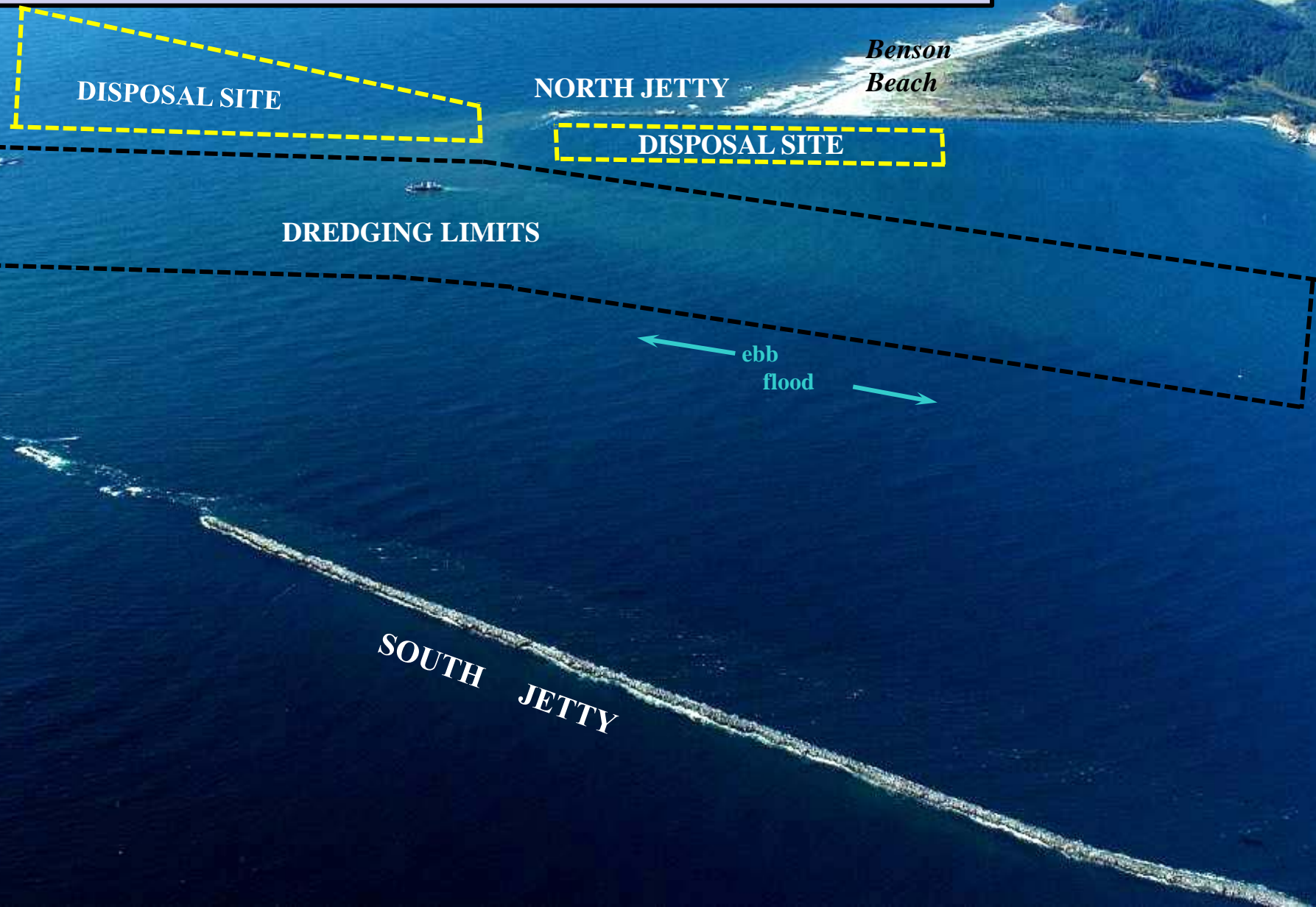
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# West Coast Entrance Bar Dredging

(Mouth of the Columbia River)

*View to the  
Northwest*



DISPOSAL SITE

NORTH JETTY

*Benson  
Beach*

DISPOSAL SITE

DREDGING LIMITS

ebb  
flood

SOUTH JETTY

# Coastal Entrance Bar Dredging

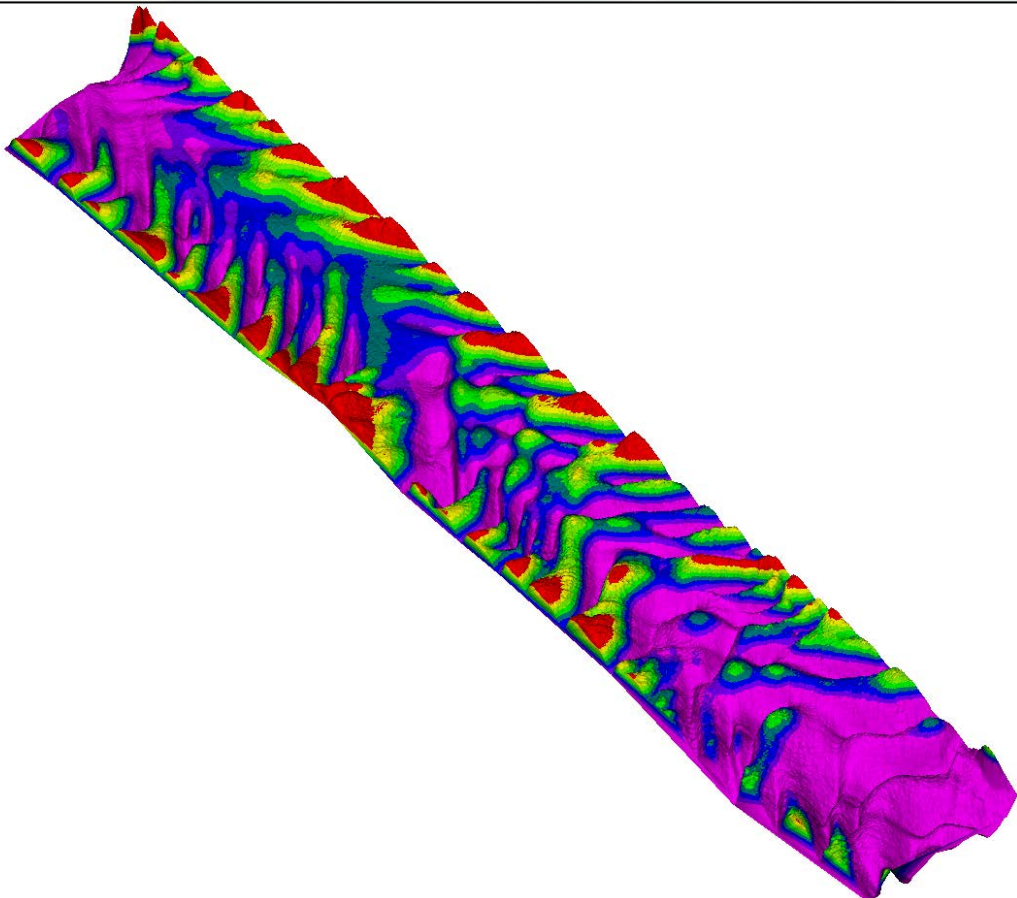
- 4-6 million cubic yards dredge annually at the Mouth of Columbia River (MCR).
- Material is typically sand which is placed in ocean disposal sites
- Typically Contracts pay \$2.50 to \$3.50 per CY
- Rough sea conditions on most coastal bars necessitate a compressed dredging season, typically July – Oct
- Two hopper dredges typically work simultaneously in the same four mile stretch.



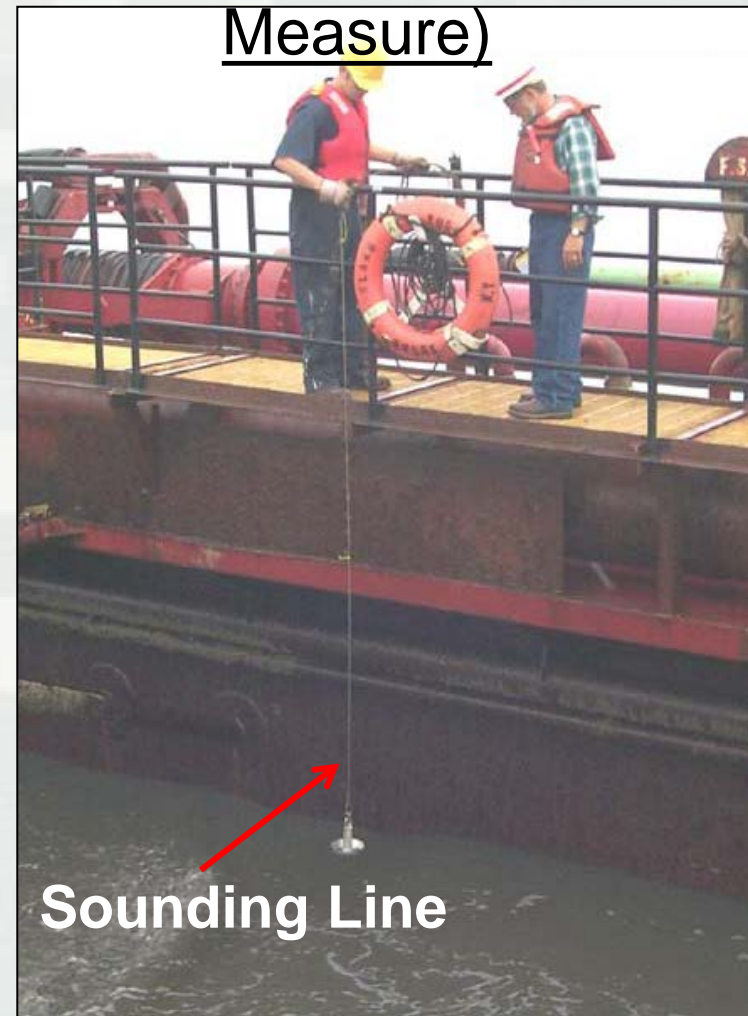
# Background

- Payment for hopper dredging has traditionally been by one of two methods:

Pre/Post Dredge Survey



Bin Measure (Hand Measure)



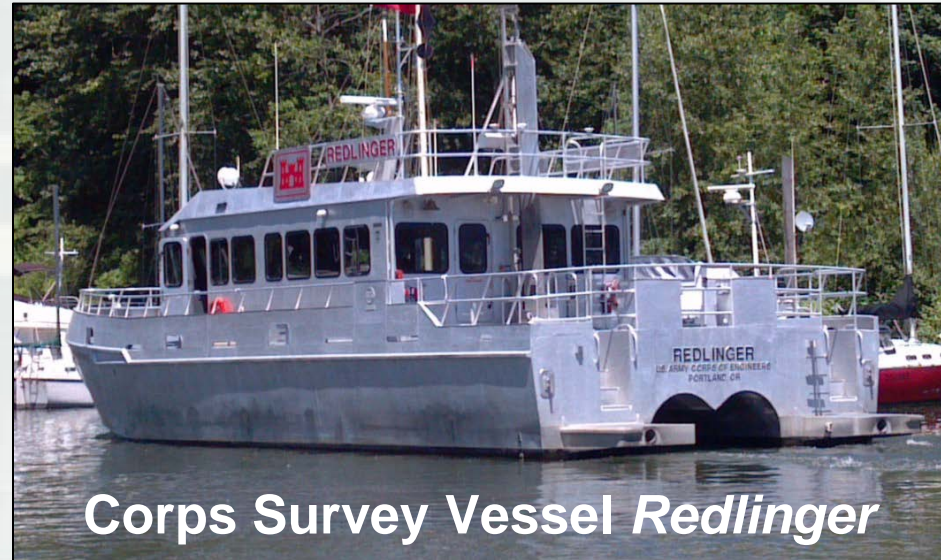
Sounding Line

# Hydrosurveys

- Pre-dredge hydrosurveys are used to identify shoaling and prioritize work
- Hydrosurveys cannot be used to determine the volume removed for payment on coastal bars
  - ▶ Sea conditions often keep survey vessels off the bar (payment surveys must be timely)
  - ▶ Wave conditions, strong currents, and and tides often prohibit accurate surveys
  - ▶ Two dredges working in close proximity (MCR) complicate hydrosurveys and accurate accounting of material



**Columbia River Bar Pilot Boat**



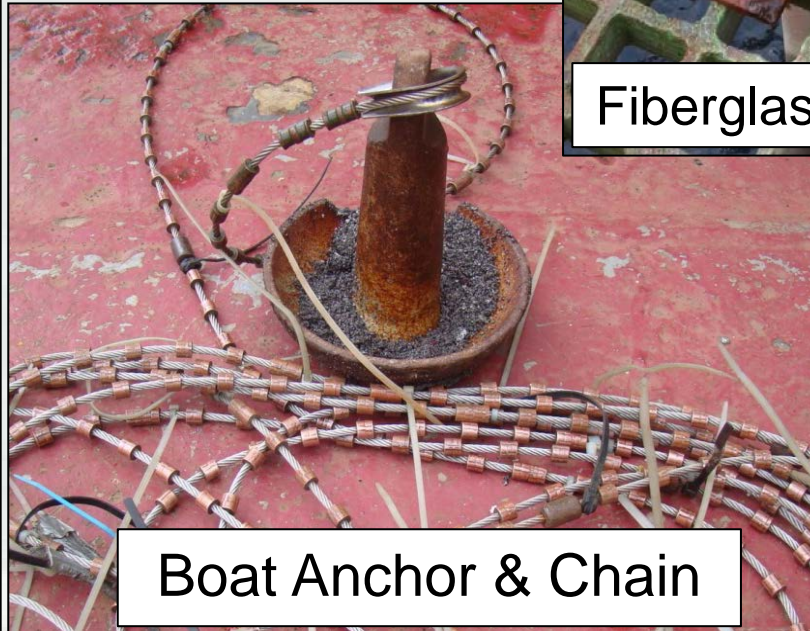
**Corps Survey Vessel *Redlinger***

# Bin Measurement of Dredged Material

(Hand Soundings)



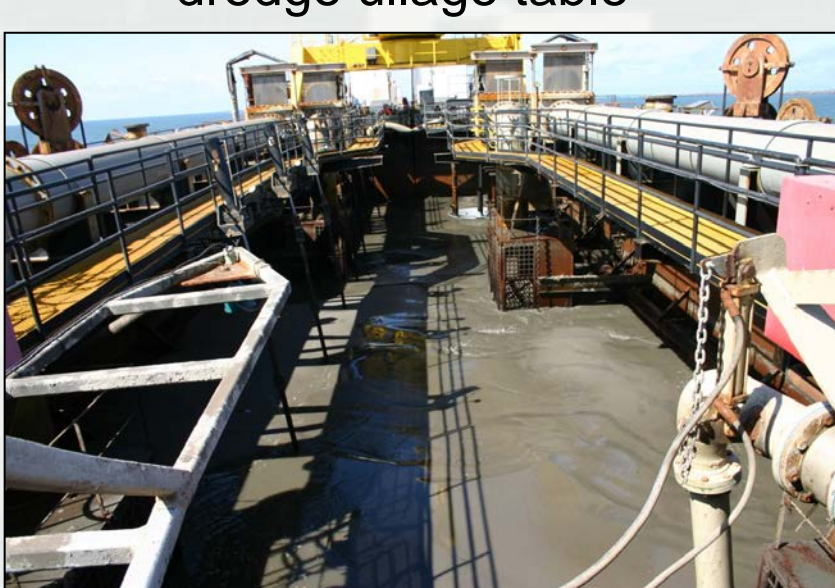
Fiberglass Tape & Weight



Boat Anchor & Chain

# Measurement of Dredged Material (Hand Sounding Method)

- Sand in the hopper has traditionally been measured by Government inspectors 24/7
- Ten measuring stations are located around the hopper
- Soundings are taken by measuring the sand surface with a hand sounding line from pre-set reference points
  - ▶ Soundings are averaged and total hopper volume is determined from the dredge ullage table



# Measurement of Dredged Material (Hand Soundings)

- Certified Ullage Table relates sounding to hopper volume

Distance to Sand Surface (ft)	Volume of Sand in Hopper (CY)
12.0	1728.0
12.1	1702.8
12.2	1677.9
12.3	1653.0
12.4	1628.4
12.5	1603.9
12.6	1579.6
12.7	1555.5
12.8	1531.5
12.9	1507.7
13.0	1484.1
13.1	1460.7
13.2	1437.4
13.3	1414.3
13.4	1391.4
13.5	1368.6
13.6	1346.0
13.7	1323.6
13.8	1301.4
13.9	1279.3





# Challenges

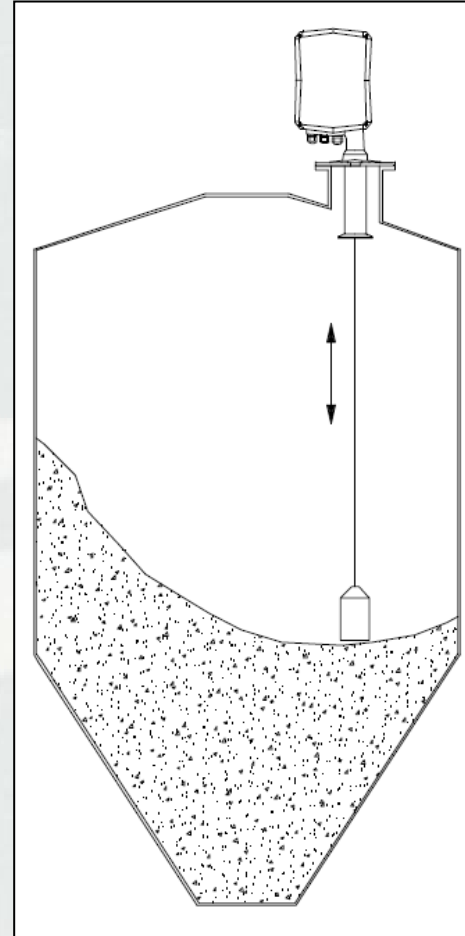
- Measuring hopper volume necessitates 24/7 inspection
- Inspection 24/7 is expensive
- Inspectors and contractors work in harsh conditions
- Significant management effort is expended in recruiting, training, scheduling and managing 24/7 inspection



# Goals of an Automated Ullage Measurement System

- Closely replicate hand soundings so that contractors can use historical data as a basis for bidding

- Reduce cost and safety risks by minimizing exposure of Inspection staff
- Ability to withstand harsh marine environments
- Appropriate for coarse grained material



# Automated Ullage Sensors

- Over the years, several options for determining hopper volume that don't require manual soundings have been considered but none duplicate hand sounding data
- The automated ullage sensor system (Nivobob) has undergone testing for several years and is being used this year as the required measurement method in Portland District in lieu of hand soundings
- Initial results are very good and this will likely be the future required pay method for all dredge areas where pay volume is measured in the hopper



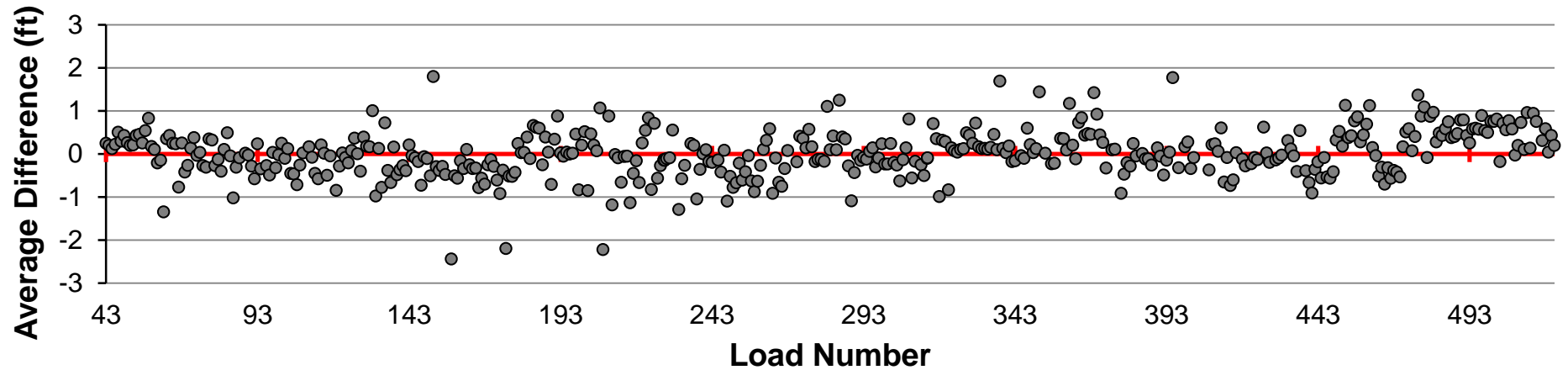
# Automated Ullage Sensor Data Collection & Test Phases

- Dredges
  - ▶ Terrapin Island 2009 (Two Nivobobs)
  - ▶ Yaquina and Dodge Island 2010 (Two Nivobobs)
  - ▶ Yaquina and Terrapin Island 2011 (Two Nivobobs)
  - ▶ Stuyvesant 2012 & 2013 (Ten Nivobobs) – Full scale test
  - ▶ Bayport 2014 (Ten Nivobobs) – Contract payment method
- Collection Locations
  - ▶ Mouth of the Columbia River
  - ▶ Columbia River (Upstream of the mouth)
  - ▶ Shallow water ports on the Oregon Coast (Yaquina)
  - ▶ San Francisco Main Ship Channel
  - ▶ Humboldt Bay Entrance Channel

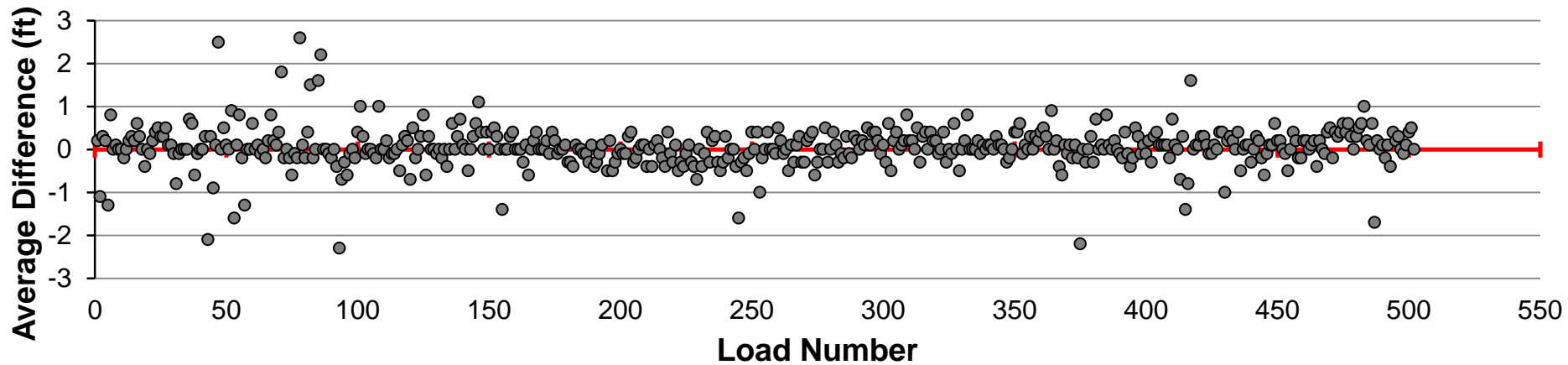
# Test Results

Difference Between the Average of Hand Soundings and the Average of Nivobob Measurements

2012

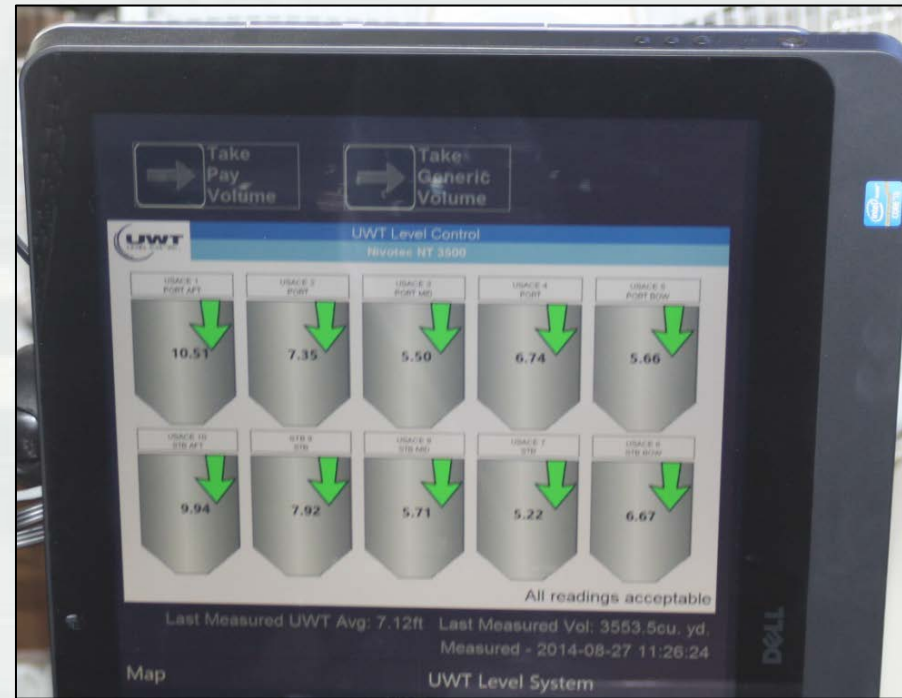
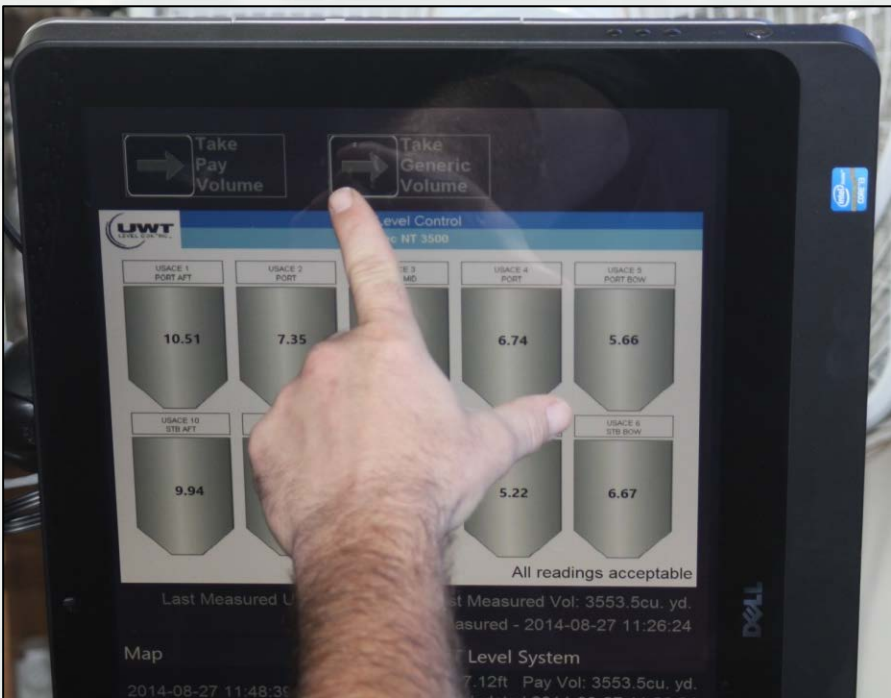


2013



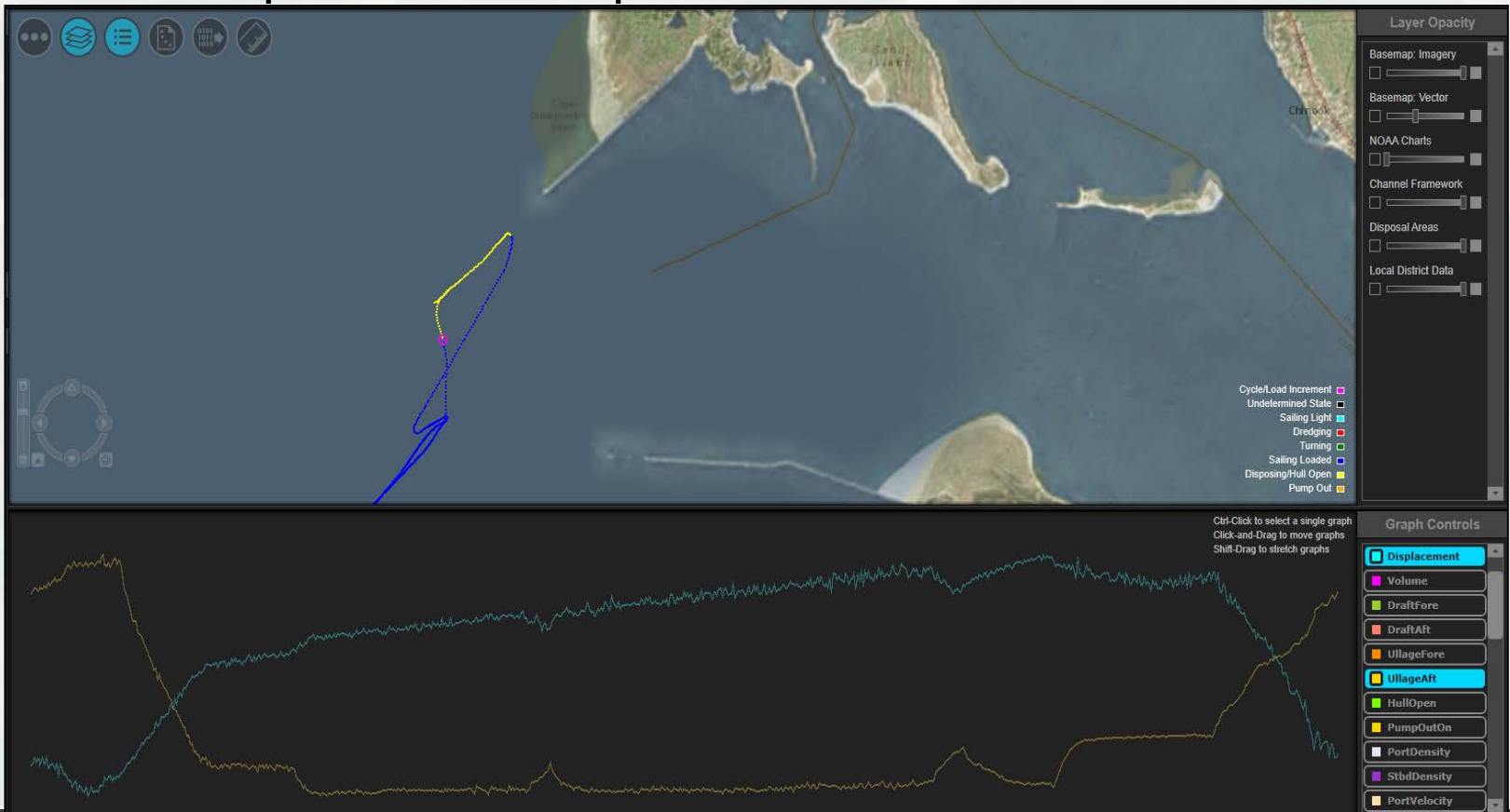
# System

- Sensor: Nivobob 3300® Ullage Sensors
- Remote operation and digital collection capabilities
- Central communication and control system
- Nivobob technicians can remotely troubleshoot and calibrate internal offsets from their office



# DQM Integration

- National Dredging Quality Management Program (DQM)
- On board sensors monitor and document dredging operations at 10 second intervals
- Nivobob measurements and volumes can be collected by the DQM center and reproduced in reports with other DQM data

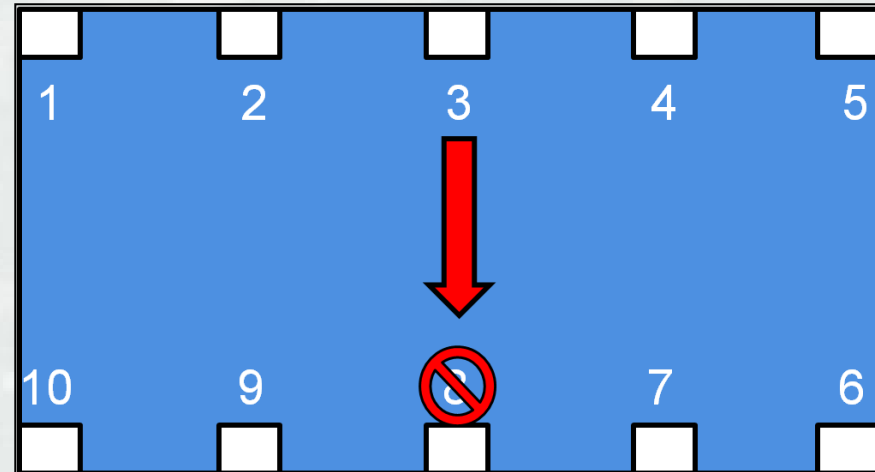


# When Sensors Malfunction

A sensor malfunction is defined as any sounding outside the range of the average plus or minus 2.5 times the standard deviation

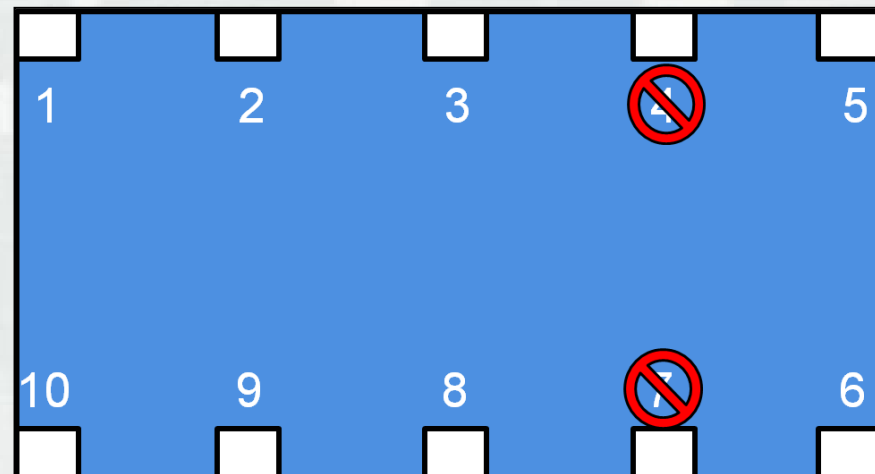
## 1 Unacceptable Sounding:

- Use corresponding sounding from the sensor across the hopper
- Payment reflects 5% reduction from calculated payment volume



## 2 Unacceptable Soundings:

- Average remaining 8 sensor soundings
- Payment reflects 5% reduction from calculated payment volume





# Total System Failure

- Total System Failure: 3 or more unacceptable soundings or failure to record the ullage soundings
- Contractor required to immediately notify the Government and a second inspector may be mobilized
- Contractor shall conduct hand soundings until system is repaired

## 2014 Summary

Loads: 1037

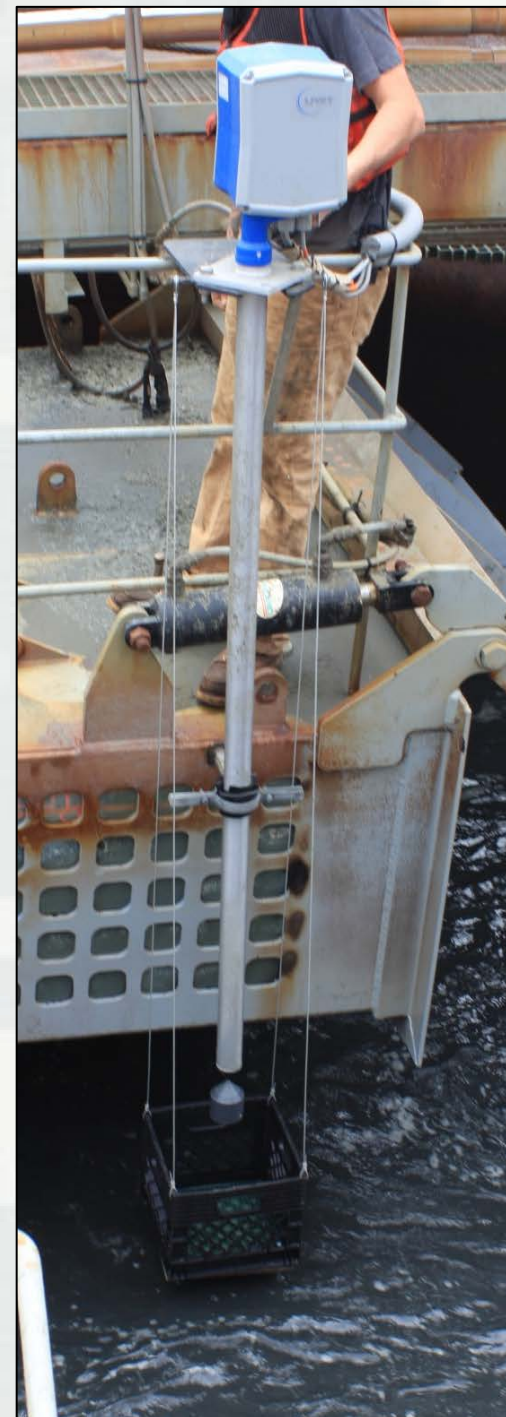
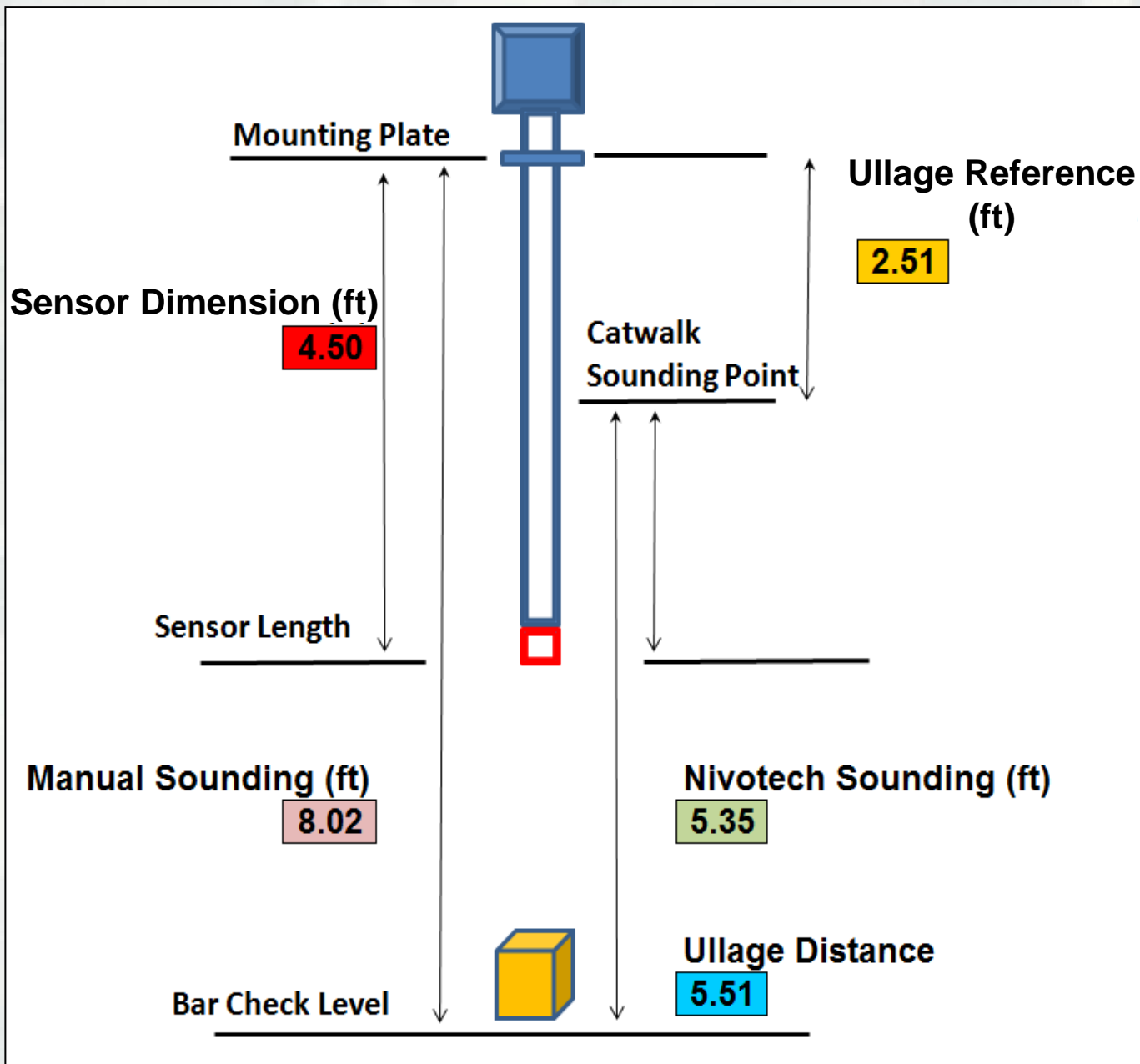
*Total Volume: 3,806,119 CY*

Unacceptable Soundings: 7

System Failures: 0



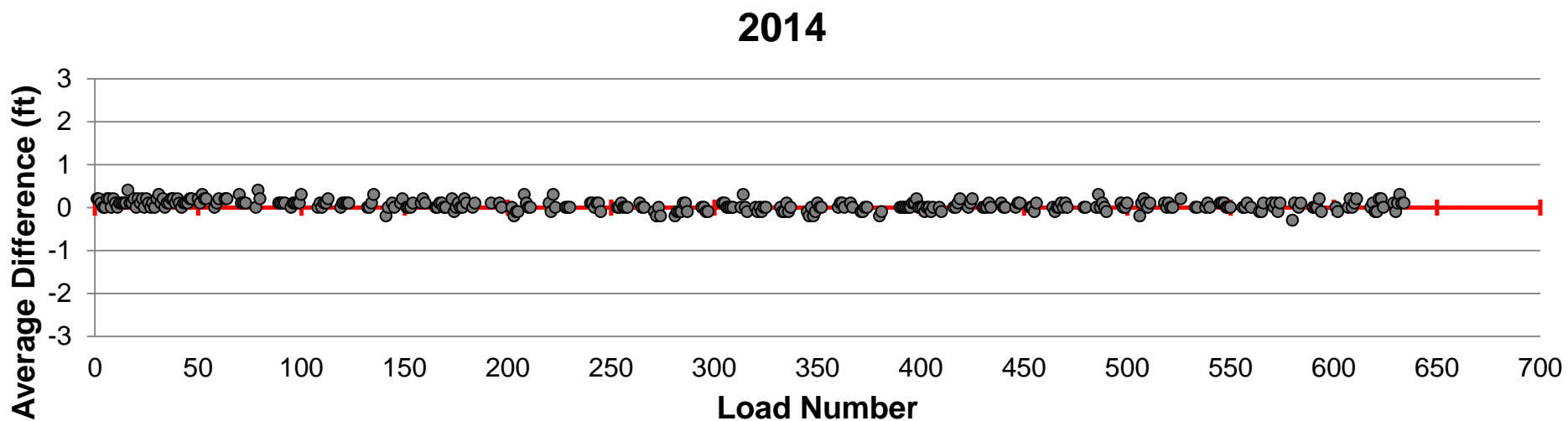
# Accuracy Verification



# West Coast Hopper 2014

- Automated ullage sensors used as primary payment method for ~ 3,410,000 CY dredged between MCR and CR
- \$6,966,500 to be paid based on automated ullage sensor measurements

Difference Between the Average of Hand Soundings and the Average of Nivobob Measurements



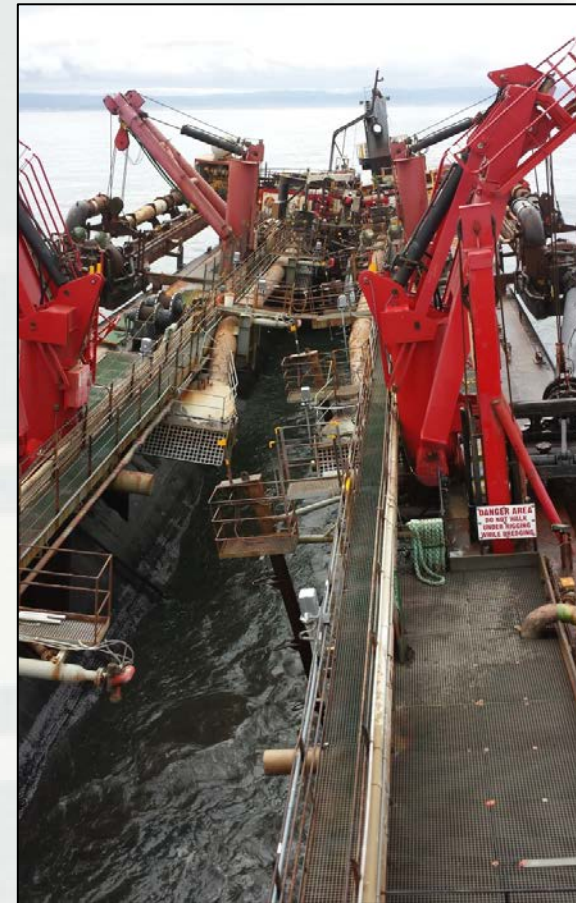
# Approximate Cost

- Automated Ullage Sensor System Cost Breakdown:
  - ▶ \$6,500 (per sensor: minimum of 12 required)
  - ▶ \$11,000 (control)
  - ▶ \$26,000 (Nivobob tech pre setup inspection & setup)
  - ▶ \$25,000 + (Contractor installation)
- **Total Cost: \$125,000 +**
  - ▶ Cost variability is dependent on installation time/complexity, hopper type/size and labor
  - ▶ This is a one time cost; sensors can be permanently installed for use on future projects

Large Bottom Dump Hopper



Medium Split Hull Hopper



# Potential Benefits

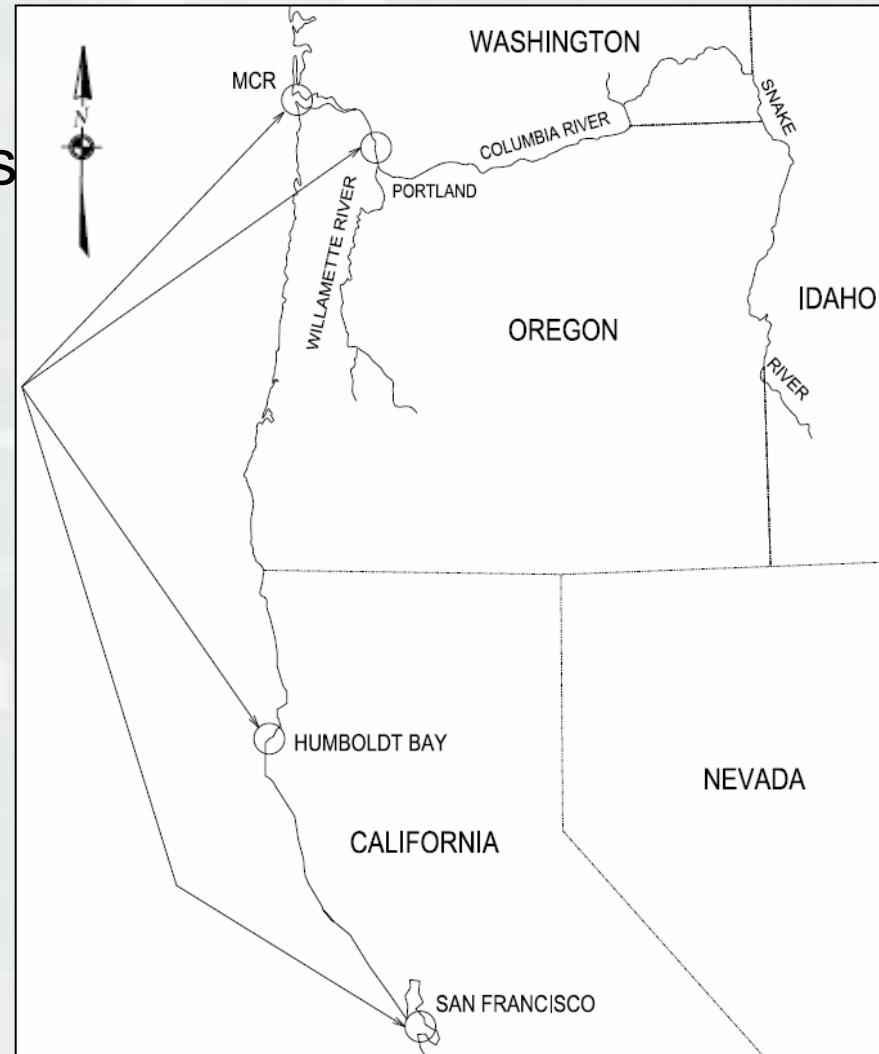
- Savings of \$10,000 to \$15,000 per week in inspection costs
- Improved safety: less time on the deck for inspectors and contractors = reduced safety risk
- Improves DQM database
- More accurate production tracking and cost estimating (potential to reduce non-payable depth)

*Sounding Decks*



# What's Next?

- 2014 data analysis
- Expand to other work areas
- Re-evaluate 5% reduction
- Additional alarms for malfunctions
- Adjustable guide pipes



# Automated Ullage Sensor in Action!!

# QUESTIONS?

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