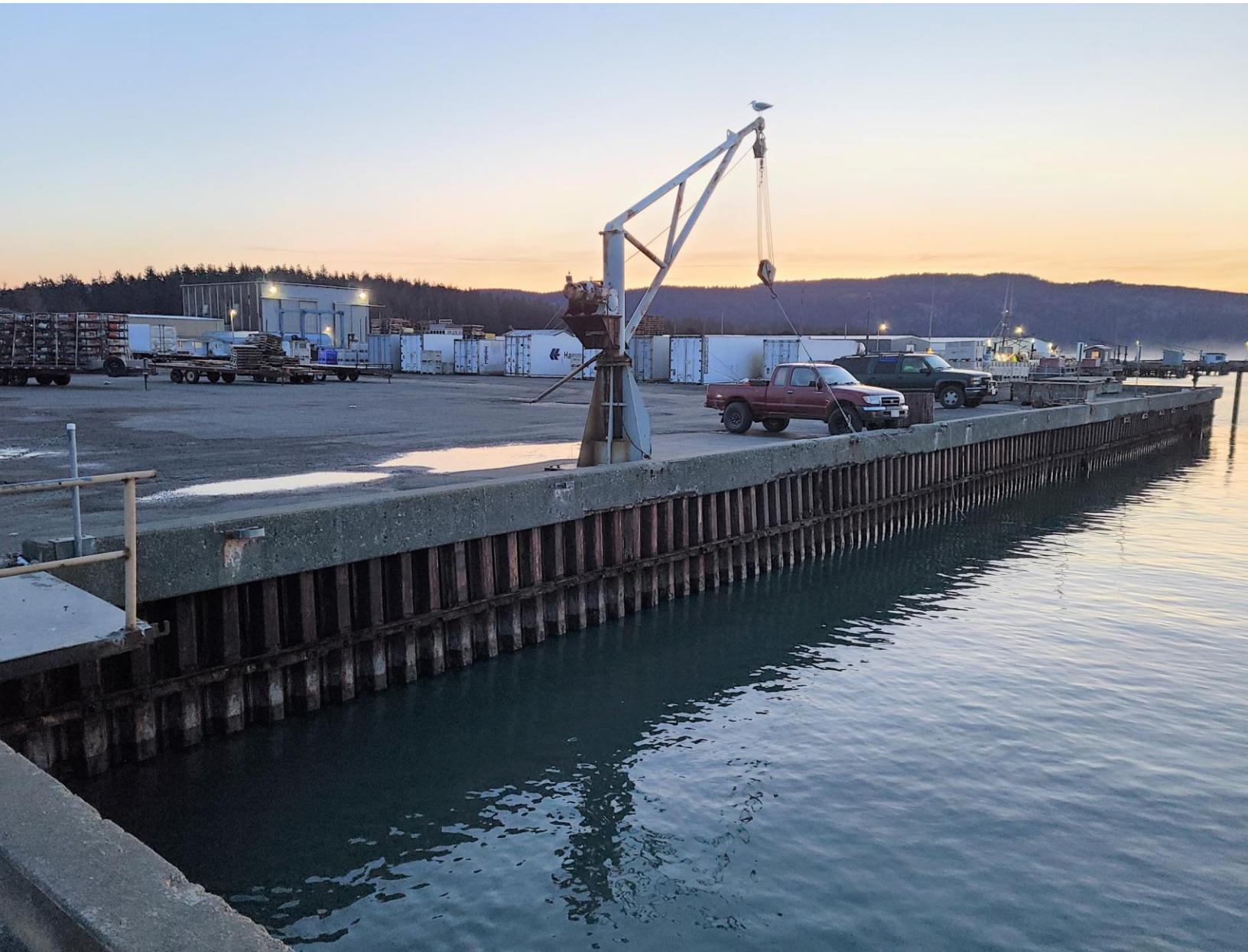
FINAL DELIVERABLE
Produced For Crescent City Harbor District
04/17/2023

moffatt & nichol

SEAWALL CONDITION ASSESSMENT REPORT

Crescent City, CA



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Executive Summary

The Crescent City Harbor District (Harbor District) retained the services of Moffatt & Nichol (M&N) to perform a condition assessment of the Harbor District Seawall. The services under this agreement included an above-water condition assessment of the 1940's steel sheet pile bulkhead seawall adjacent to the Citizens Dock. The field observations were evaluated to ascertain an overall condition assessment rating according to ASCE Manuals and Reports on Engineering Practice Number 130, "Waterfront Facilities Inspection and Assessment", 2015 Edition (ASCE 130), recommend next steps and provide an opinion on remaining service life.

The steel sheet pile bulkhead was rated as "**Critical**"[1]. The bulkhead is beyond its design life and has very advanced deterioration from corrosion, significantly affecting the load-bearing capacity of the sheet piles, walers, and tie-rods. Local failures are obvious due to the significant deterioration in sheet piles, walers, and tie-rod hardware. Global failure of the bulkhead due to bulging and hinging of the sheet piles above large corrosion holes near the mudline was observed.

Repair of the bulkhead is not possible or recommended based on the number of large corrosion holes, significant section loss and global failure. Recommendations of this condition assessment are as follows:

- Immediately restrict all pedestrian, vehicle, and equipment access at least 20 feet from the face of the bulkhead with fencing and signage to protect public safety. This recommendation was communicated to the Harbor District immediately after the condition assessment was conducted, and M&N understands that this has been implemented.
- Replace the bulkhead as soon as possible.

[1] ASCE Manuals and Reports on Engineering Practice Number 130, "Waterfront Facilities Inspection and Assessment", 2015 Edition, Table 2-14 Condition Assessment Ratings (provided in Appendix C)

1. Introduction

The Harbor District retained the services of Moffatt & Nichol (M&N) to perform a condition assessment at the Harbor District Seawall. The services under this agreement included an above-water condition assessment of the 300-foot-long steel sheet pile bulkhead seawall located at the end of Citizens Dock Road. The field observations were evaluated to ascertain an overall condition assessment rating according to ASCE Manuals and Reports on Engineering Practice Number 130, "Waterfront Facilities Inspection and Assessment", 2015 Edition (ASCE 130), recommend next steps and provide an opinion of remaining service life.

1.1. Scope of Work

This site inspection and condition assessment effort included the following structure and elements, as shown on Figure 1.

- North-south bulkhead
- West-east bulkhead

The bulkhead was assessed for deterioration and section loss, misalignment of the overall structure, signs of differential settlement between elements, displacement, and for loss of backfill material.

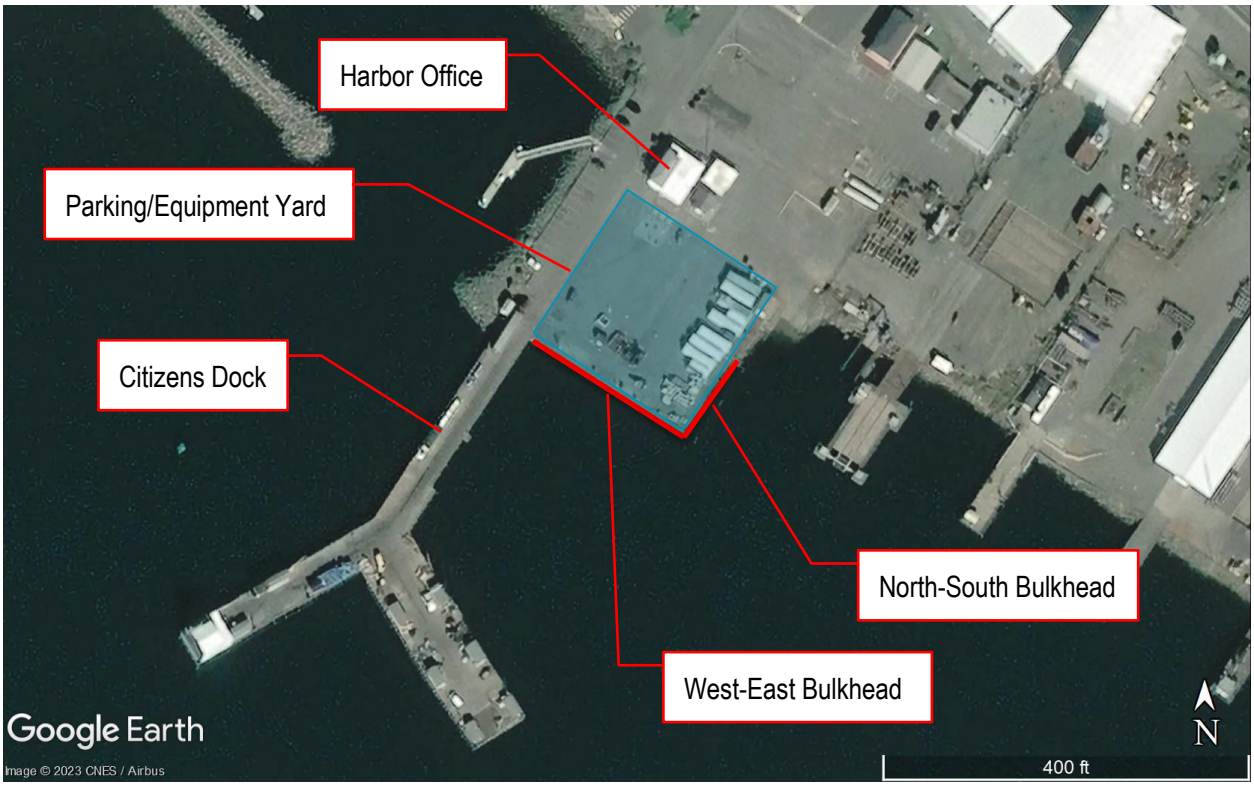

Figure 1. Aerial Image of Site

2. Description of Structure

The steel sheet pile bulkhead is a tie-back system with deadman anchors constructed in two phases, the first in the 1940s and the second in the 1960s (see Figure 2). The bulkhead is comprised of interlocking vertical steel sheet piles, upper and lower steel walers, buried steel tie-rods and deadman anchors, and a reinforced concrete cap. Asphalt paving covers the majority of the yard along the bulkhead with a concrete pad and jib crane near the dock. Adjacent to the bulkhead is the Citizens Dock abutment, which appears to be connected to the bulkhead but is not part of this condition assessment report.

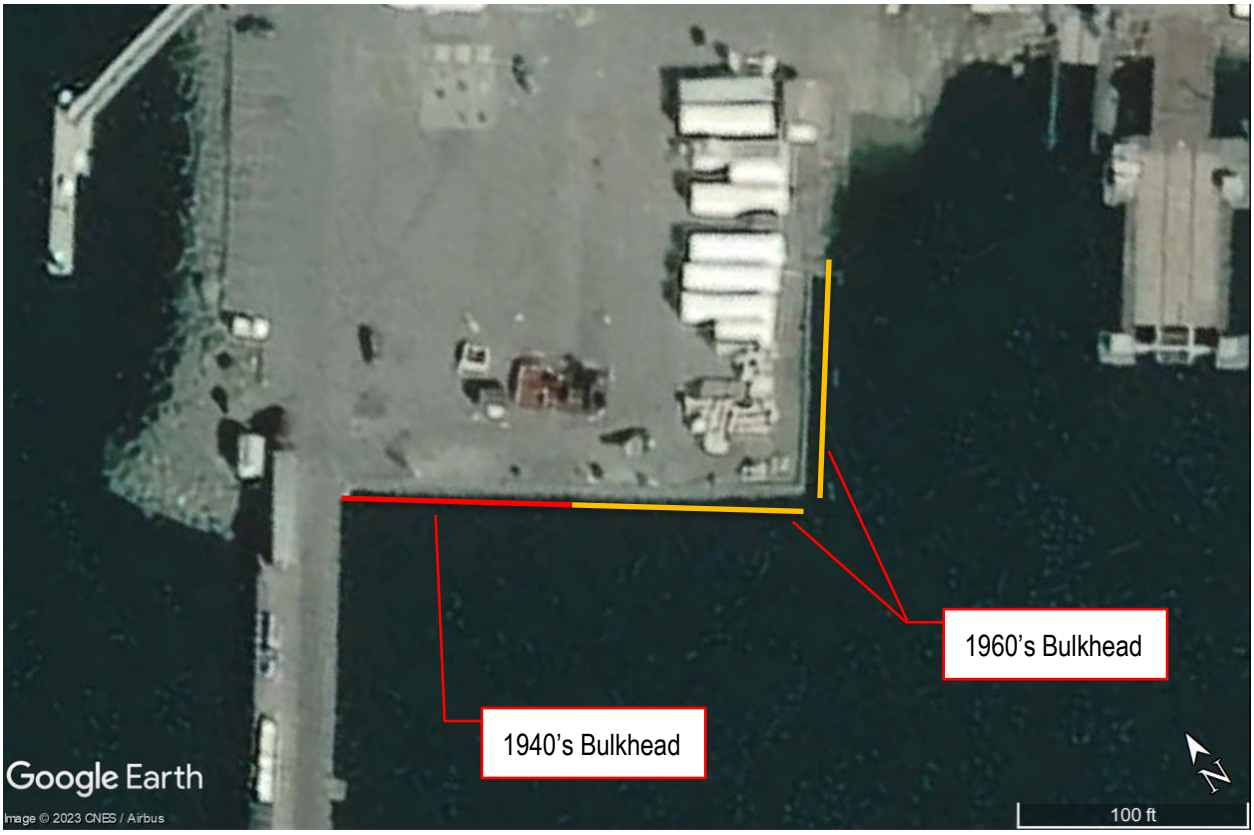

Figure 2. Bulkhead Layout by Date of Construction

Photographs of typical defects and conditions of the bulkhead components are provided in Appendix A. A previous assessment of the bulkhead was completed in 1997 by M&N and is attached for reference in Appendix B.

2.1. Steel Sheet Pile Bulkhead

As-built or construction records of the bulkhead were not available for review. The steel sheet pile section is similar in dimensions and shape to a PDA27 section[2]; however, this cannot be confirmed without as-built or construction records. Field measurements were taken and indicated an original web and flange thickness of 3/8-inch. The width of the sheets from interlock-to-interlock is approximately 16 inches. The depth of the sheets is approximately 5 inches. The previous inspection report (Appendix B) suggested the driven depth of the sheets varied from 4 to 12 feet below mudline at the time of construction.

The 1940's bulkhead is approximately 100 feet long in a west-east orientation, starting at STA 0+00 at the Citizens Dock abutment and continuing to 1+00 (see Photo 1). The 1960's bulkhead continues the bulkhead

[2] USS Steel Sheet Piling Design Manual, 1984.

southeast to STA 2+00 (see Photo 2) before turning northeast in a north-south orientation to STA 3+02 (see Photo 3).

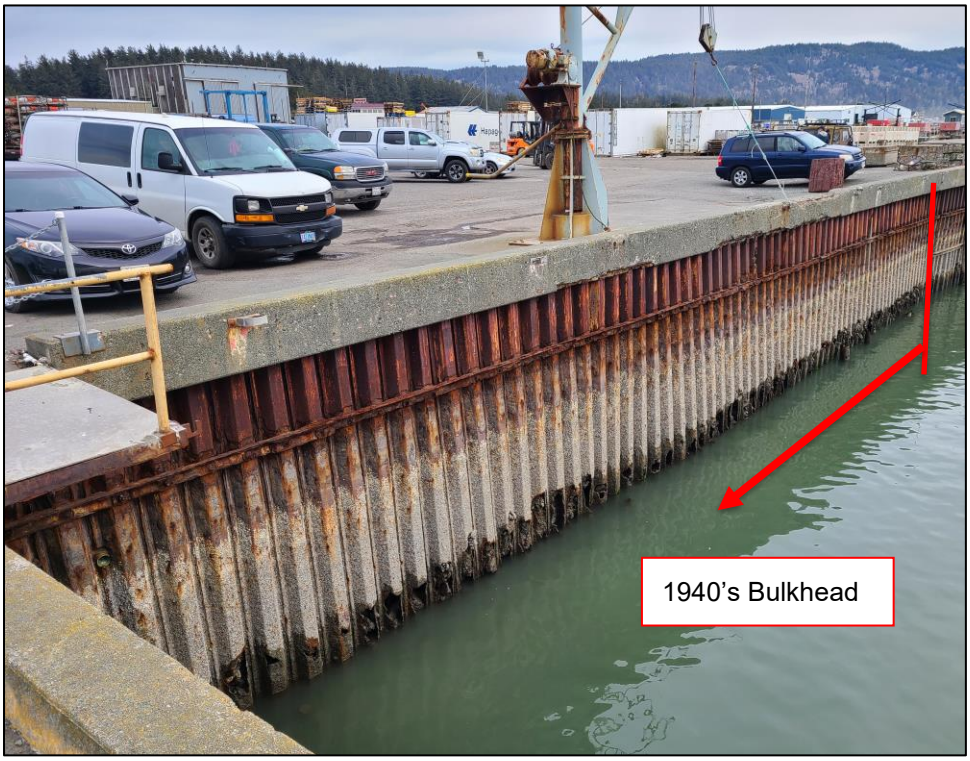

Photo 1. 1940's Bulkhead (STA 0+00 to 1+00)

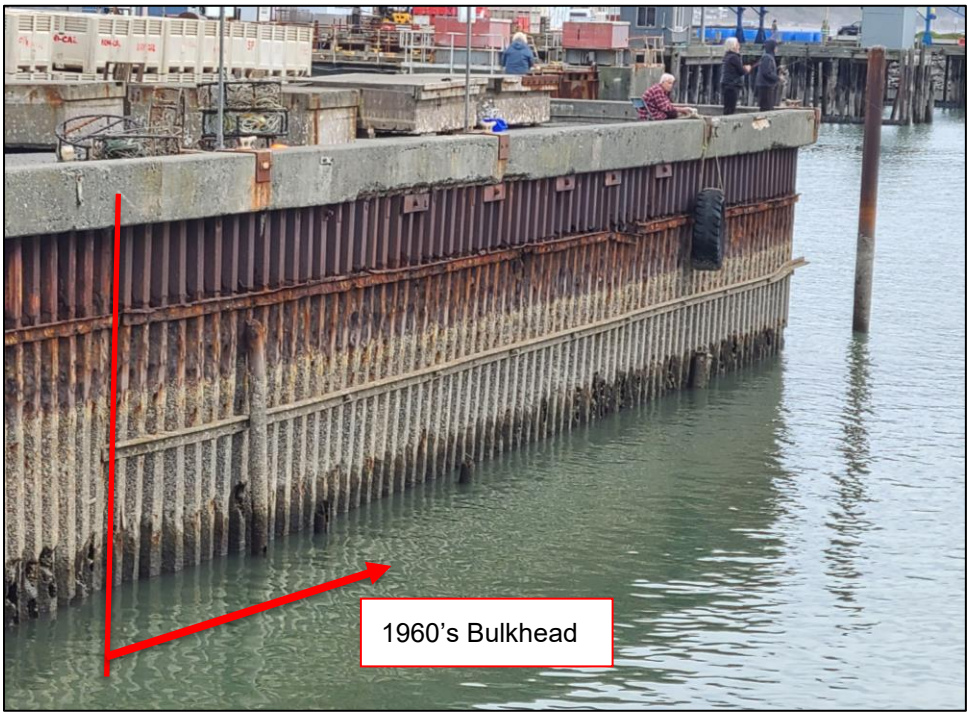

Photo 2. 1960's Bulkhead (STA 1+00 to 2+00)

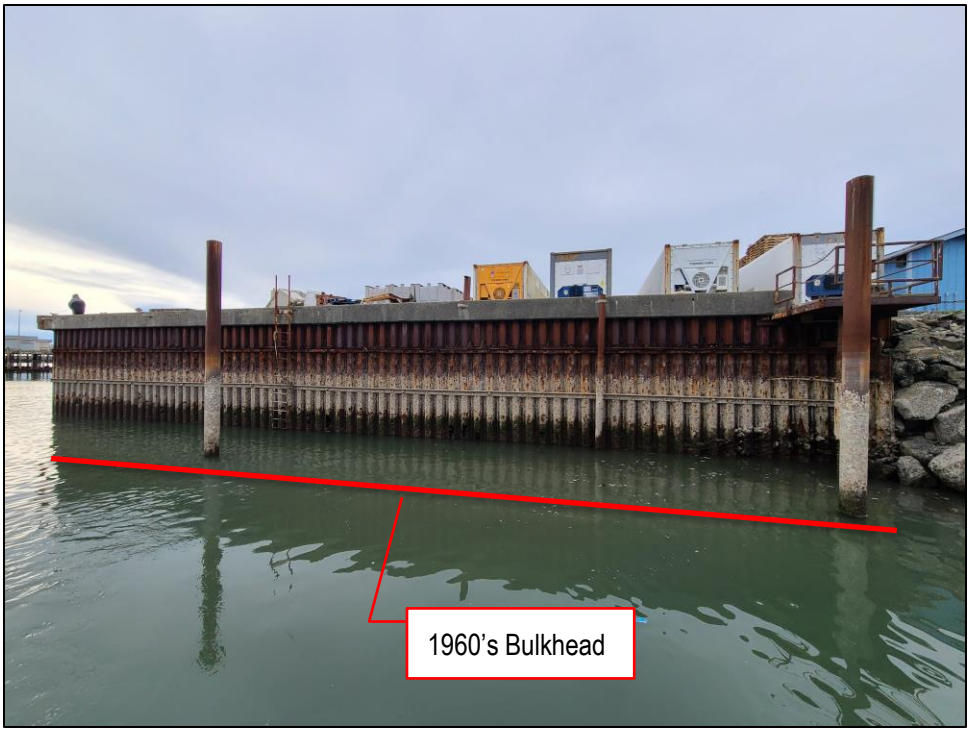

Photo 3. 1960's Bulkhead (STA 2+00 to 3+02)

2.1.1. Walers, Tie-Rods & Deadman Anchors

The upper steel waler is a continuous steel angle from STA 0+00 to 3+02 and is approximately 4'-8" below the concrete cap (see Photo 4). Field measurements were not possible due to the limited section remaining. The lower steel waler is present from STA 1+00 to 3+02 and was field measured to be approximately a 4 x 6 x 3/4 angle with tie-back rods every 7th to 8th sheet (see Photo 5). The tie-rods were measured to be approximately 1-1/2-inch diameter. Per the previous inspection report, the 1940's deadman anchors are a system of timber piles, and the 1960's deadman anchors are 8-inch steel H-piles.

Photo 4. Typical Upper Waler from STA 0+00 to 1+00

Photo 5. Typical Upper and Lower Waler from STA 1+00 to 3+02

2.1.2. Concrete Cap, Mooring Hardware, and Fender System

The reinforced concrete cap is approximately 24 inches high by 18 inches wide and continuous along the length of the bulkhead (see Photo 6 and Photo 7). Angled steel tie rods embedded in the cap were observed at two locations along the 1960's bulkhead due to sinkholes, spaced at 20 feet (see Photo 8). Four 24-inch mooring cleats are spaced along the west-east bulkhead and welded to a steel plate that is thru-bolted to the cap (see Photo 9). The steel fender piles originally along the bulkhead are gone, with only the attachment hardware on the cap and a few pile stubs remaining (see Photo 10). Two gangway platforms and steel guide piles for floats are present but excluded from the inspection and assessment.

Photo 6. Typical Concrete Cap, Looking from the Yard

Photo 7. Typical Concrete cap, Looking from the Water

Photo 8. Angled Steel Tie Rod at Cap

Photo 9. Typical 24-inch Mooring Cleat

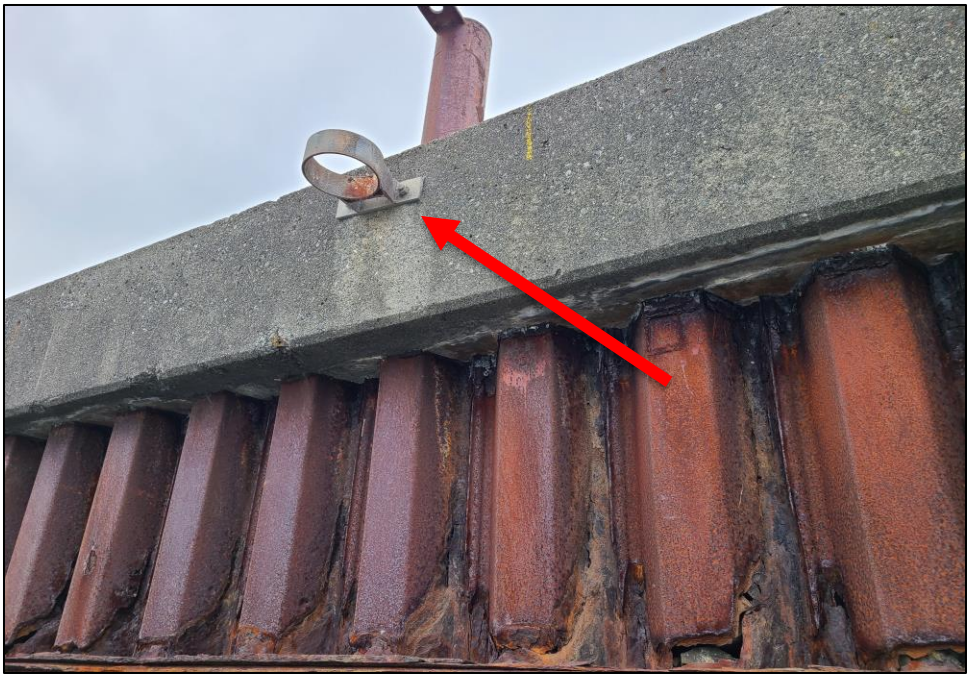

Photo 10. Typical Fender Pile Attachment Hardware

2.1.3. Yard Paving

The yard area adjacent to the bulkhead is primarily asphalt paving (see Photo 11). There is a 15-foot-wide concrete pad along the bulkhead from STA 0+27 to 0+67 (see Photo 12).

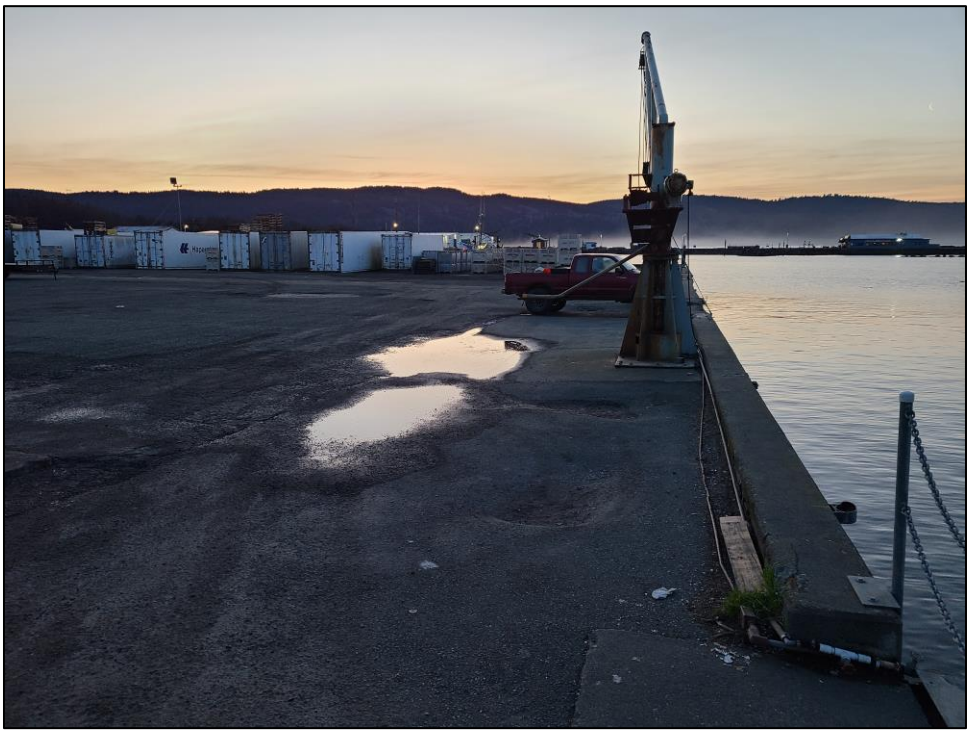

Photo 11. Yard Area Adjacent to the Bulkhead, Looking East

Photo 12. Concrete Pad Adjacent to the Bulkhead, Looking South

3. Facility Condition Assessment Methodology

The above-water inspection methodology was based on ASCE 130 which provides guidance on inspection types and specific structure considerations depending on objectives, frequency of inspection, and the level of damage.

M&N conducted the above-water inspection from the bulkhead as well as a small work skiff on February 16, 2023. The inspection was conducted during a negative tide for visual access to the full height of the bulkhead. A Level I effort inspection was conducted for all visible elements of the bulkhead, as defined in Section 3.1.3 of ASCE 130. Elements assessed as part of the condition assessment effort were assigned an element level damage rating, with damages defined as minor, moderate, major, or severe. Appendix C provides portions of ASCE 130 for reference. Following completion of the field work, element level damage ratings in combination with visual observations were used to assign an overall facility condition assessment rating, defined as good, satisfactory, fair, poor, serious, or critical in accordance with Table 2-14 of ASCE 130.

3.1. Inspection Limitations & Exclusions

The inspection and assessment excluded the Citizens Dock abutment, riprap slopes adjacent to the bulkhead, mudline survey, jib crane, and gangway access platforms. Buried elements, including the tie-rods and deadman anchors, except where exposed due to sinkholes, are also excluded. All observations were non-destructive in nature and did not involve testing or removal of marine growth.

4. Condition Assessment Findings

Field observations are summarized for each bulkhead element type below. Field observation notes are provided in Appendix D, and photographs representing typical defects and existing conditions are provided in Appendix A.

4.1. Steel Sheet Pile Bulkhead

4.1.1. Steel Sheet Piles

The steel sheet piles have major and severe levels of corrosion, section loss, and holes throughout. The sheets from STA 0+00 to 1+00 have the most significant amount of corrosion near the mean lower low water (MLLW) level and also appear to have buckled above the corrosion holes. Large voids in the backfill were observed from STA 0+00 to 1+00.

4.1.1.1. Mudline Measurements

Mudline elevations were measured from the top of bulkhead cap, see Figure 3. Measurements were taken intermittently along the length of the bulkhead and extrapolated between measurements.

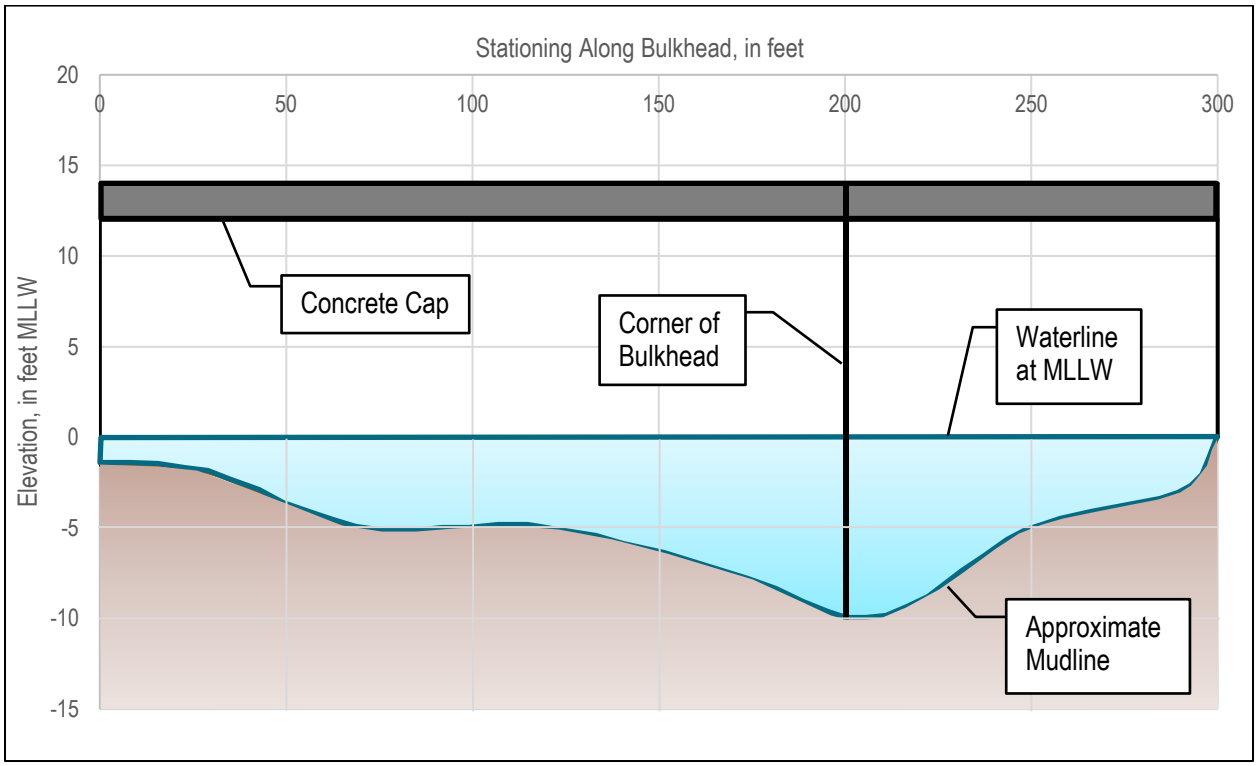

Figure 3. Approximate Mudline Elevations in feet referenced to MLLW

4.1.2. Walers and Hardware

The upper waler has major to severe levels of corrosion and section loss throughout its length. The waler has up to 100% section loss at several locations. The tie-rod hardware has severe corrosion and up to 100% section loss.

The lower waler has minor corrosion and section loss throughout its length. At STA 2+00 the lower waler is disconnected from the bulkhead.

4.1.3. Fender Piles

The steel fender piles have severe section loss, are disconnected from the attachment hardware, and many are only stub piles exposed at low tide.

4.2. Concrete Cap

The concrete cap has moderate to severe damage, including open corrosion spalls with exposed and corroding reinforcement. Vertical and shear cracks were observed at multiple locations.

4.2.1. Mooring Cleats

Several of the mooring cleats have severe damage with broken horns.

4.3. Yard Adjacent to the Bulkhead

Moderate to severe sinkholes/subsidence of up to 18 inches deep were observed along the length of the bulkhead. The severe sinkholes have exposed the backside of the steel sheet piles and cap tie-rods. The concrete pad adjacent to the bulkhead appears to have subsided approximately 4 inches.

5. Overall Facility Condition Assessment Rating

An overall Condition Assessment Rating (CAR) is assigned to the bulkhead. The CAR is based on the findings of visual observations. The condition assessment scale includes the following six categories: Good, Satisfactory, Fair, Poor, Serious, and Critical. The six CARs and descriptions defined in Appendix C.

The steel sheet pile bulkhead is rated as "**Critical**." Very advanced deterioration from corrosion has significantly affected the load-bearing capacity of the sheet piles, walers, and anchor rods. Local failures are obvious due to the significant deterioration in sheet piles at walers and the tie-rod hardware. Global failure of the 1940's bulkhead due to bulging and hinging of the sheet piles above corrosion holes near the mudline was observed. Loading restrictions and public access recommendations are provided in Section 6.

6. Recommendations

The bulkhead is well beyond its design life and has very advanced corrosion resulting in localized and global failures. Fill material continues to wash out through the holes in the sheets resulting in subsidence and sinkholes behind the bulkhead. The 1940's sheet pile bulkhead appears to have buckled just above the corrosion holes. Repair of the bulkhead is not practical or recommended based on the large corrosion holes and significant amount of section loss throughout the bulkhead.

Recommended actions include:

- Immediately restrict all pedestrian, vehicle, and equipment access to at least 20 feet from the face of the bulkhead with fencing and signage.
- Remove and replace the bulkhead as soon as possible.

7. References

- Sheet Pile Bulkhead Investigation. Moffatt & Nichol, December 1997
  - Provided in Appendix B
- ASCE Manuals and Reports on Engineering Practice Number 130, "Waterfront Facilities Inspection and Assessment", 2015 Edition
  - Portions provided in Appendix C
- USS Steel Sheet Piling Design Manual, 1984

Appendix A: Photographs of Typical Defects

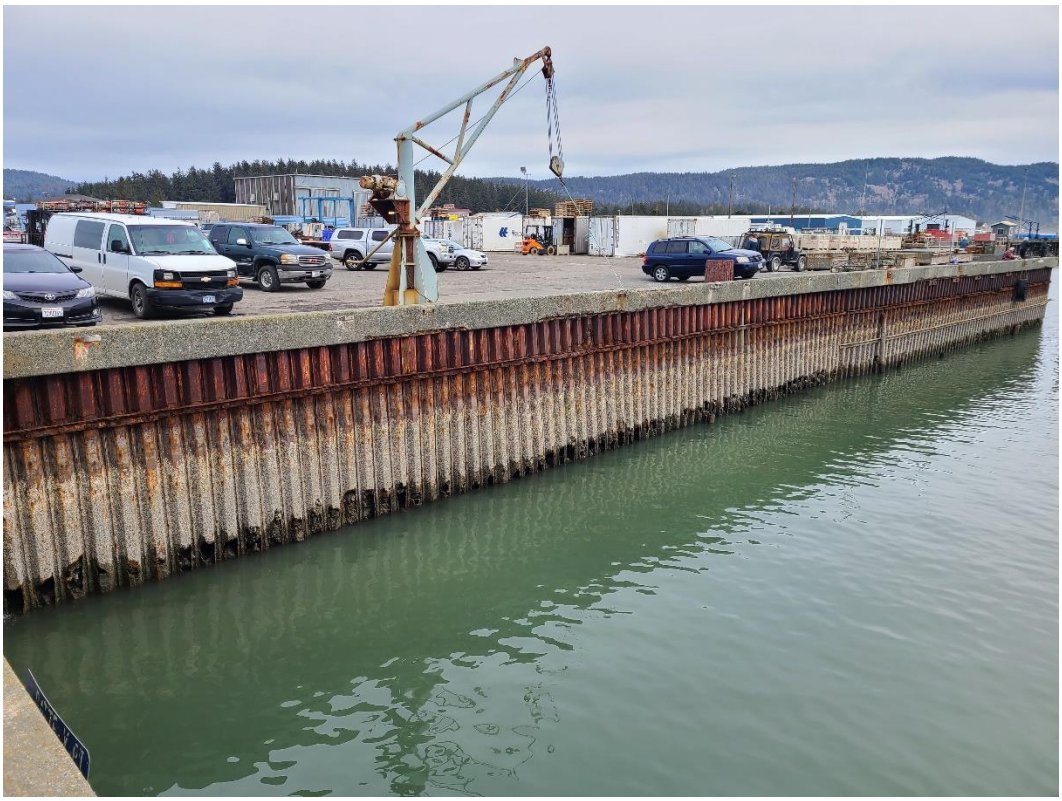

Photo 1. West-East Bulkhead, looking North

Photo 2. Severe corrosion holes from STA 0+00 to 1+00

Photo 3. Buckling of bulkhead from STA 0+00 to 1+00

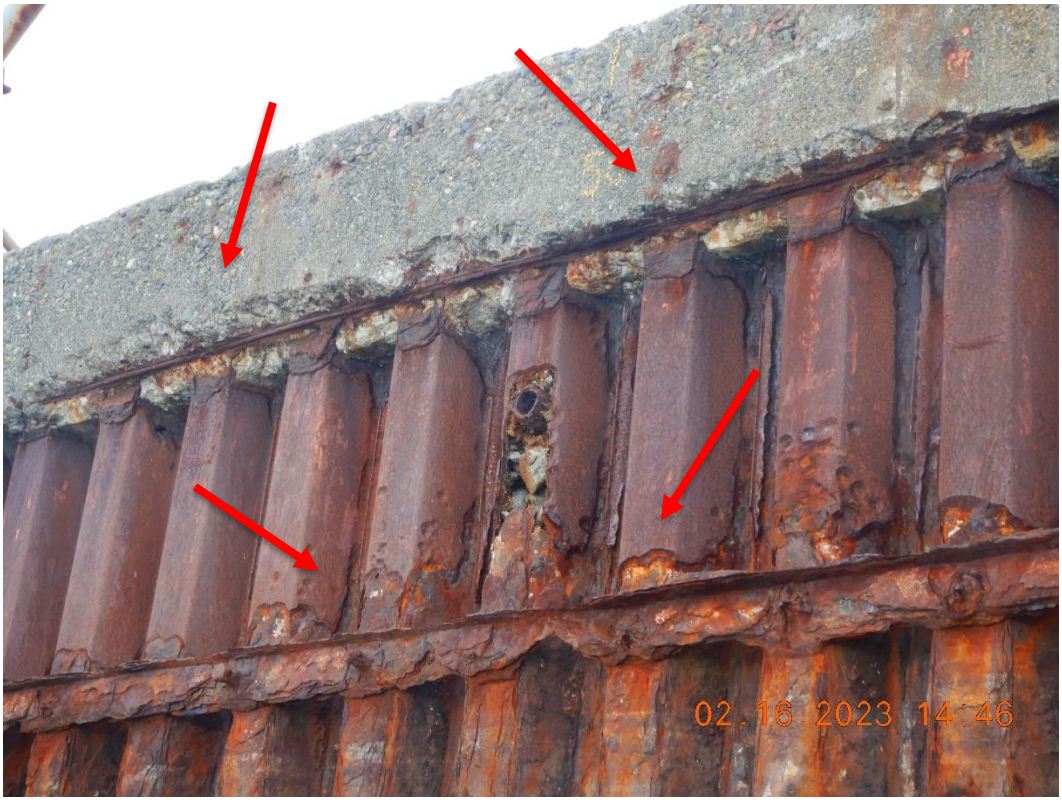

Photo 4. Typical major concrete cap spalling; typical severe upper waler corrosion from STA 0+00 to 2+00

Photo 5. Severe corrosion of upper waler at STA 1+60

Photo 6. Typical severe corrosion holes and lower waler from STA 1+00 to 2+00

Photo 7. Bent and disconnected lower waler at STA 2+00; typical severe corrosion above upper waler from STA 1+00 to 2+00

Photo 8. North-South bulkhead, looking west

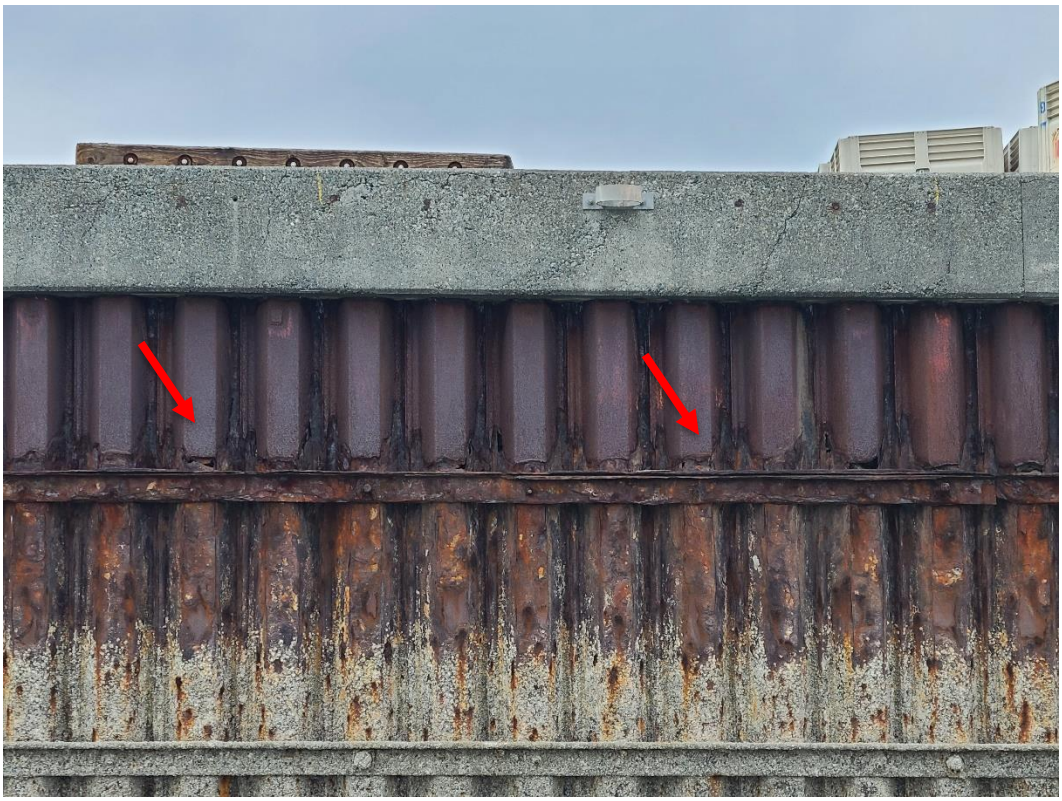

Photo 9. Typical severe corrosion above upper waler from STA 2+00 to 3+00

Photo 10. Typical corrosion holes and lower waler from STA 2+00 to 3+00

Photo 11. Severe corrosion at platform support pile at STA 3+00

Photo 12. Typical broken fender pile remaining along bulkhead

Photo 13. Typical concrete cap

Photo 14. Severe open corrosion spalling (OCS) with exposed and corroding reinforcement from STA 0+43 to 0+70

Photo 15. Severe OCS with exposed and corroding reinforcement from STA 1+70 to 1+90

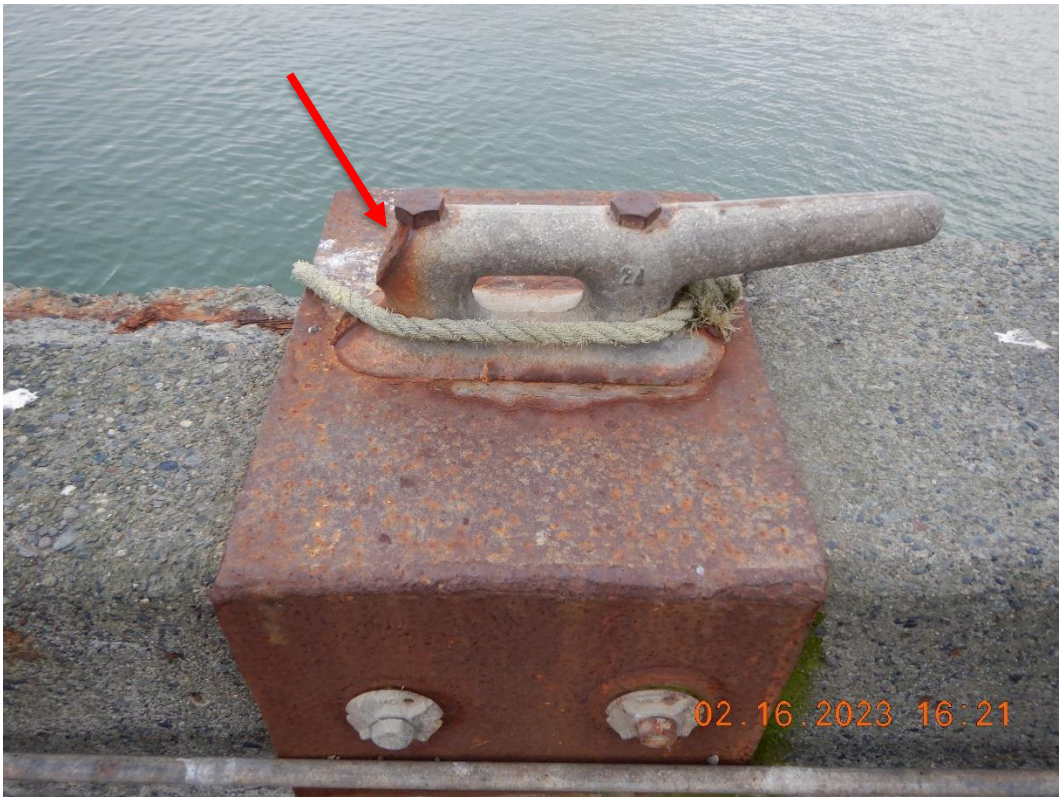

Photo 16. Broken mooring cleat horn at STA 1+73

Photo 17. Moderate sinkhole in asphalt paving at STA 0+12

Photo 18. Severe sinkhole at STA 1+73

Photo 19. Severe sinkhole at STA 1+90

Appendix B: Sheet Pile Bulkhead Investigation, December 1997

SHEET PILE BULKHEAD INVESTIGATION
Crescent City Harbor District
Crescent City, California

Prepared By:

MOFFATT & NICHOL ENGINEERS
3000 Citrus Circle, Suite 230
Walnut Creek, California
M&N File No. 4099

Date Of Site Investigation:
11 December 1997

Investigating Staff:
Brad Porter, P.E.

1. SUMMARY

The bulkhead wall at Citizen's Dock was built in two phases. The older wall is approximately fifty years old and at the end of its expected useful life. The later wall is 38 years old and shows signs of significant deterioration. Replacement, at an approximate cost of $300,000 is recommended. There are repair options that will extend the life of the wall approximately ten additional years, which range in cost from $29,000 to $93,000. If replacement is not performed, survey points have been placed behind the wall that should be measured on a regular basis to assess ground settlement. This might help to identify any impending failure.

2. HISTORY

The bulkhead is located at the end of Citizens Dock Road and adjacent to Citizen's Dock in Crescent City Harbor. The bulkhead wall was built in two phases; the first phase was built in the 1940's (estimated from undated construction documents) and the second phase (addition) was built in 1962 (Figure 1). Both phases used 30 foot long 3/8-inch thick steel sheet piles driven to a depth of between 4 and 12 feet, and supported by a tie-back system. The top is encased in a concrete cap. The 1940's tie-back system consisted of one waler located 4'-8" below the concrete cap and tied to a system of timber piles. The 1962 addition tie-back system has two walers, one located in line with the 1940's waler, and the other 9'-2" below the cap. These walers as well as the cap are tied back to 8-inch steel H piles. A section through both the 1940's and the 1962 addition are shown in Figure 2.

The first phase was built for a 30,000 sq. ft. parking lot, launching platform and floating docks. It was comprised of a steel sheet pile wall 100 ft. long on the west side extending south from an existing steel sheetpile bulkhead (abutment to Citizens Dock), and a steel sheet pile return wall 50 feet long on the south. There was a 150 ft. long riprap extension on the east end of the south wall. This first phase of the wall is shown in Photograph 1.

The second phase extended the west wall an additional 100 ft. to the south, doubling the available parking area. A new 100 ft. long steel sheet pile wall was built on the south side with a 100 ft. long rip rap extension at the eastern end of the wall. An elevation of the west wall, showing both the 1940's and 1962 wall is shown in Photograph 2.

The steel sheet piles have corroded. Particularly in the 1940's wall, corrosion has created holes in the lower portion of the sheet piles between mean lower low water (MLLW) and mean sea level (MSL). The soil in back of the wall, at the holes, has partially washed out leaving void spaces behind the wall. The surface of the parking lot, behind the wall, is developing localized depressions, apparently due to the soil loss at the lower portion of the wall.

3. INVESTIGATION/EXISTING CONDITIONS

On December 11, 1997 a site visit was made to investigate the condition of the bulkhead wall. Four test pits were excavated behind the wall to observe the condition of the tie back system and to determine whether there were voids in the upper portion of the wall backfill. The pits were dug to an approximate depth of 10 feet to expose the lower tie-backs behind the 1962 wall. No pits were dug behind the 1940's wall because this would have required removal of concrete paving along the wall and interference with underground power lines. Seven nails were placed and the elevations surveyed in the asphalt parking lot behind the wall. The locations of the test pits and nails are shown in Figure 3. Photographs 17, 18 and 19 show test pit locations and the tie-back system. The nails can be surveyed in the future to indicate settlement caused by soil loss behind the wall. The wall was examined from the waterside by boat at low tide (-0.4 MLLW at time of observation). Observations from the visit are summarized below.

3.1 SHEET PILES

1. 1940's Wall (northern 100 ft. of the west wall, see Photographs 8 through 12.).

    - Completely rusted through at mean low water (MLW) for 30-40% of wall length (Figure 4).
    - Voids extend 3-5 ft. back into the wall backfill at MLW elevation.
    - Portion above mean sea level is intact, 40-60% of material remains.
    - Concrete cap has some spalled concrete exposing the rebar (Photograph 4).

2. 1962 Wall (southern 100 ft. of the west wall and south wall, see Photographs 6, 7, 8 and 13 through 16).

    - West Wall (see Photographs 6, 7, and 8) isolated holes are rusted through at low water. The openings equate to about 5-7% of the wall length.
    - Portion above mean sea level is intact, 50-70% of material remains.
    - South wall (see Photographs 13 through 16) two locations which have corroded through, one has water running out continuously at low tide, indicating extensive voids in backfill.

A bow was also noticed in the west wall as shown in Photographs 3 and 5. No detrimental effects from this bowing were observed. It may be that the bow has been there for many years, perhaps since the original construction.

3.2 TIE BACK SYSTEM

1. 1940's wall. The tie-back system for this wall was not examined because of concrete paving and electrical utility interference.

2. 1962 Addition.

    - Buried steel piles in good condition, 90% of material remains.
    - Buried portion of tie rods in good condition, 90% of material remains.
    - Walers are badly corroded, 30-50% of material remains.
    - Nuts on end of tie rods are badly corroded, 20-35% of material remains.

3.3 BACKFILL

- Backfill at four test pit areas was sound - no voids were encountered.
- Backfill was sandy shale, predominantly granular and well drained.

3.4 CONCLUSION

The 1940's bulkhead wall is at the end of its expected life. The exposed steel is badly corroded with holes at the waterline and is therefore in need of replacement. The 1962 addition has fewer holes at the waterline than the 1940's wall. The buried tie back system of the 1962 addition is in relatively good condition and could be reused. The 1940's tie-back system uses timber piles, which may have deteriorated due to the opening in the sheet pile wall. Fortunately, the 1940's wall in the area with extensive corrosion is not as high as the remainder of the west wall. It may be that the single waler has therefore been able to support the wall. This same type of corrosion in the longer portions of the wall might have had much more severe results.

If no corrective action is taken, the steel sheets will continue to corrode, resulting in larger holes and associated growth of the cavities behind the wall at the MLW elevation. There are two likely modes of failure of the wall.

1. Failure Mode 1 - Breach at Wall Base
   The bottom of the wall continues to corrode but the tiebacks hold the top of the wall in place. The top of the wall would remain fixed and the base would "kick out" along with the lower soil. This would cause the soil in back of the wall to settle as much as a few feet. This is the most likely failure mode and could occur in the 1940's wall in the near future; it is unlikely that the 1962 wall would fail in this way for another 5-15 years.

2. Failure Mode 2 - Breach at Top
   If the tie back connections at the walers yield due to their corroded condition, the top of the wall would lean out causing lateral movement, or spreading, of the surface soil in back of the wall. Given the overall age and condition of the wall this could trigger a rupture of a vertical sheet pile seam and a complete breach of the wall. Although it is possible this could happen in a sudden way (within hours) it is more likely that a

leaning of the wall would show localized bowing at the location of the failing tie-rod connection. This would be expected to occur over a period of days or months.

4. ALTERNATIVES AND COSTS

4.1 REPLACEMENT WALL

A new steel or concrete sheet pile wall could be driven a few feet outside of the old wall, and tied into the existing tie-back system (see Figure 5). Although the 1940's wall is in need of replacement sooner then the 1962 wall, there would be a premium to pay for additional mobilization if replacement was done at separate times.

Estimated Construction Cost: $300,000

4.2 REPAIR

Three repair alternatives are discussed below. The purpose of each of these alternatives is to address the weakness in the wall caused by corrosion in the steel plate near the waterline. As noted during the field investigation, the connection of the tie-back system to the steel plate is severely corroded and also needs repair. It is therefore recommended, if the walls are to be repaired, that the attachment of the tie-back system to the wall be repaired regardless of the repair alternative selected.

Replace Corroded Tie-back Nuts. Replace the corroded nuts that are exposed on the ends of the tie rods, this would require cutting off approximately 2 feet from the ends of the tie rods and threading on a new rod, or welding a new rod onto the end of the existing rods.

Estimated Construction Cost:	1940's	$4,000
	1962	$18,000

1. Riprap at Toe/Grout Holes.
   Place riprap at the toe of the 1940's portion of the existing wall (Figure 6) and grout between the stones to halt soil migration from behind the wall. This would require that the floating docks be removed from in front of the wall and that the boat hoist could not be used at this location. Riprap is not required at the 1962 wall at this time, but the holes should be grouted and the condition of the wall monitored regularly.

   Estimated Construction Cost: $32,000

2. Bridge Plate Behind.
   Excavate from behind the wall and place a metal plate to bridge the holes in the existing sheet pile (Figure 7). This should be done on the 1940's wall immediately and could be done as needed on the 1962 wall although as the wall continues to

corrode less material will be available to attach to in the future. If the 1962 wall is not done, the holes should be grouted as in Alternative 1.

Estimated Construction Cost:	1940's only	$35,000
	1940's and 1962	$75,000

3. Piles and Plate in Front.
   Place a new steel plate on the front of the wall (Figure 8), attached by welding to the wall on the top of the plate. The bottom of the plate will be held in place by new steel piles driven in front of the plates. The existing void spaces behind the sheet piles will be pressure grouted to fill the voids. Because of the cost of mobilization for a pile driver, the entire wall should be done at one time.

Estimated Construction Cost:	1940's and 1962	$68,000

5. RECOMMENDATIONS

The wall is in a deteriorated condition and should be replaced or repaired. If the parking lot and other uses adjacent to the wall are to continue, it is recommended that the wall be replaced. Fifty years is about the maximum life span of a steel sheet pile wall. Any of the repair alternatives considered will add 10-15 years to the life of the existing wall but will not halt the continuing deterioration of other parts of the wall that do not yet show distress or impending failure. Repair will also require increased maintenance costs, although some of the work may possibly be performed by Harbor District Staff. Complete replacement is the least cost option over the expected life of the wall.

If replacement is not performed in the near future, the Harbor District should monitor the settlement that is occurring behind the wall. Nails were set behind the wall and their elevations were recorded during the field investigation (Figure 3). These should be measured for settlement every 3 months in order to help detect if failure of the wall is impending. The wall face should be examined on a regular basis to observe both the extent of the corrosion and loss of material from behind the wall through the corroded openings.

Appendix C: Damage and Condition Assessment Ratings from ASCE 130

Table 2-5. Damage Ratings for Steel Elements[3]

Damage Rating		Existing Damage[4]	Exclusions [Defects Requiring Elevation to the Next Higher Damage Rating(s)]
NI	Not Inspected	Not inspected, inaccessible, or passed by[5]	
ND	No Defects	• Protective coating or wrap intact • Light surface rust • No apparent loss of material	
MN	Minor	• Protective coating or wrap damaged and loss of thickness up to 15% of nominal at any location • Less than 50% of perimeter or circumference affected by corrosion at any elevation or cross section • Loss of thickness up to 15% of nominal at any location	Minor damage not appropriate if • Changes in straight line configuration or local buckling • Corrosion loss exceeding fabrication tolerances (at any location).
MD	Moderate	• Protective coating or wrap damaged and loss of thickness 15 to 30% of nominal at any location • More than 50% of perimeter or circumference affected by corrosion at any elevation or cross section • Loss of thickness 15 to 30% of nominal at any location	Moderate damage not appropriate if • Changes in straight line configuration or local buckling • Loss of thickness exceeding 30% of nominal at any location
MJ	Major	• Protective coating or wrap damaged and loss of nominal thickness 30 to 50% at any location • Partial loss of flange edges or visible reduction of wall thickness on pipe piles • Loss of nominal thickness 30 to 50% at any location	Major damage not appropriate if • Changes in straight line configuration or local buckling • Perforations or loss of wall thickness exceeding 50% of nominal
SV	Severe	• Protective coating or wrap damaged and loss of wall thickness exceeding 50% of nominal at any location • Structural bends or buckling, breakage, and displacement at supports, loose, or lost connections • Loss of wall thickness exceeding 50% of nominal at any location	

[3] ASCE Waterfront Facilities Inspection and Assessment Manual No. 130, 2015
[4] Any defect listed is sufficient to identify relevant damage grade.
[5] If not inspected due to inaccessibility or passed by, note as such.

Table 2-6. Damage Ratings for Reinforced Concrete Elements[6]

Damage Rating		Existing Damage[7]	Exclusions [Defects Requiring Elevation to the Next Higher Damage Rating(s)]
NI	Not Inspected	Not inspected, inaccessible, or passed by[8]	
ND	No Defects	Good original hard surface, hard material, sound	
MN	Minor	• Mechanical abrasion or impact spalls up to 1 in. in depth • Occasional corrosion stains or small pop-out corrosion spalls • General cracks up to 1/16 in. in width	Minor damage not appropriate if • Structural damage • Corrosion cracks • Chemical deterioration[9]
MD	Moderate	• Structural cracks up to 1/16 in. in width • Corrosion cracks up to 1/4 in. in width • Chemical deterioration: random cracks up to 1/16 in. in width; “soft” concrete and/or rounding of corners up to 1 in. deep • Mechanical abrasion or impact spalls greater than 1 in. in depth	Moderate damage not appropriate if • Structural breakage and/or spalls • Exposed reinforcement • Loss of cross section due to chemical deterioration beyond rounding of corner edges
MJ	Major	• Structural cracks 1/16 in to 1/4 in. in width and partial breakage (through section cracking with structural spalls) • Corrosion cracks wider than 1/4 in. and open or closed corrosion spalls (excluding pop-outs) • Multiple cracks and disintegration of surface layer due to chemical deterioration • Mechanical abrasion or impact spalls exposing the reinforcing	Major damage not appropriate if • Loss of cross section exceeding 30% due to any cause
SV	Severe	• Structural cracks wider than 1/4 in. or complete breakage • Complete loss of concrete cover due to corrosion of reinforcing steel with more than 30% of diameter loss for any main reinforcing bar • Loss of bearing and displacement at connections • Loss of concrete cover (exposed steel) due to chemical deterioration • Loss of more than 30% of cross section due to any cause	

[6] ASCE Waterfront Facilities Inspection and Assessment Manual No. 130, 2015.

[7] Any defect listed is sufficient to identify relevant damage grade.

[8] If not inspected due to inaccessibility or passed by, note as such.

[9] Chemical deterioration: sulfate attack, alkali-silica reaction, alkali-aggregate reaction, alkali-carbonate reaction ettringite distress, or other chemical/concrete deterioration.

Table 2-14. Condition Assessment Ratings[10]

Condition Rating		Description
6	Good	No visible damage or only minor damage noted. Structural elements may show very minor deterioration, but no overstressing observed. No repairs are required.
5	Satisfactory	Limited minor to moderate defects or deterioration observed but no overstressing observed. No repairs are required.
4	Fair	All primary structural elements are sound but minor to moderate defects or deterioration observed. Localized areas of moderate to advanced deterioration may be present but do not significantly reduce the load-bearing capacity of the structure. Repairs are recommended, but the priority of the recommended repairs is low.
3	Poor	Advanced deterioration or overstressing observed on widespread portions of the structure but does not significantly reduce the load-bearing capacity of the structure. Repairs may need to be carried out with moderate urgency.
2	Serious	Advanced deterioration, overstressing, or breakage may have significantly affected the load-bearing capacity of the primary structural components. Local failures are possible, and loading restrictions may be necessary. Repairs may need to be carried out on a high-priority basis with urgency.
1	Critical	Very advanced deterioration, overstressing, or breakage has resulted in localized failure(s) of primary structural components. More widespread failures are possible or likely to occur, and load restrictions should be implemented as necessary. Repairs may need to be carried out on a very high-priority basis with strong urgency.

Definition of a Level I inspection Effort[9]

Includes a close visual examination above and underwater or a tactile examination using large sweeping motions of the hands where visibility is limited underwater. Although the Level I effort is often referred to as a “swim by” inspection, it must be detailed enough to detect obvious major damage or deterioration due to overstress or other severe deterioration. It should confirm the continuity of the full length of all members and system components and detect undermining or exposure of normally buried elements. A Level I effort may also include limited probing of the substructure and adjacent channel bottom.

[10] ASCE Waterfront Facilities Inspection and Assessment Manual No. 130, 2015.

Appendix D: Field Observation Notes

STATION		DEFECT	DEFECT RATING	DEFECT DIMENSION			COMMENT
START	END			HEIGHT / LENGTH	WIDTH	DEPTH	
-	-	TYPICAL CAP HAS MECHANICAL SPALLING, CRACKS, ETC.	MN	-	-	-	
0+00	0+40	SECTION LOSS OF UPPER WALER/HARDWARE UP TO 50% LOSS	SV	40'	-	-	
0+00	1+00	CORROSION HOLES IN SHEETS	SV	100'	42"	48"	VOIDS PARTIALLY FILLED/BLOCKED WITH GRAVEL/CONCRETE
0+00	1+00	BUCKLING OF SHEETS ABOVE CORROSION HOLES	SV	100'	-	-	
0+00	1+00	NO LOWER WALER	-	100'	-	-	
0+00	1+00	CORROSION AT INTERLOCKS ABOVE UPPER WALER	MJ	100'	6"	-	
0+06	-	PIPE PENETRATION IN BULKHEAD	ND	4"	4"	-	
0+06	0+07	OCS AT TOP EDGE OF CAP	MJ	12"	3"	3"	EXPOSED BAR
0+12	-	SINKHOLE IN PAVING	MD	72"	48"	8"	
0+24	-	SINKHOLE IN PAVING	MD	36"	48"	6"	
0+25	0+35	OCS TOP EDGE OF CAP	MJ	10'	4"	4"	EXPOSED BARS
0+28	0+60	CONCRETE SLAB	-	32'	15'	-	
0+30	1+86	BOLTS VISIBLE - MAY BE INTERNAL LOWER WALER	-	-	-	-	
0+40	2+00	SECTION LOSS OF UPPER WALER/HARDWARE UP TO 100% LOSS	SV	-	-	-	
0+43	0+65	OCS TOP EDGE OF CAP	MJ	22'	4"	4"	EXPOSED BAR
0+49	0+70	OCS AT TOP OF CAP WITH SECTION LOSS OF EXPOSED BARS	MJ	21'	12"	6"	UP TO 50% SECTION LOSS OF EXPOSED BARS
0+50	-	CORROSION HOLE IN SHEET	SV	5"	12"	-	ABOVE UPPER WALE
0+55	-	DEEP VOID	SV	-	48"	72"	
0+60	0+67	SUBSIDENCE OF CONCRETE PAD	MD	84"	15'	4"	
0+74	-	PIPE PENETRATION IN BULKHEAD	ND	4"	4"	-	
0+95	-	SHEAR CRACK IN CAP	MD	48"	1/8"	-	
1+00	1+50	ISOLATED CORROSION HOLES	SV	50'	42"	-	
1+00	2+00	CORROSION HOLES ABOVE UPPER WALER	SV	100'	6"	-	
1+00	2+00	CORROSION OF LOWER WALER	MN	100'	-	-	
1+08	-	STEEL PLATE WITH 1.5" DIA. BOLTS	-	-	-	-	
1+10	-	BROKEN CLEAT	SV	-	-	-	
1+17	-	STEEL PLATE WITH 1.5" DIA. BOLTS	-	-	-	-	
1+20	1+40	OCS SOFFIT EDGE OF CAP	MJ	20'	4"	4"	EXPOSED BAR
1+25	1+35	CCS AT TOP AND SIDE OF CAP	MD	10'	-	-	
1+37	-	STEEL PLATE WITH 1.5" DIA. BOLTS	-	-	-	-	
1+37	-	CORROSION AT CLEAT	MN	-	-	-	
1+48	-	STEEL PLATE WITH 1.5" DIA. BOLTS	-	-	-	-	
1+56	-	STEEL PLATE WITH 1.5" DIA. BOLTS	-	-	-	-	
1+67	-	STEEL PLATE WITH 1.5" DIA. BOLTS	-	-	-	-	
1+70	-	VERTICAL CRACK IN CAP	MN	24"	1/8"	-	
1+73	-	BROKEN CLEAT	SV	-	-	-	
1+73	-	SINKHOLE IN BACKFILL	SV	36"	24"	18"	EXPOSED CAP TIE ROD
1+73	1+90	OCS AT TOP OF CAP	SV	17'	12"	6"	EXPOSED BARS
1+88	1+91	OCS TOP EDGE OF CAP	MJ	3'	4"	4"	EXPOSED BAR

STATION		DEFECT	DEFECT RATING	DEFECT DIMENSIONS			COMMENT
START	END			HEIGHT / LENGTH	WIDTH	DEPTH	
1+90	-	SINKHOLE IN BACKFILL	SV	96"	36"	18"	EXPOSED CAP TIE ROD
1+98	-	SINKHOLE IN BACKFILL	SV	24"	6"	6"	
2+00	-	LOWER WALER DISCONNECTED AT CORNER	SV	-	-	-	
2+00	3+00	SECTION LOSS OF UPPER WALER/HARDWARE UP TO 50% LOSS	SV	100'	-	-	
2+00	3+00	CORROSION HOLES IN SHEETS, APPROX. 10% OF SHEETS	SV	12"	6"	-	TYPICAL CORROSION HOLE SIZE
2+00	3+00	CORROSION HOLES ABOVE UPPER WALER	SV	100'	6"	-	
2+00	3+00	CORROSION AT LOWER WALER	MN	100'	-	-	
2+31	-	OCS AT TOP OF CAP	MJ	8"	3"	1.5"	EXPOSED BAR
2+50	2+80	SINKHOLE IN BACKFILL	MD	30'	96"	6"	BACKFILL SUBSIDENCE

- Stationing along the bulkhead starts at 0+00 nearest to the Citizen's Dock. Station 2+00 is the corner of the bulkhead. Station 3+00 is nearest the boat ramp.
- See Appendix C for Defect Rating definitions.