moffatt & nichol

1132 Bishop Street, Suite 1595
Honolulu, HI 96813

(808) 533-7000
www.moffattnichol.com

September 26, 2017

Mr. Neal Imada, P.E.
Hawaii Community Development Authority
547 Queen Street
Honolulu, HI 96813

Subject: Letter Report for Fisherman's Wharf Structural Inspection and Evaluation, Kewalo Basin, Honolulu, Hawaii

Dear Mr. Imada:

This letter report contains a summary of Moffatt & Nichol's (M&N) findings and recommendations related to the Kewalo Basin Harbor Fisherman's Wharf Structural Inspection and Evaluation. M&N was engaged by the Hawaii Community Development Authority (HCDA) to perform an above water inspection of the wharf to assess changes to the structural condition since the previous detailed structural survey conducted in 2012. This letter report provides an assessment of the general condition of the wharf structure and identifies areas of structural safety concerns that should be considered and addressed by the HCDA.

OVERVIEW OF FINDINGS

A significant increase in corrosion related degradation has occurred between the inspections performed by M&N in 2012 and 2017. General recommendations regarding the current and future serviceability for the original wharf built in 1924 and the wharf extension built in 1968 are summarized below.

<u>Original Wharf Built in 1924</u>

- After the 2012 inspection, it was determined that this wharf could no longer service vehicular traffic. Pedestrian access was unrestricted.
- The current level of deterioration observed in 2017 requires further prohibitions including prohibiting pedestrian access to a majority of the deck area (see Figure 14).
- Figures indicating specific regions of the wharf that pedestrians may use to access moored vessels are provided (see Figure 14).
- Due to the observed rate of deterioration, it is recommended the owner execute its planned project to repair/replace the wharf superstructure (deck, beams and girders), close all access to the wharf to pedestrians or increase the inspection rate (annually).
- Patch repairs are unviable. Many of the prior repairs installed in the 1980's and 1990's and 2000's have failed. If construction were to begin today, a complete replacement of

decks, beams and some of the pile caps/bents would be required to restore a serviceable wharf meeting minimum code requirements.
- The time required to design, obtain permits and start construction will result in further deterioration, possibly at an accelerated rate. Complete replacement of all elements excluding the piles is recommended.
- Life Cycle Cost Analysis including the considerations of required permitting can help HCDA decide between a rehabilitation or replacement of the entire structure including the piles.

Wharf Extension Built in 1968

- After the 2012 inspection, it was determined that vehicular access to the wharf should be restricted to a 20 ft. wide strip against the landside of the wharf.
- The current level of deterioration observed in 2017 requires further prohibitions of vehicular and pedestrian access (see Figure 14).
- The types of new spalls observed at many locations appear to indicate that the chloride concentration at the level of the main flexural reinforcement has already, or will shortly, reach the threshold for the onset of corrosion. Literature indicates that once the corrosion process initiates spalling can begin within 5 to 10 years.

Furthermore, where pedestrian and vehicle access should be prohibited, it is recommended that more substantive barriers be constructed to prevent access to those areas of the wharf and clear, strong warnings be posted to warn users of the facility of the life safety hazards due to the deteriorated condition of the wharf structure.

WHARF BACKGROUND AND REPAIR HISTORY

Kewalo Basin Harbor is a medium-draft, mixed-use harbor located along Ala Moana Boulevard, approximately one mile east of Honolulu Harbor between the Honolulu International Airport and Waikiki. Kewalo Basin currently provides accommodations for a mix of commercial operators (charter, fishing and excursion) and pleasure craft owners.

“Fisherman’s Wharf”, historically referred to as the “Kewalo Wharf”, is in the northwest corner of Kewalo Basin Harbor (see Figure No. 1). The wharf structure is a pile-supported, marginal wharf of concrete construction, originally built to support tuna packing operations at Kewalo Basin.

Based on available reference drawings, Fisherman’s Wharf is composed of two separate wharf segments. The first segment of wharf was constructed circa 1924 and is approximately 25 ft wide x 460 ft long (Bent Nos. 0 to 23 shown on Figure 3), extending southwest from the bulkhead at the north end of the harbor adjacent to Ala Moana Boulevard (see Photo 1). The second segment of wharf was extended to the south circa 1968 and is approximately 60 ft wide x 200 ft long (Bent Nos. 24 to 35 shown on Figure 3).

The 1924 superstructure is composed of reinforced concrete construction. The wharf deck is a cast-in-place concrete deck that varies in thickness between 10-1/2 in. (between gridlines A and C) and 14-1/2 in. (between gridlines C and D). The wharf deck is supported by continuous concrete beams in the longitudinal direction of the wharf and vary in dimension (3 ft 4 in. deep by 2 ft wide along gridline A, 2 ft 11 in. deep by 1 ft 6 in. wide along gridlines B and C, 5 ft deep by 1 ft 3 in. wide along gridline D). The longitudinal beams are supported by 3 ft 4 in. deep by 1 ft 4 in. wide concrete pile cap beams spaced at 20 ft intervals. Each pile cap beam is supported by a vertical 16 in. square concrete pile at gridline A and vertical 18 in. square concrete piles at gridlines B, C and D. The original landside abutment of the wharf included a precast concrete panel bulkhead supported by 16 in. square concrete piles to retain the backland fill and provide contiguous access from the landside onto the wharf. Reinforced concrete tie beams and deadman anchors were constructed behind the wharf and attached to each pile cap beam to resist lateral loads transverse to the wharf.

The 1968 superstructure has a 12 in. thick wharf deck composed of a 6 in. thick precast, prestressed concrete planks with a 6 in. thick reinforced concrete topping. The wharf deck is spanning in the longitudinal direction of the wharf and supported by 3 ft deep by 2 ft 6 in. wide pile caps at 18 ft intervals. Each pile cap is supported by six 12 in. square prestressed concrete piles (two piles are battered). A steel sheet pile wall supports the backland fill and the wharf extends approximately 3 ft beyond the bulkhead line, providing contiguous access from the landside onto the wharf.

The wharf is outfitted with a mix of painted timber and concrete bull rails, rubber tire and cylindrical rubber fenders along the wharf face, mooring bits, and intermediate mooring cleats. Other topside features include a surface-mounted potable water service line and hose bibs extending along the face of the wharf, a range light, and a telephone booth. (see Photo No. 14)

Available reference drawings indicate that the wharf was the subject of several repair and improvement projects since its construction, including:

- Harbors Project H.C. 716, Kewalo Wharf Fender Revisions, 1945
- Harbors Project H.C. 836, Kewalo Wharf Steel Sheet Piling, installed between 1941 and 1945.
    - *Notes on the drawing indicate that the original bulkhead had failed between Bent Nos. 18 and 23 (makai end of the wharf) in October 1941 and steel sheet piling was driven inboard of the bulkhead to stabilize the shoreline and to mitigate continued deterioration of the concrete bulkhead. The steel sheet piling extends as far north as Bent No. 3 which is adjacent to a City and County box culvert drain.*
- Harbors Project H.C. 1260, Repairs at Kewalo Wharf, 1976.

  - *These repairs entailed strengthening the facia beam fronting the wharf between Bent Nos. 0 and 17 and replacing the timber fender system with slung rubber tire fenders.*
- Harbors Project H.C. 1467, Subsidence Repairs at Kewalo Wharf, 1982.
  - *These repairs entailed installing additional steel sheet piling along the makai end of the original 1924 Kewalo Wharf and local placement of grout along west side of 1968 Kewalo Wharf to mitigate subsidence of the upland fill.*
- Harbors Projects, Substructure Repairs at Kewalo Wharf.
  - H.C. 1548, Pile Cap, Beam and Deck Soffit Repairs, Bents 12 to 19, 1983.
  - H.C. 1591, Pile Cap, Beam and Deck Soffit Repairs, Bents 5 to 12, 1984.
  - H.C. 1605, Pile Cap, Beam and Deck Soffit Repairs, Bents 0 to 5, 1985.
- Harbors Project H.C. 1664, Concrete Repairs at Kewalo Wharf, 1987.
  - *These repairs entailed repairing cracks in the concrete deck and beams between Bent Nos. 13 and 19.*
- Harbors Project H.C. 1788, Replace Fender System at Kewalo Wharf, 1992.
  - *These repairs entailed strengthening the facia beam fronting the wharf between Bent Nos. 17 and 33.5 and replacing the timber fender system with slung rubber tire fenders.*

INSPECTION SCHEDULE

The below deck inspection took place on August 10 and 11, 2017. The above deck inspection took place on August 11 and September 6, 2017. The weather was mixed with periods of heavy showers and sunny conditions.

INSPECTION FINDINGS

<u>Above-Water Inspection</u>

Topside Inspection (refer to Figure 2 at the end of this report)

A general condition survey of the asphalt pavement, the exposed deck surface, front marginal beam and the wharf appurtenances was performed. A summary of the topside inspection findings is as follows:

1. Asphalt Pavement

   The wharf deck between Bents 13 and 35 were covered with a thin asphalt topping. The asphalt is in poor condition with visible cracks and delamination (see Figure 2 for approximate areas where asphalt no longer exists between Bent 13 and 35). The exposed edges of asphalt were between ½ to ¾ in. thickness.

On the 1968 section of deck, there were no deck drains noted. The slope on the deck appears to be minimal (approximately ½% slope per the original drawings). Areas of asphalt delamination serve to collect and trap water runoff and the asphalt should be removed to allow proper drainage. Prior to any resurfacing project, it is recommended that a topographic survey and structural inspection of the underlying concrete deck be performed. The topographic survey can be used to assess if the existing slope is adequate to allow proper drainage. A structural inspection of the underlying concrete deck is also recommended if an asphalt resurfacing project is undertaken so the condition of the concrete deck can be assessed in areas currently obscured by existing asphalt.

2. Exposed Concrete Deck Surface

A chain-drag survey was limited to the areas with exposed concrete deck. The purpose of this type of survey is to identify surface delaminations, horizontal cracks which are below the surface and have not yet propagated to the surface. Delaminated concrete is often caused by corrosion of the top layer of reinforcing steel. The extent of top deck concrete delamination is shown in Figure No. 2.

a. 1924 Wharf Deck

Approximately 30% of the deck surface between Bent Nos. 0 and 13 is delaminated. This is approximately a 300% increase in damaged area from the previous wharf inspection conducted in 2012. While sounding indicated the presence of delamination, the horizontal cracking did not propagate to the surface and there were no visual signs of exposed and corroding reinforcing steel.

The deck between Bents Nos. 13 thru 23 was partially covered with asphalt topping. Observation of damage to concrete was limited to areas where the asphalt concrete topping was missing. Where delaminated concrete was identified adjacent to areas covered with asphalt concrete, it is suspected the concrete delamination continued and extended beneath the asphalt concrete, however, the precise extent could not be determined through visual observation and with the common hand tools employed for this investigation. Approximately 20% of the exposed concrete deck surface was observed to be delaminated.

b. 1968 Wharf Deck

The 1968 concrete deck is mostly covered with an asphalt concrete topping. Observation of damage to concrete was limited to areas where the asphalt concrete topping was missing. Where delaminated concrete was identified adjacent to areas covered with asphalt concrete, it is suspected the concrete delamination continued

and extended beneath the asphalt concrete, however, the precise extent could not be determined through visual observation and with the common hand tools employed for this investigation. Approximately 35% of the exposed concrete deck surface was observed to be delaminated

3. Front Marginal Beam

   The fascia of the front marginal beam has localized delamination, spalling and cracking along its entire length. The front marginal beam generally remains in a serviceable condition to provide the backboard to the rubber fenders. Several areas of the facia beam could not be observed due to vessels moored along the wharf.

4. Wharf Appurtenances

   With the exception of a heavily corroded bollard at the south end of the 1968 section of wharf (see Photo 13), the topside appurtenances appear to be in good to fair condition. The heavily damaged bollard should be immediately removed from service.

Under-Deck Inspection (refer to Figures 3 to 13 at the end of this report)

A Level I survey (visual / tactile) of the under-deck elements including the bulkhead, deck soffit, longitudinal beams, pile caps and pile tops was carried out. Figures 3 thru 10 reflect the increase in structural damages below the wharf deck that have occurred between this inspection and the previous wharf inspection conducted in 2012.

A summary of the under-deck inspection findings is as follows:

1. Bulkhead

   Gaps were observed between the concrete bulkhead panels between Bent Nos. 15 to 23, possibly indicating settlement. A review of the past projects suggests that there was a failure of the original bulkhead at the south end of the original wharf that occurred in the early 1940's. A steel sheet pile wall was driven inshore of the wharf to stabilize the bulkhead. The steel sheet pile wall was not visible during the inspection, but it appears that the repair was effective since there is no obvious indication or reports of ongoing settlement or movement behind the wharf.

   The appearance of a large void at Bent No. 23 was also addressed in 1982, by installing steel sheet piling inboard of the existing wharf. It appears that the repair was effective since there is no obvious indication or reports of ongoing settlement or movement of the wharf in this area. Since there is no evidence of ongoing settlement issues in this

location additional site investigation involving localized excavations are not required at this time to determine the actual conditions of the buried bulkhead walls.

2. Deck Soffit

a. 1924 Wharf Soffit

Approximately 25% of the 1924 deck soffits is spalled with large areas of exposed and corroding reinforcing steel. This is approximately a 170% increase of damaged area from the previous wharf evaluation conducted in 2012. An example of a spalled soffit area with fractured slab reinforcing steel is shown in Photo 7.

The areas between Bent Nos. 0-5, 5-12, and 12-19 were reportedly repaired in 1985, 1984 and 1983 respectively. Numerous locations of failed concrete repairs were noted between the bent numbers indicated above.

The area between Bent Nos. 0-1 and between gridlines C and D is a few inches above the tidal zone and was not accessible by the field team. Access to this low soffit area would require a dive team and it is not known if the damage observed in this area has significantly increased since the 2012 field investigation.

The 1924 section of Fisherman's Wharf currently has posts and chains at the north and south ends prohibiting vehicles access (see Photos 2 thru 4). There are no signs posted restricting pedestrian access. During the site inspection, ship operators were observed walking across the 1924 section of deck. Additional deck restrictions are discussed in the SUMMARY section of this report.

b. 1968 Wharf Soffit

Approximately 10% of the 1968 deck soffits is spalled with large areas of exposed and corroding reinforcing steel. This is a 200% increase in damage from the previous wharf evaluation conducted in 2012.

The majority of the prestressed concrete plank soffits appear to exhibit small areas of delamination, which are consistent throughout the deck soffit (Refer to Figure No. 11 thru 13). Many of these small delaminated areas have occurred since the previous 2012 inspection. The repetition and location of these damages appears to be consistent with typical locations of precast panel lifting inserts used to place the panels during construction. The lifting panel inserts likely have about ½ inch less concrete cover than the high strength prestressing strands in the planks. Since the corrosion of this hardware is significant enough

to result in spalling, it is likely that the chloride concentration at the level of the prestressing strands is sufficient to initiate corrosion. Typically, once this type of corrosion initiates, it can take as little as about 5 years before spalling is observed.

Several prestressed panels adjacent to the bulkhead have exposed reinforcing steel and prestressing steel strands which have already corroded causing the concrete to spall and further accelerate atmospheric corrosion of the reinforcement. On twelve panels, the steel strands were noted to be completely severed due to corrosion loss (example of this condition is shown on Photo No. 11). The proximity of the damaged planks to the bulkhead suggests that the combination of relatively low deck height and splash from waves breaking against the bulkhead is accelerating the deterioration in these areas.

This type of corrosion is especially critical since once prestressing steel begins to corrode, the strength and ductility of the prestressed concrete plank is significantly reduced. Prestressed planks with exposed and damaged prestressing steel strands should be repaired or removed and reconstructed.

There are posts and chains along the north end of the 1968 section of Fisherman's Wharf; however, there is a section without posts and chains that allow vehicles to access the 1968 wharf construction (see Photo 5). During the site inspection, ship operators were observed to temporarily park on the 1924 section of deck to load supplies onto the vessel. Additional deck restrictions are discussed in the SUMMARY section of this report.

3. Longitudinal Beams

    a. 1924 Wharf Longitudinal Beams

    The longitudinal beams in the 1924 structure are in poor condition with extensive spalling and exposed corroding reinforcing steel. In numerous areas, the shear stirrups are completely exposed and are broken along the bottom and sides of the beam. The extent of the damage covers nearly 97% of the length of the rear marginal beam above the bulkhead soldier piles, and approximately 85% of the intermediate beams (see Photos No. 8 and 10).

    b. 1968 Wharf Longitudinal Beams

    The longitudinal beams in the 1968 structure are in fair condition. New areas of corrosion were noted since the 2012 inspection. The extent of the damage covers approximately 25% of the longitudinal beams.

4. Pile Caps

    a. 1924 Pile Caps

    The 1924 pile caps are in moderate condition, with spalling and/or exposed corroding reinforcing steel on 60% of the 1924 structure. This is approximately a 600% increase in damage from the previous wharf evaluation conducted in 2012.

    b. 1968 Pile Caps

    The 1968 pile caps are in fair condition, with spalling and/or exposed corroding reinforcing steel on 60% of the 1968 structure. This is approximately a 240% increase in damage from the previous wharf evaluation conducted in 2012.

5. Piles

    The above-water portions of the piles in Gridlines B, C, and D are in good condition with only minor defects including surface spalls and hairline cracks.

    The above-water portion of the piles in Gridline A (along the bulkhead) are typically in a moderate to poor condition. Moderate defects included surface spalls, horizontal and vertical cracks up to 1/4 in. width. Poor conditions included areas of failed repairs with exposed reinforcing steel extending from the pile cap down 2 to 3 feet below the tidal zone (see Photo No. 9).

<u>Below-Water Inspection</u>

Underwater inspections were not included in the scope of work.

LOAD CARRYING CAPACITY EVALUATION

A limited structural analysis of select wharf components was performed to evaluate wharf live load restrictions. The following assumptions and evaluation criteria were used when performing the load carrying capacity evaluation:

- Wharf dimensions shown on record drawings were assumed to be correct. A detailed survey of wharf structural member sizes was not performed.
- Damages noted during the above water field investigation performed August-September 2017 were considered.
- Below water damages to piles and buried wharf components are not known and were not considered.

- The 1924 record drawings do not contain material properties for concrete and reinforcing steel and material assumptions were made using material properties consistent with the era of construction (based on AASHTO Manual for Bridge Evaluation).
- The 1968 record drawings contained material properties for concrete, reinforcing steel and prestressing steel and these properties were assumed to be correct.
- The load combinations provided in the American Association of State Highway and Transportation Officials (AASHTO) Manual for Bridge Evaluation (2nd Edition, 2010 with 2015 interim revisions) was used to determine vehicle live load restrictions
- The load combinations provided in the 2015 International Building Code (IBC) was used to determine uniform live load restrictions

A summary of the load evaluation results is presented below:

a. 1924 Wharf Live Load Evaluation

Damages have significantly progressed since the 2012 wharf inspection and evaluation. The existing chain link fencing (Shown in Photos 2 thru 4) at each end of the 1924 section of wharf should be maintained to prohibit vehicle access. Based on the existing level of structural damage, maximum live loading should be limited to pedestrians (i.e., 50 pounds per square foot [psf]) only within the limited areas indicated below:

- Between Bents 1 and 2 (50 psf max live load)
- Between Bents 5 and 8 (50 psf max live load)
- A strip extending a maximum of 5’-0” from the edge of deck between Bents 1 and 23 (50 psf max live load)

A prohibition on pedestrian and/or live loads should be imposed on all other areas of the 1924 wharf deck that are not specifically mentioned above (see Figure 14).

b. 1968 Wharf Live Load Evaluation

Precast, prestressed panel and pile cap damage have significantly increased since the 2012 inspection and evaluation. The following restrictions are recommended for the 1968 section of wharf:

- Prohibit all access to the area between gridlines 24 and 31 and gridlines A and B (See Figure 14 for refinement of specific area).
- Prohibit all vehicles which exceed 5,000 lbs. Gross Vehicle Weight (GVW) and prohibit all occupancies or uses which exceed 100 psf to the area between gridlines 24 and 27 and between gridlines B and D.

- Prohibit all vehicles which exceed 20,000 lbs. Gross Vehicle Weight (GVW) and prohibit all occupancies or uses which exceed 100 psf to the area between gridlines 27 and 31 and between gridlines B and D.
- Prohibit all vehicles which exceed 20,000 lbs. Gross Vehicle Weight (GVW) and prohibit all occupancies or uses which exceed 100 psf to the area between gridlines 31 and 35.

It is recommended that immediate measures be taken to prohibit vehicles from accessing the 1968 wharf deck from the north end of the deck by extending the access barriers (see Photo 5) to prevent vehicles from entering prohibited areas mentioned above. Vehicle access to the 1968 wharf, if necessary, could be provided via an existing access lane that is currently closed on the southwest corner of the wharf.

Figure 14 of this report provides a graphic that summarizes the 1924 and 1968 wharf live load restrictions mentioned above.

WHARF REPAIR

The extensive deterioration observed at the original 1924 wharf suggests that the 1924 section of wharf has reached the end of its useful service life. Major repairs and/or replacement of the superstructure is necessary to facilitate use of the deck of this section of the wharf. Additionally, the advanced deterioration observed at the 1968 wharf suggest that repairs should be performed immediately to maintain the structural integrity of the wharf and extend the structural service life.

Repair drawings for Fisherman's Wharf were prepared by Moffatt & Nichol in May 2015. Based on the additional damages that were observed in this inspection, it is recommended that the repair drawings be updated to incorporate the additional structural damages. If the repair is not anticipated to be performed soon, annual structural inspections should be performed to monitor the load carrying capacity of the structure. An updated damage survey and reassessment of the repair strategy should be timed with the issuance of the repair design documents to minimize the risk of change orders due to continued deterioration before the start of construction.

ADDITIONAL CONSIDERATIONS

It is important to note that concrete exposed to sea water can be subjected to several chemical and physical actions. This would include chloride-induced corrosion of the steel reinforcement and chemical attack. Prior to any concrete repair work on the 1968 segment of wharf, we recommend that concrete samples be taken of the existing wharf deck and sent to a certified testing laboratory to determine the material quality and viability of future repair work.

Experience has shown that localized repairs to deteriorated concrete provide an average service life of 10 to 15 years. However, the underlying cause of the deterioration, which includes chloride penetration into the concrete, typically remains intact. This often results in areas adjacent to repaired areas deteriorating at an accelerated rate.

A life cycle cost analysis (LCCA) comparing repair options with full reconstruction of the entire superstructure was not performed under this evaluation. LCCA would take into consideration the intended long-term use of the facility, desirable structural service life and compare this against the options of repairing the facility with reoccurring maintenance vs. reconstructing a new facility.

OPINION OF PROBABLE COST

An Opinion of Probable Construction Cost (OPCC) was prepared in June 2015 as part of the Kewalo Basin Repair project. Using the approximate % increase in structural damages observed during this inspection, and adjusting the cost estimate to present day dollars, below is a table that shows the increase in anticipated construction cost if the repair project were to start in January 2018.

Table 1 – Comparison between 2015 OPCC and 2018 OPCC

Description	2015 OPCC	2018 OPCC
1924 Wharf	$2,117,000	$2,358,000
1968 Wharf	$645,000	$1,560,000*
Subtotal	$2,762,000	$3,918,000
Mob/Demob (7%)	$194,000	$274,000
Subtotal	$2,956,000	$4,192,000
General Supervision (8%)	$237,000	$335,000
Subtotal	$3,193,000	$4,527,000
Overhead and Profit(15%)	$479,000	$679,000
Total Estimated Contractor Cost	$3,672,000	$5,206,000
Contingency (5%)	$184,000	$260,000
Total	$3,856,000	$5,466,000
Total (Rounded) OPCC	$3,900,000	$5,500,000

*The amount indicated above includes concrete repairs to 15% of the top of 1968 wharf deck that is currently covered by asphalt concrete topping. Concrete deck damage below asphalt concrete topping was not observable during field investigation.

SUMMARY

The original 1924 wharf is in an advanced state of deterioration in need of substantial repairs and/or full replacement in the short term to meet the functional and operational uses of the wharf. Damage has significantly increased since the previous wharf evaluation conducted in 2012. Based on the observed damages for the 1924 wharf segment, the following immediate course of action is recommended:

- Maintain prohibition of all vehicle traffic on the 1924 wharf segment. Maintain adequate measures using striping, barricades, signage, etc. to prevent vehicles from driving over this portion of deck;
- Limit loading to pedestrian loading in the locations shown on Figure 14. Implement adequate measures using deck striping, signage, etc. to restrict public access.

The 1968 wharf addition is in a moderate state of deterioration, although the extent of observable damage on the soffits of pile caps and the precast deck panels warrants significant restrictions on the usable deck area. Based on the observed damages, the following immediate course of action is recommended:

- Prohibit vehicles from accessing the 1968 wharf section from the north end of the structure. Implement adequate measures using striping, barricades, signage, etc. Vehicle access should be limited to the access lane located on the south end of the 1968 wharf.
- Prohibit all live loads above the precast planks adjacent to the bulkhead (refer to Figure 14 for specific area). Implement adequate measures to prevent accidental access to these areas and avoid the use of heavy barricades on the deck;
- Vehicles accessing the 1968 segment of wharf between gridlines 24 and 27 and outside of prohibited areas indicated above should be limited to personally owned vehicles with 5,000 lbs. maximum GVW or a live load of 100 pounds per square foot (psf) acting non-concurrently (refer to Figure 14 for specific area);
- Vehicles accessing the 1968 segment of wharf between gridlines 27 and 35 and outside of prohibited areas indicated above should be limited to 10,000 lbs GVW or a live load of 100 pounds per square foot (psf) acting non-concurrently (refer to Figure 14 for specific areas);

Furthermore, where pedestrian and vehicle access should be prohibited, it is recommended that more substantive barriers be constructed to prevent access to those areas of the wharf

and clear, strong warnings be posted to warn users of the facility of the life safety hazards due to the deteriorated condition of the wharf structure.

The wharf load restrictions provided above are based on structural damages noted during field observations conducted August and September 2017. Structural damages have significantly progressed since the previous wharf evaluation conducted in 2012. It is strongly recommended that repairs to, or replacement of, the 1924 and 1968 wharf deck and superstructure should be performed as soon as possible to maintain the integrity of the structure. If repairs are not anticipated to be performed soon, annual structural inspections should be performed to monitor the load carrying capacity of the structure and re-evaluate load carrying capacity.

Repair drawings that were prepared by Moffatt & Nichol in 2015 should be updated to incorporate the additional damages noted during this inspection. An Opinion of Probable Construction Cost (OPCC) associated with the 2015 repair was updated based on the additional damages noted during the 2017 inspection. The current OPCC for the overall repair project if awarded January 2018 is $5.5M, which is a 40% increase from the 2015 OPCC.

We thank you for the opportunity to assist the HCDA with this important project, and we trust the contents of this letter report met with your expectations for this project. Please feel free to contact me, or Mr. Dean Kokubun, if you have any questions about the contents of this letter, or if you need any assistance moving forward with this work.

Sincerely,

MOFFATT & NICHOL

Brian Enomoto, P.E.
Project Manager

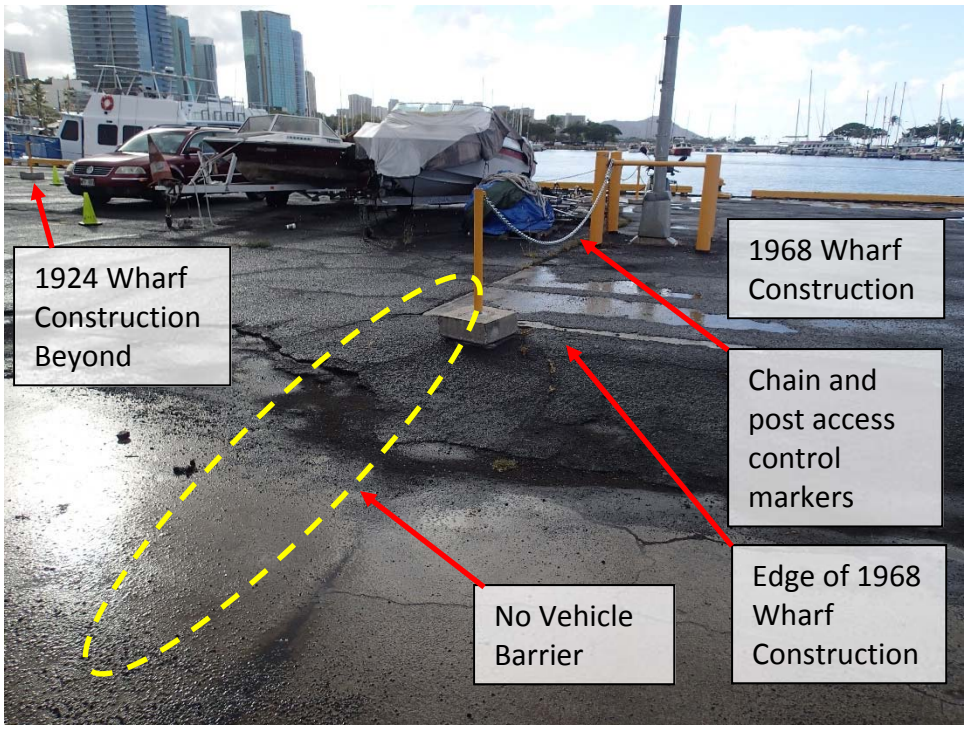
Attachments: Photographs, Inspection Plans, Vehicle and Pedestrian Operational Restriction Plan

1 - General view of Fisherman's Wharf. Photo taken from north end of 1924 section of wharf looking South-West.

2 - Fisherman's Wharf, looking south from Ala Moana Blvd end of 1924 section of wharf. Chain and posts prohibit vehicles onto the 1924 section of wharf deck.

3 – Fisherman's Wharf, looking south at the 1968 wharf construction (1924 wharf construction in foreground). Chain and posts prohibit vehicles onto the 1924 section of wharf deck.

4 - Fisherman's Wharf, looking north at the 1924 wharf construction (1968 wharf construction in foreground). Chain and posts prohibit vehicles onto the 1924 section of wharf deck.



5 –North end of 1968 wharf construction looking east. Note chain and posts separating 1968 and 1924 wharf construction does not restrict vehicles from accessing 1968 portion of wharf

6 – Fisherman's Wharf, looking north from end of 1968 wharf. Note poor condition of asphalt topping

7 – Typical deck soffit and longitudinal beam damage under 1924 wharf. Note exposed and fractured slab reinforcing steel

8 – Typical condition of the rear marginal beam with exposed and corroding reinforcing steel. The remaining portion of a previous beam repair area is shown hanging.

9 – Example of damage at the top of some piles along Gridline A (bulkhead) on the 1924 wharf.

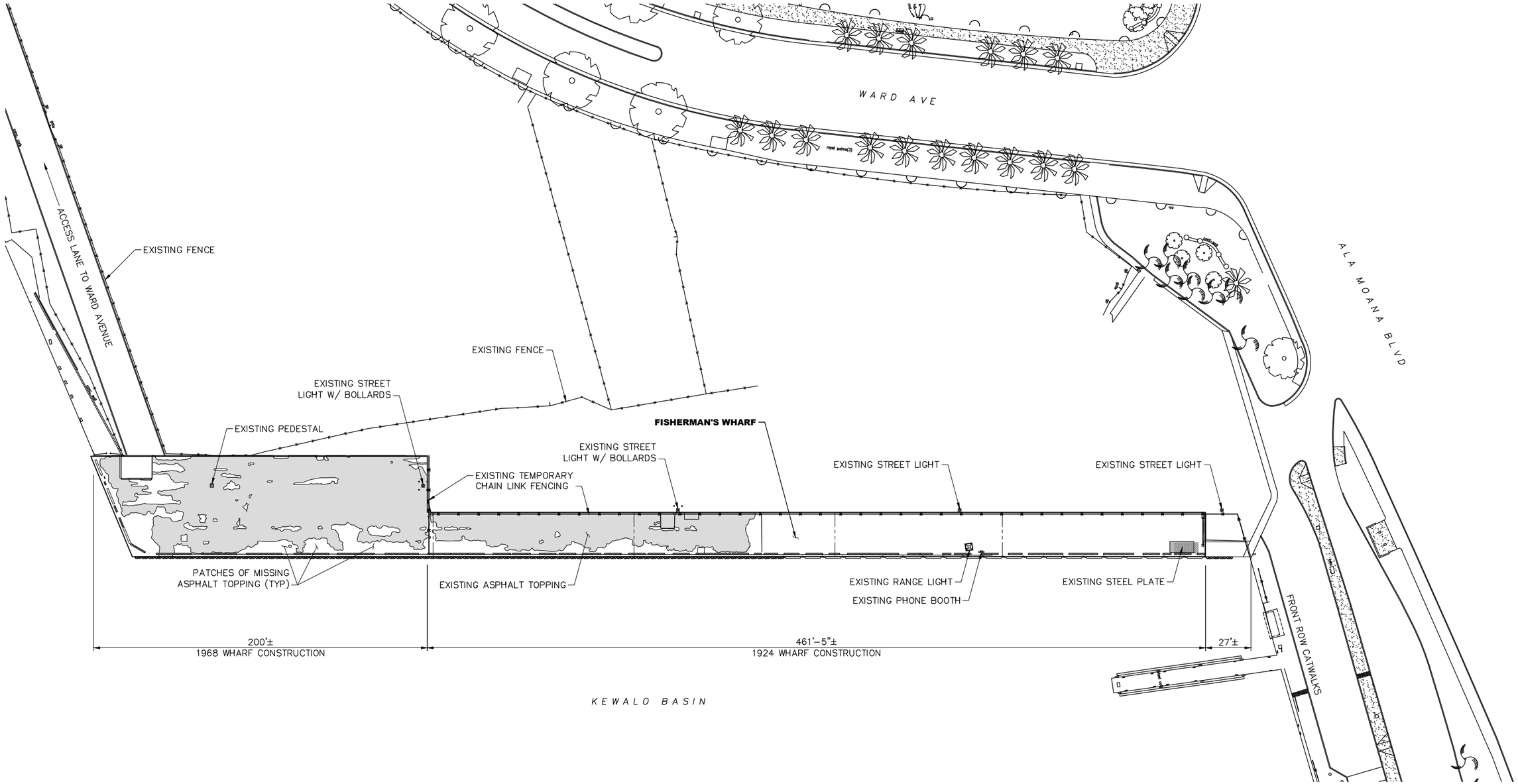
10 – Example of location with extensive beam spalling and fractured beam bottom reinforcing steel and shear stirrups on the 1924 wharf.

11 – Soffit of precast-prestressed plank with broken prestressing strands on the 1968 wharf

12 – Spalling along soffit of 1968 wharf pile cap

13 – Mooring cleat with significant corrosion (near collapse) at south end of 1968 wharf

14 – 1924 section of wharf near gridline 7 with range light, telephone booth and bull rails along wharf edge



LEGEND

PAVEMENT ASPHALT TOPPING (APPROXIMATE)

30' 0' 30' 60'

SCALE: 1"=60'

DRAWING SCALES SHOWN BASED ON 11"x17" DRAWING

N

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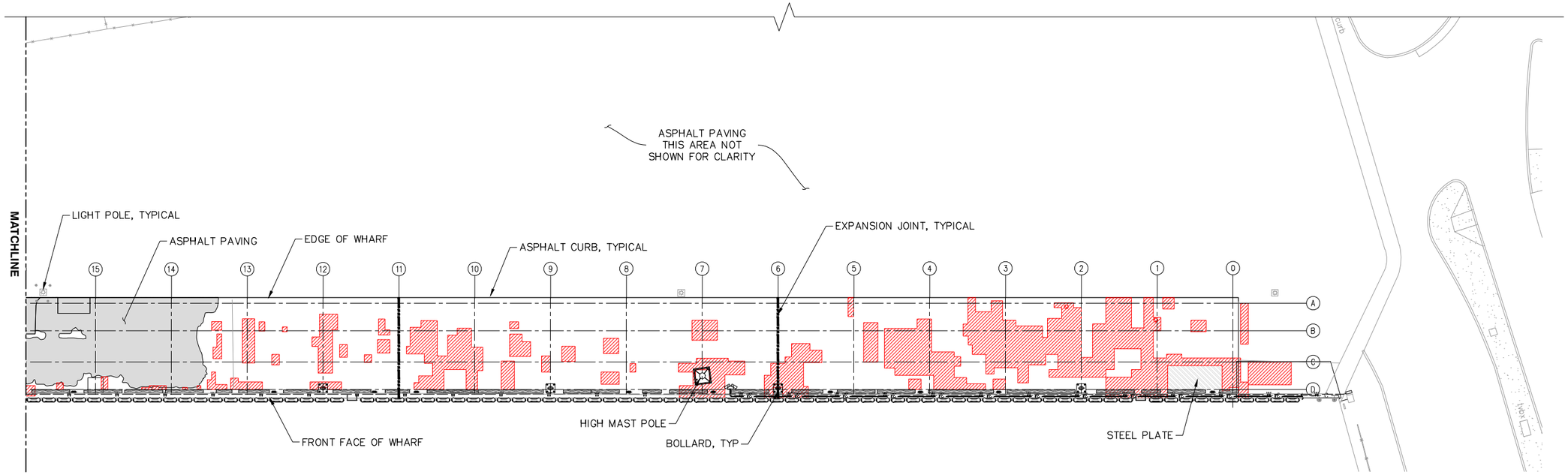
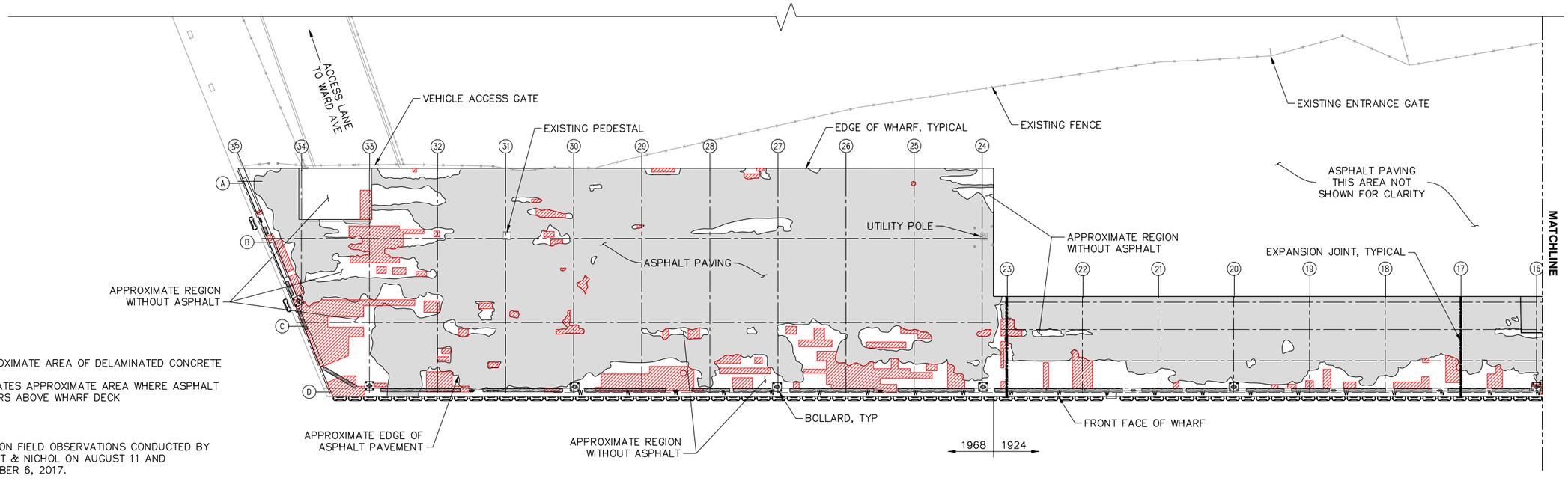
FISHERMAN'S WHARF STRUCTURAL INSPECTION AND EVALUATION

PROJECT SITE MAP

FIGURE 1 OF 14





LEGEND

- APPROXIMATE AREA OF DELAMINATED CONCRETE
- INDICATES APPROXIMATE AREA WHERE ASPHALT OCCURS ABOVE WHARF DECK

NOTES:

1. BASED ON FIELD OBSERVATIONS CONDUCTED BY MOFFATT & NICHOL ON AUGUST 11 AND SEPTEMBER 6, 2017.
2. DELAMINATED CONCRETE AREAS IS BASED ON CHAIN DRAG SURVEY.
3. CONCRETE DAMAGES SHOWN IS LIMITED TO EXPOSED CONCRETE AREAS.

15' 0' 15' 30'

SCALE: 1"=30'

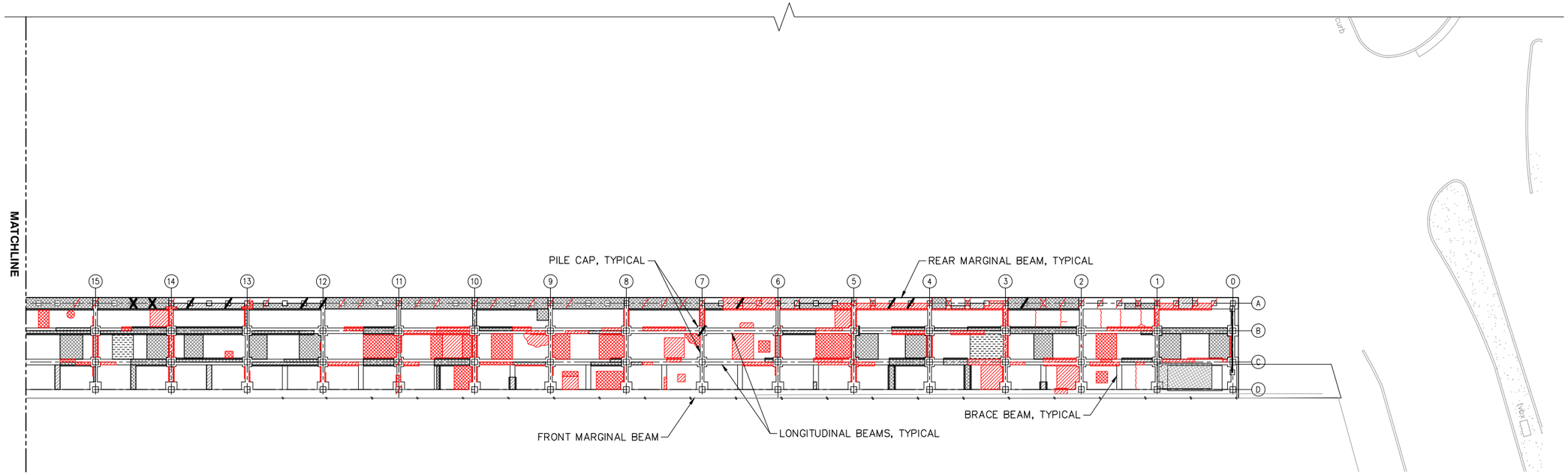
DRAWING SCALES SHOWN BASED ON 11"x17" DRAWING

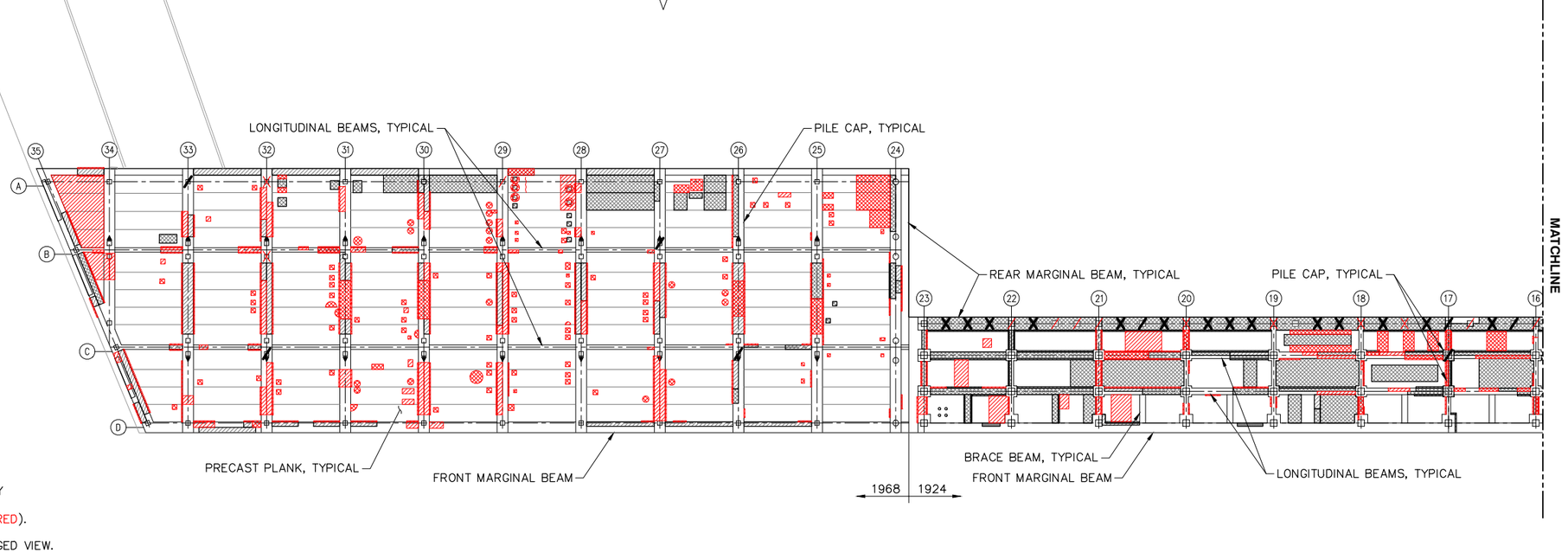
moffatt & nichol

FISHERMAN'S WHARF STRUCTURAL
INSPECTION AND EVALUATION

ABOVE DECK SPALL PLAN - OVERALL

FIGURE 2 OF 14





LEGEND

- OPEN CORROSION SPALL (OCS)
- CLOSED CORROSION SPALL (CCS)
- FORM WORK
- FAILED REPAIR
- PILE MINOR DEFECTS
- PILE MODERATE DEFECTS

NOTES:

1. BASED ON FIELD OBSERVATIONS CONDUCTED BY MOFFATT & NICHOL ON MARCH 8 AND 9, 2012 (IN BLACK) AND AUGUST 10 AND 11, 2017 (IN RED).
2. SEE FIGURE 4 THROUGH FIGURE 13 FOR ENLARGED VIEW.

15' 0' 15' 30'

SCALE: 1"=30'

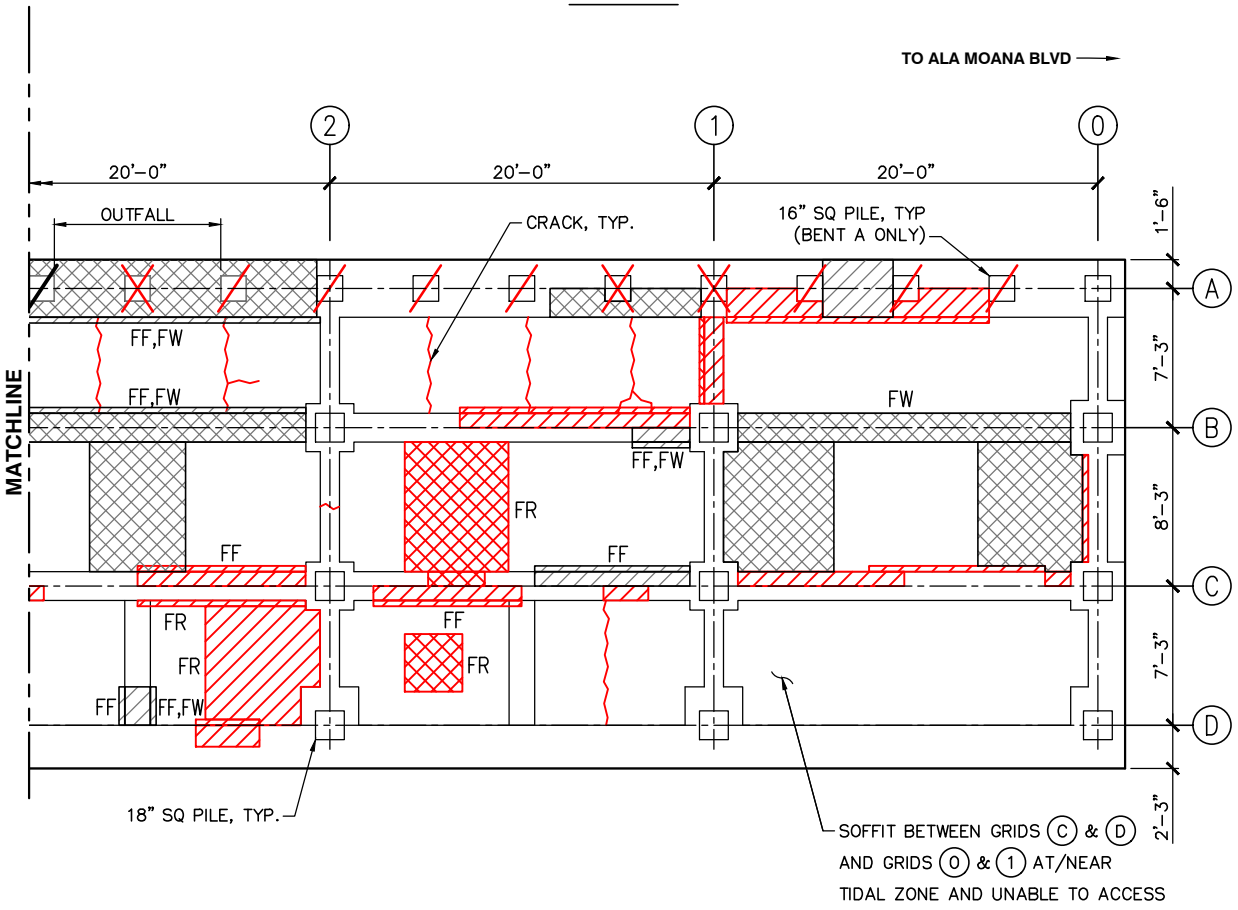
DRAWING SCALES SHOWN BASED ON 11"x17" DRAWING

moffatt & nichol

FISHERMAN'S WHARF STRUCTURAL INSPECTION AND EVALUATION

REFLECTED SOFFIT PLAN - OVERALL

FIGURE 3 OF 14



LEGEND

- OPEN CORROSION SPALL (OCS)
- CLOSED CORROSION SPALL (CCS)
- PILE REPAIR
- MINOR DEFECTS
- MODERATE DEFECTS

FF = FULL FACE
FL = FULL LENGTH
FR = FAILED REPAIR
FW = FULL WIDTH

NOTE:
BASED ON FIELD OBSERVATIONS CONDUCTED BY MOFFATT & NICHOL ON MARCH 8 AND 9, 2012 (IN BLACK) AND AUGUST 10 AND 11 2017 (IN RED).

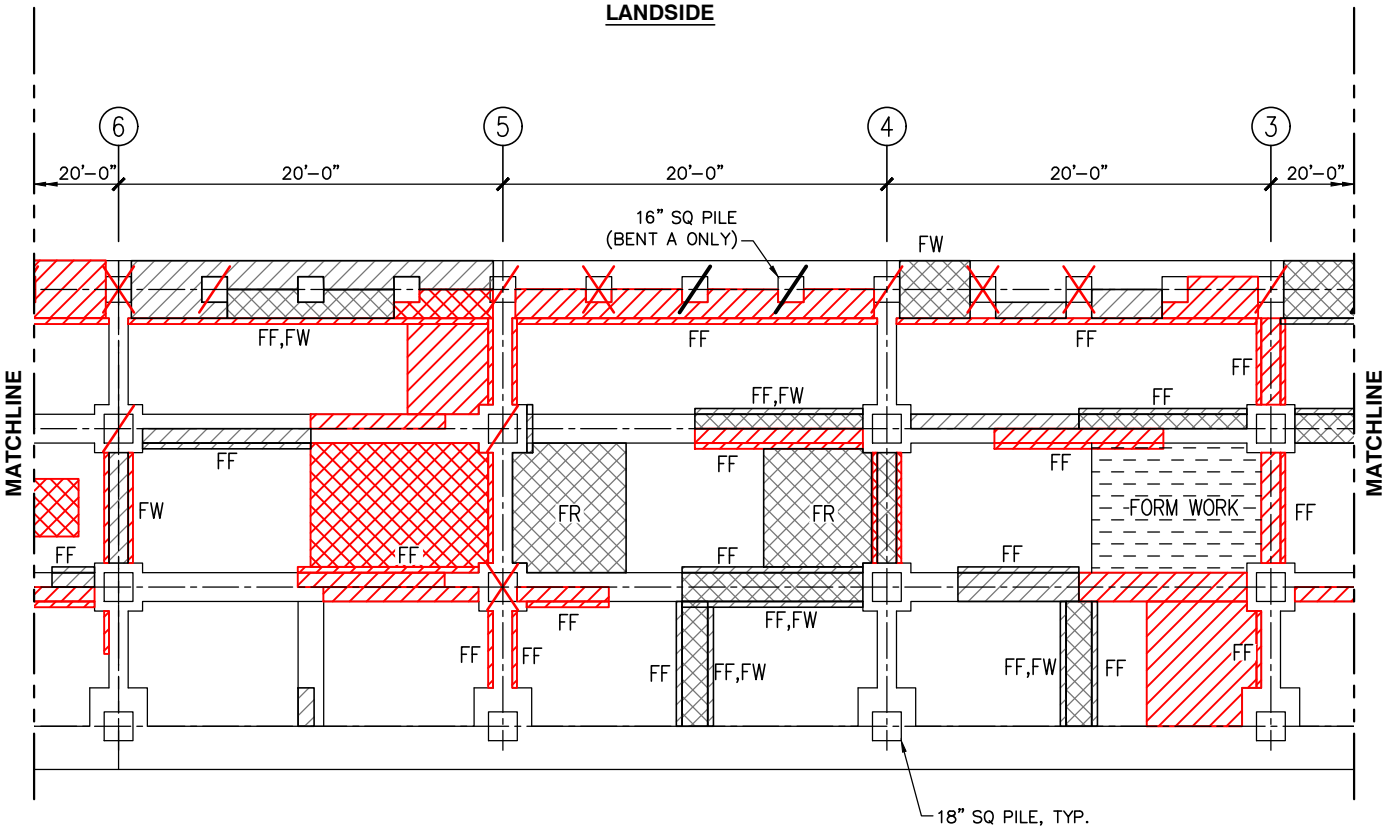
SCALE: 1" = 10'

FISHERMAN'S WHARF STRUCTURAL INSPECTION AND EVALUATION

REFLECTED SOFFIT PLAN (1 OF 10)

FIGURE 4 OF 14

moffatt & nichol



LEGEND

- OPEN CORROSION SPALL (OCS)
- CLOSED CORROSION SPALL (CCS)
- PILE REPAIR
- MINOR DEFECTS
- MODERATE DEFECTS

FF = FULL FACE
FL = FULL LENGTH
FR = FAILED REPAIR
FW = FULL WIDTH

NOTE:
BASED ON FIELD OBSERVATIONS CONDUCTED BY MOFFATT & NICHOL ON MARCH 8 AND 9, 2012 (IN BLACK) AND AUGUST 10 AND 11 2017 (IN RED).

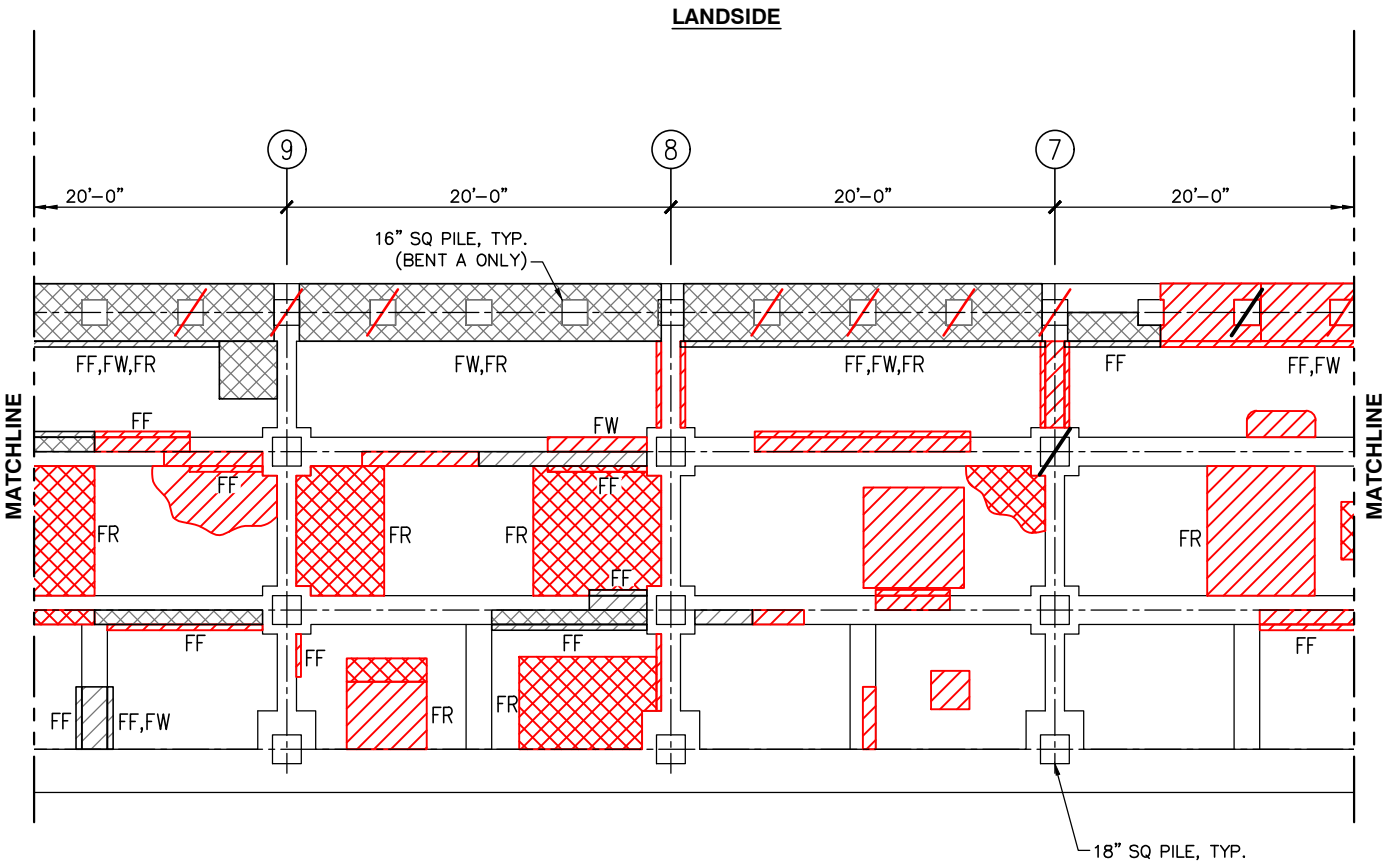
SCALE: 1" = 10'

FISHERMAN'S WHARF STRUCTURAL INSPECTION AND EVALUATION

REFLECTED SOFFIT PLAN (2 OF 10)

FIGURE 5 OF 14

moffatt & nichol



LEGEND

- OPEN CORROSION SPALL (OCS)
- CLOSED CORROSION SPALL (CCS)
- PILE REPAIR
- MINOR DEFECTS
- MODERATE DEFECTS

FF = FULL FACE
FL = FULL LENGTH
FR = FAILED REPAIR
FW = FULL WIDTH

NOTE:
BASED ON FIELD OBSERVATIONS CONDUCTED BY MOFFATT & NICHOL ON MARCH 8 AND 9, 2012 (IN BLACK) AND AUGUST 10 AND 11 2017 (**IN RED**).

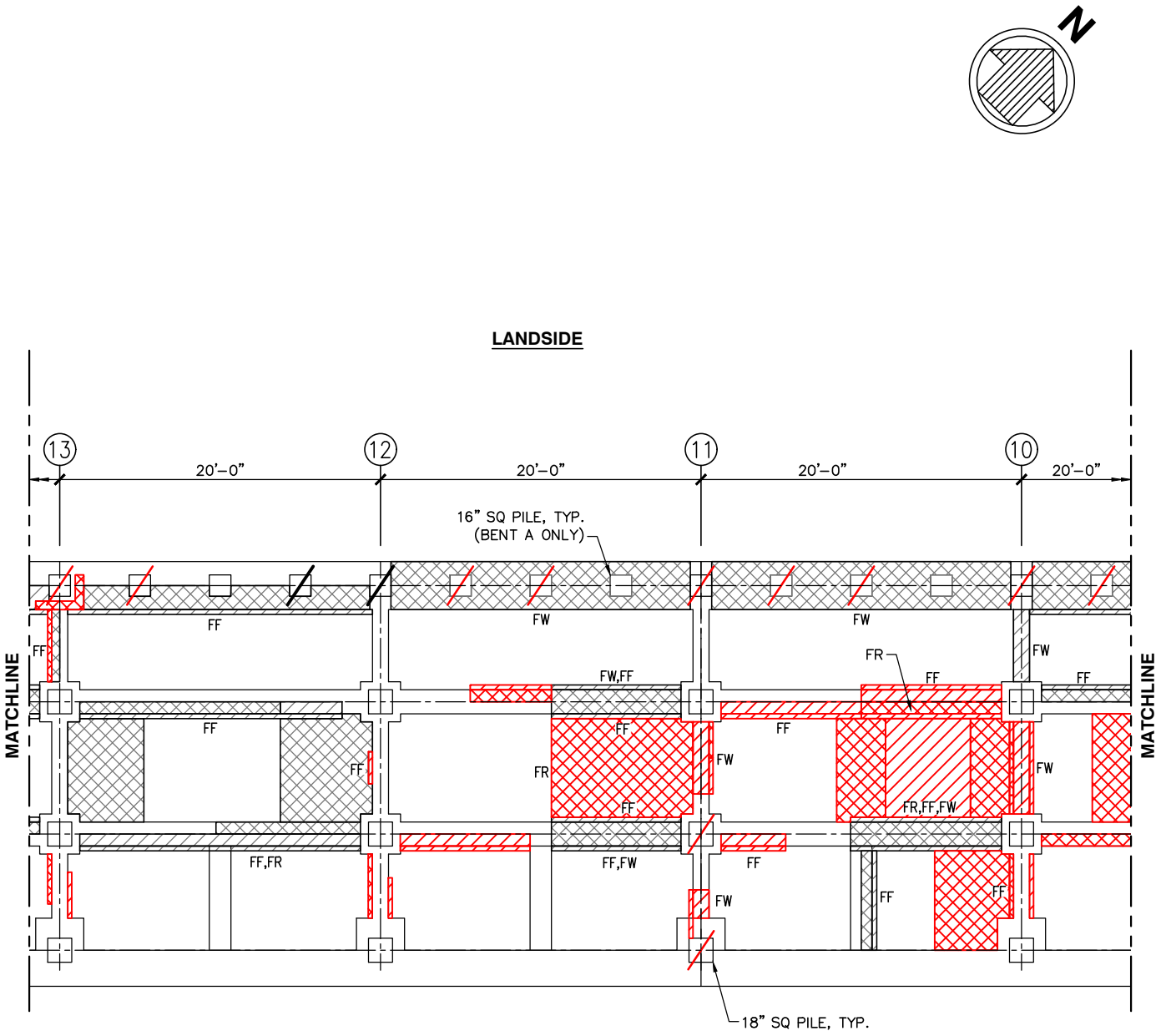
SCALE: 1" = 10'

FISHERMAN'S WHARF STRUCTURAL
INSPECTION AND EVALUATION

REFLECTED SOFFIT PLAN (3 OF 10)

FIGURE 6 OF 14

moffatt & nichol



LEGEND

- OPEN CORROSION SPALL (OCS)
- CLOSED CORROSION SPALL (CCS)
- PILE REPAIR
- MINOR DEFECTS
- MODERATE DEFECTS

FF = FULL FACE
FL = FULL LENGTH
FR = FAILED REPAIR
FW = FULL WIDTH

NOTE:
BASED ON FIELD OBSERVATIONS CONDUCTED BY MOFFATT & NICHOL ON MARCH 8 AND 9, 2012 (IN BLACK) AND AUGUST 10 AND 11 2017 (**IN RED**).

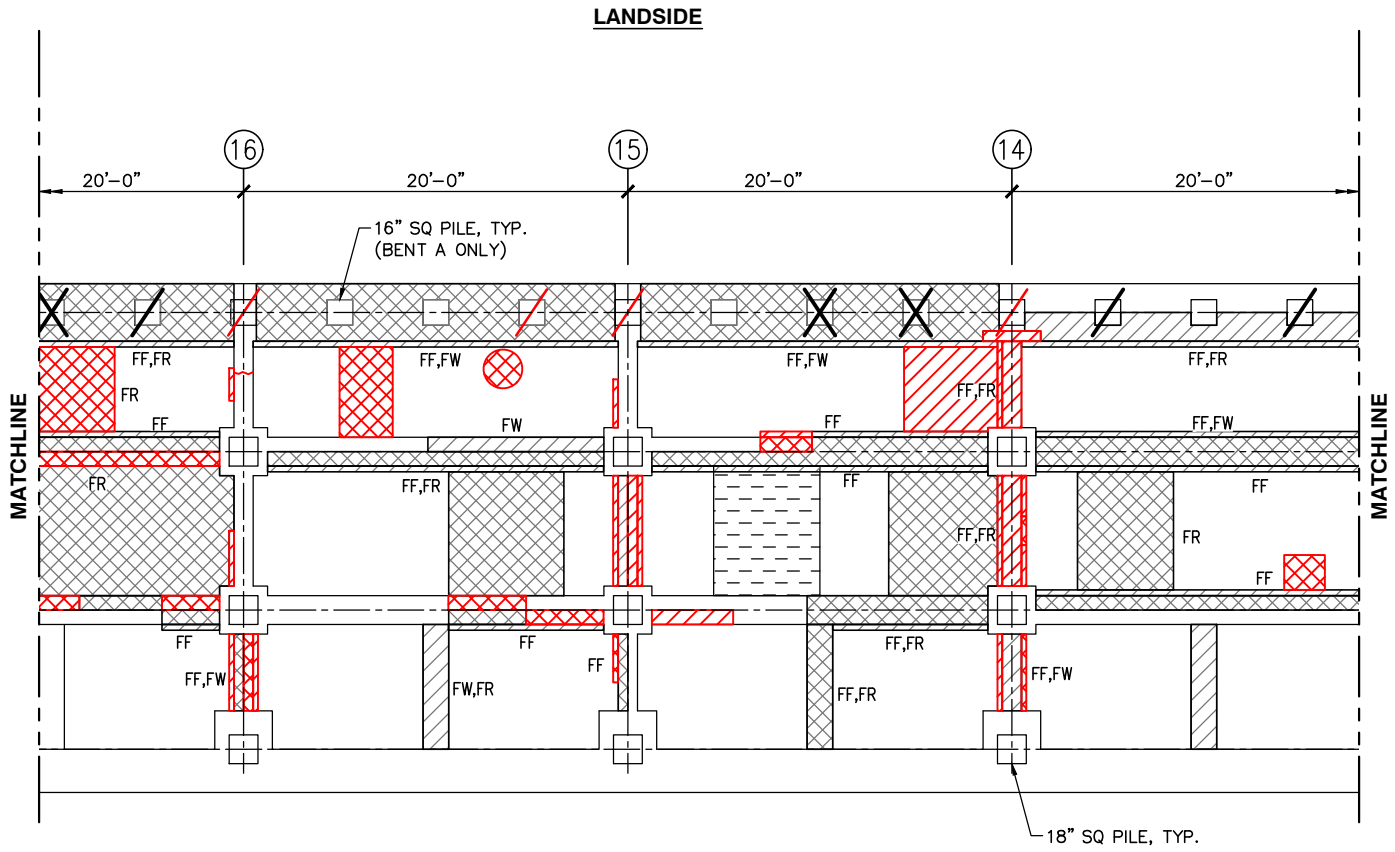
SCALE: 1" = 10'

FISHERMAN'S WHARF STRUCTURAL
INSPECTION AND EVALUATION

REFLECTED SOFFIT PLAN (4 OF 10)

FIGURE 7 OF 14

moffatt & nichol



LEGEND

- OPEN CORROSION SPALL (OCS)
- CLOSED CORROSION SPALL (CCS)
- PILE REPAIR
- MINOR DEFECTS
- MODERATE DEFECTS

FF = FULL FACE
FL = FULL LENGTH
FR = FAILED REPAIR
FW = FULL WIDTH

NOTE:
BASED ON FIELD OBSERVATIONS CONDUCTED BY MOFFATT & NICHOL ON MARCH 8 AND 9, 2012 (IN BLACK) AND AUGUST 10 AND 11 2017 (**IN RED**).

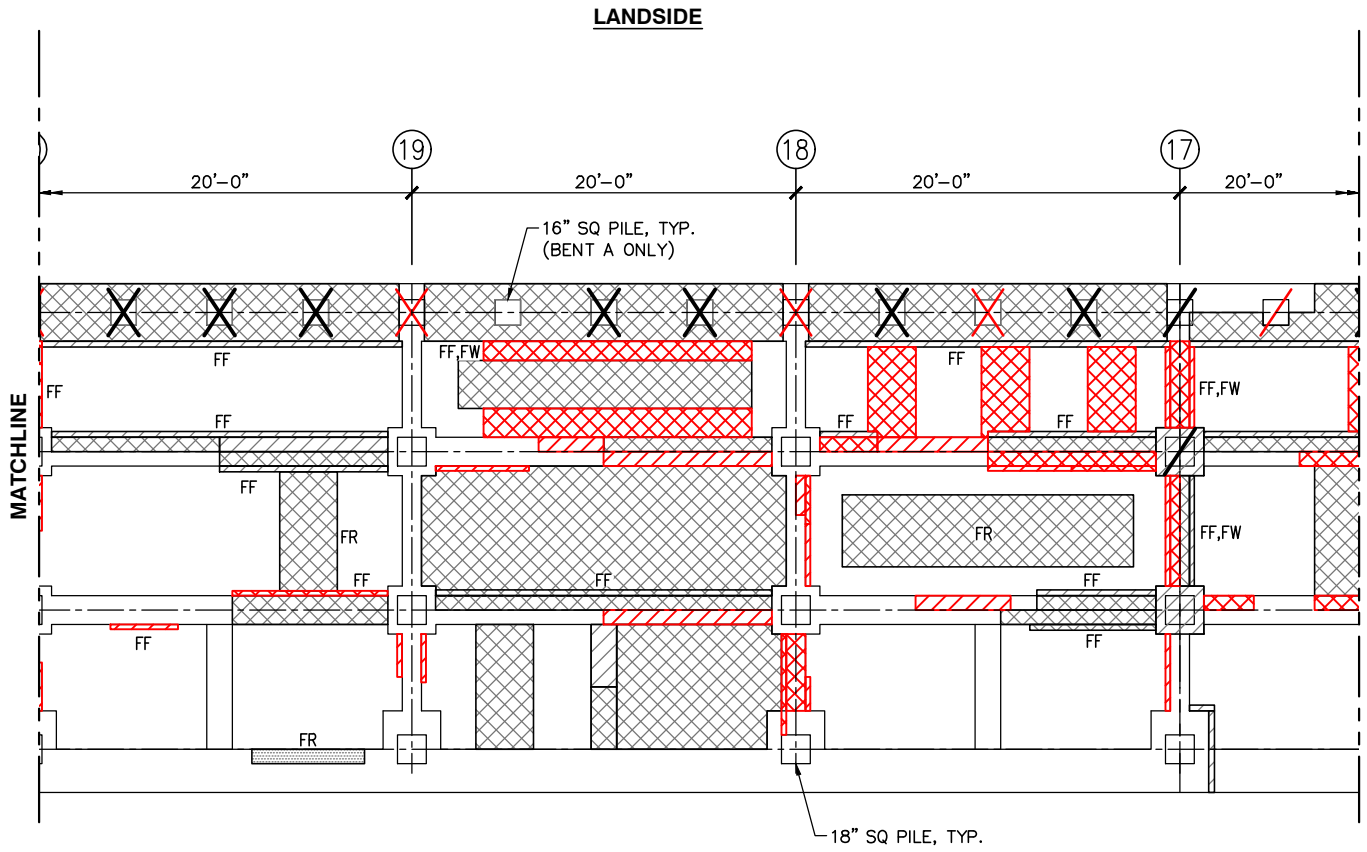
SCALE: 1" = 10'

FISHERMAN'S WHARF STRUCTURAL INSPECTION AND EVALUATION

REFLECTED SOFFIT PLAN (5 OF 10)

FIGURE 8 OF 14

moffatt & nichol



LEGEND

- OPEN CORROSION SPALL (OCS)
- CLOSED CORROSION SPALL (CCS)
- PILE REPAIR
- MINOR DEFECTS
- MODERATE DEFECTS

FF = FULL FACE
FL = FULL LENGTH
FR = FAILED REPAIR
FW = FULL WIDTH

NOTE:
BASED ON FIELD OBSERVATIONS CONDUCTED BY MOFFATT & NICHOL ON MARCH 8 AND 9, 2012 (IN BLACK) AND AUGUST 10 AND 11 2017 (IN RED).

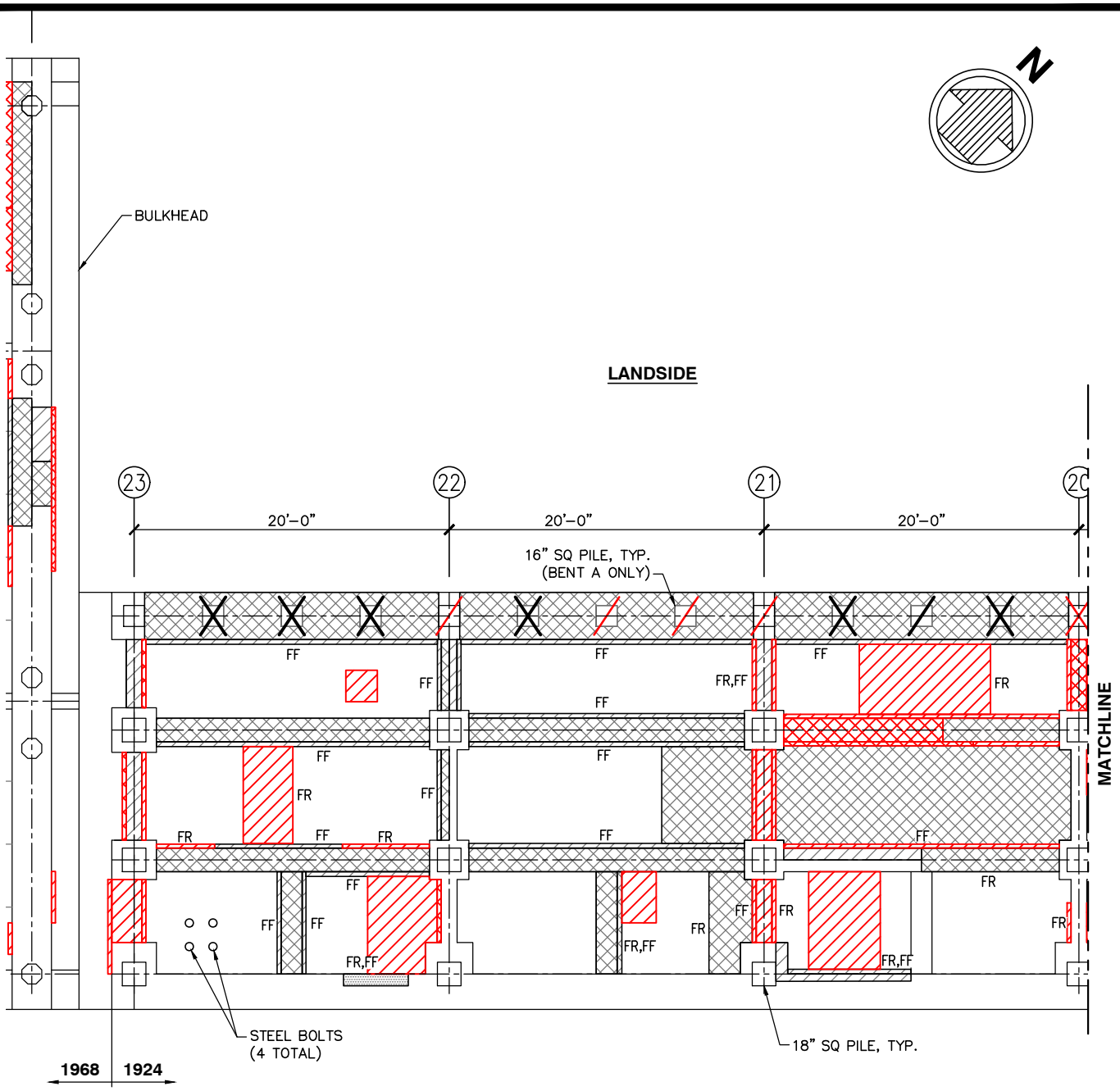
SCALE: 1" = 10'

FISHERMAN'S WHARF STRUCTURAL INSPECTION AND EVALUATION

REFLECTED SOFFIT PLAN (6 OF 10)

FIGURE 9 OF 14

moffatt & nichol



LEGEND

- OPEN CORROSION SPALL (OCS)
- CLOSED CORROSION SPALL (CCS)
- PILE REPAIR
- MINOR DEFECTS
- MODERATE DEFECTS

FF = FULL FACE
FL = FULL LENGTH
FR = FAILED REPAIR
FW = FULL WIDTH

NOTE:
BASED ON FIELD OBSERVATIONS CONDUCTED BY MOFFATT & NICHOL ON MARCH 8 AND 9, 2012 (IN BLACK) AND AUGUST 10 AND 11 2017 (IN RED).

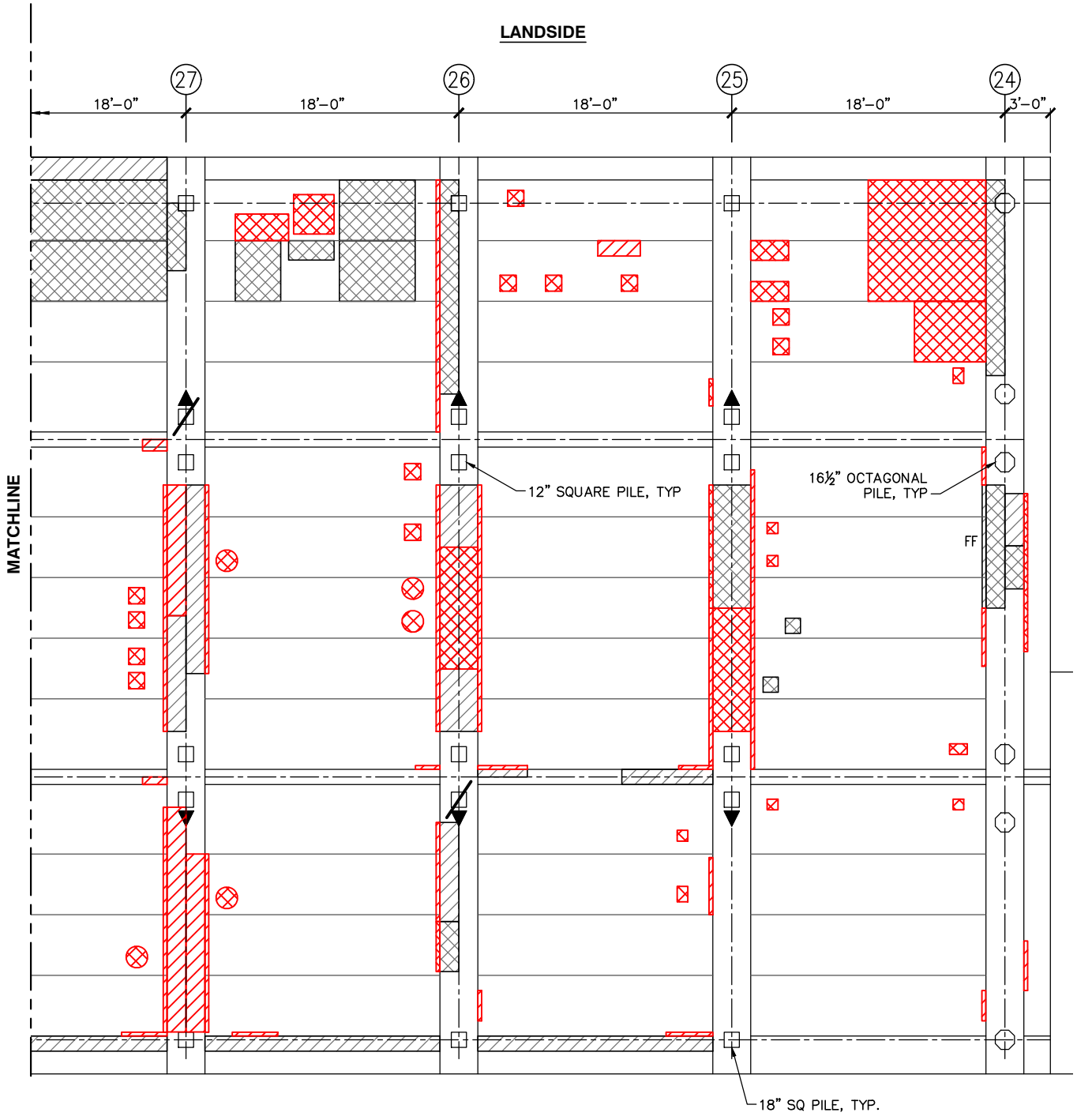
SCALE: 1" = 10'

FISHERMAN'S WHARF STRUCTURAL INSPECTION AND EVALUATION

REFLECTED SOFFIT PLAN (7 OF 10)

FIGURE 10 OF 14

moffatt & nichol



LEGEND

- OPEN CORROSION SPALL (OCS)
- CLOSED CORROSION SPALL (CCS)
- PILE REPAIR
- MINOR DEFECTS
- MODERATE DEFECTS

FF = FULL FACE
FL = FULL LENGTH
FR = FAILED REPAIR
FW = FULL WIDTH

NOTE:
BASED ON FIELD OBSERVATIONS CONDUCTED BY MOFFATT & NICHOL ON MARCH 8 AND 9, 2012 (IN BLACK) AND AUGUST 10 AND 11 2017 (IN RED).

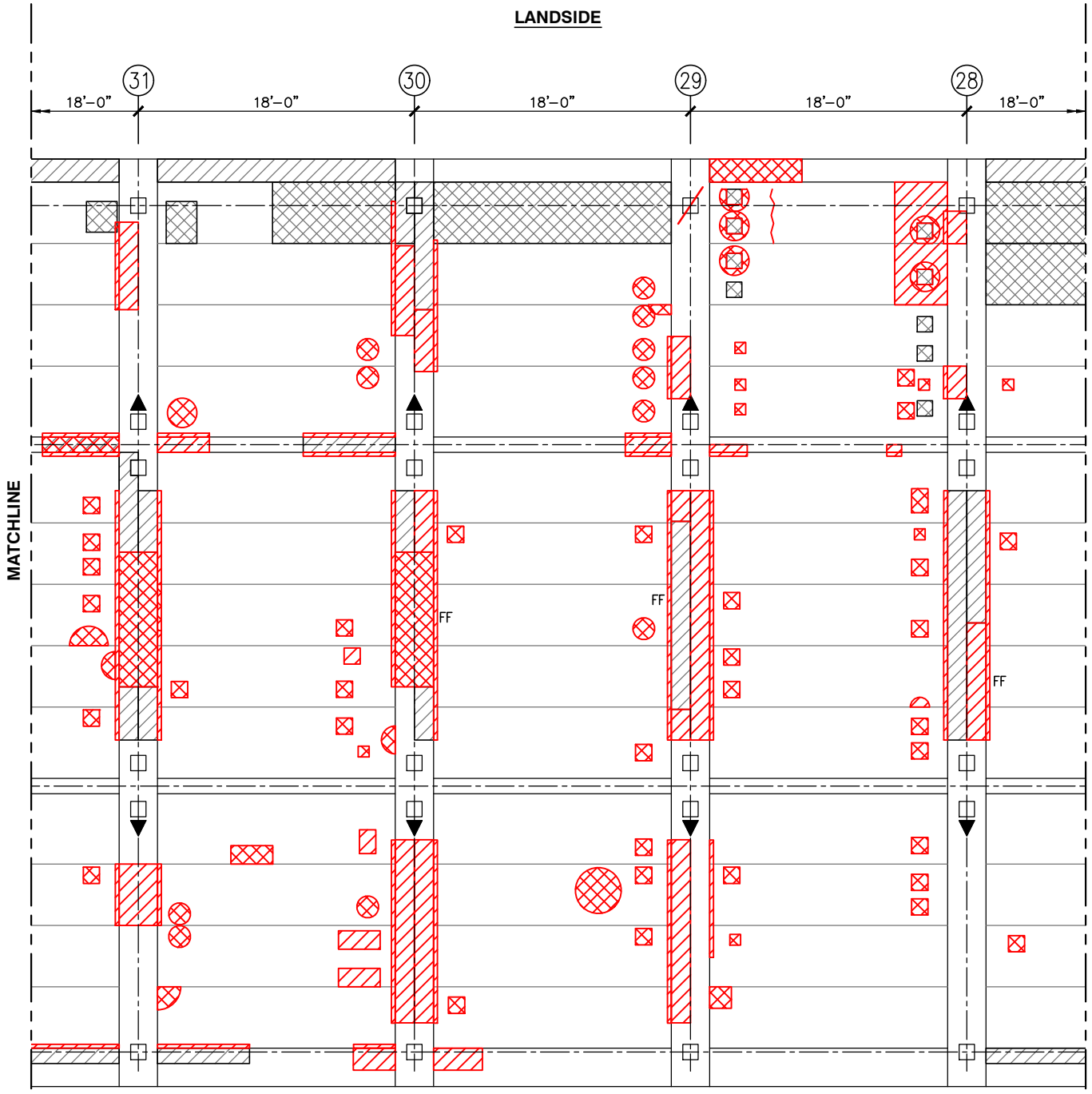
SCALE: 1" = 10'

FISHERMAN'S WHARF STRUCTURAL INSPECTION AND EVALUATION

REFLECTED SOFFIT PLAN (8 OF 10)

FIGURE 11 OF 14

moffatt & nichol



LEGEND

- OPEN CORROSION SPALL (OCS)
- CLOSED CORROSION SPALL (CCS)
- PILE REPAIR
- MINOR DEFECTS
- MODERATE DEFECTS

FF = FULL FACE
FL = FULL LENGTH
FR = FAILED REPAIR
FW = FULL WIDTH

NOTE:
BASED ON FIELD OBSERVATIONS CONDUCTED BY MOFFATT & NICHOL ON MARCH 8 AND 9, 2012 (IN BLACK) AND AUGUST 10 AND 11 2017 (**IN RED**).

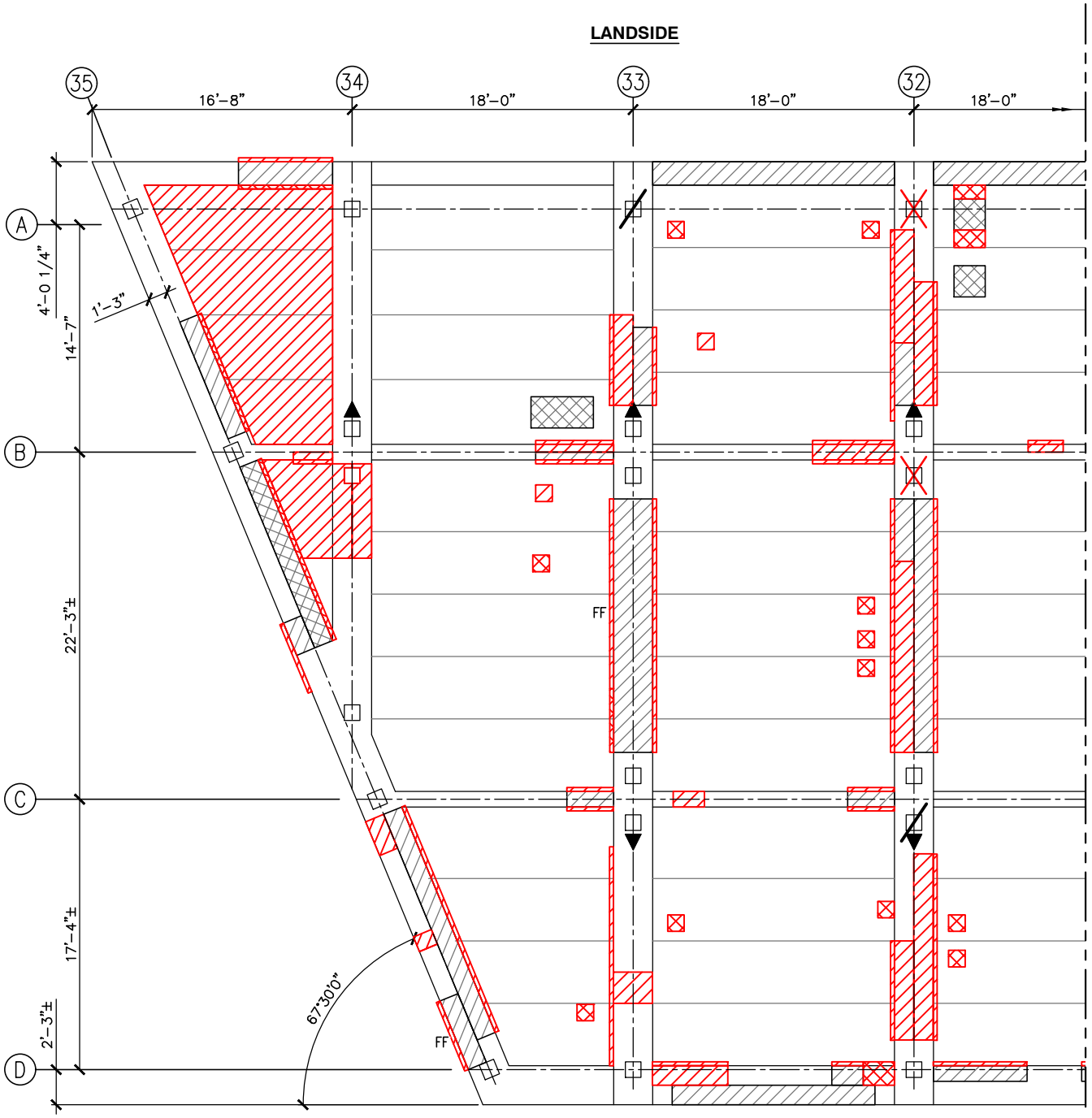
SCALE: 1" = 10'

FISHERMAN'S WHARF STRUCTURAL INSPECTION AND EVALUATION

REFLECTED SOFFIT PLAN (9 OF 10)

FIGURE 12 OF 14

moffatt & nichol



LEGEND

- OPEN CORROSION SPALL (OCS)
- CLOSED CORROSION SPALL (CCS)
- PILE REPAIR
- MINOR DEFECTS
- MODERATE DEFECTS

FF = FULL FACE
FL = FULL LENGTH
FR = FAILED REPAIR
FW = FULL WIDTH

NOTE:
BASED ON FIELD OBSERVATIONS CONDUCTED BY MOFFATT & NICHOL ON MARCH 8 AND 9, 2012 (IN BLACK) AND AUGUST 10 AND 11 2017 (IN RED).

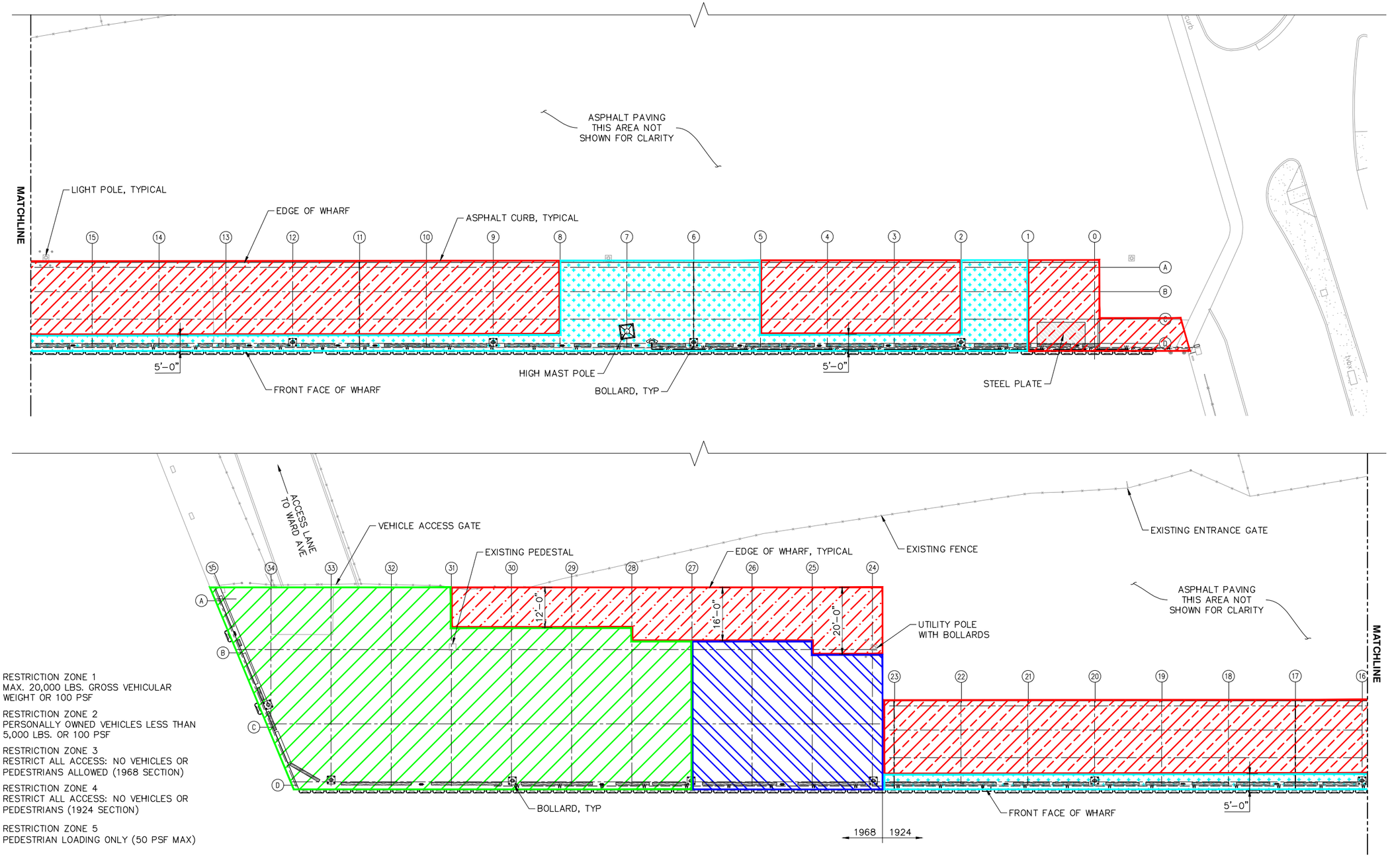
SCALE: 1" = 10'

FISHERMAN'S WHARF STRUCTURAL INSPECTION AND EVALUATION

REFLECTED SOFFIT PLAN (10 OF 10)

FIGURE 13 OF 14

moffatt & nichol



LEGEND

- RESTRICTION ZONE 1
  MAX. 20,000 LBS. GROSS VEHICULAR WEIGHT OR 100 PSF
- RESTRICTION ZONE 2
  PERSONALLY OWNED VEHICLES LESS THAN 5,000 LBS. OR 100 PSF
- RESTRICTION ZONE 3
  RESTRICT ALL ACCESS: NO VEHICLES OR PEDESTRIANS ALLOWED (1968 SECTION)
- RESTRICTION ZONE 4
  RESTRICT ALL ACCESS: NO VEHICLES OR PEDESTRIANS (1924 SECTION)
- RESTRICTION ZONE 5
  PEDESTRIAN LOADING ONLY (50 PSF MAX)

NOTES:

1. BASED ON FIELD OBSERVATIONS CONDUCTED BY MOFFATT & NICHOL ON AUGUST 11 AND SEPTEMBER 6, 2017.

15' 0' 15' 30'

SCALE: 1"=30'

DRAWING SCALES SHOWN BASED ON 11"x17" DRAWING

moffatt & nichol

FISHERMAN'S WHARF STRUCTURAL INSPECTION AND EVALUATION

VEHICLE AND PEDESTRIAN OPERATIONAL RESTRICTIONS

FIGURE 14 OF 14