MOTT MACDONALD

DRAFT

Point Hudson

Marina Breakwater Rehabilitation

Task 1 – Design Refinement

Port of Port Townsend

PORT OF PORT TOWNSEND

August 30, 2017

Task 1 - Design Refinement Overview

- Contractor/ Supplier Outreach
  - Information on cost and constructability
- Construction Phasing and Schedule
  - Key issues to consider
- Breakwater Wave Performance and Design
  - Advance design, select final design concept
- Updated Costs

Contractor/ Supplier Outreach

Contractor Feedback – Key Points

- Meet with Orion Marine (Walter Thompson and Ira Nelson)
  - Walter worked on the steel pile repair inside Point Hudson.
  - Concerns barge access and phasing
  - Blocking boaters is going to be an issue
  - They foresee 3-4 month project timeline
  - Will be a period where the marina will be exposed to waves
    - Barge could be used to block some waves during small chop but would be moved during storms that would greatly expose and impact the boaters in the marina.
  - Prefer using steel caps over concrete for significant cost savings
  - Suggested walkway be prefabricated Aluminum trusses.
  - Cost savings by reducing number of pile sizes

Contractor Feedback – Key Points

- Meet with Pacific Pile and Marine (Michael Martin)
  - Also thought phasing was critical
  - Pile driving will require pile shoes as hitting rock during driving is very likely.
  - Prefer working with all steel than concrete due to existing rocks causing seating issues for the panels.
  - Prefer steel piles instead of concrete due potential for damage during install
  - Also prefer using steel caps over concrete for cost savings
  - Barge equipment can handle max 4’ armor stone.

Supplier Feedback – Key Points

- Conversation with Concrete Tech (Jim Parkins)
  - Can provide an all concrete breakwater using prestressed piles and panels
  - Prestressed concrete panels can also be used vertically as wave reflection wall
  - Concrete will be challenging if there is existing rock it has to avoid

Supplier Feedback

- Conversation with Skyline Steel (Errynne Bell)
  - Paint Epoxy Coating typical steel provides 10-15 years of additional design life, before coating need major repair or replacement.
    - Could last longer depending on maintenance frequency
  - Galvanizing sheets and pile provides 7-10 years of additional design
  - Lead time is 6-10 weeks for standard stocked sized piles and sheets
    - 3-4 months for other sections
  - Skyline is able to meet Buy America with some standard sheets, all pipe is domestic
  - Typical stocked bare steel sheets are usually about $0.80/lb.
    - Custom sizes can be 25% higher
  - Straight seam welded pipe is 25% more expensive than spiral weld but will be more durable for pile driving through rock.
    - Could be mitigated by requiring the contractor to have extra piles

Summary of Outreach – Key Findings

- Steel combi walls with piles are the right choice for this site
  - Concrete will not work when trying to drive through all the existing rock
- Steel pile caps are easier and cheaper to work with compared to concrete
  - Can be used with a prefabricated future walkway
- Reducing the total number of different sized piles and sheets will be easier to construct
- Demo and Construction Phasing will be important

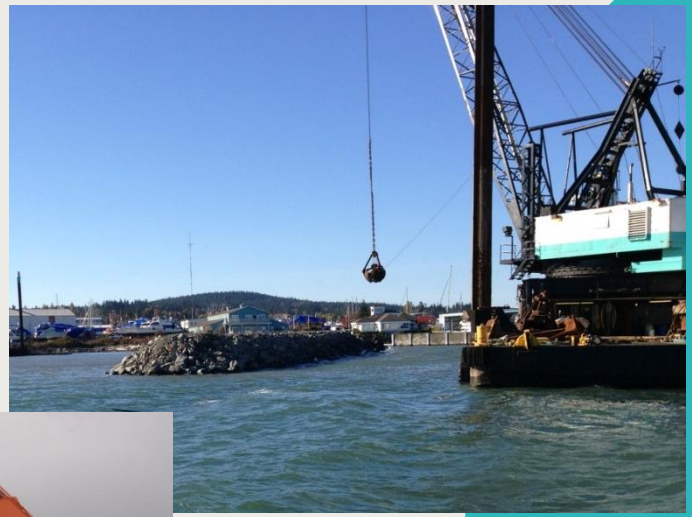
Example Breakwaters With Steel Cap

- Astoria, OR Breakwater
- No coating
- Steel cap design

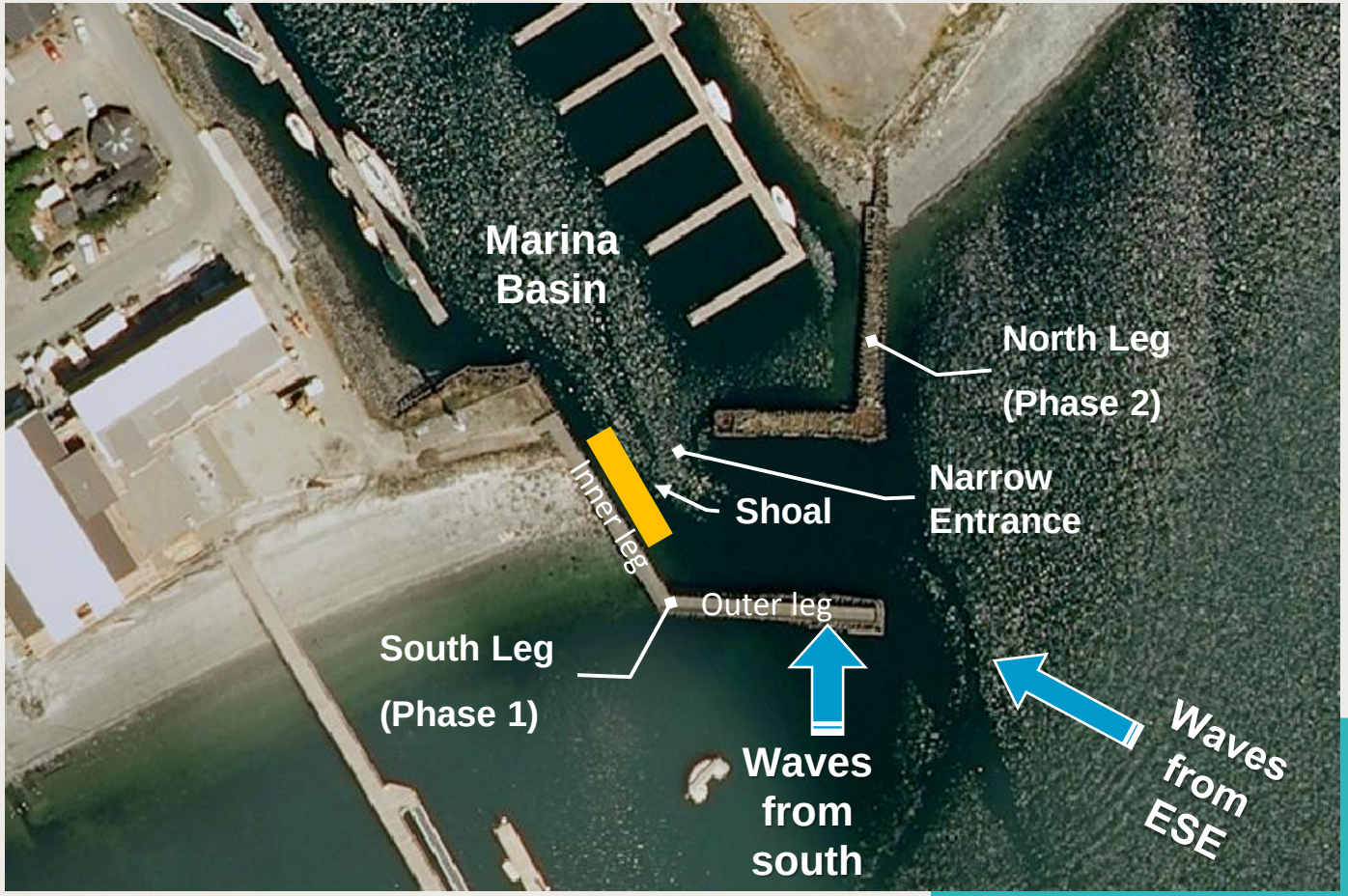
Construction Phasing

Construction Demolition and Phasing

- Phasing of the demolition and construction of the South leg will be critical to getting the work completed.
- Due to barge size needed for pile driving, a barge will not be able to enter the marina without removing part of the existing breakwater
- The following is the sequence we have discussed with Contractors

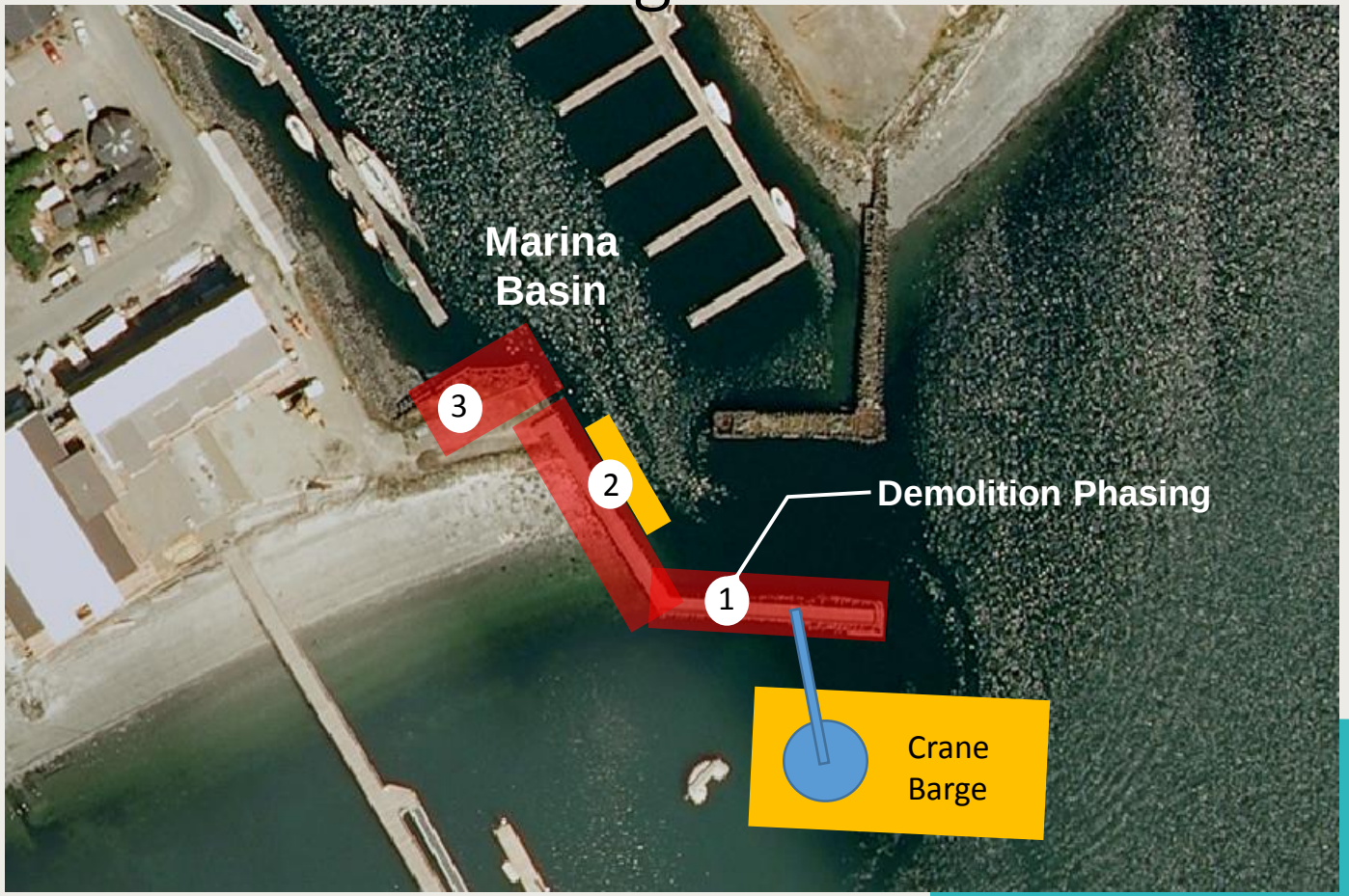


Site Overview



- Note
  - Shoal
  - Wave Direction
  - North leg not being impacted.

Construction Phasing - Demolition



- The contractor will need remove the outer leg to gain access to remove the other parts of the breakwater

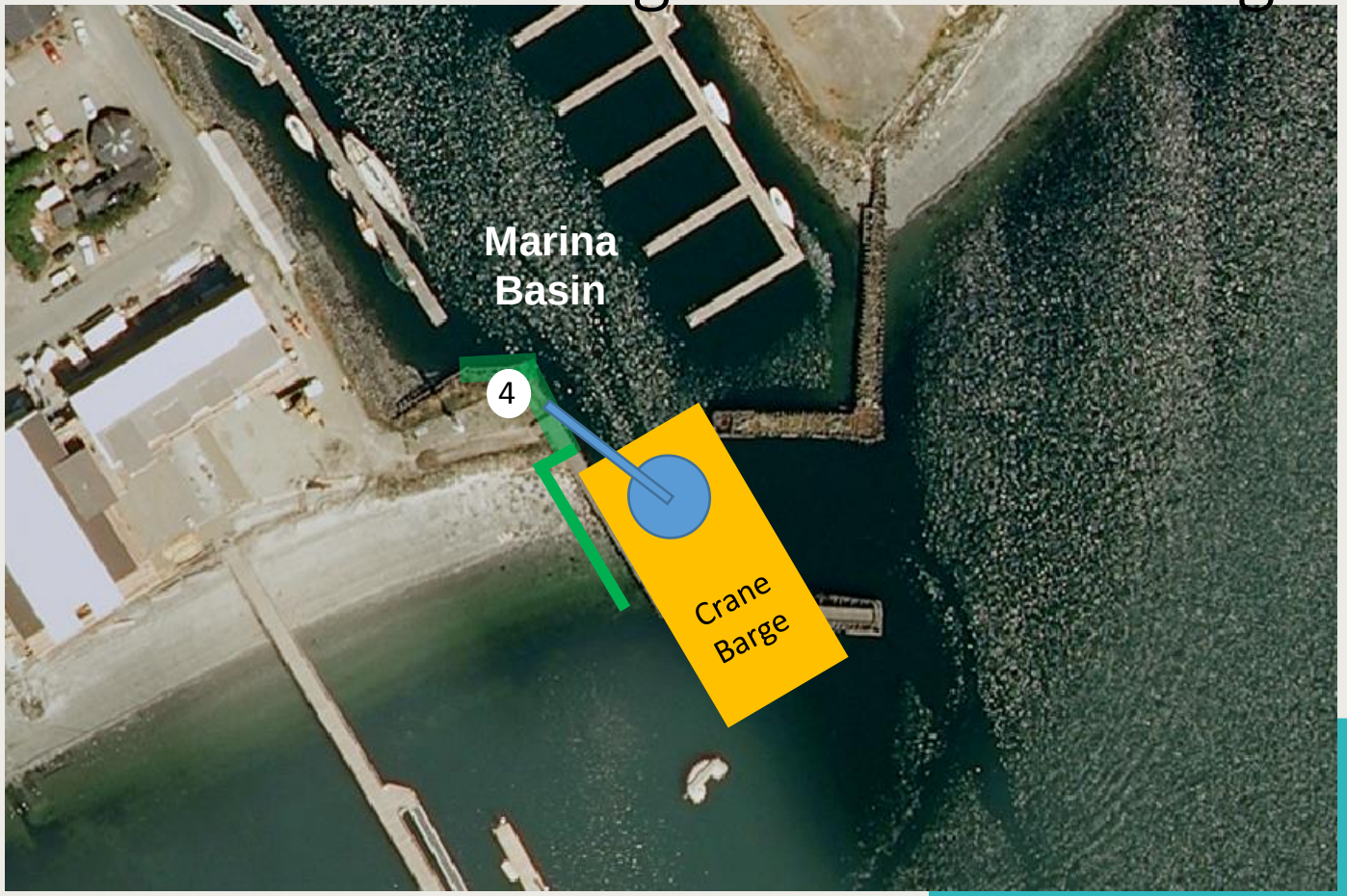
Construction Phasing - Demolition

- Once the outer leg is removed the contractor will remove the inner leg and shoal and drive the beach side segment of the rock box to prevent the beach from migrating into the channel

Construction Phasing - Demolition

- Once the inner leg and shoal is removed the barge will have full access to enter the marina

Construction Phasing – Build South Leg



- Since upland access is limited, the contractor will start pile driving the inner wall sections

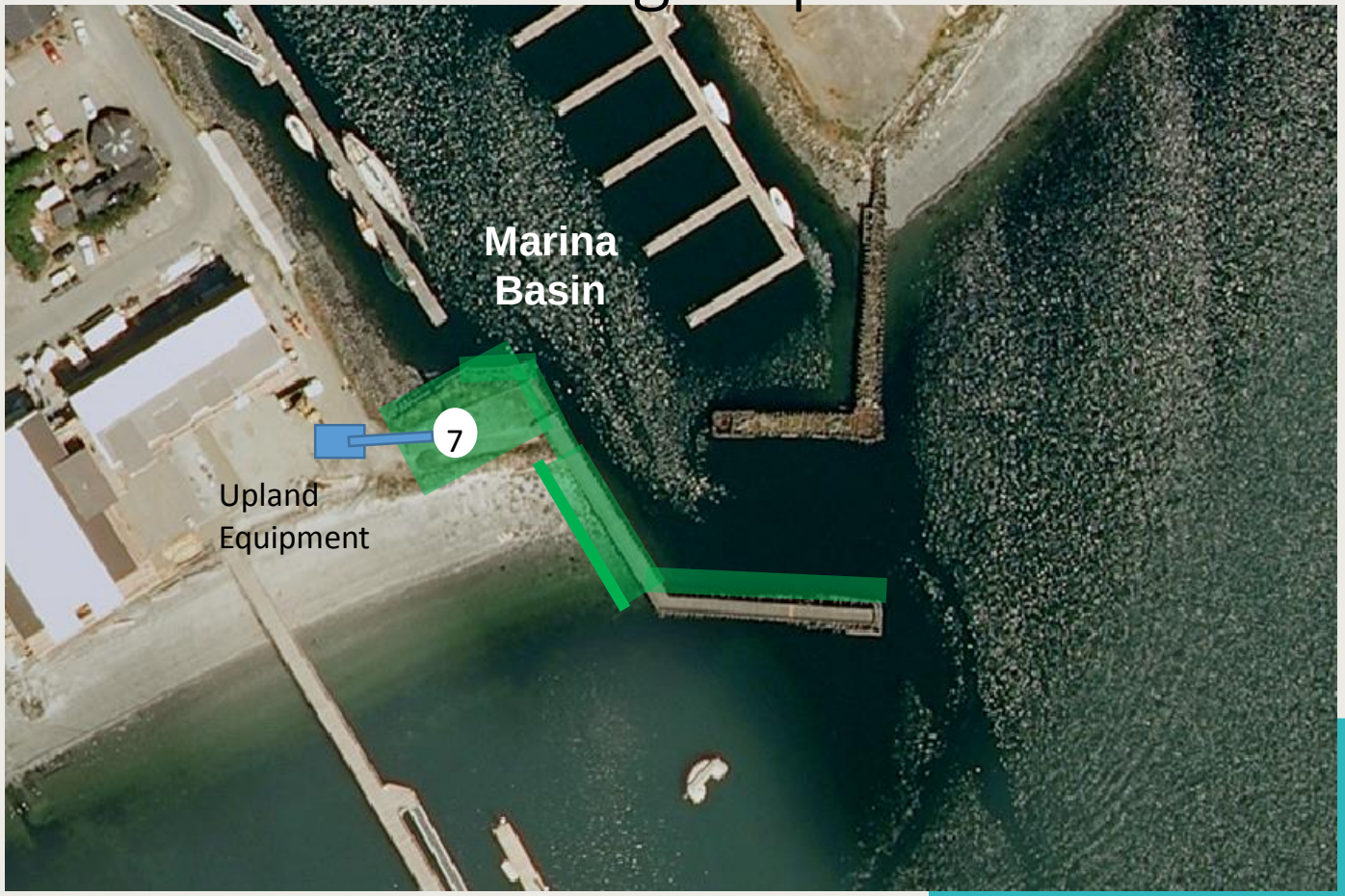
Construction Phasing - Build South Leg

- Since the marina will be exposed we believe constructing the outer leg first will help to protect the marina.

Construction Phasing - Build South Leg

- The rocks box will likely be one of the last elements installed on the breakwater due to complexity.

Construction Phasing - Upland



- Lastly upland work will be completed with smaller upland equipment.
- This work could happen any time after demo
- Would need to protect and restore uplands

Construction Access vs Risk vs Cost

- It is important the Port determines criteria for marina access vs construction access. It will impact cost and duration of construction.
  - Also important the tenants are made aware and their input is included in a decision.
- Work completed in the summer will reduce the likelihood the marina will be impacted by a storm when exposed during demolition but will impact more boaters during the high season.
  - The tenants may also want to have input if they would rather have access during the summer or reduce risk to their boats from storms in the fall.
- The more the contractor has to allow access to the marina, the more time and cost it will be.
- High tides are likely critical times the contractor will want to work
  - More good high tides in the summer
- Will night shifts be allowed?

Construction Phasing Summary

- The proposed construction is likely to take 3-4 months with the marina and moorage exposed to large waves and wind events (1-2 months of duration). Access and time of year will be critical to the cost of construction and protection of the existing moorage
- Other potential phasing options
  - Demo part of the north wall to allow the barge to gain more access into the marina. Disadvantage to this option is that the marina will be exposed to more waves long term. Adding some new wall back here will also be challenging to integrate with the rest of the breakwater.
  - Mobilize a large crane upland with some temporary shoring or support. Currently looks like there is not enough access width between the existing slope and building.

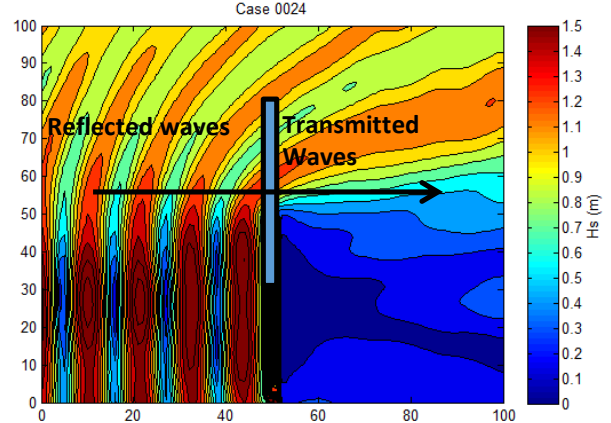
Breakwater Wave Performance and Design

Wave Protection

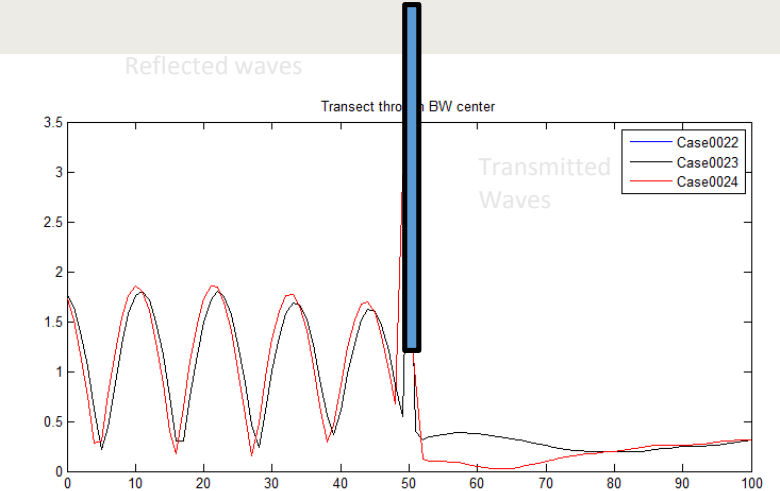
- Review previous wave analysis and reasons for current design.
- Proposed breakwater performance compared to the existing breakwater
- Recommend alterative for final design refinement of the inner leg

Wave Model Parameter Tuning (Completed Previously)

- Performed detailed computer model testing and calibration of model parameters (approximately 30 cases run)
- Selected refined model parameters for use in analysis of revised breakwater alternative layouts.
- See preliminary design presentations dated Dec. 05, 2014 for more information.



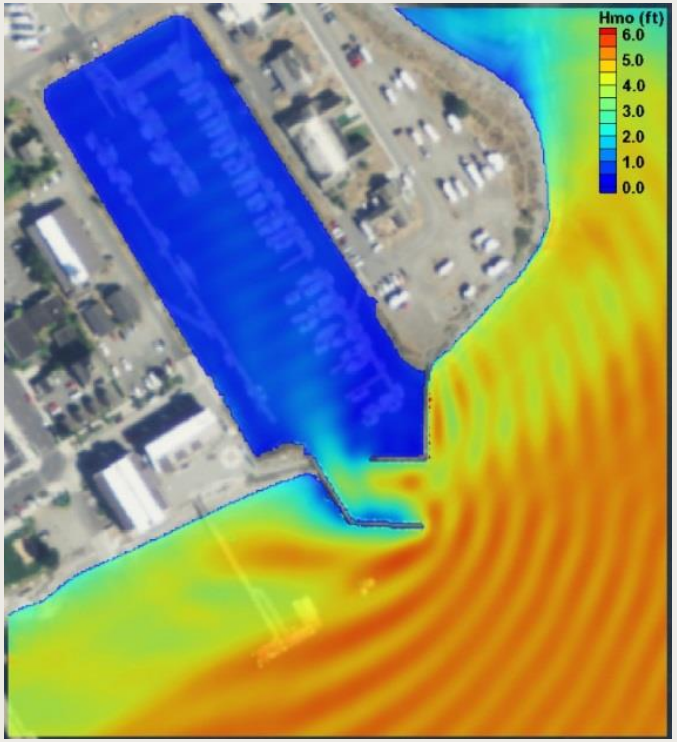
Example Case 24 Plan View



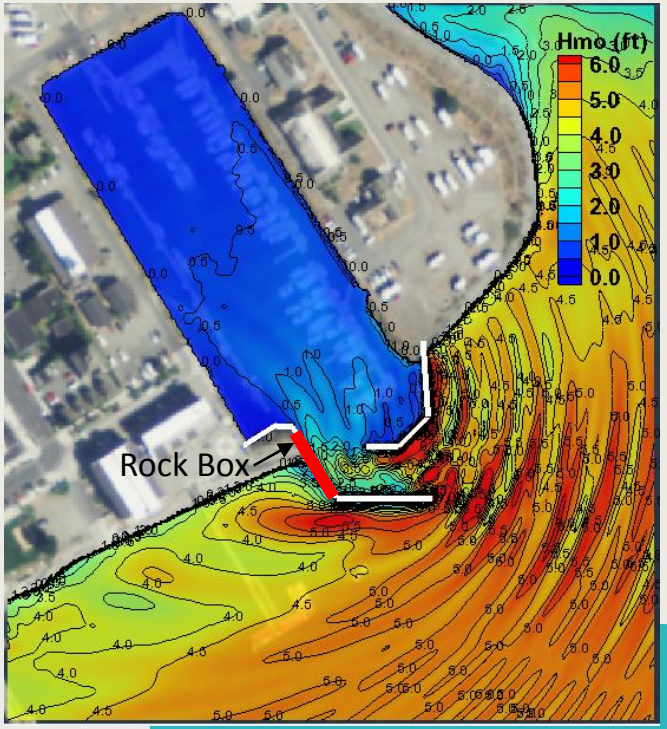
Example Cross Section

Compare Performance - 50 Year Storm MHHW

Existing Condition, 50% Reflective all segments



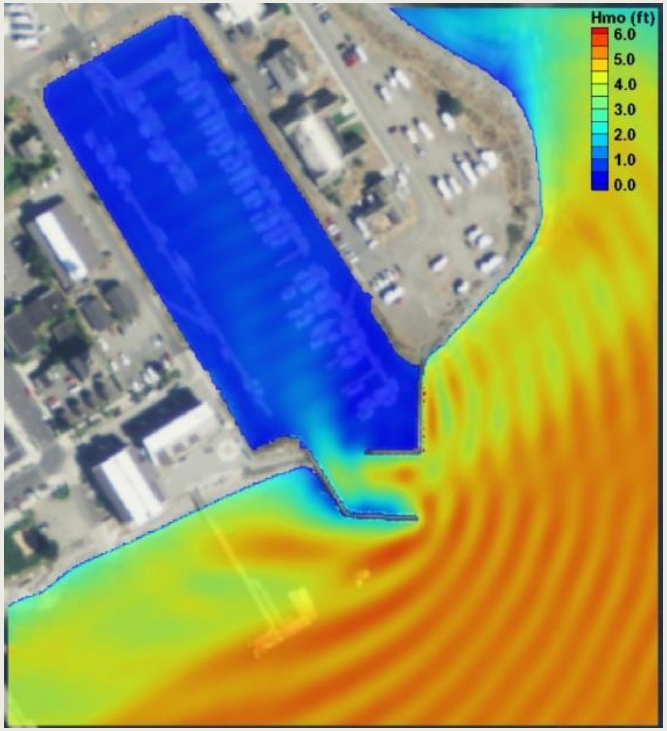
Current Design with Wave Absorbing Section



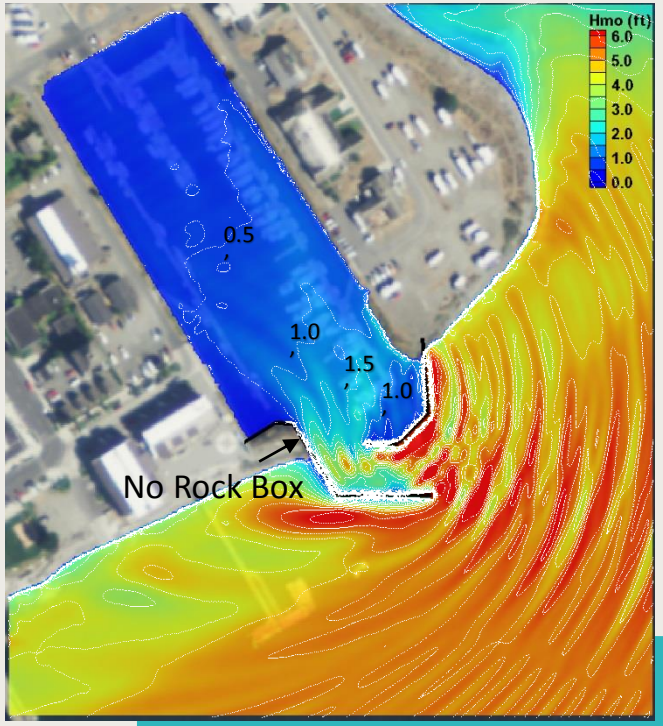
- Wave penetration fairly similar, slightly worse than existing

Compare Performance - 50 Year Storm MHHW

Existing Condition, 50% Reflective all segments



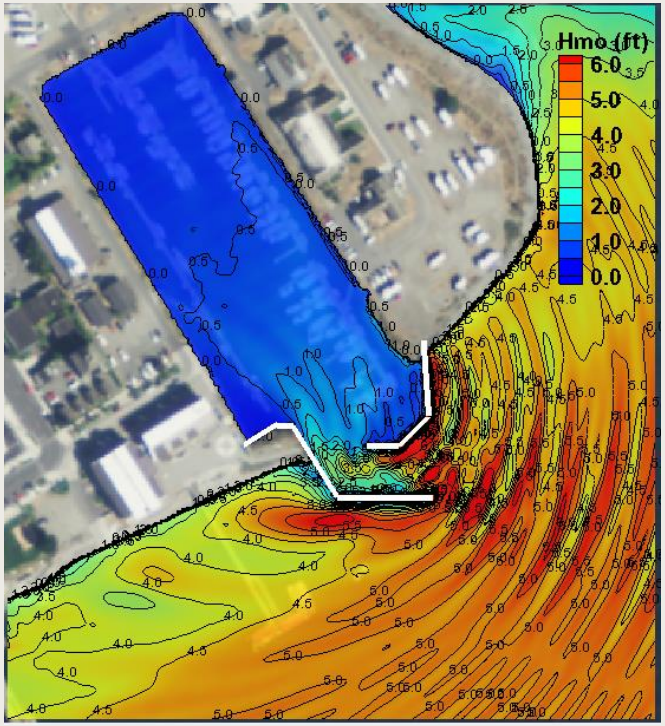
Fully Reflective Design, no wave absorbing section



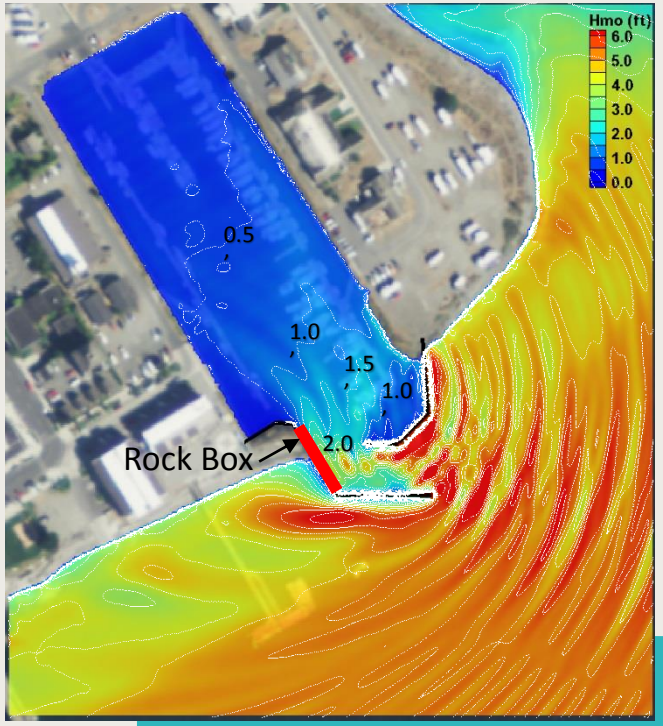
- Wave penetration worse than existing

Compare Performance - 50 Year Storm MHHW

Current Design with Wave Absorbing Section



Fully Reflective Design, no wave absorbing section

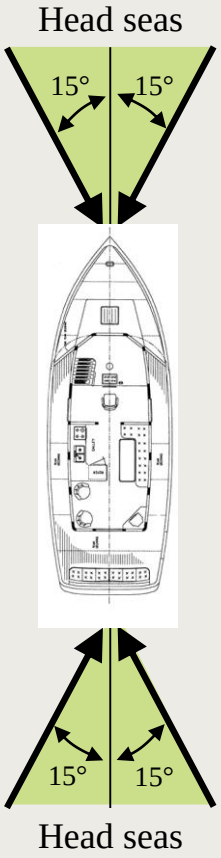


- Benefits of the Rock Box

Wave Protection Mooring Guidelines

WAVE CRITERIA FOR MOORING BASIN (State of Alaska ADOT&PF)

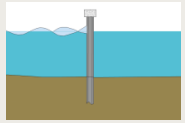
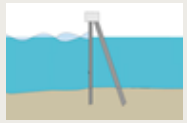
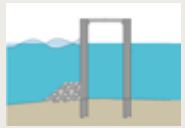
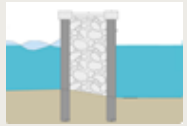
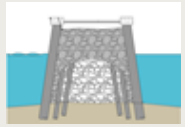
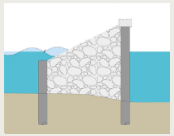
Recurrance Interval: Once per	50 years	1 Year	Week
For Wave Heights (inches):			
Head Sea,T<2	12	12	12
Head Sea,2<T<6	24	12	6
Head Sea,T>6	24	12	6
Beam Sea,T<2	9	12	12
Beam Sea,2<T<6	9	6	3
Beam Sea,T>6	9	6	3
For Horizontal Motion (inches):			
Head Sea,T<2			
Head Sea,2<T<6			
Head Sea,T>6	48	24	18
Beam Sea,T<2			
Beam Sea,2<T<6			
Beam Sea,T>6	24	12	9



★ Current Design is close to meeting criteria

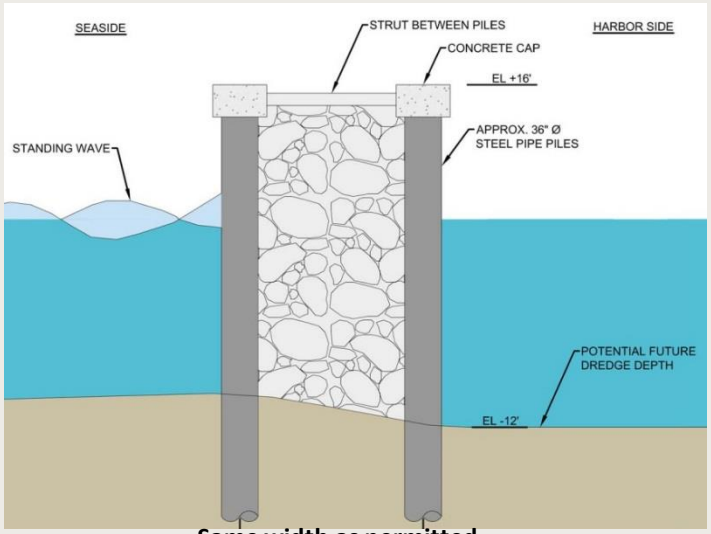
Wave height (ft)	Existing	Current Design	Fully Ref Design	Criteria (ft)
Pt#1	5.0	6.0	6.0	NA
Pt#2	4.0	4.0	4.0	NA
Pt#3	0.5 ✓	1.0 ★	1.5	0.75
Pt#4	0.4 ✓	0.5 ✓	0.5 ✓	2.0
Pt#5	0.5 ✓	0.5 ✓	0.5 ✓	0.75

Typical Section Alternatives Original Considered

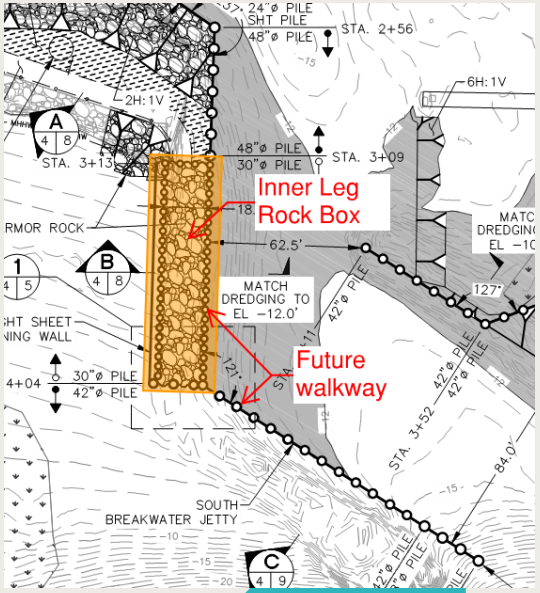







Alt Wall System Type	Wall Cost $/FT	Environmental Impacts	Wave Climate	Navigation Width
Cantilever	$3k to $5k	Small	Worse	Much better
Batter	$4k to $5.5k	Small	Worse	Better
Pile Frame	$6k to $8k	Med	Worse	Same
Vertical Rock	$8k to $11k	Med	Same	Same
Recycle Existing	$7k to $10k	Med	Better	Worse
Sloped Rock	$9k to $11k	Large	Same	Worse

Current Design Selected at South Inner Leg to Reduce Wave Penetration



Same width as permitted

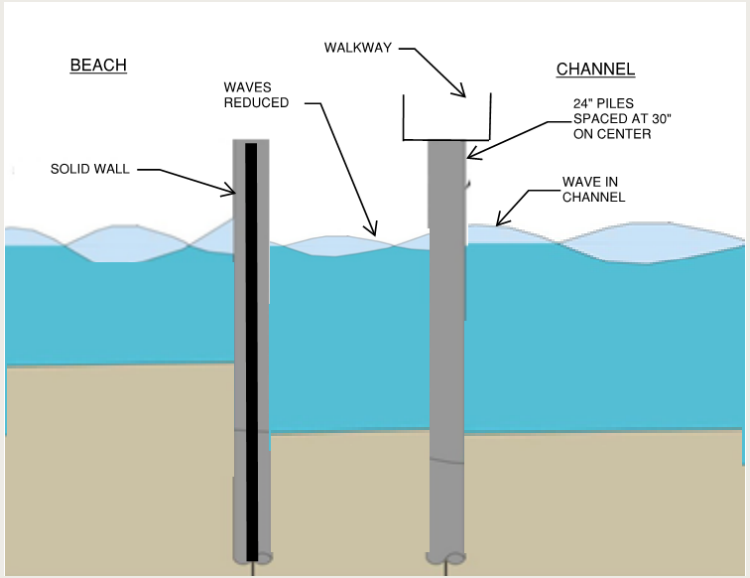


- Proposed design was intended to mimic proven existing design and performance.

Cost = $9.5k/ft

- Pros
  - Site specific proven performance
- Cons
  - Challenging to construct
  - Expensive

Refined Alternative Concept 1



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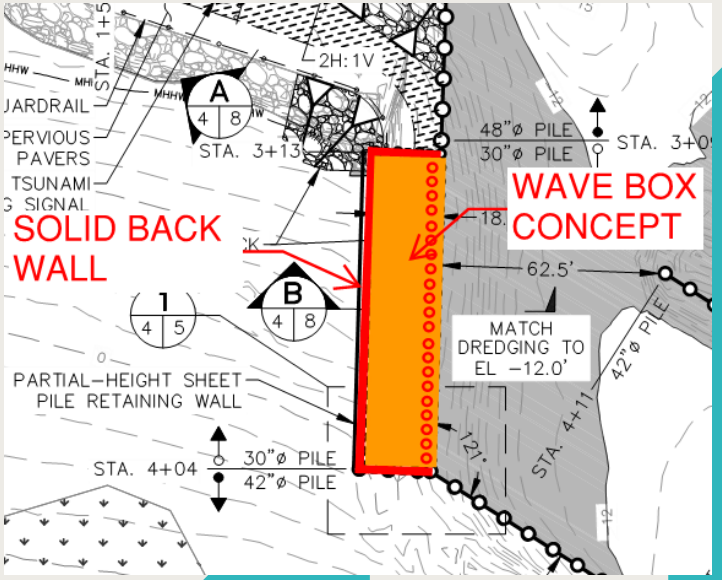
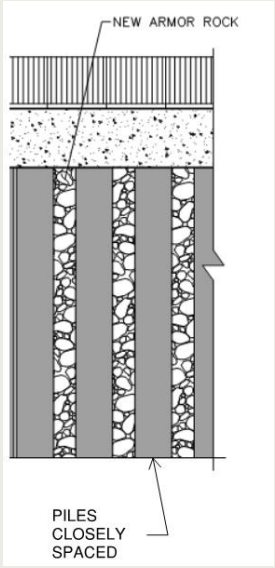
Cost = $9k/ft

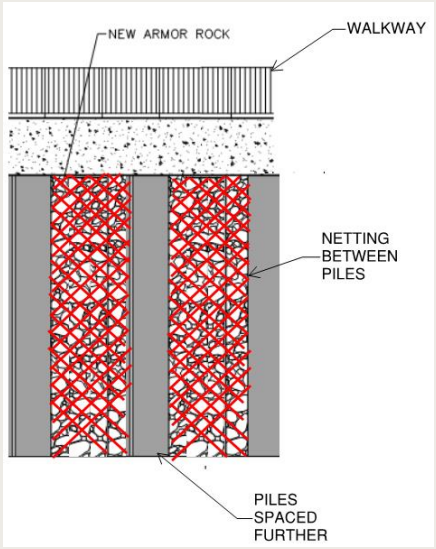


- Pros
  - No rock, all steel
- Cons
  - Cost is similar to current design

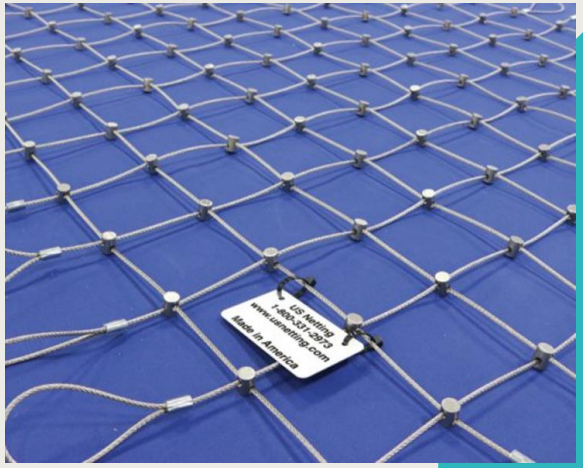
Refined Alternative Concept 2



EXISTING WALL
ELEVATION VIEW



REFINED WALL
ELEVATION VIEW

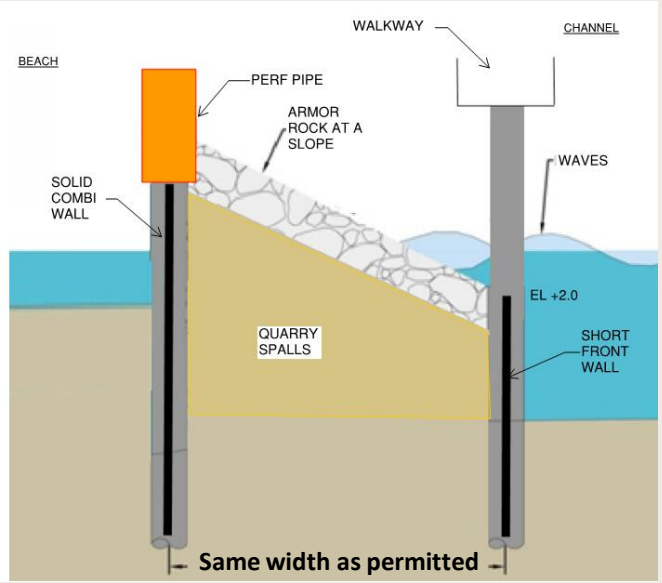


- Netting to hold in armor rock
- Stainless steel would last the longest but would require replacement at about 20-25 years.
- $8-10/ sqft

Cost = $8k/ft

- Pros
  - Wider distance between piles increases wave performance and reduces cost
- Cons
  - Maintenance would be high, net would need to be replaced which could be expensive

Refined Alternative Concept 3

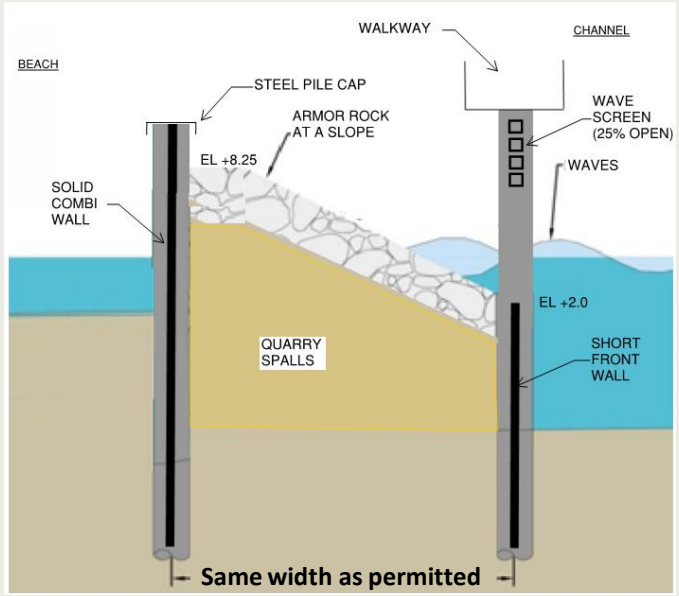


Cost = $8k/ft

PERF PIPE - This project under construction for Monaco perf pipe to absorb wave energy. Like our concept, but much larger.

- Pros
  - Good wave performance
  - Lower cost
- Cons
  - Maintenance maybe high for the perf pipe
  - Less proven history

Refined Alternative Concept 4 (Recommended)

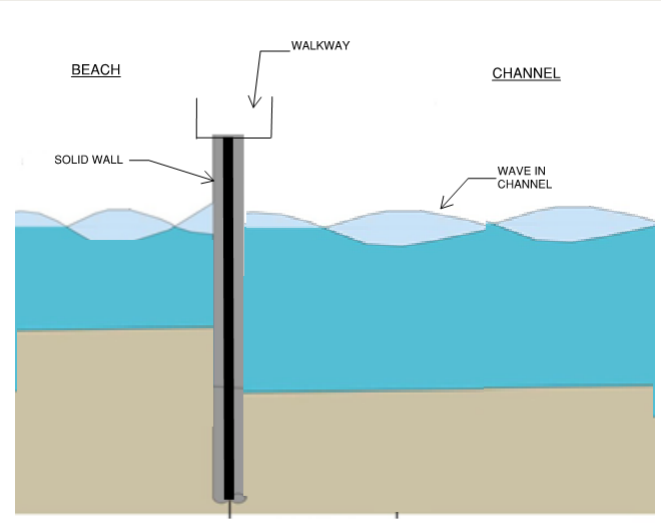


- Wave screen (timber or steel)

Cost = $8k/ft

- Pros
  - Best wave performance
  - Lower cost
- Cons
  - Will potentially need maintenance for wave screen
  - Rock slope will need to be maintained

Refined Alternative Concept 5



Cost = $4.5k/ft

- Pros
  - Simple construction
  - No rock, all steel
  - Low maintenance
- Cons
  - No wave absorption
  - Would not meet moorage criteria for up to 25% of the marina

Other Alternatives Considered

- Middle Harbor, SF, CA
- Steel coated sheets
- Breaks between sheets to dissipate energy
- Allows sediment transport which would be a major problem for our site

Summary of Refinement

- There is potential for saving money using a modified rock box, with a rock slope inside a box
- Recommend Concept 4 with the slope and wave screen
- Performance could be higher but with slightly higher maintenance costs

Updated Costs

Summary of Cost information

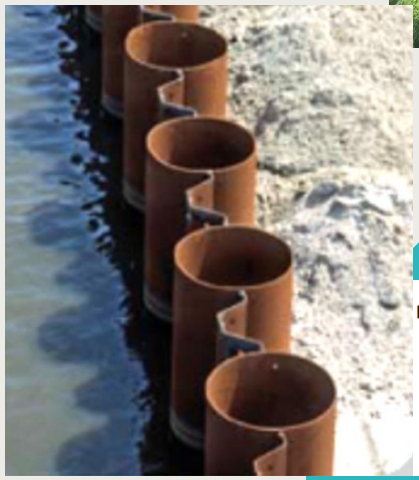
- There will be cost savings going to a steel pile cap over concrete
- Assume 10% general construction inflation from 2015 to 2018.
- Likely some cost savings and reduced lead time using standard stocked sheets compared to using the most refined sized sheets and piles. Will know more after final design.
- Costs will increase the more restrictions the Contractor has to work in allowing access and working in the winter.

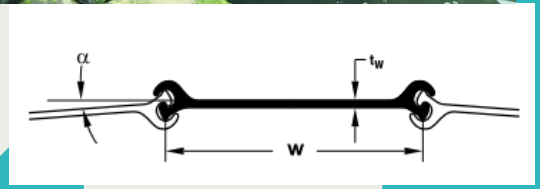
Galvanizing vs Painted

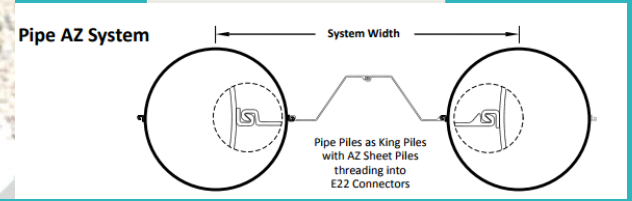
- Painted
  - Adds 10-15 years of protection before complete paint replacement or major maintenance is required
  - Would need to be inspected and maintained regularly and full replaced at least once over the design life
  - More expensive for Z sheet systems
- Galvanizing
  - Adds 10 years (Can be up to 15-20 years in Puget Sound) of effective protection before corrosion begins.
  - Maintenance requires adding new sacrificial anodes, or adding new impressed current (active protection).
- Cost
  - Paint more expansive for Z sheet systems
  - Paint and galvanizing is similar cost for flat sheets

Flat Sheets vs Z Sheets

- Z sheets are easier to install and drive
- Z sheets are wider requiring few total pipe piles
- Flat sheets are more aesthetic
- Flat sheets are 15% less expansive than Z sheets if both systems are painted







Recommendation

- If painted, use flat sheets
  - Additional piles may need to be permitted.
- If galvanized, Z sheets are probably better due to constructability

Example Breakwaters with Flat Sheets

- Blaine Harbor, WA
- Galvanized steel sheets pre welded to pipe
- Reduces driving time and labor

Flat Sheets vs Z Sheets vs Painted vs Galv

Cost Comparisons, higher is more expansive

	Z Sheets	Flat Sheets
Painted	114%±	104%±
Galvanized	100% (Base)	102%±

*We do not recommend painted Z sheets. All other systems are comparable. Aesthetic and maintenance preferences are considerations.

Note: Values only consider installed wall costs, do not include any other components of construction. Final design will impact numbers slightly.

Construction Cost Update

South Wall Design

- Changing to a steel cap = $100,000 in savings
- Rock Box refinement = up to $100,000 in savings
  - Removing Rock Box completely could save up to $450k but would increase waves in the marina
- Potential steel price increase = $125,000
- Construction Inflation over 3 years (2015-2018) ~+10% = $300,000
- **Total Construction Cost Increase = $225,000**

North Wall Design

- Changing to a steel cap = $100,000 in savings
- Potential steel price increase = $70,000
- Construction Inflation over 4 years (2015-2019) ~+13% = $280,000
- **Total Construction Cost Increase = $250,000**

Note: Cost does not include A/E or refined section wall design from Geotech borings

Conclusions

- Task 1 Refinements
  - Steel Cap is preferred over concrete
  - Construction phasing will be critical
  - Some refinements can be made to the Rock Box design to reduce cost
  - Overall Construction costs have increased slightly
  - The most refinement to the design will happen once we get the new Geotech borings.
- Decisions Needed from the Port
  - Keep Rock Box?
  - Galvanized vs Painted?
  - Flat sheets vs Z sheets? Flat sheets will require more piles which may need to be permitted.
  - Buy America?

Questions ?