PORT OF PORT TOWNSEND

Point Hudson Marina Breakwater Improvement Project

MOTT MACDONALD

Work Status Update

June 8th 2016

PORT OF PORT TOWNSEND

Outline

- Current Work Objective
- Site History & Existing Conditions
- 2014 Condition Summary
- 2016 Site Visit
- Alternative Evaluation

Objective

- Evaluate feasibility and options for breakwater rehabilitation in lieu of replacement to reduce construction costs

Breakwater History- Pre Marina (Military Use)

Breakwater History - Facility

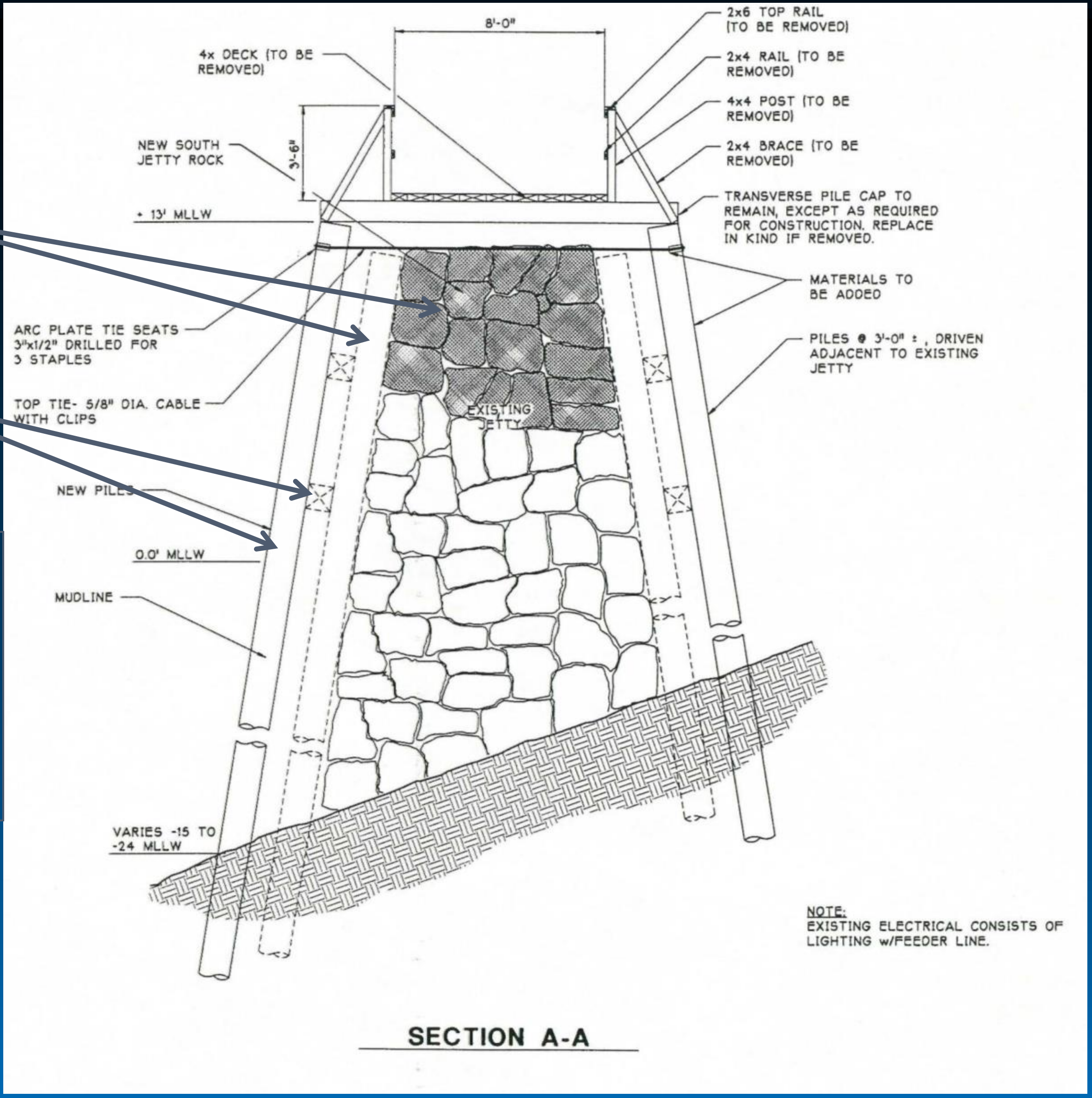
- Original 1934 Design by Military
  - Creosote Treated Timber Piling
  - Creosote Treated Timber Walers (2 to 3 Rows)
  - Armor Rock
  - Steel Cable Tiebacks
- Major Rehabilitation in 1969
  - Conversion from Pier/Breakwater to Breakwater
  - New Outer Piles
  - New Center Cables Tied to Existing Piles
- Retrofit in 1996 - End 60’ of S. Breakwater, Bend & End 12’ of N. Breakwater
  - New ACZA Treated Timber Piling
  - Steel Cable Wrapped Around New Piling
  - Supplemental Armor Rock

Breakwater History – Cross Section

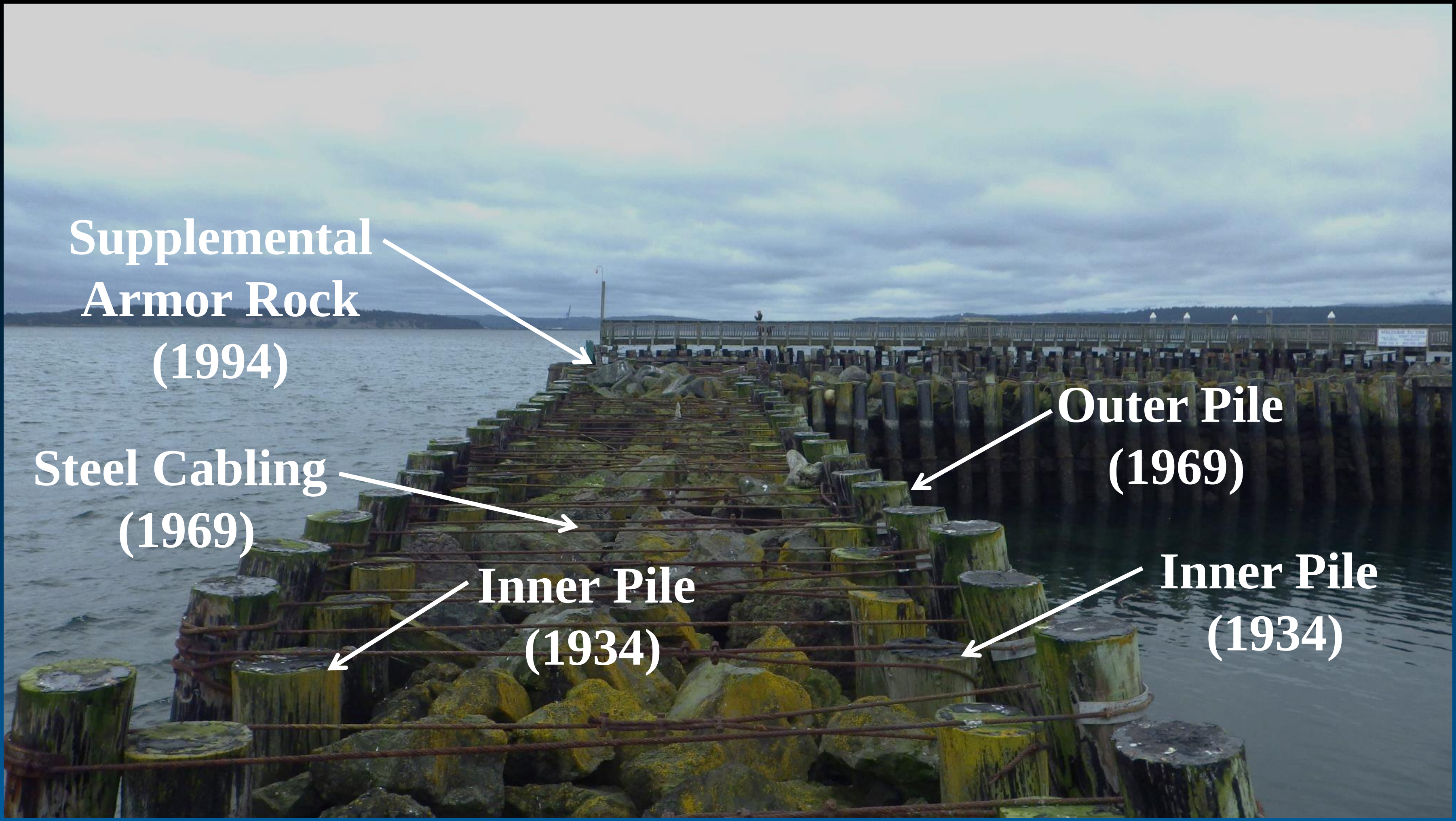
1934

1969 Rehabilitation

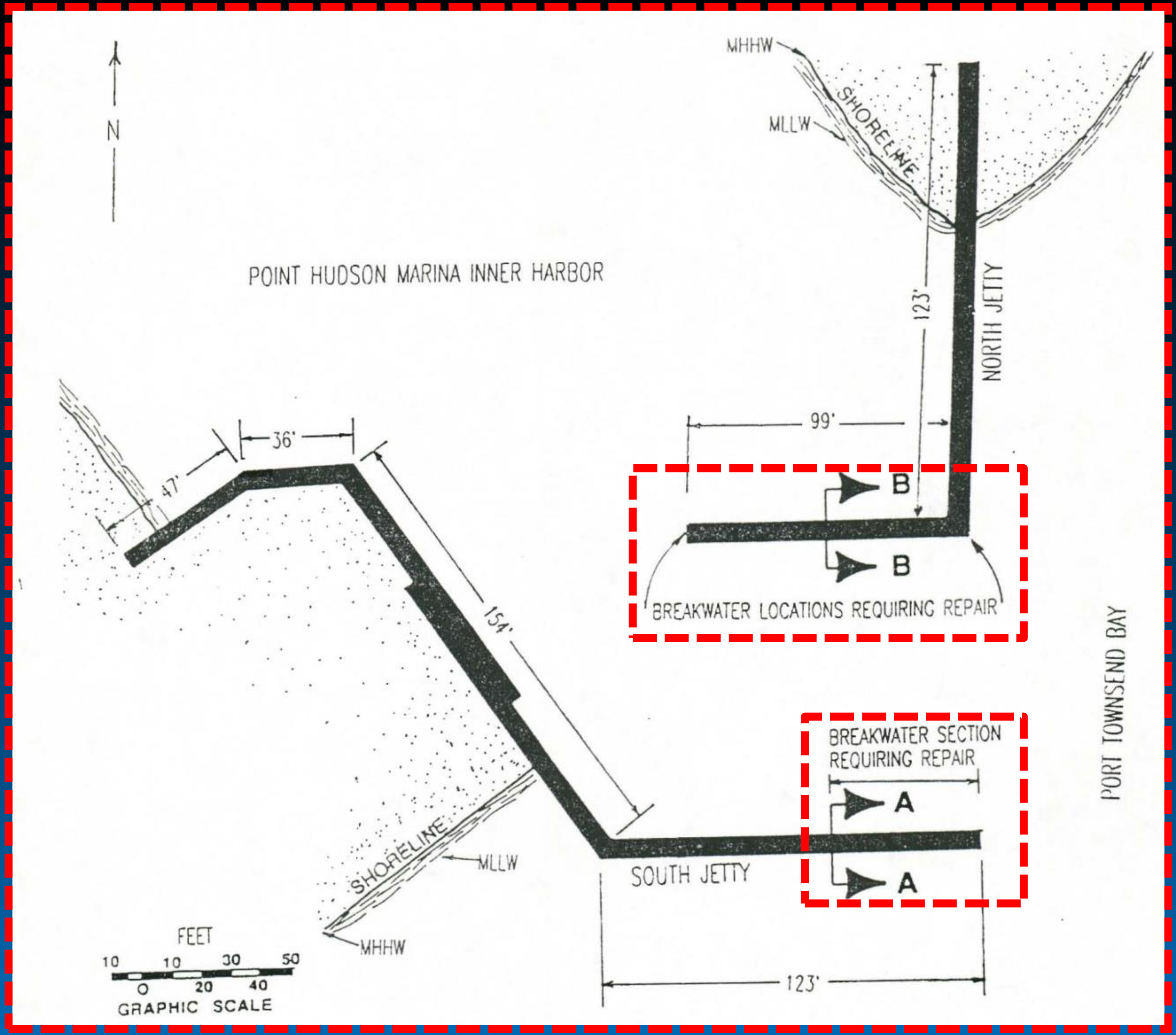
Note: 1969 Rehabilitation added piles and tiebacks and some cap stone



Breakwater History - Section



Breakwater History – Facility Improvements (1996)



Breakwater History - Materials

- Original Creosote Treated Timber Piling
  - Typical Life Expectancy of 35 to 80 Years
  - Excellent Quality Lumber
- Original Creosote Treated Timber Walers
  - Typical Life Expectancy of 35 to 50 Years
- Galvanized Steel Cable Tiebacks
  - Galvanizing Has Typical Life Expectancy of 20 - 30 Years in Marine Environments, Then Rapid Deterioration Begins
- ACZA Treated Timber Piling
  - Typical Life Expectancy Much Less Than Creosote Treated Timber Piling, Typically 20 to 35 Years
- Armor Rock
  - Marine Basalt – Low Quality. Typical Life Expectancy of 20 to 40 Years

2014 BREAKWATER CONDITION SUMMARY

2014 Breakwater Condition – Breakwater Components

Breakwater Condition – Breakwater Components

Top Cable (1969)

Outer Pile (1969)

Upper Waler (1934)

Center Cable (1969)

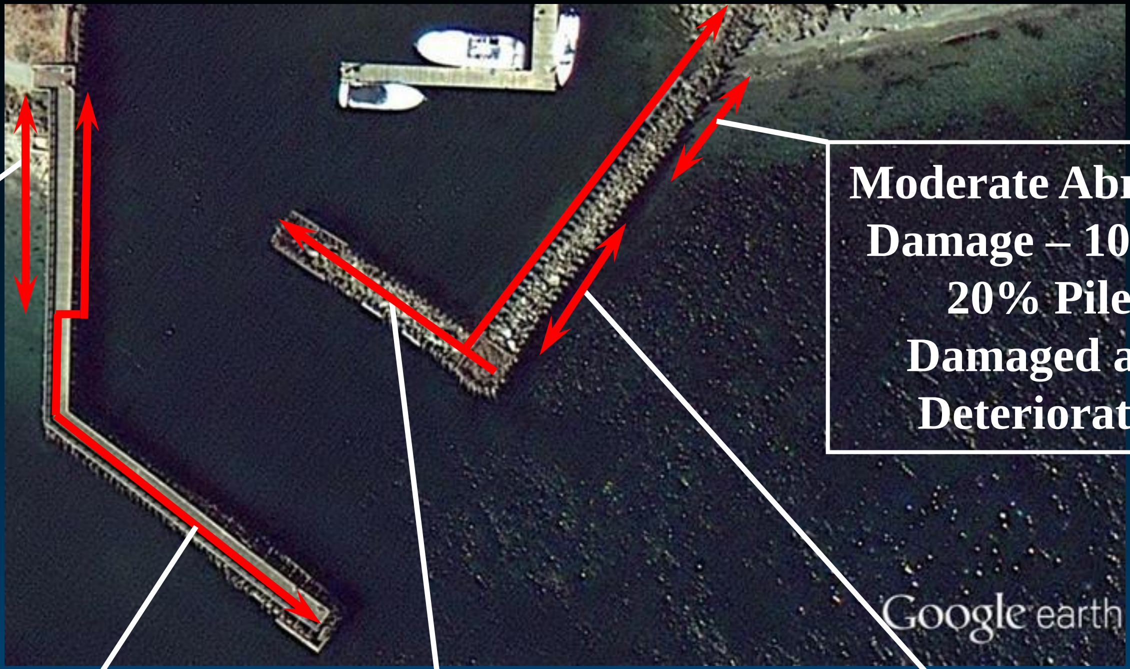
Armor Rock (1934)

Inner Pile (1934)

Lower Waler (1934) (Not Visible)

Note: >75% Inner Piles (1935)Observed to be Highly Deteriorated, Not Contributing to Structural Stability. Assessment Focused on Outer Piles.

Breakwater Condition – Outer Piles



Moderate Abrasion Damage – 10% to 20% Piles Damaged and Deteriorated

Moderate to Severe Abrasion Damage 20% to 30% Piles Damaged and Deteriorated

10% to 20% of Piles Sounded Somewhat Hollow, Exposed Side Worse than Sheltered Side

10% to 20% of Piles Sounded Somewhat Hollow, Exposed Side Worse than Sheltered Side

Severe Marine Borer Attack , 20% to 30% Piles Damaged and Deteriorated

Breakwater Condition – Outer Piles

- Varying Levels of Deterioration Depending on Exposure, Damage
- Likely Shallow Embedment – Highly Compacted Sand Layer 0.8ft to 2ft Below Mudline (Landau Biological Assessment/Evaluation, September 2005)
- Piles Beyond Useful Service Life

Piles in Poor Condition

Piles in Fair Condition

Breakwater Condition – Outer Piles

- Marine Borer Attack
- Varying Levels of Deterioration
- Decay Where Creosote Treatment Penetrated by Bolts, Thru Rods

Inner Pile (1934) : Decay at Penetration

Outer Pile (1969): Marine Borer Attack

Breakwater Condition – Outer Piles

- Abrasion Penetrated Creosote Protective Treatment, Subsequent Decay/Marine Borer Attack

Inner Pile (1934) Abraded & Decayed

Outer Pile (1969) Abraded, Decaying (Hollow Sounding)

Breakwater Condition – Upper & Lower Walers

Walers Completely Deteriorated – Minimal Load Carrying Capacity

Walers Completely Deteriorated – Minimal Load Carrying Capacity

Breakwater Condition – Upper & Lower Walers

- Highly Deteriorated – Minimal Capacity
- Minimal Contribution to Structure Stability – Decreased System Capacity
- Loss of Stone Confinement
- Walers Beyond Useful Service Life

Deteriorated Waler

Loss of Armor Rock

Breakwater Condition – Steel Cable Tiebacks

10% Cables Severed, Remainder Deteriorated, Areas Exposed to Wave Splash Worst

10% to 20% of Cables Severed, Remainder Deteriorated, or Highly Deteriorated

5% to 10% of Cables Severed, Remainder Deteriorated

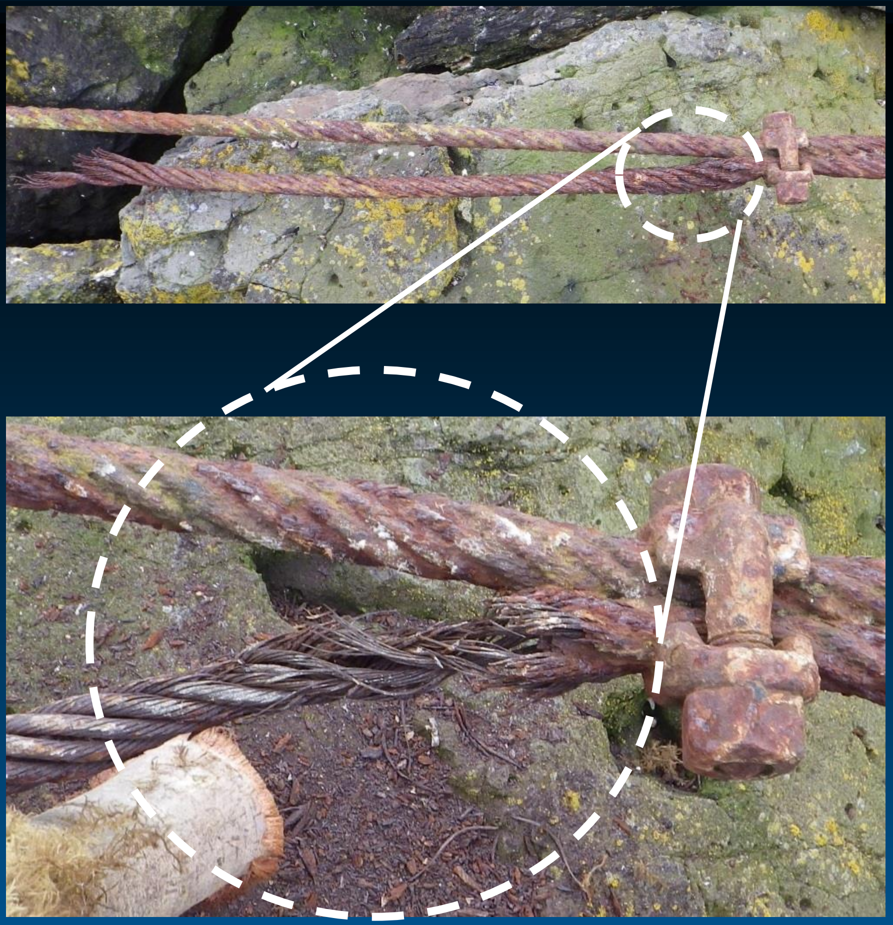
Breakwater Condition – Steel Cable Tiebacks

- Pile Top – Cables Wrapped Around Pile Tops to Provided Lateral Support
- Intermediate – Cables Wrapped Between New and Old Piling – 90%+ Missing, Remainder Highly Deteriorated

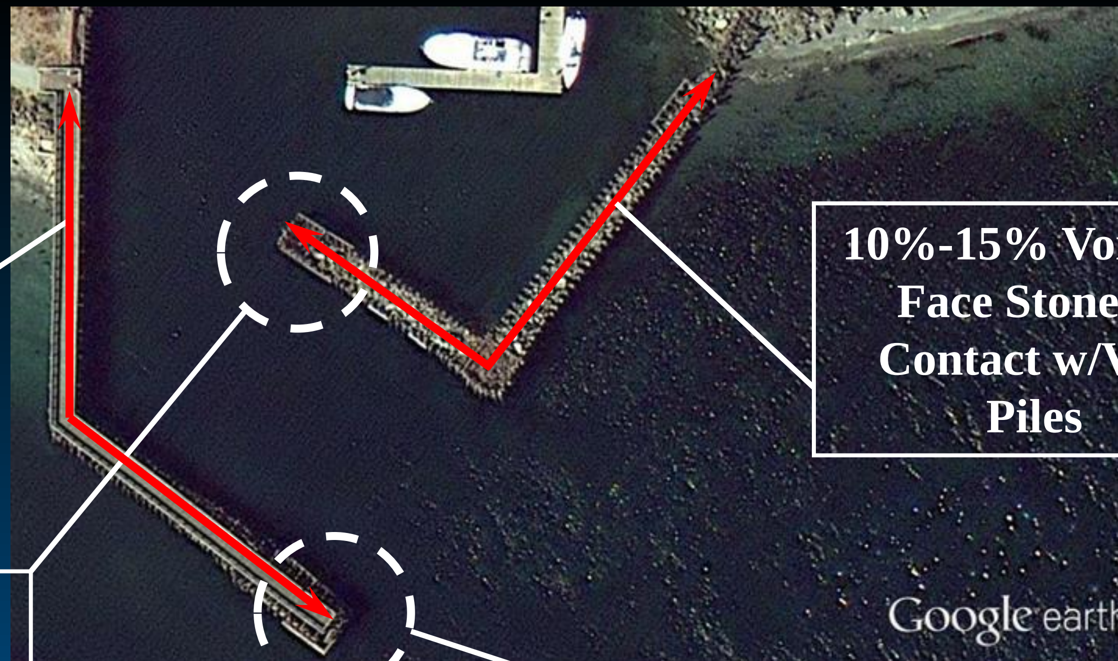
Intermediate Cables

Breakwater Condition – Steel Cable Tiebacks

- Level of Deterioration Difficult to Determine Visually
- Caked on Rust
- Cable End Examined, Estimated <10% Capacity Remaining
- Cable Beyond Useful Service Life



Breakwater Condition – Armor Rock



10%-15% Voids in Face Stone in Contact w/Vertical Piles

10%-15% Voids in Face Stone in Contact w/Vert Piles

6’ Height of Armor Rock Lost at End

6’ Height of Armor Rock Lost at End

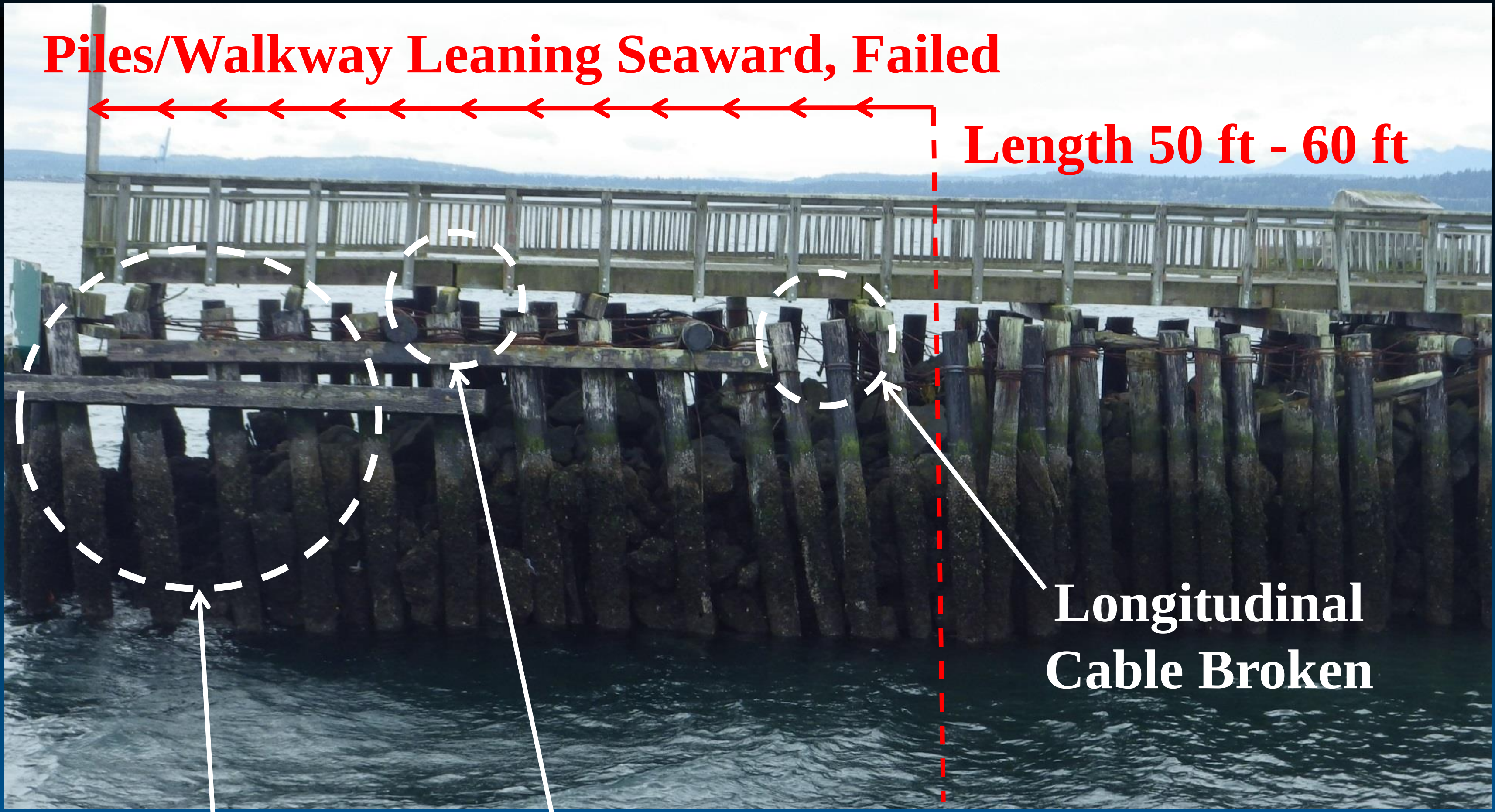
Breakwater Condition – Armor Rock

- Appears to be Matts Matts Sourced Marine Basalt – Low Quality Stone
- Highly Fractured
- >50% of Stone in Deteriorated to Highly Deteriorated State; beyond its useful service life

Breakwater Condition – Armor Rock

- Armor Rock Spalls to 12” x 12” x 8” Pieces, Which are Being Pulled From Between Piles by Wave Action
- Loss of Waler Results in Decreased Confinement of Armor Rock
- Large rock loss at vulnerable breakwater ends

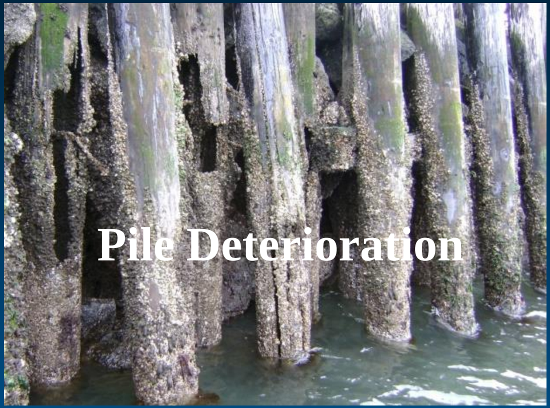
Breakwater Condition – S. Breakwater End, Walkway



Lost Stone

Stringer Nearly Unseated, Pile Cap Rotated

Breakwater Condition



Breakwater Condition – 2014 Assessment Summary

- *<u>Walers</u>: Highly Deteriorated, No Longer Functional*
- *<u>Steel Cable Tiebacks</u>: Deteriorated to Highly Deteriorated, Some Already Failed, At End of Useful Life.*
- *<u>Armor Rock</u>: At Age of Increasing Deterioration Rate, Beyond Useful Service Life*
- <u>Piles</u>: Near End of Useful Life, Abrasion Damage, Marine Borer Attack Damage, Decaying
- <u>Overall Structural System</u>: Substantially Less Stable than Original Construction, Higher Stresses
- <u>S. Breakwater End</u>: Walkway Stringer Nearly Unseated, Entire 60’ End Portion Failed, Leaning Seaward
- <u>Walkway</u>: End 60’ Near End of Useful Life, Needs Monitoring. Remainder in Good/Moderate Condition

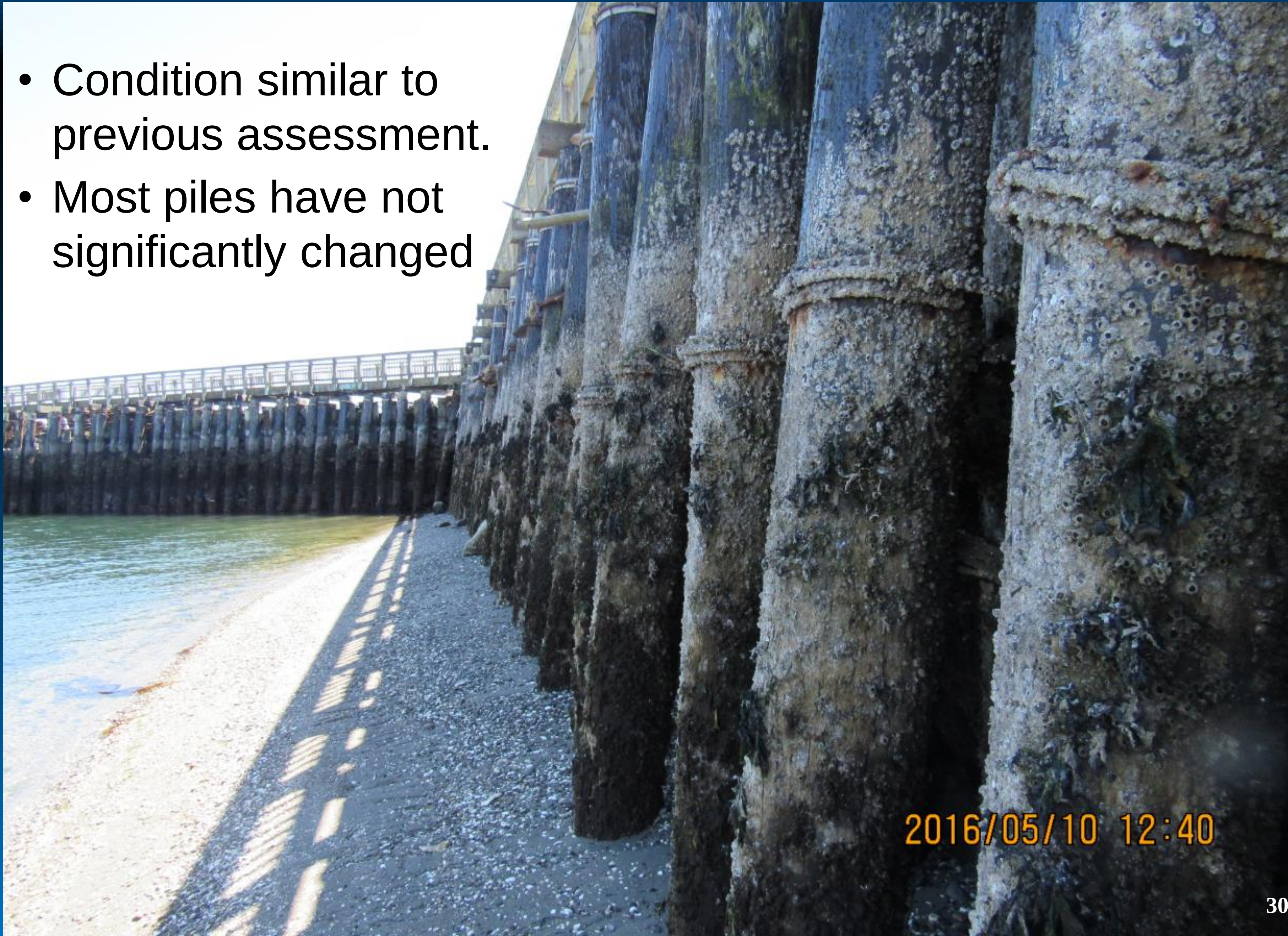
Breakwater Condition – 2014 Summary

- Full Replacement recommended
- Phasing of Replacement is possible with some localized re-habilitation
- South Breakwater is 1st Priority

2016 SITE VISIT

5/10/16 Site Visit Condition – Piles

- Condition similar to previous assessment.
- Most piles have not significantly changed



5/10/16 Site Visit Condition – Piles

- Condition similar to previous assessment.
- Most piles have not significantly changed

5/10/16 Site Visit Condition – Waler

- Waler no longer functioning structurally in any capacity, only supporting some rock from coming through

5/10/16 Site Visit Condition – Tiebacks

- Tiebacks very corroded, more likely broken

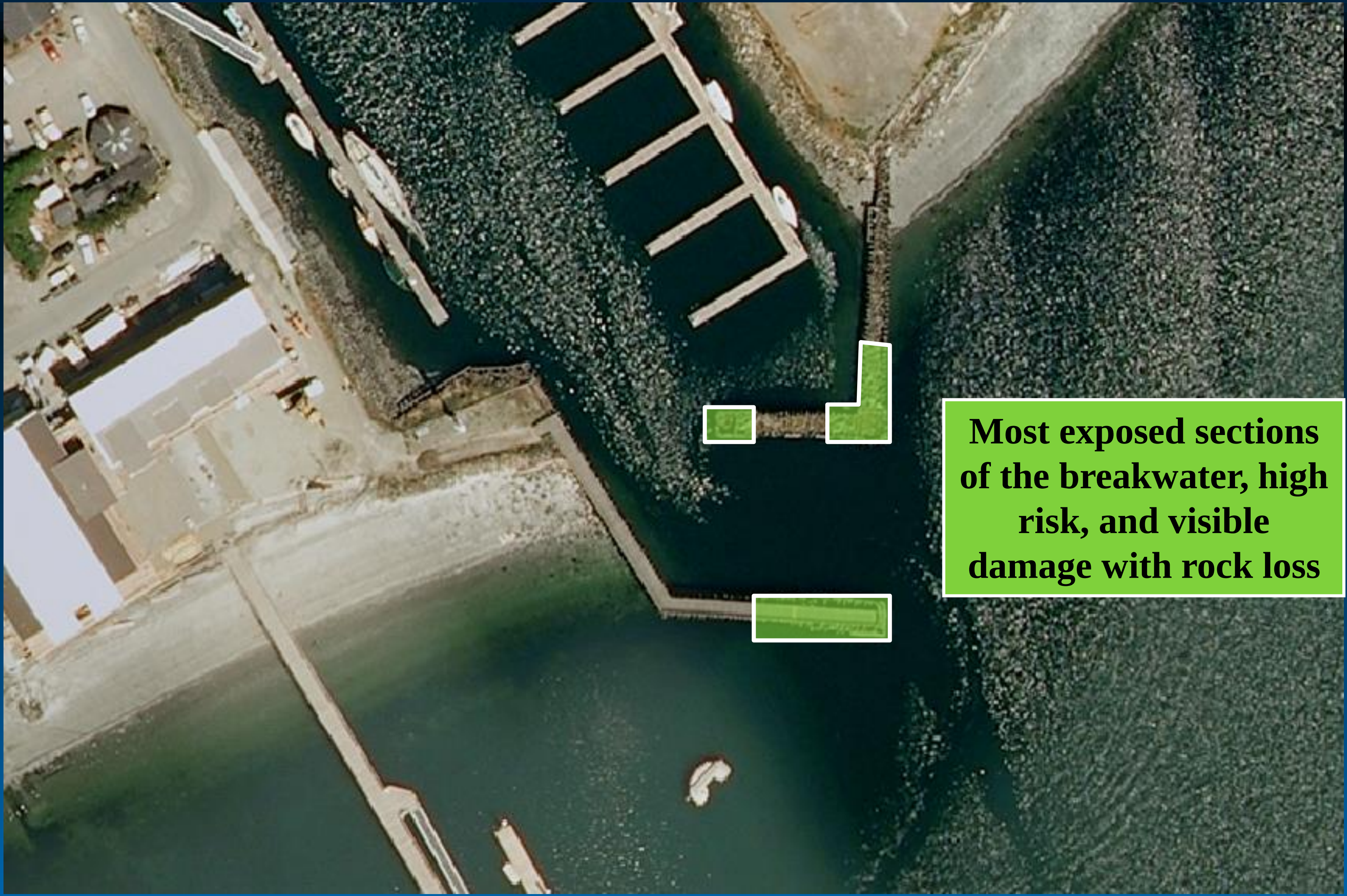
5/10/16 Site Visit Condition – Armor Rock

- Armor Rock continuing to break down and exit through piles

5/10/16 Site Visit Condition – Outer Breakwater

- Condition similar to previous assessment.
- May have slightly more rock loss in critical areas.

Critical Rehabilitation Areas



Breakwater Condition – 2016 Assessment Update

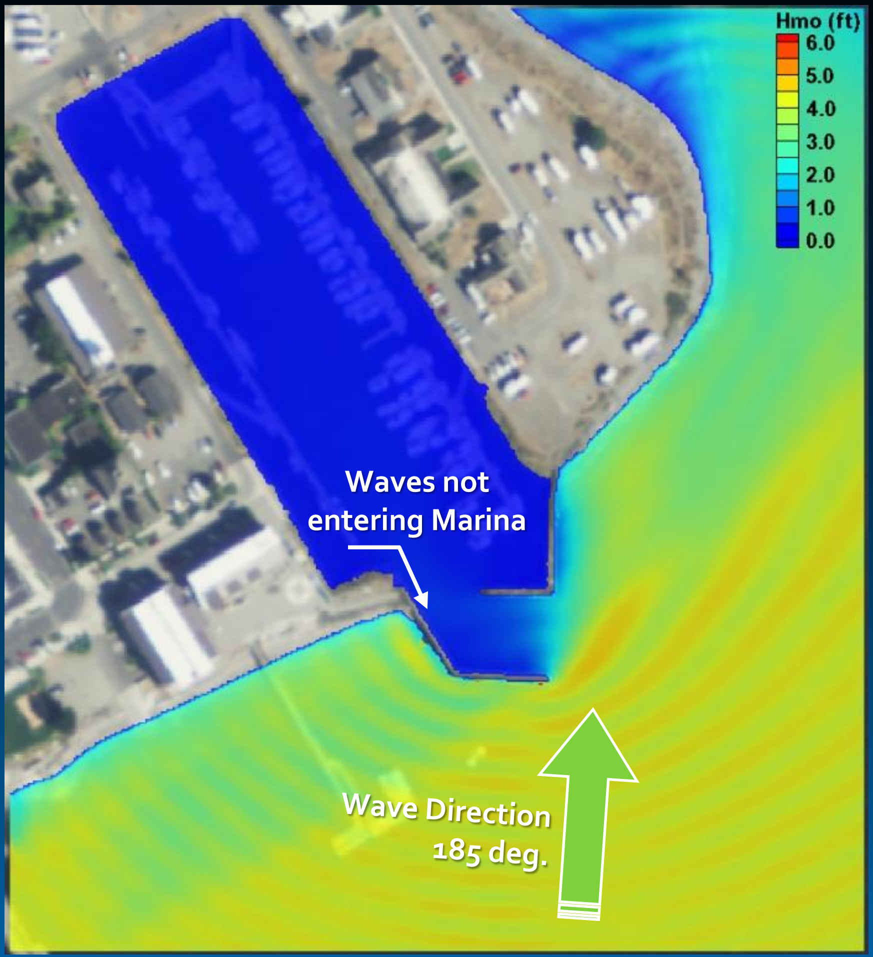
What has occurred the last 2 years :

- Walers: Unchanged, No Longer Functional
- Steel Cable Tiebacks: More deterioration, More have Failed, At End of Useful Life.
- Armor Rock: Continuing to Deteriorate, More rocks have likely come through the piles.
- Piles: Mostly unchanged from the previous assessment, Still Abrasion Damage, Marine Borer Attack Damage, Decaying
- Overall Structural System: Substantially Less Stable than Original Construction, Higher Stresses
- S. Breakwater End: Walkway Stringer Nearly Unseated, Entire 60’ End Portion Failed, Leaning Seaward

Environmental Conditions

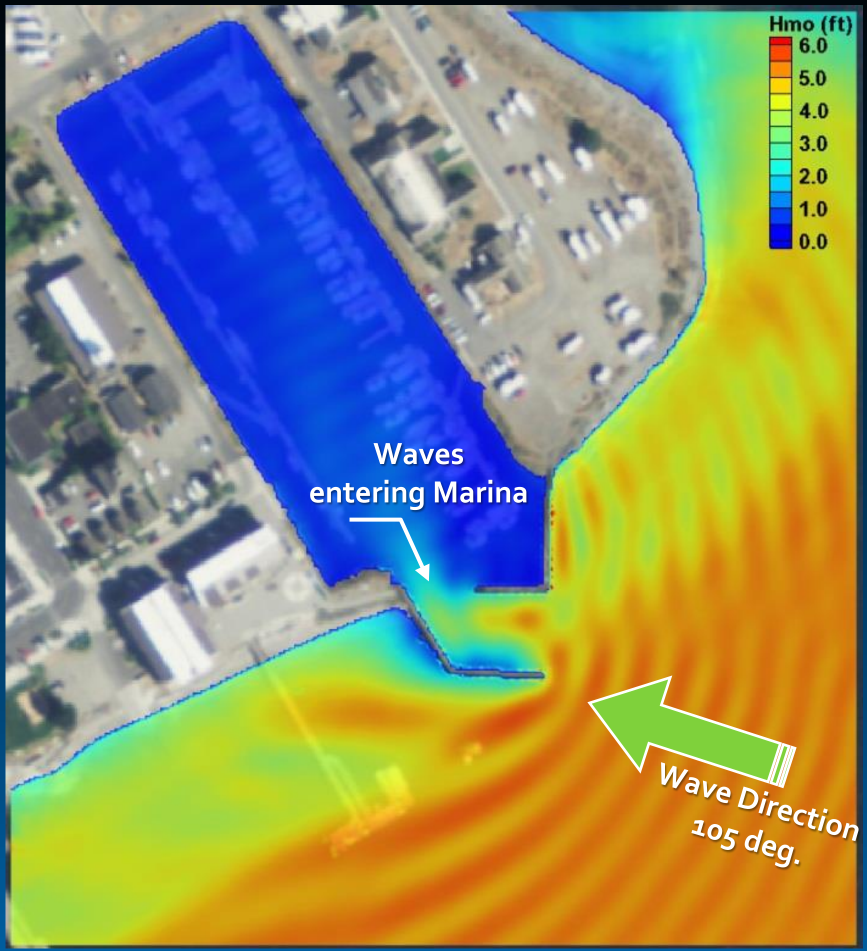
Existing Conditions – Wind Waves

Wind from 160 Deg.



Hmo = 4.0 ft , Tp = 4.0

Wind from 110 Deg.



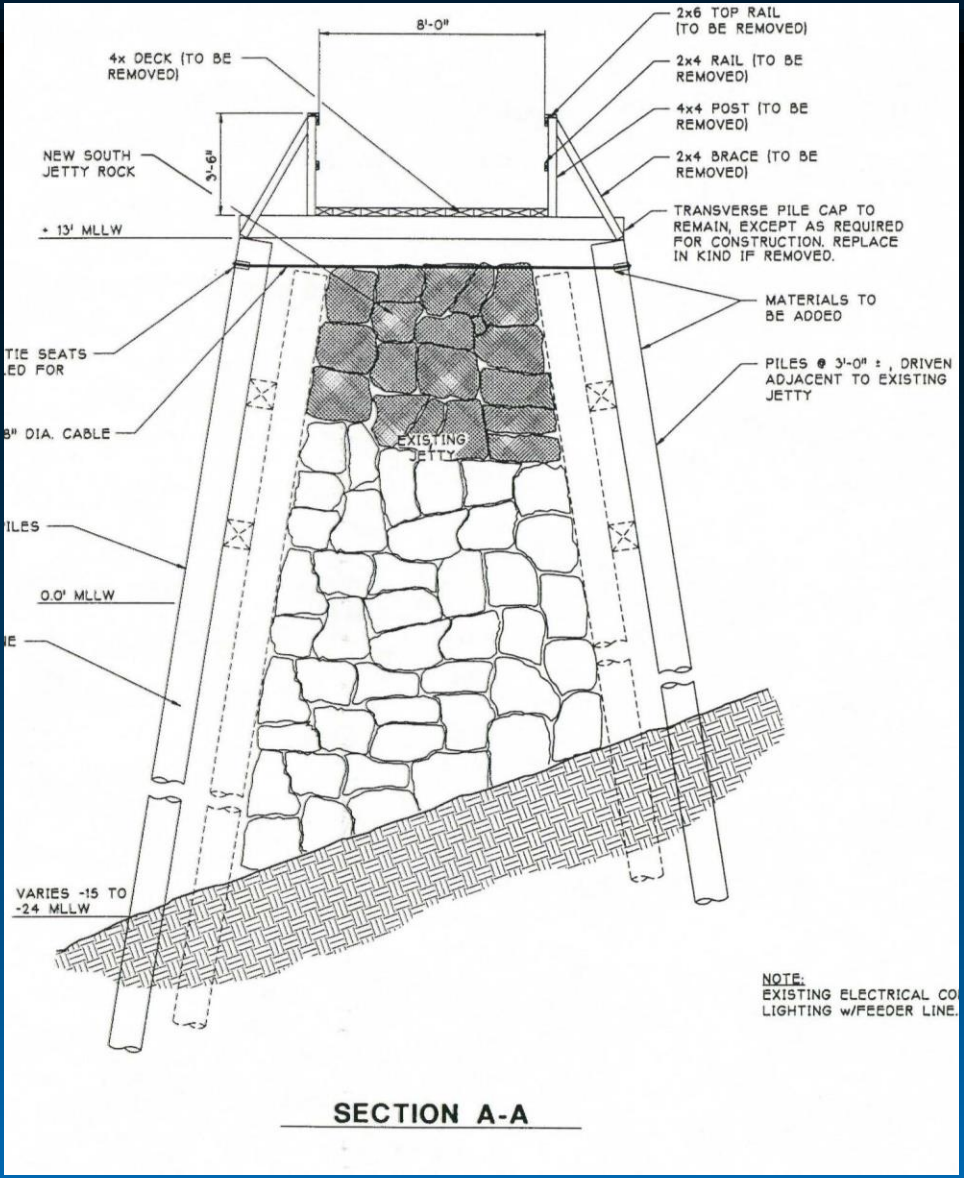
Hmo = 5.0 ft , Tp = 4.5

Existing Site Conditions - Overview

REPAIR/ REHABILIATION ASSESSMENT

Repair/Rehabilitation?

- Structure Condition
  - Cable Breakage
  - Localized Collapse
  - Pile Breakage
  - Stone Breakage
- Feasibility?
  - Difficult; Risk during construction
  - Complete Section Replacement vs. Partial Repair
  - Cost of Rehab vs Replacement
  - Numerous failure modes at multiple locations – better to respond to need than to design in advance

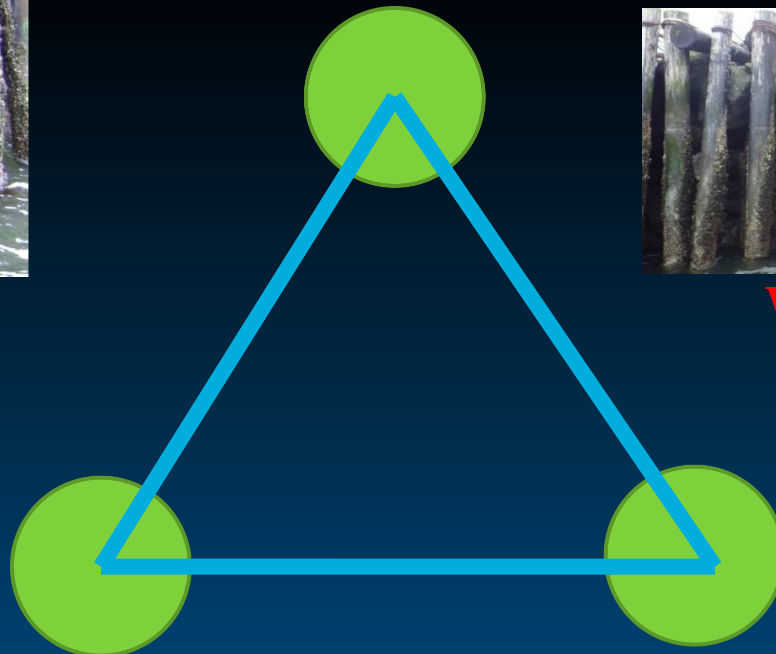


Three major components of the Existing Breakwater

Pile Deterioration

Piles and Walers

Waler Deterioration



Tiebacks

Armor Rock

Cable Deterioration

Like a stool, all three components critical to proper function of the breakwater

Stone Deterioration

Three major components of the Existing Breakwater

Difficulty of Rehabilitation

- Tiebacks – Easiest and cheapest to repair, but only on the top, lower tiebacks not possible to replace
- Piles and Walers – Can add piles, not cheap but doable, Walers very challenging to replace
- Armor Rock – Very challenging to fix, very expensive, most feasible on the outside of the existing breakwater

Rehabilitation/ Repair Options

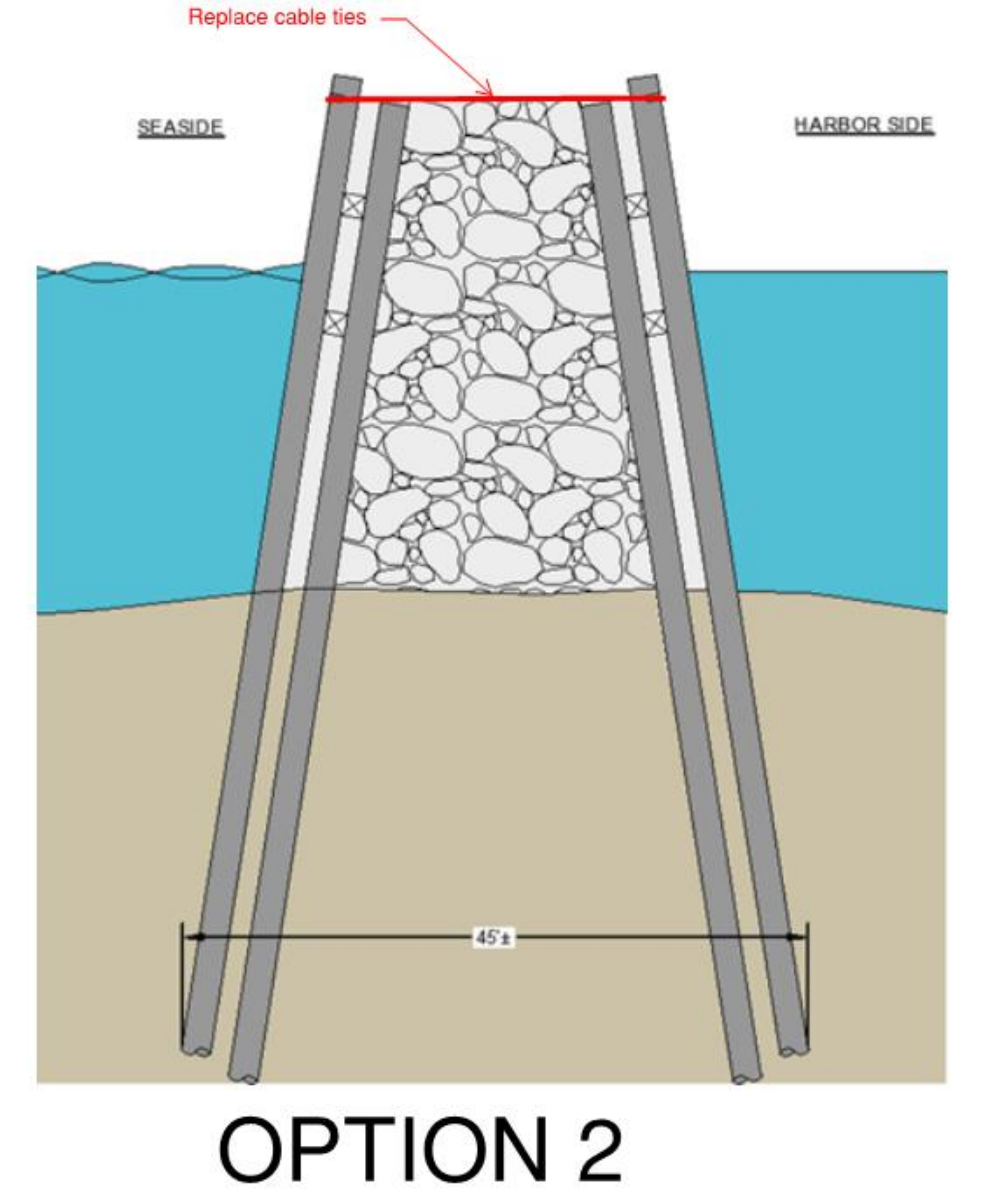
Rehabilitation

- Purpose: Conduct Improvements to extend life 10 to 15 years to defer replacement
- Multiple Options likely needed due to variable nature of current condition and complexity of structure.
- All rehabilitation/repair options will require establishing a sinking fund for the future maintenance and repair
- Continued deterioration and repair work should be anticipated
- No options eliminate the potential for major costs in the next 10 to 15 years except for full replacement.

Rehabilitation Options

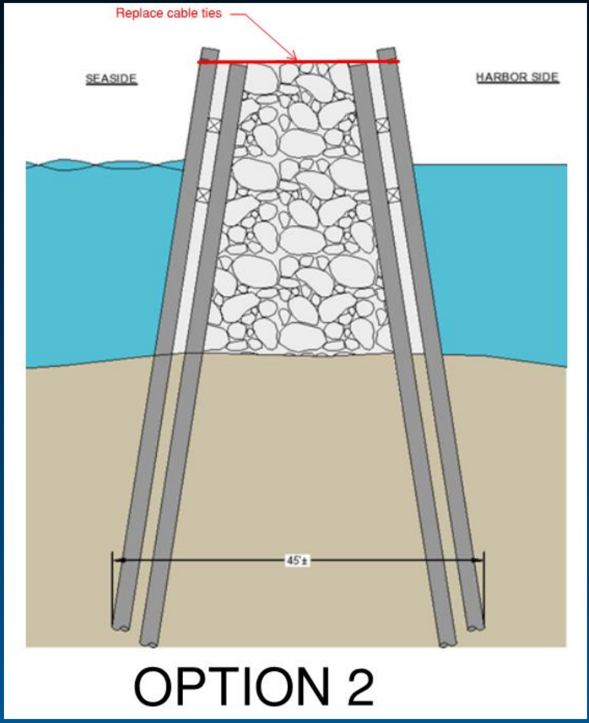
- Option 1 – Do Nothing
  - Advantages
    - No upfront costs
    - No wasted costs or infrastructure that may not be compatible with the proposed replacement
    - Can focus all money on areas that fail instead of predicting areas to fail
  - Limitations
    - Failure mostly likely that could result in partially blocking the marina channel or damage of moored vessels
    - Fixing damage after occur maybe more expensive
    - More unpredictability

Rehabilitation Options - Tieback

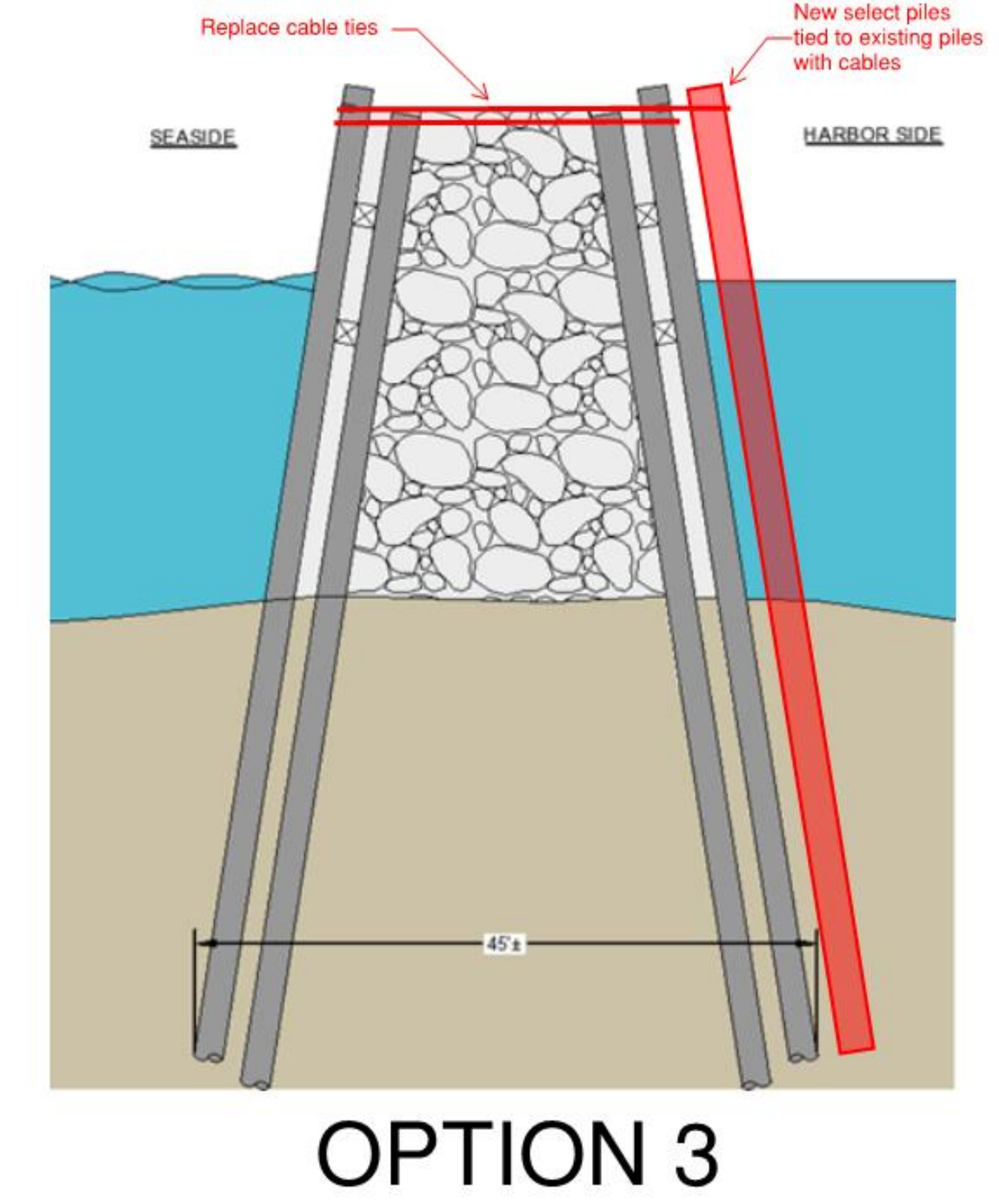


Rehabilitation Options - Tieback

- Option 2 – New Cables Tying Existing Piles
  - Replace all the existing tieback cables with new galvanized cable.
  - Advantages
    - Low Costs
    - No pile driving
    - Will reduce potential for unzipping if portions of the breakwater failed
  - Limitations
    - Does not fix the piles or the armor rock
    - Failure from pile breaking and loss of rock could result in blocking the marina channel
    - Fixing damage maybe more expensive
    - Rocking still exiting through the piles
  - Cost
    - Roughly $200/LF

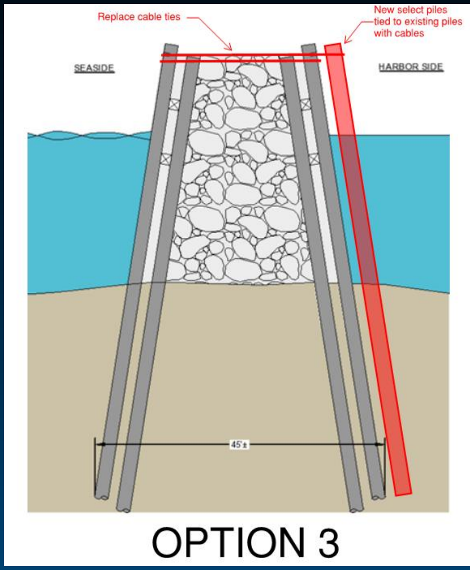


Rehabilitation Options – Tiebacks with Localized Piles

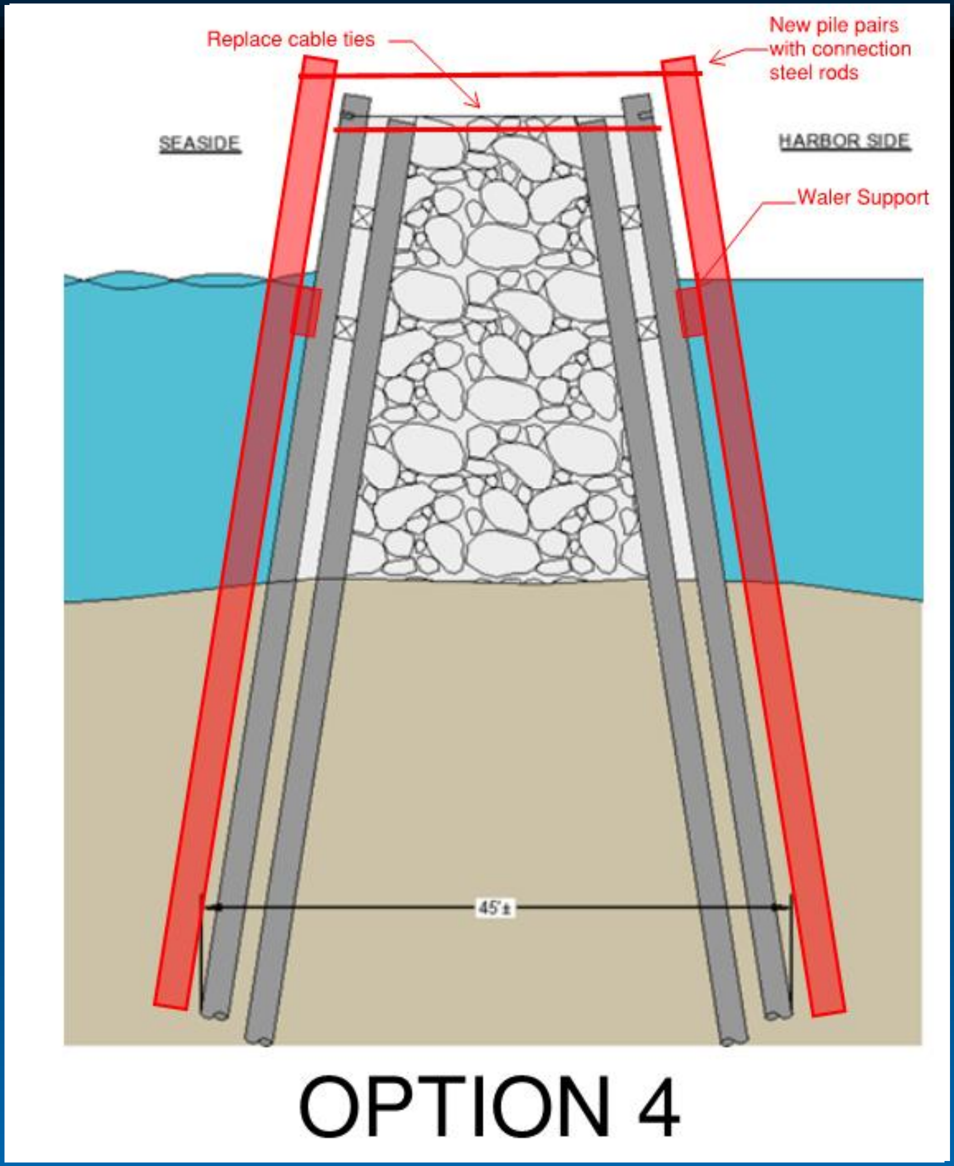


Rehabilitation Options – Tiebacks with Localized Piles

- Option 3 – Drive Select Piles and New Cables Tying Existing Piles
  - Drive new steel pipe piles at select locations where rock is exiting and where existing timber piles are in distressed condition.
  - Advantages
    - Reinforce weakened sections
    - Limited pile driving
  - Limitations
    - Does not fix all the piles or help the armor rock
    - Driving may cause further damage to the existing structure
    - Doesn't fix all the locations
    - Piles would likely not be compatible with future replacement
  - Cost
    - Roughly $1,750/LF

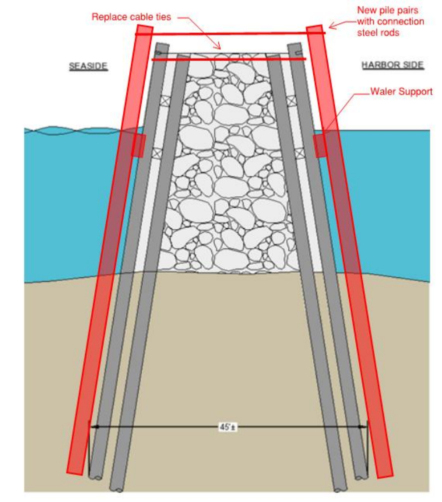


Rehabilitation Options – Pile Pairs and Tieback



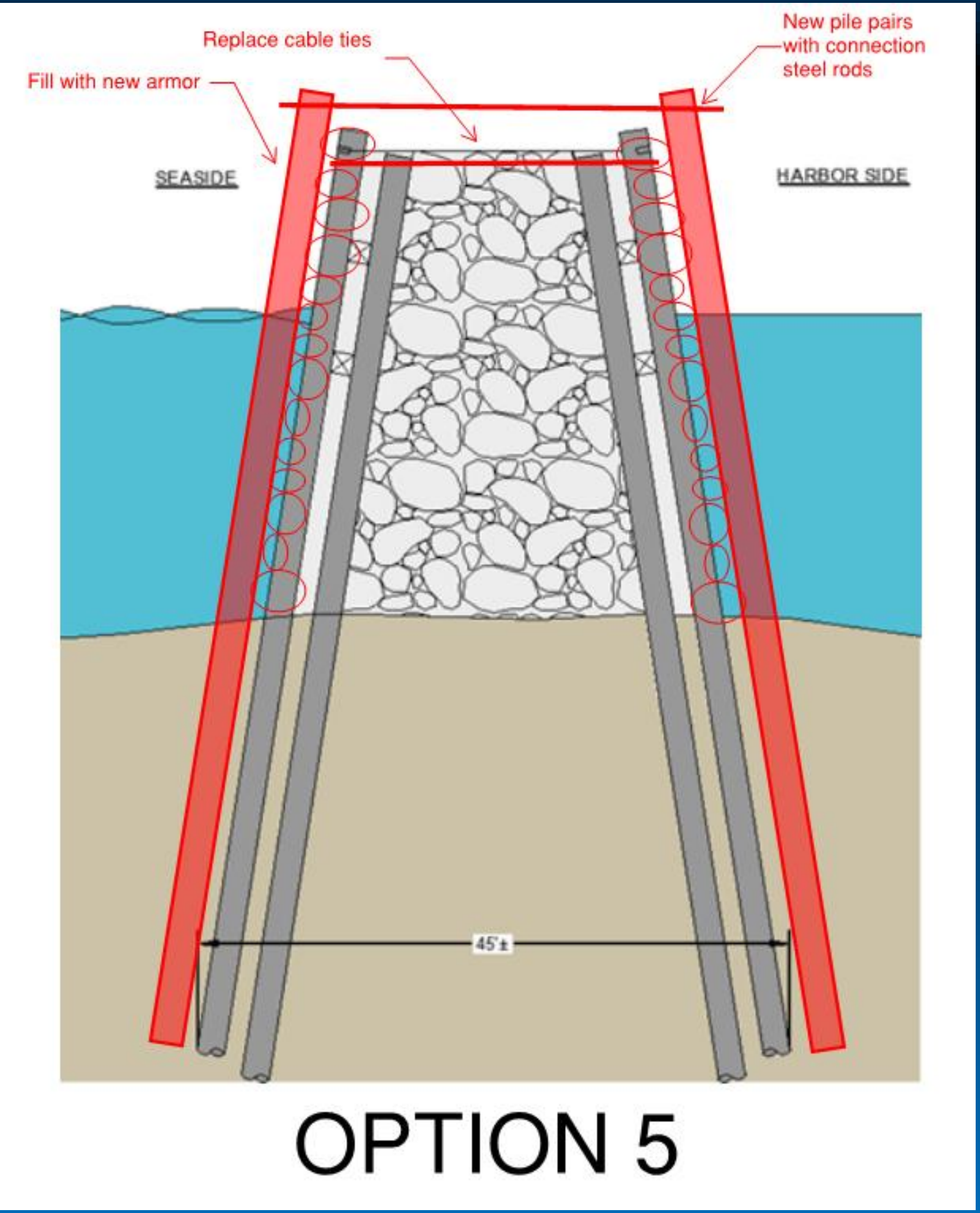
Rehabilitation Options - Pile Pairs and Tieback

- Option 4 – Drive Pile Pairs and New Cables Tying Existing Piles
  - Drive pair of new steel pipe piles at a nominal spacing on the two most exposed legs to reinforce existing structure.
  - Advantages
    - Significantly reinforce exposed sections
    - A fair amount of pile driving required
  - Limitations
    - Does not fix the armor rock
    - Driving may cause further damage to the existing structure
    - Doesn’t fix all the locations
    - Piles that would compatible with future replacement would increase cost
  - Cost
    - ~ $3,500/LF



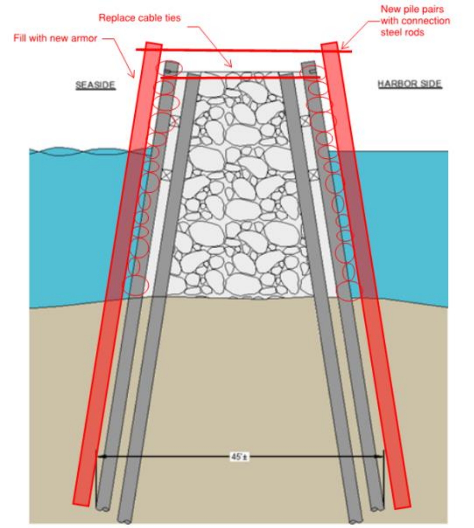
OPTION 4

Rehabilitation Options – Piles, Tieback and Rock



Rehabilitation Options - Piles, Tieback and Rock

- Option 5 – Reinforce existing wall with new piles and rock – South Seaward Section
  - Drive pile pair, and add new armor rock between new piles and old structure
  - Advantages
    - Fixes all three major components, tiebacks, piles and armor rock
  - Limitations
    - Doesn’t fix all the locations
    - High Costs
    - Piles want to be small in this condition, to make piles large enough to be reusable it really drives up the cost.
  - Costs
    - ~$7,000 to $8,000/LF
    - Piles could be reused that could save $1,300/LF

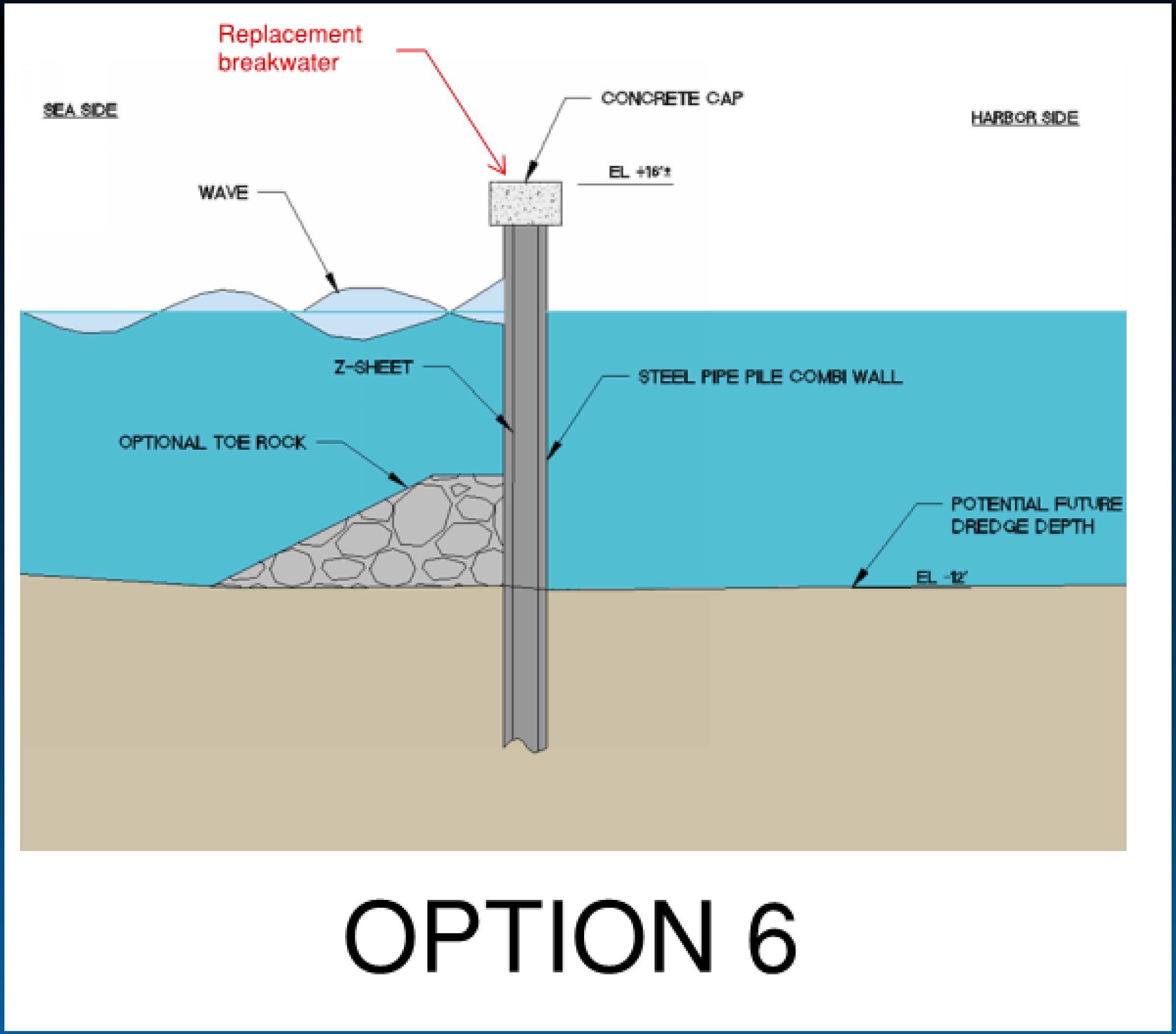


OPTION 5

Rehabilitation Considerations

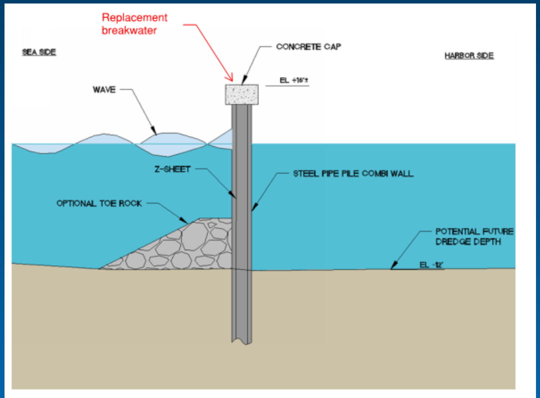
- Cost of major rehabilitation could be ½ to ¾ the cost of replacement, would cost more in the long run due to added maintenance,
- 10-15 yr fix compared to 40+ yr service life of replacement
- No option will eliminate risk except for full replacement
- Any work done today to keep existing structure is a sinking fund.
- Dive inspection and more detailed assessment recommend for no replacement options - $15-$20k

Replacement Options



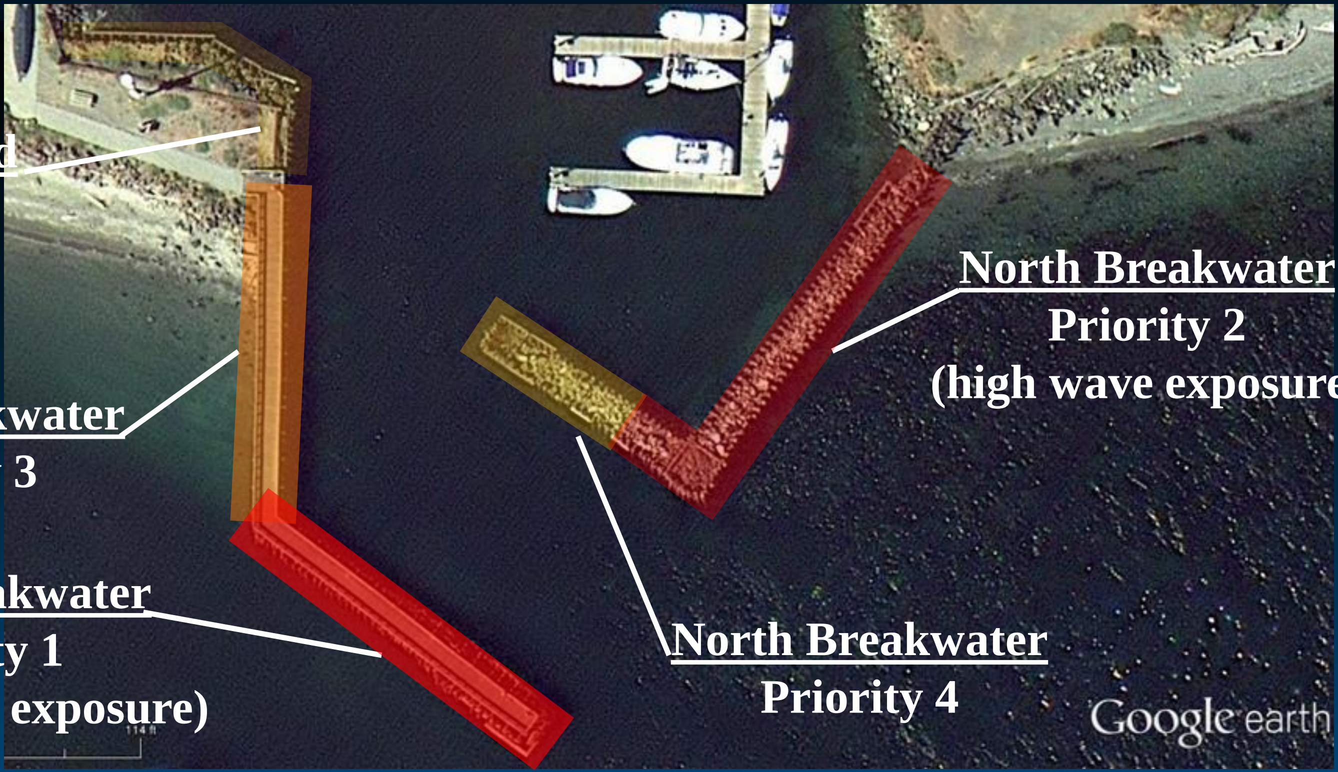
Replacement Options

- Option 6 – Demo Breakwater with Replacement Design
  - Demo piles and remove rock and install replacement design.
  - Advantages
    - Permanent solution
    - Lowest likely hood of failure
    - Reduces footprint
  - Limitations
    - Demolishing part of the breakwater may be tricky
    - Doesn’t fix all the locations
  - Costs
    - $7,000 to $10,000/LF



OPTION 6

Breakwater Component - Improvement Priority



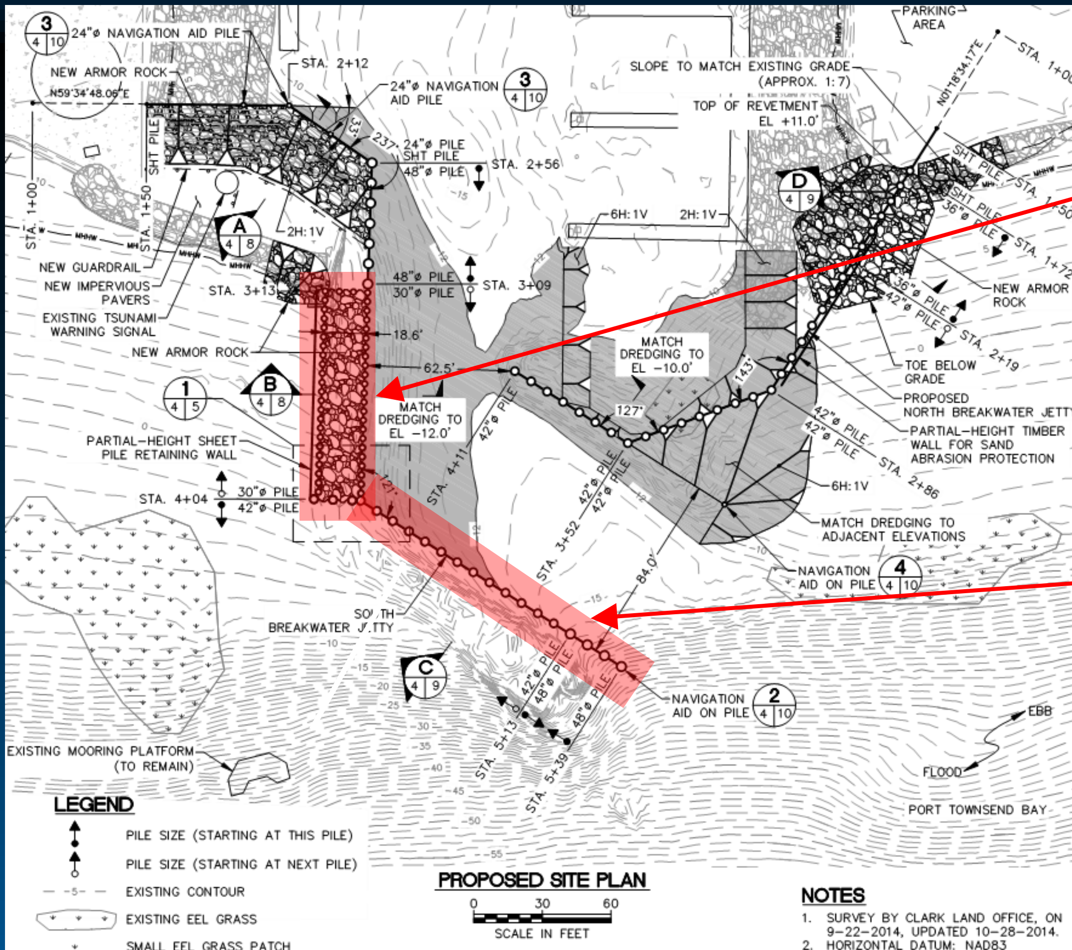
- South breakwater in worse condition than North breakwater.
- South breakwater is more critical in wave protection than the North breakwater.
- Overall South breakwater priority (1,3) should be replaced over the North breakwater
- If North breakwater is not replaced, it should be rehabilitated

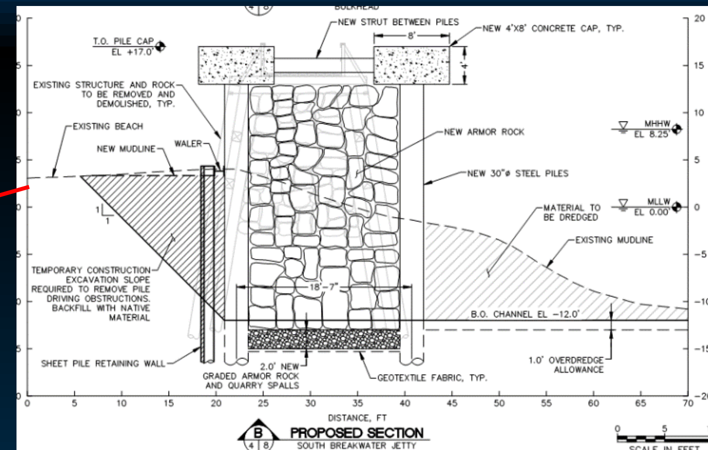
Conclusions

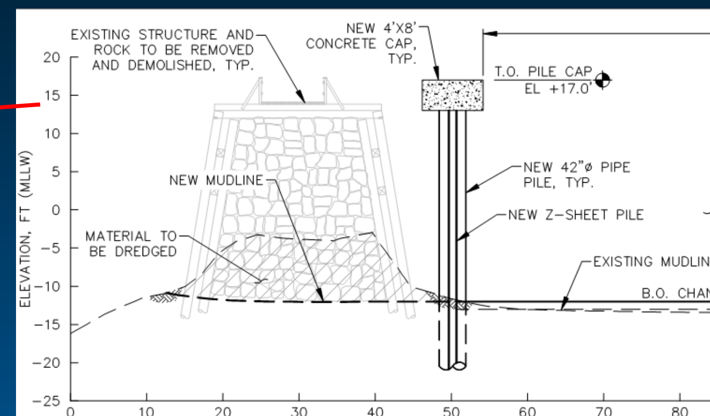
- Major Rehabilitation – Cost could be ½ to ¾ the cost of replacement, would cost more in the long run due to added maintenance
- Moderate Rehabilitation – Lower cost with more maintenance/repairs; shorter life span.
- Risk of Failure - No option will eliminate risk of failure except for full replacement
- Sinking Fund – Recommended for any rehabilitation option; amount depends on type of rehabilitation.
- Replacement vs. Rehabilitation – If cost reduction from full replacement is needed, consider the following:
  - Replace the South Breakwater
  - Rehabilitate the north breakwater for a 10-15 year repair w/ sinking fund.

Recommended Phasing Plan

South Breakwater Replacement Design







- Replace the South Breakwater using permitted design
- Design uses steel combi wall and a steel piled rock box which reduces wave climate in the marina.
- New wall alignment inside existing breakwater on seaward leg.

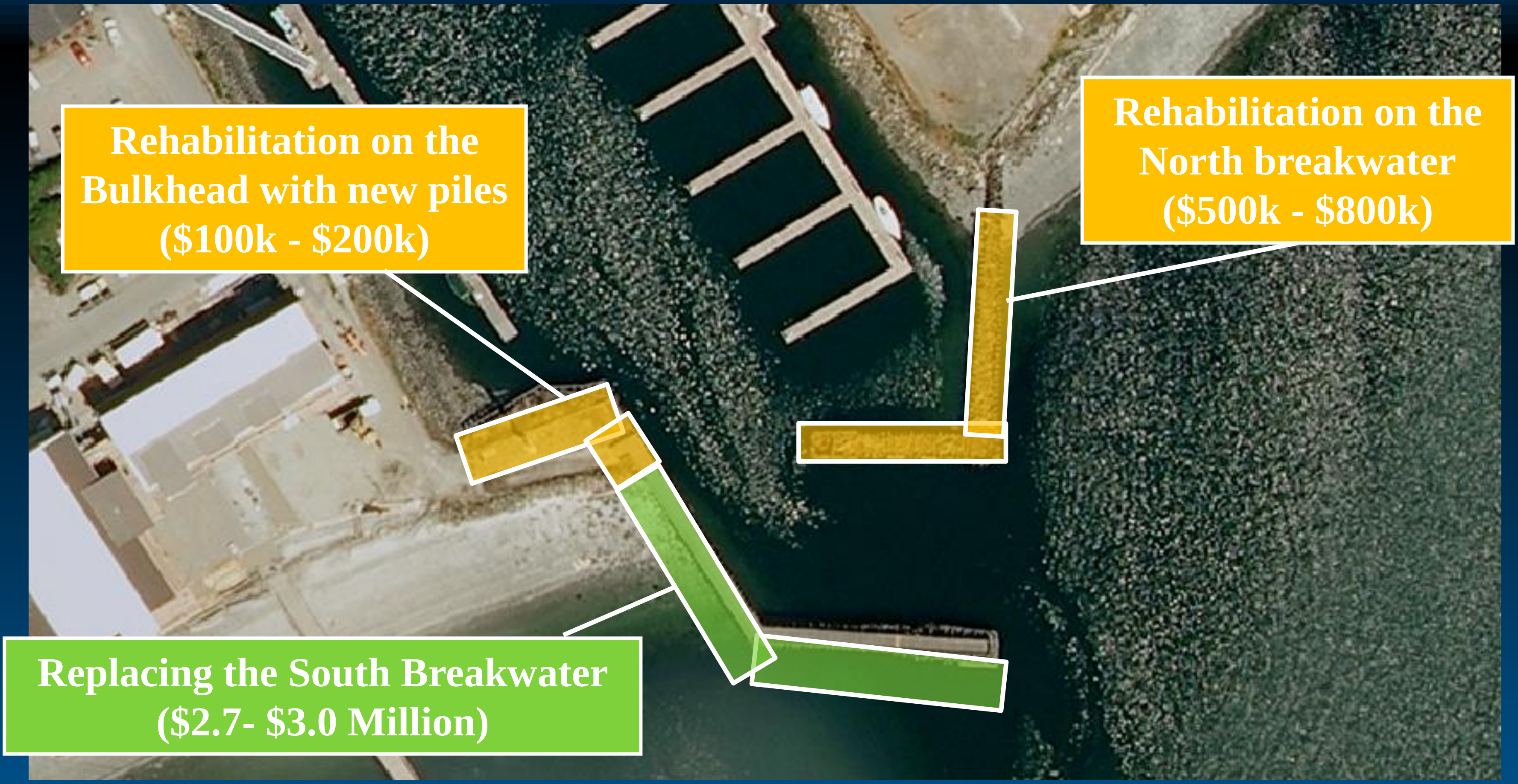
North Breakwater Rehabilitation Plan

- Recommend some localized rehabilitation to extend the life of the north breakwater
- Would need to tailor the rehabilitation per the localized issue along the breakwater
- All cabling should be replaced with a combination of options (3,4 and 5)

South Bulkhead Rehabilitation Plan

- Build upon emergency work with additional new steel pile strengthening to support the rock up the slope

Construction Costs



- Replacement costs uses previous cost estimate
- No dredging costs included
- Costs do not consider rehabilitation piles to be reused in replacement
- Total Cost would be $3.3-$4.0 Million depending on final design and further analysis and does not consider mitigation costs which could offset any savings

Discussion – S. Replace + N. Rehabilitation

- Inspection & Assessment.
  - N. Breakwater for rehab
- Engineering.
  - Detailed engineering to finalize type and locations for rehab
- Dredging.
  - No dredging along north breakwater
- Construction Phasing.
  - Replace + Rehab
- Mitigation.
  - Differences?
- Permitting.
  - Modification to permit application?

PORT OF PORT TOWNSEND

Point Hudson Marina Breakwater Improvement Project

Work Status Update

June 8th 2016

MOTT MACDONALD

PORT OF PORT TOWNSEND