BRIDGEHAVEN MARINA CONDITION ASSESSMENT

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Draft Technical Memorandum
Bridgehaven Marina Condition Assessment

1. Introduction

This technical memorandum outlines the results of a reconnaissance level assessment of the Bridgehaven Community Club Association (BCCA) Marina facilities. A site visit was conducted on February 16, 2017 during the afternoon at low tide.

2. Scope

Mott MacDonald was scoped to conduct a reconnaissance level assessment of the existing marina facilities. The following elements were included in the assessment:

- Bulkhead
- Overlook Structure
- Gangway
- Marina Floats & Piles
- Boat Ramp
- Breakwater
- North Beach Erosion
- Dredging (Entrance Channel & Marina)

General level I visual inspection and observation was scoped and conducted. A detailed level II or III type inspection for topside or a dive inspection was not performed under this scope of services. Analysis of sedimentation and coastal geomorphic processes were beyond the scope of this phase I assessment. Assessments includes recommendations relative to short (1 to 3 years), intermediate (3 to 10 years) and long term (10+ years).

The features and their respective location at the site which were part of the assessment are shown in Figure 1 of Appendix A. A more detailed photographic description of the feature condition is shown in Figures 2 to 13 in Appendix A. The marina layout and 2001 bathymetry of the marina are provided in Appendix B.

3. Bulkhead

- Background: Two bulkhead types exist at the marina to retain and protect the upland areas (including Gazebo and parking lot). These two types include a stone and timber bulkhead constructed in 1961/1962. The stone bulkhead varies from 6ft to 8ft in height and is a gravity type wall system. The timber bulkhead varies in height from 5ft to 7ft and is a "soldier pile" type wall system composed of creosote treated timber soldier piles and pressure treated lagging to retain the backfill. The length of stone bulkhead was estimated to be 200 ft and the timber bulkhead 140 ft.

- Condition Assessment:
  - General. A significant number of sink holes were observed within the upland backfill areas of both bulkheads. Toe scour was observed along the entire north timber bulkhead.
  - Stone Bulkhead. Armor stones appear to be in good condition. A few sinkholes were noted. No serious stone material degradation or overall stability concerns observed. Stone bulkhead generally good condition.
  - Timber Bulkhead. Timber piles and lagging appear to be in average condition. Geotextile fabric appears to be in adequate condition but as currently exposed is susceptible to puncture from debris impact. If punctured, the loss of backfill will accelerate and bulkhead condition will further deteriorate. Exposure of the backfill and undermining of the bottom lagging is a serious concern for continued loss of backfill and correspondingly to bulkhead stability.
  - Toe Scour. Scour was observed at the toe of the entire length of the north timber bulkhead, and in many areas, has progressed below the bottom of the timber lagging boards. The undermining of the bottom lagging boards is contributing to the loss of backfill materials and the formation of sink holes.
- Recommendations:
  - General. Repairs to the existing timber bulkhead are needed in the immediate to short term to protect the integrity of the structure. Other than localized sinkhole repairs, the stone bulkhead should continue to be monitored but currently doesn't require more extensive repair work.
  - Repairs (short to intermediate term). Install lagging boards on the waterward side of timber piles below the beach level and extending above the bottom of the existing lagging. Installation of geotextile fabric and backfill within the voids between the outer and inner lagging. Excavate sinkholes and backfill with granular rock fill. Seal up gaps in timber lagging. Install missing top lagging boards.
  - Long-Term Rehabilitation. Best long-term remedy is to remove backfill, install new lagging down to bottom of beach level, reinstall geotextile, backfill and retrofit tiebacks. If piles deteriorate further, reducing lateral loading on the wall may be needed. This would consist of removing the upper couple feet of wall and creating a 5- to 10-ft setback bench for plantings. An upland retaining wall would be needed at the landward edge of the new bench.
- Costs:
  - Repairs. Repairs as described above would be roughly ½ the cost of rehabilitation. The estimated cost is $20,000 to $40,000.
  - Rehabilitation. This would require a greater level of work and would be higher cost because of backfill removal, replacement of lagging, geotextile installation and replacement of backfill. Cost could be about ½ the replacement cost. Costs for timber bulkhead rehabilitation are estimated to be $55,000 to $85,000.
  - Replacement. Replacement of either structure is not needed in the short term but costs were developed for intermediate to long term planning purposes. Replacement of the stone and timber bulkheads can be about $700 to $1,100 per linear foot of wall length. This would require $140,000 to $220,000 for stone bulkhead and $100,000 to $155,000 for timber bulkhead replacement.

4. Overlook Structure

- Background: Access to the marina from the uplands is provided across a timber pile supported overlook structure. The overlook structure is located waterward of the stone bulkhead and the waterward edge (marina side) provides access to the marina by a steel truss gangway attached to the overlook. The overlook includes 24 timber support piles, timber pile caps, timber joists/stringers, and timber decking (all timber is either creosote or pressure treated lumber). The overlook is used primarily for pedestrian access from the upland parking lot to the marina floats and additional deck space outside the gangway access corridor is not regularly used nor needed. The size of the overlook structure is 1,000 SF (approximately 50ft x 20ft).

- Condition Assessment:
  - Decking. Decking boards were observed to be average condition. It appears decking have been replaced in the past.
  - Stringers. Movement of stringer relative to support pile was observed. This could indicate corrosion of connection, overloading or improper original alignment of the structure (piles are not all in alignment). Stinger timber appears to be in average condition.
  - Bracing. Nearshore piles are attached into the rock bulkhead via corroded steel cables that appear to be some form of a lateral restraint system. Two pile bents were observed to have broken timber cross bracing. The remainder of the structure had no or minimal lateral bracing.
  - Pile Caps. Pile cap to pile connection is not uniform; caps are twisted, only partially seated on the pile, are blocked in many locations (varying heights of pile top), and quality of drift pin connection is questionable. Lateral capacity of the pile cap to pile connection appears to be limited.
  - Piles. Piles were observed to have typical type and level of deterioration for the type, age, and environment they are exposed to. Two piles were observed to have advanced or severe deterioration and the remainder of piles observed to have moderate deterioration (varying levels of interior untreated core loss but outer shell intact).
  - Capacity. The vertical capacity of the structure is reduced within the area of the highly deteriorated piles. One of these piles supports the decking loads within the area in front of the gangway connection. Structure capacity is further reduced by the misalignment of the stringer to pile cap connections. Lateral capacity of the structure appears to be low given the type of construction and condition of the members.
- Recommendations:
  - Monitoring and Inspection. Until repairs are made, monitoring and inspection of these elements should be conducted on a routine basis.
  - Use. Continued use should be limited to light duty pedestrian use and large crowds should not be allowed to congregate on the overlook structure (in particular, those areas pointed out to be problematic). Warning signs to prevent large gatherings and no large loads should be considered.
  - Rehabilitation. If it is desired to preserve the overlook structure as a usable facility for the marina, rehabilitation will be needed. Rehabilitation will include replacement of pile (deteriorated pile near the gangway connection), removal of misaligned stringers, adjustment of pile caps, installation of a new stringer and replacement of decking boards. It would make the most sense to conduct a comprehensive rehabilitation of the remaining overlook structure that is needed for use and then demolish the remaining elements that are not needed. A major rehabilitation should be planned for some time in the next 5 years.
  - Removal/Replacement: A complete removal of the overlook structure, thereby eliminating the need to conduct any rehabilitation work, is an option if combined with the gangway replacement concept (see Gangway section of report).
  - Rehabilitation/Repair Concepts. Three options could be pursued for improvements to the overlook structure as follows:
    - Full removal and replacement with 60ft new gangway.
    - Full removal with short span fixed aluminum truss.

        - Full Removal with partial pier replacement (similar type of construction with timber).

- Costs:
  - Entire Structure Replacement. Complete replacement cost for the current size would range from $150,000 to $225,000.
  - Localized Rehabilitation. If the marina access corridor (8 ft wide by 10 ft long) from the uplands to the gangway were rehabilitated with the remainder of the structure demolished or decking removed, the cost would range from $40,000 to $60,000 (without demolition costs; not provided as they are similar for all concepts).
  - New Gangway. Remove entire overlook structure and replace with new 60ft gangway. See Section 5 for costs.
  - Entire Structure Demolition. The cost to demolish the entire structure would range from $10,000 to $30,000 depending on extent of structure being removed; such as only decking, stringers and piles caps are removed or entire structure is removed.

5. Gangway

- Background: Access to the marina floats is on a 35-ft long steel truss gangway which is attached to the timber overlook structure. The surface of the gangway is timber planks, plywood, and metal grating. The gangway is very steep during periods of low tide.
- Condition Assessment:
  - The gangway structure appears to be in average to good condition. The short length results in very steep slope at low water. The steep slope combined with the timber surface does not provide a desired level of user safety during access to the floats during low tide levels.
- Recommendations:
  - Although the gangway does not require immediate replacement, the installation of a new longer gangway could assist in reducing costs for the maintenance of the overlook structure. Installation of a new 60 ft length gangway could provide improved user access at lower tide levels (flatter slope) and eliminate the need for accessing the gangway across the overlook structure thereby allowing the structure to be abandoned or removed. If the gangway is not replaced, consideration for replacement of the surface material with a grip strut galvanized aggressive surface grating is recommended to improve user safety.
- Costs:
  - Replacement (60ft length). The cost of a new gangway and abutment is estimated to be $50,000 to $60,000. The cost doesn't include any overlook structure demolition.

6. Moorage Floats

- Background: Marina moorage floats were constructed by Bellingham Marine Industries and are composed of individual concrete float modules connected with a through-rod/waler system. The age of the floats is estimated to be approximately 20 years.
- Condition Assessment:
  - The float concrete, waler and thru rods appear to be in good condition for a 20-year life. Very minor concrete surface damage was observed (minimal spalling, minor cracking), thru rods appear to have normal corrosion but not excessive and pressure treated walers appear to be in good condition. Tri-braces have had damage and have had to be replaced in recent years. Community-conducted (2016) tri-brace replacement revealed the thru rods in the finger floats to be in good to very good condition. Freeboard was observed to be 13-inches. Typical freeboard for trailerable size vessels is 14-inches to 18-inches.

- Waler timber members observed to have moderate to slightly severe deteriorated in some locations. Overall condition observed to be fair.

- Recommendations:
  - General. Typical lifespan for the type of concrete floats at Bridgehaven are 30 to 50 years depending on maintenance and conditions it is exposed to. Given the general good condition of the floats at a 20-year life, it is important to implement an annual maintenance and repair program to extend the life of the structure to the maximum extent possible. Exposure of float structure elements to waves may result in the need for rehabilitation of the waler/thru-rod system sooner than a marina which is fully protected from wave action.
  - Short Term
    - Concrete Surface Crack Sealing. Floats should be inspected annually for surface cracks and sealing conducted to prevent further deterioration of concrete and reinforcing steel from saltwater and freeze-thaw. An epoxy or grout type sealant should be applied in accordance with the manufacturer's recommendations. Consultation with Bellingham Marine Industries to obtain more detailed recommendations for maintenance work should be conducted and incorporated into the annual inspection and maintenance plan.
    - Concrete Surface Spalling. Locations of concrete spalling should be repaired and sealed to prevent further deterioration of the concrete and reinforcing steel due to saltwater and freeze-thaw effects.
    - Float Freeboard. The freeboard appears to be on the lower end of typical recommended range. This could be due to marine growth on the underside of the float. Consideration should be made for cleaning the underside of the floats to decrease the dead weight to increase freeboard that will assist in minimizing splash and saltwater onto the floats. Supplemental floatation billets could also be considered to raise freeboard.
    - Tri-braces. A detailed inspection of each tri-brace should be conducted and priority of maintenance should be determined.
  - Intermediate Term.
    - Waler/Thru-Rod. Timber walers and thru rods on concrete floats typically require replacement at years 20 to 35. A major replacement of thru-rods and walers should be anticipated in the next 5 years if concrete floats are well maintained.
  - Long Term.
    - Concrete floats with periodic maintenance typically have a service life of 35 to 50 years. With proper maintenance and rehabilitation (waler/thru rods replacement and concrete repairs), the floats should be capable of meeting that typical service life.
- Costs:
  - Short Term.
    - Concrete surface repairs. Cost to conduct crack sealing and spalling repairs is estimated to be $5,000.
    - Inspection. A dive inspection of the entire marina facility should be conducted in the next 3 years. Cost varies from $3,000 to $8,000 depending on how detailed of a survey and whether under float cleaning is conducted.
  - Intermediate term.
    - Waler/Thru Road replacement cost can be on the order of $135,000 to $150,000 for the size of marina.

- Long Term.
  - Replacement costs for the concrete floats would be on the order of $225,000 to $250,000.

7. Moorage Float Piles

- Background: Float support piles are creosote timber approximately 12" to 14" in diameter connected to the floats with galvanized steel pile hoops. A total number of 24 piles exist in the marina facility.
- Condition Assessment.
  - Timber piles were observed to have typical type and level of deterioration given the age and environment they are exposed to. Three piles were observed to have advanced or severe deterioration and the remainder of piles observed to have moderate deterioration (varying levels of interior untreated core loss but outer shell intact). Approximately half of the piles exhibited large deflection under small lateral force and the remaining half were observed to be relatively firm under the same lateral force. Piles exhibiting large deflection will have reduced lateral capacity due to insufficient embedment depth.
- Recommendations:
  - Replacement of the deteriorated timber piles with steel pile would make sense at some point in the next 3 to 10 years. It would be recommended to select the piles with highest deterioration or lowest lateral capacity first but also ensure the pile replacement is spread out across the marina to get maximum benefit. Piles hoops may require adjustment to fit the new steel pile. It should be planned to replace up to five piles in the next three to five years and another 10 piles in years 5 to 10-year timeframe. A large number of piles could be replaced in the short term to take advantage of mobilization efficiencies.
- Costs: Pile replacement (No mobilization). New 12.75" diameter galvanized steel pipe piles typically cost $6,500 to $10,000 per each (including pile hoop modifications) not include mobilization. For 5 piles, the total estimated cost would be $35,000 to $50,000. If mobilization separate from the other marina work is needed, another $30,000 to $50,000 could be needed. If a separate mobilization is needed, it would be recommended to replace a larger number of pile for realize economies of scale. If complete pile replacement were pursued, the total cost would be $175,000 to $200,00.

8. Boat Ramp

- Background: A boat launch ramp exists on the south end of the marina facility property. The ramp is oriented on a curve at the south end terminus of the rock bulkhead. The ramp is constructed of cast-in-place concrete and does not have a handling float. Surface water drainage from the parking lot flows toward the south and down the ramp surface. The side and bottom edges of the ramp have recently been improved with the installation of fractured ballast rock. The toe of the ramp is located approximately at elevation +2' to +3' MLLW; thereby providing limited usability at the lower tide levels. Marina Club membership has expressed a desire to install a handling float if deemed to be feasible. The thickness and presence of reinforcing steel is not known.
- Condition Assessment: The concrete ramp surface is highly deteriorated exhibiting cracking, spalling and high surface wear (exposure of aggregates). Concrete surface patching within areas of large spalling and voids have been conducted in recent years. The ramp is aligned on a curved alignment which is not an ideal condition but is required given the site's geometric constraints. The ground located adjacent to the boat ramp is uneven and not a uniform slope matching the concrete ramp surface.

- Recommendations:
  - Ramp Concrete Slab.
    - Short Term Repairs. Cleaning and pressure washing. Filling localized areas with concrete repair materials and sealing cracks and joints are also likely be needed.
    - Intermediate Term Rehabilitation. Longer lasting concrete repairs would include saw cutting out the highly-fractured and spalled areas, repair and compacting of gravel base, installation of dowel bars around the perimeter of concrete sawcut line and installation of new concrete slab.
    - Long Term Repairs. Major rehabilitation or replacement of the ramp will need to be planned for the long term. If no repairs are conducted, a replacement could be needed in the next 10 years. The determination of need for replacement will depend upon the memberships desire for an improved driving surface and usability of a deteriorated driving surface. Replacement would include a complete new compacted base gravel and concrete slab with aggressive tread surface for traction.
  - New Handling Float.
    - Site Preparation. Installing a new float at the ramp will require grading and leveling the ground to provide an even surface for grounding of the float structure. The footprint of the proposed handling float will require excavation and placement of new compacted crushed ballast type material.
    - Float Type & Location. A handling float will need to be designed to ground out during the range of tidal cycles. A pressure treated timber frame with FRP grated surface supported with EPS filled floatation tubs and the float frame attached to grounding skids would be a recommended type of float for this application. For the intended use, it is recommended the float segments have minimum dimensions of 6 ft wide by 20 ft length. Support piles are recommended to be galvanized steel pipe with appropriately sized pile hoops.
    - Connection to Upland. A concrete abutment located above Ordinary High Water is recommended. This may be challenging to accomplish given the curved alignment of the existing ramp.
  - Costs.
    - Ramp. Maintenance, repair, rehabilitation, and replacement costs are quite variable depending on the actual scope of work needed. The following is a summary of our assessment of costs for ramp improvements:
      - Current Repairs. Concrete repair and rehabilitation work will need to be conducted in the next 1 to 3 years. The estimated costs for repairs is $5,000 to $10,000.
      - Rehabilitation. A major rehabilitation will be needed in the next 3 to 5 years. Cost could be on the order of ½ the cost of replacement.
      - Replacement. Replacement of the ramp could be on the order of $35,000 to $45,000.
    - Floats. Installation of a new handling float (assumed 6’ x 60’) with subgrade preparation and steel support piles is approximately $40,000 to $60,000.

9. Breakwater

- Background: The stone (rubblemound) breakwater was constructed at the time of marina development in the mid-1960s. The structure is approximately 280 ft in length and constructed of a basalt armor rock outer layer and smaller basalt core layer. The marina is exposed primarily to east-northeast and northeast fetches with the longest distance of 3.5 miles (Geiger, 1996). This exposure to open water generates significant wave heights in excess of 3 ft. Boat harbors typically require protection from storm waves in excess of 1.0 to 1.5 ft (ASCE, 2012). Therefore, a breakwater is needed to provide protection from the NE waves.

- Condition Assessment.
  - General. The breakwater structure was determined to be in an advanced state of deterioration including outer armor stone layer and loss of crest elevation. These elements are the two most important factors for breakwater performance and survivability during large storms. Rubblemound structures typically have a service life of 35 to 50 years for the type and quality of stone used. The breakwater armor stone is near or at the end of its service life.
  - Armor Stone. Armor stone was observed to be highly deteriorated and in an advanced state of degradation. The stone was also observed to be highly fractured resulting in breakdown into smaller, less stable pieces. The smaller armor stone pieces become mobilized by wave action during storms resulting in additional loss of crest elevation and exposure of inner layer of less stable, smaller core stone.
  - Crest Elevation. The lowering of breakwater crest elevation is of concern for the following reasons: 1) Accelerated deterioration of the breakwater can be expected (going forward) based on the current loss of armor rock on the crest and exposure of smaller and less stable core rock; 2) Greater wave energy penetration into the boat basin which will affect the marina floats (more motion putting stress on joints and tri-braces and more wave splash thereby increasing corrosion and maintenance of float steel, concrete and timber elements); and 3) Greater wave energy penetration into inner boat basin areas causing additional erosion along the toe and undermining of the bulkhead; 4) Deterioration of breakwater crest elevation can result in changes to the shoreline (erosion) along the north beach.
- Recommendations:
  - Breakwater Rehabilitation. Rehabilitate the full length of the breakwater crest and the outer exposed slope. Total estimated quantity is approximately 1,500 to 2,000 tons. Reuse onsite materials on the backside of breakwater structure and as base material for the new armor stone. Rehabilitation would include the entire front slope and crest of the structure with a 1-stone layer of properly sized and quality material armor rock.
- Costs:
  - Costs for breakwater rehabilitation is estimated to be $250,000 to $300,000 depending on mobilization. If equipment and barges are mobilized for other work (dredging and work conducted during the same equipment mobilization), then the cost may be at the lower half end of the range.

10. North Beach Erosion

- Background: Erosion of the shoreline north of the gazebo and overlook structures is occurring and is a concern regarding risk to adjacent upland structures. The length of observed eroding shoreline was estimated to be 150 ft. An additional 85 ft of shoreline along the timber bulkhead is also experiencing erosion as exhibited by the lowering of the bulkhead toe. Marina committee members described the rate of erosion to be accelerating in recent years.
- Condition Assessment:
  - Scarp. Erosional scarp located immediately adjacent to the north bulkhead was measured to vary from 3 to 4.5 ft in height. Erosional scarp is composed of sand, gravel, silt, shell fill which was likely materials excavated/dredged during the original marina construction.
  - Erosion rate: The rate of erosion appears to be accelerating based on description of community members and based on our review of historical data and photographs. Erosion rate is estimated to be about 1 to 2 ft per year on average near the gazebo structure.

- Causes of Erosion. Primary cause of erosion is the original placement of dredged material within a historical intertidal zone. Installation of the breakwater assisted in providing some protection of the shoreline fill to reduce erosion but not entirely. Therefore, erosion of the shoreline is a natural process of the beach adjusting to its new equilibrium conditions. Continued and acceleration of erosion could be a result of the breakwater crest deterioration and loss of beach level offshore within the original spit footprint thereby allowing increasingly greater level of wave energy (and frequency of occurrence) to the shoreline area just north of the gazebo.
- Need for Erosion Stabilization. Stabilization of the north beach is needed for the following reasons.
  - Protection of upland infrastructure.
  - Protection of bulkhead from toe scour to prevent further deterioration.
  - Improved public (membership) access to uplands and beach areas.
- Types of Erosion Stabilization Systems.
  - Soft and hard shoreline armoring systems could be feasible for this location. Soft shore stabilization would be a combination of beach fill, large wood debris, and cobble and vegetative plantings. Hard shoreline armoring could include the installation of riprap or other similar erosion control system.

- <u>Recommendations:</u>
  - Shore Protection Measures. Erosion protection measures will likely be needed if the upland facilities (gazebo, etc.) are intended to be protected from continued erosion. These measures could include the following:
    - Breakwater Crest Rehabilitation. Conducting breakwater rehabilitation will reduce wave action along the shoreline area and will help reduce shoreline erosion.
    - Soft Shore Stabilization. Soft shore stabilization systems could be feasible if combined with breakwater rehabilitation and installation of a sill structure. Soft shore stabilization would include a combination of sloped gravel/sand beach fill, large wood debris (above MHHW), vegetative plantings, cobble/boulder sill structure (for beach fill material retention), and dredged material placement. Further investigation of the feasibility and exact details would need to be conducted in the next phase.
    - Hard shoreline armoring. This would include the installation of riprap or other similar protection systems along the toe of the bulkhead to protect against further undermining. Hard armoring is not recommended for the beach north of the bulkhead.
    - Sill. Constructing a low-profile sill at the south terminus of the stabilization in the gap between the breakwater and the bulkhead. The sill would be constructed with flat side slopes and mostly buried. Purpose of the sill is to help retain the beach fill reduce the localized loss of beach fill into the boat basin.
    - Bulkhead Repairs. Rehabilitation work identified in the Bulkhead section should be conducted prior to or at the same time as the shore protection work.
    - Timing. Stabilization of the shoreline should be conducted in the next 2 to 5 years and coordinated with the timing of the dredging and disposal work. Stakes in the uplands should be installed as soon as possible to aid in monitoring the rate of erosion.
  - Placement of Dredged Material. Although predominant sediment transport direction is to the north, the change in shoreline geometry would require the installation of beach fill to a slope much steeper than what is stable thereby necessitating the installation of a soft shore stabilization system and sill as a transition from the beach fill to the bulkhead and marina basin. Placement of dredged material will help reduce erosion and temporarily stabilize the shoreline but will not result in a long-term erosion protection alternative. Additional measures

(see next section) for protection of the adjacent uplands will likely be required in coordination with the placement of dredged material.

- Costs:
  - Estimated length of protection is 150 to 200 ft. Soft shore stabilization system costs vary depending on imported beach material volumes, number of large wood debris pieces and total length of protection. Costs typically range from $450 to $650 per linear foot of shoreline. Total costs could be about magnitude of $90,000 to $130,000.

11. Dredging (Entrance Channel & Marina)

- Background: Sedimentation of the entrance channel and marina basin has continuously occurred since the time the marina was constructed in the 1960's. Longshore sediment drift is from south to north which transports sand and small gravel northward into the entrance channel thereby resulting in the need to conduct maintenance dredging to maintain safe access to the marina and interior channel areas. Historical dredging records indicate the following:
  - 2017/2018 (TBD) – 1,750 cubic yards, 18-ft bottom width, El -7ft
  - 2009 – 7,000 cubic yards, 40-ft bottom width, El -6ft
  - 1995 – 3,000 cubic yards, bottom width and El N/A.
  - 1991 – 4,500 cubic yards, 50ft bottom width, El -6ft
  - 1986 – 4,000 cubic yards, bottom width N/A, El -6ft

Most recent maintenance dredging work was conducted utilizing barge-mounted clamshell equipment with disposal at open water in the Puget Sound. The marina layout and 2001 bathymetry of the marina are provided in Appendix B. Current dredging plans (2014 permit) consist of removing up to 1,750 cy of material from the entrance channel and outer boat basin to an Elevation of -7' MLLW with 1-ft of over dredge allowance. Disposal is permitted to occur within the shoreline immediately adjacent to the north (within the north shoreline erosional area).

- Condition Assessment:
  - Permitted Dredging Plan. The permitted plan is a much smaller scale dredging effort (both in terms of width of channel dredge cut and total volume) relative to dredging actions prior to 2010. The permit allows for dredging up to 1,750 cy as outlined in the March 19, 2014 Tier I U.S. Army Corps (Corps) Suitability Determination for a site classified as small project, low area of concern. The site classification allows for up to 8,000 cy under the no-test threshold if approved by the Corps Dredged Material Management Office (DMMO). A revision to the permits and suitability determination would be needed for any volume greater than 1,800 cy. The Corps suitability determination was based on prior permit sediment sampling and testing work (2003, 2004) which indicated all chemicals of concern were either not detected or well below screening levels (Corps, 2014).
  - Sedimentation. Historical dredge records and technical reports developed by others were reviewed. The historical sedimentation rates were evaluated by CGS in 2002 to be 750 to 900 cy/year. The sedimentation rate between 1995 and 2009 appears to have been at least 500 cy/year. Based on historical sedimentation rates, the life expectancy of the permitted dredge plan is estimated to be 2 to 5 years.
  - Permitted Disposal Plan. The proposal to beneficially reuse dredged material within the nearshore zone located immediately north of the marina in general makes good sense with a few important items of notation. Disposal work should be conducted in strict accordance with the BMP's outlined in the permits and as further developed in the contract documents to ensure dredging contractor adherence to the permit conditions. Coordination of final design

of placement area with the design and construction of any north beach erosion stabilization plan should also be conducted.

  - Dredging. A wider entrance channel dredge area would be warranted based on our review of historical sedimentation rates and the high fixed cost of dredging equipment mobilization. Reducing the frequency of dredging events (or extending the time interval between dredging events) results in a more cost effective long term channel maintenance scheme and reduces any potential impact or disruption to the local ecosystem.
  - Disposal Scheme. The proposed plan for disposal of dredged material within the adjacent shoreline to the north seems appropriate if proper placement methods and Best Management Practices are followed. If the dredge volume is increased, the disposal scheme should be revisited to ensure compliance with permit conditions and protection of adjacent tidelands. The beneficial reuse scheme also must be reviewed and refined relative to the north shoreline stabilization plan so they integrate together into providing both a habitat and shore protection benefit.
- <u>Recommendations:</u>
  - Entrance Channel. To extend the time interval between maintenance dredging actions, it is recommended to modify the proposed dredging footprint to be wider to reduce the effects of the long shore sediment transport on encroachment into the navigation channel. The width of the dredging would need to be determined during the analysis phase, but could be on the order of magnitude of 2 to 3 times the current planned width of dredging. Dredging a wider channel is more effective for the longshore sand/gravel transport processes which are dominate at this site.
  - Dredging Equipment. If a permit revision for a larger volume and channel width is pursued, an option to allow for use of hydraulic suction (pipeline) dredging should be evaluated and considered. Evaluation of disposal schemes for the hydraulic dredging operations would need to be investigated to confirm feasibility prior to submitting any permit application.
  - Disposal. The feasibility of the north beach beneficial reuse area to accept the entire larger dredged volume would need to be investigated in more detail. If the placement of the entire larger volume in accordance with the permit requirements were not feasible, the incremental additional volume may require alternative placement/disposal such as open water. The next phase would need to investigate these details prior to submission of a permit application.
  - Permitted Work Window. A longer work window (such as 4 to 6 weeks in lieu of 2 weeks) should be requested as part of any permit modification. The longer work window will help reduce construction costs and ensure quality of work at the disposal site (adherence to BMP's and permit conditions). Additionally, the work window should be defined separately for other marina maintenance activities (breakwater, boat ramp maintenance, overlook structure, etc.) which may have a longer allowable work period due to the nature of the work or location of activities.
  - Coordination with other Rehabilitation Works. A master work plan that would include all marine work needed during mobilization of the dredging equipment should be developed to economize the construction work. This could include pile replacement, stone breakwater repairs and pile removal work that could require similar equipment as needed for the dredging work.
- <u>Costs:</u>
  - Dredging Cost (Current Plan). The cost for dredging 1,800 cy could be about $150,000 to $185,000 depending on the equipment, available time in work window, and scope of other activities conducted during the time the equipment is mobilized.

- Dredging Cost (Expanded). An expanded dredging project could likely be 4,000 to 5,000 cubic yards. The mobilization cost would be similar for the expanded as the current plan. The overall estimated cost could be $250,000 to $315,000.

12. Cost Evaluation

- Assumptions & Limitations:
    - Costs provided are based on experience and our assessment level description of scope of construction work based on a site visit and prior experience with similar improvements. Additional engineering analysis and design would be needed to better refine the scope of construction and materials for each item and therefore the corresponding estimated cost.
    - Costs assumed construction work is hired out and not self-performed by BCCA.
    - The intent of providing estimated costs is to provide an order of magnitude estimate for prioritizing future capital expenditures for development of a marine facilities capital improvement plan and not the actual cost needed to complete each individual component.
    - Cost information is variable depending on the economy and local contracting industry conditions.
    - Cost savings can be realized by bundling together activities into single contracts to take advantage of mobilization and site work efficiencies.
    - Costs provided assume local sales tax but do not include any adjustment factor for inflation.
    - Costs for engineering and regulatory permit assistance are not included. Those costs vary depending on the scope of services but typically can vary between 15% and 30% of construction costs depending on the type and value of improvements. Larger bundled projects can result in a lower percentage cost.

13. Summary

A summary of the results of the condition assessment are provided in Table 1. Development of a final prioritized list of improvements will be an iterative process which relies upon this document, input from BOCS, and some additional engineering and cost analysis. Prioritization of the improvements are a function of the condition of structure or feature, availability of funds and operability/use requirements as defined by the users. Table 1 provides a summary of repairs, rehabilitation and new construction identified during the condition assessment with a focus on cost and level of importance. This table should provide a starting point for the BCCA to develop a prioritized list of improvements.

14. Recommendations

- Develop a capital improvement plan which will outline the costs, timeline and permitting requirements for implementing projects over the next 3- to 10-year period. As part of the capital improvement plan, prioritize improvements for the next 5-year period.
- Develop preliminary engineering design, permit application materials and permit documents for the work proposed to occur in the next 5 years.
- Investigate pursuing both individual (larger actions such as dredging, erosion protection and breakwater rehabilitation) and maintenance type permits (ramp repairs, etc.) relative to activity to be conducted.

15. References

ASCE, 2012. Planning & Design for Small Craft Harbors.

Corps, 2014. Memorandum for File. Suitability of Bridgehaven Marina Maintenance dredging, Squamish Harbor, Hood Canal, Jefferson County, WA, with intertidal disposal on local beach.

CGS, 2005. REF NWS-2014-801. JARPA permit drawings

Geiger, 1996. Coastal engineering Technical Letter.

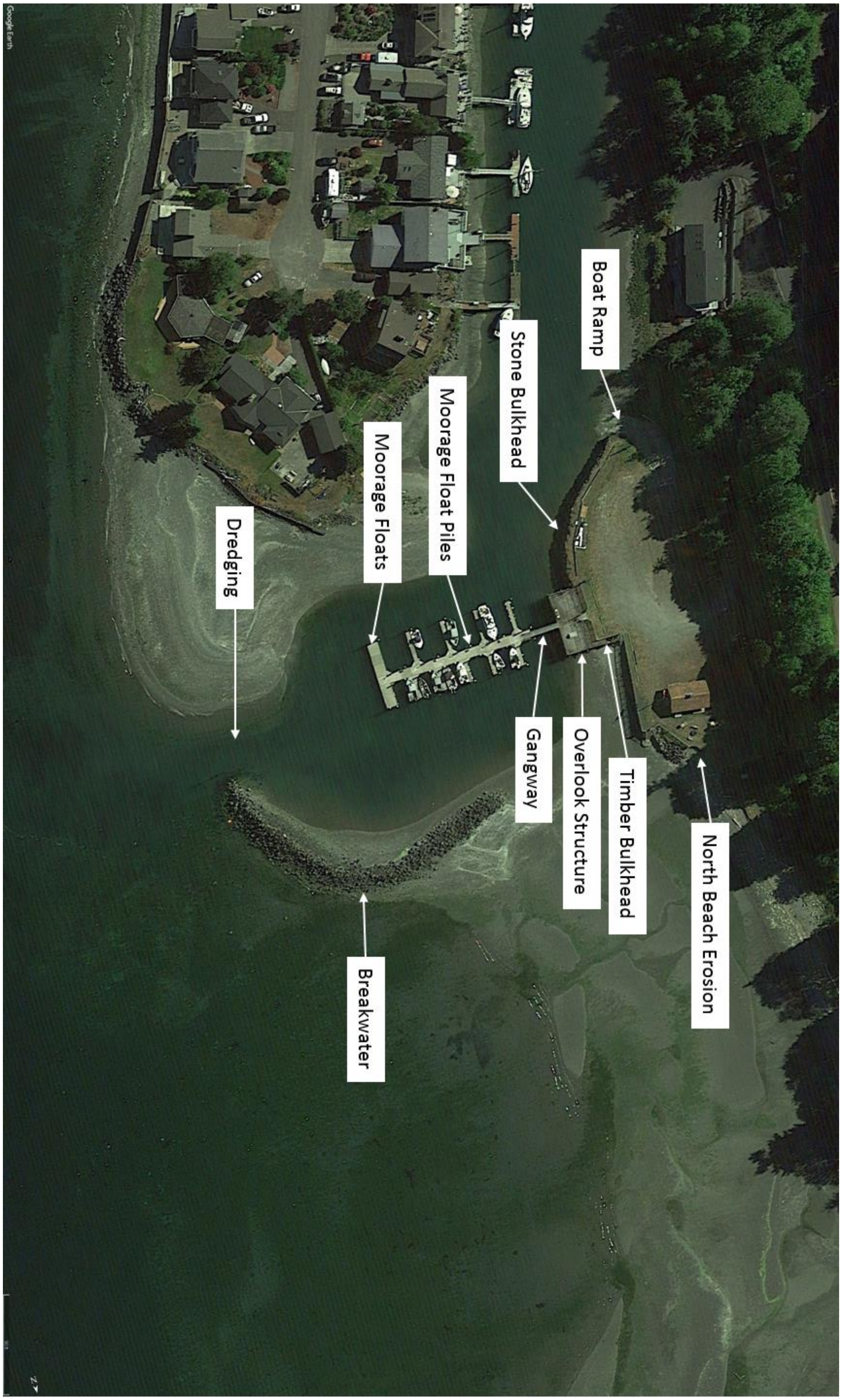
TABLE 1 – SUMMARY OF RECOMMENDED ACTIONS

Feature	Improvements	Repair Timeframe	Estimated Cost [1] (mobilization not included[2])	Level of Importance
Timber Bulkhead	• Repairs (short term)	1 to 3 yrs	\$20,000 - \$40,000	High
	• Rehabilitation	5 to 10 yrs	\$55,000 - \$85,000	Medium
Overlook	• Localized Rehabilitation - Option 1	3 to 5 yrs	\$40,000 - \$60,000	High
	• New Gangway - Option 2 (see below)	See Below	See Below	See Below
	• Full Demolition	3 to 5 yrs	\$10,000 - \$30,000	High
Gangway	• Replace with 60ft gangway to replace Overlook	3 to 5 yrs	\$50,000 - \$60,000	Medium
Moorage Floats	• Concrete and Float Maintenance	1 to 3 yrs	\$5,000 - \$10,000	High
	• Thru-rod/Waler Replacement	3 to 5 yrs	\$135,00 - \$150,000	Medium
	• Float Replacement	15+ yrs	\$225,000 - \$250,000	Low
Moorage Float Piles	• Replace 5 Pile (w/ steel piles) • Replace 10 Pile (w/ steel Piles)	2 to 5 yrs 5 to 10 yrs	\$35,000 - \$50,000 \$85,000 to \$110,000	Medium Medium
Boat Ramp	• Localized Rehabilitation	1 to 2 yrs	\$5,000 - \$10,000	High
	• Rehabilitation	3 to 5 yrs	\$15,000 - \$20,000	High
	• Replacement	10 to 15 yrs	\$35,000 - \$45,000	Low
	• New Handling Float	TBD	\$40,000 - \$60,000	Low
Breakwater	• Rehabilitation	1 to 5 yrs	\$250,000 - \$300,000	High
North Beach Erosion	• Soft Shore Stabilization[3]	2 to 5 yrs	\$90,000 - \$130,000	High
Dredging	• Current Dredge Plan (1,800 cy) – Option 1	1 to 5 yrs	\$155,000 - \$185,000	High
	• Larger Dredge Plan (4,000 cy) – Option 2	1 to 5 yrs	\$250,000 - \$315,000	High

[1] Includes sales tax. Does not include engineering, regulatory permitting or surveying work.
[2] Mobilization costs not included as it depends on which elements are included in the work plan during a single contractor mobilization effort.
[3] At same time as dredging work.

APPENDIX A

FIGURES AND PHOTOS



<u>Figure #1</u>

Aerial of project site showing primary project features.

Source: Google Earth, taken 6/27/2016.

Figure #2

Aerial of project site showing photo locations and orientations.

Source: Google Earth, taken 6/27/2016.

Photo #1

Moorage floats in good condition with some concrete surface cracks.

Source: Mott MacDonald Site Visit 02/16/2017

Photo #2

Moorage float piles with typical deterioration, multiple showing advanced deterioration.

Source: Mott MacDonald Site Visit 02/16/2017

	<u>Photo #3</u> Gangway in good condition, longer gangway recommended in lieu of overlook structure rehabilitation. Source: Mott MacDonald Site Visit 02/16/2017
	<u>Photo #4</u> Detached breakwater with deteriorated crest needing rehabilitation. Source: Mott MacDonald Site Visit 02/16/2017

	<u>Photo #5</u> Fracturing of breakwater stone. 5 Source: Mott MacDonald Site Visit 02/16/2017
	<u>Photo #6</u> Deteriorated concrete boat ramp with cracks, spalling, and surface wear. 6 Source: Mott MacDonald Site Visit 02/16/2017

Photo #7

Overlook structure requiring inspection and monitoring, may need rehabilitation or removal.

7

Source: Mott MacDonald Site Visit 02/16/2017

Photo #8

Underneath overlook structure showing pile deterioration and cap posting.

8

Source: Mott MacDonald Site Visit 02/16/2017

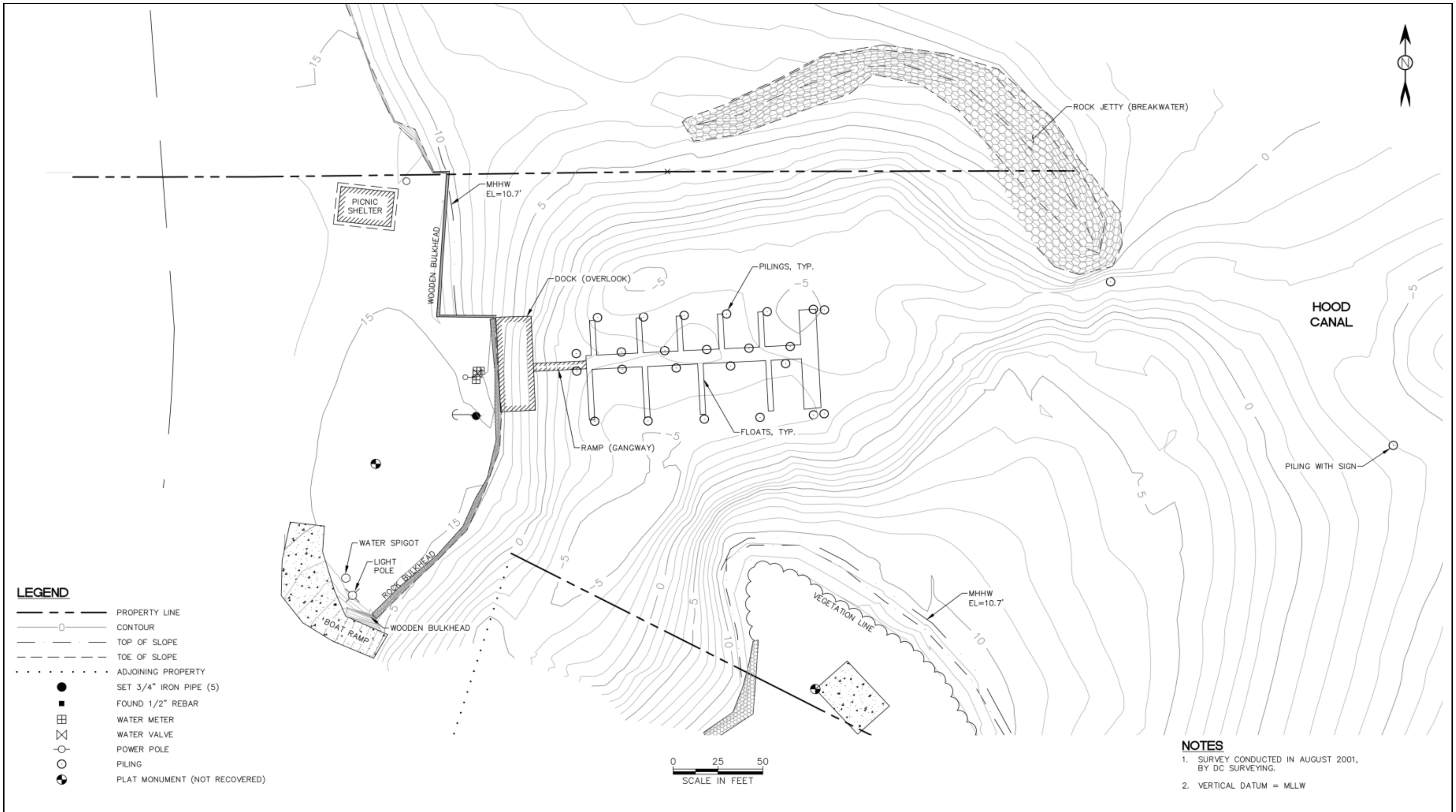
	<u>Photo #9</u> Timber bulkhead toe scour and undermining of lagging boards exposing backfill to erosion. 9 Source: Mott MacDonald Site Visit 02/16/2017
	<u>Photo #10</u> Timber bulkhead on side of overlook structure toe scour and loss of backfill. 10 Source: Mott MacDonald Site Visit 02/16/2017

	Photo #11 Stone bulkhead and overlook structure. 11 Source: Mott MacDonald Site Visit 02/16/2017
	Photo #12 Stone bulkhead looking from boat ramp. 12 Source: Mott MacDonald Site Visit 02/16/2017

	<u>Photo #13</u> North beach erosion. 13 Source: Mott MacDonald Site Visit 02/16/2017

APPENDIX B

MARINA MAP AND BATHYMETRY



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